WPPSS
NUCLEAR PROJECT
NO. 2

ENVIRONMENTAL
REPORT

OPERATING LICENSE STAGE

WASHINGTON PUBLIC POWER
SUPPLY SYSTEM

50-397
w/ ltr. dtd.
3-21-77

Washington Public Power Supply System
A JOINT OPERATING AGENCY

P. O. Box 968 3000 Geo. Washington Way Richland, Washington 99352 Phone (509) 946-1611

Docket No. 50-397

March 21, 1977
G02-77-124

Mr. Benard C. Rusche, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: WPPSS NUCLEAR PROJECT NO. 2
ENVIRONMENTAL REPORT - OPERATING LICENSE STAGE
SUBMITTAL FOR DOCKETING

Reference: Letter, R. S. Boyd, NRC to D. L. Renberger, WPPSS, dated February 17, 1977.

Dear Mr. Rusche:

Washington Public Power Supply System is hereby submitting for docketing forty-one (41) copies including three (3) notarized originals of the subject document as requested in the referenced letter. Within (10) days of notification of docketing, distribution will be made according to the attached distribution list and an affidavit to that effect provided.

Environmental Technical Specifications are being prepared for submittal by June 1, 1977.

Very truly yours,

D L Renberger

D. L. RENBERGER
Assistant Director
Generation and Technology

DLR:RKW:vws

Attachment

cc: Distribution List

Subject: WPPSS NUCLEAR PROJECT NO. 2
ENVIRONMENTAL REPORT - OPERATING LICENSE STAGE
SUBMITTAL FOR DOCKETING

STATE OF WASHINGTON)
) ss
COUNTY OF BENTON)

D. L. RENBERGER, Being first duly sworn, deposes and says: That he is the Assistant Director, Generation and Technology, for the WASHINGTON PUBLIC POWER SUPPLY SYSTEM, the applicant herein; that he is authorized to submit the foregoing on behalf of said applicant; that he has read the foregoing and knows the contents thereof; and believes the same to be true to the best of his knowledge.

DATED March 15, 1977

D L Renberger
D. L. RENBERGER

On this day personally appeared before me D. L. RENBERGER to me known to be the individual who executed the foregoing instrument and acknowledged that he signed the same as his free act and deed for the uses and purposes therein mentioned.

GIVEN under my hand and seal this 15th day of March, 1977.

Reba B. Helgesen
Notary Public in and for the State of Washington
Residing at Richland

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(After DES is issued, send 4 copies of ER & Amendments to Riedel)

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WASHINGTON PUBLIC POWER SUPPLY SYSTEM

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CHAPTER 1
PURPOSE OF THE PROPOSED FACILITY

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PURPOSE OF THE PROPOSED FACILITY

1.0 DEFINITION

In order to satisfy power needs of the Pacific Northwest region, a nuclear electric generating facility has been proposed to be operated in the State of Washington by the 2
Washington Public Power Supply System ("Supply System"). The proposed nuclear electric generating project, Washington Public Power Supply System Nuclear Project No. 2 (WNP-2) rated at 1,100 MWe, is located on a site within the 2
U. S. Department of Energy (DOE) Hanford Reservation in Benton County, Washington, approximately 12 miles north of the city of Richland, Washington.

1.0.1 The Supply System

The Supply System is a joint operating agency formed under Chapter 43.52 of the Revised Code of Washington. The Supply System was originally formed in 1957. As a joint operating agency, the Supply System is legally empowered "to generate, produce, transmit, transfer, exchange or sell electric energy and to enter into contracts for any or all such purposes." (RCW 43.52.300) The Supply System is specificatlly authorized to issue revenue bonds to finance the construction of projects and facilities undertaken by it. The management and control of the Supply System is vested in a Board of Directors composed of a representative of each of its members. The members of the Supply System have a preference right to purchase all the energy generated by the Supply System. A joint operating agency may not acquire or operate distribution properties, nor does it have a general taxing authority of any kind. The Supply System is specifically authorized to make contracts relating to the purchase, sale, interchange or wheeling of power with the Government of the United States or any agency thereof, or with any municipal corporation or public utility within or outside the State of Washington.

The business of the Supply System is conducted in public meetings of the Board of Directors and all actions taken are by resolution or motion of the Board of Directors, and all records and minutes are public pursuant to the laws of the State of Washington. An Executive Committee composed of 7 members administers the business of the Supply System between regular meetings of the Board of Directors. A Managing

Director, appointed by the Board of Directors, is the chief executive officer of the Supply System and is authorized to administer the business of the Supply System pursuant to rules, resolutions and policies promulgated by the Board of Directors. A joint operating agency such as the Supply System must obtain the approval of legislative bodies of a majority of its members prior to undertaking any project. All bonds or notes issued by the Supply System must be sold at public bidding and all contracts over a stipulated amount are required to be entered into under public biding procedures. The Supply System has no authority to impose any debt or financial obligation on the State of Washington or any of its political subdivisions, including its members. The authority granted to the Supply System by statute applies equally to the generation of electricity by "water power, by steam power, by nuclear power or by any other means whatsoever" (RCW 43.52.260).

The Supply System, whose membership is made up of 19 operating public utility districts and the municipal electrical systems of Richland, Seattle, and Tacoma, all located in the State of Washington, has its principal office in Richland, Washington. It has the power of eminent domain, but is specifically precluded from the condemnation of any plants, works or facilities owned and operated by any city, public utility district or privately-owned electric utility. The Supply System will operate WNP-2 and have continuing responsibility for its maintenance.

The Supply System owns and operates the Packwood Lake Hydro-Electric Project with a nameplate rating of 27,500-KWA. It also owns and operates an 860,000 kilowatt electric generating plant and associated facilities (the "Hanford Generating Project") located on the Hanford Reservation. Steam is provided from the New Production Reactor ("NPR"), owned and operated by the United States Department of Energy (DOE). DOE has recently negotiated a contract with the Supply System to supply steam from the NPR until July 1983. The Supply System is building two other nuclear electric generating plants on the Hanford Reservation; such facilities are known as the Washington Public Power Supply System Nuclear Project No. 1 (WNP-1) and the Washington Public Power Supply System
2 Nuclear Project No. 4 (WNP-4). In addition, two nuclear electric generating plants, Washington Public Power Supply System Nuclear Project No. 3 (WNP-3) and Washington Public Power Supply System Nuclear Project No. 5 (WNP-5) are under construction about 16 miles east of Aberdeen in Grays Harbor County, Washington.

1.0.2 WNP-2

WNP-2 ("the Project") is being undertaken pursuant to the Hydro-Thermal Power Program described in Section 1.1 developed jointly by the utilities of the Pacific Northwest and BPA. The Pacific Northwest Utilities Conference Committee ("PNUCC") represents the entities serving the loads of the West Group area of the Northwest Power Pool and assembles the loads and resources forecasts of the individual utilities into an 11-year forecast, known as the West Group Forecast past issues of which are on file with the Federal Power Commission (FPC). The forecast includes loads and resources for Northern Idaho, Washington, Oregon (except for the southeastern part of the state), a portion of Northern California, the loads and resources of Pacific Power and Light Company and Bonneville Power Administration (BPA) in Western Montana, the BPA loads and the United States Bureau of Reclamation ("USBR") resources in Southern Idaho. PNUCC also expands the forecast into a 20-year planning document titled, "Long-Range Projection of Power Loads and Resources for Thermal Planning West Group Area". Except for minor corrections and additions to the West Group forecast data, the first 11-year data of the Long-Range Projection is the same as the West Group Forecast.

In its planning, PNUCC seeks to:

a) Optimize available resources;

b) Reduce reserves required for adequate system reliability by providing for the inter-utility sharing of reserve requirements; and

c) Improve service and reliability of the region's interconnected system.

The Projects have been timed, sized and located to economically meet regional power requirements consistent with the basic philosophy of the Hydro-Thermal Power Program, of contributing to the growth and stability of the Pacific Northwest. The basic tenets of this philosophy are to:

a) Continue to preserve the environmental and natural beauties of the Northwest.

b) Make efficient and economic use of the federal regional transmission system.

c) Obtain the economics of scale from large thermal generating plants.

d) Coordinate the required large thermal generating plants with existing Pacific Northwest hydro plants, both federal and non-federal, and with future peaking generating units (both hydro-electric and combustion turbine), to achieve an economical, reliable power supply to meet the electric power requirements of the Pacific Northwest.

WNP-2 will be constructed and operated by the Supply System as part of Phase 1 of the Hydro-Thermal Power Program, a program designed to meet the anticipated needs for power in the Pacific Northwest.

Ninety-four consumer-owned utilities in the Pacific Northwest will participate in WNP-2. The public agency participants, all of which are statutory preference customers of BPA, currently obtain all or part of their power supply and other services from BPA. Each participant's share of annual costs of plant operation will be "net-billed" against the billings made by BPA to the participant on a monthly basis under its power sales and other contracts. Under the net billing arrangement, each participating utility contracts with the Supply System to purchase a portion of the WNP-2 electrical output and in turn sells this electricity to BPA for distribution over its regional transmission grid system. In payment for this power, BPA credits the amounts paid by each participant to the Supply System against amounts the participant owes BPA for power purchased and other services.

Since the participant's payments to the Supply System will be net billed, the cost of their shares of the power produced by WNP-2 will be borne by BPA customers. BPA has assured Congress that "any costs or losses to Bonneville under these agreements will be borne by all Bonneville ratepayers through rate adjustments, if necessary".

1.1 NEED FOR POWER

Until the present decade, the Pacific Northwest has relied on hydro-generation for nearly all of its electric energy requirements. Future hydro-developments in the Pacific Northwest, however, will consist largely of the installation of peaking generation because nearly all the economically feasible regional hydro sites have been developed. The integration of new thermal generating resources with the hydro resources of the Northwest to maximize reliability has been a goal of the region's power planning for many years. Utilities of the region commenced practicing coordination on a voluntary basis more than 30 years ago by the establishment of the Northwest Power Pool (NWPP).

In 1964, 14 utilities and three federal entities formalized this coordination in the area by signing the long-term Pacific Northwest Coordination Agreement which expires in 2003, a copy of which is on file with the Federal Power Commission (FPC). To meet the Northwest's firm energy requirements, five Northwest investor-owned utilities, 104 consumer-owned agencies, the Supply System and BPA, acting in concert as the Joint Power Planning Council ("The Council"), in 1968 conceived the Hydro-Thermal Power Program. The Hydro-Thermal Power Program was approved by the Secretary of the Interior on October 22, 1968, and the federal portion of the program was approved through 1981 by the Congressional enactment of the Public Works Appropriation Act of 1971.

Installation schedules were established for seven large thermal plants needed in addition to the probable hydro-generation installation to supply the requirements of the region through the operating year 1981-1982. (Phase 1 of the Hydro-Thermal Power Program.)

A review of load and resource forecasts for the region was undertaken in mid-1973 to reassess the resource requirements of the region because of slippage in the federal hydro installation schedule, the inability of the large Centralia Thermal Project to reach rated capacity because of environmental considerations, the energy crisis, and the then impending shutdown of United States Energy Research and Development Administration (ERDA) NPR which furnishes steam to the Hanford Generating Project. Consideration was given in the review to the effect on the use of electrical energy to be expected from a continuing educational program for the efficient use of all types of energy. The revised forecast indicated a continuing deficiency of both capacity and energy.

Because of the projected resource deficiency, Phase 2 of the Hydro-Thermal Power Program was formulated. It contains a schedule of thermal plant installations to eliminate, as rapidly as possible, the forecasted resource deficiencies. This installation schedule (date of commercial operation) extends through 1985. Recently the PNUCC has taken over the functions of the Joint Power Planning Council and the Council has become inactive.

The Supply System serves the region as a bulk power supplier for the numerous consumer-owned utilities throughout the region. As such, facilities built by the Supply System can realistically be considered as regional resources.

1.1.1 Load Characteristics

The characteristics of both the Pacific Northwest loads and the electrical power supply system have developed together and are relatively unique within the United States. Most of the regional power is presently being generated at hydro-electric projects, many of which are owned by the federal government. Much of the power flows to the distributing utilities over Bonneville Power Administration transmission lines. Customers in the area, other than industrial direct service customers of BPA, are served by either investor-owned utilities, public utility districts, municipal systems, or cooperative rural electrification systems. Due to the region's vast hydro-electric resources electrical energy costs in the Pacific Northwest have been quite low, leading to high per capita consumption of electrical energy. As a consequence, per capita use of other forms of energy are less than they might otherwise have been for some industrial and commercial uses and for such residential uses as cooking, water heating, and space heating. Some electrical-energy-intensive industry has also developed in the region.

The electrical supply resource of the region is entering a transition period since the major part of the economically attractive energy potential obtainable from hydro-electric projects has already been developed. Because demand fluctuates on a daily, weekly, and annual basis, additional capacity is being installed at existing hydro projects to shape energy to load requirements. The region foresees greater usage of hydro resources for peaking, with thermal resources such as WNP-2 operating as baseload units at high plant factors except for times when sufficient water supply is available to displace thermal output.

To properly assess the need for the Project, consideration must be given to the unique features of the power supply in the Pacific Northwest. Although hydro capability in the area is abundant, firm energy and dependable peaking capacity, produced from existing regional hydro resources, are limited not only by installed machine capacity but also by usable water storage volume available to the region. Existing hydro projects in the West Group area have nearly exhausted the sites that can be developed on an economical and environmentally acceptable basis. Most additional developments that can meet these conditions are either under construction or in firm planning stages with substantial amounts of money committed for planning and engineering. These additional projects have been included in load forecasts made by the Pacific Northwest Utilities Conference Committee (PNUCC).

The West Group utilities have established a "critical period" of adverse water conditions to be used in both planning and operations. Adverse stream flows of historical record, coupled with installed machine capability and storage volume usable for power production, determine the length of such critical period. By definition, under a repeat of the most adverse stream flows of historical record, no water is spilled past generating facilities except for water spilled past existing run-of-the-river facilities that are incapable of fully utilizing such adverse flows. Although additional dependable capacity, needed to shape energy to load requirements, can be added to the coordinated system by installing additional generators at existing hydro projects, only a small amount of additional firm energy can be produced by such additions. As previously stated, there is very little potential in the West Group area for additional reservoir volume required to increase firm energy production. For this reason, the area is required to construct base load thermal plants to supply the forecasted energy requirements of the area and to add hydro capacity to shape such thermal energy production to load requirements.

1.1.1.1 Utility Organizations of the Area

Prior to 1940, few high-voltage inter-tie transmission facilities existed between utilities in the Pacific Northwest. Existing tielines were used primarily for emergency purposes. Very little benefit was derived from inter-utility or intra-regional diversity. Because of isolated system operation, both firm and nonfirm power were not totally available to serve loads of the area.

Early in the 1940's, war-related industries in the area were rapidly increasing their power requirements on the utilities. At the urging of the Federal War Production Board, the utilities stepped up construction and installation of generating facilities and joined together to coordinate the power output of all installed facilities. Bonneville Power Administration had been formed by an act of Congress in 1937 and was given authority to construct transmission facilities in order to market federal power produced by projects in the area built by the Corps of Engineers and the Bureau of

Reclamation. These BPA lines formed a transmission network interconnecting most of the utilities in the area and made power from all the major power projects in the Pacific Northwest available on an areawide basis. Because of this transmission network, the area's utilities were able to coordinate resources.

a) The Northwest Power Pool (NWPP)

The NWPP was formed by the operating management of the generating utilities in the Pacific Northwest for the purpose of coordinating the operation of the hydro and thermal resources of the area in order to optimize, to the extent possible, the availability of firm power to serve the loads of the area. Coordinated operation also provided a means:

1) Of resolving problems of interconnected operation of utility systems;

2) Of utilizing to the greatest advantage possible nonfirm power in the area; and

3) Of reducing required reserves to a minimum by pooled use of such reserves.

Membership in the NWPP includes consumer- and investor-owned generating utilities, BPA, the Corps of Engineers the United States Bureau of Reclamation (USBR) and two Canadian utilities. Member utilities in the United States serve loads in the states of Montana, Idaho, Utah, Wyoming, Washington, Oregon and Northern California.

In order to accomplish the objectives of pooling, the NWPP employed a staff of engineers, known as the Coordinating Group, to make studies and forecasts, on a short-term basis, necessary to best utilize the pooled resources to serve the loads of the area. A "critical period" concept was developed. Reservoir regulation studies are made on a coordinated system basis and reservoir operating rule curves are established each year for each reservoir, such that with a repeat of the most adverse water conditions of history, firm loads of the area can be carried. Loads above the critical period firm resource capability are relegated to a nonfirm or interruptible basis.

Voluntary coordiantion worked to the advantage of both the utilities and industry and therefore was continued after the war ended.

One of the factors contributing to the success of NWPP was that each member utility maintained its independent utility responsibility in planning and operating its system but worked through the pool to coordinate these functions with other utilities to the best advantage of the region.

b) Pacific Northwest Utilities Conference Committee (PNUCC)

The NWPP devotes its efforts primarily to short-term planning and resource coordination and to current operating problems. Management soon recognized the benefits that were afforded to utilities through the efforts of the NWPP and decided to expand those benefits through coordination of long-term planning for construction and installation of generating facilities. PNUCC was organized, also on a voluntary basis, to accomplish this purpose. PNUCC is an informal association of public and private utilities in the Pacific Northwest. Membership is open to all utilities in the Pacific Northwest but many of the smaller utilities depend upon BPA to represent them. PNUCC established a Loads and Resources Subcommittee and delegated to it the responsibility for assembling the loads and resources forecasts made annually by the utility members and compiling them into a single forecast document. When PNUCC was formed, lead time for installation of hydrogeneration was approximately four years. Forecasts were made for an 11-year period beyond the current operating year to provide adequate time for planning and installation of additionally required resources.

By 1968 lead time for installation of generating facilities had increased to about 10 years, necessitating the expansion of the West Group forecast to a long-range forecast covering loads and probable resources for an additional 9-year period. This expanded forecast is titled, "Long-Range Projection of Power Loads and Resources for Thermal Planning" and is commonly referred to as the "Blue Book" because of the color of its cover.

c) Canadian Treaty and Columbia Storage Power Exchange

On January 17, 1961, the "Treaty Between the United States of America and Canada Relating to the Cooperative Development of the Water Resources of the Columbia River Basin" ("Canadian Treaty") was signed by the United States and Canada. Among other things, this treaty and the notes exchanged pursuant to the treaty provided for the construction, maintenance and operation by Canada of three dams and storage reservoirs in British Columbia on the Columbia River and its tributaries.

The controlled release of water stored in those reservoirs provides flood control and increases the dependable capacity and usable energy produced at hydro-electric power projects on the Columbia River in the United States. The treaty specifies that the United States and Canada are each entitled to one-half of this increase of dependable capacity and usable energy.

Canada offered to sell its share of the Treaty Benefits to a single entity in the United States in order to obtain money to construct the dams. No single entity with the ability to finance such a purchase existed in the Pacific Northwest so utility management formed a non-profit-no-stock corporation called the Canadian Storage Power (CSPE) to raise the capital required and purchase the Canadian entitlement to the treaty benefits (Canadian Entitlement).

CSPE resold the Canadian Entitlement to 41 investor-owned and consumer-owned utilities in the Pacific Northwest under tri-party exchange agreements between CSPE, Bonneville and the individual utilities whereby CSPE delivers Canadian Entitlement capacity and energy as received from the Columbia River hydro-electric developments in the United States to the purchasing utility. Each utility, in turn, exchanges such capacity and energy with Bonneville for federal capacity and energy shaped within limits, as necessary to meet the utilities load requirements.

Although the Canadian Entitlement was surplus to the needs of the Pacific Northwest at the time of the purchase, forecasts indicated it would be usable in the area in the early 1970's. The cost of the Canadian Entitlement was higher than the power production costs in the Pacific Northwest but was lower than power production costs in California. Consequently, most of the Canadian Entitlement was in turn sold to California utilities on a five-year pull-back provision. A portion was committed to the State of California through the 1982-1983 operating year. All of the Canadian Entitlement sold to California utilities has been withdrawn.

d) Pacific Northwest Coordination Agreement

Early in the negotiations pertaining to the Canadian Treaty and to CSPE it became apparent that voluntary coordination could not insure compliance with all the provisions and operating procedures that would be required when Canadian Treaty power became available.

Negotiations were therefore started to formalize coordination of generating utilities affected by the Canadian Treaty provisions. On September 15, 1964, the Pacific Northwest Coordination Agreement ("Coordination Agreement") was signed by three federal entities and 14 generating utilities having facilities affected by the treaty.

Among other things, the Coordination Agreement provides, on a regular basis, for:

1) Establishing a Critical Period based on historical water records.

2) Making Critical Period reservoir regulation studies on an integrated system basis and establishing reservoir operating curves (Energy Content Curves and Critical Rule Curves).

3) Determining Firm Load Carrying Capability (FLCC) for the Coordinated System and for each System.

4) Establishing required forced outage reserves for the Coordinated System and for each System.

5) Coordinating maintenance outages for the best resource usability by each System and by the Coordinated System.

6) Mandatory interchange of capacity and energy between Systems to assure the ability of each System and the Coordinated System to carry firm load up to the determined FLCC.

7) Conservation of nonfirm energy by coordinated use of available reservoir storage volume.

8) Use of third party transmission, as available, for Coordination Agreement requirements.

9) Mandatory release of water from upstream reservoirs, stored above Energy Content Curve, or delivery by upstream reservoir owner of equivalent energy in lieu of water releases.

10) Computation of and payment for upstream and coordination benefits, subject to the FPC approval.

11) Determination of priorities on use of facilities for Coordination Agreement requirements.

12) Determination of rates to be paid for Coordination Agreement services.

13) Restoration of FLCC to those Systems whose FLCC is reduced due to the lengthened Critical Period occasioned by the additional storage provided under the Canadian Treaty. Restoration is accomplished by the Systems who gain FLCC from the increased storage (Columbia River main stream projects) sharing a portion of the gain with the Systems (off stream projects) who lose FLCC.

The Coordination Agreement treats the Coordinated System as being a single utility system having a single capacity and energy requirement and with total resources dedicated to serve that requirement. The NWPP Coordinating Group was expanded to provide the necessary engineering required to assemble and publish load and resource data relating the immediately upcoming Critical Period, to run reservoir regulating studies for planned reservoir operation, to determine FLCC and reserves and, in general, to guide operations under the Coordination Agreement.

Under provisions of the Coordination Agreement each System representative, in joint meeting with other System representatives, is permitted to adjust, within limits, the plan for reservoir operation of its System reservoirs to meet its System's individual requirements. Such adjustments do not permit the reduction of coordinated System firm capability without a commensurate reduction in estimated firm load to be carried.

By coordinating the resources of the Coordination Agreement signatories, both in planning and under operating conditions, additional firm capability is made available to the area and nonfirm energy is conserved to a greater extent than is possible under isolated utility planning and operation. Emergency assistance is provided to each System as required. Coordinated System-wide sharing of forced outage reserves reduces the amount of such reserves below what would be required under isolated system operation. Additional resources brought on line by a System become a part of the Coordinated System resources unless the System constructing such facilities declares them to be outside the Coordinated System and operates then on an isolated basis.

Signing of the Coordination Agreement did not eliminate the NWPP since some members of the Pool do not have generating facilities that are affected by provisions of the Canadian Treaty, and therefore, are not signatory to the Coordination Agreement. The NWPP coordinates the resources of its members, including utilities in British Columbia, who are not in the Coordination Agreement with the resources of the Coordinated System and further assists the area by analyzing and, to the extent possible, solving the operating problems of regional interconnected operation as they arise.

e) West Group Area of NWPP

NWPP was divided into two groups early in its existence, because of technical communication problems within the NWPP, mainly due to the inability of the telephone company to set up conference calls between all members. Utilities in Montana, Idaho, Utah and Wyoming became the East Group and those in Washington, Oregon and Northern California, plus BPA, the Corps of Engineers and the USBR became the West Group.

When PNUCC assigned the responsibility for load and resource forecasting to its Subcommittee on Loads and Resources, all NWPP members were requested to submit relevant data to the subcommittee. The East Group and British Columbia declined. The PNUCC Forecast therefore became known as the West Group Forecast.

The West Group Area utilities serve loads in the area comprised of Northern Idaho, Washington, Oregon except for the southeastern part of the state, a portion of Northern California, the area in Western Montana served by BPA and Pacific Power and Light Company and the area in Southern Idaho served by BPA with resources of the USBR located in that area.

f) Western Systems Coordinating Council (WSCC)

In 1967 management of the major utilities in 13 western states organized the WSCC in order to improve system reliability through coordinated planning and operation and to assess adequacy of power resources to meet forecasted load. Full membership is open to all utilities in the area who have bulk power supply resources or major transmission facilities that could affect bulk power deliveries. Associate membership is available to all utilities in the area who do not meet the requirements of full membership. Membership is voluntary.

WSCC through its planning and operating committees has formulated and published "WSCC Reliability Criteria" consisting of two parts, namely:

1) Reliability Criteria for System Design

2) Minimum Operating Reliability Criteria

Systems in the Pacific Northwest have agreed to adopt these criteria.

WSCC was the first reliability council to be formed. As other areas organized councils, WSCC promoted the formation of the National Electric Reliability Council (NERC) to which all regional councils belong. NERC coordinates the activities of all regional councils and correlates regional council replies to requests from the FPC for information relative to reliability and adequacy of power resources and reserves. The NWPP, as a subregion, reports on such matters for all member utilites through WSCC.

1.1.1.2 West Group Historical Data

PNUCC, since it was organized, has coordinated planning and forecasting for the West Group area and has a long-term record of reliability in forecasting. The historical winter peak firm load, the historical 12-month average firm load (energy demand), and the projections of these same values
1 for each year's West Group Forecast from 1967 through 1977 have been summarized in Tables 1.1-1 (a) and (b) and 1.1-2 (a) and (b) respectively. This information has also been presented graphically in Figures 1.1-1 and 1.1-2.

1.1.1.3 Long Range Projection of Power Loads and Resources for Thermal Planning - West Group Area (Long Range Projection)

Forecasts assembled by the PNUCC Loads and Resources Subcommittee treat the West Group area as one large system having a single capacity and energy load requirement and a single critical period capacity and energy capability.

Each utility member of PNUCC annually submits forecasts of the following items by months for the ensuing 11 years, and by years for an additional 9 years:

a) Capacity and energy load requirements;

b) Critical period capacity and energy capabilities;

c) Schedule of imports into, and exports from, the West Group area;

d) Exchanges of capacity and energy with other utilities within the West Group area;

e) New resources to be added and existing resources to be retired.

The first 11 years are included in both the West Group Forecast[1] and in the Long-Range Projection[2] but the final 9 years are included only in the Long-Range Projection. Table 1.1-3 is a summary, on a noncoincidental basis, of the recently prepared Long-Range Projection for the years 1978-1979 through 1997-1998. This forecast is a basis for planning for transmission line construction, resource installation and reserve requirements for the West Group Area. Table 1.1-3 shows a cumulative annual load growth for the 11-year period from 1978-1979 through 1988-1989 of 3.9% from 16,721,000 average kilowatts to 24,445,000 average kilowatts. This compares to the estimated national cumulative annual load growth of 4.5% (see Figure 1.1-3). 2

New generation planned for installation in the West Group Area through 1985 is discussed in Section 1.1.2.

The Pacific Northwest region has strong transmission ties with the Southwest and British Columbia and uses these ties for interregional transfers of surplus capacity and energy and for emergency assistance. Some firm capacity and energy interchanges also flow over these inter-ties. Only the firm interchanges over these ties are included in the compilation of the Long-Range Projection. The need for WNP-2 is based on the forecast contained in Table 1.1-3.

1.1.1.4 Methodology of Forecasts

No single method of forecasting loads and resources is employed in compiling the Long-Range Projection. Rather, it is a compilation and summarization of the forecasts of the individual utilities serving the loads of the West Group area. The compilation and summarization is done by the PNUCC Loads and Resource Subcommittee.

The smaller consumer-owned utilities in the West Group area do not submit individual load and resource forecasts directly to the PNUCC Loads and Resource Subcommittee. Forecasts for such utilities are prepared cooperatively by the utility and BPA and are then included in the BPA loads and resource report to PNUCC. The method used by BPA and the utilities in the preparation of the forecasts is described in a BPA "Load Estimating Manual".(3) The technique suggested in this manual is to break the load into component parts and examine the factors affecting growth in that component. Although historical trends are recognized as one method, the need to relate the growth of each component to economic pressures is emphasized. For example, because of the large space heating component of load in the region, that load is usually treated independently within the service area, with population growth and heating load saturation considered.

Seven large member utilities of the Supply System listed below submit individual forecasts to PNUCC.

a) The City of Seattle, Department of Lighting

b) The City of Tacoma, Department of Lighting

c) Snohomish County Public Utility District No. 1

d) Cowlitz County Public Utility District No. 1

e) Clark County Public Utility District No. 1

f) Chelan County Public Utility District No. 1

g) Grays Harbor County Public Utility District No. 1

The methodology used by these utilities are described below.

City of Seattle, Department of Lighting

Both peak and energy forecasts are based on historical data adjusted to current conditions. Loads are segregated by standard classifications: residential, commercial, light industry and heavy industry. Historical growth trends for each classification are analyzed and an estimated future growth rate assigned. Previous year data are then extrapolated for current year and for the next three years and adjusted to meet the previous 11-year forecast load curve at the end of the third year of the new forecast. If a large adjustment is required, a completely new analysis is done and a new 20-year forecast is prepared. Seattle has recently had a study prepared by an independent consultant, titled Energy 1990, in which an independent load and resource forecast is included.

City of Tacoma, Department of Lighting

Loads are segregated as to heat sensitivity. A heat sensitivity curve is drawn for 100% sensitivity at 20-degrees F and 0% sensitivity at 70-degrees F. Normal months temperatures are taken from the Weather Bureau's long-term determination. Previous year's heat sensitive loads are temperature adjusted by months. A curve fitting program has been developed to extrapolate temperature adjusted historical data on a month by month basis to derive the peak and energy forecasts for an 11-year period. A similar program is used for non-heat sensitive loads. The two forecasts are then combined to give an 11-year forecast of peak and energy requirement for use as required by planning programs. This forecast is then expanded by years to complete the 20-year forecast.

Snohomish County PUD

The previously mentioned BPA Load Estimating Manual is used as a guide to developing forecasts of peak and energy requirements. Power Supply personnel of the District work closely with BPA in applying this guide. Because of the large loads of such industries as aerospace and wood processing, adjustments to the methodology are incorporated to assure a forecast representative of the utility load.

New forecasts are made at intervals of approximately three years and upgraded yearly. If a yearly review indicates wide variance from previously used data, such as population growth rate, customer usage or industrial expansion, a completely new forecast is prepared.

Cowlitz County PUD

Each class of customer is evaluated independently. Population growth, levels of usage, saturation and expected changes in large industrial loads are considered in the load forecasts.

In estimating the power requirements of the District, a number of general assumptions have been made relative to the future economy of the region. The recent announcements of expansions by both Longview Fibre Company and Weyerhaeuser at the Longview site and the dedication to environmental improvements at the sites indicates the local economy will remain strong; therefore, in the current forecast the economy of the county is assumed to remain healthy with continued expansion and technological improvements of the industrial sector.

The load estimated is normalized for average weather conditions and other variable factors that affect the power and energy requirements. It is assumed that awareness of the need to conserve all forms of energy resources will not drastically change the historic pattern of electric energy growth. The assumption is based on the opinion that more efficient use of electric energy will be made, but electric energy will be substituted for other energy resources because of environmental and conservation reasons. The load forecast does not provide for a major conversion from other energy resources to electric energy; for example major conversion to electrified vehicles.

Completely new forecasts are made whenever an annual review of the previous forecast, as updated, indicates that data relative to population growth rate, industrial expansion or customer usage have changed to the extent that updating of previous load data has given a distorted forecast.

Clark County PUD

The District makes its own forecasts of peak and energy requirements essentially based on the BPA guidelines adjusted to fit the District's needs. The forecast is then reviewed in detail with BPA both to ensure that data used are reasonably in accord with regional data and to fit that forecast into those of other BPA customers. The forecast is updated annually based on the previous year's data. A completely independent analysis and forecast is made whenever there appears to be a major change in the demographic or industrial trends.

Chelan County PUD

This utility has two separate systems and makes a separate forecast for each system since the character of the loads in the systems vary somewhat. These two forecasts are then combined into a single utility forecast to be submitted to PNUCC.

Historical records of monthly and annual energy consumption and system load factors are used for forecast purposes. By means of computer programs, load growth rates by months are established and monthly percentages of annual energy consumption are determined. This historical annual energy consumption curve is plotted and extrapolated for the forecast period. Monthly peak requirements are then determined by applying average historical monthly load factors to forecasted monthly energy consumption.

Grays Harbor County PUD

This utility prepares a load forecast in cooperation with BPA based on the BPA guidelines, modified to meet the particular needs of the District. This major load projection is made on approximately four or five year intervals and updated annually.

The methodology used by these utilities has been included to suggest the detail used in developing the Long-Range Projection. Three points should be emphasized. The first is that most of the larger utilities look at their load growth in individual segments, considering population and economic growth within their service areas. Generally they do not rely on straight projections of historical trends but temper such projections with insight into causative factors.

Secondly, BPA, in its capacity of providing regional transmission facilities, provides an overview of the independent forecasts, particularly for the smaller utilities. Finally, Table 1.1-1 (a) and (b) and 1.1-2 (a) and (b) together with Figures 1.1-1 and 1.1-2 show the degree of accuracy of the PNUCC at predicting peak demand and energy load. This record shows a general success of the methodology as applied.

1.1.15 Accuracy of Forecasts

The 10-year history of West Group forecasts compared to loads has been presented in Tables 1.1-1 (a) and (b) and 1.1-2 (a) and (b). The percent accuracy of the forecast is the difference between actual load experienced and the forecasted load, unadjusted for weather, divided by the forecasted load.

For forecasted capacity, the percent accuracy ranges overall
1 from +16.7% to -3.4%. Accuracy for the three operating years next succeeding the date of forecast ranges from +11.8% to -3.4%. For the operating year next succeeding the date of forecast the accuracy ranges from 11.1% to -3.4%.

The range of accuracy for forecasted energy is as follows:

2 Overall from 15.9% to -0.7%

1 Next three operating years 9.6% to -0.7%

Next operating year 5.7% to -0.4%

Because of the rapidly changing conditions relative to energy use, it is difficult to estimate the accuracy that has been achieved in the forecasts recently issued. There are a number of factors which must be considered in such an estimate. The operating years 1972-1973 and 1973-1974 (through December 1973) were very dry. Coupled with the national energy shortage, these dry months caused a severe reduction in area reservoir storage. All utilities of the area engaged in intensive conservation compaigns and were able to effect, on the average, a 7% to 8% reduction from expected use of electric power. Because of these reductions, no mandatory curtailment of firm loads was required. Weather conditions changed radically in January 1974 with rain and snow falling in abundant quantities. Reservoirs soon returned to normal elevations and surplus power was generated for transmission to California to assist utilities in that state in fuel conservation efforts. Precipitation continued in above-normal amounts, not only assuring reservoir refilling, but also building up a snow pack far above normal with consequent predictions of heavy spill conditions in the run-off months. Campaigns for electric power use curtailment were rapidly switched to educational programs for wise use of energy. Generation of excess power continued to the point of loading inter-regional transmission lines to maxmimum capacity. Because of the surplus power availability in the area, loads have increased to near normal and export of surplus energy still continues.

The effects of conservation and of conversion to electric power usage are in opposing directions. It is difficult to determine at this time which effect will be dominant in the next few years. West Group utility forecasters have considered these matters and folded them into the recent forecast of future loads. Consensus among those responsible for compiling the forecast is that its accuracy is probably within the range of accuracy of previous forecasts.

1.1.16 Area Purchase from Outside West Group Area

Consumer-owned utilities estimate no capacity imports and energy imports of 123 million KWH per year through 1982-1983 operating year and zero purchases of firm capacity and energy from outside the West Group area during the remaining period of the forecast; however, these do from time to time purchase available nonfirm energy from British Columbia and California utilities and elsewhere when such nonfirm energy is not available from within the West Group area.

The federal system estimates energy imports during the next decade of up to 4.1 billion kilowatt-hours per year on the basis of energy returned from peak/energy exchange contracts with Caifornia utilities.

Investor-owned utilities estimate an import of capacity and energy ranging from maximum of 2,020,000 kilowatts of capacity and 10.8 billion kilowatt-hours of energy in 1980-1981 down to 240,000 kilowatts of capacity and 0.6 billion kilowatt-hours of energy per year in 1997-1998. Imports include Pacific Power & Light Company transfers from Pacific Power & 2
Light Company Wyoming Division, Portland General Electric Company Contract with Southern California Edison Company, Washington Water Power Company peak/energy exchange contract with San Diego Gas & Electric Company, Washington Water Power Company contracts with the Montana, Idaho, and Utah Power Companies and Puget Sound Power & Light Company contracts with Salt River Project and Utah Power Company.

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Except for the purchase of plant service power when a plant is not operating, the applicant does not make any purchase of power from either within or outside the region. Its only sales are of power from its projects to the participants in those projects.

1.1.17 Load Components

The power needs of a nation or region depend largely upon the size of the population, the standard of living of its people, and the character of its economy. Economists use, as a measure of the standard of living and productivity of an economy, the quantity of energy used residentially, industrially and commercially. The proper perspective for analyzing past load growth and estimated future load growth can be obtained by comparing the power needs in four main categories:

a) Residential, including farms

b) Commercial

c) Industrial

d) Combined use for irrigation, street and highway lighting and other miscellaneous uses.

Figure 1.1-4 shows load growth past and future by these categories.

Figure 1.1-5 shows that from 1950 to 1973, the increase in total residential load of the Pacific Northwest (from 5 1/2 billion kilowatt-hours in 1950 to 33 billion kilowatt-hours in 1973), was more than five times the 1950 total residential load. Of this total growth, less than 20% was due to the increase in the number of residential consumers occasioned by population growth; thus, approximately 80% resulted from the rise in the use per consumer. The increase in electric space heating load, from 378 million kilowatt-hours in 1950 to 10.9 billion kilowatt-hours in 1973 (more than 28 times) was responsible for over 38% of the increase in residential consumption. Unless electric space heating load is limited by supply or regulation, it is predicted that there will be approximately three times as many homes electrically heated 20 years from now. Total residential space heating load is expected to reach 25 billion kilowatthours by that time.

Commercial loads and service industries have historically been one of the fastest growing segments of our economy. If past trends are used for projection, it is expected that an additional 160,000 new commercial customers will be on line in the next 20 years. Commercial loads are expected to increase from 1.1 billion kilowatt-hours in 1970 to 3.8 billion kilowatt-hours in 1990.

Technological advances historically have resulted in greater availability and use of electrical equipment, increased automation and improved working conditions. These, in turn, have resulted in a higher per capita energy usage, a higher per capita production, and a higher per capita income. Several of the heavy industries involving the use of electrical energy in the Northwest include pulp, paper, plywood, lumber, chlorine, aluminum, fertilizers, steel, and other manufactured materials produced and used in, or exported from, the region. Industrial loads are expected to more than double from about 50 to 117 billion kilowatt-hours by 1990.

Figure 1.1-6 is the coordinated System load duration curve for the operating year 1981-1982. This load duration curve is expected to be similar to those for the first few years that WNP-2 is scheduled to be in service.

1.1.1.8 Interruptible Loads

As federal hydro project power became available in the late 1930's not all of it was salable to the utilities of the area. The surplus was therefore available to BPA to sell to industry at a very attractive price. During the war years of the early 1940's, the light metals and other industries developed rapidly in the Pacific Northwest. These industries were able to consume large amounts of both firm and nonfirm energy and contributed greatly to the economic and electrical growth of the region. Firm power sales contracts were written by BPA to cover the base loads of these plants and nonfirm power was sold on an interruptible-type contract to provide the industries with power for excess production from time to time without the necessity of increasing the base firm power purchases. Power sold under interruptible contract could be curtailed any time nonfirm power was unavailable. Until recently, curtailment was made only for lack of nonfirm energy supply since the federal system had a large surplus of installed capacity. However, in recent years, curtailment has been made on several occasions because of insufficient capacity to supply excess energy during heavy load hours. Some utilities have contracts with industrial customers for interruptible power and are able to serve such customers either from nonfirm power developed on their own systems or by purchase from BPA or a combination of both. In some instances, utilities have written agreements or signed contracts for firm power sales, interruptible on peak hours if required to reduce the utility's peak hour demands. The City of Seattle Lighting Department had such a contract with Alcoa and presently has a letter of agreement with the Boeing Company Wind Tunnel and with Bethlehem Steel Company for such interruptible power.

In recent years, as firm utility loads increased at a rate greater than the rate at which firm resources were being installed and industrial loads also increased, it became necessary for BPA to limit sales of additional firm power to industry. BPA and area industries cooperatively worked out a new type of industrial rate under which industry purchases up to 75% of its load requirements on a "Modified Firm Power" rate and the remainder of its needs on the "Interruptible Power" rate. Modified firm rate is 5 cents per kilowatt per month less than the Firm Power rate. When present direct service industrial power sales contracts expire, Bonneville Power Administration expects to replace them with contracts for the sale of power under the new rate schedule for industrial firm power included in BPA's revised rate schedules, which became effective on December 20,1974.

The following quote from the 1974 Bonneville Wholesale Power Rate Schedule describes these classes of power:

> "1.1 <u>FIRM POWER</u>: Firm power is power which the Administrator will make continuously available to a purchaser to meet its load requirements except when restricted because the operation of generating or transmission facilities used by the Administrator to serve such purchaser is suspended, interrupted, interfered with, curtailed or restricted as the result of the occurrence of any condition described in the Uncontrollable Forces

or Continuity of Service sections of the General Contract Provisions of the contract. Such restriction of firm power shall not be made until industrial firm power has been restricted in accordance with section 1.4 and dance with section 1.2.

1.2 MODIFIED FIRM POWER: Modified firm power is power which the Administrator will make continuously available to a purchaser on a contract demand basis subject to:

(a) the restriction applicable to firm power, and

(b) the following:

When a restriction is made necessary because the operation of generating or transmission facilities used by the Administrator to serve such purchaser and one or more firm power purchasers is suspended, interrupted, interfered with, curtailed or restricted as a result of the occurrence of any condition described in the Uncontrollable Forces or Continuity of Service sections of the General Contract Provisions of the contract, the Administrator shall restrict such purchaser's contract demand for modified firm power to the extent necessary to prevent, if possible or minimize restriction of any firm power, provided, however, that (1) such restriction of modified firm power shall not exceed at any time 25 percent of the contract demand therefor and (2) the accumulation of such restrictions of modified firm power during any calendar year, expressed in kilowatt-hours, shall not exceed 500 times the contract demand therefor. When possible, restrictions or modified firm power will be made ratably with restrictions of industrial firm power based on the proportion that the respective contract demands bear to one another. The extent of such restrictions shall be limited for modified firm power by this subsection and for industrial firm power by section 8 of the General Contract Provisions (Form IND-18) of the contract.

1.3 FIRM CAPACITY: Firm capacity is capacity which the Administrator assures will be available to a purchaser on a contract demand basis except when operation of generating or transmission facilities used by the Administrator to serve such purchaser is suspended, interrupted, interfered with, curtailed or restricted as the result of the occurrence of any condition described in the Uncontrollable Forces or Continuity of

Service sections of the General Contract Provisions of the contract.

1.4 <u>INDUSTRIAL FIRM POWER</u>: Industrial firm power is power which the Administrator will make continuously available to a purchaser on a contract demand basis subject to:

(a) the restriction applicable to firm power, and

(b) the following:

(1) The restrictions given in section 8, "Restriction of Deliveries," of the General Contract Provisions (Form IND-18) of the contract.

(2) When a restriction is made necessary because of the operation of generating or transmission facilities used by the Administrator to serve such purchaser and one or more firm power purchasers is suspended, interrupted, interfered with, curtailed or restricted as a result of the occurrence of any condition described in the Uncontrollable Forces or Continuity of Service sections of the General Contract Provisions of the contract, the Administrator shall restrict such purchaser's contract demand for industrial firm power to the extent necessary to prevent, if possible, or minimize restriction of any firm power. When possible, restrictions of industrial firm power will be made ratably with restrictions of modified firm power based on the proportion that the respective contract demands bear to one another. The extent of such restrictions shall be limited for modified firm power by section 1.2(b) of the General Rate Schedule Provisions and for industrial firm power by section 8 of the General Contract Provisions (Form IND-18) of the contract.

No additional Firm Power is presently available to BPA for sale to industry under new long-term contracts.

Availability of non-firm power has been very high over a period of many years, but the building of new dams in the West Group area and on the Columbia River and its tributaries in Canada has converted much of the energy previously available only on a nonfirm basis into firm energy. Future availability of nonfirm power is expected to be much lower than it has been in the past and will be sold by BPA under the BPA H-5 wholesale non-firm energy rate.

1.1.1.9 Facts Potentially Affecting Demand

Electrical power, like many other products, has an elasticity of demand. This elasticity varies from area to area depending upon the relation between many factors such as availability of electric power compared to availability of alternate sources of power, relative costs of alternate sources, intensity of promotional advertising and activities with respect to competing types of energy, and energy costs compared to average consumer income. These factors as they exist in the Pacific Northwest are discussed in this section.

a) Advertising and Energy Conservation

The Pacific Northwest electrical energy supply has depended on the development of hydro-electric resources throughout the region, particularly on the Columbia River. The development of this resource was encouraged, on a multipurpose basis, for the hydro-electric supply as well as for flood protection, navigation, and irrigation. In the past, excess energy was available for sale, particularly during high flow, off-peak periods. By encouraging the sale of such energy, the average price to consumers of the region was reduced to levels among the lowest in the nation.

As the economical hydro resource approaches full utilization, the picture changes, particularly with the advent of the Columbia River's large upstream hydro storage reservoirs which permit considerably more latitude in energy usage timing. That the picture was changing was generally foreseen by regional utility management a few years ago, and the advertising policy of the region changed markedly towards conservation - the wise usage of energy. The programs followed by some of the larger utilities in the region are:

1) Seattle City Light - Promotional advertising and activity was ended January 1, 1971. At that time a program of education relative to the wise and efficient use of electricity was started. This program was carried on mostly through bill stuffers and handouts. Early in 1973, an intensive conservation program was begun using bill stuffers, handouts, radio, televison, and newspaper advertising. Because of the critical shortage that had developed in hydro capability (reduced stream flows and below-normal reservoir elevations) the public was urged to reduce their energy consumption as much as possible. 2

In 1977 a Conservation Office was established to coordinate and monitor a long-range conservation program with a goal of reducing the projected 1990 demand by about 20 percent. This program involves conservation projects in the residential, commercial, and industrial sectors.

2) Tacoma City Light - Early in 1970, Tacoma ceased all promotional advertising and activity. Little advertising was done until the summer of 1973 when the "Be-A-Watt-Watcher" educational program was started using mostly bill stuffers and handouts. Consideration is now being given to starting an educational campaign urging installation of storm windows and doors, and adding insulation to homes plus education relative to efficient use of electricity.

3) Snohomish County Public Utility District - Promotional advertising and activity was ended early in 1972. An intensive educational program was started in early 1973 apprising customers of the critical hydro capability shortage and advising them to use electricity wisely and efficiently and promoting the installation of home insulation. The present program is based on providing information relative to wise use of energy.

4) Cowlitz County Public Utility District - All promotional advertising and activity ended early in 1972. In the summer of 1972 an educational program was instituted relative to the need for economical use of electricity. In early 1973, an intensive campaign on conservation was begun using all news media, bill stuffers, handouts, etc. Speakers were made available to civic organizations, church and community groups and schools to help educate the general public on the immediate need to conserve electricity and the long-range need to conserve electricity and the long-range need to conserve energy of all kinds. Presently, the effort is toward economical use of energy in total.

5) Clark County Public Utility District - All promotional advertising and activity ceased in early 1972. An educational program on nuclear power production and the wise use of electricity was started late in 1972. Early in 1973, and intensive campaign was stated to inform the public of the hydro capability shortage. Since January 1974 the campaign has gone back to education on economical use of power.

6) Chelan County Public Utility District - Promotional activities and advertising were reduced early in 1972 and ended entirely in August 1972. Early in 1973, an intensive conservation program was put into operation using radio and newspaper advertising. Presently, American Public Power Association's recommended advertising is being used.

7) Electric League of the Pacific Northwest - The utilities of the Puget Sound Area (Seattle City Light, Tacoma City Light, Snohomish County Public Utility District and Puget Sound Power and Light Company), electrical contractors and electrical equipment supply firms are members of this organization. The League has for many years advertised for the benefit of League members. Prior to 1971, this advertising was promotional in nature. In 1971 and 1972, the thrust was shifted to environmental aspects of power production and use. In 1973, the League institued in intense conservation program encouraging installation of insulation and economical use of energy. Advertising was by radio, television and new media. In 1974, the program dropped back to education on efficient use of energy.

b) Bulk Power Costs

Prior to the establishment of BPA in 1937, each utility 2
in the area operated essentially on an isolated system basis, providing its own power supply, including reserves, as well as its own required transmission. The few inter-tie transmission lines that existed were relatively light and were used primarily for emergency purposes. A small amount of nonfirm power transactions occurred from time to time. Power supply was from a mixture of hydro and thermal plants. Cost of power varied from utility to utility.

In 1938 BPA adopted its first schedule of wholesale 2
power rates based on a kilowatt-year concept. At-site delivery (within 15 miles of generation) was priced at $14.50 per kilowatt-year and elsewhere on the Bonneville System the charge was $17.50 per kilowatt-year. Based on a "capacity with associated energy" concept, this rate translates into 2 mills per kilowatt-hour for 100% load factor and 4 mills per kilowatt-hour for 50% load factor. Nonfirm power was sold for $11.50 per kilowatt-year.

These rates were basically demand charges with no charge for associated energy that could be fitted into a load. A utility with hydro generation and associated reservoir seasonal storage could absorb energy at 100% load factor for the greater part of the operating year while the utility without such facilities could only absorb energy at its system load factor rate.

As more utilities requested federal power for use in their system load, BPA added rate schedules to meet the needs of these customers. In addition to existing rates, firm capacity rates and demand-energy rates were developed. The nonfirm rate was eventually broken into two parts with a demand rate maintained for "Interruptible Power" and a straight energy rate established for nonfirm energy purchases used for such purposes as thermal displacement.

The cost of power under the BPA wholesale rate schedules remained basically unchanged until December 1965, when the cost of firm power was increased by an average of about 3%. On December 20, 1974 BPA established the rate schedules presently in effect which increased wholesale power costs by an average of 27%. Transition of the power supply available from BPA from mostly hydro generation to a mix of hydro and large thermal power plant generation is the major factor contributing to the necessity for the increase in rates. The consumer owned and Federal portions of Phase 1 of the Hydro-Tehrmal Power Program, previously described, melds the higher cost of thermal power into the lower cost federal hydro power through the use of the "net billing" concept previously described. Thus, the cost of nonfederal thermal power delivered to BPA under Phase 1 of the Hydro-Thermal Power Program is spread to all BPA ratepayers through the cost-melding process. WNP-2 is included under the net billing portion of the Phase 1 program.

In addition to increasing the cost of power, the present BPA schedule of rates changes the concept under which power is sold in order to more nearly approach a cost-of-service concept. The rates are in the form of a two-part, demand-energy type with the level of the rates being higher for winter loads than for summer loads.

BPA estimates that an increase in wholesale power costs to a total requirements customer (a utility that purchases all of its power requirements from BPA) does not have more than a 40% impact on that customer's resale rates since that is the approximate percentage of total costs associated with power supply.(5) 2

Future increases in the cost of wholesale power will have an effect on future load requirements. The degree to which the load growth pattern of the area is impacted depends upon several factors. The most important factor to a given utility its ability to meld higher costs of power purchased from the federal system with the relatively stable cost of the hydro that is either self-generated or purchased from other nonfederal low cost hydro sources. The amount of federal power purchased in comparison to the total power supply determines the degree to which the increased cost of federal power will affect the overall cost of power required to serve load.

Another factor relative to the effect on the load growth of a system is the affluence of the customers served by a utility. In a community where the cost of electricity to a customer is relatively low compared to the customer's income, the rate increase will have little effect while in a low income area where the cost of power consumers a much larger share of income, more reduction in growth rate may be noted.

The West Group area utilities have considered these factors in preparing the data submitted to PNUCC for inclusion in the West Group Forecast. PNUCC is studying a program to account for price elasticity of demand. But at present, the majority of the individual forecasts do not account for this.

1.1.2 Power Supply

The applicant is a member of PNUCC, the cooperative group of utilities in the Pacific Northwest presently responsible for coordinating regional long-range power supply planning. PNUCC assembles forecasts made by individual utilities and publishes a composite forecast for this group of utilities. The Northwest Power Pool (NWPP) is the cooperative agency responsible for short-range planning (up to the length of time encompassed by the existing Critical Period of the area) and for day-to-day operation.

The NWPP, including both the East Group and the West Group, is considered a sub-regional group of the Western Systems Coordinating Council and reports to WSCC for the entire area on such matters as: (1) load and resource forecasts; (2) system reliability; (3) transmission capabilities; (4) capacity and energy transfer capability with other regions; (5) answers to Federal Power Commission Dockets which can be submitted on a regional basis; (6) regional operating problems that could affect other areas, and (7) major regional power outages.

The applicant is not a utility and therefore makes no direct report to any of the region's organizations. But all of its resources and operating characteristics are included in all regional reports through the utilities who are participants in the applicant's projects.

2 WNP-2, scheduled for initial operation in December, 1980, will be one of the major thermal projects constructed under Phase 1 of the Hydro-Thermal Power Program, which was planned to meet the load requirements of the West Group area through
2 1985. The Hydro-Thermal Power Program is discussed in more detail in Section 1.1.2.1 of this report.

1.1.2.1 Long-Range Planning

Prior to 1967, long-range planning for power supply requirements was carried on individually by each utility in the area with the PNUCC summarizing and correlating load and resource forecasting of the individual utilities and acting as a forum for review of resources required to carry projected firm area loads. Up to that point in time, federal forecasts showed a surplus of federal resources over the amount required to carry forecasted non-federal resources. Northwest utilities capable of installing resources planned to do so only to the extent that the long-range costs of power from such resources would be less than the expected costs of federal hydro-power.

By 1967 it was apparent the era of federal resource surplus was rapidly drawing to a close. Also the ability of utilities to install additional hydro capability was limited since few hydro sites remained that could meet the test of economic development as well as environmental acceptability.

Since thermal generation was the only viable alternative to hydro generation, utilities recognized that cooperative long-range planning was necessary to obtain economy of scale for future resource installations. Formation of the Joint

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Power Planning Council provided the vehicle for such cooperative planning. The Hydro-Thermal Power Program was conceived by the Council, consisting of 110 electric cooperatives, public utilities and private utilities in the Pacific North-west. Recently PNUCC whose membership is nearly identical to that of the Council has expanded its responsibilities to include those formerly attributed to the Council and the Council has become inactive. Most of the power supply in the region has been historically generated from hydro-electric resources, but the remaining hydro projects to be developed will be essentially for peaking power rather than for base load. Thermal power will provide an increasing portion of the base load resources in the future. The combination of hydro peaking and large-scale thermal generating plants was found by the Council to be the soundest approach to achieve the aims of the Hydro-Thermal Power Program. The principles of Phase 1 of this program and the federal government's participation through BPA, the Army Corps of Engineers and the Bureau of Reclamation, have been endorsed by current and previous Administrations and by Congress.

In summary, the members of the Council have concluded that the Hydro-Thermal Power Program will:

a) Best preserve the environment, including the natural beauties of the Pacific Northwest.

b) Make efficient and economic use of the Federal Columbia River Power System.

c) Obtain the economies of scale from large thermal generating plants.

d) Meld the large thermal generating plants with exiting hydro generating units and the peaking generation units which will be installed at existing dams, to achieve the most economic and reliable power supply to meet the power requirements of the Pacific Northwest.

Phase 1 of the Hydro-Thermal Power Program of thermal generating plants for installation through 1985* is tabulated as follows:

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*Extended from 1981 to 1985 due to slippage in plant construction schedules.

Principal Sponsor	Location	Type	Capacity (MW)	Scheduled Date of Commercial Operation*	Probable Energy Date**
Pacific Power & Light Co. and The Washington Water Power Company (Centralia Project)	Centralia, WA	Coal-fired	1,400	Operating	
Portland General Electric Company (Trojan Project	St. Helens, OR	Nuclear	1,130	Operating	
Pacific Power & Light Co. (Jim Bridger Project)	Rock Springs, WY	Coal-fired	500 500	Operating	
2 Washington Public Power Supply System Nuclear Project No. 2)	Hanford, WA	Nuclear	1,100	Dec 1980	May 1981
Washington Public Power Supply System (Nuclear Project No. 1)	Hanford, WA	Nuclear	1,250	Dec 1982	June 1983
Washington Public Power Supply System (Nuclear Project No. 3)	Satsop, WA	Nuclear	1,240	Jan 1984	June 1984
Portland General Electric Company (Pebble Springs Project No. 1)	Boardman OR	Nuclear	1,260	Apr 1986	Apr 1986

*Date on which construction schedule is based.

**Most probable date energy will be available, based on national experience. This is the basis for resource planning.

In response to the combined efforts of the Council, BPA, and the individual utilities involved, legislation was enacted to allow consumer-owned and investor-owned utilities jointly to construct, own and operate generating facilities. Plans for the first of such plants were formulated and executed for the construction of the 1,400 MW Centralia coal fired thermal project under the joint ownership concept. Four investor-owned utilities own 72 percent of the project and four consumer-owned utilities own the other 28 percent as tenants-in-common.

Under the Hydro-Thermal Power Program, the federal system will supply transmission and install peaking generation at federal projects to integrate the output of thermal plants, to be built by Northwest utilities, into the total generating resources of the area. Phase 1 of the Hydro-Thermal Power Program is expected to provide the resources required in the region through 1985.

Under Phase 2 of the Hydro-Thermal Power Program, announced on December 14, 1973, the area utilities identified additional projects which are currently under investigation to meet forecasted load growth through 1989. While the specific role of BPA has changed somewhat from Phase 1, in Phase 2 the area will continue to build generation and transmission facilities on a cooperative schedule. The thermal generating plants included in Phase 2 are tablulated as follows: | 2

Principal Sponsor	Location	Type	Capacity (MW)	Scheduled Date of Commercial Operation*	Probable Energy Date**
Puget Sound Power & Light (Colstrip Project No. 1)*	Colstrip, MT	Coal-fired	330	Operating	
Puget Sound Power Supply (Colstrip Project No. 2)*	Colstrip, MT	Coal-fired	330	Operating	
Pacific Power & Light Co. (Jim Bridger Proj. No. 4)	Rock Springs,	Coal-fired	334	Dec 1979	Dec 1979

| 2

*Not specifically identified as a Phase 2 project.

Principal Sponsor	Location	Type	Capacity (MW)	Scheduled Date of Commercial Operation*	Probable Energy Date**
Puget Sound Power Supply (Colstrip Project No. 3)*	Colstrip MT	Coal-fired	700	Apr 1982	Apr 1982
Portland General Electric Company (Carty Coal Proj.)	Boardman, OR	Coal-fired	530	July 1980	Nov 1980
Puget Sound Power & Light (Colstrip Project No. 4)*	Colstrip, MT	Coal-fired	700	Feb 1983	Feb 1983
Puget Sound Power & Light Company (Skagit Proj. No. 1)	Sedro Wooley, WA	Nuclear	1,288	July 1985	July 1985
2 Washington Public Power Supply System (Nuclear Proj. No. 4)	Hanford, WA	Nuclear	1,250	June 1984	Dec 1984
Washington Public Power Supply System (Nuclear Proj. No. 5)	Satsop, WA	Nuclear	1,240	July 1985	Dec 1985
Puget Sound Power & Light Company (Skagit Proj. No. 2)	Sedro Wooley, WA	Nuclear	1,288	July 1987	July 1987
Portland General Electric Company (Pebble Springs Project No. 2)	Boardman, OR	Nuclear	1,260	Apr 1989	Apr 1989

Although the overall planning of resource installation is carried out on a cooperative basis, each utility reserves the right to determine which project it will participate in and the extent of such participation. Since planning is done on the basis of installing sufficient resources in the area to meet load requirements, individual utility forecasts of power requirements are included in the regional plan.

*Not specifically identified as a Phase 2 project.

1.1.2.2 Short-Term Planning

The NWPP carries out the short-term, cooperative planning for all systems in the pool. This short-term planning consists of:

a) Planning the coordinated use of both federal and non-federal resources, including pooling of reserve requirements, to provide the greatest practicable output of firm power from those resources.

b) Determining the length of the Critical Period to be used and the adverse water available for power production in that period.

c) Determining the amount of firm capacity and energy loads that can be carried under adverse water conditions by each member of the pool and by the pool as a whole.

d) Determining operating rule curves for each reservoir included in pool resources.

In addition to the short-term planning functions for NWPP, the Coordinating Group performs additional short-term planning functions required by the Coordination Agreement such as (1) Computing the reserve requirements of each System and the Coordinated System: (2) preparing a schedule of capacity and energy interchanges between Systems based on water availability under adverse conditions; and (3) other planning functions, some of which are listed under d) "Pacific Northwest Coordination Agreement" in Section 1.1.1.1 of this report.

Under c) above, any System having either capacity or energy load greater than the amount of firm resource available to that System must:

a) Supply firm resources at least equal to the indicated deficiency, from those within the Coordinated System which are not currently committed to serve Coordinated System firm loads, or

b) Supply firm resources at least equal to the indicated deficiency, from outside the Coordinated System; or

c) Assign the estimated firm load which is above the capability to carry such load (as determined in b) above) to a nonfirm status and serve it only from nonfirm power available from any source; or

d) Totally interrupt such excess firm load if no nonfirm power is available.

Although these planning functions are carried out on a group basis, each system maintains the right, within limits, to operate its system to meet its system requirements. One such limitation contained in the Coordination Agreement is that planned reservoir operation cannot be altered to a degree that will cause spill of firm energy on the Coordinated System.

1.1.3 Capacity Requirements

In order to determine system generating capacity requirements, a number of factors must be considered, not the least of which is the amount of firm capacity load that the system expects to serve. Other factors to consider include:

a) Capacity required to replace units out of service for scheduled maintenance;

b) Capacity required for replacing the capacity of units that are forced out of service or that are forced to reduce output;

c) Capacity to serve unanticipated load growth; and

d) Capacity required to assure system reliability.

The forecasting methods used in the West Group area to determine the future capacity load that the system expects to serve were discussed in Section 1.1.1.4. All the other factors can be grouped under the general heading of reserves.

1.1.3.1 Capacity Reserves

System reliability (the ability to serve firm load with interruptions held to a level acceptable to both customer and system) is dependent upon the amount of capacity available to the system with which to serve the requirements of its customers at the time those requirements occur and is measured in percent. Thus, a system with 100 percent reliability would always be capable of serving its customers' requirements without interruption or curtailment. It is entirely possible, although not economically feasible, to install enough generating capability to attain 100 percent reliability of power supply and to install enough transmission, transformation and distribution equipment to deliver that capacity to customers without interruption. Each system, or pool of systems, must therefore determine the level of reliability it can maintain, on an economic basis, that will be acceptable to customers.

The degree of reliability attainable on a system or pool of systems is dependent upon the amount of capacity maintained in the system over and above the capacity demand of the load being served. This capacity surplus to load can be generally classified as reserves. All of the factors previously mentioned that go into determining the total generating capacity requirements of a system, except load requirements, can be put in this classification.

Some of the factors previously mentioned overlap; therefore, a subdivision of classification is helpful in discussing reserves in general. One possible subdivision is as follows:

a) Standby Reserves

    1) Load Growth Reserves for:

        (a) Forecasted Load Growth

        (b) Unexpected Load Growth

    2) Scheduled Maintenance Reserves

    3) Forced Outage Reserves for

        (a) Total Unit Outage

        (b) Partial Unit Outage

        (c) Capacity unattainable due to nonpower purposes

        (d) Capacity unattainable due to operating conditions

b) Spinning Reserves

    1) Reserves for largest single contingency outage for:

        (a) Generation Outage

        (b) Transmission Line Outage

    2) Reserve for continuous load regulation

    3) Reserves for frequency bias obligations

Spinning reserves are standby reserves that are immediately available to replace generation forced out of service or curtailed for any reason.

Reliability can also be expressed in terms of the frequency of loss of load due to power supply being less than load requirements. Although many large utilities use a criteria for adequacy of reliability based on loss of load not more frequently than once in 10 years, the West Group area uses a criteria of loss of load not more often than every 20 years. Excerpts from the 1970 FPC National Power Survey relative to adequacy of reserve levels follows:

<u>Reserve Practices</u>

> "Individual systems and power pools utilize a variety of methods for determining appropriate reserve levels. The methods vary from use of a simple percent of peak load, to matching reserves to the capability of the largest unit or pair of units in service, to very complicated calculations of outage probability taking into consideration such elements as number and size of units, forced outage rates, and expected load patterns. Reserve margins considered adequate for most systems, including the spinning reserve component, range between 15 and 25 percent of peak load.
>
> Each system, pool, or coordinating group develops spinning reserve criteria which it believes will show the minimum appropriate reserve for that particular power supply entity. Generally, the level of such reserve and its distribution among generating units takes into consideration the system characteristics and rate of required responses. The variations in practices reflect such things as differences in sizes and types of units, the number and capability of transmission interconnections, the geographical extent and configuration of a system, and pertinent operating agreements among interconnected systems."

The West Group Systems of the Northwest Power Pool serve a large geographical area. Major systems serving customers in the West Group area are parties to the Pacific Northwest Coordination Agreement. A major benefit of such an agreement is to provide for capacity reserves on a coordinated use basis. The Coordination Agreement states "The Coordinated System shall maintain reserve capacity at a level sufficient to protect against loss of load to the extent the probability of load loss in a contract year shall be no greater than the equivalent of one day in 20 years. The determination of such probability shall be based upon characteristics of peak load variability and generating equipment forced outage rates."

The Coordination Agreement provides that every utility, to the extent practicable, will operate its own system as though the Coordinated System were being operated by a single entity.

Provision for capacity and energy exchanges assures each utility of assistance from the entire Coordinated System such that a loss of resources on one system will not cause loss of load on that system as long as there are resources in the area capable of carrying the total area load, and assures that nonfirm loads of the area will be curtailed in order to supply power to firm loads regardless of the utilities involved.

The Coordination Agreement is a contractual agreement which determines the actual reserves that each utility is required to maintain under normal operating conditions during the current operating period, based on the "Critical Period" of record (adverse water).

The region is presently experiencing a shift from a system which is nearly all hydro to one of combined hydro and thermal generation. Such a shift in the nature of power supply requires a corresponding shift in reserve planning. Past experience has shown a reserve of 5 percent of installed hydro generating capacity to be adequate and for planning purposes the area had assumed a thermal reserve requirement equal to 15 percent of installed thermal capacity. Recently, agreement has been reached in the PNUCC that the following criteria for capacity reserves will be used for planning:

a) For the first operating year of the forecast total planned reserves for capacity will be 12 percent of total area peak load for January.

b) For each subsequent year the percent of area peak load for January required for total reserves will be increased by one percent (1%) of January peak load until the percentage reaches 20 percent.

1.1.3.2 Effects of Operation of the Projects on the Coordinated System

For purposes of this statement adjustments have been made to the Long-Range Projection (1978 Blue Book) because of recent changes in expected plant capacity and energy output and expected commercial operating dates for the WPPSS nuclear projects under construction and planned. These changes and |2 their effect on the Long-Range Projections are incorporated in Table 1.1-4.

If WNP-2 is available as expected (Probable Energy Date) to meet the winter peak load of the operating year 1981-1982, the capacity reserves, based on the data on the Blue Book will be 22.9 percent of area loads. If WNP-2 does not begin operation as planned the capacity reserves will be reduced to 19.3 percent. Capacity reserves with and without WNP-2 are compared to the desired reserves in Figure 1.1-7.

2 Thermal plants like WNP-2 are planned as base-load additions to the system and thus are important elements of the energy capability of the system. In the ten year period 1978-1987 there are total energy deficits ranging from 450 to 2373 average megawatts (MWe) with deficits on the order of 2000 MWe in the period 1980-1984, as shown in Figure 1.1-8. The Federal System interruptible loads of approximately 1000 MWe could reduce the deficits to the level shown in Figure 1.1-8 for firm energy. Firm energy deficits range from 64 MWe to 1298 MWe in 1978-1984, with surpluses of 316 MWE to 655 MWe in 1985-1987. However, without WNP-2 there are firm energy deficits in every year 1978-1987.

1.1.4 Statement on Area Need

As explained in Section 1.1 and elsewhere in this report, tha applicant does not itself engage in the distribution of electrical power to the retail market but serves as a bulk electrical power supplier to utility systems in the West Group area. The need for capacity and energy was therefore developed in Section 1.1 on the Coordinated System basis rather than on the applicant's requirements. This section contains additional statements relative to regional power requirements and to reserve criteria of the West Group area.

The Public Power Council (PPC), an organization of 104 consumer owned utilities in the Pacific Northwest, has determined that the Project is needed in the area to assure an adequate power supply for such consumer owned utility customers. Table 1.1-6 indicates how the capability of the Project will be utilized in the BPA and Public Agency loads.

The Joint Power Planning Council and the PNUCC have made regional studies to determine the regional resource requirements and have promulgated the results of these studies by issuance of a tabulation of projects required under Phase 1 and Phase 2 of the Hydro-Thermal Power Program as discussed in Section 1.1.2.1 Tables 1.1-7 and 1.1-8 indicate how the

Project fits into area resource requirements. Each of these tables shows the regional deficiency with and without the Project. Also each shows such deficiency based on the probable energy date (milestone concept) and on the scheduled date of commercial operation.

PPC and PNUCC committees regularly review updated load forecasts and plant installation schedules in order to ensure a reliable power supply. If needed, requests to advance or delay plant installation dates will be made by these organizations to plant sponsors.

1.1.4.1 Reserve Criteria of the Area

For planning purposes the PNUCC has agreed upon the following minimum reserve requirements (previously stated in Section 1.1.3.1) for use in resource requirement analysis for the Long-Range Projection which is the study used by the region in planning power supply.

Starting with the forecast for the 1974-1975 to 1994-1995 years the following criteria for capacity reserves were adopted for planning: 2

a) For the first year of the current forecast total planned reserves for capacity will be 12 percent of total area peak load for January.

b) For each subsequent year the percent of area peak load for January required for total reserves will be increased by one percent (1%) of January peak load until the percentage reaches 20 percent.

Also WSCC through its planning and operating committees has formulated and published "WSCC Reliability Criteria" consisting of two parts, namely:

a) Reliability Criteria for System Design (6)

b) Minimum Operating Reliability Criteria (7)

Planned Area Reserves can be found in Figure 1.1-7.

Required reserves for actual operating conditions are determined in Critical Period Reservoir Regulation Studies and Reserve Studies prepared annually for the ensuing Critical Period (presently a 43-1/2 month period). Reserves are calculated for the Coordinated System by probability methods and distributed among Systems according to iso-probability as specified in Exhibit 4 of the Agreement. A more detailed discussion of the reserves required by the Agreement is contained in Section 1.1.3.1.

1.2 OTHER OBJECTIVES

The applicant has discussed potential beneficial byproduct uses of cooling water from Supply System projects with federal, state and local agencies as well as several potential private sponsors. The Supply System will continue to cooperate with these potential sponsors and report developments in the area of possible agricultural, industrial, recreational and economic aspects of any byproduct use of the project's cooling facilities.

The design, construction and operation of this project, the scheduling of which is vital to the power needs of the region, cannot be made contingent upon unknown restrictions and/or successful implementation of a complex unrelated byproduct use. In the event that the cooling water facilities, included as a part of this project, can be adapted to byproduct uses the Supply System will cooperate to the maximum practicable extent.

1.3 CONSEQUENCES OF DELAY

If WNP-2 is delayed beyond the scheduled commercial operation dates the most important direct effects will be to increase the cost of the Project and decrease the energy generating capability that is an integral part of the region's electric generating resource planning schedule. A delay could also produce secondary effects which are less well defined, such as curtailment of power to serve industrial loads.

A delay in Project development schedule prior to commercial operation would cause an increase in cost, the magnitude of which would depend upon when such a delay occurred. Under the present financing scheme for WNP-2, a delay which is incurred near the end of the construction period after essentially all of the construction funds have been expended would cause the largest increase in cost. This would be due to the requirement to pay carrying costs on the funds expended until WNP-2 can begin to generate power and thus revenues. Additional costs would be incurred for salaries and other fixed costs associated with maintaining the staff for WNP-2.

Shortages of electricity would create increased demands for alternative energy sources such as coal, oil and natural gas. The substitution of fossil fuel resources for electric energy means using scarce depletable resources, particularly oil or natural gas, when relatively abundant nuclear fuel could be used instead. Power shortages would only intensify our existing shortages of oil and natural gas.

The problem of air pollution, particularly in urban areas, would be aggravated by the substitution of fossil fuels for nuclear or hydro generated electricity. Consequent damages to property and hazards to public health associated with increased air pollution, while difficult to evaluate in monetary terms, would nevertheless be real and substantial.

An industrialized economy depends on electricity. Two-thirds of all electric energy, both in the nation and in the Pacific Northwest, is used in commerce and industry. An inadequate power supply for industry means reduced capital investment, fewer jobs, decreased payrolls, less production and lower living standards. To government it means the increased burden of welfare and unemployment payments, concurrent with a decrease of personal and corporate tax receipts.

1.3.1 Power Curtailment

A qualitative calculation of the impact of power curtailment in terms of dollars would be difficult to perform. However, there is presently a method which has been developed on how to curtail the use of electrical power if the system is unable to meet demands. A permanent deficiency in electric power generating sources would result first in a shutdown of large industrial loads utilizing interruptible power. Long term shutdown of these facilities would undoubtedly reduce the residential demand as a result of reduced employment and economy in the area.

In the Northwest, the thermal generating resources must be scheduled to allow the region to serve the firm load requirements during the period of low flow in the region's rivers (critical water period). During the average water years, it is possible to generate amounts of electric energy that are greater than would be available during a critical water year. This power, however, cannot be sold as firm power and is unusable by the average consumer.

In 1972 the Northwest Power Pool drafted plans for curtailing loads in the event of long term power shortages. These plans supplement, but serve an entirely different purpose from, the existing procedures, which cover short term load shedding. The latter are designed to limit power system breakup in the event of sudden power failures, and expedite the return to normal operation. The load curtailment procedures are intended to minimize the impact of prolonged power shortages. These long term emergencies could result from weather conditions, shortages of transmission capacity, generating capacity, energy capability or combinations thereof.

The load curtailment proposal has been drafted jointly by 18 power generating utilities and agencies serving the four northwestern states, British Columbia, Utah, and portions of adjacent states.

Following curtailment of interruptible power there are three possible curtailment levels that might be followed in an emergency. The first two would be voluntary, and the third would involve mandatory curtailment of firm customer power loads. The first level measures would be implemented by the systems actually experiencing an emergency and consist of the following:

a) Level One Curtailment

1) Curtail non-essential utility uses such as floodlighting, sign lighting, display lighting, office lighting, etc.

2) Eliminate electric heating and air conditioning in utility owned houses, buildings and plants where feasible.

3) Indicate, and instruct employees to turn off lights, motors and other uses of electricity when not needed.

4) Discontinue service to electrical customers in accordance with contractual provisions.

5) Request large industrial customers to reduce non-essential load.

6) Request all other customers to reduce non-essential load by appeals through appropriate news media channels.

7) Where feasible, reduce voltages at the distribution or subtransmission level.

b) Level Two Curtailment

If the above actions do not solve the problem and additional assistance is required, then level two is implemented. This involves assistance from the balance of Northwest Power Pool systems. Level two curtailment involves essentially the same steps in the same order as level one - with the entire Northwest Power Pool participating.

If application of level one and two measures fail to resolve the problem it will be necessary to curtail customer load on an involuntary basis by individual systems. This would occur at the third level.

c) Level Three Curtailment

Level three constitutes load shedding in a manner and sequence which will maintain the integrity of the maximum portion of the total system. Level three will be accomplished as follows:

1) Interrupt service to industrial customers to the extent that this can be done after considering customers load and system conditions.

2) Interrupt service to selected distribution feeders throughout the service area for a short period of time, alternating among circuits. Service to distribution feeders should be interrupted in order of the classification priority - that is interrupt service to the least essential first, and so on. Every effort will be made to provide continuous service to the essential public utilities, police, fire stations, hospitals and the like.

3) Records will be maintained so that during subsequent power shortages, care will be taken to locate interruptions throughout the service area in an equitable manner.

This plan has been formally adopted by the Operating Committee of the Northwest Power Pool and has been submitted via the Western Systems Coordinating Council to the Federal Power Commission in response to FPC Docket R-405.

Power cutbacks were experienced in the winters of 1972-1973 and 1973-1974 where interruptible power was curtailed so that water could be conserved for firm power requirements. The costs of these cutbacks are not known but are certainly substantial; obviously, this is an adverse situation. The current power supply with its lack of thermal base-load generating capacity must be supplemented as soon as possible to minimize the social and economic damage to the area.

Without new thermal resources added to the region's power supply, the Pacific Northwest faces a period of many years of serious deficiency in capacity. Although future regional load is expected to increase at a reduced rate, significant increases in generating capacity will be required and are scheduled. A means for reducing future deficiency, especially in 1980, 1981 and 1982, is completion of the Supply System's WNP-2. One can anticipate that any delays in the completion of this project or other planned projects, according to current forecasts, will increase the period of inadequate capacity and increase the economic impact on the area. (See Table 1.1-7)

An additional important advantage of WNP-2 is that it will improve the reliability of the area power supply. The Pacific Northwest's reliance on hydro-electric power has made it uniquely dependent upon nature.

TABLE 1.1-1(a)
PACIFIC NORTHWEST UTILITIES CONFERENCE COMMITTEE
WEST GROUP AREA
COMPARISON OF ACTUAL WITH ESTIMATED WINTER PEAK LOADS
(MEGAWATTS)

Date of Estimate	1967-68	1968-69 1/	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1967 (Jan. 17)	13,919	15,021	16,021	16,922	17,427	18,809	20,285	21,675	23,083	24,519
1968 (Feb. 1)		15,032	15,943	16,927	17,377	18,848	20,487	21,772	23,086	24,664
1969 (Feb. 15)			15,645	16,634	17,125	18,531	19,843	21,101	22,228	23,450
1970 (Jan. 15)				16,424	17,061	18,593	19,764	21,134	22,267	23,495
1971 (Jan. 1)					17,022	18,407	19,742	20,949	22,089	23,278
1972 (Feb. 1)						17,902	19,270	20,567	21,796	22,945
1973 (Feb. 1)							19,227	20,400	21,649	22,814
1974 (Feb. 1)								20,413	21,612	23,311
1975 (Feb. 1)									21,333	22,503
1976 (Mar. 1)										22,080
Actual Winter Peak	13,309	15,540	15,030	15,725	16,876	18,259	18,707	18,444	19,580	21,457

1/ Minimum temperatures of record occurred at a number of weather stations in the Pacific Northwest during December 1968

Source: BPA Requirements Section, unpublished data, February 7, 1978

TABLE 1.1-1(b)
PACIFIC NORTHWEST UTILITIES CONFERENCE COMMITTEE
WEST GROUP AREA
PERCENT DEVIATION BETWEEN ACTUAL AND ESTIMATED WINTER PEAK FIRM LOADS

Date of Estimate	1967-68	1968-69 1/	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1967 (Jan. 17)	4.4	(3.4) 2/	6.2	7.1	3.2	2.9	7.8	16.3	15.2	12.5
1968 (Feb. 1)		(3.4)	5.7	7.1	2.9	3.1	8.7	16.7	15.2	13.0
1969 (Feb. 15)			4.0	5.5	1.5	1.5	5.8	14.0	11.9	8.5
1970 (Jan. 15)				4.3	1.1	1.8	5.4	14.1	12.1	8.7
1971 (Jan. 1)					0.9	0.8	5.3	13.4	11.4	7.8
1972 (Feb. 1)						(1.6)	3.0	11.8	10.2	6.5
1973 (Feb. 1)							2.8	11.1	9.6	5.9
1974 (Feb. 1)								11.1	9.4	8.0
1975 (Feb. 1)									8.2	4.6
1976 (Mar. 1)										2.8

1/ Minimum temperatures of record occurred at a number of weather stations in the Pacific Northwest during December 1968

2/ Parentheses () indicate actual loads greater than estimated loads

Source: BPA Requirements Section, unpublished data, February 7, 1978.

TABLE 1.1-2(a)
PACIFIC NORTHWEST UTILITIES CONFERENCE COMMITTEE
WEST GROUP AREA
COMPARISON OF ACTUAL WITH ESTIMATED 12 MONTHS AVERAGE FIRM LOADS1/
(MEGAWATTS)

Date of Estimate	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1967 (Jan. 17)	8,888	9,562	10,252	10,826	11,056	11,852	12,815	13,663	14,508	15,334
1968 (Feb. 1)		9,649	10,970	10,970	11,215	12,112	13,277	14,081	14,842	15,819
1969 (Feb. 15)			10,061	10,745	11,020	11,868	12,730	13,565	14,208	14,896
1970 (Jan. 15)				10,617	10,964	11,988	12,779	13,681	14,321	15,033
1971 (Jan. 1)					10,807	11,688	12,507	13,279	13,947	14,614
1972 (Feb. 1)						11,541	12,375	13,100	13,846	14,482
1973 (Feb. 1)							12,409	13,054	13,807	14,472
1974 (Feb. 1)								12,971	13,678	14,719
1975 (Feb. 1)									13,446	14,173
1976 (Mar. 1)										13,934
Actual 12-Mo. Avg.	8,722	9,628	10,101	10,537	10,694	11,321	11,703	12,329	12,836	13,299

1/ Firm loads differ from total loads by the interruptable loads supplied by BPA to large industrial customers. Firm loads are used in this comparison because of the high variability to interruptable loads

Source: BPA Requirements Section, unpublished data, February 7, 1978.

TABLE 1.1-2(b)
PACIFIC NORTHWEST UTILITIES CONFERENCE COMMITTEE
WEST GROUP AREA
PERCENT DEVIATION BETWEEN ACTUAL AND ESTIMATED 12 MONTHS AVERAGE FIRM LOADS

Date of Estimate	1967-68	1968-69 1/	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1967 (Jan. 17)	1.9	(0.7) 2/	1.5	2.7	3.3	4.5	8.7	9.8	11.5	13.3
1968 (Feb. 1)		0.2	1.9	3.9	4.7	6.5	11.9	12.4	13.5	15.9
1969 (Feb. 15)			(0.4)	1.9	3.0	4.6	8.1	9.1	9.7	10.7
1970 (Jan. 15)				0.8	2.5	5.6	8.4	9.9	10.4	11.5
1971 (Jan. 1)					1.0	3.1	6.4	7.1	8.0	9.0
1972 (Feb. 1)						1.9	5.4	5.9	7.3	8.2
1973 (Feb. 1)							5.7	5.5	7.0	8.1
1974 (Feb. 1)								4.9	6.2	9.6
1975 (Feb. 1)									4.5	6.2
1976 (Mar. 1)										4.6

1/ Minimum temperatures of record occurred at a number of weather stations in the Pacific Northwest during December 1968

2/ Parentheses () indicate actual loads greater than estimated loads

Source: BPA Requirements Section, unpublished data, February 7, 1978.

SUMMARY OF LOADS AND RESOURCES

(Sheet 1 of 3)

Figures are January Peak and Contract Year Energy in Megawatts

	1978-79 PK	1978-79 AVG	1979-80 PK	1979-80 AVG	1980-81 PK	1980-81 AVG	1981-82 PK	1981-82 AVG	1982-83 PK	1982-83 AVG	1983-84 PK	1983-84 AVG	1984-85 PK	1984-85 AVG
LOADS														
1 SYSTEM LOADS 1/	24616	16071	25871	16867	27228	17757	28591	18715	29878	19505	30979	20219	32239	20972
2 EXPORTS 2/	2148	650	2090	629	2108	647	1709	496	1711	339	1562	203	1563	205
3 TOTAL LOADS	26764	16721	27961	17496	29336	18404	30300	19211	31589	19844	32541	20422	33802	21177
RESOURCES														
4 MAIN HYDRO 3/	27242	11612	28939	11633	29246	11677	29748	11717	29973	11709	30425	11714	30496	11716
5 INDEPENDENT HYDRO	659	433	659	433	659	433	659	433	659	433	659	433	659	433
6 TOTAL HYDRO	27901	12045	29598	12066	29905	12110	30407	12150	30632	12142	31084	12147	31155	12149
7 EX. SM. THRM. & MISC. 4/	243	56	243	56	236	55	236	55	236	55	236	55	235	55
8 COMB. TURBINES 5/	1225	103	1225	109	1225	109	1225	109	1225	109	1225	109	1225	109
9 HANFORD 6/	0	515	0	515	0	515	0	515	0	515	0	0	0	0
10 IMPORTS 7/	1697	1394	1986	1580	2020	1608	1868	1567	1816	1501	1757	1477	1695	1378
11 CENTRALIA	1313	919	1313	919	1313	919	1313	919	1313	919	1313	919	1313	919
12 TROJAN	1130	791	1130	791	1130	791	1130	791	1130	791	1130	791	1130	791
13 COLSTRIP 1 & 2	330	251	330	251	330	251	330	251	330	251	330	251	330	251
14 WNP 2	0	0	0	0	0	110	1100	687	1100	825	1100	825	1100	825
15 BOARDMAN (CARTY COAL)	0	0	0	0	477	191	477	334	477	358	477	358	477	358
16 COLSTRIP 3 & 4	0	0	0	0	0	0	0	74	490	435	980	693	980	736
17 WNP 1	0	0	0	0	0	0	0	0	0	63	1250	765	1250	938
18 WNP 4	0	0	0	0	0	0	0	0	0	0	0	0	1250	437
19 WNP 3	0	0	0	0	0	0	0	0	0	0	0	62	1240	760
20 SKAGIT 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21 WNP 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22 PEBBLE SPRINGS 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23 SKAGIT 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24 PEBBLE SPRINGS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25 TOTAL RESOURCES	33839	16074	35625	16287	36636	16659	38086	17452	38749	17964	40882	18452	43381	19706
26 HYDRO,SM.THML.& MISC.RES. 8/	1468	0	1533	0	1568	0	1593	0	1604	0	1627	0	1631	0
27 LARGE THERMAL RES. 8/	416	0	416	0	488	0	653	0	726	0	987	0	1360	0
28 PLANNING RESERVES 8/	533	0	872	0	1210	0	1433	0	1895	0	2059	0	2187	0
29 LOAD GROWTH RESERVES 8/	537	340	522	316	546	321	613	373	555	341	593	349	525	369
30 REALIZATION FACTOR 9/	929	0	1007	0	1009	0	1034	0	1045	0	1068	0	1072	0
31 HYDRO MAINTENANCE 10/	0	53	0	53	0	53	0	55	0	53	0	54	0	57
32 BPA NW-SW INTERTIE LOSSES 11/	84	20	84	20	84	20	57	11	57	1	50	0	53	0
33 NET RESOURCES	29872	15661	31371	15898	31731	16265	32706	17013	32867	17569	34498	18049	36456	19280
34 SURPLUS OR DEFICIT	3108	-1060	3410	-1598	2395	-2139	2406	-2198	1278	-2275	1957	-2373	2654	-1897
35 BPA IND. INTERRUPTIBLE 12/	983	996	1037	1035	1115	1101	1113	1115	1065	1065	1075	1075	1085	1085

TABLE 1.1-3

(Sheet 2 of 3)

Figures are January Peak and Contract Year Energy in Megawatts

	1985-86 PK	1985-86 AVG	1986-87 PK	1986-87 AVG	1987-88 PK	1987-88 AVG	1988-89 PK	1988-89 AVG	1989-90 PK	1989-90 AVG	1990-91 PK	1990-91 AVG	1991-92 PK	1991-92 AVG
LOADS														
1 SYSTEM LOADS	33511	21751	34853	22550	36295	23393	37740	24271	39249	25182	40013	26120	42347	27080
2 EXPORTS	1565	207	989	209	248	201	106	174	106	174	103	171	103	171
3 TOTAL LOADS	35076	21958	35842	22759	36543	23594	37846	24445	39355	25356	40916	26291	42450	27251
RESOURCES														
4 MAIN HYDRO	30538	11697	30534	11696	30607	11680	30613	11674	30613	11674	30613	11674	30613	11674
5 INDEPENDENT HYDRO	659	433	659	433	659	433	659	433	659	433	659	433	659	433
6 TOTAL HYDRO	31197	12130	31193	12129	31266	12113	31272	12107	31272	12107	31272	12107	31272	12107
7 EX. SM. THRM. & MISC.	225	53	225	53	225	53	225	53	225	53	225	53	225	53
8 COMB. TURBINES	1225	109	1225	109	1225	109	1225	109	1225	109	1225	109	1225	109
9 HANFORD	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10 IMPORTS	1628	1318	1557	1162	1479	890	1396	683	1142	602	1028	507	907	447
11 CENTRALIA	1313	919	1313	919	1313	919	1313	919	1313	919	1313	919	1313	919
12 TROJAN	1130	791	1130	791	1130	791	1130	791	1130	791	1130	791	1130	791
13 COLSTRIP 1 & 2	330	251	330	251	330	251	330	251	330	251	330	251	330	251
14 WNP 2	1100	825	1100	825	1100	825	1100	825	1100	825	1100	825	1100	825
15 BOARDMAN (CARTY COAL)	477	358	477	358	477	358	477	358	477	358	477	358	477	358
16 COLSTRIP 3 & 4	980	736	980	736	980	736	980	736	980	736	980	736	980	736
17 WNP 1	1250	938	1250	938	1250	938	1250	938	1250	938	1250	938	1250	938
18 WNP 4	1250	860	1250	938	1250	938	1250	938	1250	938	1250	938	1250	938
19 WNP 3	1240	930	1240	930	1240	930	1240	930	1240	930	1240	930	1240	930
20 SKAGIT 1	1288	773	1288	966	1288	966	1288	966	1288	966	1288	966	1288	966
21 WNP 5	1240	434	1240	853	1240	930	1240	930	1240	930	1240	930	1240	930
22 PEBBLE SPRINGS 1	0	189	1260	803	1260	945	1260	945	1260	945	1260	945	1260	945
23 SKAGIT 2	0	0	0	0	1288	773	1288	966	1288	966	1288	966	1288	966
24 PEBBLE SPRINGS 2	0	0	0	0	0	0	0	189	1260	803	1260	945	1260	945
25 TOTAL RESOURCES	45873	21614	47058	22761	48341	23465	48264	23634	49270	24167	49156	24214	49035	24154
26 HYDRO,SM.THRL.& MISC.RES.	1632	0	1632	0	1636	0	1636	0	1636	0	1636	0	1636	0
27 LARGE THERMAL RES.	1740	0	1929	0	2122	0	2122	0	2311	0	2311	0	2311	0
28 PLANNING RESERVES	2360	0	2731	0	2814	0	3078	0	3164	0	3461	0	3715	0
29 LOAD GROWTH RESERVES	635	377	679	394	687	411	712	423	739	438	755	450	807	473
30 REALIZATION FACTOR	1074	0	1074	0	1077	0	1078	0	1078	0	1078	0	1078	0
31 HYDRO MAINTENANCE	0	58	0	58	0	58	0	58	0	51	0	51	0	51
32 BPA NW-SW INTERTIE LOSSES	59	0	26	0	1	0	1	0	0	0	0	0	0	0
33 NET RESOURCES	38382	21179	38987	22309	40004	22996	39638	23153	40342	23678	39915	23713	39488	23630
34 SURPLUS OR DEFICIT	3306	-779	3145	-450	3461	-598	1792	-1292	987	-1678	-1001	-2578	-2962	-3621
35 BPA IND. INTERRUPTIBLE	1095	1095	1105	1105	1115	1115	1125	1125	1135	1135	1145	1145	1154	1155

TABLE 1.1-3

(Sheet 3 of 3)

Figures are January Peak and Contract Year Energy in Megawatts

	1992-93 PK	1992-93 AVG	1993-94 PK	1993-94 AVG	1994-95 PK	1994-95 AVG	1995-96 PK	1995-96 AVG	1996-97 PK	1996-97 AVG	1997-98 PK	1997-98 AVG
LOADS												
1 SYSTEM LOADS	44050	28087	45818	29153	47659	30259	49607	31410	51638	32625	53752	33899
2 EXPORTS	103	171	103	172	103	211	103	239	122	327	122	327
3 TOTAL LOADS	44153	28258	45921	29325	47762	30470	49713	31649	51760	32952	53874	34226
RESOURCES												
4 MAIN HYDRO	30613	11674	30613	11674	30613	11674	30613	11674	30613	11674	30613	11674
5 INDEPENDENT HYDRO	659	433	659	433	659	433	659	433	659	433	659	433
6 TOTAL HYDRO	31272	12107	31272	12107	31272	12107	31272	12107	31272	12107	31272	12107
7 EX. SM. THRM. & MISC.	225	53	225	53	225	53	225	53	225	53	225	53
8 COMB. TURBINES	1225	109	1225	109	1225	109	1225	109	1225	109	1225	109
9 HANFORD	0	0	0	0	0	0	0	0	0	0	0	0
10 IMPORTS	777	314	636	249	484	121	321	73	240	67	240	67
11 CENTRALIA	1313	919	1313	919	1313	919	1313	919	1313	919	1313	919
12 TROJAN	1130	791	1130	791	1130	791	1130	791	1130	791	1130	791
13 COLSTRIP 1 & 2	330	251	330	251	330	251	330	251	330	251	330	251
14 WNP 2	1100	825	1100	825	1100	825	1100	825	1100	825	1100	825
15 BOARDMAN (CARTY COAL)	477	358	477	358	477	358	477	358	477	358	477	358
16 COLSTRIP 3 & 4	980	736	980	736	980	736	980	736	980	736	980	736
17 WNP 1	1250	938	1250	938	1250	938	1250	938	1250	938	1250	938
18 WNP 4	1250	938	1250	938	1250	938	1250	938	1250	938	1250	938
19 WNP 3	1240	930	1240	930	1240	930	1240	930	1240	930	1240	930
20 SKAGIT 1	1288	966	1288	966	1288	966	1288	966	1288	966	1288	966
21 WNP 5	1240	930	1240	930	1240	930	1240	930	1240	930	1240	930
22 PEBBLE SPRINGS 1	1260	945	1260	945	1260	945	1260	945	1260	945	1260	945
23 SKAGIT 2	1288	966	1288	966	1288	966	1288	966	1288	966	1288	966
24 PEBBLE SPRINGS 2	1260	945	1260	945	1260	945	1260	945	1260	945	1260	945
25 TOTAL RESOURCES	48905	24021	48764	23956	48612	23828	48449	23780	48368	23774	48368	23774
26 HYDRO,SM.THML.& MISC.RES.	1636	0	1636	0	1636	0	1636	0	1636	0	1636	0
27 LARGE THERMAL RES.	2311	0	2311	0	2311	0	2311	0	2311	0	2311	0
28 PLANNING RESERVES	4024	0	4342	0	4658	0	5007	0	5375	0	5758	0
29 LOAD GROWTH RESERVES	839	501	675	521	927	545	967	574	1006	694	1045	675
30 REALIZATION FACTOR	1078	0	1078	0	1078	0	1078	0	1078	0	1078	0
31 HYDRO MAINTENANCE	0	51	0	51	0	51	0	51	0	51	0	51
32 BPA NW-SW INTERTIE LOSSES	0	0	0	0	0	0	0	0	0	0	0	0
33 NET RESOURCES	39017	23469	38522	23384	38002	23232	37450	23155	36962	23119	36540	23088
34 SURPLUS OR DEFICIT	-5136	-4789	-7399	-5941	-9760	-7238	-12260	-8494	-14798	-9833	-17334	-11138
35 BPA IND. INTERRUPTIBLE	1164	1165	1174	1174	1184	1184	1194	1193	1204	1203	1214	1213

FOOTNOTES FOR TABLE 1.1-3

1/ Area loads are estimated firm loads of private utility and public agency systems, Federal agencies, and BPA industrial customers. BPA industrial customer loads also include interruptible loads. Loads also include area transmission losses.

2/ Exports include deliveries to California utilities under the CSPE agreement, peak/energy exchange contracts with PSW, transfers of Centralia power to Central Valley Project, WWP Co. contracts with Utah, Idaho, and Montana Power Companies, PSP&L Co. contracts with Utah Power Co. and Salt River Project, PGE Co. contracts with Pacific Gas and Electric Co. and Southern California Edison Co., Eugene Water and Electric Board contracts with Southern California Municipalities, BPA contracts with Montana Power Co. (M.P. Co.) for geographic preference, wheeling payments, Hanford-NPR exchange, Hanford-NPR extension, WNP No. 1 deliveries, and M.P. Co's. share of restoration from the West Group Area as per Pacific Northwest Coordination Agreement.

3/ Hydro resources are the same as those shown in the 1978 West Group Forecast Report.

4/ Existing small thermal and miscellaneous includes old existing steam plants, small diesel generators, and miscellaneous small industrial purchases.

5/ Combustion turbines include PP&L's Libby unit, PGE's Bethel, Harborton, and Beaver units, PSP&L's Whidbey Island and Whitehorn units, and WWP's Othello and Northeast units.

6/ Hanford-NPR operation is based on gross production of 4.5 billion kilowatt-hours per year in 1978-79 through 1982-83. The plant is considered not dependable as a peaking resource.

7/ Imports include energy returned to the PNW from peak/energy exchange contracts with PSW utilities, PGE Co. contract with Southern California Edison Co., PP&L Co. transfers from PP&L Co. Wyoming Division, PSP&L Co. contract with Montana and Utah Power Companies and Salt River Project, WWP Co. contracts with Montana and Idaho Power Companies, and EW&EB contracts with Southern California Municipalities.

8/ Total reserve requirements on peak are based on 12 percent of the total area loads for the first year, increasing at a rate of one percent per year up to 20 percent, and remaining at 20 percent thereafter. Reserve requirements on energy are based on one-half year's load growth of utility-type loads. Reserves are broken down into major components.

9/ Realization factor is the adjustment to the Federal hydro peaking capability to reflect inability of the Federal system to achieve its full peaking capability at any one specific instance.

10/ Hydro maintenance on energy is the estimated maintenance required during the critical storage period and is the same as shown in the 1977 West Group Forecast report. Peak hydro maintenance is included with the peak forced outage reserves.

11/ BPA's NW-SW Intertie losses are associated with deliveries over the Intertie under contracts with Pacific Southwest utilities.

12/ BPA industrial interruptible loads are served directly by BPA and are included in Line 1 above. Line losses associated with the interruptible loads are not included.

TABLE 1.1-4

WEST GROUP LARGE THERMAL ADDITIONS
BASED ON SCHEDULED DATES OF COMMERCIAL OPERATION (1)
CAPACITY IN MEGAWATTS
ENERGY IN AVERAGE MEGAWATTS

Year Ending June 30	1979 Pk	1979 Av	1980 Pk	1980 Av	1981 Pk	1981 Av	1982 Pk	1982 Av	1983 Pk	1983 Av	1984 Pk	1984 Av	1985 Pk	1985 Av	1986 Pk	1986 Av	1987 Pk	1987 Av	1988 Pk	1988 Av	1989 Pk	1989 Av
Boardman (Carty)					477	286		72														
WNP-2.					1100	550		248		27												
Colstrip - 3&4							490	74	490	416		245										
WNP-1&4							1250	418		500	1250	62		766		109						
WNP-3&5											1250	372		558	1240	744		186				
Skagit-1&2															1288	773		193	1288	773		
Pebble Springs-1&2																189	1260	756				189
Regional Totals:																						
Annual					1577	816	1740	812	490	943	2490	679		1324	2528	1815	1260	1135	1288	773		189
Cumulative . . .					1577	816	3317	1668	3807	2611	6297	3290	6297	4614	8825	6429	10,085	7564	11,373	8337	11,373	8526
Public Agency Totals:																						
Annual					1100	550	1250	686		527	2118	121		1157	1116	779	189	167		0		189
Cumulative . . .					1100	550	2350	1236	2350	1763	4468	2086	4468	3243	5584	4022	5773	5860	5773	5860	5773	6049

(1) - Based on West Group Forecast 1-1-78

Amendment 2
October 1978

TABLE 1.1-5

WEST GROUP LARGE THERMAL ADDITIONS
BASED ON PROBABLE ENERGY DATE (1)
PEAK CAPACITY IN MEGAWATTS
ENERGY IN AVERAGE MEGAWATTS

Year Ending June 30	1979 Pk	1979 Av	1980 Pk	1980 Av	1981 Pk	1981 Av	1982 Pk	1982 Av	1983 Pk	1983 Av	1984 Pk	1984 Av	1985 Pk	1985 Av	1986 Pk	1986 Av	1987 Pk	1987 Av	1988 Pk	1988 Av	1989 Pk	1989 Av
Boardman (Carty)					477	191		143		24												
WNP-2.						110	1100	578		137												
Colstrip - 3&4								74	490	360	490	259		43								
WNP-1&4										62	1250	704	1250	610		422		78				
WNP-3&5												62	1240	698	1240	604		418		78		
Skagit-1&2															1288	773		193	1288	773		193
Pebble Springs-1&2																189	1260	614		142		189
Regional Totals:																						
Annual					477	301	1100	795	490	583	1740	1025	2490	1351	2528	1988	1260	1304	1288	993	0	382
Cumulative . . .					477	301	1577	1096	2067	1679	3807	2704	6297	4055	8025	6043	10,085	7346	11,373	8339	11,373	8721
Public Agency Totals:																						
Annual							1100	578		199	1250	747	2118	1099	1116	960	189	546		91		28
Cumulative . . .							1100	578	1100	777	2350	1524	4468	2623	5584	5428	5773	5974	5773	6065	5773	6093

(1) - Based on West Group Forecast 3-1-78

Amendment 2
October 1978

TABLE 1.1-6

PUBLIC AGENCY - BPA ENERGY RESOURCES AND REQUIREMENTS

(Average Megawatts)

		Probable Energy Date				Scheduled Date			
Year Ending June 30	Estimated Requirements (1)	Estimated Resources (1)	Unsatisfied Requirements	WPPSS No. 2	Unsatisfied Requirements w/o WPPSS-2	Estimated Resources (Adjusted) (2)	Unsatisfied Requirements (3)	WPPSS No. 2	Unsatisfied Requirements w/o WPPSS-2
1979	10,980	10,490	490		490	10,490	490		
1980	11,453	10,620	833		833	10,602	833		
1981	12,214	10,809	1,405	110	1,515	11,259	955	550	1,505
1982	12,725	11,266	1,459	687	2,146	11,379	1,346	798	2,144
1983	13,016	11,376	1,640	825	2,465	11,750	1,266	825	2,091
1984	13,290	11,771	1,519	825	2,344	12,237	1,053	825	1,878
1985	13,666	12,866	800	825	1,625	13,272	394	825	1,219
1986	14,045	13,811	234	825	1,059	14,168	(123)	825	702
1987	14,435	14,205	230	825	1,055	14,274	161	825	986
1988	14,858	14,080	778	825	1,603	14,080	778	825	1,603
1989	15,294	14,080	1,214	825	2,039	14,080	1,214	825	2,039

(1) Blue Book Table 2 adjusted for duplication in Federal and Public Agency values.
(2) Adjusted for difference in added resources between Probable Energy Date and Scheduled Date.
(3) () denotes surplus resource over requirements

TABLE 1.1-7

WEST GROUP ENERGY RESOURCES AND REQUIREMENTS

(Average Megawatts)

		Probable Energy Date				Scheduled Date			
Year Ending June 30	Estimated Requirements (1)	Estimated Resources (2)	Unsatisfied Requirement With WPPSS No. 2	WPPSS No. 2	Unsatisfied Requirement Without WPPSS No. 2	Estimated Resources Adjusted (3)	Unsatisfied Requirement With WPPSS No. 2	WPPSS No. 2	Unsatisfied Requirement Without WPPSS No. 2
1979	16,721	15,661	1,060		1,060	15,661	1,060		
1980	17,496	15,898	1,598		1,598	15,898	1,598		
1981	18,404	16,265	2,139	110	2,249	16,800	1,604	550	2,154
1982	19,211	17,013	2,198	687	2,885	17,148	2,063	798	2,861
1983	19,844	17,569	2,275	825	3,100	17,943	1,901	825	2,726
1984	20,422	18,049	2,373	825	3,198	18,515	1,907	825	2,732
1985	21,177	19,280	1,897	825	2,722	19,686	1,491	825	2,316
1986	21,958	21,179	779	825	1,604	21,474	484	825	1,309
1987	22,759	22,309	450	825	1,275	22,386	373	825	1,198
1988	23,594	22,996	598	825	1,423	22,996	598	825	1,423
1989	24,445	23,153	1,292	825	2,117	23,153	1,292	825	2,117

(1) From 1978 Blue Book, Table 1, Line 3
(2) From 1978 Blue Book, Table 1, Line 33
(3) Estimated Resources adjusted from Probable Energy Date to Scheduled Date.

TABLE 1.1-8

WEST GROUP CAPACITY (PEAK) RESOURCES AND REQUIREMENTS

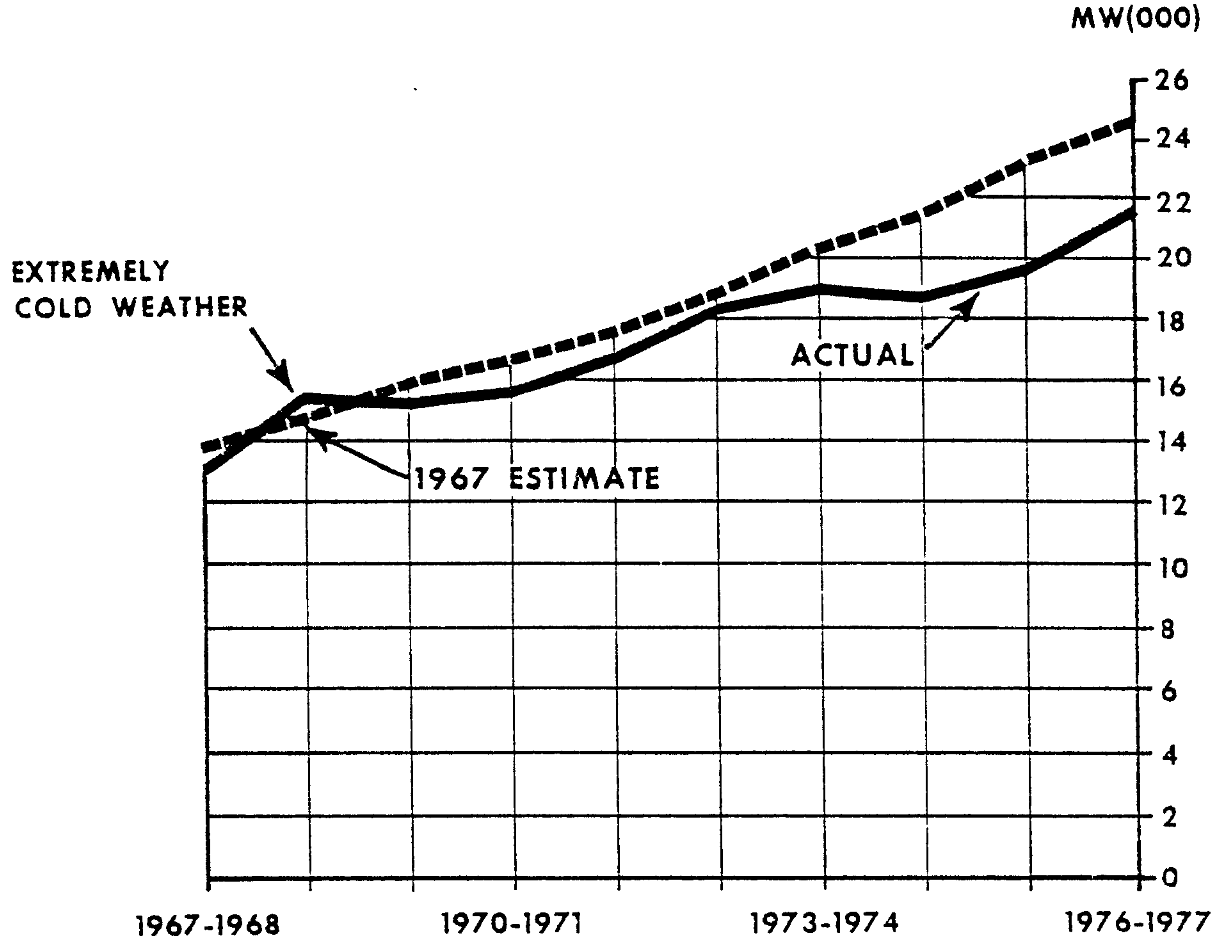
(Megawatts)

		Probable Energy Date				Scheduled Date			
Year Ending June 30	Estimated Requirements (1)	Estimated Resources (2)	Unsatisfied Requirements With WPPSS No. 2(4)	WPPSS No. 2	Unsatisfied Requirement Without WPSS No. 2 (4)	Estimated Resources Adjusted (3)	Unsatisfied Requirement With WPPSS No. 2(4)	WPPSS No. 2	Unsatisfied Requirements Without WPPSS No.2 (4)
1979	26,764	29,872	(3,108)		(3,108)	29,872	(3,108)		(3,108)
1980	27,961	31,371	(3,410)		(3,410)	31,371	(3,410)		(3,410)
1981	29,336	31,731	(2,395)		(2,395)	32,831	(3,495)	1,100	(2,395)
1982	30,300	32,706	(2,406)	1,100	(1,306)	32,706	(2,406)	1,100	(1,306)
1983	31,589	32,867	(1,278)	1,100	(178)	3,4117	(2,528)	1,100	(1,428)
1984	32,541	34,498	(1,957)	1,100	(857)	35,738	(3,197)	1,100	(2,097)
1985	33,802	36,456	(2,654)	1,100	(1,554)	36,456	(2,654)	1,100	(1,554)
1986	35,076	38,382	(3,306)	1,100	(2,206)	38,382	(3,306)	1,100	(2,206)
1987	35,842	38,987	(3,145)	1,100	(2,045)	38,987	(3,145)	1,100	(2,045)
1988	36,543	40,004	(3,461	1,100	(2,361)	40,004	(3,461)	1,100	(2,361)
1989	37,846	39,638	(1,792)	1,100	(692)	39,638	(1,792)	1,100	(692)

(1) From 1978 Blue Book, Table 1, Line 3
(2) From 1978 Blue Book, Table 1, Line 33
(3) Estimated Resources adjusted from Probable Energy Date to the Scheduled Date.
(4) () Indicates surplus over requirements

ESTIMATED VS. ACTUAL WINTER PEAK LOADS

PNW-WEST GROUP AREA

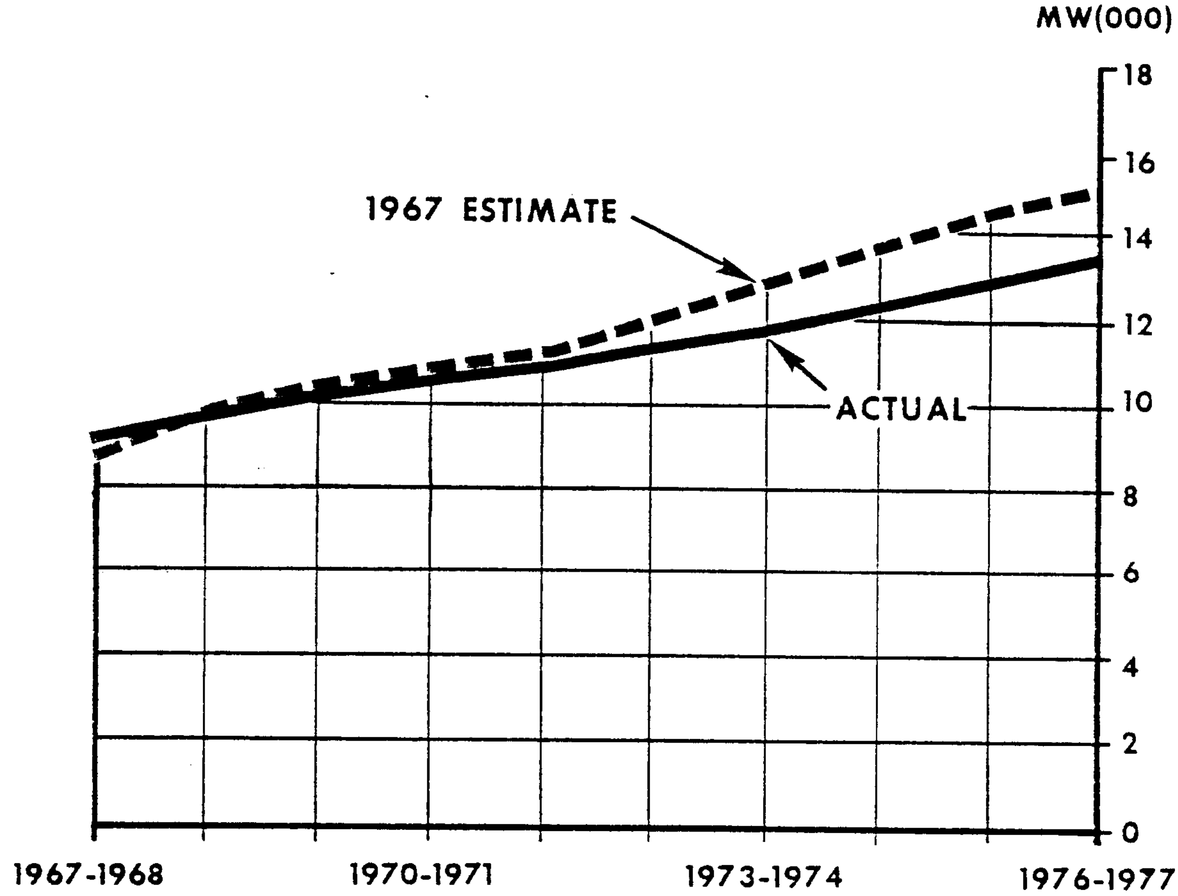


Amendment 2, October 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	ESTIMATED VERSUS ACTUAL WINTER FIRM PEAK LOADS PNW-WEST GROUP AREA FIG. 1.1-1

ESTIMATED VS. ACTUAL ANNUAL AVERAGE FIRM LOADS

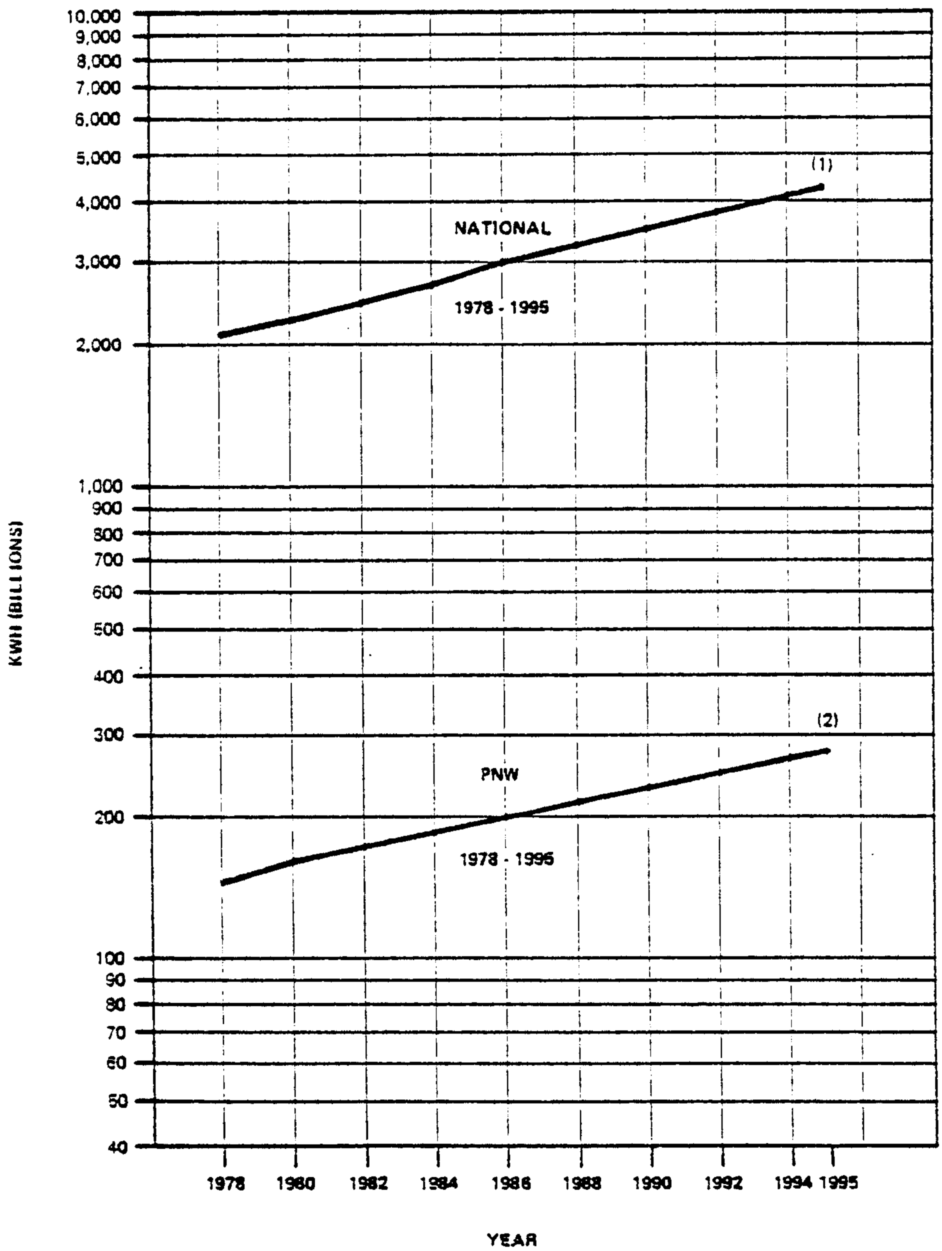
PNW-WEST GROUP AREA



Amendment 2, October 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	ESTIMATED VERSUS ACTUAL ANNUAL AVERAGE FIRM LOADS PNW-WEST GROUP AREA FIG. 1.1-2

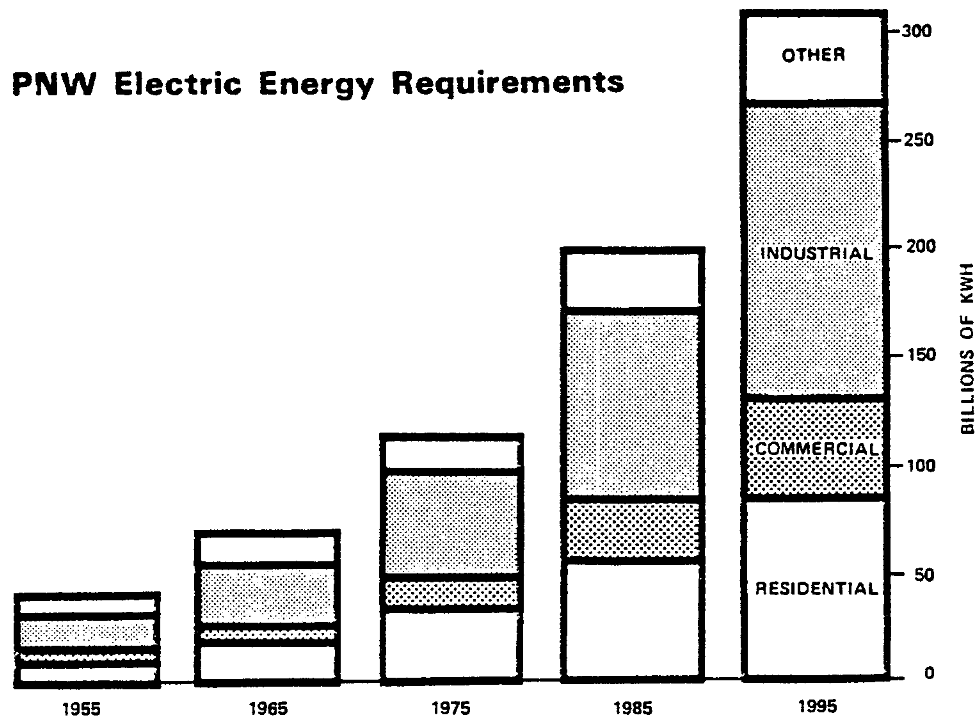
U. S. & PNW (WEST GROUP AREA) ENERGY LOADS



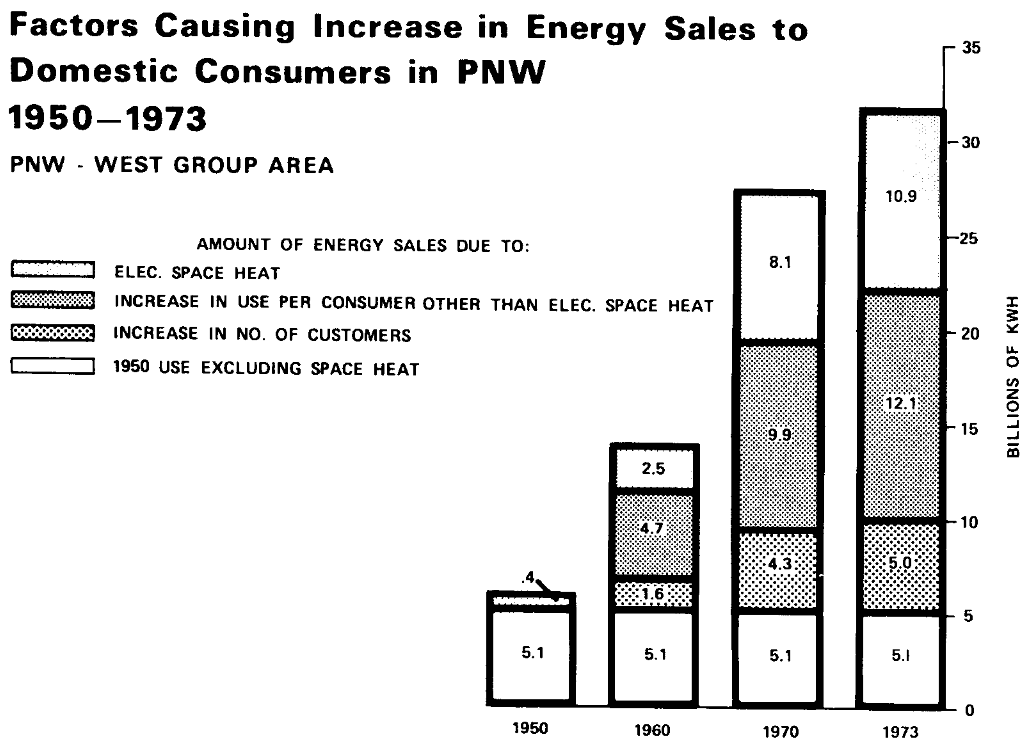
1) ELECTRICAL WORLD, SEPT. 15, 1977
2) BLUE BOOK, 1978 - 79 THROUGH 1997 - 98

Amendment 2, October 1978

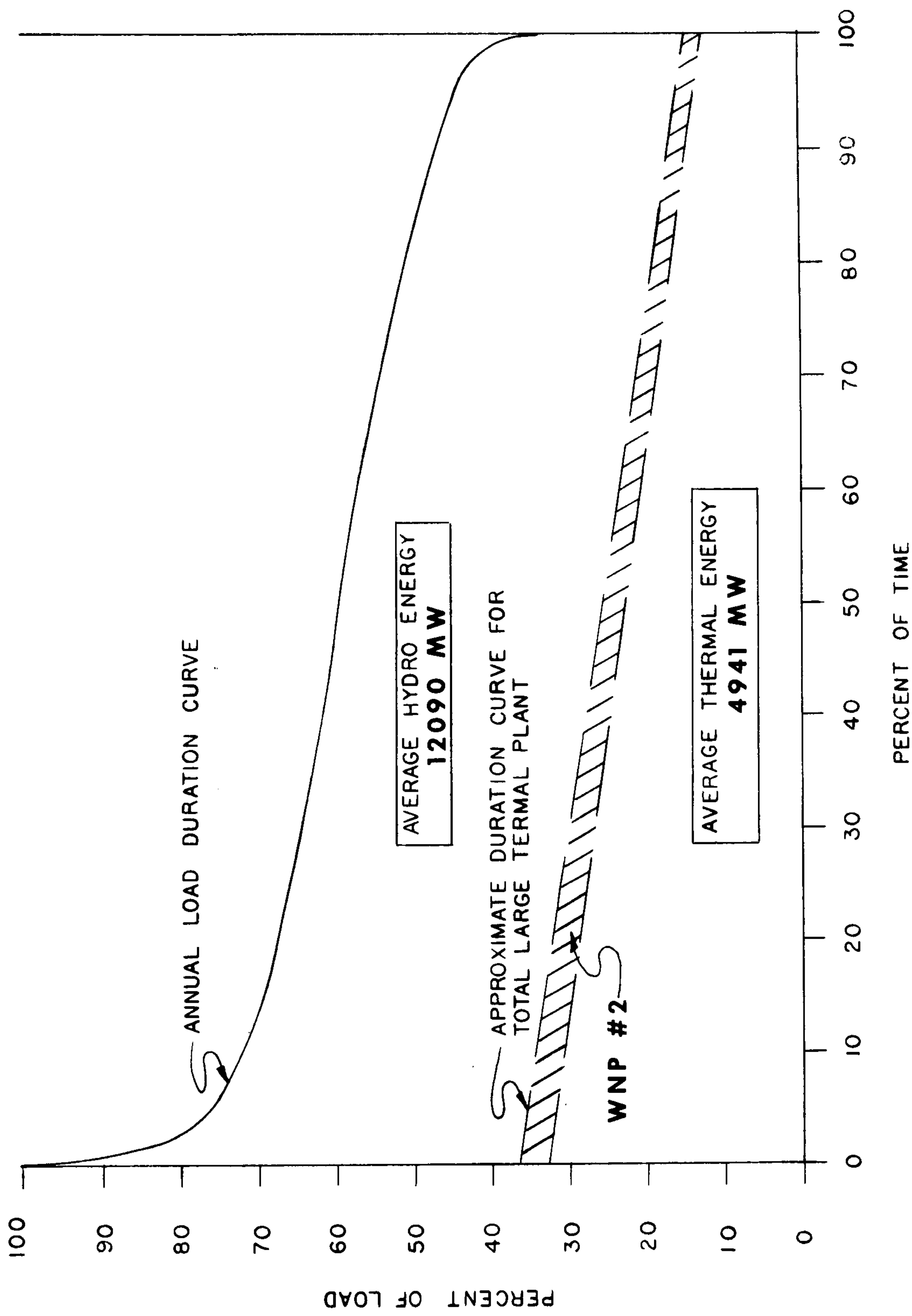
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	U.S. & PNW (WEST GROUP AREA) PEAK LOADS
	FIG. 1.1-3



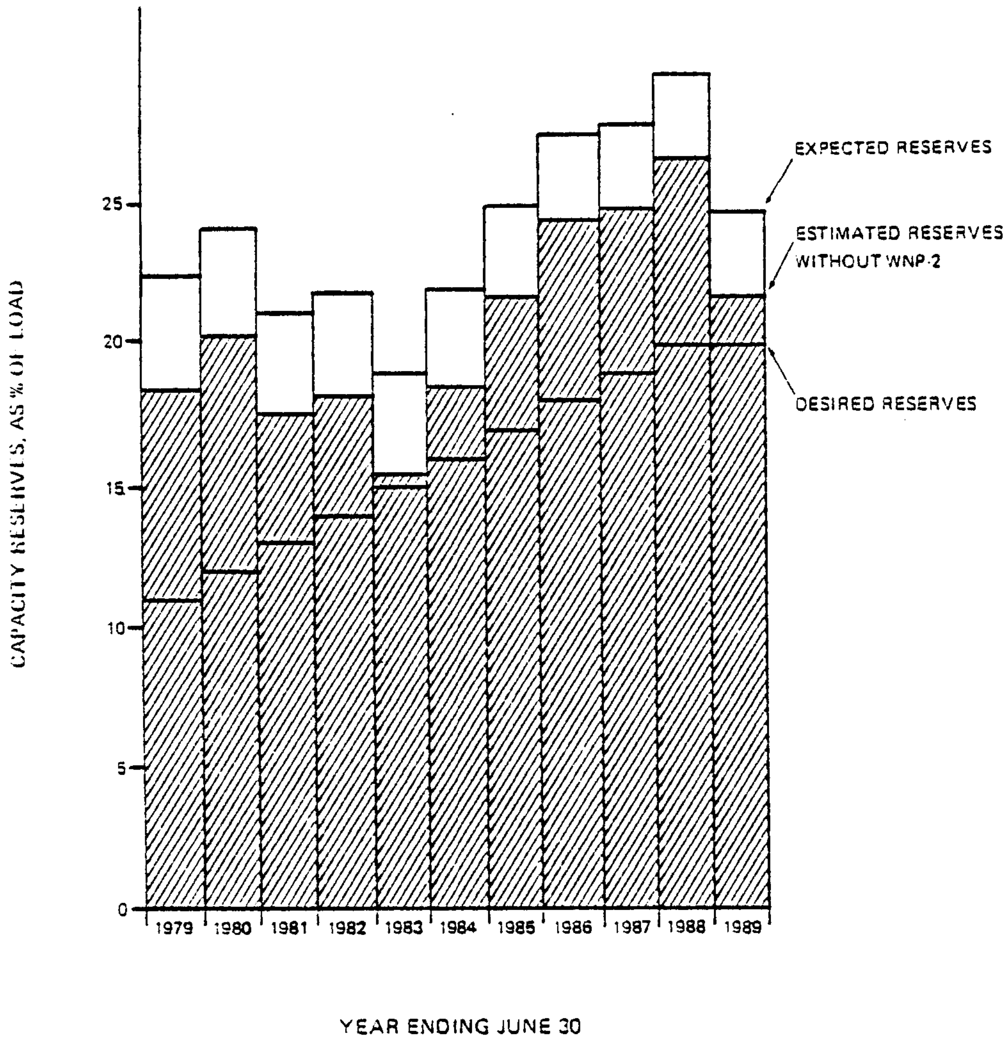
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	ELECTRIC ENERGY REQUIREMENTS BY MAJOR CONSUMER CATEGORIES PACIFIC NORTHWEST (WEST GROUP AREA) FIG. 1.1-4



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FACTORS CAUSING INCREASE IN ENERGY SALES TO DOMESTIC CONSUMERS IN WEST GROUP OF PNW 1950 - 1973
	FIG. 1.1-5

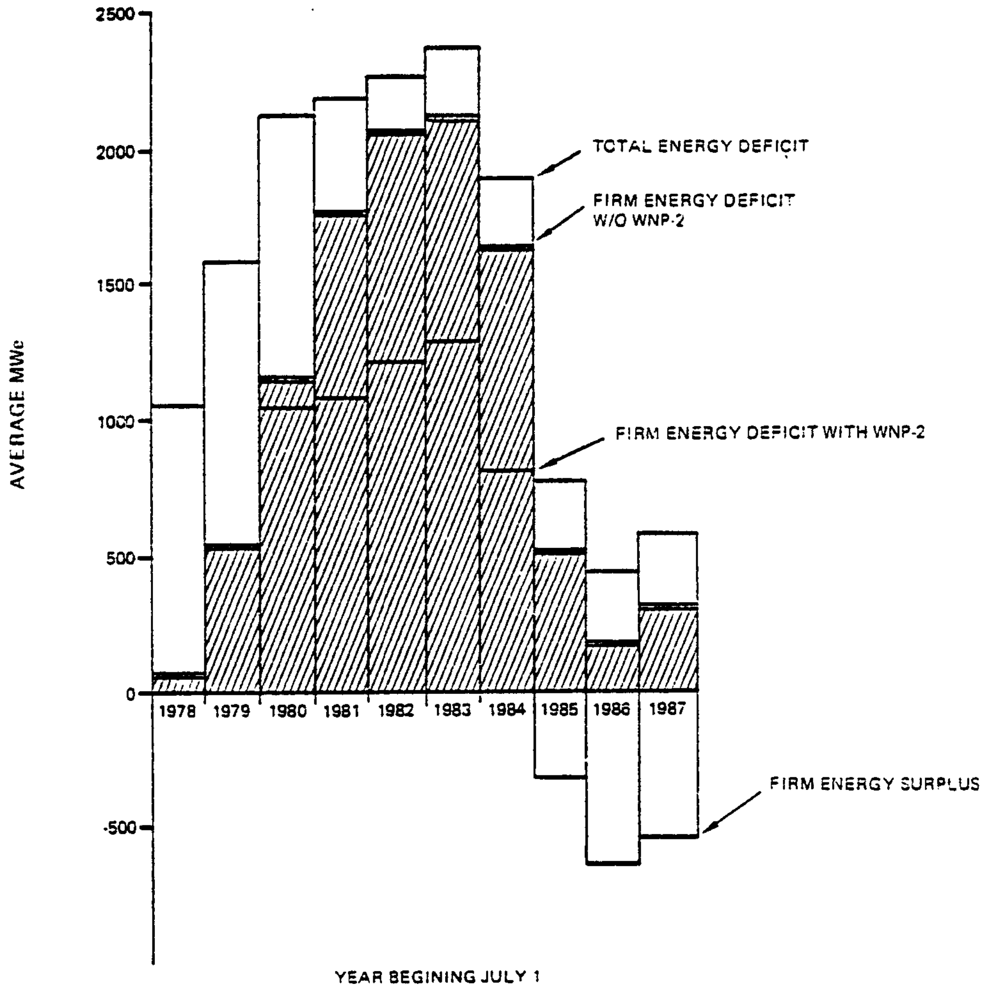


WASHINGTON PUBLIC POWER SUPPLY SYSTEM **WPPSS NUCLEAR PROJECT NO. 2** **Environmental Report**	WEST GROUP AREA LOAD CRITICAL WATER 1981-82
	FIG. 1.1-6



Amendment 2, October 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	ESTIMATED CAPACITY RESERVES 1979-1989 FIG. 1.1-7



Amendment 2, October 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	ESTIMATED ENERGY RESERVES 1978-1987 FIG. 1.1-8

CHAPTER 2
THE SITE AND ENVIRONMENTAL INTERFACES

CHAPTER 2

THE SITE AND ENVIRONMENT INTERFACES

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 Site Location and Description

2.1.1.1 Specification of Location

The Washington Public Power Supply System's (WPPSS or the Supply System) Nuclear Project No. 2 (WNP-2) is on property leased from the United States Department of Energy (DOE) (formerly the Energy Research and Development Administration) within the Hanford Site in the southeastern part of the State of Washington (See Figure 2.1-1). The Hanford Site is comprised of 134 square miles (86,050 acres) in Grant and Franklin Counties, and 425 square miles (271,930 acres) in Benton County (See Figure 2.1-2).

WNP-2 is located in Section 5 of Township 11 north, Range 28 east, Willamette Meridian. The center of the primary containment vessel is located at latitude 46° 28' 18" N and longitude 119° 19' 58" W. The approximate Universal Transverse Mercator Coordinates are 5,148,840 meters north and 320,930 meters east. The plant is approximately 3 1/4 miles west of the Columbia River. 4

WNP-2 is 12 miles north of the center of Richland, Washington, the nearest incorporated community. Approximate airline distances from the site to major cities in the Pacific Northwest are listed in the following table.

City	Direction From Site	Distance From Site
Spokane, Washington	Northeast	120 miles
Butte, Montana	East	330 miles
Walla Walla, Washington	Southeast	55 miles
Boise, Idaho	Southeast	260 miles
Portland, Oregon	West-Southwest	180 miles
Yakima, Washington	West	55 miles
Seattle, Washington	West-Northwest	160 miles
Vancouver, British Columbia	Northwest	260 miles

4

Within the Hanford Site, WNP-2 is 18 miles southeast of the Hanford Generating Project and 2 3/4 miles northeast of the Fast Flux Test Facility (FFTF) which is under construction for DOE. WPPSS Nuclear Projects Nos. 1 and 4 (WNP-1/4) are under construction 0.9 miles east-southeast and 0.8 miles east-northeast of WNP-2, respectively. The H. J. Ashe Substation is located 0.5 miles north of WNP-2 (See Figure 2.1-3).

The site is about 11 miles north of the Richland Airport and 18 miles northwest of both Vista Airport near Kennewick and the Tri-Cities Airport near Pasco. The Tri-Cities and the Richland Airports have regularly scheduled commercial airline service. Hughes Air West
4 serves the Tri-Cities Airport and Cascade Airways services both airports.

Adjacent to the WNP-2 site but not within the confines of the plant boundary, is a 9-acre burial site containing radioactive waste matter disposed by the Atomic Energy Commission (See Figure 2.1-3). Known as the Wye Burial Ground, the area is appropriately marked and will be adequately secured. The area is under the control of the DOE waste management program and is not considered a hazard to the public nor to the plant's operation. Neither the public nor the WNP-2 operating personnel will have access to this burial site.

2.1.1.2 Site Area

The Washington Public Power Supply System has leased from DOE 1089 acres of which approximately 202 acres will be modified by construction activities. Of these, only about 30 acres will be used for WNP-2 structures and auxiliary facilities during its operation. The remaining 1059 acres will remain or will be returned to their natural state.

The plant property line is shown in Figure 2.1-3. In addition, Figure 2.1-4 and 3.1-1 show the location of pertinent structures, facilities and the railroad spur linking the site with the Burlington Northern Railroad at Richland.

The site area, as defined by the tract of land over which WPPSS will control access of individuals consists of the plant property and the area included within the exclusion area (See Figure 2.1-3). Part of the exclusion area is beyond the property line of WNP-2 and its control is discussed in greater detail in sub-section 2.1.2. The site area is entirely within the boundaries of DOE's Hanford Site.

The site is situated near the middle of a relatively flat, essentially featureless plain which is best described as a desert shrub-steppe with sage brush and bitter brush interspersed with native perennial and alien cheat grasses extending in a northerly, westerly and southerly direction for several miles. On the east, the site is bounded by the Columbia River. The plain is characterized by slight topographic relief with a maximum relief across the plant site of approximately ten feet, and a plant site grade level of 441 feet above Mean Sea Level (MSL) (See Figure 2.1.4).

As shown in Figure 2.1-3, the exclusion area is a circle with its center at the reactor and a radius of 1950 meters. This area meets the 10CFR Part 100.11(a)(1) criteria. Industrial facilities located in the site area are the WNP-1/4 projects, the H.J. Ashe Substation, and a permanent meteorological tower. An Emergency Response/Plant Support Facility is planned for a location 3/4 mile southwest of the plant on WPPSS property. Highway and railway facilities near the site area are shown in Figures 2.1-3, 2.1-5 and 2.1-6. 4

2.1.1.3 Boundaries for Establishing Effluent Release Limits

An area slightly larger than one square mile has been established as the limit of the restricted area for which radiation concentrations have been calculated in conformance with 10CFR Part 20.106(a). The restricted area includes the WNP-2 plant and facilities, meteorological tower, a portion of the main railroad line and access road, as well as the Wye Burial Ground (See Figure 2.1-3). The plant's effluent release points are shown in Figures 3.1-6. 4

2.1.2 Exclusion Area Authority and Control

2.1.2.1 Authority

A letter from the DOE Richland Operations office to the Managing Director of the Supply System[1] advises that DOE has the authority to sell or lease land on the Hanford Site. The letter further states as follows:

> "This authority is contained in Section 120 of the Atomic Energy Community Act of 1955, as amended, and Section 161G of the Atomic Energy Act of 1954, as amended. There is also general federal disposal authority available under the Federal Property Administrative Services Act of 1949, as amended."

As shown in Figure 2.1-3, the 1950 meter radius exclusion area does extend outside the plant property at several locations. All land outside the plant property but within the exclusion area is managed by DOE as part of the Hanford Site. In recognition of requirements specified in 10CFR 100.3(a), that require a licensee to have control over access to the exclusion area, the following terms have been made a part of the site property lease agreement between the Supply System and DOE. Quoting from page 8, item 7 "Exclusion Area":

"The Commission recognizes the exclusion area as provided for in the operating license and will undertake no action or activity which would interfere with or restrict the Supply System's right to fully comply with this condition of the operating license."

Any actions taken within the exclusion area but outside the plant property are under the control of DOE. All rail shipments on the track which traverses the property are also under control of DOE and are also subject to the above quoted provisions of the Lease.

The only roads which traverse the exclusion area are the WNP-2 and WNP-1/4 access roads shown in Figure 2.1-3. Access by land from outside of the Hanford Site to the project site is by other DOE roads. Travel within the exclusion area on the access road will be restricted by the Washington Public Power Supply System.

In the event that evacuation or other control of the exclusion area should become necessary, appropriate notice will be given to the DOE - Richland Operations Office for control of non-Supply System originated activities.

The above provisions provide the necessary assurances that the exclusion area will be properly controlled. If at some time in the future, the Supply System should decide that an easement would be useful in ensuring continued control, there is a provision in Paragraph 5(b) of the lease as follows:

> "Subject to the provisions of Section 161(q) of the Atomic Energy Act of 1954, as amended, the Commission has authority to grant easements for the rights-of-way for roads, transmission lines and for any other purpose and agrees to negotiate with the Supply System for such rights-of-way over the Hanford Operations Area as are necessary to service the Leased Premises."

Pursuant to this provision, the Supply System could obtain from DOE an easement over the exclusion area in question which would assure that neither the construction of permanent structures nor the conducting of activities inconsistent with the exclusion area would be carried on therein.

2.1.2.2 Control of Activities Unrelated to Plant Operation

The exclusion area will encompass the WPPSS Nuclear Projects Nos. 1 and 4, their respective access roads, and the H. J. Ashe Substation. Other than these facilities there are no activites unrelated to the operation of WNP-2 within the exclusion area. Both WNP-1 and 4 and their respective access roads (see Figure 2.1-3), will be owned and operated by WPPSS. The H. J. Ashe Substation will be owned by the Bonneville Power Administration and is considered a part of WNP-2 normal operation.

2.1.3 Population Distribution

Table 2.1-1 presents the compass sector population estimates for 1980 and the forecasts for the same compass sectors by decade from 1990 to 2030.* Cumulative totals are also shown in Table 2.1-1. This table may be keyed to Figures 2.1-7 and 2.1-8 which show the sectors and major population centers within 10 and 50 miles of the site. The population centers, within 50 miles of the site are the Tri-City area of

* Population estimates out to 50 miles were derived to serve the licensing requirements of WNP-1, 2, and 4. Therefore, estimates were made relative to the centroid of the triangle formed by the three reactors. This point is located 2800 ft east of WNP-2 and has coordinates Long 119°19'18"W, Lat 46°28'19" N. This shift does not affect the overall accuracy or applicability of the population distribution projections. 5

Richland, Pasco and Kennewick, and the communities lying along the Yakima River from Prosser to Wapato. It can be seen from Figure 2.1-7 that there are no towns located within 10 miles of the site, with the exception of a small part of Richland. There are no residents of incorporated Richland within the 10-mile radius.

5 The 1990 to 2030 forecasts presented here(2) are based on: a) 1979 population figures provided by the Washington State Office of Financial Management; b) Benton and Franklin County Traffic Analysis Zone population distributions; c) computed annual average area growth rates from 1975 through 1979 which were utilized to obtain the total 1980 population estimated for each area, and d) county forecasts prepared by the Bonneville Power Administration.(3),(4)

2.1.3.1 Population Within 10 Miles

The 10-mile radius around the site is shown in Figure 2.1-7. In 1980, an estimated 1306 people were living within this radius. The nearest inhabitants occupy farms which are located east of Columbia River and are thinly spread over five compass sectors. There are no permanent inhabitants located within three miles of the site. Only about 80 persons reside between the 3-mile and the 5-mile radii and all are east of the Columbia River. Within a 5-mile radius of the site, there
5 are no proposed public facilities (schools, hospitals, etc.), business facilities, or primary transportation routes for use by large numbers of people.

In 1980, an estimated 1,306 persons, 65% of whom are in the NE to SE sectors in Franklin County east of the Columbia River, resided within a 10-mile radius of the site. This number represents only 0.5% of the total population within a 50-mile radius.

The population within the 10-mile radius is estimated at 2,676 in 1990, 3,614 in 2000, and 3,877 in 2010. By 2020, the population within the 10-mile radius is estimated at 4,073 which is a 212% increase over 1980.

No significant changes in land use within five miles are anticipated. The Hanford Site is expected to remain dedicated primarily to industrial use without private residences. No change in the use of the land east of the Columbia River is expected since it currently is irrigated to about the maximum amount practicable.

The industrial areas in the northern part of Richland and the residential area SSW of the Yakima River near the Horn Rapids Dam are within
5 the 10-mile radius. The residential area near the Horn Rapids Dam is unincorporated. The primary increase in population within the 10-mile radius is expected to be in this area (see Figure 2.1-7).

2.1.3.2 Population Between 10 and 50 Miles

As indicated in Table 2.1-1, about 251,684 people were estimated to be
living within a 50-mile radius of the WNP-2 project in 1980. Begin-
ning with the 10-mile radius, the population count increases rapidly
because of the Tri-City region to the south and south-southeast.
Total population within the 20-mile radius was estimated to be 91,734
in 1980 or about 37% of the total within 50 miles. When the 30-mile
radius is reached, another 52,000 persons can be added to the resident
population, making the number of residents within the entire 30-mile 5
radius total 143,735. Most of this zone's population count stems from
the contribution of compass sectors containing the Tri-Cities and the
residents of the fringe areas. Based on 1980 census reports, the
Tri-Cities are the only significantly large population centers located
in the 10 to 30-mile zone: Richland (33,578), Kennewick (34,397), and
Pasco (17,944). The next 10 miles (to the 40-mile range) adds another
41,135 persons for a total 40-mile radius count of 184,870 while the
50-mile range adds the final 66,814 persons for a total of 251,684
persons living within a 50-mile radius of the construction site in
1980.

The primary future increase in population is expected to be in the SE to SSW sectors which include the entire Tri-Cities and adjoining areas. Little increase is generated westward. The population increases in the rural areas are based on the expected increase in irrigated agriculture. The rest of the population is primarily in the Tri-City area as a result of increased activity on the Hanford Site and expansion of agricultural activities throughout the general region.

From the estimated 1980 population of 251,684, the population is pro-
jected to be 301,943 in 1990, 336,115 in 2000 and 360,395 in 2010 5
within the 50-mile radius. By 2020, the population within the 50-mile
radius is estimated at 379,930, and by 2030 at 383,828, which is a 53%
increase over 1980.

2.1.3.3 Transient Population

The transient population consists of agricultural workers needed for
harvesting crops produced in the region, industrial and construction
workers both on and off the Supply System's WNP-1/4 project sites, and
sportsmen engaged in hunting, fishing, and boating. Figure 2.1-9
shows the distribution of the transient population relative to the
point cited on page 2.1-5. 5

Table 2.1-3 lists industrial employment within ten miles of the project site. The majority of these individuals are directly involved with research and operation of various programs and facilities for the Department of Energy and its contractors on the Hanford Site. Most of this workday population reside within 10 to 30 miles of the project and are included in the totals discussed in Subsection 2.1.3.2. The workday population total of approximately 19,500 includes the WNP-2 construction work force which will be reduced to operating levels at the time of OL issuance.

Agricultural workers within the 50-mile radius during early spring and late fall months, consist mostly of permanent residents numbering between 2000 and 3000 laborers. In the summer months during peak harvest, the agricultural labor force is an estimated 34,000.[5] Within the 10-mile radius an estimated 1000 migrant workers are employed during the peak months of May and June. These workers are concentrated in the north to south-southeast sectors on the irrigated farm
5 units located east of the Columbia River in Franklin County.[6,7] Approximately 925 of these workers reside temporarily between the 5-10 mile radii; the remaining 75 are located within 5 miles of the site.

Hunting and fishing activities within the 10-mile radius are also centered in the north to south-southeast sectors along the Columbia River. The number of fishermen and hunters in this area varies with the season, the weather, the day of the week, and the time of day. The main hunting season is from mid-October until the end of January, and the main fishing season is from June through November. The heaviest use of the area for both sports is on weekends and holidays in the early morning hours. It is estimated that the peak number of hunters and/or fishermen present in the area would total 1,000.[6,8] It is estimated that, on the average, 10 hunters are present in the area on weekdays; the number increases to 50 on weekends and holidays. The average number of fishermen present are 50 and 100 for weekdays, and weekends and holidays, respectively. Hunters and fishermen also have access to the Yakima River in the SW and SSW sectors where they may total 50.

2.1.4 Uses of Adjacent Lands and Waters

Land use within a three (3) mile radius of the WPPSS Nuclear Projects includes the Fast Flux Test Facility (FFTF). Also included are the associated roadways and railroads, circulating water pumphouses on the
5 Columbia River, and the Supply System's Emergency Response/Plant Support Facility. No other facilities are located in this area. Between the three (3) and five (5) mile radii, in the five eastern sectors, is an area devoted to agriculture.

Significant changes in land use outside five miles include urban residential and irrigated agricultural development. Most major new irrigation developments have occurred in the Hermiston-Boardman area in Oregon and in the Plymouth area in Washington. Other new developments are in the hills adjacent to the Snake River east of Pasco, along the Yakima River west and north of West Richland, and in the hills northwest of the Hanford Site. Significant new irrigation development is expected in the Horse Heaven Hills southwest of the Tri-Cities (about 300,000 acres) and in the Columbia Basin Project north and east of the Columbia River (now totaling 570,000 acres).

The principal sources of water for the irrigated areas south and west of the Tri-Cities are the Columbia, Snake, and Yakima Rivers. Groundwater is being pumped in the hills northwest of the Hanford Site and is expected to be used for new areas surrounding Pasco. New irrigation in the Columbia Basin Project will receive its water from Grand Coulee Dam on the Columbia River.

Scattered throughout the area within 50 miles of the project are a number of livestock and dairy operations. The number of individual livestock animals per location ranges from one to 250 and are utilized for both personal and commercial beef processing, as well as for breeding. There are eight beef processing plants located within 50 miles that provide beef to outlets outside the area, with the largest plant processing approximately 1000 head per day. The area within 50 miles is predominantly a feeder area during non-growing season, and causes the number of livestock to fluctuate on a seasonal basis.

There are three (3) dairy operations located within ten (10) miles of the site. An estimated 95 additional milk producers are located within the area between the 10 and 50 mile radii.[9] The milk produced from these dairies is collected and transported to processing plants 5
located as far away as Portland, Oregon and Spokane, Washington. Table 2.1-2 provides distances to the nearest livestock, dairy animals, and vegetable gardens.

Hunting and fishing is extensive within the fifty (50) mile radius. Much of the farm land is open to hunters, with upland bird and waterfowl being the most popular. Fishing occurs on the Columbia, Snake, Yakima, and Walla Walla Rivers, as well as in isolated lakes and ponds. The Columbia River is the closest area in which hunting and fishing can occur. Fishing and hunting can occur on both banks of the river as far upriver as the Hanford Townsite. Within 10 miles of the site is an area designated as Controlled Hunting Area B. This area contains the Ringold Wildlife Refuge and the Wahluke Wildlife Refuge, consisting of approximately 4,000 acres of Department of Energy land managed by the Washington State Department of Game. Located adjacent to this area's southern boundary and within five miles of the site is the Ringold Fish Hatchery. This facility encourages steelhead fishing within one mile of its location. These three (3) areas experienced a total of 291,000 user-days by hunters and fishermen in a one (1) year period between 1978 and 1979.[10]

TABLE 2.1-1
(SHEET 1 OF 2)

POPULATION DISTRIBUTION BY COMPASS SECTOR AND DISTANCE FROM THE SITE

		1980		1990		2000		2010		2020		2030	
Distance (Miles)	Direction (Compass Segment)	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total
0-3	All	0	0	0	0	0	0	0	0	0	0	0	0
3-5	N-NNE	0	0	0	0	0	0	0	0	0	0	0	0
	NE	10	10	35	35	48	48	52	52	55	55	86	86
	ENE	22	32	43	78	56	104	60	112	63	118	64	150
	E	22	54	43	121	56	160	60	172	63	181	64	214
	ESE	22	76	43	164	56	216	60	232	63	244	64	278
	SE	4	80	6	170	9	225	11	243	11	255	12	290
	SSE-NNW	0	80	0	170	0	225	0	243	0	255	0	290
5-10	N	26	106	58	228	77	302	83	326	87	342	88	378
	NNE	83	189	126	354	152	454	162	488	170	512	172	550
	NE	155	344	198	552	224	678	240	728	252	764	254	804
	ENE	114	458	157	709	177	855	190	918	200	964	202	1006
	E	135	593	200	909	257	1112	276	1194	290	1254	293	1299
	ESE	168	761	276	1185	341	1453	366	1560	385	1639	389	1688
	SE	190	951	406	1591	536	1989	575	2135	604	2243	610	2298
	SSE	45	996	253	1844	308	2297	330	2465	347	2590	350	2648
	S	50	1046	272	2116	483	2780	518	2983	544	3134	550	3198
	SSW	235	1281	535	2651	809	3589	867	3850	911	4045	920	4118
	SW	25	1306	25	2676	25	3614	27	3877	28	4073	29	4147
	WSW-NNW	0	1306	0	2676	0	3614	0	3877	0	4073	0	4147
10-20	N	332	1638	371	3047	398	4012	427	4304	449	4522	454	4601
	NNE	328	1966	371	3418	397	4409	426	4730	447	4969	452	5053
	NE	399	2365	562	3980	588	4997	630	5360	662	5631	669	5722
	ENE	792	3157	835	4815	855	5852	917	6277	964	6595	974	6696
	E	461	3618	479	5294	544	6396	583	6860	613	7208	619	7315
	ESE	192	3810	430	5724	576	6972	618	7478	650	7858	657	7972
	SE	4155	7965	5221	10945	5821	12793	6242	13720	6561	14419	6627	14599
	SSE	49178	57143	63483	74428	70917	83710	76043	89763	79932	94351	80734	95333
	S	28943	86086	37672	112100	45434	129144	48717	138480	51208	145559	51722	147055
	SSW	1592	87678	1772	113872	1922	131066	2061	140541	2166	147725	2188	149243
	SW	3106	90784	3597	117469	.894	134960	4175	144716	4389	152114	4433	153676
	WSW	950	91734	1048	118517	1108	136068	1188	145904	1248	153362	1260	154936
	W	0	91734	0	118517	0	136068	0	145904	0	153362	0	154936
	WNW	0	91734	0	118517	0	136068	0	145904	0	153362	0	154936
	NW	0	91734	0	118517	0	136068	0	145904	0	153362	0	154936
	NNW	0	91734	0	118517	0	136068	0	145904	0	153362	0	154936

TABLE 2.1-1
(SHEET 2 OF 2)

Distance (Miles)	Direction (Compass Segment)	1980 Number	1980 Cumulative Total	1990 Number	1990 Cumulative Total	2000 Number	2000 Cumulative Total	2010 Number	2010 Cumulative Total	2020 Number	2020 Cumulative Total	2030 Number	2030 Cumulative Total
20-30	N	1501	93235	1837	120354	2055	138123	2203	148107	2316	155678	2339	157275
	NNE	5759	98994	6487	126841	7123	145246	7638	155745	8029	163707	8110	165385
	NE	2015	101009	2174	129015	2274	147520	2438	158183	2563	166270	2589	167974
	ENE	1717	102726	1760	130775	1786	149306	1915	160098	2013	168283	2033	170007
	E	151	102877	194	130969	220	149526	236	160334	248	168531	250	170257
	ESE	153	103030	240	131209	305	149831	327	160661	344	168875	348	170605
	SE	6138	109168	6512	137721	6738	156569	7225	167886	7594	176469	7670	178275
	SSE	24116	133284	32559	170280	36360	192929	38987	206873	42032	218501	42454	220729
	S	187	133471	678	170958	975	193904	1045	207918	1098	219599	1109	221838
	SSW	875	134346	1218	172176	1426	195330	1529	209447	1607	221206	1623	223461
	SW	6165	140511	7147	179323	7737	203067	8296	217743	8720	229926	8808	232269
	WSW	1626	142137	1799	181122	1908	204975	2046	219789	2151	232077	2173	234442
	W	1191	143328	1325	182447	1429	206404	1532	221321	1610	233687	1626	236068
	WNW	185	143513	280	182727	297	206701	318	221639	334	234021	338	236406
	NW	40	143553	44	182771	48	206749	51	221690	54	234075	55	236461
	NNW	182	143735	200	182971	218	206967	234	221924	246	234321	249	236710
30-40	N	980	144715	1096	184065	1127	208094	1208	223132	1270	235591	1283	237993
	NNE	3198	147913	3663	187728	3983	212077	4271	227403	4490	240081	4536	242529
	NE	650	148563	800	188528	745	212822	799	228202	846	240927	850	243379
	ENE	421	148984	447	188975	475	213297	509	228711	535	241462	540	243919
	E	128	149112	136	189111	141	213438	152	228863	160	241622	162	244081
	ESE	167	149279	176	189287	182	213620	195	229058	205	241827	208	244289
	SE	464	149743	484	189771	497	214117	533	229591	560	242387	566	244855
	SSE	592	150335	844	190615	955	215072	1023	230614	1076	243463	1087	245942
	S	4680	155015	5653	196268	6368	221440	6828	237442	7172	250635	7250	253192
	SSW	256	155271	424	196692	529	221969	567	238009	596	251231	602	253794
	SW	473	155744	661	197353	786	222755	842	238851	885	252116	894	254688
	WSW	21871	177615	24729	222082	26890	249645	28833	267684	30362	282478	30665	285353
	W	3578	181193	3949	226031	4273	253918	4582	272266	4816	287294	4864	290217
	WNW	1399	182592	1459	227490	1579	255497	1693	273959	1780	289074	1798	292015
	NW	703	183295	770	228260	836	256333	896	274855	942	290016	952	292967
	NNW	1575	184870	1738	229998	1899	258232	2036	276891	2140	292156	2161	295128
40-50	N	17872	202742	19730	249728	21572	279804	23130	300021	24312	316468	24556	319684
	NNE	893	203635	1019	250747	1121	280925	1202	301223	1263	317731	1275	320959
	NE	926	204561	1139	251886	1275	282200	1367	302590	1437	319168	1451	322410
	ENE	213	204774	243	252129	375	282575	402	302992	423	319591	427	322837
	E	241	205015	258	252387	268	282843	287	303279	302	319893	305	323142
	ESE	864	205879	925	253312	961	283804	1030	304309	1083	320976	1095	324237
	SE	2084	207963	2245	255557	2349	286153	2518	306827	2646	323622	2673	326910
	SSE	1740	209703	1920	257477	2072	288225	2222	309049	2336	325958	2359	329269
	S	16540	226243	16406	273883	17708	305933	18987	328036	19958	345916	20158	349427
	SSW	2610	228853	2895	276778	2972	308905	3186	331222	3349	349265	3428	352855
	SW	421	229274	443	277221	476	309381	509	331731	535	349800	541	353396
	WSW	809	230083	892	278113	965	310346	1035	332766	1088	350888	1099	354495
	W	18515	248598	20481	298594	22179	332525	23780	356546	24996	375884	25247	379742
	WNW	1742	250340	1903	300497	2043	334568	2191	358737	2303	378187	2326	382068
	NW	812	251152	859	301356	905	335473	970	359707	1020	379207	1030	383098
	NNW	532	251684	587	301943	642	336115	688	360395	723	379930	730	383828

TABLE 2.1-2

DISTANCES FROM WNP-2 TO VARIOUS ACTIVITIES

	Radius (miles)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
Site Boundary		0.3	0.3	0.4	1.1	1.5	1.2	0.8	0.7	0.7	0.7	0.6	0.5	0.2	0.2	0.3	0.3
Milk Animal	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nearest Residence	5	-	-	-	3.9	4.3	4.3	4.9	-	-	-	-	-	-	-	-	-
Nearest Vegetable Garden	5	-	-	-	3.9	4.3	4.3	4.9	-	-	-	-	-	-	-	-	-
Nearest Dairy	10	-	-	-	-	-	7.5	6.5	-	-	-	-	-	-	-	-	-
Nearest Livestock	10	-	-	6.0	3.9	4.3	-	-	7.5	9.5	9	-	-	-	-	-	-

TABLE 2.1-3

INDUSTRY WITHIN A 10 MILE
RADIUS OF SITE

EMPLOYER	NO. OF EMPLOYEES
Department of Energy	
400 Area (HEDL-FFTF)	1,187
300 Area (HEDL)	2,918
3000 Area (PNL)	2,016
1100 Area (Rockwell)	440
600 Area (Rockwell)	220
Pacific Northwest Laboratory (non-DOE)	380
Exxon - Horn Rapids Road Facility	750
George Washington Way Facility	90
UNC Commercial	80
Nortec	80
U. S. Testing	55
Sigma	30
Olympic Associates	18
Western Sintering	14
Futronix, Inc.	12
Quadrex	9
Miscellaneous	60
Washington Public Power Supply System	
Headquarters Complex	1,021
WNP-2 Site (Construction Force)	3,000
WNP-1/4 Site (Construction Force)	7,000
WNP-2 Site (Projected Operations Personnel	295
WNP-1/4 Site (Projected Operations Personnel)	588

Note: DOE employment outside the 10-Mile radius includes:

200 Area (Rockwell, E-1779, W-1361)	3,140
100 Area (UNC)	993
700 Area (DOE)	1,800

Employment totals are as of January 1981.

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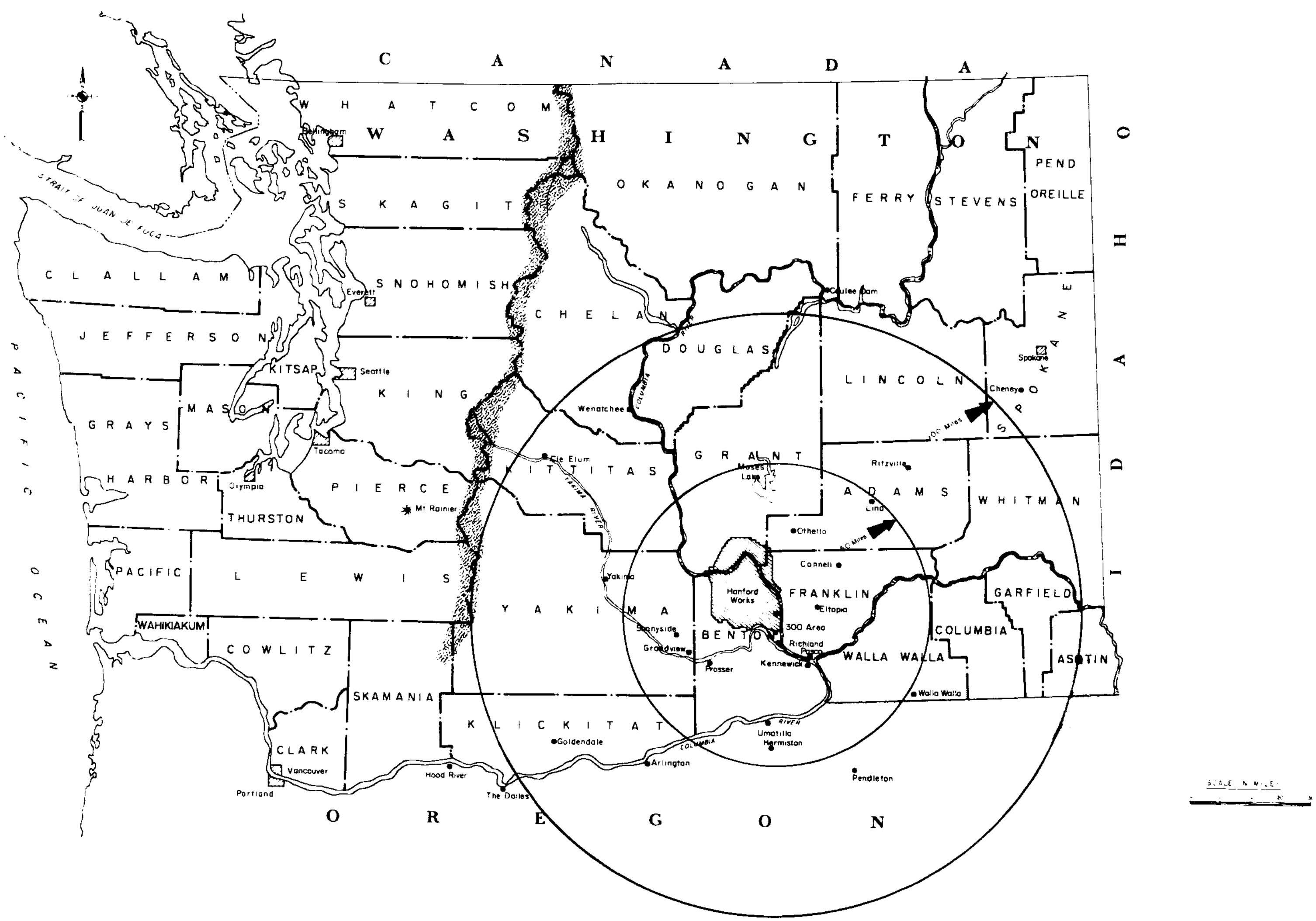
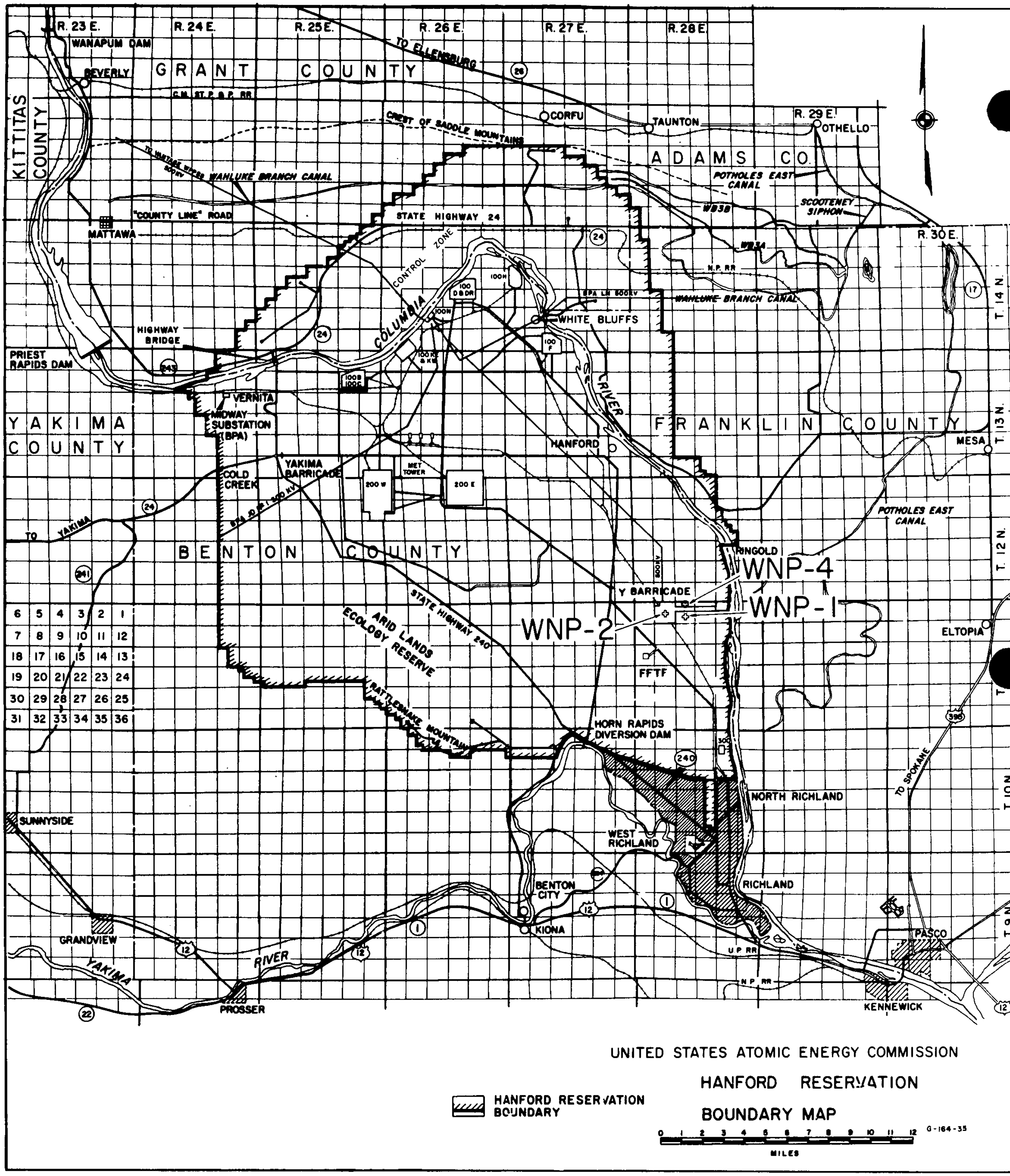
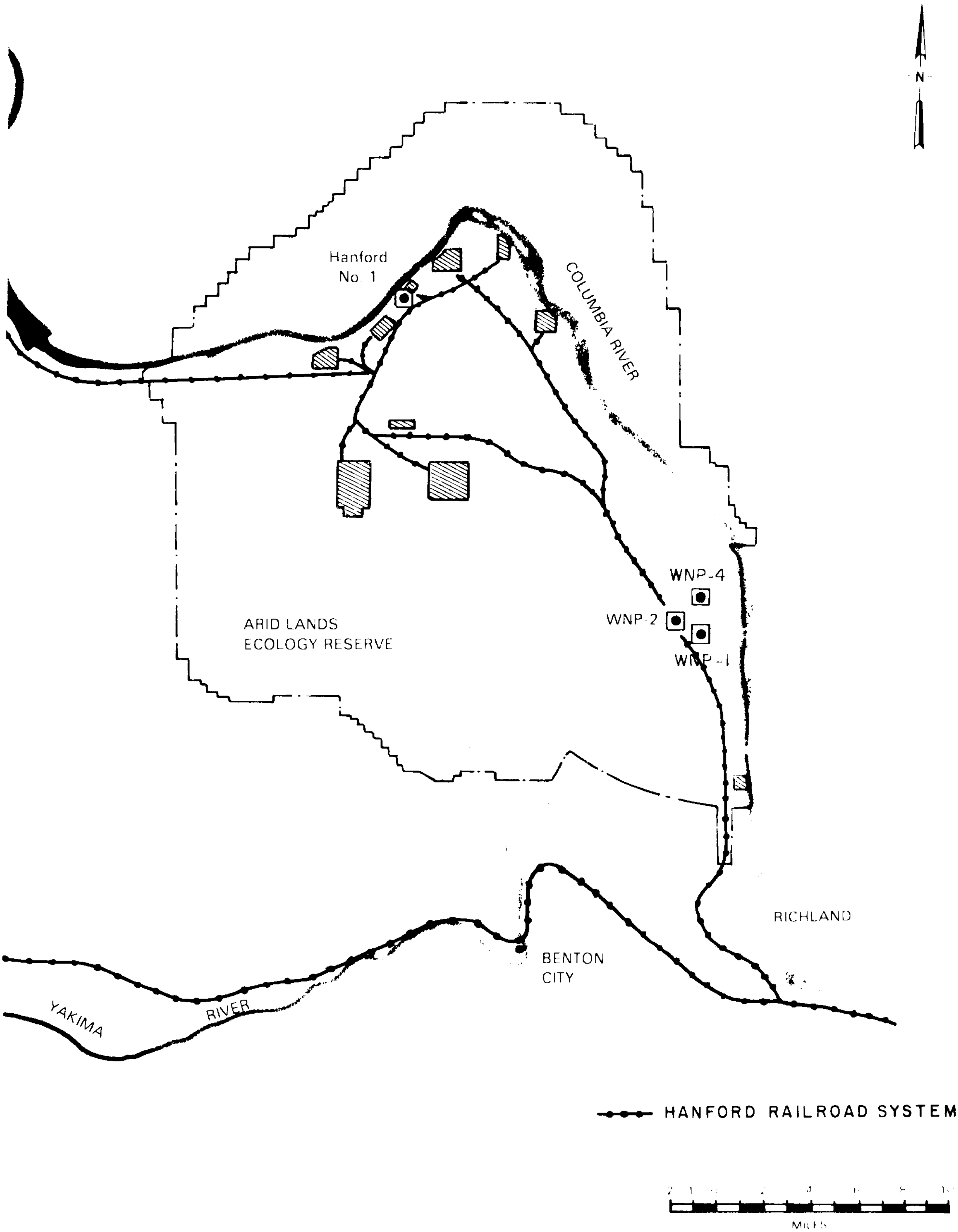


SITE LOCATION MAP

FIG. 2.1-1



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	HANFORD RESERVATION BOUNDARY MAP
	FIG. 2.1-2



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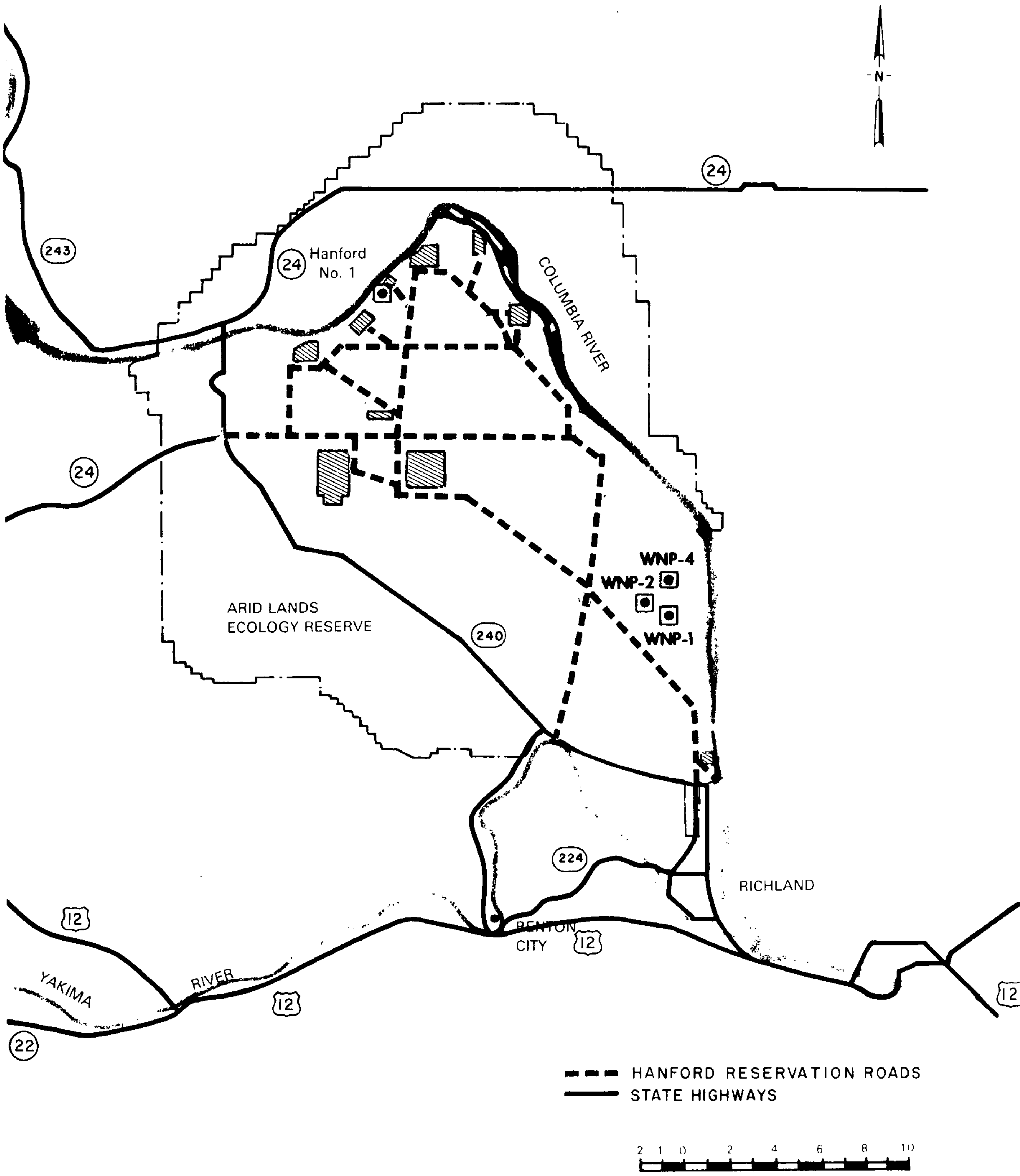
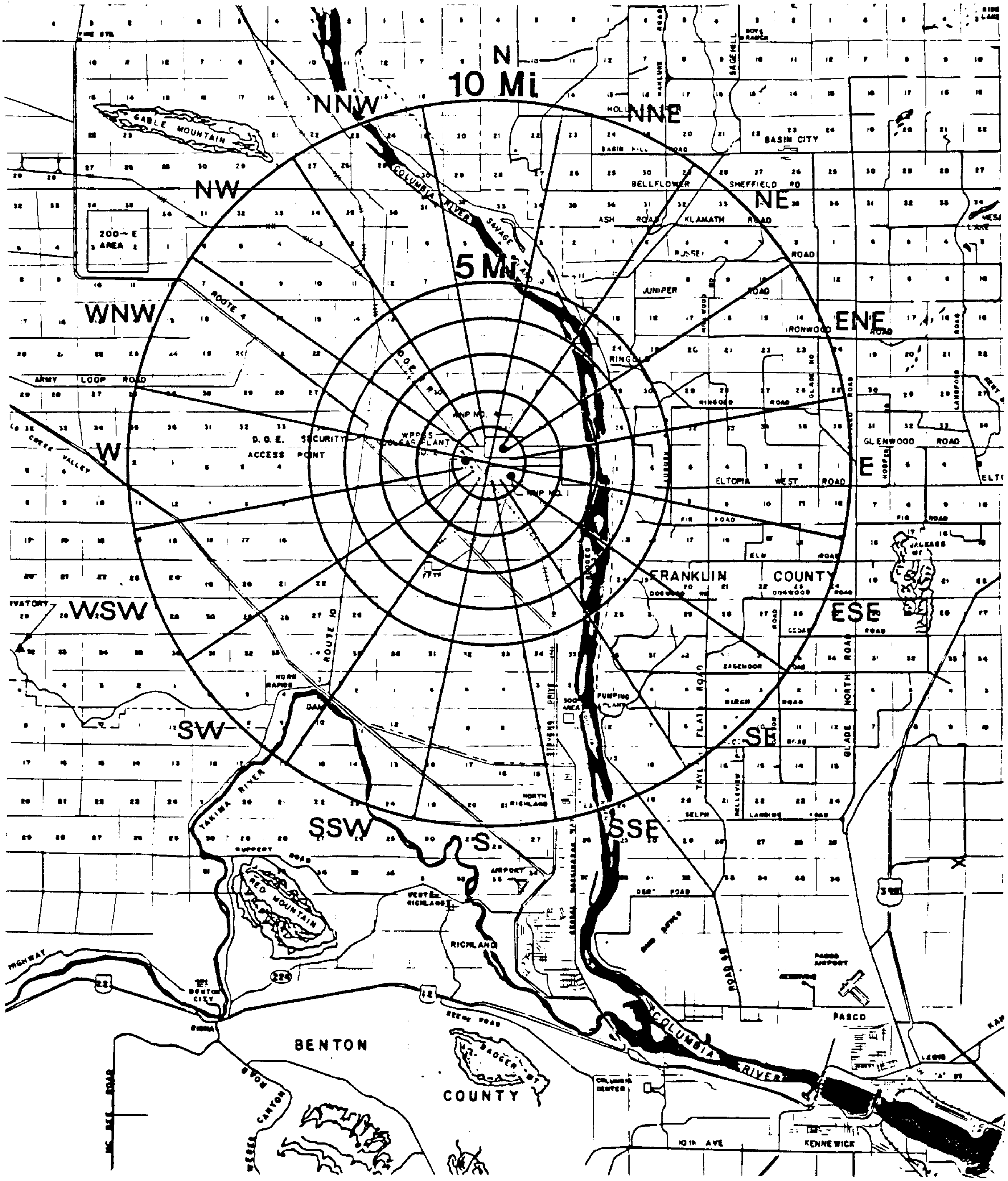
HANFORD RESERVATION
RAILROAD SYSTEM

FIG. 2.1-5

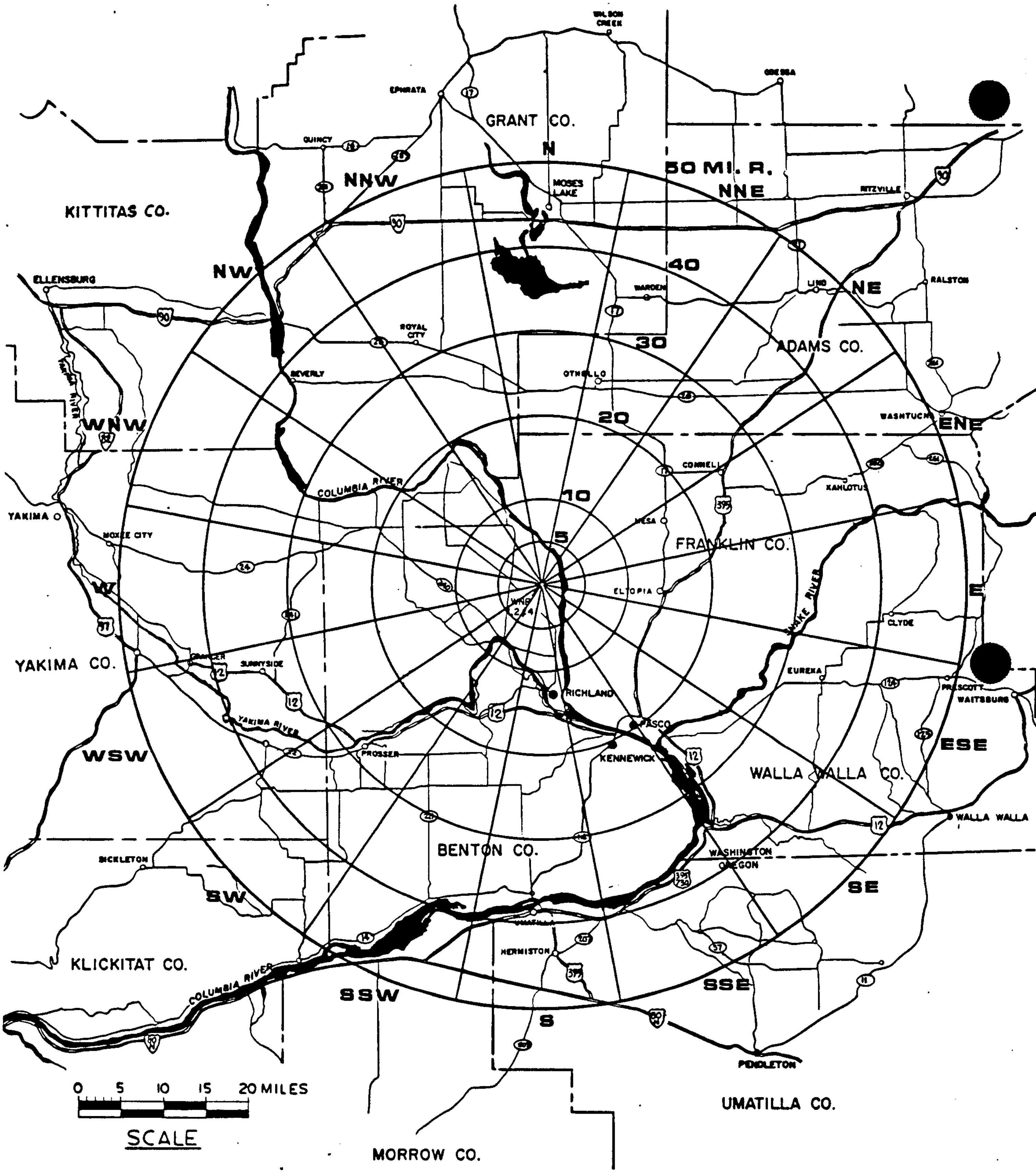


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	HANFORD RESERVATION ROAD SYSTEM FIG. 2.1-6



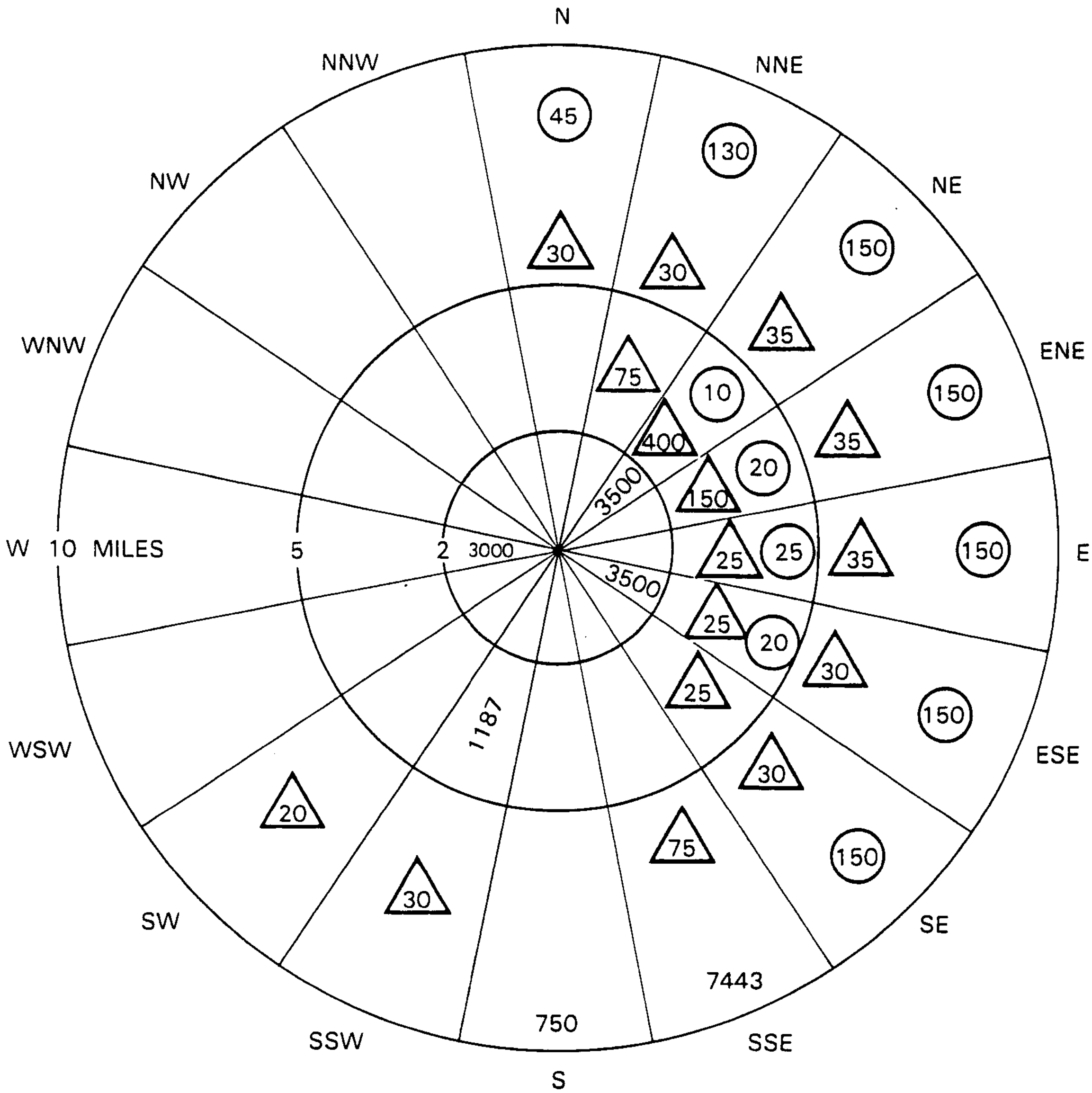
Amendment 5, July 1981

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PROJECT AREA MAP - 10 MILE RADIUS
	FIG. 2.1-7



Amendment 5, July 1981

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PROJECT AREA MAP - 50 MILE RADIUS
	FIG. 2.1-8



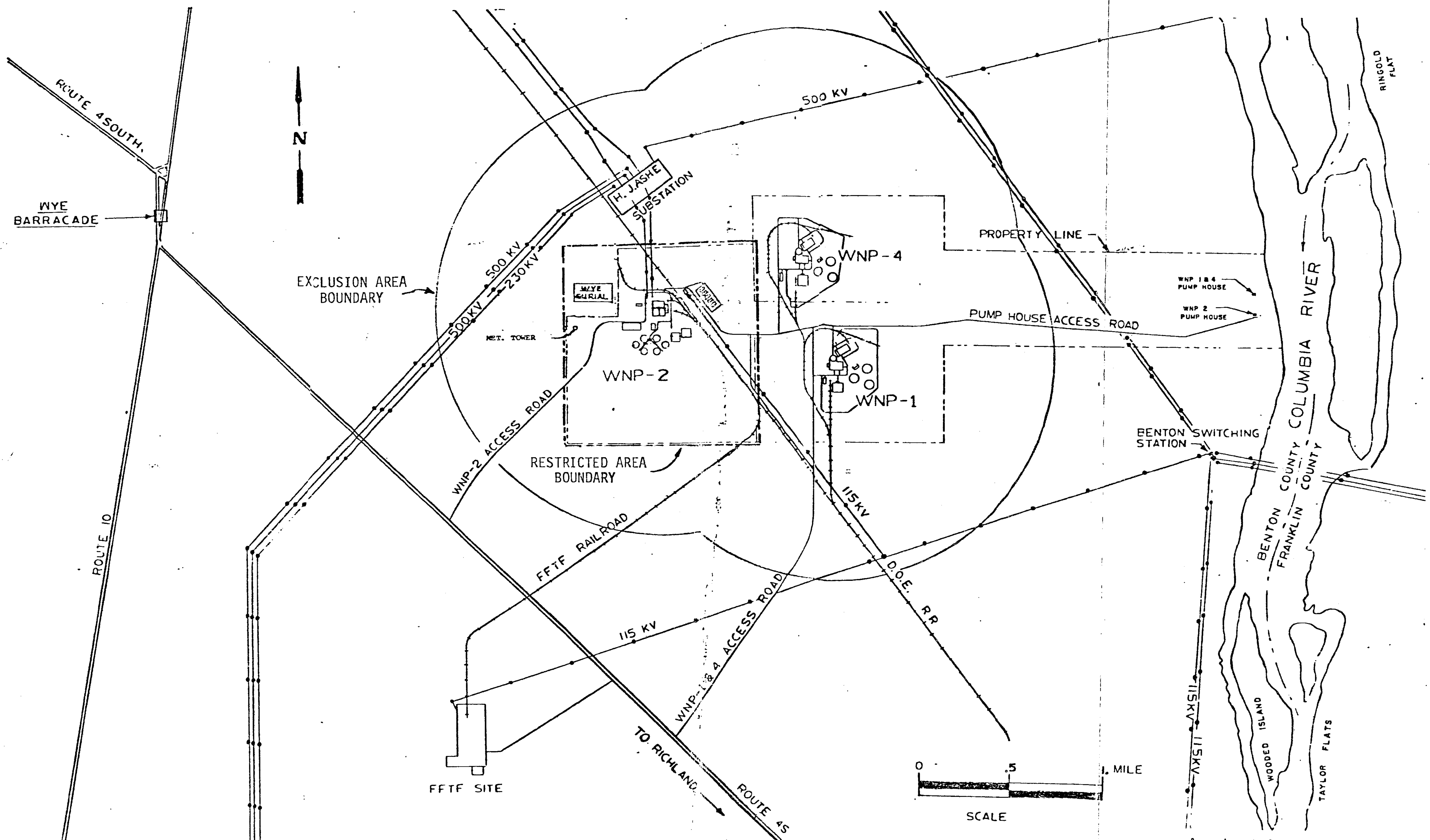
KEY

Industrial Employees	3000
Migratory Agricultural Workers	(150)
Sportsmen	△30

Amendment 5, July 1981

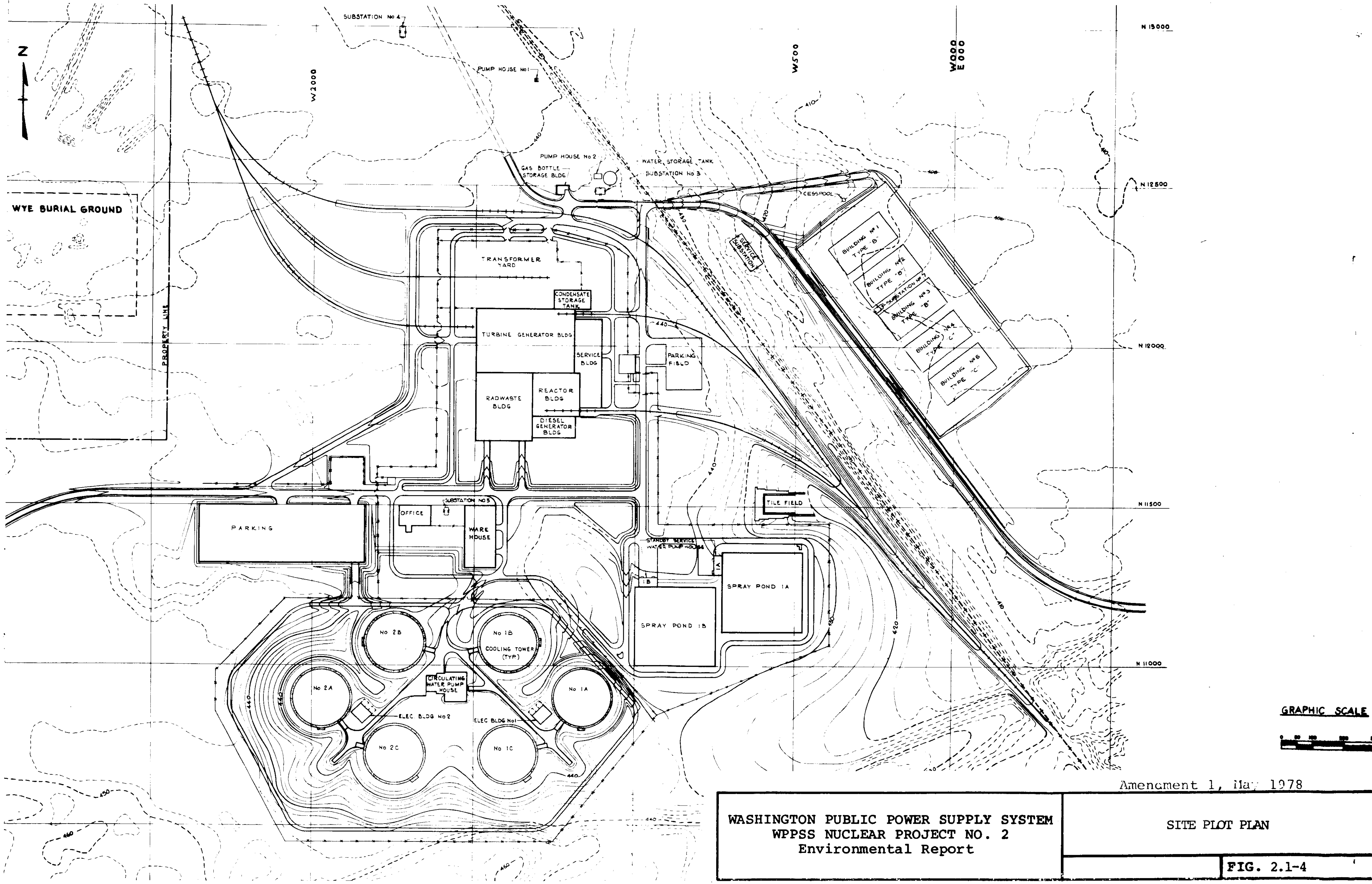
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	DISTRIBUTION OF TRANSIENT POPULATION WITHIN 10 MILES OF SITE FIG. 2.1-9

FIGURES DELETED



Amendment 4, October 1980

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SITE PLAN
	FIG. 2.1-3



Amendment 1, May 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SITE PLOT PLAN
	FIG. 2.1-4

2.2 ECOLOGY

2.2.1 Terrestrial Ecology

The sagebrush-bitterbrush vegetation type surrounds and occupies about 100 square miles on the Department of Energy Hanford Site (Figure 2.2-1). The WNP-2 and WNP-1/4 exclusion zone and corridor to the Columbia River occupy about 8 square miles of the same vegetation. Although sagebrush, Artemisia tridentata, and bitterbrush, Purshia tridentata, are the conspicuous plants in stands without a fire history, much of the land in the vicinity of WNP-2 and WNP-1/4 is devoid of shrubs because of an extensive wildfire (17,000 acres) which occurred in the summer of 1970.[3] The conspicuous vegetation on the burned acreage consists of about 30 herbaceous species, especially cheatgrass, Bromus tectorum. Other important herbs are bursage, Ambrosia acanthicarpa, Russian thistle, Salsola kali, and Sandberg bluegrass, Poa sandbergii.

Even without the stresses imposed by wildfire, the vegetation is not representative of pristine conditions. The widespread occurrence of cheatgrass, an introduced alien weed, suggests that overgrazing by sheep and cattle in past years (pre-1943) has been instrumental in the spread of cheatgrass. There are no plans to reintroduce livestock grazing to the site area nor is there any evidence to expect that cheatgrass will be replaced by native plant species over a 30 to 40 year time span. Cheatgrass does play an important role in community function by retarding wind erosion, providing seed for birds and pocket mice, and herbage for insects. 4

Past experience and field observations indicate that the soil is very sandy and susceptible to wind erosion, especially following events that destroy the sparse vegetation cover. Vegetation distrubances must therefore be kept to minimal acreage. Reseeding of distrubed soil requires special attention to the selection of plant species and planting season to successfully reestablish a suitable vegetative cover in a reasonable time period. Table 2.2-1a presents a list of terrestrial organisms identified near the project site.

Five vegetation study locations were established in the vicinity of the project site in 1974.[29] Most of the land immediately around the construction zones had been burned in the 1970 fire, leaving only small unburned patches of shrubs. Three stands were selected as "unburned" study locations. The other two sites were selected as representative of "burned" vegetation. Plots were read in April or early May at what was judged to be the peak of vegetation development. Five plots, each 0.1 m^2, were harvested to obtain an estimate of peak live above-ground herbaceous phytomass during the years 1975, 1976, 1977 and 1978. 4

Four species of shrubs were encountered in 1978 on the study plots.[29] These were bitterbrush, P. tridentata; sagebrush, A. tridentata; and two species of rabbitbrush, Chrysothamnus nauseoseus and C. viscidiflorus. Snow buckwheat, Eriogonum niveum Dougl., a sub-shrub, was abundant in only one plot. One plot was dominated by sagebrush with a sparse representation of rabbitbrush; a second plot was dominated by bitterbrush; and a third consisted of bitterbrush and sagebrush (mixed) in approximately equal proportions. Total shrub canopy-cover ranged between 14 and 37 percent. The sagebrush plot had the lowest density, 85 shrubs per 1000 m^2; the bitterbrush plot had 95 and the mixed plot 114.

In 1978, twenty-nine species of herbaceous plants were observed on the study plots.[29] These were grouped into four categories: (1) annual grasses, (2) annual forbs, (3) perennial grasses and (4) perennial forbs. Cheatgrass, Bromus tectorum, clearly dominated the canopy cover. Nonburned and burned plots were similar as far as canopy cover was concerned. Sixteen species of annual forbs were counted on the study plot. Tansy mustard, Descurainia pinnata; tumble mustard, Sisymbrium altissimum; jagged chickweed, Holosteum umbellatum and Russian thistle, Salsola kali, were the most important contributors to canopy cover. Annual forbs contributed about 25 percent to canopy cover and nonburned and burned plots had about the same amount of forb canopy cover. Only two species of perennial grasses were observed on the study plots. Sandberg bluegrass, Poa sandbergii Vasey, contributed 9 percent to canopy cover. Needle and thread, Stipa comata, was present but in small amounts. Nine species of perennial forbs were encountered on the study plots but they contributed only three percent to canopy cover.

4 A summary of four years of field observations (1975 - 1978) shows that the smallest amount of canopy cover was produced in 1977.[29] It was also by far the driest of the four years with only 1.21 inches of rain between October 1976 and April 1977. This was the only year in which cheatgrass failed to dominate canopy cover. The 1978 growing season was wetter than usual and cheatgrass promptly regained vegetative dominance. Annual forbs also contributed more canopy cover in 1978 than in previous years. Canopy cover was not greatly different between nonburned and burned plots except in 1976 when annual grasses contributed 61 percent of the canopy cover in the burned plots compared to only 42 percent in the unburned plots. The production of herbaceous phytomass is expressed as $g/m^2/yr$. The year of lowest production was 1977 when only 10 g/m^2 of dry phytomass was produced. Mean annual values ranged between 10 and 195 g/m^2 while the 4-year average was 126 g/m^2.

The animal populations are sparse and characteristic of the shrub-steppe ecosystems of the Hanford Site.[1,2] The only big game mammal is the mule deer, Odocoileus hemionus. With the sparse cover around WNP-2 and WNP-1/4, deer use the area as a foraging zone, retiring to the sand dune area a mile or so north where they are infrequently disturbed by human trespass. The nearest surface water available to deer is the Columbia River. The sparse riparian shrub-willow community also provides deer forage but little cover. The bulk of the Hanford Site mule deer herd subsists in the sand dunes area near the abandoned village of Hanford, about 7 miles north of WNP-2 and WNP-1/4.

The important fur-bearing animals are the coyote (Canis latrans) and the badger (Taxidea taxus). These animals are wanderers and use the area as a foraging ground. They are not numerous and accurate estimates of population density and daily movement patterns are the objective of specialized research studies. There is no information on harvests for pelts because the Hanford Site area is not open for trapping of animals.

The most important medium-sized mammal is the black-tailed jackrabbit (Lepus californicus). Populations of jackrabbits in steppe regions fluctuate widely from year to year depending upon a number of environmental variables including weather, predation, and disease.

Small mammal populations were investigated in burned and unburned portions of the bitterbrush-cheatgrass ecosystem from 1974 to 1978 using live traps.[29] Five hundred and six individual animals representing five species were trapped, marked and released over a total of 11,600 trap nights. The great basin pocket mouse (Perognathus parvus) was the most abundant animal trapped with 418 individuals captured. Second was the deer mouse (Peromyscus maniculatus) with 65 individuals. The northern grasshopper mouse (Onychomys leucogaster) was represented by 15 individuals, the western harvest mouse (Reithrodontomys megalotis) by eight individuals, and the Townsend ground squirrel (Spermophilus townsendii) by one individual. There were more animals trapped in the unburned vegetation than on the grid with a recent fire history.

Clearly the most abundant small mammal in the bitterbrush cheatgrass ecosystem in terms of population numbers and food chain dynamics is the pocket mouse. The yearly cycle of activity for this species begins in March and April as the adults emerge from winter torpor to breed. A second peak is normally seen in late summer with the recruitment of young into the population.

Birds were counted in a 20-acre study plot, established in 1976, located just 4
west of WNP-2.[29] The study plot was surveyed on three consecutive mornings
of observations during the spring breeding season of 1977 and 1978. The west-
ern meadowlark, horned lark, sage sparrow and white-crowned sparrows were
observed most commonly; all other species were observed incidentally.

The habitat in the vicinity of the project site is not suitable for California quail or Chinese ring-necked pheasants, which are more abundant elsewhere on the Hanford Site, especially riparian habitats along the Columbia River north of WNP-2 and WNP-1/4. Although chukar partridges normally live and reproduce in dry, shrub-steppe habitats, the project area is not suited for these birds. The birds are especially abundant in the Rattlesnake Hills ten miles west of the project site, where the topography is more broken, vegetation more grassy, and the soils stony.

The region is a hunting ground for birds of prey, with the Swainson's hawk prevalent in spring and summer and the golden eagle in the winter season. The bald eagle has been observed on the Hanford Site at various times and is the only wildlife species observed to frequent the area that is on the list of threatened or endangered species. Habitat significant to the bald eagle will not be disturbed by the construction and operation of WNP-1/4 and WNP-2 project.

The islands in the immediate vicinity of the site and downstream have a mixed composition with a substrate of either sand and gravel or cobblestone and gravel. Sagebrush communities and willows are established on the dunes of the larger islands. Approximately 200 pairs of nesting geese produce 700 goslings annually and an estimated 100 pairs of ducks also nest on these islands.(30)

The Columbia River is a natural migration route for the Pacific Flyway
4 waterfowl. Several million ducks and geese use the Columbia River Basin
during movement to and from the northern breeding grounds. The waterfowl
common to the area are shown in Table 2.2-1a. An aerial census was made in
1973 to estimate the number of ducks, Canadian geese, Great blue heron, and
eagles nesting on the Columbia River (31). In mid-November, more than 20,000
ducks and 1,200 geese were observed resting on the river. The majority of
these birds were located upstream of the project site.

Two islands, one near Ringold (river mile 354) and another near Coyote Rapids (river mile 382), are used as rookeries by colonies of California and ring-billed gulls. Approximately 6000 nesting pairs produce 10,000 to 20,000 young annually.

2.2.1.1 Threatened and Endangered Species

The plants and animals living in the area are widespread and common in steppe vegetation (rangeland) in the dry parts of Eastern Oregon and Eastern Washington. However, rangeland acreage diminishes each year primarily as a result of an expanding agricultural use of land through extension of irrigation systems. As the land is converted from rangeland to irrigated agriculture, native plant and animal populations diminish. One function of the 100 square mile area of Arid Lands Ecology (ALE) Reserve (Rattlesnake Hills Research Natural Area) on the Hanford Site is to provide a refugium for native plants and animals.(4)

The Bald Eagle (Haliaetus leucocephalus) is the only threatened animal specie
(Federal designation) to occur in the area of the WPPSS projects. The pop-
ulation on the Hanford DOE Site has increased over the years from five (5)
birds in the 1960's to over 15 birds in the late 1970's. Eagles generally
arrive during mid-November, with a peak abundance occuring in late November
4 through early February, and begin to depart in mid-February. They do not nest
in the area. There are no other Federally designated threatened or endangered
animals or plants living in the WNP-2 and WNP-1/4 site area. The American
peregrine falcon (Falcon peregrinus anatum) is an endangered specie (Federal
designation) which may at times appear along the corridors although the exact
ranges are not known.

The construction and operation of the nuclear facilities is not expected to result in the damage or loss of any species presently regarded as endangered or threatened.

2.2.2 Aquatic Ecology

The physical and chemical characteristics of the Columbia River in the vicinity of WNP-1, 2 and 4 are presented in Section 2.4. Comprehensive 1 evaluations of the ecological characteristics of the Columbia River are presented in references 5, 6, 7, 12, and 32. 4

Studies concerned with the various aquatic organisms in the Columbia River, relating mainly to influence of reactor operation, were conducted for over 30 years; a bibliography with abstracts of these investigations was published in 1973[8] and updated in 1979.[33] The following paragraphs summarize the 4 essential ecological characteristics of the major communities. Figure 2.2-2 is a simplified diagram of the food-web relationships in selected Columbia River biota and represents probable major energy pathways. The Columbia River presents a very complex ecosystem in terms of trophic relationships due to its size, the number of man-made alterations, the diversity of the biota, and the size and diversity of its drainage basin.

Streams in general, especially smaller ones, depend greatly upon allocthonous input of organic matter to drive the energetics of the system. Large rivers, particularly the Columbia because it is a series of lentic reservoirs, contain a significant population of autochthonous primary producers (phytoplankton and periphyton) which contribute the basic energy needs. The dependence of the free-flowing Columbia River in the Hanford area upon an authochthonous food base is reflected by the faunal constituents, particularly the herbivores in the second trophic level. Filter-feeding insect larvae such as caddisfly larvae, and periphyton grazers such as limpets and some mayfly nymphs are typical forms present. Shredders and large detrital feeders (such as the large stonefly nymphs) which are typical of smaller streams are absent. The presence of large numbers of the herbivorous suckers also attests to the presence of a significant periphytic population. Carnivorous species are numerous, as would be expected in a system of this size. A list of aquatic organisms identified from the Columbia River is presented in Table 2.2-1b. 4

2.2.2.1 Phytoplankton

Diatoms are the dominant algae in the Columbia River, usually representing over 90% of the population. The main genera in the vicinity of WNP-2 and WNP-1/4 include Cyclotella, Asterionella, Melosira, and Synedra; lentic forms that originate in the impoundments behind the upstream dams are dominant in this section of the river. The phytoplankton also contain a number of species derived from the periphyton or sessile algae community. This is particularly true of the Columbia River in the vicinity of the project site because of the fluctuating water levels due to operation of Priest Rapids Dam immediately upstream from Hanford. Periphytic algae exposed to the air for part of the day may dry up and become detached and suspended in the water when the river level rises again. Peak biomass of net phytoplankton is about 2.0 g dry wt/m^3 in May and winter values are less than 0.1 g dry wt/m^3.[9] Figure 2.2-3 illustrates the seasonal fluctuations in plankton biomass. A spring increase with a second pulse in late summer and autumn was observed in the

Hanford section of the Columbia River in previous studies.[10,11] The spring pulse is probably related to increasing light and warming of the water rather than to availability of nutrients. The coincident decrease of PO_4 and NO_3, essential nutrients for algae growth, may be partially related to uptake by the increasing phytoplankton populations but is also highly influenced by the dilution of these nutrients by the increased flows due to high runoff at this time. The extent of dilution depends upon the concentration of these nutrients in the runoff waters. However, these nutrients do not decrease to concentrations limiting to algae growth at any time of the year. Green and blue-green algae occur mainly in the warmer months but in substantially fewer numbers than the diatoms.

Aquatic studies were performed in the vicinity of WNP-2 and WNP-1/4,
September 1974 through March 1980.[34-39] The Columbia River phytoplankton
community passing WNP-1/4 and WNP-2 have been examined to determine species
composition, relative abundance and pigment concentration. Community comp-
4 osition was similar 1975 through 1979. Seasonal trends for phytoplankton
pigment concentrations and density (No/ml) were also similar. Micrograms of
chlorophyll *a* per liter ranged from 1.3 to 20.2, while density values ranged
from 119 in January to 2878 in May.[38]

2.2.2.2 Periphyton

4

Dominant diatom genera include *Melosira* and *Gomphonema* and in spring and summer luxuriant growths of the filamentous green algae *Stigeoclonium* and *Ulothrix* occur. Net Production Rate (NPR), as measured from 14-day colonization of artificial substrates, varied from 0.07 mg dry wt/cm^2/day in August to less than 0.01 mg dry wt/cm^2/day in December and January.[13] Figure 2.2-4 shows the seasonal pattern of NPR. This represents the 14-day growth on clean glass slides and not the increment on an established community. NPR was highly correlated with solar energy and chlorophyll *a* concentration on the slides during the 2-week exposure. The colonization conditions obtained in these studies began from a bare surface, and after 2 weeks the communities were probably still in the log-growth phase. Correlations among biomass measurements were highest between dry weight and ash weight, due mainly to the high population of diatoms with silica frustules.

2.2.2.3 Macrophytes

4 Macrophytic substrates along the river bed and shoreline in the vicinity of the project site consists mainly of Ringlold formation with sand, gravel, and larger boulders on the surface. The widely varying diurnal flows cause large areas along the river shoreline to be alternately flooded and dry during each day. These characteristics have precluded the development of a rooted macrophyte community such as is commonly found in sloughs and backwaters.

2.2.2.4 Zooplankton

The zooplankton population in the Columbia River at WNP-1/4 and WNP-2 is low in number and varies seasonally. Seasonal trends for microcrustacea are similar 1974 through 1980.[39] Copepods dominate in the late fall, winter and spring. Cladocerans dominate in the summer and early fall. *Bosmina* sp. 4
is the dominant cladoceran observed at WNP-1/4 and WNP-2. The density (number/m^3) of zooplankters was similar 1974 through 1980. The density ranged from 22 in November to 776 in August.[39] Zooplankton form only a minor dietary item (0.3% of the total diet) for young salmon in the Hanford portion of the river.[16]

2.2.2.5 Benthos

4

Dominant organisms presently found in the vicinity of WNP-1/4 and WNP-2 site include insect larvae, sponges, molluscs, flatworms, leeches, crayfish, and oligochaetes. The daily fluctuating water levels, due to the manipulation of flow by an upstream hydroelectric dam, have destroyed a part of this fauna in the littoral zone. Near the old Hanford townsite, ten miles upstream, midge larvae (Chironomidae) and caddisfly larvae (Trichoptera) are the most numerous benthic organisms, averaging 121 and 208 organisms/ft^2, respectively.[5] Caddisfly larvae and molluscs (Mollusca) are predominant in terms of biomass, averaging 2.24 and 1.23 g wet wt/ft^2, respectively. Total benthic organisms averaged 375/ft^2 and 3.59 g wet wt/ft^2 during 1951-52. These figures are approximations of these populations due to the difficulty in sampling all of the bottom in a large river such as the Columbia. Sampling was restricted to the shallow shoreline, and even there variations between replicate samples were sometimes greater than seasonal variations.

Since September 1974 benthic macrofauna and microflora samples have been collected in the vicinity of WNP-1/4 and WNP-2.[34-39] Benthic microflora are dominated by diatoms and the most common genera are *Navicula*, *Nitzschia* and *Synedra*. The highest density (number/m^2) was observed in March and December when small pennate diatoms dominated the benthic flora.[39]

Benthic macrofauna populations near WNP-1/4 and WNP-2 are dominated by midge 4
fly (Chironomidae) and caddisfly (Trichoptera) larvae. These two taxa comprise 90% of the benthic macrofauna with other taxa never accounting for more than a few percent of the total community. The highest densities have been observed in September. The seasonal trend is for densities to increase between June and September and decrease between September and December.

2.2.2.6 Fish

Forty-four species of fish have been identified in the Hanford area of the 4
Columbia River,[40] none of which are presently considered rare, threatened, or endangered. Table 2.2-1b lists the species present and although most are resident, the anadromous salmon and steelhead trout represent the species of greatest commercial and recreational importance; hence, most fisheries research has been concerned with the salmonids. 4

Salmon spawn in the fall, leaving eggs to incubate in the redds from late fall to mid-winter. From mid to late winter the eggs hatch into fry which emerge from the gravel from February through April. Following emergence, the juveniles begin their migration to the Pacific Ocean. The peak seaward migration of all juvenile salmonids in the lower Columbia River, including those produced in the Hanford reach, occurs in mid-April to mid-June. However, the out-migration of salmonids produced in areas upstream of Priest Rapids Dam is now later than in the past, apparently because of delays in
4 | passage through the reservoir complex.[22]

The salmonids all have a similar life cycle but each species and race matures at a different rate. This results in differences in timing and duration of life stages and activities. Timing and numbers of upstream migrants are shown in Figure 2.2-5. These data were obtained at, and in the vicinity of, Bonneville Dam. Corps of Engineers fish counts at other dams on the Columbia River and major tributaries also show timing of migration.[24] Only slight variations will be noted in timing of migration pulses depending on river miles traveled and migratory pathway, i.e., main channel migrants or tributary migrants. Adult salmonids move through the Hanford portion of the river during all months of the year, but the greatest numbers pass through during the spring to early fall. Peak adult migration periods are generally as
4 | follows:

Sockeye - July-August
Chinook - April-May, July-September
Coho - September-October
Steelhead - August-October

Studies on the routes of migration through the Hanford stretch of the river indicate the preference for the east-northeast bank (across the river from the intakes for the plants), a pattern which persists from Priest Rapids Dam
4 | downstream to Richland.[22]

The Hanford reach of the Columbia River serves as a migration route to and from upstream spawning grounds; fall chinook salmon and steelhead trout also spawn in the Hanford section of the river. Population estimates were made of the locally spawning chinook salmon redds in the section of river from Richland to Priest Rapids Dam (Table 2.2-3). For the period 1947 to 1972 the average number of chinook salmon spawners was almost 9500 fish, with a range of 450 to 31,600.[26] Since 1962, the local fall chinook salmon spawning population represents 15 to 20% of the total fall chinook escapement to the river.[27] This recent increase in relative importance of the Hanford section for chinook spawning may result from the destruction of other mainstem spawning grounds by river impoundments.

The chinook juveniles move through the Hanford section of the Columbia in two age classes: young-of-the-year and yearlings. The young-of-the-year in particular inhabit the areas near shore where they feed as they move downstream. They are present from late winter through midsummer, with greatest numbers in April, May, and June.

Average annual steelhead spawning population estimates for the years 1962-1971 are about 10,000 fish.[28] Counts in 1976 and 1977 were about 9800 and 9200 fish, respectively. The annual estimated 1963-1968 sport catch in the section of river from Ringold, just downstream from the Hanford Site boundary, to the mouth of the Snake River (a distance of about 30 miles) was approximately 2700 fish. 4

The shad, another anadromous species, may also spawn in the Hanford section of the river. Young-of-the-year of this fish are collected during the summer. The upstream range of the shad has increased since the mid 1950s, possibly as the result of increased impoundment of water in the lower and middle river. In 1956 fewer than 10 adult shad ascended McNary Dam; in 1966 about 10,000 passed upstream. The whitefish are resident in the Hanford section of the river and support a winter sport fishery. During the period of maximum plutonium production reactor operation, upstream movement of whitefish and other resident species was demonstrated by the capture of fish containing greater than background levels of radionuclides at Priest Rapids Dam, upstream of the Hanford Reservation.

Other game species such as sturgeon, smallmouth bass, crappie, and sunfish are also fairly abundant in the Hanford section of the Columbia, and are important game species.

A total of 37 species representing 12 families of fish have been collected from September 1974 through March 1980 in the vicinity of WNP-1/4 and WNP-2. Greatest catches and, hence, assumed abundance of most fish species near occur in spring and summer and coincide with spawning, fry emergence and increased movement due to warmer water temperatures. Chinook salmon (*Oncorhynchus tshawytscha*), Northern squawfish (*Ptychocheilus oregonensis*), redside shiner (*Richardsonius balteatus*), sculpins (*Cottus* spp.), suckers (*Catostomus* spp.), and chiselmouth (*Acrocheilus alutaceus*) generally comprised over 90% of the annual total catch. Most Hanford fishes are opportunistic and utilize juvenile and adult aquatic insects, mainly caddisflies and midge flies, smaller fish and occasionally zooplankton for food. Bottom feeders ingest periphyton. 4

TABLE 2.2-1a

TERRESTRIAL FLORA AND FAUNA NEAR WNP-1/4 and WNP2

Plants	
Shrubs	
Big Sagebrush	*Artemesia tridentata*
Bitterbrush	*Purshia tridentata*
Green rabbitbrush	*Chrysothamnus viscidiflorus*
Gray rabbitbrush	*C. nauseosus*
Spiny hopsage	*Grayia spinosa*
Snow Eriogonum	*Eriogonum niveum*
Forbs	
Longleaf phlox	*Phlox longifolia*
Balsamroot	*Balsamorhiza careyana*
Sand dock	*Rumex venosus*
Scurt pea	*Psoralea lanceolata*
Lupine	*Lupinus laxiflorus*
Pale evening primrose	*Oenothera pullida*
Desert mallow	*Sphaeralcea munroana*
Cluster lily	*Brodiaea douglasii*
Sego lily	*Calochortus macrocarpus*
Tansy mustard	*Descurainea pinnata*
Tumble mustard	*Sisymbrium altissimum*
Cryptantha	*Cryptantha circumscissa*
Russian thistle	*Salsola kali*
Fleabane	*Erigeron filifolius*
Grasses	
Sandberg bluegrass	*Poa sandbergii*
Cheatgrass	*Bromus tectorum*
Indian ricegrass	*Oryzopsis hymenoides*
Squirrel tail	*Sitanion hystrix*
Six weeks fescue	*Festuca octoflora*
Thickspike wheatgrass	*Agrophyron dasystachum*
Riprarian Vegetation	
Willow	*Salix exigua* and others
Cottonwood	*Populus trichocarpa*
Sedges	*Carex* spp.
Rushes	*Juncus* sp.
Horsetail	*Equisetum* sp.
Cocklebur	*Xanthium* sp.
Wild onion	*Allium* sp.

TABLE 2.2-1a (Cont'd)

Birds

Mallard	Anas platyrhynchos
Green-winged teal	Nettion carolinense
Blue-winged teal	Querquedula discors
Cinnamon teal	Q. cyanoptera
Gadwall	Chaulelasmus streperus
Baldpate	Mareca americana
Pintail	Dafila acuta tzitzihoa
Shoveller	Spatula clypeata
Canvas-back	Nyroca valisineria
Scaup	N. affinis
American goldeneye	Glaucionetta clangula americana
Buffle-head	Charitonetta albeola
Ruddy duck	Erismatura jamaicensis rubida
American merganser	Mergus merganser americanus
Coot	Fulica americana
Horned grebe	Colymbus auritus
Western grebe	Aechmophorus occidentalis
Pied-billed grebe	Podilymbus podiceps
Canada goose	Branta canadensis
Snow goose	Chen hyperborea
White-fronted goose	Anser albifrons
Whistling swan	Cygnus columbianus
Great blue heron	Ardea herodius
White pelican	Pelicanus erythrorhynchos
Cormorant	Phalacrocorax auritus
California gull	Larus californicus
Ring-billed gull	L. delewarensis
Common tern	Sterna hirundo
Foster's tern	S. forster
Killdeer	Oxyechus vociferus
Long-billed curlew	Numenius americanus
Chukar partridge	Alectoris graeca
California quail	Lophortyx califorica
Ring-necked pheasant	phasianus colchicus torquatus
Sage hen	Centrocercus urophasianus
Mourning dove	Zenzidura macroura
Red-tailed hawk	Buteo borealis
Swainson's hawk	B. swainsoni
Sparrow hawk	Falco sparverius
Golden eagle	Aquila chrysaetos canadensis
Bald eagle	Haliaetus leucocephalus
Osprey	Pandion haliaetus carolinensis
Burrowing owl	Speotyto cunicularia
Horned owl	Bubo virginianus
Raven	Corvus corax
American magpie	Pica pica hudsonia

TABLE 2.2-1a (Cont'd)

Red-shafted flicker	*Colaptes cafer*
Horned lark	*Octocoris alpestris*
Western meadowlark	*Sturnella neglecta*
Loggerhead shrike	*Lanius ludovicianus*
Western kingbird	*Tyrannus verticalis*
Eastern kingbird	*Tyranus verticalis*
White-crowned sparrow	*Zonotrichia leucophrys*
Sage sparrow	*Melospiza melodia*
Say's phoebe	*Sayornis saya saya*
Mammals	
Mule deer	*Odocoileus hemionus*
Coyote	*Canis latrans*
Bobcat	*Lynx rufus*
Badger	*Taxidea taxus*
Skunk	*Mephitis mephitis*
Weasel	*Mustela frenata*
Raccoon	*Procyon lotor*
Beaver	*Castor canadensis*
Muskrat	*Ondatra zibethica*
Porcupine	*Erethizon dorsa*
Blacktail jackrabbit	*Lepus californicus*
Cottontail rabbit	*Sylvilagus floridanus*
Ground squirrel	*Citellus townsendi*
Pocket mouse	*Peromyscus parvus*
Deer mouse	*P. maniculatus*
Harvest mouse	*Reithrodontomys megalotis*
Grasshopper mouse	*Onchomys leucogaster*
Pocket gopher	*Thomomys* sp.
Reptiles	
Northern Pacific Rattlesnake	*Crotalus viridus oreganus*
Great Basin gopher snake (bull snake)	*Pituophis melanoleucus deserticola*
Western yellow-bellied racer	*Coluber constrictor mormon*
Northern side-blotched lizard	*Uta stansburiana stansburiana*
Western fence lizard	*Sceloperus occidentalis*
Short-horned lizard	*Phrynosoma douglassi*
Great basin spadefoot toad	*Scaphiopus intermontanus*

TABLE 2.2-1b

COLUMBIA RIVER BIOTA[(a)]

Organism
Phylum Acanthocephala
Neoechinorhynchus rutili
N. cristatus
Pomphorhynchus bulbocolli
Bulbodactnitis sp.
Phylum Bryozoa
Plumatella sp.
Pectinatella sp.
Phylum Mollusca
Class Gastropoda
Stagnicola nuttalliana
Physa nuttallii
Fluminicola nuttalliana
Fisherola nuttallii
Stagnicola apicina
Radix japonica
Gyraulis vermicularis
Parapholyx effusa costata
P. e. neritoides
Lymnaea stagnalis
Lymnaea sp.
Planorbis sp.
Class Bivalvia
Anodonta nuttalliana
Corbicula fluminea
Margaritifera margaritifera
Pisidium columbianum
Anodonta compressum
Anodonta californiensis
Phylum Annelida
Class Oligochaeta
Xironogiton instabilis
Triannulata montana
Chaetogaster sp.
Class Hirudinea
Placobdella montifera
Illinobdella moorei
Erpobdella punctata
Theromyzon rude
Piscicola sp.
Helobdella stagnalis

Organism
Phylum Arthropoda
Class Arachnida
Hydracarina sp.
Aranedia sp.
Class Crustacea
Order Anostraca
Steptocephalus seali
Order Diplostraca
Leptodora kindtii
Diaphanosoma brachyurum
Alona rectangula
A. affinis
A. quadrangularis
A. costata
Chydoris sphaericus
Pleuroxus denticularis
Sida crystallina
Eurecercus lemallatus
Camptocercus rectirostris
Daphnia galeata mendotae
Scapholebercis kingi
Ceriodaphnia pulchella
Bosmina sp.
B. longirostis
Illyocryptus sordidus
I. spinifer
Macrothrix laticornis
Monospilus dispar
Leydigia quadrangularis
Pleuroxus trigonellus
Order Calanoida
Canthocamptus sp.
C. staphylinoides
C. vernalis
C. biscuspidatus thomasi
Diaptomus sp.
D. ashlandi
Bryocamptus zschokkei
Order Cyclopoida
Cyclops sp.
Order Amphipoda
Gammarus sp.

Organism
Phylum Arthropoda (contd)
Order Decapoda
Pacifasticus (lenius-culus) trowbridgii
Class Insecta
Order Coleoptera
Gyrinus sp.
Order Ephemeroptera
Paraleptophlebia bicornuta
Baetis sp.
Ephoron album
Ephemerella yosemite
E. sp.
Hexagenia sp.
Stenonema sp.
Order Plecoptera
Arcynepteryx paralla
Pteronarcys californica
Isogenus sp.
Perlodes americana
Order Trichoptera
Glossosoma velona
Hydropsyche cockerelli
Hydropsyche sp.
H. californica
Leptocella sp.
Limnophilus sp.
Hydroptila argosa
Brachycentrus occidentalis
Rhacophila coloradensis
Psychomyia flavida
Cheumatopsyche enomis
C. campyla
Leucotrichia pictipes
Arthripsodes annulicornis
Mystacides alafimbriata
Lepidostoma strophis
Order Lepidoptera
Argyractis angulatalis
Order Diptera
Tipulidae
Chironomidae
Simulium vittatum
Simulium sp.

Organism
Order Hemiptera
Notonecta sp.
Gerris sp.
Sigara sp.
Order Collembola
Family Hypogasturidae
Phylum Tardigrada
Macrobiotus sp.

TABLE 2.2-1b
(Cont'd)

Organism

Phylum Chlorophyta
Ulothrix zonata
Stigeoclonium lubricum
Cladophera crispata
C. glomerata
Zoochlorella parasitica
Chara Braunii Gmelin
C. vulgaris
Tetraspora sp.
Oedogonium sp.
Spirogyra sp.
Plesdorina sp.
Pediastrum sp.
Staurastrum sp.
Coelastrum sp.
Ankistrodesmus sp.
Pandorina sp.
Scenedesmus sp.
Rhizoclonium fontanum

Phylum Chrysophyta
Hydrurus foetidus
Botrydium granulatum
Eunotia pectinalis
Melosira granulata
M. varians
Cyclotella bodanica
C. glomerata
C. melosiroides
Stephanodiscus astraea
S. a. var. minuta
S. niagarea
Rhizosolenia eriensis
Tabellaria fenestrata
Diatoma vulgare
Fragilaria crotonensis
F. harrisonii
F. construens
F. virescens
Asterionella formosa
Synedra ulna
S. u. var. danica
S. acus
S. rumpens
S. pulchella
S. parasitica
Cocconeis placentula

Organism

Phylum Chrysophyta (contd)
C. pediculus
Frustulia rhomboides
F. vulgaris
Nedium productum
Diploneis elliptica
Navicula oblonga
Cymbella prostrate
C. turgida
C. leptoceros
C. naviculiformis
C. cistula
C. ventriocosa
C. tumida
Gomphonema parvulum
G. olivaceum
Epithemia turgida
Rhopalodia gibba
Nitzschia dissipata
N. palea
Ceratoneis sp.
Cymatopleura solea
C. elliptica
Suriella linearis

Phylum Cyanophyta
Aulosira implexa
Oscillatoria anquina
O. chalybea
O. limosa
O. proboscidea
O. princeps
O. spendida
O. tenuis
O. t. var. natans
Phormidium autumnale
P. favosum
P. inundatum
P. retzii
P. subfuscum
P. tenue
P. uncinatum
Lyngbya aerugineocaerulea
L. aestuarii
L. Diguetii
L. versicolor
Symploca muscorum

Organism

Phylum Cyanophyta (contd)
Anabaena oscillarioides
Nostoc caeruleium
N. ellipsosporum
N. sphaericum
Aphanizomenon flos-aquae
Tolypothrix distorta
T. lanata
T. tenuis
Plectonema nostocorum
Amphithrix janthina
Calothrix parietana
Gloeotrichia echinulata
G. natans
Audouinella violacea

Phylum Pyrrnophyta
Ceratium sp.

Phylum Tracheophyta
Family Najadaceae
Potomogeton sp.
Family Hydrocharitaceae
Anacharis sp.
Elodea sp.
Family Lemnaceae
Lemna sp.
Family Polygonaceae
Polygonum sp.
Family Ceratophyllaceae
Ceratophyllum demersum
Family Cyperaceae
Family Juncaceae

Animals
Phylum Protozoa
Acanthocystis sp.
Actinosphaerium sp.
Vorticella sp.
Epistylis sp.
Phylum Porifera
Spongilla lacustris
Phylum Coelenterata
Craspedacusta sowerbii
Hydra sp.

Organism

Phylum Platyhelminthes
Class Turbellaria
Dugesia dorocephala
Class Trematoda
Actinocleidus sp.
Urocleidus sp.
Dactylogyrus spp.
Gyrodactylus spp.
Phyllodistomum sp.
Lecithaster salmonis
Diplostomum sp.
Posthodiplostomum minimum
Brachyphallus crenatus
Neascus spp.
Allocreadium sp.
Crepidostomum farionis
Crepidostomum sp.
Octomacrum sp.
Cestrahelmins rivularus
Plagioporus spp.
Class Cestoidea
Corallobothrium fimbriatum
Proteocephalus ambloplitis
P. ptychocheilus
P. salmonidicola
Phyllobothrium sp.
Caryophyllaeus sp.
Ligula intestinalis
Diphyllobothrium sp.
Bothriocephalus sp.
Schistocephalus solidius
Eubothrium salvelini

Phylum Aschelminthes
Class Rotifera
Dapidia sp.
Kellicotia sp.
Syncheata sp.
Notholca sp.
Polyarthra sp.
Trichocerca sp.
Keratella sp.
Class Nematoda
Rhabdochona sp.
Contracaecum sp.
Philonena onchorhynchi
Bulbodacnitus sp.
Metabronena sp.
Cystidicola sp.
Camallanus sp.

(a) Classification after - T. I. Storer, R. L. Usinger, R. C. Stebbins, J. W. Wybakken, General Zoology, Fifth edition, McGraw-Hill Book Co., New York, 1972.

TABLE 2.2-1b (Cont'd)

	Organism	
	Phylum Chordata	
	Class Cyclostomata	
	Entosphenus tridentatus	Pacific Lamprey
	Lampetra ayresi	River Lamprey
	Class Osteichthyes	
	Acipenser transmontanus	White Sturgeon
	Oncorhynchus tshawytscha	Chinook Salmon
	O. nerka	Sockeye or Blueback Salmon
	O. kisutch	Coho or Silver Salmon
	Salmo gairdneri	Steelhead or Rainbow Trout
	S. clarki	Cutthroat Trout
	Salvelinus malma	Dolly Varden
	Prosopium williamsoni	Mountain Whitefish
	Alosa sapidissima	American Shad
	Catastomus platyrhynchus	Mountain Sucker
	C. columbianus	Bridgelip Sucker
	C. macrocheilus	Largescale Sucker
	Cyprinus carpio	Carp
	Tinca tinca	Tench
	Richardsonius balteatus	Redside Shiner
	Ptychocheilus oregonensis	Northern Squawfish
	Acrocheilus alutaceus	Chiselmouth
	Mylocheilus caurinus	Peamouth
4	R. cataractae	Longnose Dace
	R. osculus	Speckled Dace
	R. falcatus	Leopard Dace
	Ictalurus nebulosus	Brown Bullhead
	I. melas	Black Bullhead
4	I. natalis	Yellow Bullhead
	I. punctatus	Channel Catfish
4	Gasterosteus aculeatus	Threespine Stickleback
	Perca falvescens	Yellow Perch
	Stizostedion vitreum	Walleye
	Lepomis macrochirus	Bluegill
	L. gibbosus	Pumpkinseed
	Pomoxis annularis	White Crappie
	P. nigromaculatus	Black Crappie
	Micropterus salmoides	Largemouth Bass
	M. dolomieui	Smallmouth Bass
	Lota lota	Burbot
	Cottus asper	Prickly Sculpin
	C. beldingii	Piute Sculpin
4	C. perplexus	Reticulate Sculpin
	C. rhotheus	Torrent Sculpin
	C. bairdi	Mottled Sculpin
4	Percopsis transmountana	Sand Roller
	Coregonus clupeaformis	Lake Whitefish

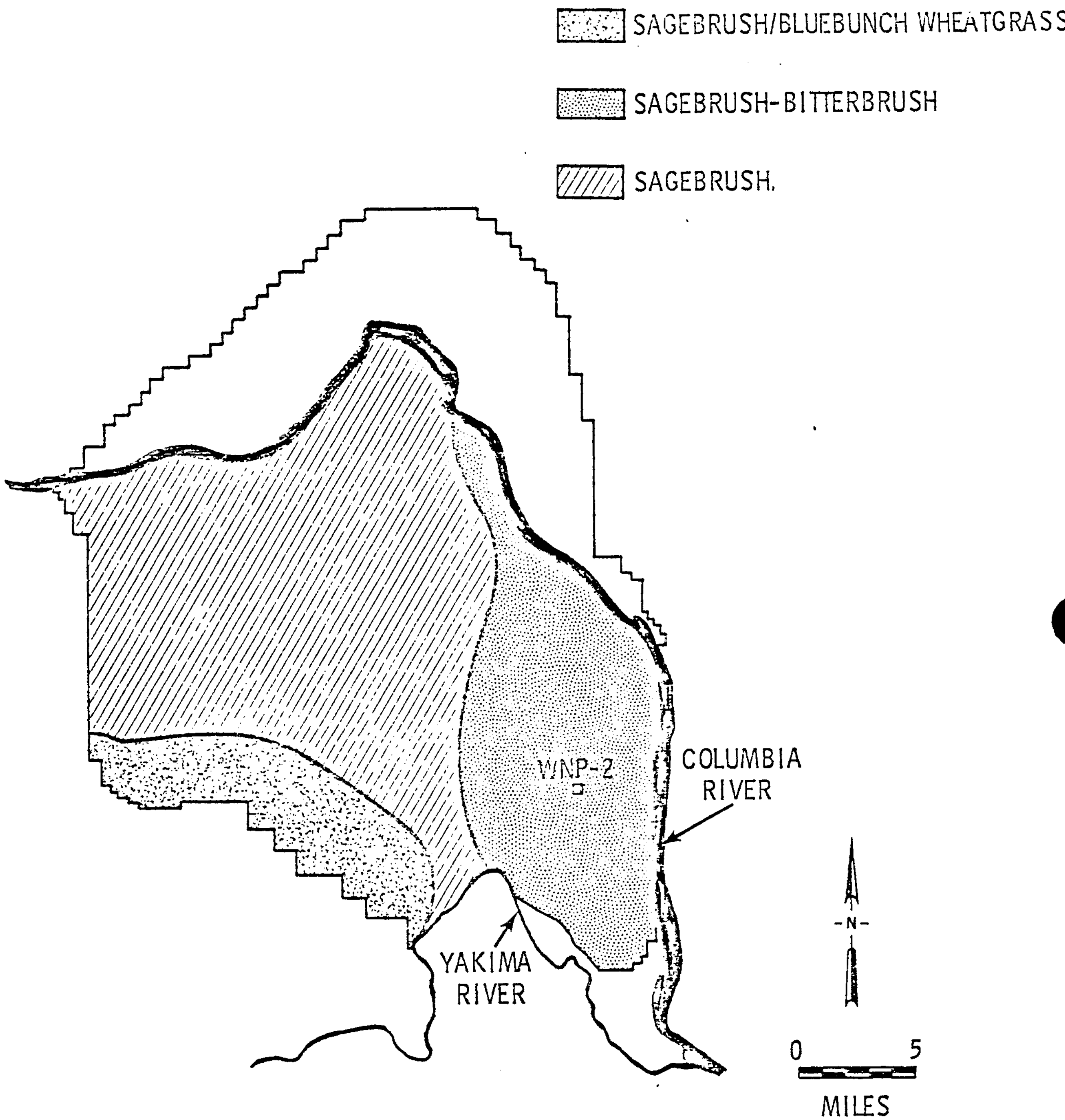
TABLE 2.2-2

NUMBER OF SPAWNING FALL CHINOOK SALMON AT HANFORD, 1947-1977
(population estimate based on 7 fish per redd)

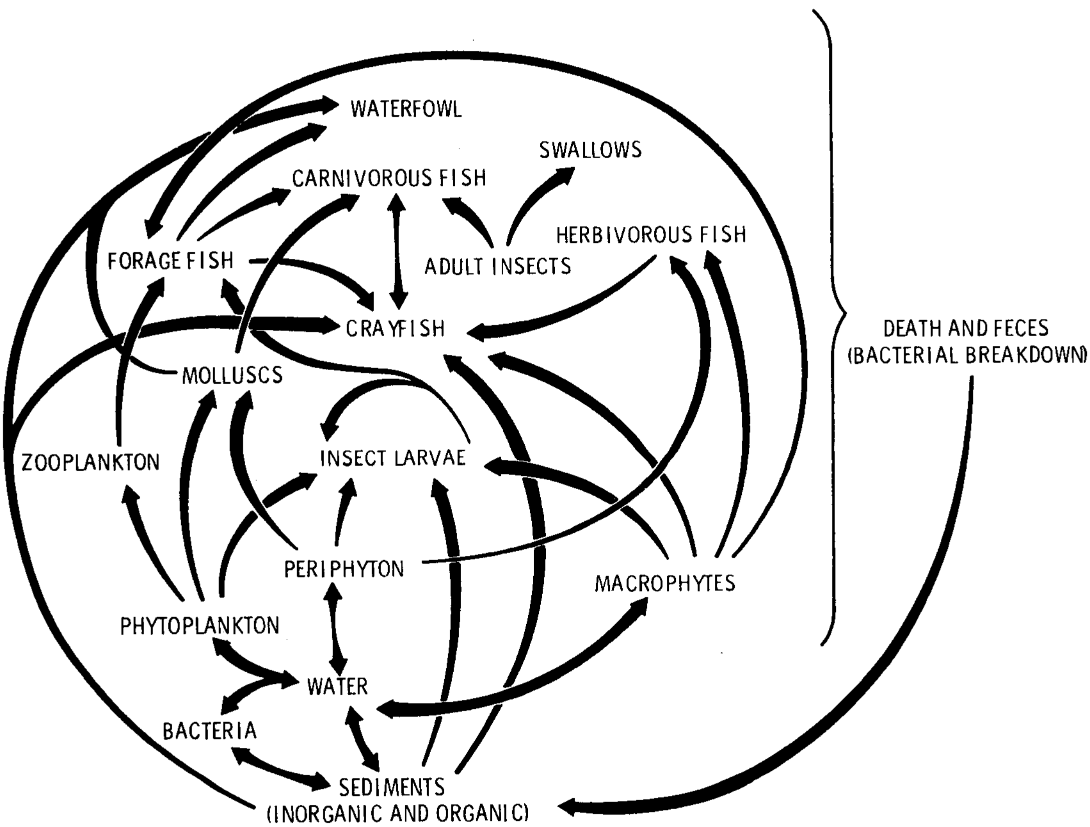
Year	Number of Redd[a]	Population Estimate
1947	240	1680
1948	785	5500
1949	330	2310
1950	316	2210
1951	314	2200
1952	539	3770
1953	149	1040
1954	157	1100
1955	64	490
1956	92	640
1957	872	6100
1958	1485	10400
1959	281	1970
1960	295	2070
1961	939	6570
1962	1261	8830
1963	1303	9120
1964	1477	10300
1965	1789	12500
1966	3101	21700
1967	3267	22900
1968	3560	24900
1969	4508	31600
1970	3813	26700
1971	3600	25200
1972	876	6130
1973	2965	20800
1974	728	5100
1975	2683	18800
1976	1951	13657
1977	3240	22680

2

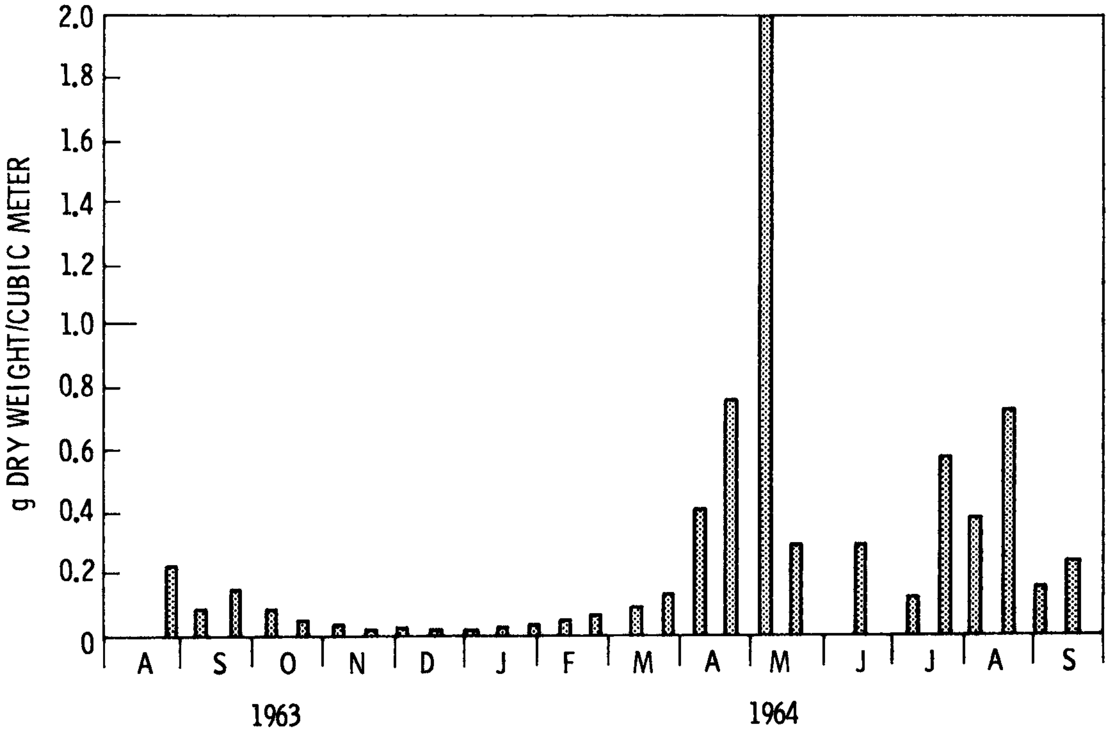
(a) Redd counts obtained by aerial surveys.



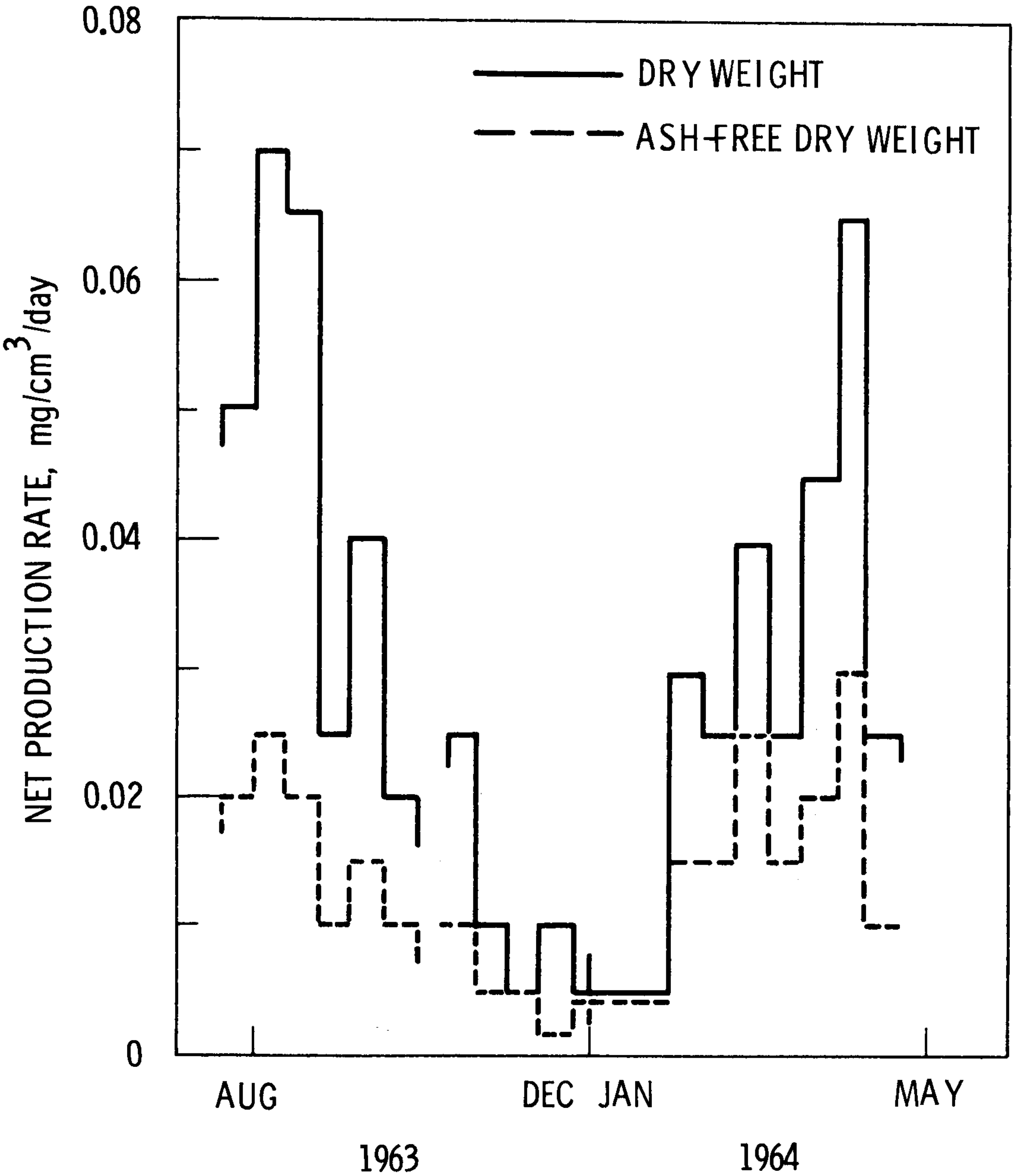
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	DISTRIBUTION OF MAJOR PLANT COMMUNITIES (VEGETATION TYPES) ON THE ERDA HANFORD RESERVATION, BENTON COUNTY, WA	
		FIG. 2.2-1



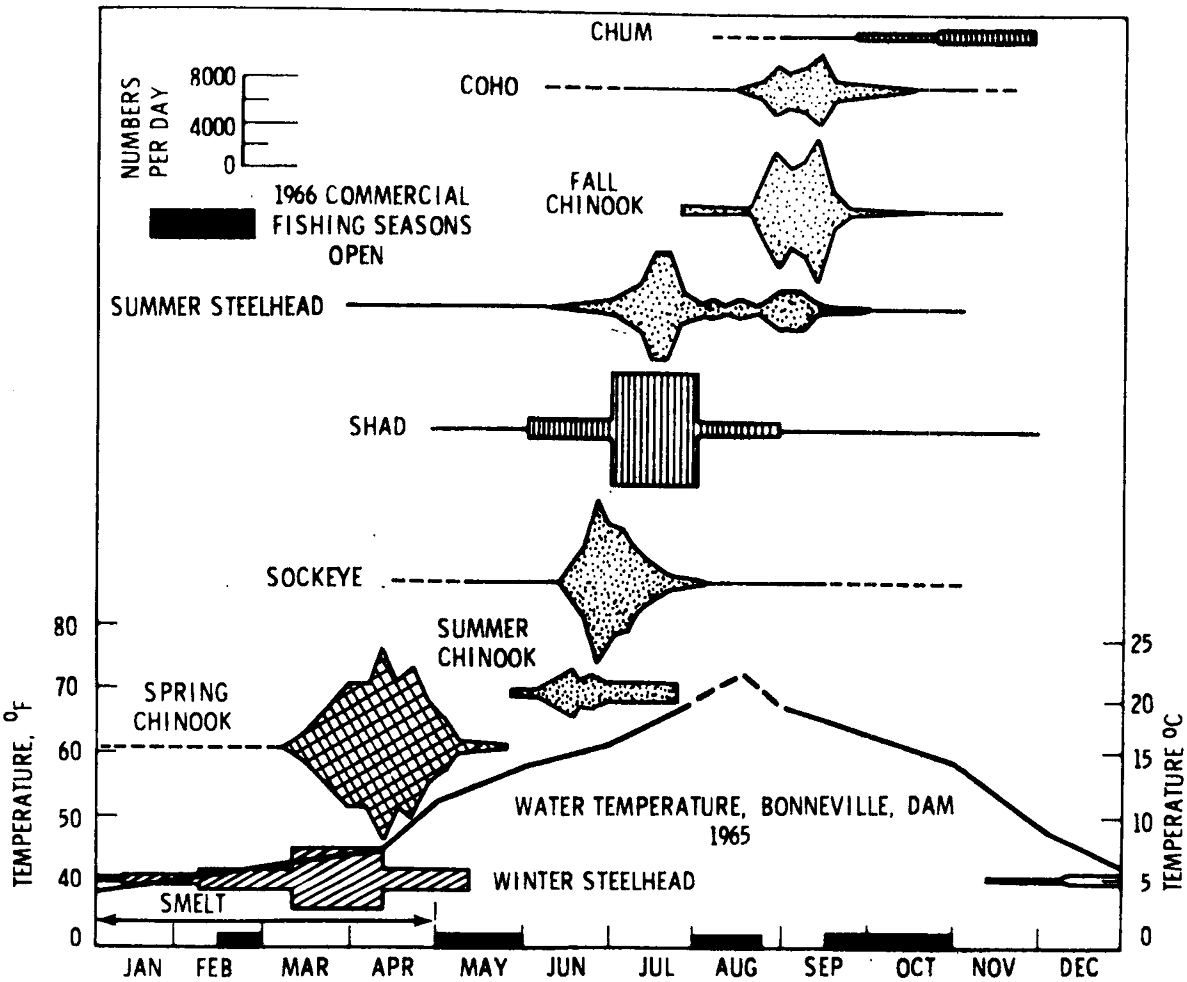
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FOOD-WEB OF COLUMBIA RIVER
	FIG. 2.2-2



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SEASONAL FLUCTUATION OF PLANKTON BIOMASS
	FIG. 2.2-3



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SEASONAL FLUCTUATION OF NET PRODUCTION RATE OF PERIPHYTON FIG. 2.2-4



- Dotted - Bonneville Dam Fishway data 1966
- Slant - estimated based on gill netting in lower river
- Crosshatch - estimated based on 17-yr average run size and timing of gill net catches
- Vertical - Bonneville Dam data (minimum estimate, not quantitative)

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	TIMING OF UPSTREAM MIGRATIONS IN THE LOWER COLUMBIA RIVER FIG. 2.2-5

2.3 METEOROLOGY

The Hanford Reservation lies in the Lower Columbia Basin, lowest elevation of any part of Central Washington. The low elevation assists in creating a relatively mild continental steppe climate, subject to somewhat wide seasonal range in temperature. Annual precipitation of approximately 6.4 in. falls mainly during the winter months. The average summer temperature is 73.7°F, while during the winter months the mean daily temperature is 32.4°F.

The primary source of meteorological data for WNP-2 is the 240-ft tower with a complete meteorological data system, which operated between March 1974 and June 1976. The system will be reactivated upon plant fuel load. The Hanford Meteorology Station (HMS) and the 410-ft Hanford Meteorology Tower located about 14 miles northwest of the WNP-2 site provided the data for the construction permit Environmental Report. A 23-ft temporary meteorology tower was was operated for 2 years previous to the installation of the 240-ft tower for the purpose of evaluating cooling tower orientation. The meteorological equipment located at these sites is discussed in Subsection 6.1.3. Table 2.3-1 presents the averages and extremes of various climatic elements at Hanford revised to include data up to and including 1975. More comprehensive climatological summaries of Hanford data are presented by Stone[1] based on observations up to 1970. The data for the following subsections are detailed in the tables and figures. While the tables and discussion of the onsite meteorological measurement program pertain specifically to the first year of data (April 1, 1974 - March 31, 1975), the second annual cycle of data displayed the same general characteristics. The complete data set is presented and discussed in Section 2.3 of the WNP-2 Final Safety Analysis Report.

2.3.1 Stability, Wind Speed and Direction

Annual average wind roses for the site are given in Figures 2.3-1 to -6. The wind rose in Figures 2.3-1, -2 and -3 are for onsite data for the three measurement heights (7, 33 and 245 ft). Figure 2.3-4 gives the onsite wind rose breakdown by four Hanford stability classes at the 33-ft level. HMS wind roses for the 200-ft level derived from 15 years of data (1955-1970) are given in Figure 2.3-5. Surface winds at various stations in the region are summarized as 8-point roses in Figure 2.3-6. The onsite joint frequency of wind speed, direction and stability data for winds at 33 ft are contained in Table 2.3-2 for five classes of Hanford stability criteria while Table 2.3-3 contains the annual summaries for

7, 33, and 245 ft for direction and speed. Tables 2.3-4 through -15 present joint distributions of wind speed and direction on a monthly basis (April 1974 through March 1975) for the onsite data.

Table 2.3-16 shows the joint distribution of stability, wind speed and direction derived from 15 years (1955-1970) of data taken at the HMS tower. These seasonal and annual tables are based on winds at 200 ft and stability defined by the temperature difference between the surface and 200 ft.

The climatological representativeness of the year of onsite data used in the diffusion computations is listed in Tables 2.3-17 and -18. Table 2.3-17 is a month by month comparison of climatic elements at HMS with longer term values. Average wind speed, insolation, precipitation, and relative humidity were close to the long-term values.

Table 2.3-18 presents a summary comparison of diffusion elements computed from the 1 year of WNP-2 data with similar elements computed from 15 years HMS data. The difference in the number of recorded calms is primarily the result of the lower threshold of the onsite instruments, these differences may also be partly the result of topographic influences. The wind direction frequencies cannot be expected to necessarily be comparable because of the separation between the stations. Comparison of the HMS and onsite data demonstrate differences which are readily attributable to local topographical effects such as the orientation of the river valley near the site. Although the differences in the stability classes are partly the result of the layer used for the stability definition, there is some evidence that part of the greater percentage of stable conditions at WNP-2 may be a real difference.

Tables 2.3-19a through -19h contain joint frequency summaries of the onsite data grouped by Pasquill stabilities categories.

The nearest routine radiosonde data that may be applied to this region are obtained at Spokane, the only station located in the relatively flat basin region between the Cascade Mountain Range to the west and the Rocky Mountains to the east. These data will be representative in a regional
1 sense, but cannot be expected to be exact in near surface atmospheric structure as a result of the distance (180 km) and elevation differences (site $\sim$440'MSL, Spokane $\sim$2350'MSL). Table 2.3-28 gives the monthly average daily maximum and minimum mixing height data for Spokane.

2.3.2 Temperature

Table 2.3-20 contains a temperature comparison between the WNP-2 site and HMS. These onsite temperatures are from the 8-ft level on the new meteorological system. By assuming an adiabatic lapse rate of 0.548°F/100 ft, over the 283-ft elevation difference between HMS and the WNP-2 site, a temperature difference can be expected of about 1.5°F between the dry bulb temperature data measured at the two sites.

2.3.3 Humidity

Table 2.3-21 gives a comparison of monthly wet bulb temperatures from the 1 year of onsite data and HMS. Table 2.3-22 contains the frequency occurrence of wet bulb values as a function of time of day based on data from the onsite meteorological system.

Figures 2.3-7 to -10 indicate diurnal and monthly and annual averages and extremes of temperature and humidity at HMS. Summaries of onsite humidity data have been prepared both on a monthly and annual basis in joint frequency wind speed direction formats. In addition, computer tapes of hourly summarized operation including humidity data have been generated.

During July 1975 the moisture in the lower atmosphere at HMS was abnormally high. In the period of record, 1957-1970, hourly wet bulb temperatures in a range 70 to 74°F had occurred an average of three times each July. In the period July 4 through July 12, 1975, there were 104 hourly observations in the range 70 to 74°F. On July 9 there were 17 consecutive hours in that range. Wet bulb temperatures of 75°F have not occurred in the Hanford area until this episode. On July 8, 9, and 10 there were a total of seven such hourly observations. The air temperatures were also high during this period. The HMS average relative humidity for July 1975 was 37.5% compared to the record of 40.5 set in 1955.

Figures 2.3-7 to -10 and Table 2.3-1 and Tables 2.3-23 present additional climatological humidity information from the HMS.

2.3.4 Precipitation

Precipitation data are presented in Figures 2.3-11 and -12, and Tables 2.3-24 and -25. Tables 2.3-26a through e are joint wind direction and speed summaries of rainfall intensities over the year of onsite data. No deviation from the regional low precipitation pattern was found.

2.3.5 High Velocity Winds

Surveys of data on high winds over this region indicate that higher winds tend to occur at the higher, more exposed elevations, although all sites in this region have experienced relatively high winds. High wind speeds result from squall lines, frontal passages, tight pressure gradients and thunderstorms. One small tornado has been observed on the Hanford Reservation. There is indication that this area has been affected by hurricanes, but no complete statistics are readily available that present frequency of occurrence of high winds produced or accompanied by a particular meteorological event. The highest reported winds produced at HMS by any cause are tabulated in Table 2.3-27. The Hanford tower is at a slightly higher elevation and hence might be expected to experience higher winds than at the WNP-2 site. Although based on different periods this tendency may be inferred from Tables 2.3-17 and 2.3-18. Figure 2.3-13(2) indicates the return probability of any peak wind gust at HMS again due to any cause. The highest recorded peak gust at the 50-ft level at HMS in the period 1945 to the present was 80 mph.

2.3.6 Severe Weather

Since the submission and the construction permit Environmental Report the local climatology for thunderstorms and tornados has not significantly changed. No additional observations of tornados have been made in the Hanford region. The frequency of occurrrence of thunderstorms has been updated in Table 2.3-1.

TABLE 2.3-1a

AVERAGES AND EXTREMES OF CLIMATIC ELEMENTS AT HANFORD (BASED ON ALL AVAILABLE RECORDS TO AND INCLUDING THE YEAR 1975)

	TEMPERATURE (°F)														
	1912-1975 AVERAGES							1912-1975 EXTREMES							
								DAILY MAXIMUM				DAILY MINIMUM			
	DAILY MAXIMUM	DAILY MINIMUM	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	RECORD HIGHEST	YEAR	RECORD LOWEST	YEAR	RECORD HIGHEST	YEAR	RECORD LOWEST	YEAR
Jan.	37.0	22.2	29.6	42.5	1953	12.1	1950	72	1971	-2	1950	53	1971	-23	1934
Feb.	45.4	27.6	36.4	44.5	1958	21.4	1929	71	1924	-3	1950	55	1932	-23	1950
Mar.	56.5	33.7	45.1	49.9	1926	39.4	1955	83	1960	24	1960	54	1942	6	1955
Apr.	66.1	39.9	53.1	59.6	1934	47.5	1955	95	1934	41	1945	60	1956	12	1935
May	75.6	48.0	61.9	68.8	1947	56.6	1933	103	1936+	49	1918	70	1956	28	1954
June	83.2	55.4	69.4	75.4	1922	63.0	1953	110	1912	55	1966	81	1924	33	1933
July	91.9	61.1	76.5	81.8	1960	72.4	1963	115	1939	59	1966	82	1925	41	1935
Aug.	89.4	59.3	74.3	81.5	1967	69.8	1964	113	1961	63	1920	81	1961	40	1918
Sept.	79.6	50.7	65.2	71.7	1967	58.8	1926	102	1950	52	1934+	72	1955	25	1926
Oct.	65.3	40.7	53.0	59.0	1952	48.8	1930	90	1933	31	1935	60	1945+	6	1935
Nov.	48.6	31.5	40.0	46.0	1954+	31.3	1955	75	1975	14	1955	52	1959+	-1	1955
Dec.	39.3	26.0	32.7	42.0	1933	18.5	1919	68	1933	-3	1919	56	1975	-27	1919
Year	64.8	41.3	53.1	81.8	July 1960	12.1	Jan. 1950	115	July 1939	-3	Feb 1950+	82	July 1925	-27	Dec 1919

	DEGREE DAYS (BASE 65°F)									
	HEATING 1945-1975 TOTALS					COOLING 1960-1975 TOTALS				
	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR
Jan.	1085	1640	1950	694	1953	0	0	----	0	----
Feb.	778	1147	1956	576	1958	0	0	----	0	----
Mar.	641	794	1955	476	1947	0	0	----	0	----
Apr.	386	522	1955	266	1947	1	5	1968+	0	1975+
May	154	255	1962	36	1947	49	99	1971	3	1962
June	34	90	1953	3	1958	192	310	1969	59	1971
July	3	22	1955	0	1975+	404	518	1960	232	1963
Aug.	5	32	1960	0	1974+	338	508	1967	171	1964
Sept.	71	179	1972	13	1967	107	216	1967	27	1970
Oct.	377	479	1946	200	1952	2	10	1971	0	1975+
Nov.	747	1008	1955	567	1954	0	0	----	0	----
Dec.	990	1224	1964	822	1957	0	0	----	0	----
Year	5271	1640	Jan. 1950	0	July 1975+	1093	518	July 1960	0	Oct. 1975+

	PRECIPITATION (INCHES)													
	1912-1975 TOTALS													
								SNOW, ICE PELLETS (SLEET)						
	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR	MAX. IN 24 HOURS	YEAR	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MAX. IN 24 HOURS	YEAR	MAXIMUM DEPTH	YEAR
Jan.	0.92	2.47	1970	0.13	1962+	1.08	1948	5.1	23.4	1950	7.1	1954	12.0	1969
Feb.	0.60	3.08	1940	T	1967+	1.24	1916	2.4	26.0	1916	5.6	1975	10.0	1969
Mar.	0.37	1.86	1957	0	1942+	0.59	1949	0.3	4.2	1951	2.2	1957+	2.3	1957
Apr.	0.38	1.22	1969	0	1933+	0.53	1951	T	T	1975+	T	1975+	0	----
May	0.47	2.03	1972	0	1931	1.39	1972	T	T	1960	T	1960	0	----
June	0.56	2.92	1950	0	1919	1.50	1934	0	0	----	0	----	0	----
July	0.15	0.81	1966	0	1939+	0.73	1914	0	0	----	0	----	0	----
Aug.	0.20	1.18	1920	0	1955+	0.69	1975	0	0	----	0	----	0	----
Sept.	0.30	1.34	1947	0	1961+	0.82	1947	0	0	----	0	----	0	----
Oct.	0.58	2.72	1957	0	1917+	1.91	1957	[illegible]	1.5	1973	1.5	1973	1.5	1973
Nov.	0.86	3.05	1926	T	1939+	0.78	1966	1.3	12.7	1955	4.8	1955	5.1	1946
Dec.	0.89	2.53	1931	0.11	1946	1.00	1958	3.9	19.1	1964	5.4	1965	12.1	1964
Year	6.28	3.08	Feb. 1940	0	Oct. 1957	1.91	June 1934	13.0	26.0	Feb. 1916	7.1	Jan. 1954	12.1	Dec. 1964

	WIND (mph)									RELATIVE HUMIDITY (%)								
	1945-1975 AVERAGES						PEAK GUSTS			1946-1975 AVERAGES					1946-1975 EXTREMES			
	PREVAILING DIRECTION	MEAN MONTHLY SPEED	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	SPEED	DIRECTION	YEAR	MEAN	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	HIGHEST	YEAR	LOWEST	YEAR
Jan.	NW	6.6	10.3	1972	3.1	1955	80	SW	1972	75.2	88.8	1960	60.0	1963	100	1975+	13	1963
Feb.	NW	7.1	9.4	1961	4.6	1963	65	SW	1971	70.0	86.9	1963	54.0	1967	100	1975+	14	1962
Mar.	WNW	8.4	10.7	1964	5.9	1958	70	SW	1956	55.8	65.9	1950	44.0	1965	100	1974+	12	1965+
Apr.	WNW	9.1	11.1	1972+	7.4	1958	73	SSW	1972	46.5	64.5	1963	36.9	1966	100	1973+	9	1954
May	WNW	9.9	10.5	1965+	5.8	1957	71	SSW	1948	42.3	61.9	1948	31.2	1966	100	1975+	7	1953
June	WNW	9.2	10.7	1949	7.7	1950+	72	SW	1957	39.5	53.5	1950	30.0	1949	100	1972+	10	1964+
July	WNW	8.6	9.6	1963	6.8	1955	55	WSW	1968	31.8	40.5	1955	21.9	1959	99	1972	6	1951
Aug.	WNW	8.0	9.1	1946	6.0	1956	66	SW	1961	34.8	43.8	1968	24.5	1967	100	1972+	7	1951
Sept.	WNW	7.5	9.2	1961	5.4	1957	65	SSW	1953	40.6	55.1	1959	33.2	1974	100	1962+	10	1962+
Oct.	WNW	6.7	9.1	1946	4.4	1952	63	SSW	1950	57.0	74.2	1962	42.5	1952	100	1975+	10	1952
Nov.	NW	6.1	7.9	1945	2.9	1956	64	SSW	1949	73.5	88.1	1972	64.2	1963+	100	1975+	16	1959
Dec.	NW	6.1	8.3	1968	3.9	1963+	71	SW	1955	80.1	90.5	1950	69.0	1968	100	1975+	26	1972
Year	WNW	7.7	11.1	Apr. 1972+	2.9	Nov. 1956	80	SW	Jan. 1972	53.9	90.5	Dec. 1950	21.9	July 1959	100	Dec. 1975+	6	July 1951

	SKY COVER (SCALE 0-10)					SOLAR RADIATION (LANGLEYS)*								
	1946-1975 AVERAGES (SUNRISE TO SUNSET)					1953-1975 AVG. DAILY TOTALS					1953-1975 EXTREME DAILY TOTALS			
	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR
Jan.	7.8	9.0	1969	4.3	1949	120	136	1973	88	1955	277	1969	16	1971+
Feb.	7.4	8.9	1961	5.9	1964	202	238	1960	164	1954	422	1958	37	1970+
Mar.	6.9	7.9	1950	4.9	1965	340	388	1965	305	1961	542	1968	47	1972
Apr.	6.4	8.1	1963	3.7	1951	475	535	1973	374	1963	704	1972	75	1974
May	5.8	7.7	1960	4.5	1949	576	634	1970	511	1962	782	1959	67	1962
June	5.3	7.0	1950	2.8	1961	628	698	1960	563	1953	821	1971	112	1965
July	2.8	4.5	1974+	0.9	1953	659	714	1973	588	1955	808	1974	118	1972
Aug.	3.2	5.9	1968	0.6	1955	558	613	1955	475	1968	721	1957	107	1959
Sept.	4.0	6.1	1959	1.4	1975	423	463	1975	354	1959	591	1970	61	1957
Oct.	5.9	8.0	1975	3.9	1952	262	299	1958	216	1975	434	1973	33	1974
Nov.	7.6	9.1	1972	6.2	1957	132	180	1957	97	1964	295	1971	14	1969
Dec.	8.1	9.2	1962	6.8	1954	92	116	1970	57	1969	196	1972	9	1973
Year	5.9	9.2	Dec. 1962	0.6	Aug. 1955	372	714	July 1973	57	Dec. 1969	821	June 1971	9	Dec. 1973

EXTREME AVERAGES OR TOTALS AND YEAR OR SEASON OF OCCURRENCE

1912-1975 TEMPERATURE AVERAGES (°F)

HIGHEST ANNUAL	56.2	1958+
LOWEST ANNUAL	50.2	1929
HIGHEST WINTER (D-J-F)	41.1	1933-34
LOWEST WINTER	24.2	1948-49
HIGHEST SPRING (M-A-M)	58.2	1947
LOWEST SPRING	48.0	1955
HIGHEST SUMMER (J-J-A)	78.2	1958
LOWEST SUMMER	70.3	1954
HIGHEST FALL (S-O-N)	56.6	1963
LOWEST FALL	49.6	1946

1912-1975 PRECIPITATION TOTALS (IN.)

GREATEST ANNUAL	11.45	1950
LEAST ANNUAL	3.26	1967
SNOW, ICE PELLETS (SLEET)		
GREATEST SEASONAL	43.6	1915-16
LEAST SEASONAL	0.3	1957-58

1945-1975 WIND SPEED AVERAGE (mph)

HIGHEST ANNUAL	8.3	1968+
LOWEST ANNUAL	6.3	1957

1946-1975 RELATIVE HUMIDITY AVERAGE (%)

HIGHEST ANNUAL	57.9	1950+
LOWEST ANNUAL	49.4	1967

1946-1975 SKY COVER AVERAGES (SUNRISE TO SUNSET, SCALE 0-10)

HIGHEST ANNUAL	6.4	1966
LOWEST ANNUAL	5.1	1949

1953-1975 SOLAR RADIATION AVERAGE DAILY TOTAL (LANGLEYS)

HIGHEST ANNUAL	390	1973
LOWEST ANNUAL	357	1967

TABLE 2.3-1b
(sheet 2 of 2)

NUMBER OF DAYS (1945-1975)**

	CLEAR					PTLY CLDY	CLOUDY					THUNDERSTORMS				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan.	4	7	1963	0	1955+	7	20	27	1969	17	1963	0	0	----	0	----
Feb.	5	9	1968+	1	1972+	7	17	26	1958	12	1964	#	1	1972+	0	1975+
Mar.	6	12	1965+	2	1961	9	15	22	1968	9	1965	#	1	1969+	0	1975+
Apr.	7	12	1962	1	1963	11	13	21	1963	6	1956	1	3	1948	0	1975+
May	9	14	1973	2	1960	11	11	19	1960	6	1958	2	7	1956	0	1974+
June	10	21	1961	5	1972+	10	10	15	1973+	5	1960+	3	8	1972+	0	1963+
July	20	26	1960	13	1974	7	3	9	1974	1	1961	2	7	1975	0	1973+
Aug.	19	30	1955	11	1968	7	4	13	1968	0	1955	2	8	1953	0	1974+
Sept.	15	27	1975	8	1969	8	7	13	1969	1	1975	1	4	1959	0	1975+
Oct.	10	14	1970	1	1975	8	13	22	1973	9	1970	#	1	1975+	0	1974+
Nov.	4	10	1957	1	1973+	6	19	25	1973+	15	1961	0	0	----	0	----
Dec.	3	7	1972+	1	1962+	6	22	28	1962	18	1967+	#	1	1971	0	1975+
Year	112	30	Aug. 1955	0	Jan. 1955+	97	154	28	Dec. 1962	0	Aug. 1969+	11	8	June 1972+	0	----

	HEAVY FOG (VIS. 1/4 MI. OR LESS)					PRECIP. 0.10 INCH OR MORE					SNOW 1.0 INCH OR MORE				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan.	5	14	1965	0	1949	3	8	1970	0	1972+	2	10	1950	0	1967+
Feb.	3	11	1963	0	1971+	2	5	1961+	0	1972+	2	4	1975+	0	1974+
Mar.	1	5	1951	0	1975+	2	8	1957	0	1973+	#	2	1957+	0	1975+
Apr.	#	1	1975+	0	1974+	1	5	1948	0	1973+	0	0	----	0	----
May	#	1	1958	0	1975+	2	4	1967+	0	1968+	0	0	----	0	----
June	#	1	1971	0	1975+	2	8	1950	0	1973+	0	0	----	0	----
July	0	0	----	0	----	1	3	1974+	0	1973+	0	0	----	0	----
Aug.	#	1	1959	0	1975+	1	4	1975	0	1974+	0	0	----	0	----
Sept.	#	1	1957	0	1975+	1	5	1959	0	1975+	0	0	----	0	----
Oct.	1	6	1962	0	1974+	2	8	1950	0	1972+	#	1	1973	0	1975+
Nov.	6	13	1965	0	1960	3	10	1973	0	1967	#	6	1955	0	1974+
Dec.	8	17	1950	2	1968+	3	9	1964	0	1949+	2	6	1964	0	1974+
Year	24	17	Dec. 1950	0	----	23	9	Dec. 1964	0	Sept. 1975+	6	10	Jan. 1950	0	---

	NUMBER OF DAYS (1945-1975): 3" OR MORE SNOW ON GND.					NUMBER OF DAYS (1945-1975): PEAK GUST 40 MPH OR GREATER					NUMBER OF DAYS (1912-1975): MAX. TEMP. 90 OR ABOVE				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan.	5	23	1969	0	1975+	3	11	1972	0	1973+	0	0	----	0	----
Feb.	3	16	1950	0	1974+	3	6	1961+	0	1973+	0	0	----	0	----
Mar.	0	0	----	0	----	3	9	1956	1	1973+	0	0	----	0	----
Apr.	0	0	----	0	----	3	7	1972	0	1967	#	4	1926	0	1975+
May	0	0	----	0	----	2	6	1971+	0	1963+	3	11	1924	0	1974+
June	0	0	----	0	----	2	6	1973	0	1971+	9	20	1940+	0	1953
July	0	0	----	0	----	1	4	1962+	0	1975+	21	29	1941	8	1963
Aug.	0	0	---	0	----	1	5	1951	0	1974+	18	29	1915	7	1948
Sept.	0	0	----	0	----	2	4	1946	0	1975+	5	16	1938	0	1970+
Oct.	0	0	----	0	----	2	8	1967	0	1974+	#	1	1933	0	1975+
Nov.	#	10	1955	0	1975+	2	5	1973+	0	1974+	0	0	----	0	----
Dec.	2	14	1955	0	1975+	3	8	1957+	0	1969+	0	0	----	0	----
Year	10	23	Jan 1969	0	---	27	11	Jan 1972	0	--	56	29	July 1941+	0	---

	NUMBER OF DAYS (1912-1975): MAX. TEMP. 100 OR ABOVE					MAX. TEMP. 32 OR BELOW					MIN. TEMP. 32 OR BELOW					MIN. TEMP. 0 OR BELOW				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan.	0	0	----	0	----	11	29	1937	0	1967+	28	31	1960+	9	1953	2	14	1950	0	1975+
Feb.	0	0	----	0	----	3	15	1956	0	1974+	22	28	1944+	5	1958	1	9	1929	0	1975+
Mar.	0	0	----	0	----	#	2	1960	0	1975+	16	25	1944+	6	1968+	0	0	----	0	----
Apr.	0	0	----	0	----	0	0	----	0	----	5	15	1935	0	1974+	0	0	----	0	----
May	#	1	1966+	0	1975+	0	0	----	0	----	#	3	1938	0	1975+	0	0	----	0	----
June	1	9	1970	0	1975+	0	0	----	0	----	0	0	----	0	----	0	0	----	0	----
July	7	16	1971+	0	1963+	0	0	----	0	----	0	0	----	0	----	0	0	----	0	----
Aug.	4	16	1942	0	1975+	0	0	---	0	----	0	0	----	0	----	0	0	----	0	----
Sept.	#	2	1955+	0	1975+	0	0	----	0	----	#	4	1933+	0	1975+	0	0	----	0	---
Oct.	0	0	----	0	----	#	2	1935	0	1975+	5	12	1916	0	1962+	0	0	----	0	----
Nov.	0	0	----	0	----	2	15	1955	0	1974+	17	30	1936	4	1949	#	1	1955+	0	1975+
Dec.	0	0	----	0	----	8	19	1914	0	1974	26	31	1963+	14	1933	1	14	1919	0	1975+
Year	12	16	July 1971+	0	----	24	29	Jan. 1937	0	----	119	31	Dec. 1963+	0	----	4	14	Jan. 1950+	0	---

NUMBER OF DAYS

CLEAR (0-3 TENTHS SKY COVER, SR TO SS)

GREATEST ANNUAL (1946-75)	141	1951
LEAST ANNUAL (1946-75)	85	1966

CLOUDY (8-10 TENTHS SKY COVER, SR TO SS)

GREATEST ANNUAL (1946-75)	181	1969+
LEAST ANNUAL (1946-75)	84	1949

THUNDERSTORMS

GREATEST ANNUAL (1945-75)	23	1948
LEAST ANNUAL (1945-75)	3	1949

HEAVY FOG (VIS. 1/4 MILE OR LESS)

GREATEST SEASONAL (1945-75)	42	1950-51
LEAST SEASONAL (1945-75)	9	1948-49

PRECIPITATION 0.10 INCH OR MORE

GREATEST ANNUAL (1946-75)	39	1950
LEAST ANNUAL (1946-75)	10	1965

SNOW 1.0 INCH OR MORE

GREATEST SEASONAL (1946-75)	15	1955-56
LEAST SEASONAL (1946-75)	0	1957-58

3 IN. OR MORE SNOW ON GROUND

GREATEST SEASONAL (1946-75)	40	1964-65
LEAST SEASONAL (1946-75)	0	1966-67+

PEAK GUST 40 MPH OR GREATER

GREATEST ANNUAL (1945-75)	41	1961
LEAST ANNUAL (1945-75)	13	1958

MAX. TEMPERATURE 90 OR ABOVE

GREATEST ANNUAL (1912-75)	85	1940+
LEAST ANNUAL (1912-75)	31	1964

MAX. TEMPERATURE 100 OR ABOVE

GREATEST ANNUAL (1912-75)	32	1942
LEAST ANNUAL (1912-75)	1	1954

MAX. TEMPERATURE 32 OR BELOW

GREATEST SEASONAL (1912-75)	53	1955-56
LEAST SEASONAL (1912-75)	1	1937-38

MIN. TEMPERATURE 32 OR BELOW

GREATEST SEASONAL (1912-75)	141	1916-17
LEAST SEASONAL (1912-75)	75	1957-58

MIN. TEMPERATURE 0 OR BELOW

GREATEST SEASONAL (1912-75)	18	1949-50
LEAST SEASONAL (1912-75)	0	1974-75+

REFERENCE NOTES

* CALORIES/cm^2

** SKY COVER AND PRECIPITATION OBSERVATIONS NOT BEGUN UNTIL 1946

\# LESS THAN 1/2

\+ ALSO ON EARLIER YEARS

LOCATION AND HISTORY

PRESENT LOCATION 25 MILES NW OF RICHLAND, WASHINGTON

LATITUDE 46°34' N; LONGITUDE 119°36' W ELEVATION 733 FEET

OBSERVATIONS FROM 1912 TO 1944 WERE BY UNITED STATES WEATHER BUREAU COOPERATIVE OBSERVERS AT A SITE ABOUT 10 MILES ENE OF PRESENT LOCATION. SINCE 1944 OBSERVATIONS HAVE BEEN MAINTAINED ON A 24 HOUR-A-DAY BASIS BY THREE DIFFERENT ERDA CONTRACTORS.

TABLE 2.3-2a

ANNUAL JOINT FREQUENCY FOR
HANFORD STABILITY CLASSES FOR WNP-2 BASED ON WINDS AT
33 FT AND TEMPERATURES BETWEEN 245 AND 33 FT - VERY UNSTABLE
(TEMPERATURE CHANGE LESS THAN -2.5 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	0	0	0	0	0	0	0
NE	0	0	0	1	0	0	0	0	1
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0
S	0	0	0	2	1	0	0	0	3
SSW	0	0	0	1	0	0	0	0	1
SW	0	0	0	0	0	1	0	0	1
WSW	0	0	0	0	0	1	0	0	1
W	0	0	0	0	1	0	1	0	2
WNW	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	1	0	2	0	0	0	3
TOTAL	0	0	1	4	4	2	1	0	12

TABLE 2.3-2b

ANNUAL JOINT FREQUENCY FOR
HANFORD STABILITY CLASSES FOR WNP-2 BASED ON WINDS AT
33 FT AND TEMPERATURES BETWEEN 245 and 33 FT - UNSTABLE
(TEMPERATURE CHANGE LESS THAN -1.5 AND GREATER THAN OR
EQUAL -2.5 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	11	50	26	11	0	0	0	98
NE	0	6	21	15	1	0	0	0	43
ENE	0	1	22	17	0	0	0	0	40
E	0	3	9	11	0	0	0	0	23
ESE	0	2	17	6	0	0	0	0	25
SE	0	1	37	9	0	0	0	0	47
SSE	0	3	63	25	1	0	0	0	92
S	0	4	46	82	21	5	0	0	158
SSW	0	3	29	48	31	7	0	2	120
SW	0	7	33	20	32	13	1	1	107
WSW	0	5	24	25	20	10	5	3	92
W	0	5	37	30	29	6	2	1	110
WNW	0	7	28	15	19	17	6	0	92
NW	0	6	31	21	15	14	9	0	96
NNW	0	8	49	37	13	3	1	0	111
N	0	8	82	38	12	0	0	0	140
VAR	0	13	42	5	0	0	0	0	60
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	2	17	13	3	0	0	15	50
TOTAL	0	95	637	443	208	75	24	22	1504

TABLE 2.3-2c
(sheet 2 of 3)

ANNUAL JOINT FREQUENCY FOR
HANFORD STABILITY CLASSES FOR WNP-2 BASED ON WINDS AT
33 FT AND TEMPERATURES BETWEEN 245 AND 33 FT - NEUTRAL
(TEMPERATURE CHANGE LESS THAN -0.5 AND GREATER THAN
EQUAL -1.5 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	18	38	18	2	0	0	2	78
NE	0	18	25	10	1	2	0	0	54
ENE	0	18	32	12	0	0	0	1	63
E	0	16	27	7	0	0	0	1	51
ESE	0	32	30	4	0	0	0	1	67
SE	0	32	43	8	4	0	0	1	88
SSE	0	22	67	29	3	0	0	0	121
S	0	23	66	73	31	2	0	1	196
SSW	0	33	62	83	65	8	3	6	[illegible]
SW	0	25	28	38	32	19	4	1	148
WSW	0	22	25	17	16	9	1	0	91
W	0	18	30	26	26	10	6	3	119
WNW	0	33	47	47	42	30	6	1	206
NW	0	33	77	53	38	21	5	9	236
NNW	0	39	81	38	14	2	0	2	176
N	0	29	42	46	11	0	0	0	128
VAR	0	18	12	0	0	0	0	0	30
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	3	2	3	0	0	0	4	12
TOTAL	0	433	733	512	285	103	25	33	2124

TABLE 2.3-2d
(sheet 2 of 3)

ANNUAL JOINT FREQUENCY FOR
HANFORD STABILITY CLASSES FOR WNP-2 BASED ON WINDS AT
33 FT AND TEMPERATURES BETWEEN 245 AND 33 FT - STABLE
(TEMPERATURE CHANGE LESS THAN 3.5 AND GREATER THAN
OR EQUAL -0.5 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	43	34	5	0	0	0	0	82
NE	0	34	43	2	3	0	0	3	85
ENE	0	23	35	2	0	0	0	6	71
E	0	26	23	2	0	0	0	1	52
ESE	0	38	29	4	0	0	0	0	71
SE	0	35	69	31	2	1	0	0	138
SSE	0	43	123	103	12	3	0	1	285
S	0	56	114	104	38	1	0	4	317
SSW	0	39	108	75	52	28	3	5	310
SW	0	35	83	33	34	6	2	4	197
WSW	0	45	68	47	12	6	3	3	184
W	0	46	78	69	17	3	0	7	220
WNW	0	72	111	139	82	24	6	3	437
NW	0	60	176	136	33	5	0	2	412
NNW	0	67	141	49	7	0	0	4	268
N	0	60	55	10	1	0	0	1	127
VAR	0	31	15	3	1	0	0	0	50
CALM	1	0	0	0	0	0	0	0	1
UNKNO	0	2	10	6	1	0	0	21	40
TOTAL	1	760	1315	820	295	77	14	65	3347

TABLE 2.3-2e
(sheet 3 of 3)

ANNUAL JOINT FREQUENCY FOR
HANFORD STABILITY CLASSES FOR WNP-2 BASED ON WINDS AT
33 FT AND TEMPERATURES BETWEEN 245 AND 33 FT - VERY STABLE
(TEMPERATURE CHANGE GREATER THAN
OR EQUAL 3.5 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	69	41	1	0	0	0	0	111
NE	0	72	37	3	0	0	0	0	112
ENE	0	56	28	0	0	0	0	0	84
E	0	51	7	0	0	0	0	0	58
ESE	0	40	11	0	0	0	0	0	51
SE	0	20	31	1	0	0	0	0	52
SSE	0	23	68	25	0	0	0	2	118
S	0	23	67	50	0	0	0	3	143
SSW	0	21	42	20	2	0	0	0	85
SW	0	31	25	5	0	0	0	1	62
WSW	0	29	24	5	0	0	0	1	59
W	0	19	16	11	0	0	0	0	46
WNW	0	36	29	10	1	0	0	1	77
NW	0	51	62	17	0	0	0	2	132
NNW	0	59	75	5	0	0	0	0	139
N	0	79	52	1	0	0	0	0	132
VAR	0	28	4	0	0	0	0	0	32
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	1	0	0	0	0	10	11
TOTAL	0	707	620	154	3	0	0	20	1504

TABLE 2.3-2f
(sheet 3 of 3)

ANNUAL JOINT FREQUENCY FOR
HANFORD STABILITY CLASSES FOR WNP-2 BASED ON WINDS AT
33 FT AND TEMPERATURES BETWEEN 245 AND 33 FT - STABILITY UNKNOWN
(TEMPERATURE CHANGE IN DEGREES F PER 200 FT UNKNOWN)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	3	0	0	0	0	0	3
NE	0	1	3	1	0	0	0	0	5
ENE	0	0	2	0	0	0	0	0	2
E	0	2	3	0	0	0	0	0	5
ESE	0	1	1	0	0	0	0	0	2
SE	0	0	1	1	0	0	0	0	2
SSE	0	1	2	0	0	0	0	0	3
S	0	0	0	2	0	0	0	0	2
SSW	0	0	0	2	1	0	0	0	3
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	1	0	0	0	0	0	1
W	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0
NW	0	0	3	1	2	1	0	0	7
NNW	0	1	0	0	0	0	0	0	1
N	0	1	0	1	0	0	0	0	2
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	3	7	4	3	0	0	214	231
TOTAL	0	10	26	12	6	1	0	214	269

TABLE 2.3-3a

ANNUAL JOINT FREQUENCY OF WIND SPEED AND DIRECTION FOR WNP-2 AT 7 FT FROM 4/74 TO 3/75

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	130	132	34	1	0	0	5	302
NE	0	76	92	10	2	0	0	3	183
ENE	0	77	85	13	0	0	0	1	176
E	0	64	59	8	0	0	0	0	131
ESE	0	101	64	8	0	0	0	0	173
SE	0	173	147	29	2	0	0	1	352
SSE	0	236	300	52	3	0	0	1	592
S	0	265	424	231	21	2	0	3	946
SSW	0	240	248	232	66	4	0	3	793
SW	0	259	171	123	87	10	0	1	651
WSW	0	199	143	96	52	8	0	3	501
W	0	237	169	103	42	15	0	4	570
WNW	0	308	212	179	116	27	3	10	855
NW	0	366	330	154	66	11	1	6	934
NNW	0	257	254	88	12	1	0	3	615
N	0	216	163	74	5	0	0	1	459
VAR	0	189	70	8	1	0	0	0	268
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	3	2	0	0	0	0	254	259
TOTAL	0	3396	3065	1442	476	78	4	299	8760

TABLE 2.3-3b

ANNUAL JOINT FREQUENCY OF WIND SPEED AND DIRECTION FOR WNP-2 AT 33 FT FROM 4/74 TO 3/75

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	141	166	50	13	0	0	2	372
NE	0	131	127	32	5	2	0	3	300
ENE	0	103	119	31	0	0	0	7	260
E	0	98	69	20	0	0	0	2	189
ESE	0	113	88	14	0	0	0	1	216
SE	0	88	181	50	6	1	0	1	327
SSE	0	92	323	182	16	3	0	3	619
S	0	106	293	313	91	8	0	8	819
SSW	0	96	241	229	151	43	6	13	779
SW	0	99	169	96	98	39	7	7	515
WSW	0	101	143	94	48	26	9	7	428
W	0	88	161	136	73	19	9	11	497
WNW	0	148	215	211	144	71	18	5	812
NW	0	150	349	228	88	41	14	13	883
NNW	0	174	346	129	34	5	1	6	695
N	0	177	231	96	24	0	0	1	529
VAR	0	90	73	8	1	0	0	0	172
CALM	1	0	0	0	0	0	0	0	1
UNKNO	0	10	38	26	9	0	0	264	347
TOTAL	1	2005	3332	1945	801	258	64	354	8760

TABLE 2.3-3c
(sheet 2 of 2)

ANNUAL JOINT FREQUENCY OF
WIND SPEED AND DIRECTION FOR WNP-2 AT 245 FT FROM 4/74 TO 3/75

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	58	129	101	26	4	0	3	321
NE	0	42	113	76	15	2	5	0	253
ENE	0	37	96	59	11	2	0	1	206
E	0	38	96	35	3	1	0	2	175
ESE	0	59	114	47	4	3	0	0	227
SE	0	68	165	91	29	8	4	2	367
SSE	0	58	228	186	106	13	4	0	595
S	0	74	233	321	210	57	5	1	901
SSW	0	62	174	212	236	109	88	2	883
SW	0	62	133	99	[illegible]	62	55	1	496
WSW	0	56	116	93	81	33	33	5	417
W	0	49	144	105	102	61	24	8	493
WNW	0	57	147	187	201	184	108	14	898
NW	0	64	239	295	289	132	71	6	1096
NNW	0	68	231	205	97	11	1	5	618
N	0	71	187	137	41	6	0	4	446
VAR	0	35	31	9	3	0	0	0	78
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	1	4	10	5	0	0	270	290
TOTAL	0	959	2580	2268	1543	688	398	324	8760

TABLE 2.3-4

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, APRIL 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 4/74 AT WPPSS2 FOR 3

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	5	8	6	0	0	0	0	19
NE	0	2	15	4	0	0	0	1	22
ENE	0	1	2	0	0	0	0	0	3
E	0	3	3	0	0	0	0	0	6
ESE	0	6	4	1	0	0	0	0	11
SE	0	4	12	6	1	0	0	0	23
SSE	0	4	26	21	0	0	0	3	54
S	0	8	18	19	12	0	0	7	64
SSW	0	4	16	29	30	2	0	13	94
SW	0	4	18	9	15	4	0	6	56
WSW	0	3	10	12	5	3	1	7	41
W	0	3	14	16	17	4	1	8	63
WNW	0	7	19	26	40	21	8	2	123
NW	0	5	23	15	9	11	3	1	67
NNW	0	5	17	5	1	0	0	2	30
N	0	3	14	5	1	0	0	0	23
VAR	0	2	5	0	0	0	0	0	7
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	14	14
TOTAL	0	69	224	174	131	45	13	64	720

TABLE 2.3-5

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, MAY 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 5/74 AT WPPSS2 FOR 33 F

SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	5	11	0	0	0	0	0	16
NE	0	7	3	3	0	0	0	0	13
ENE	0	1	6	2	0	0	0	0	9
E	0	8	6	0	0	0	0	0	14
ESE	0	6	9	0	0	0	0	0	15
SE	0	1	16	1	0	0	0	0	18
SSE	0	9	38	13	0	0	0	0	60
S	0	10	27	45	10	0	0	0	92
SSW	0	5	30	49	16	4	2	0	106
SW	0	3	15	18	13	3	0	0	52
WSW	0	6	19	30	13	1	0	0	69
W	0	3	23	35	13	5	0	0	79
WNW	0	11	24	34	17	10	0	0	96
NW	0	4	14	10	13	4	2	0	47
NNW	0	3	13	7	0	0	0	0	23
N	0	4	7	1	0	0	0	0	12
VAR	0	7	8	0	0	0	0	0	15
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	8	8
TOTAL	0	93	269	248	95	27	4	8	744

TABLE 2.3-6

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, JUNE 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 6/74 AT WPPSS2 FOR 33 F

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	5	12	1	0	0	0	0	18
NE	0	7	9	4	0	0	0	1	21
ENE	0	6	16	9	0	0	0	0	31
E	0	3	14	7	0	0	0	0	24
ESE	0	4	16	6	0	0	0	0	26
SE	0	4	23	10	0	0	0	0	37
SSE	0	7	34	11	0	0	0	0	52
S	0	4	20	18	10	2	0	1	55
SSW	0	6	20	12	12	1	0	0	51
SW	0	3	11	6	4	5	0	0	29
WSW	0	3	15	5	3	1	1	0	28
W	0	2	18	14	13	2	3	0	52
WNW	0	2	24	19	10	10	2	0	67
NW	0	3	15	20	8	5	2	0	53
NNW	0	6	17	3	0	0	0	0	26
N	0	6	11	1	0	0	0	0	18
VAR	0	0	4	0	1	0	0	0	5
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	10	38	26	9	0	0	44	127
TOTAL	0	81	317	172	70	26	8	46	720

TABLE 2.3-7

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, JULY 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 7/74 AT WPPSS2 FOR 33

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	3	13	2	0	0	0	0	18
NE	0	11	12	1	0	0	0	0	24
ENE	0	3	9	6	0	0	0	0	18
E	0	10	14	6	0	0	0	0	30
ESE	0	6	18	1	0	0	0	0	25
SE	0	10	26	4	0	0	0	0	40
SSE	0	3	37	16	1	0	0	0	57
S	0	6	27	32	5	0	0	0	70
SSW	0	9	16	18	9	2	0	0	54
SW	0	7	22	14	6	0	1	0	50
WSW	0	6	12	11	3	1	2	0	35
W	0	7	14	19	9	0	0	0	49
WNW	0	5	18	18	17	5	0	0	63
NW	0	11	18	21	13	4	0	0	67
NNW	0	10	25	4	2	0	0	0	41
N	0	8	22	5	0	0	0	0	35
VAR	0	5	24	3	0	0	0	0	32
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	36	36
TOTAL	0	120	327	181	65	12	3	36	744

TABLE 2.3-8

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, AUGUST 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 8/74 AT WPPSS2 FOR 33

SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	16	21	11	0	0	0	0	48
NE	0	12	19	6	3	2	0	0	42
ENE	0	9	6	0	0	0	0	0	15
E	0	10	4	4	0	0	0	0	18
ESE	0	12	9	0	0	0	0	0	21
SE	0	6	25	1	0	0	0	0	32
SSE	0	8	39	16	0	0	0	0	63
S	0	7	33	28	4	3	0	0	75
SSW	0	11	24	17	13	1	0	0	66
SW	0	8	16	8	0	1	0	0	33
WSW	0	9	18	1	0	0	0	0	28
W	0	4	13	6	3	0	0	0	26
WNW	0	8	19	13	22	10	1	0	73
NW	0	12	27	12	8	8	0	0	67
NNW	0	4	35	10	0	0	0	0	49
N	0	15	32	10	0	0	0	0	57
VAR	0	12	5	1	0	0	0	0	18
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	13	13
TOTAL	0	163	345	144	53	25	1	13	744

TABLE 2.3-9

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, SEPTEMBER 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 9/74 AT WPPSS2 FOR 33

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	19	29	10	11	0	0	0	69
NE	0	21	11	5	2	0	0	0	39
ENE	0	20	20	0	0	0	0	0	40
E	0	17	7	0	0	0	0	0	24
ESE	0	15	11	1	0	0	0	0	27
SE	0	7	11	3	0	0	0	0	21
SSE	0	1	13	7	0	0	0	0	21
S	0	8	22	25	4	0	0	0	59
SSW	0	5	18	11	3	1	0	0	38
SW	0	12	11	3	3	0	0	0	29
WSW	0	8	5	3	1	0	0	0	17
W	0	12	10	10	4	0	0	0	36
WNW	0	9	12	17	12	5	1	0	56
NW	0	9	19	24	8	4	1	0	65
NNW	0	12	29	14	3	0	1	0	59
N	0	15	38	28	12	0	0	0	93
VAR	0	10	8	1	0	0	0	0	19
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	8	8
TOTAL	0	200	274	162	63	10	3	8	720

TABLE 2.3-10

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, OCTOBER 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 10/74 AT WPPSS2 FOR 33 F

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	26	15	1	0	0	0	0	42
NE	0	26	17	0	0	0	0	0	43
ENE	0	26	22	1	0	0	0	0	49
E	0	20	4	0	0	0	0	0	24
ESE	0	15	2	0	0	0	0	0	17
SE	0	15	19	2	0	0	0	0	36
SSE	0	16	21	8	0	0	0	0	45
S	0	13	25	13	0	0	0	0	51
SSW	0	15	21	6	0	0	0	0	42
SW	0	12	13	1	0	0	0	0	26
WSW	0	15	11	2	0	0	0	0	28
W	0	12	9	10	5	1	0	0	37
WNW	0	21	11	15	11	6	0	0	64
NW	0	17	17	12	7	0	0	0	53
NNW	0	29	20	9	2	0	0	0	60
N	0	37	24	3	0	0	0	0	64
VAR	0	16	4	0	0	0	0	0	20
CALM	1	0	0	0	0	0	0	0	1
UNKNO	0	0	0	0	0	0	0	42	42
TOTAL	1	331	255	83	25	7	0	42	744

TABLE 2.3-11

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, NOVEMBER 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 11/74 AT WPPSS2 FOR 33 F

		SPEED CLASS(MPH)							
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	18	14	4	0	0	0	2	38
NE	0	10	13	2	0	0	0	1	26
ENE	0	13	10	7	0	0	0	1	31
E	0	6	2	0	0	0	0	0	8
ESE	0	12	3	0	0	0	0	0	15
SE	0	14	13	7	0	0	0	0	34
SSE	0	7	28	15	3	0	0	0	53
S	0	12	29	29	5	0	0	0	75
SSW	0	11	32	14	19	1	0	0	77
SW	0	12	20	6	8	4	0	0	50
WSW	0	9	6	5	2	2	0	0	24
W	0	12	14	3	1	2	0	3	35
WNW	0	22	14	7	5	1	0	2	51
NW	0	27	34	12	0	1	0	1	75
NNW	0	24	34	2	0	0	0	0	60
N	0	30	17	3	0	0	0	0	50
VAR	0	11	2	0	0	0	0	0	13
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	5	5
TOTAL	0	250	285	116	43	11	0	15	720

TABLE 2.3-12

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, DECEMBER 1974

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 12/74 AT WPPSS2 FOR 33 F

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	12	3	2	0	0	0	0	17
NE	0	9	5	2	0	0	0	0	16
ENE	0	5	4	0	0	0	0	0	9
E	0	6	1	0	0	0	0	0	7
ESE	0	8	1	1	0	0	0	0	10
SE	0	9	6	5	1	0	0	0	21
SSE	0	5	26	25	3	1	0	0	60
S	0	11	39	35	14	1	0	0	100
SSW	0	14	23	29	9	4	3	0	82
SW	0	14	11	9	2	0	0	0	36
WSW	0	16	17	6	3	2	1	0	45
W	0	20	15	7	3	3	4	0	52
WNW	0	27	25	21	6	1	1	0	81
NW	0	17	59	11	3	0	0	1	91
NNW	0	29	27	6	0	0	0	0	62
N	0	21	12	0	1	0	0	0	34
VAR	0	8	3	1	0	0	0	0	12
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	9	9
TOTAL	0	231	277	160	45	12	9	10	744

TABLE 2.3-13

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, JANUARY 1975

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 1/75 AT WPPSS2 FOR 33 F

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	11	17	6	0	0	0	0	34
NE	0	13	11	4	0	0	0	0	28
ENE	0	10	12	5	0	0	0	6	33
E	0	5	10	1	0	0	0	2	18
ESE	0	15	5	2	0	0	0	1	23
SE	0	10	14	1	0	1	0	1	27
SSE	0	13	17	15	2	1	0	0	48
S	0	10	14	16	6	0	0	0	46
SSW	0	6	18	10	15	3	0	0	52
SW	0	15	14	5	7	4	2	1	48
WSW	0	13	16	4	3	6	3	0	45
W	0	8	8	8	4	0	0	0	28
WNW	0	23	14	13	0	0	0	1	51
NW	0	20	37	19	3	0	0	10	89
NNW	0	29	47	22	0	0	0	4	102
N	0	11	17	15	0	0	0	1	44
VAR	0	7	3	1	0	0	0	0	11
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	17	17
TOTAL	0	219	274	147	40	15	5	44	744

TABLE 2.3-14

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, FEBRUARY 1975

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 2/75 AT WPPSS2 FOR 33 F

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	15	15	2	0	0	0	0	32
NE	0	8	8	0	0	0	0	0	16
ENE	0	5	8	0	0	0	0	0	13
E	0	4	2	0	0	0	0	0	6
ESE	0	5	5	1	0	0	0	0	11
SE	0	6	10	3	1	0	0	0	20
SSE	0	14	20	13	4	1	0	0	52
S	0	14	11	18	8	2	0	0	53
SSW	0	9	8	10	9	18	1	0	55
SW	0	4	9	3	9	4	4	0	33
WSW	0	9	7	3	7	4	1	0	31
W	0	4	11	6	1	1	1	0	24
WNW	0	7	14	9	2	2	1	0	35
NW	0	12	54	45	10	3	2	0	126
NNW	0	14	45	24	14	0	0	0	97
N	0	16	19	19	1	0	0	0	55
VAR	0	5	2	1	0	0	0	0	8
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	5	5
TOTAL	0	151	248	157	66	35	10	5	672

TABLE 2.3-15

MONTHLY SUMMARIES OF JOINT FREQUENCY OF WINDS FOR WNP-2, MARCH 1975

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED DURING 3/75 AT WPPSS2 FOR 33 F

SPEED CLASS(MPH)

	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	6	8	5	2	0	0	0	21
NE	0	5	4	1	0	0	0	0	10
ENE	0	4	4	1	0	0	0	0	9
E	0	6	2	2	0	0	0	0	10
ESE	0	9	5	1	0	0	0	0	15
SE	0	2	6	7	3	0	0	0	18
SSE	0	5	24	22	3	0	0	0	54
S	0	3	28	35	13	0	0	0	79
SSW	0	1	15	24	16	6	0	0	62
SW	0	5	9	14	31	14	0	0	73
WSW	0	4	7	12	8	6	0	0	37
W	0	1	12	2	0	1	0	0	16
WNW	0	6	21	19	2	0	4	0	52
NW	0	13	32	27	6	1	4	0	83
NNW	0	9	37	23	12	5	0	0	86
N	0	11	18	6	9	0	0	0	44
VAR	0	7	5	0	0	0	0	0	12
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	63	63
TOTAL	0	97	237	201	105	33	8	63	744

TABLE 2.3-16a

SEASONAL PERCENT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION AT HMS VS. ATMOSPHERIC STABILITY USING TEMPERATURE DIFFERENCE BETWEEN 3 AND 200 FOOT LEVELS AND WINDS AT 200 FEET FOR THE PERIOD 1955-1970 (Windspeeds are in MPH in the left column.)

SEASON - SPRING

		NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VAR.	CALM	TOTAL
0 - 3	VS	0.15	0.13	0.09	0.14	0.21	0.23	0.16	0.13	0.14	0.21	0.15	0.38	0.27	0.31	0.27	0.22	0.14	0.23	3.55
	MS	0.08	0.11	0.08	0.10	0.17	0.20	0.07	0.08	0.08	0.08	0.07	0.14	0.09	0.10	0.14	0.12	0.08	0.08	1.86
	N	0.10	0.20	0.11	0.14	0.20	0.19	0.07	0.07	0.06	0.07	0.03	0.12	0.06	0.13	0.18	0.22	0.15	0.07	2.15
	U	0.51	0.70	0.39	0.46	0.29	0.31	0.12	0.20	0.16	0.14	0.11	0.14	0.17	0.30	0.36	0.67	0.50	0.01	5.56
4 - 7	VS	0.15	0.13	0.12	0.15	0.18	0.30	0.20	0.24	0.20	0.35	0.52	0.93	0.99	0.92	0.53	0.34	0.01	0.	6.25
	MS	0.08	0.12	0.10	0.16	0.18	0.33	0.16	0.18	0.15	0.19	0.27	0.44	0.37	0.37	0.23	0.22	0.01	0.	3.57
	N	0.06	0.10	0.07	0.13	0.12	0.25	0.13	0.11	0.07	0.08	0.10	0.13	0.18	0.21	0.16	0.10	0.02	0.	2.02
	U	1.00	1.03	0.69	0.61	0.52	0.71	0.46	0.60	0.56	0.65	0.38	0.40	0.58	1.28	1.19	1.27	0.23	0.	12.15
8 -12	VS	0.11	0.15	0.14	0.10	0.08	0.13	0.22	0.14	0.14	0.24	0.61	1.29	2.06	1.54	0.51	0.22	0.	0.	7.67
	MS	0.11	0.10	0.04	0.06	0.07	0.20	0.21	0.18	0.28	0.37	0.58	1.13	1.45	0.98	0.25	0.14	0.	0.	6.15
	N	0.07	0.04	0.05	0.05	0.06	0.10	0.10	0.06	0.09	0.14	0.18	0.18	0.31	0.39	0.10	0.08	0.	0.	1.98
	U	0.55	0.44	0.19	0.14	0.12	0.26	0.23	0.25	0.55	0.80	0.72	0.43	0.77	1.52	0.56	0.55	0.00	0.	8.08
13-18	VS	0.06	0.04	0.04	0.04	0.00	0.05	0.17	0.03	0.02	0.07	0.34	0.50	1.20	1.34	0.15	0.11	0.	0.	4.16
	MS	0.09	0.07	0.02	0.03	0.02	0.09	0.16	0.12	0.26	0.58	1.12	1.75	3.43	1.89	0.14	0.12	0.	0.	9.89
	N	0.09	0.02	0.01	0.01	0.01	0.05	0.05	0.08	0.10	0.20	0.29	0.21	0.39	0.38	0.04	0.04	0.	0.	1.95
	U	0.41	0.21	0.05	0.02	0.01	0.03	0.08	0.11	0.37	0.84	1.00	0.41	0.88	1.17	0.12	0.22	0.	0.	5.90
19-24	VS	0.	0.00	0.00	0.01	0.	0.01	0.02	0.01	0.	0.01	0.04	0.02	0.06	0.20	0.01	0.	0.	0.	0.38
	MS	0.05	0.02	0.01	0.01	0.00	0.04	0.08	0.07	0.18	0.51	0.72	0.45	1.99	1.36	0.03	0.02	0.	0.	5.52
	N	0.02	0.02	0.01	0.	0.	0.01	0.02	0.07	0.10	0.19	0.20	0.08	0.30	0.35	0.01	0.01	0.	0.	1.41
	U	0.12	0.06	0.01	0.01	0.	0.	0.01	0.04	0.26	0.63	0.72	0.21	0.52	0.75	0.02	0.04	0.	0.	3.40
OVER 24	VS	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.00	0.01	0.	0.00	0.	0.	0.	0.	0.	0.01
	MS	0.01	0.01	0.	0.	0.	0.	0.01	0.05	0.19	0.45	0.26	0.06	0.75	0.84	0.	0.01	0.	0.	2.62
	N	0.01	0.00	0.00	0.00	0.	0.	0.01	0.01	0.07	0.24	0.14	0.03	0.24	0.26	0.	0.	0.	0.	1.02
	U	0.02	0.03	0.02	0.	0.	0.	0.	0.02	0.17	0.84	0.59	0.14	0.33	0.56	0.01	0.01	0.	0.	2.73
TOTALS	VS	0.47	0.46	0.39	0.44	0.47	0.72	0.76	0.54	0.50	0.89	1.65	3.12	4.58	4.32	1.47	0.88	0.15	0.23	22.03
	MS	0.42	0.42	0.25	0.36	0.45	0.85	0.69	0.67	1.15	2.17	3.02	3.97	8.09	5.54	0.79	0.62	0.09	0.08	29.61
	N	0.35	0.38	0.24	0.33	0.39	0.61	0.37	0.40	0.48	0.91	0.95	0.75	1.48	1.72	0.48	0.45	0.17	0.07	10.54
	U	2.62	2.46	1.35	1.23	0.93	1.32	0.90	1.23	2.07	3.89	3.52	1.74	3.25	5.58	2.25	2.76	0.74	0.01	37.83

TABLE 2.4-16b
(sheet 2 of 5)

SEASON - SUMMER

		NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VAR.	CALM	TOTAL
0 - 3	VS	0.08	0.07	0.06	0.06	0.06	0.10	0.05	0.08	0.05	0.10	0.13	0.18	0.16	0.16	0.08	0.12	0.06	0.10	1.68
	MS	0,05	0.04	0,04	0.05	0.08	0,12	0,04	0,07	0.04	0.05	0.06	0,12	0,09	0.11	0,04	0,07	0,06	0,05	1,16
	N	0.10	0.10	0,09	0.12	0.10	0.15	0,07	0.06	0.07	0.06	0.08	0.07	0,07	0.11	0.10	0.15	0.10	0.05	1,64
	U	0,42	0,65	0,28	0.37	0.36	0,37	0,18	0,31	0.16	0.32	0.21	0,24	0,18	0.35	0,37	0,57	0,93	0,02	6,28
4 - 7	VS	0,14	0,13	0,10	0,13	0.12	0,21	0,14	0,11	0.13	0.18	0.35	0,78	0,81	0.51	0,38	0,21	0,01	0.	4,45
	MS	0.08	0.08	0.06	0.10	0.16	0.19	0.07	0.10	0.07	0.17	0.22	0.40	0.27	0.22	0.13	0.05	0.01	0.	2,38
	N	0,09	0,07	0,08	0.08	0.16	0,21	0,08	0,09	0.07	0.10	0.09	0,17	0,16	0.22	0,15	0,12	0.03	0.	1,98
	U	1,58	1,55	0,88	1,08	0,89	1,16	0,76	0,98	0,92	1,11	0.84	0,88	0,85	1.66	1,47	1,79	0,87	0.	19,27
8 -12	VS	0,14	0,16	0,09	0,09	0,11	0,08	0,16	0,09	0,06	0.13	0.49	1,18	2,04	1.28	0,44	0,18	0,	0.	6,71
	MS	0,09	0,10	0,03	0,09	0.11	0,12	0,10	0,05	0.06	0.19	0.48	1,25	1,49	0.63	0,13	0,12	0,	0.	5,04
	N	0.05	0.03	0.05	0.04	0.05	0.06	0.04	0.02	0.04	0.08	0.15	0.18	0.30	0.29	0.05	0.03	0.	0.	1.46
	U	0,78	0,54	0,20	0,18	0,18	0,23	0,15	0,22	0,53	1,21	1,06	0,62	0,99	1.95	0,66	0,66	0,01	0,	10,17
13-18	VS	0,04	0,04	0,02	0,03	0.	0,02	0,08	0,01	0,01	0,02	0,11	0,30	1,36	1.44	0,15	0,03	0.	0.	3,65
	MS	0,06	0,05	0,04	0,04	0,01	0,03	0,05	0,03	0,07	0,18	0,62	1,47	4,79	2,03	0,13	0,05	0.	0.	9,64
	N	0,02	0,02	0,01	0,01	0,00	0,02	0,03	0,03	0,03	0,10	0,29	0,24	0,44	0.36	0,02	0,02	0.	0.	1,64
	U	0,24	0,16	0,06	0,04	0,02	0,05	0,05	0,04	0,18	0,87	1,04	0,37	0,97	1,69	0,10	0,13	0.	0.	6,02
19-24	VS	0.	0,01	0,00	0.	0.	0,	0,	0.	0.	0.	0.01	0.	0,03	0.22	0,00	0.	0.	0.	0,27
	MS	0,02	0,03	0,02	0,01	0,00	0,00	0,01	0,02	0,03	0,09	0,18	0,29	2,77	2.70	0,02	0,01	0.	0.	6,19
	N	0,01	0,03	0,01	0,00	0.	0.	0,	0.	0,02	0,07	0,16	0,07	0,51	0.58	0,01	0,00	0.	0.	1,47
	U	0,05	0,07	0,01	0,01	0.	0.	0,02	0,02	0,07	0,27	0,45	0,15	0,48	1.27	0,02	0,01	0.	0.	2,89
OVER 24	VS	0.	0,00	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0,00	0.	0,	0.	0,	0.	0,01
	MS	0,00	0,01	0,	0,	0.	0,00	0,00	0,00	0,01	0,03	0,03	0,02	1,02	1.63	0,00	0.	0.	0.	2,77
	N	0,00	0,01	0.	0.	0.	0.	0,01	0,01	0,01	0,03	0,08	0,02	0,49	0.79	0,00	0.	0.	0.	1,44
	U	0,	0,03	0,01	0,	0,	0,	0,	0,	0,03	0,15	0,24	0,07	0,26	1.02	0,01	0.	0,	0,	1,80
TOTALS	VS	0,40	0,40	0,27	0,31	0,29	0,40	0,42	0,29	0,25	0,44	1,09	2,45	4,39	3,61	1,06	0,53	0,06	0,10	16,77
	MS	0,30	0,31	0,19	0,27	0,37	0,46	0,27	0,27	0,27	0,70	1,58	3,54	10,44	7.33	0,46	0,30	0,07	0,05	27,19
	N	0,29	0,25	0,23	0,25	0,32	0,44	0,23	0,21	0,23	0,43	0,85	0,76	1,96	2,35	0,33	0,31	0,12	0,05	9,62
	U	3,08	3,00	1,45	1,67	1,45	1,81	1,15	1,57	1.88	3,94	3.83	2,32	3,73	7.93	2,63	3,17	1,81	0,02	46,42

TABLE 2.3-16c
(sheet 3 of 5)

SEASON - FALL

		NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VAR.	CALM	TOTAL
0 - 3	VS	0.31	0.31	0.25	0.32	0.43	0.60	0.34	0.35	0.32	0.31	0.31	0.55	0.54	0.66	0.63	0.52	0.30	0.87	7.91
	MS	0.20	0.21	0.19	0.27	0.38	0.54	0.23	0.20	0.12	0.12	0.18	0.17	0.23	0.37	0.29	0.39	0.15	0.60	4.84
	N	0.37	0.43	0.38	0.41	0.40	0.51	0.21	0.16	0.15	0.11	0.08	0.13	0.16	0.35	0.46	0.37	0.16	0.39	5.24
	U	0.71	0.97	0.57	0.63	0.48	0.31	0.14	0.11	0.06	0.13	0.09	0.11	0.15	0.31	0.53	0.70	0.36	0.08	6.42
4 - 7	VS	0.28	0.23	0.17	0.18	0.28	0.50	0.47	0.43	0.38	0.49	0.67	1.20	1.53	1.48	0.92	0.49	0.02	0.	9.73
	MS	0.19	0.12	0.16	0.15	0.27	0.44	0.29	0.17	0.19	0.20	0.19	0.33	0.51	0.70	0.47	0.32	0.01	0.	4.71
	N	0.13	0.13	0.06	0.12	0.25	0.31	0.13	0.09	0.07	0.08	0.08	0.13	0.21	0.54	0.36	0.15	0.01	0.	2.85
	U	0.88	0.74	0.46	0.48	0.60	0.52	0.23	0.18	0.25	0.24	0.21	0.17	0.36	0.94	1.23	1.22	0.08	0.	8.81
8 -12	VS	0.17	0.08	0.06	0.06	0.04	0.17	0.31	0.11	0.13	0.32	0.68	1.50	2.49	2.37	0.77	0.27	0.	0.	9.55
	MS	0.10	0.05	0.03	0.03	0.10	0.23	0.27	0.16	0.22	0.43	0.48	0.76	1.26	1.45	0.41	0.13	0.	0.	6.10
	N	0.05	0.05	0.01	0.03	0.03	0.09	0.08	0.07	0.05	0.07	0.15	0.11	0.23	0.60	0.17	0.06	0.	0.	1.85
	U	0.45	0.26	0.05	0.03	0.05	0.11	0.04	0.08	0.17	0.28	0.35	0.20	0.32	1.11	0.56	0.44	0.00	0.	4.50
13-18	VS	0.06	0.03	0.01	0.02	0.00	0.05	0.10	0.03	0.02	0.08	0.25	0.43	1.54	1.93	0.21	0.04	0.	0.	4.79
	MS	0.09	0.05	0.00	0.02	0.01	0.09	0.15	0.18	0.31	0.63	0.87	0.97	2.18	1.85	0.17	0.12	0.	0.	7.70
	N	0.04	0.02	0.00	0.00	0.	0.04	0.04	0.07	0.09	0.14	0.21	0.11	0.26	0.37	0.09	0.05	0.	0.	1.55
	U	0.25	0.22	0.01	0.	0.	0.03	0.03	0.03	0.10	0.34	0.45	0.14	0.42	0.63	0.09	0.13	0.	0.	2.78
19-24	VS	0.	0.00	0.00	0.	0.	0.	0.01	0.01	0.01	0.01	0.04	0.03	0.09	0.19	0.	0.00	0.	0.	0.38
	MS	0.05	0.03	0.03	0.	0.00	0.01	0.05	0.18	0.27	0.57	0.54	0.24	0.99	1.04	0.03	0.02	0.	0.	4.04
	N	0.00	0.01	0.01	0.	0.	0.02	0.02	0.04	0.10	0.19	0.20	0.02	0.13	0.23	0.01	0.02	0.	0.	1.00
	U	0.04	0.03	0.01	0.	0.	0.	0.01	0.01	0.07	0.32	0.34	0.08	0.23	0.37	0.01	0.02	0.	0.	1.55
OVER 24	VS	0.	0.	0.	0.	0.	0.	0.	0.01	0.01	0.	0.00	0.	0.	0.	0.	0.	0.	0.	0.02
	MS	0.	0.01	0.	0.	0.	0.	0.02	0.08	0.30	0.43	0.21	0.07	0.31	0.40	0.01	0.	0.	0.	1.84
	N	0.01	0.01	0.00	0.	0.	0.	0.01	0.02	0.09	0.19	0.09	0.03	0.07	0.13	0.00	0.00	0.	0.	0.66
	U	0.01	0.05	0.01	0.	0.	0.	0.	0.01	0.09	0.39	0.24	0.07	0.09	0.21	0.01	0.	0.	0.	1.16
TOTALS	VS	0.83	0.66	0.49	0.58	0.76	1.32	1.22	0.94	0.87	1.21	1.95	3.70	6.18	6.63	2.52	1.32	0.32	0.87	32.38
	MS	0.63	0.46	0.40	0.46	0.76	1.32	1.02	0.98	1.40	2.38	2.48	2.53	5.49	5.82	1.37	0.97	0.16	0.60	29.24
	N	0.60	0.64	0.47	0.56	0.68	0.96	0.49	0.46	0.56	0.78	0.82	0.54	1.08	2.23	1.09	0.65	0.16	0.39	13.16
	U	2.34	2.17	1.10	1.14	1.13	0.97	0.45	0.42	0.75	1.71	1.69	0.77	1.57	3.56	2.43	2.50	0.44	0.08	25.23

TABLE 2.3-16d
(sheet 4 of 5)

SEASON — WINTER

		NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VAR.	CALM	TOTAL
0 - 3	VS	0,29	0.35	0.23	0.30	0.36	0,58	0,39	0,37	0.27	0.30	0.31	0.48	0,41	0.61	0,50	0,54	0,35	0.73	7,36
	MS	0.38	0.36	0.34	0.42	0.69	0.82	0,48	0.39	0.24	0.24	0.20	0.40	0,46	0.66	0,64	0.59	0,23	1.30	8,83
	N	0,62	0.64	0.51	0.66	0.74	0.91	0,55	0,32	0.23	0.22	0.21	0.39	0,45	0.75	0,89	0.91	0,14	1.42	10,56
	U	0.30	0.25	0.20	0.15	0.12	0.07	0,03	0,05	0.04	0.03	0.01	0.06	0,08	0.14	0,22	0.23	0,05	0,06	2,08
4 - 7	VS	0,29	0,21	0.16	0,21	0,22	0,33	0,30	0,36	0.25	0.36	0,48	0.93	0,99	1.10	0,92	0,53	0,06	0.	7,70
	MS	0,33	0.29	0.22	0.21	0.26	0,47	0,31	0.23	0.20	0.27	0.27	0.53	0,84	1.42	1,08	0.65	0,03	0.	7,62
	N	0,20	0.21	0.18	0.16	0.23	0,28	0,23	0,09	0.07	0.14	0.16	0,23	0,53	1.23	0,66	0.34	0,00	0.	4,93
	U	0,31	0,25	0,16	0,12	0,10	0,09	0,04	0,03	0,05	0,02	0.02	0,05	0,12	0.64	0,55	0.41	0,01	0.	2,96
8 -12	VS	0,09	0,05	0,03	0,03	0,05	0,13	0,15	0,12	0.13	0.29	0.59	0,95	1,41	1.79	0,70	0,15	0,	0.	6,67
	MS	0,15	0.07	0,03	0,06	0,11	0.30	0,19	0,13	0.25	0.36	0,45	0,69	1,67	3.10	0,72	0,18	0,00	0.	8,45
	N	0,07	0.06	0.03	0,01	0,03	0,09	0,06	0,03	0.05	0.07	0,08	0.10	0,86	1.87	0,28	0,09	0,	0.	3,78
	U	0,14	0.08	0,03	0,01	0.01	0,02	0,01	0,02	0.08	0.04	0.10	0,07	0,28	1.07	0,29	0,14	0,	0.	2,40
13-18	VS	0,05	0.03	0,	0.00	0.	0,04	0,04	0,05	0.09	0.19	0.31	0,51	0,89	1.41	0,17	0,03	0,	0.	3,81
	MS	0,15	0,05	0,01	0,01	0,05	0,08	0,16	0,26	0.36	0.78	0,88	0,76	1,73	3.16	0,29	0,12	0,	0.	8,85
	N	0,07	0.01	0,00	0.01	0.01	0,02	0,02	0,03	0.07	0.14	0.15	0,08	0,67	1.21	0,08	0,06	0,	0.	2,62
	U	0,13	0,03	0,00	0,00	0.	0.	0,00	0,01	0,08	0,10	0,20	0,11	0,26	0.44	0,06	0,08	0,	0.	1,51
19-24	VS	0,	0.	0.	0.	0.	0,01	0,02	0,01	0.04	0.07	0,05	0,05	0,08	0.12	0,00	0.	0,	0.	0,45
	MS	0,04	0.03	0.	0.	0.01	0,03	0,10	0,18	0,36	0.96	0.56	0,35	0,44	0.70	0,05	0,03	0,	0.	3,85
	N	0,03	0.01	0,	0.00	0.01	0.	0,01	0,03	0,09	0,14	0,12	0,03	0,07	0.18	0,01	0,06	0,	0.	0,79
	U	0,03	0,04	0,01	0.	0.	0.00	0,00	0,01	0.04	0,13	0,14	0,03	0,06	0.14	0,00	0,03	0,	0.	0,67
OVER 24	VS	0,	0.	0,	0.	0.	0,00	0,01	0,01	0,04	0,04	0.01	0,01	0,	0.	0,	0.	0,	0.	0,12
	MS	0,02	0,00	0,	0.	0.	0,02	0,06	0,21	0,69	0,99	0,41	0,11	0,12	0,13	0,01	0,02	0,	0.	2,79
	N	0,03	0.02	0,	0.	0.	0.	0,01	0,03	0.14	0.23	0.05	0,02	0,01	0.02	0,	0,03	0,	0.	0,61
	U	0,04	0,00	0,	0.	0.	0.	0.	0,01	0,08	0,20	0,16	0,02	0,01	0.04	0,00	0,01	0,	0.	0,57
TOTALS	VS	0,72	0,63	0,42	0,55	0,63	1,10	0,91	0,92	0,81	1,26	1,75	2,92	3,79	5,03	2,30	1,25	0,41	0,73	26,12
	MS	1,07	0,81	0,59	0,70	1,12	1,73	1,30	1,39	2,10	3,61	2,77	2,85	5,26	9,17	2,77	1,59	0,26	1,30	40,39
	N	1,02	0,96	0,72	0,83	1,01	1,30	0,87	0,52	0,66	0,93	0,77	0,85	2,60	5,26	1,93	1,49	0,14	1,42	23,29
	U	0,95	0,66	0,41	0,29	0,23	0,18	0,08	0,13	0,36	0,53	0,64	0,34	0,80	2,46	1,13	0,91	0,06	0,06	10,20

TABLE 2.3-16e
(sheet 5 of 5)

ANNUAL

		NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VAR.	CALM	TOTAL
0 - 3	VS	0.21	0.21	0.15	0.20	0.26	0.38	0.23	0.23	0.20	0.23	0.22	0.40	0.34	0.43	0.37	0.35	0.21	0.48	5.11
	MS	0.17	0.18	0.16	0.21	0.33	0.42	0.20	0.18	0.12	0.12	0.13	0.21	0.22	0.31	0.28	0.29	0.13	0.50	4.15
	N	0.30	0.34	0.27	0.33	0.36	0.44	0.22	0.15	0.13	0.11	0.10	0.18	0.18	0.33	0.41	0.41	0.13	0.48	4.87
	U	0.49	0.64	0.36	0.40	0.31	0.27	0.12	0.17	0.10	0.16	0.10	0.14	0.14	0.27	0.37	0.54	0.46	0.04	5.09
4 - 7	VS	0.21	0.18	0.14	0.17	0.20	0.33	0.28	0.28	0.24	0.35	0.50	0.96	1.08	1.00	0.69	0.39	0.02	0.	7.02
	MS	0.17	0.15	0.13	0.15	0.22	0.36	0.21	0.17	0.15	0.21	0.24	0.42	0.50	0.68	0.47	0.31	0.02	0.	4.56
	N	0.12	0.13	0.10	0.12	0.19	0.26	0.14	0.10	0.07	0.10	0.11	0.16	0.27	0.55	0.33	0.18	0.01	0.	2.94
	U	0.94	0.90	0.55	0.58	0.53	0.62	0.37	0.45	0.45	0.51	0.37	0.38	0.48	1.13	1.11	1.18	0.30	0.	10.84
8 - 12	VS	0.13	0.11	0.08	0.07	0.07	0.13	0.21	0.11	0.12	0.24	0.59	1.23	2.00	1.74	0.60	0.20	0.	0.	7.65
	MS	0.11	0.08	0.03	0.06	0.10	0.21	0.19	0.13	0.20	0.34	0.50	0.96	1.47	1.53	0.38	0.14	0.00	0.	6.43
	N	0.06	0.04	0.03	0.03	0.04	0.09	0.07	0.04	0.06	0.09	0.14	0.14	0.42	0.78	0.15	0.06	0.	0.	2.26
	U	0.48	0.33	0.12	0.09	0.09	0.15	0.11	0.14	0.34	0.59	0.56	0.33	0.59	1.42	0.52	0.45	0.00	0.	6.31
13-18	VS	0.05	0.03	0.02	0.02	0.00	0.04	0.10	0.03	0.03	0.09	0.25	0.43	1.25	1.53	0.17	0.05	0.	0.	4.10
	MS	0.10	0.05	0.02	0.02	0.02	0.07	0.13	0.15	0.25	0.54	0.87	1.24	3.04	2.23	0.18	0.10	0.	0.	9.03
	N	0.05	0.01	0.01	0.01	0.00	0.03	0.04	0.05	0.07	0.14	0.24	0.16	0.44	0.58	0.06	0.04	0.	0.	1.94
	U	0.26	0.13	0.03	0.01	0.01	0.03	0.04	0.05	0.18	0.54	0.68	0.26	0.64	0.98	0.09	0.14	0.	0.	4.07
19-24	VS	0.	0.00	0.00	0.00	0.	0.00	0.01	0.01	0.01	0.02	0.04	0.02	0.06	0.18	0.00	0.00	0.	0.	0.37
	MS	0.04	0.03	0.01	0.00	0.00	0.02	0.06	0.11	0.21	0.53	0.50	0.33	1.55	1.49	0.03	0.02	0.	0.	4.91
	N	0.02	0.02	0.00	0.00	0.00	0.01	0.01	0.03	0.08	0.15	0.17	0.05	0.25	0.34	0.01	0.02	0.	0.	1.17
	U	0.06	0.05	0.01	0.00	0.	0.00	0.01	0.02	0.11	0.34	0.41	0.12	0.32	0.63	0.01	0.03	0.	0.	2.13
OVER 24	VS	0.	0.00	0.	0.	0.	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.	0.	0.	0.	0.	0.04
	MS	0.01	0.01	0.	0.	0.	0.01	0.02	0.08	0.30	0.47	0.22	0.06	0.55	0.76	0.00	0.01	0.	0.	2.50
	N	0.01	0.01	0.00	0.00	0.	0.	0.01	0.02	0.08	0.17	0.09	0.03	0.21	0.30	0.00	0.01	0.	0.	0.93
	U	0.02	0.03	0.01	0.	0.	0.	0.	0.01	0.09	0.40	0.31	0.08	0.17	0.46	0.01	0.00	0.	0.	1.57
TOTALS	VS	0.60	0.54	0.39	0.47	0.53	0.88	0.83	0.67	0.61	0.95	1.61	3.05	4.73	4.89	1.83	1.00	0.23	0.48	24.29
	MS	0.60	0.50	0.36	0.45	0.67	1.08	0.82	0.83	1.22	2.21	2.46	3.23	7.33	6.96	1.34	0.87	0.14	0.50	31.57
	N	0.56	0.55	0.42	0.49	0.60	0.82	0.49	0.40	0.48	0.76	0.85	0.72	1.78	2.88	0.95	0.72	0.15	0.48	14.11
	U	2.25	2.08	1.08	1.09	0.94	1.07	0.65	0.84	1.27	2.53	2.43	1.30	2.35	4.90	2.11	2.34	0.77	0.04	30.03

TABLE 2.3-17

CLIMATOLOGICAL REPRESENTATIVENESS OF THE YEAR USED IN THE DIFFUSION COMPUTATIONS
(These data are based on climatological observations at the Hanford Meteorology Station located 14 miles northwest of the site)

Month	Insolation		50' Wind Speed		3' Average Air Temperature		Precipitation		Relative Humidity	
	1M	LT(23)	1M	LT(31)	1M	LT(59)	1M	LT(59)	1M	LT(30)
4-74	440ly	475ly	10.3 MPH	9.1 MPH	52.9 °F	53.2 °F	0.46"	0.40"	50.4%	46.5%
5-74	590	576	9.0	8.9	57.9	61.8	0.28	0.45	43.5	42.3
6-74	685	628	9.0	9.2	72.6	69.4	0.12	0.57	30.4	39.5
7-74	639	659	8.1	8.6	74.5	76.4	0.71	0.14	32.0	31.8
8-74	578	558	7.5	8.0	75.5	74.2	T	0.19	33.0	34.8
9-74	456	423	7.3	7.5	68.0	65.2	0.01	0.30	33.0	40.6
10-74	287	262	5.6	6.7	52.5	53.1	0.21	0.58	46.0	57.0
11-74	107	132	5.5	6.2	41.6	40.0	0.71	0.85	74.7	73.5
12-74	90	92	5.9	6.0	36.2	32.6	0.97	0.86	78.7	80.1
1-75	113	120	6.4	6.6	32.5	29.4	1.43	0.93	79.0	75.2
2-75	208	202	7.5	7.1	33.7	36.2	0.98	0.62	74.0	70.0
3-75	348	340	8.9	8.4	42.5	45.2	0.33	0.36	56.0	55.8
AVERAGE	378	372	7.6	7.7	53.4	53.1	6.21	6.25	52.6	53.9

KEY: LT(N) - long term for N years for entry
1M - single month as listed at left
T - Trace

TABLE 2.3-18

COMPARISON OF ONSITE AND LONG-TERM DIFFUSION ELEMENTS
(Annual Percent and Frequency of Occurrence)

Stability Classification	WNP-2 Onsite Data[a] (1 year)	Hanford Meteorology[b] Station (15 years)
Very Stable	17.74	24.29
Moderately Stable	38.47	31.58
Neutral	25.05	14.21
Unstable	17.74	30.01
Wind Direction	33'	50'
NNE	4.42	3.6
NE	4.22	3.4
ENE	3.07	2.1
E	2.38	2.4
ESE	2.56	2.6
SE	3.88	3.7
SSE	7.35	2.8
S	9.69	3.2
SSW	8.93	4.1
SW	6.11	7.2
WSW	5.07	8.5
W	5.89	9.8
WNW	9.65	16.0
NW	10.49	16.6
NNW	8.27	4.9
N	5.94	4.5
Var	2.04	2.4
Calm	0.01	2.2
Wind Speed (mph)		
Calm	0.01	2.20
1-3	23.73	25.43
4-7	39.63	33.30
8-12	23.09	23.89
13-18	9.47	11.58
19-24	3.05	4.45
25-up	0.75	1.36

(a) 4/74 to 3/75 winds at 33 ft, stability based on change in air temperature between 33 and 245 ft. Values normalized to 100% data.

(b) 1955-1970 winds at 50 ft, stability based on change in air temperature between 3 and 200 ft.

TABLE 2.3-19a

JOINT FREQUENCY TABLES BY PASQUILL STABILITY GROUPS FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FT LEVEL (TEMPERATURE CHANGE LESS THAN -2.1 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	2	0	1	0	0	0	3
NE	0	0	0	6	0	0	0	0	6
ENE	0	0	4	3	0	0	0	0	7
E	0	0	2	1	0	0	0	0	3
ESE	0	0	0	1	0	0	0	0	1
SE	0	0	1	2	0	0	0	0	3
SSE	0	0	3	3	1	0	0	0	7
S	0	0	0	9	5	3	0	0	17
SSW	0	0	1	2	5	0	0	0	8
SW	0	0	2	1	5	4	1	0	13
WSW	0	0	0	0	3	2	3	2	10
W	0	0	1	3	5	2	2	0	13
WNW	0	0	1	2	4	7	2	0	16
NW	0	0	1	1	3	3	4	0	12
NNW	0	0	2	6	2	1	1	0	12
N	0	0	2	1	3	0	0	0	6
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	6	7	5	0	0	2	20
TOTAL	0	0	28	48	42	22	13	4	157

Note: The speed class headings represent the following wind speeds.

Calm:	0 to 0.22 mph
1-3:	0.23 to 3.49 mph
4-7:	3.50 to 7.49 mph
8-12:	7.50 to 12.49 mph
13-18:	12.50 to 18.49 mph
19-24:	18.50 to 24.49 mph
25-up:	24.50 mph and up

TABLE 2.3-19b
(sheet 2 of 8)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED
FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FT LEVEL
(TEMPERATURE CHANGE LESS THAN -1.9 AND GREATER
THAN OR EQUAL -2.1 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	3	4	1	0	0	0	8
NE	0	0	4	3	0	0	0	0	7
ENE	0	0	0	0	0	0	0	0	0
E	0	1	1	1	0	0	0	0	3
ESE	0	0	3	3	0	0	0	0	6
SE	0	0	7	2	0	0	0	0	9
SSE	0	0	8	3	0	0	0	0	11
S	0	0	4	17	7	0	0	0	28
SSW	0	0	2	7	1	2	0	0	12
SW	0	0	3	3	2	1	0	0	9
WSW	0	1	3	3	1	3	1	1	13
W	0	1	11	4	7	0	0	0	23
WNW	0	0	5	2	8	3	2	0	20
NW	0	0	6	7	4	2	1	0	20
NNW	0	1	7	8	4	0	0	0	20
N	0	0	13	3	1	0	0	0	17
VAR	0	1	5	1	0	0	0	0	7
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	1	2	1	0	0	0	3	7
TOTAL	0	6	87	72	36	11	4	4	220

Note: The speed class headings represent the following wind speeds.

Calm: 0 to 0.22 mph
1-3: 0.23 to 3.49 mph
4-7: 3.50 to 7.49 mph
8-12: 7.50 to 12.49 mph
13-18: 12.50 to 18.49 mph
19-24: 18.50 to 24.49 mph
25-up: 24.50 mph and up

TABLE 2.3-19c
(sheet 3 of 8)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED
FROM 4/74 THROUGH 3/75 AT WPPSS2 for 33 FT LEVEL
(TEMPERATURE CHANGE LESS THAN -1.6 AND GREATER
THAN OR EQUAL -1.9 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	6	33	16	7	0	0	0	62
NE	0	4	14	5	1	0	0	0	24
ENE	0	0	12	12	0	0	0	0	24
E	0	1	5	7	0	0	0	0	13
ESE	0	2	13	2	0	0	0	0	17
SE	0	0	19	4	0	0	0	0	23
SSE	0	1	31	18	0	0	0	0	50
S	0	3	34	40	7	2	0	0	86
SSW	0	1	20	28	21	3	0	1	74
SW	0	2	22	12	15	5	0	1	57
WSW	0	4	13	17	12	4	1	0	51
W	0	2	19	20	14	3	1	1	60
WNW	0	3	16	5	6	5	1	0	36
NW	0	6	17	7	7	7	4	0	48
NNW	0	3	28	13	6	2	0	0	52
N	0	4	50	28	7	0	0	0	89
VAR	0	8	27	3	0	0	0	0	38
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	1	9	4	0	0	0	9	23
TOTAL	0	51	382	241	103	31	7	12	827

Note: The speed class headings represent
the following wind speeds.

Calm: 0 to 0.22 mph
1-3 : 0.23 to 3.49 mph
4-7 : 3.50 to 7.49 mph
8-12: 7.50 to 12.49 mph
13-18: 12.50 to 18.49 mph
19-24: 18.50 to 24.49 mph
25-up: 24.50 mph and up

TABLE 2.3-19d
(sheet 4 of 8)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED
FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FT LEVEL
(TEMPERATURE CHANGE LESS THAN -0.5 AND GREATER
THAN OR EQUAL -1.6 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	23	50	24	4	0	0	2	103
NE	0	20	26	12	1	2	0	0	61
ENE	0	19	38	14	0	0	0	1	72
E	0	17	28	9	0	0	0	1	55
ESE	0	32	31	4	0	0	0	1	68
SE	0	33	53	9	4	0	0	1	100
SSE	0	24	88	30	3	0	0	0	145
S	0	24	74	91	34	2	0	1	226
SSW	0	35	68	95	69	10	3	7	287
SW	0	31	34	42	42	23	4	1	177
WSW	0	22	34	22	20	11	1	0	110
W	0	20	36	29	30	11	6	3	135
WNW	0	37	53	53	43	32	7	1	226
NW	0	33	84	59	39	23	5	9	252
NNW	0	43	93	48	15	2	0	2	203
N	0	33	59	52	12	0	0	0	156
VAR	0	22	22	1	0	0	0	0	45
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	3	3	4	0	0	0	5	15
TOTAL	0	471	874	598	316	116	26	35	2436

Note: The speed class headings represent the following wind speeds.

Calm:	0 to 0.22 mph
1-3 :	0.23 to 3.49 mph
4-7 :	3.50 to 7.49 mph
8-12:	7.50 to 12.49 mph
13-18:	12.50 to 18.49 mph
19-24:	18.50 to 24.49 mph
25-up:	24.50 mph and up

TABLE 2.3-19e
(sheet 5 of 8)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED
FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FT LEVEL
(TEMPERATURE CHANGE LESS THAN 1.6 AND GREATER
THAN OR EQUAL -0.5 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	25	12	2	0	0	0	0	39
NE	0	22	31	1	0	0	0	2	56
ENE	0	16	25	0	0	0	0	3	44
E	0	14	18	2	0	0	0	1	35
ESE	0	26	15	4	0	0	0	0	45
SE	0	23	39	22	2	1	0	0	87
SSE	0	31	69	74	11	3	0	1	189
S	0	38	67	66	29	1	0	0	201
SSW	0	22	59	48	45	28	3	5	210
SW	0	19	57	25	31	6	2	3	143
WSW	0	24	44	41	12	6	3	3	133
W	0	32	51	52	15	3	0	2	155
WNW	0	50	62	103	82	24	6	1	348
NW	0	33	121	115	32	5	0	0	306
NNW	0	43	82	43	7	0	0	3	178
N	0	38	35	9	1	0	0	1	84
VAR	0	14	9	3	1	0	0	0	27
CALM	1	0	0	0	0	0	0	0	1
UNKNO	0	1	6	6	1	0	0	11	25
TOTAL	1	471	822	616	269	77	14	36	2306

Note: The speed class headings represent the following wind speeds.

Calm:	0 to 0.22 mph
1-3:	0.23 to 3.49 mph
4-7:	3.50 to 7.49 mph
8-12:	7.50 to 12.49 mph
13-18:	12.50 to 18.49 mph
19-24:	18.50 to 24.49 mph
25-up:	24.50 mph and up

TABLE 2.3-19f
(sheet 6 of 8)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FT LEVEL (TEMPERATURE CHANGE LESS THAN 4.4 AND GREATER THAN OR EQUAL 1.6 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	34	28	3	0	0	0	0	65
NE	0	15	20	2	3	0	0	1	41
ENE	0	21	16	2	0	0	0	3	42
E	0	19	6	0	0	0	0	0	25
ESE	0	16	16	0	0	0	0	0	32
SE	0	17	40	10	0	0	0	0	67
SSE	0	17	76	36	1	0	0	0	130
S	0	20	63	47	9	0	0	5	144
SSW	0	20	68	35	8	0	0	0	131
SW	0	20	32	9	3	0	0	1	65
WSW	0	29	35	7	0	0	0	0	71
W	0	20	32	26	2	0	0	5	85
WNW	0	33	39	43	1	0	0	2	118
NW	0	34	64	25	1	0	0	3	127
NNW	0	31	76	8	0	0	0	1	116
N	0	38	33	1	0	0	0	0	72
VAR	0	22	7	0	0	0	0	0	29
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	1	4	0	0	0	0	10	15
TOTAL	0	407	655	254	28	0	0	31	1375

Note: The speed class headings represent the following wind speeds.

Calm: 0 to 0.22 mph
1-3: 0.23 to 3.49 mph
4-7: 3.50 to 7.49 mph
8-12: 7.50 to 12.49 mph
13-18: 12.50 to 18.49 mph
19-24: 18.50 to 24.49 mph
25-up: 24.50 mph and up

TABLE 2.3-19g
(sheet 7 of 8)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED
FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FT LEVEL
(TEMPERATURE CHANGE GREATER THAN
OR EQUAL 4.4 DEGREES F PER 200 FT)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	53	35	1	0	0	0	0	89
NE	0	69	29	2	0	0	0	0	100
ENE	0	47	22	0	0	0	0	0	69
E	0	44	6	0	0	0	0	0	50
ESE	0	36	9	0	0	0	0	0	45
SE	0	15	21	0	0	0	0	0	36
SSE	0	18	46	18	0	0	0	2	84
S	0	21	51	41	0	0	0	2	115
SSW	0	18	23	12	1	0	0	0	54
SW	0	27	19	4	0	0	0	1	51
WSW	0	21	13	4	0	0	0	1	39
W	0	13	11	2	0	0	0	0	26
WNW	0	25	19	3	0	0	0	1	48
NW	0	44	53	13	0	0	0	1	111
NNW	0	52	58	3	0	0	0	0	113
N	0	63	39	1	0	0	0	0	103
VAR	0	23	3	0	0	0	0	0	26
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	1	0	0	0	0	10	11
TOTAL	0	589	458	104	1	0	0	18	1170

Note: The speed class headings represent the following wind speeds.

Calm:	0 to 0.22 mph
1-3:	0.23 to 3.49 mph
4-7:	3.50 to 7.49 mph
8-12:	7.50 to 12.49 mph
13-18:	12.50 to 18.49 mph
19-24:	18.50 to 24.49 mph
25-up:	24.50 mph and up

TABLE 2.3-19h
(sheet 8 of 8)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED
FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FT LEVEL
(TEMPERATURE CHANGE IN DEGREES F PER 200 FT UNKNOWN)

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	3	0	0	0	0	0	3
NE	0	1	3	1	0	0	0	0	5
ENE	0	0	2	0	0	0	0	0	2
E	0	2	3	0	0	0	0	0	5
ESE	0	1	1	0	0	0	0	0	2
SE	0	0	1	1	0	0	0	0	2
SSE	0	1	2	0	0	0	0	0	3
S	0	0	0	2	0	0	0	0	2
SSW	0	0	0	2	1	0	0	0	3
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	1	0	0	0	0	0	1
W	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0
NW	0	0	3	1	2	1	0	0	7
NNW	0	1	0	0	0	0	0	0	1
N	0	1	0	1	0	0	0	0	2
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	3	7	4	3	0	0	214	231
TOTAL	0	10	26	12	6	1	0	214	269

Note: The speed class headings represent the following wind speeds.

Calm:	0 to 0.22 mph
1-3 :	0.23 to 3.49 mph
4-7 :	3.50 to 7.49 mph
8-12:	7.50 to 12.49 mph
13-18:	12.50 to 18.49 mph
19-24:	18.50 to 24.49 mph
25-up:	24.50 mph and up

TABLE 2.3-20

COMPARISON OF MONTHLY AVERAGE AND
EXTREMES OF HOURLY AVERAGE AIR TEMPERATURES

	WNP-2 (1)			HMS (3')			
	One Year of Data			One Year of Data	Long-Term Summary (2)		
	Average	Max	Min	Average	Average	Max	Min
Jan	32.3	55.4	18.1	32.0	29.4	66	-23
Feb	33.8	60.4	12.8	33.6	36.2	71	-23
Mar	41.9	64.8	21.8	42.0	45.2	83	26
Apr	52.2	76.2	35.1	52.5	53.2	95	12
May	57.4	84.8	36.9	57.9	61.8	103	28
Jun	72.5	103.5	45.9	73.3	69.4	110	33
Jul	73.6	104.5	49.6	74.8	76.4	115	41
Aug	74.7	103.8	50.6	76.3	74.2	113	40
Sep	66.9	91.5	45.9	68.3	65.2	102	25
Oct	51.7	80.8	31.7	52.0	53.1	90	6
Nov	42.1	60.5	24.7	42.1	40.0	73	-1
Dec	33.8	59.6	20.8	35.7	32.6	68	-27
YEAR	53.5 (°F)	104.5	12.8	53.5	53.1	115	-27

(1) One year of data at 7', 4/74 to 3/75. All values are hourly averages.
(2) Surface air temperature observations at Hanford townsite and HMS for period 1912-1970. Maximums and minimums are observed values.

TABLE 2.3-21

COMPARISON OF MONTHLY
AVERAGES OF WET BULB TEMPERATURES

	WNP-2 One Year(1)	HMS One Year(2)	HMS Long Term(3)
Jan	30.3	30.0	27.9
Feb	30.9	31.0	33.6
Mar	36.2	36.0	37.3
Apr	44.7	43.9	42.8
May	47.2	46.5	49.1
Jun	56.0	54.5	54.5
Jul	57.4	41.0	42.3
Aug	58.0	43.2	42.8
Sep	52.6	52.0	52.6
Oct	43.8	42.0	45.4
Nov	39.3	38.0	36.4
Dec	34.5	33.0	31.2
YEAR	44.3 (°F)	43.4	43.8

(1) One year of WNP-2 data at 33', 4/74 to 3/75.
(2) One year of HMS data at 3', 4/74 to 3/75.
(3) 20 years of HMS data at 3', 1950-1970.

TABLE 2.3-22a

FREQUENCY OF OCCURRENCE OF WET BULB VALUES
A FUNCTION OF TIME OF DAY BASED ON WNP-2 SITE DATA 4/74 - 3/75
(Wet Bulb intervals are given in the left column in °F.)

TIME OF DAY

	1	2	3	4	5	6	7	8	9	10	11	12	13
-20	0	0	0	0	0	0	0	0	0	0	0	0	0
-20 -15	0	0	0	0	0	0	0	0	0	0	0	0	0
-15 -10	0	0	0	0	0	0	0	0	0	0	0	0	0
-10 - 5	0	0	0	0	0	0	0	0	0	0	0	0	0
- 5 0	0	0	0	0	0	0	0	0	0	0	0	0	0
0 5	0	0	0	0	0	0	0	0	0	0	0	0	0
5 10	0	0	0	0	0	0	0	0	0	0	0	0	0
10 15	2	2	2	1	1	1	1	2	1	1	1	0	0
15 20	1	2	4	7	9	8	9	8	5	3	3	3	3
20 25	14	15	18	14	14	16	18	15	9	8	8	6	6
25 30	35	33	35	42	41	43	41	34	30	24	14	10	7
30 35	44	51	46	47	50	45	42	37	32	33	39	43	33
35 40	54	51	58	57	60	67	60	51	44	41	45	39	50
40 45	73	73	65	65	61	56	53	55	52	51	52	50	45
45 50	43	44	52	54	51	47	51	47	39	49	51	54	52
50 55	48	50	49	48	51	51	38	39	43	42	39	44	49
55 60	39	33	27	23	18	23	39	41	36	38	49	50	50
60 65	8	6	5	3	4	3	8	18	23	33	39	43	46
65 70	0	1	0	0	0	0	0	0	3	5	6	8	12
70 75	0	0	0	0	0	0	0	0	0	0	0	0	0
75 80	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0
UNKNO	4	4	4	4	5	5	5	18	48	37	19	15	12
TOTAL	365	365	365	365	365	365	365	365	365	365	365	365	365

AVERAGE FOR HOUR

41,458 40,579 40,262 42,287 45,282 46,998

41,852 40,930 40,166 41,040 43,750 46,103 4',662

TABLE 2.3-22b
(sheet 2 of 2)

TIME OF DAY

	14	15	16	17	18	19	20	21	22	23	24	TOTAL
-20	0	0	0	0	0	0	0	0	0	0	0	0
-20-15	0	0	0	0	0	0	0	0	0	0	0	0
-15-10	0	0	0	0	0	0	0	0	0	0	0	0
-10- 5	0	0	0	0	0	0	0	0	0	0	0	0
- 5 0	0	0	0	0	0	0	0	0	0	0	0	0
0 5	0	0	0	0	0	0	0	0	0	0	0	0
5 10	0	0	0	0	0	0	0	0	0	0	0	0
10 15	0	0	0	0	1	1	1	1	2	2	2	25
15 20	3	2	2	2	1	1	3	4	2	2	1	88
20 25	6	6	5	7	8	10	9	8	10	9	12	251
25 30	7	7	10	11	14	16	18	23	26	35	39	597
30 35	26	24	28	31	35	41	46	47	55	47	44	965
35 40	49	51	50	50	52	48	46	48	44	56	49	1220
40 45	53	51	51	48	44	48	50	62	56	57	65	1336
45 50	50	52	48	47	49	52	55	43	52	44	52	1178
50 55	49	52	51	51	43	42	49	55	48	49	44	1124
55 60	52	47	46	44	51	46	39	45	46	48	44	974
60 65	47	45	44	45	44	41	35	22	19	11	9	601
65 70	15	21	24	23	17	14	9	4	1	1	0	164
70 75	0	0	0	0	0	0	0	0	0	0	0	0
75 80	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
UNKND	8	7	6	6	6	3	3	3	4	4	4	234
TOTAL	365	365	365	365	365	365	365	365	365	365	365	8760

AVERAGE FOR HOUR

48,166 48,279 47,205 45,191 43,472 42,290

48,430 47,950 46,198 44,272 42,846 44,266

TABLE 2.3-23

MONTHLY AVERAGES OF PSYCHROMETRIC DATA BASED ON PERIOD OF RECORD 1950-70

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
AVERAGES													
Dry Bulb	30.3	37.5	44.0	52.5	61.8	69.9	77.5	75.3	67.0	53.2	40.1	33.4	53.5
Wet Bulb	27.9	33.6	37.3	42.8	49.1	54.5	57.9	57.3	52.6	45.4	36.4	31.2	43.8
Rel. Hum.	76.0	69.7	55.0	46.4	41.8	39.4	31.5	34.9	39.9	57.7	72.6	80.8	53.8
Dewpoint	23.2	27.4	27.3	30.4	36.0	41.2	42.3	42.8	39.5	36.9	31.1	27.5	33.8
DRY BULB MONTHLY AVERAGE EXTREMES													
Highest	43.0	44.0	48.7	56.2	68.7	75.5	82.8	82.5	72.0	59.1	45.8	38.8	56.3
Year	1953	1958	1963	1956	1958	1969	1960	1967	1967	1952	1954	1953	1958
Lowest	12.9	25.8	39.6	48.3	57.2	64.2	73.2	70.6	61.6	50.3	32.3	26.5	51.0
Year	1950	1956	1955	1955	1962	1953	1963	1964	1970	1968	1955	1964	1955+
WET BULB MONTHLY AVERAGE EXTREMES													
Highest	39.3	40.7	40.8	45.1	54.6	58.6	61.2	61.1	56.5	47.7	42.3	35.8	46.5
Year	1953	1958	1968	1962	1958	1958	1958	1961	1963	1962	1954	1966	1958
Lowest	12.4	23.4	32.9	39.3	45.4	51.4	55.6	54.9	48.3	42.4	29.6	25.0	41.8
Year	1950	1956	1955	1955	1959	1954	1954	1964	1970	1960	1955	1964	1955
REL. HUM. MONTHLY AVERAGE EXTREMES													
Highest	89.0	87.0	66.0	64.0	*52.0	54.0	40.0	44.0	55.0	74.0	80.0	90.0	58.0
Year	1960	1963	1950	1963	1962+	1950	1955	1968	1959	1962	1956	1950	1950+
Lowest	60.0	54.0	44.0	37.0	31.0	34.0	22.0	24.0	34.0	42.0	64.0	69.0	49.0
Year	1963	1967	1965	1966	1966	1960	1959	1967	1952	1952	1963+	1968	1967
DEWPOINT MONTHLY AVERAGE EXTREMES													
Highest	34.4	36.7	34.0	37.1	43.8	47.5	46.6	46.9	45.4	43 5	38.3	34.3	37.7
Year	1953	1958	1961	1953	1957	1958	1958	1961	1963	1962	1954	1950	1958
Lowest	6.5	17.3	20.8	26.2	30.4	37.5	35.4	38.4	33.8	32.1	24.0	21.0	31.5
Year	1950	1956	1965+	1955	1964	1954	1959	1955	1970	1970	1959	1951	1955

+ Also in earlier years
* Although not included in these tables, an average of 63% was recorded in 1943

TABLE 2.3-24

MISCELLANEOUS SNOWFALL STATISTICS: 1946 THROUGH 1970

	Oct	Nov	Dec	Jan	Feb	Mar	Season
AVERAGE NUMBER OF DAYS WITH DEPTH AT 0400 PST							
1" or More	0	1	5	10	5	*	21
3" or More	0	1	2	5	3	0	11
6" or More	0	0	1	3	1	0	5
12" or More	0	0	*	*	0	0	*
RECORD GREATEST NUMBER OF DAYS WITH DEPTH AT 0400 PST							
1" or More	0	(1955) 11	(1964+) 17	(1969) 31	(1950) 17	(1951) 3	(1955-56) 54
3" or More	0	(1955) 10	(1955) 14	(1969) 23	(1950) 16	0	(1949-50) 33
6" or More	0	0	(1964) 12	(1965) 23	(1969+) 8	0	(1949-50) 23
12" or More	0	0	(1964) 4	(1969) 1	0	0	(1964-65) 4
RECORD GREATEST DEPTH							
	(1957) 0.3	(1946) 5.1	(1964) 12.1	(1969) 12.0	(1969) 10.0	(1957) 2.3	(Dec 1964) 12.1
GREATEST IN 24 HOURS							
	(1957) 0.3	(1955) 4.8	(1965) 5.4	(1954) 7.1	(1959) 5.2	(1957+) 2.2	(Jan 1954) 7.1
AVERAGE PERCENT OF WATER EQUIVALENT OF ALL PRECIPITATION							
	2	14	46	48	29	14	26

( ) Denotes year of occurrence
\+ Denotes also in earlier years
* Denotes less than 1/2 day

TABLE 2.3-25

AVERAGE RETURN PERIOD (R) AND EXISTING RECORD (ER) FOR VARIOUS PRECIPITATION AMOUNTS AND INTENSITY DURING SPECIFIED TIME PERIODS AT HANFORD (BASED ON EXTREME VALUE ANALYSIS OF 1947-1969 RECORDS)

	AMOUNT (INCHES) TIME PERIOD							INTENSITY (INCHES PER HOUR) TIME PERIOD						
R (Years)	20 Min	60 Min	2 Hrs	3 Hrs	6 Hrs	12 Hrs	24 Hrs	20 Min	60 Min	2 Hrs	3 Hrs	6 Hrs	12 Hrs	24 Hrs
2	0.16	0.26	0.30	0.36	0.48	0.62	0.72	0.49	0.26	0.15	0.12	0.08	0.052	0.030
5	0.24	0.40	0.48	0.55	0.77	0.95	1.06	0.72	0.40	0.24	0.18	0.13	0.079	0.044
10	0.37	0.50	0.59	0.67	0.96	1.17	1.28	1.1	0.50	0.30	0.22	0.16	0.098	0.053
25	0.47	0.62	0.74	0.83	1.21	1.45	1.56	1.4	0.62	0.37	0.28	0.20	0.121	0.065
50	0.53	0.72	0.85	0.96	1.40	1.66	1.77	1.6	0.72	0.42	0.32	0.23	0.138	0.074
100	0.60	0.81	0.96	1.07	1.59	1.87	1.99	1.8	0.81	0.48	0.36	0.27	0.156	0.083
250	0.68	0.93	1.11	1.22	1.82	2.13	2.26	2.0	0.93	0.55	0.41	0.30	0.177	0.094
500	0.73	1.02	1.22	1.33	2.00	2.34	2.47	2.2	1.02	0.61	0.44	0.33	0.195	0.103
1000	0.80	1.11	1.33	1.45	2.20	2.55	2.63	2.4	1.11	0.67	0.48	0.37	0.212	0.112
ER	*	0.59	0.88	1.08	1.68	1.88	1.91	*	0.59	0.44	0.36	0.28	0.157	0.080
		6/12	10/1	10/1	10/1-2	10/1-2	10/1-2		6/12	10/1	10/1	10/1-2	10/1-2	10/1-2
DATE	--	1969	1957	1957	1957	1957	1957	--	1969	1957	1957	1957	1957	1957

* No records have been kept for time periods of less than 60 minutes. However, the rain gage chart for 6-12-69 shows that 0.55 inch occurred during a 20-minute period from 1835 to 1855 PST. An additional 0.04 inch occurred between 1855 and 1910 to account for the record 60-minute amount of 0.59 inch.

TABLE 2.3-26a

WNP-2 ONSITE JOINT FREQUENCY DISTRIBUTION OF WINDS FOR RAIN INTENSITY CLASSES, RAIN INTENSITY GREATER THAN OR EQUAL TO .016 INCHES PER HOUR

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	2	2	0	0	0	0	0	4
NE	0	2	3	0	0	0	0	0	5
ENE	0	2	1	0	0	0	0	0	3
E	0	1	4	0	0	0	0	0	5
ESE	0	7	2	0	0	0	0	0	9
SE	0	1	1	2	1	0	0	0	5
SSE	0	4	6	6	4	1	0	0	21
S	0	3	3	5	0	0	0	0	11
SSW	0	3	3	4	3	1	0	0	14
SW	0	1	3	4	1	0	0	0	9
WSW	0	1	2	1	0	1	0	0	5
W	0	0	3	2	0	0	1	0	6
WNW	0	0	5	7	0	0	0	0	12
NW	0	5	10	5	1	0	0	0	21
NNW	0	2	10	2	0	0	0	0	14
N	0	0	1	0	0	0	0	0	1
VAR	0	2	1	0	0	0	0	0	3
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	1	1
TOTAL	0	36	60	38	10	3	1	1	149

TABLE 2.3-26b

WNP-2 ONSITE JOINT FREQUENCY DISTRIBUTION OF WINDS FOR RAIN INTENSITY CLASSES, RAIN INTENSITY GREATER THAN OR EQUAL TO 0.50 INCHES PER HOUR

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	1	1	0	0	0	0	0	2
NE	0	1	0	0	0	0	0	0	1
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	1	0	0	0	0	1
SSE	0	0	0	3	2	0	0	0	5
S	0	0	0	0	0	0	0	0	0
SSW	0	0	0	2	0	0	0	0	2
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	0	1	0	0	0	0	1
W	0	0	0	1	0	0	0	0	1
WNW	0	0	2	0	0	0	0	0	2
NW	0	0	1	3	0	0	0	0	4
NNW	0	0	1	1	0	0	0	0	2
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	0	0
TOTAL	0	2	5	12	2	0	0	0	21

TABLE 2.3-26c
(sheet 2 of 3)

WNP-2 ONSITE JOINT FREQUENCY DISTRIBUTION
OF WINDS FOR RAIN INTENSITY CLASSES, RAIN INTENSITY
GREATER THAN OR EQUAL TO .100 INCHES PER HOUR

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0

TABLE 2.3-26d

WNP-2 ONSITE JOINT FREQUENCY DISTRIBUTION
OF WINDS FOR RAIN INTENSITY CLASSES, RAIN INTENSITY
GREATER THAN OR EQUAL TO .016 INCHES PER HOUR

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	0	0	0	0	0
S	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0		0	0	0
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0	0	0
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0

TABLE 2.3-26e
(sheet 3 of 3)

WNP-2 ONSITE JOINT FREQUENCY DISTRIBUTION OF WINDS FOR RAIN INTENSITY CLASSES, RAIN INTENSITY GREATER THAN OR EQUAL TO .500 INCHES PER HOUR

	SPEED CLASS(MPH)								
	CALM	1-3	4-7	8-12	13-18	19-24	25-UP	UNKNO	TOTAL
NNE	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0
ENE	0	0	0	0	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0
ESE	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0
SSE	0	0	0	0	1	0	0	0	1
S	0	0	0	0	0	0	0	0	0
SSW	0	0	0	0	0	0	0	0	0
SW	0	0	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0	0	0
W	0	0	0	0	0	0	0	0	0
WNW	0	0	1	0	0	0	0	0	1
NW	0	0	0	0	0	0	0	0	0
NNW	0	0	0	1	0	0	0	0	1
N	0	0	0	0	0	0	0	0	0
VAR	0	0	0	0	0	0	0	0	0
CALM	0	0	0	0	0	0	0	0	0
UNKNO	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	1	1	0	0	0	3

TABLE 2.3-27

MONTHLY AND ANNUAL PREVAILING DIRECTIONS, AVERAGE SPEEDS, AND PEAK GUSTS: 1945-1970 AT HMS (50 foot level)

							PEAK GUST		
MONTH	PREVIOUS DENSITY	AVERAGE SPEED	HIGHEST AVERAGE	YEAR	LOWEST AVERAGE	YEAR	SPEED	DENSITY	YEAR
Jan	NW	6.4	9.6*	1953	3.1	1955	65**	S	1967
Feb	NW	7.0	9.4	1961	4.6	1963	63	SW	1965
Mar	WNW	8.4	10.7	1964	5.9	1958	70	SW	1956
Apr	WNW	9.0	11.1	1959	7.4	1958	60	WSW	1969
May	WNW	8.8	10.5	1965+	5.8	1957	71	SSW	1948
Jun	WNW	9.2	10.7	1949	7.7	1950+	72	SW	1957
Jul	WNW	8.6	9.6	1963	6.8	1955	55	WSW	1968
Aug	WNW	8.0	9.1	1946	6.0	1956	66	SW	1961
Sep	WNW	7.5	9.2	1961	5.4	1957	65	SSW	1953
Oct	WNW	6.7	9.1	1946	4.4	1952	63	SSW	1950
Nov	NW	6.2	7.9	1945	2.9	1956	64	SSW	1949
Dec	NW	6.0	8.3	1968	3.9	1963+	71	SW	1955
YEAR	WNW	7.6	8.3	1968+	6.3	1957	72**	SW	1957 (Jun)

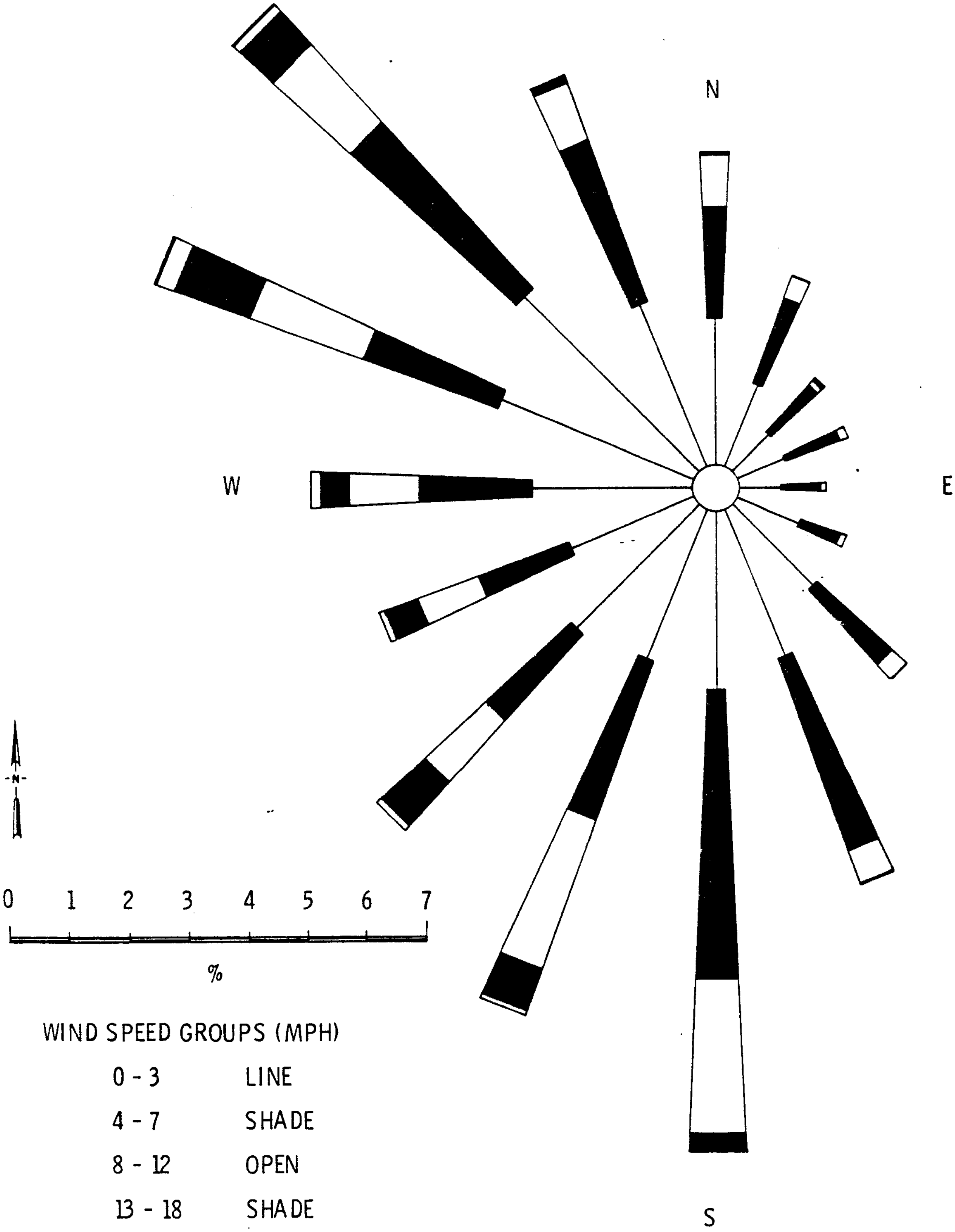
* The average speed for January, 1972, was 10.3 mph.
** On January 11, 1972, a new all-time record peak gust of 80 mph was established.

TABLE 2.3-28

MONTHLY MEANS OF DAILY MIXING HEIGHT AND AVERAGE WIND SPEED[a]

	Average Daily Minimum (Morning)		Average Daily Maximum (Afternoon)	
	Meters	Meters/sec	Meters	Meters/sec
January	302	4.8	295	4.6
February	341	4.8	658	5.3
March	388	5.6	1331	5.6
April	350	5.4	1966	6.7
May	288	4.7	2243	5.9
June	263	4.3	2440	5.7
July	208	3.9	2703	5.2
August	235	4.1	2439	4.8
September	189	3.6	1922	4.9
October	192	3.8	1076	5.2
November	300	4.3	505	4.6
December	367	4.5	316	4.6

a. Spokane, WA, Radisonde Data, Period of Record 1/60 - 12/64.

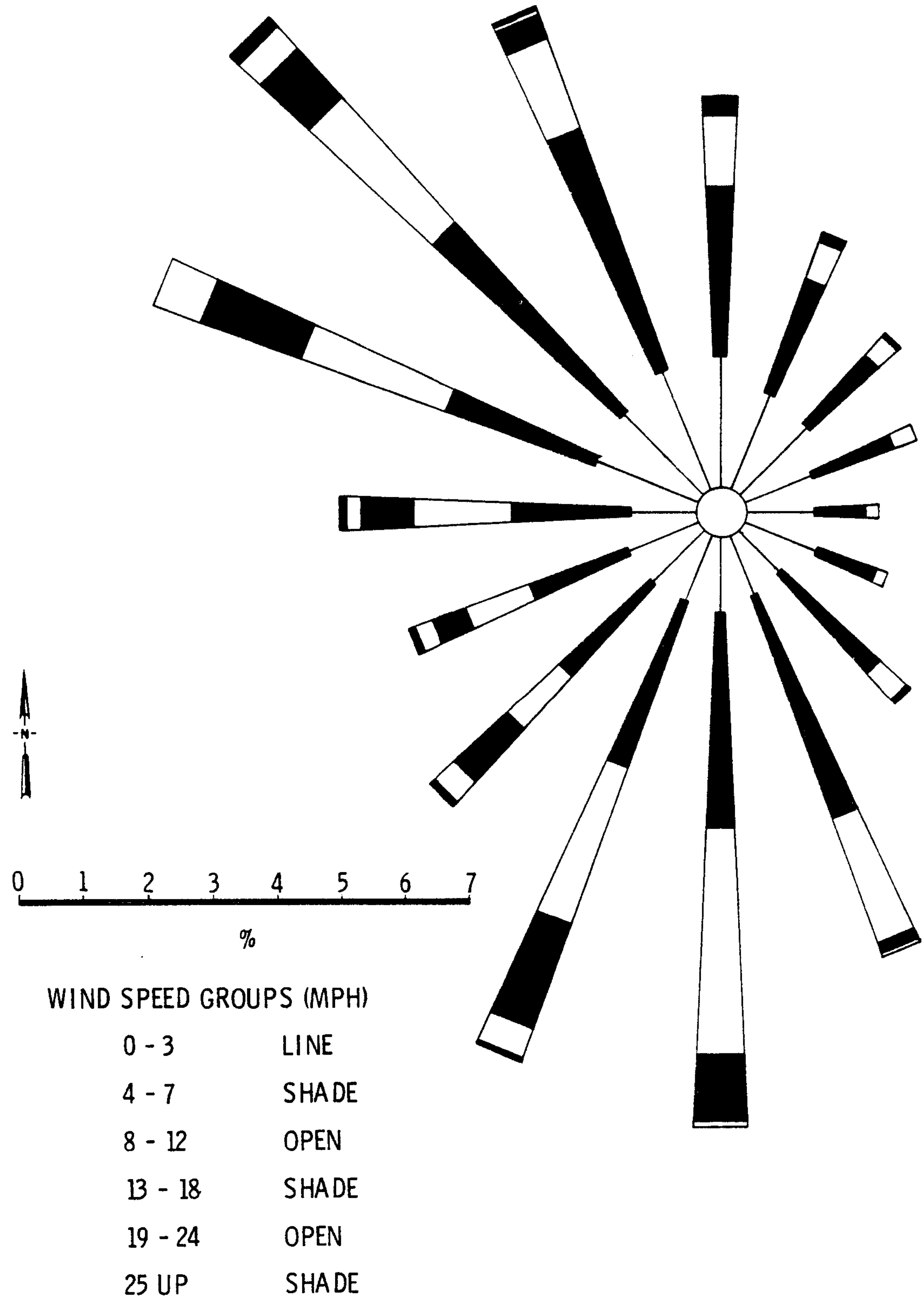


WIND SPEED GROUPS (MPH)

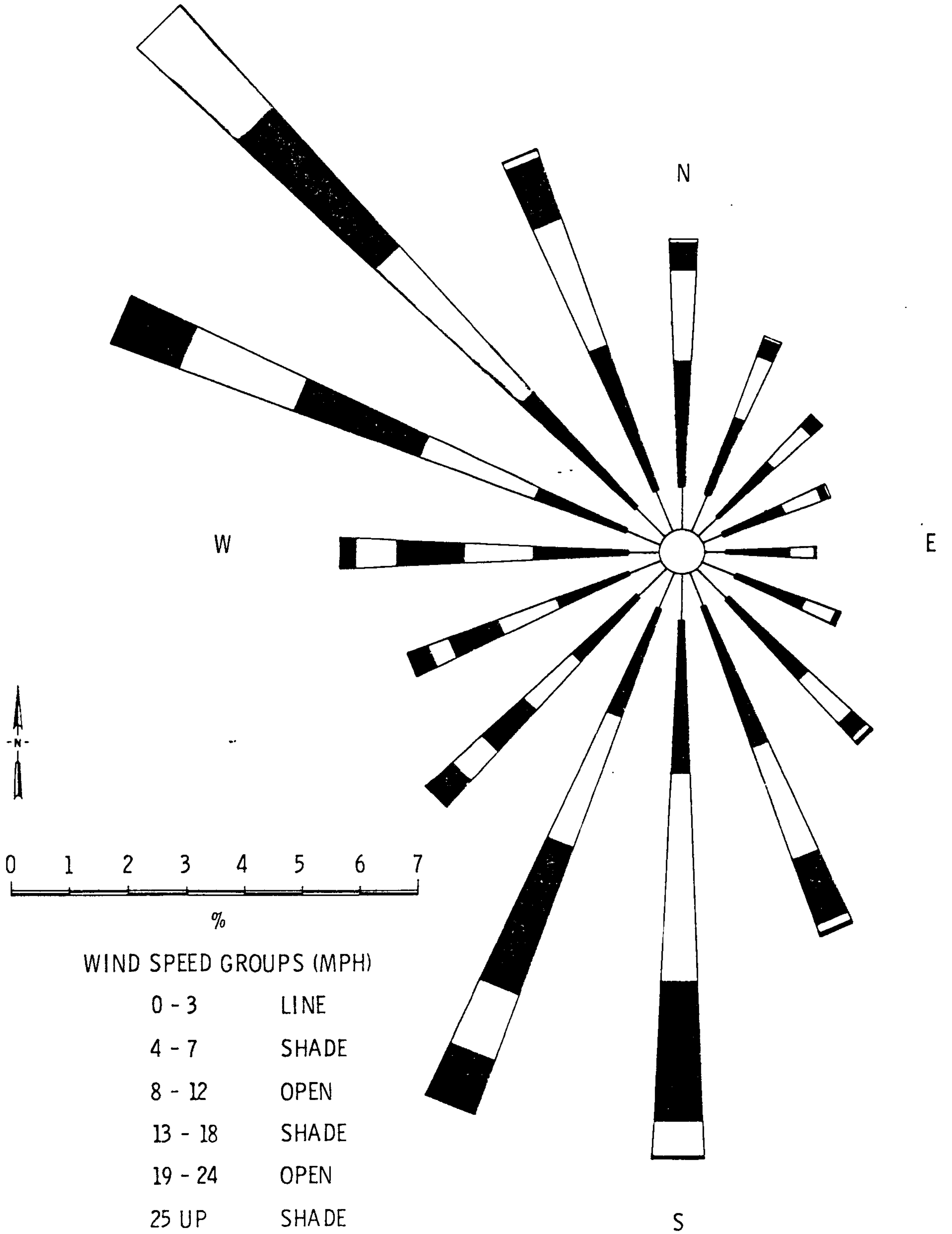
0 - 3	LINE
4 - 7	SHADE
8 - 12	OPEN
13 - 18	SHADE
19 - 24	OPEN
25 UP	SHADE

Amendment 4, October 1980

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	WIND ROSE FOR WNP-2 FOR 4-74 TO 3-75 AT THE 7 FT LEVEL FIG. 2.3-1

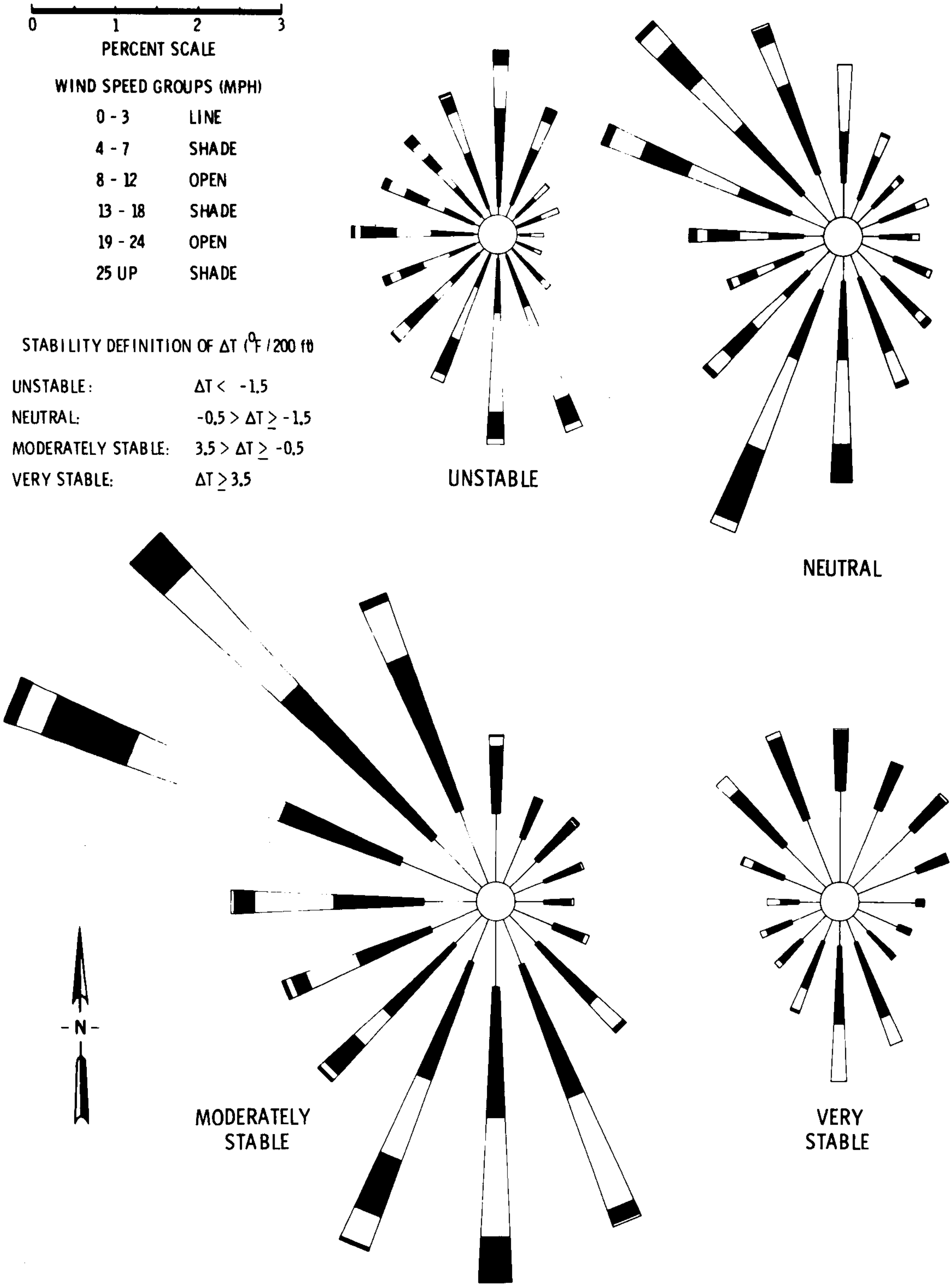


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	WIND ROSE FOR WNP-2 FOR 4-74 TO 3-75 AT THE 33 FT LEVEL FIG. 2.3-2

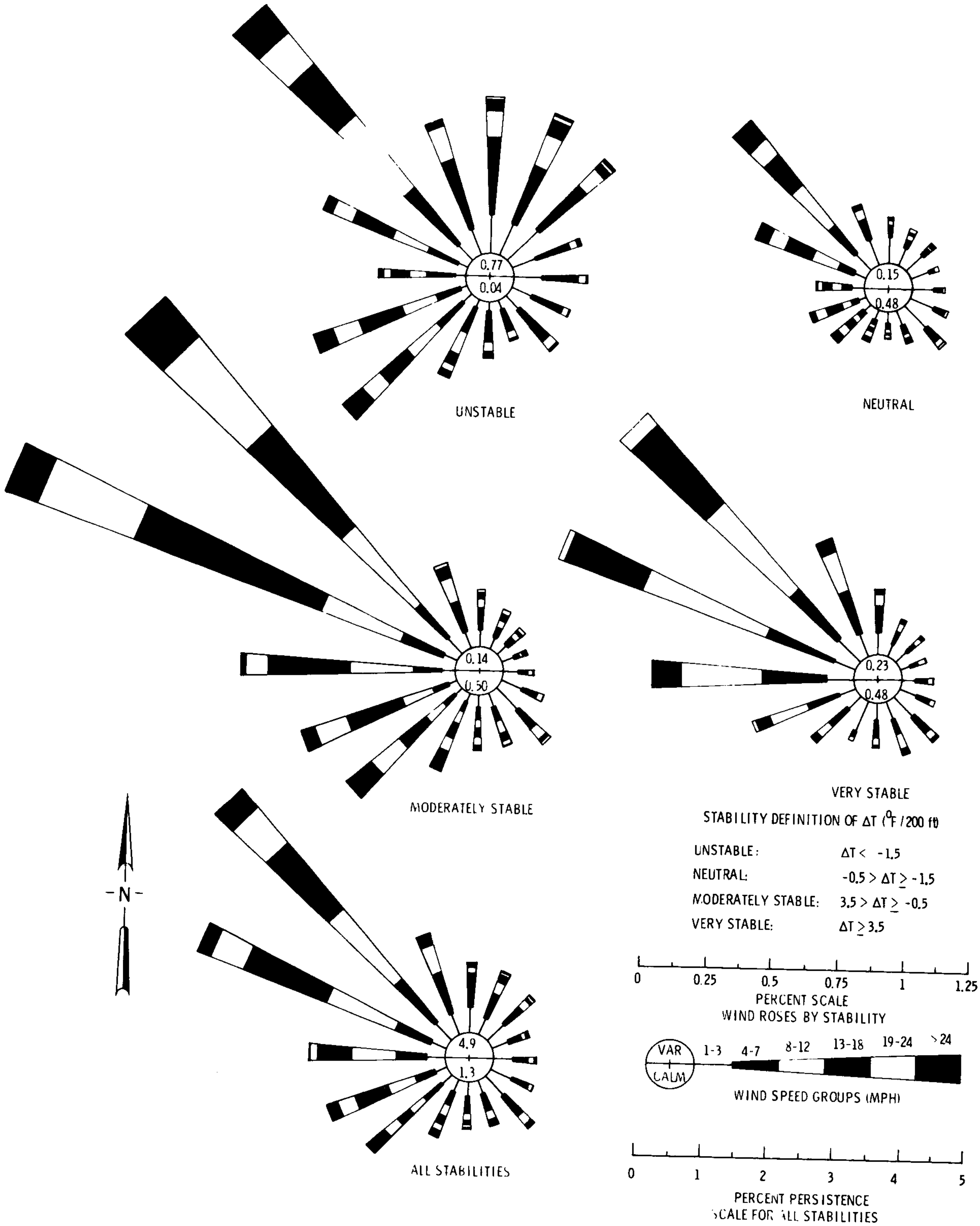


Amendment 4, October 1980

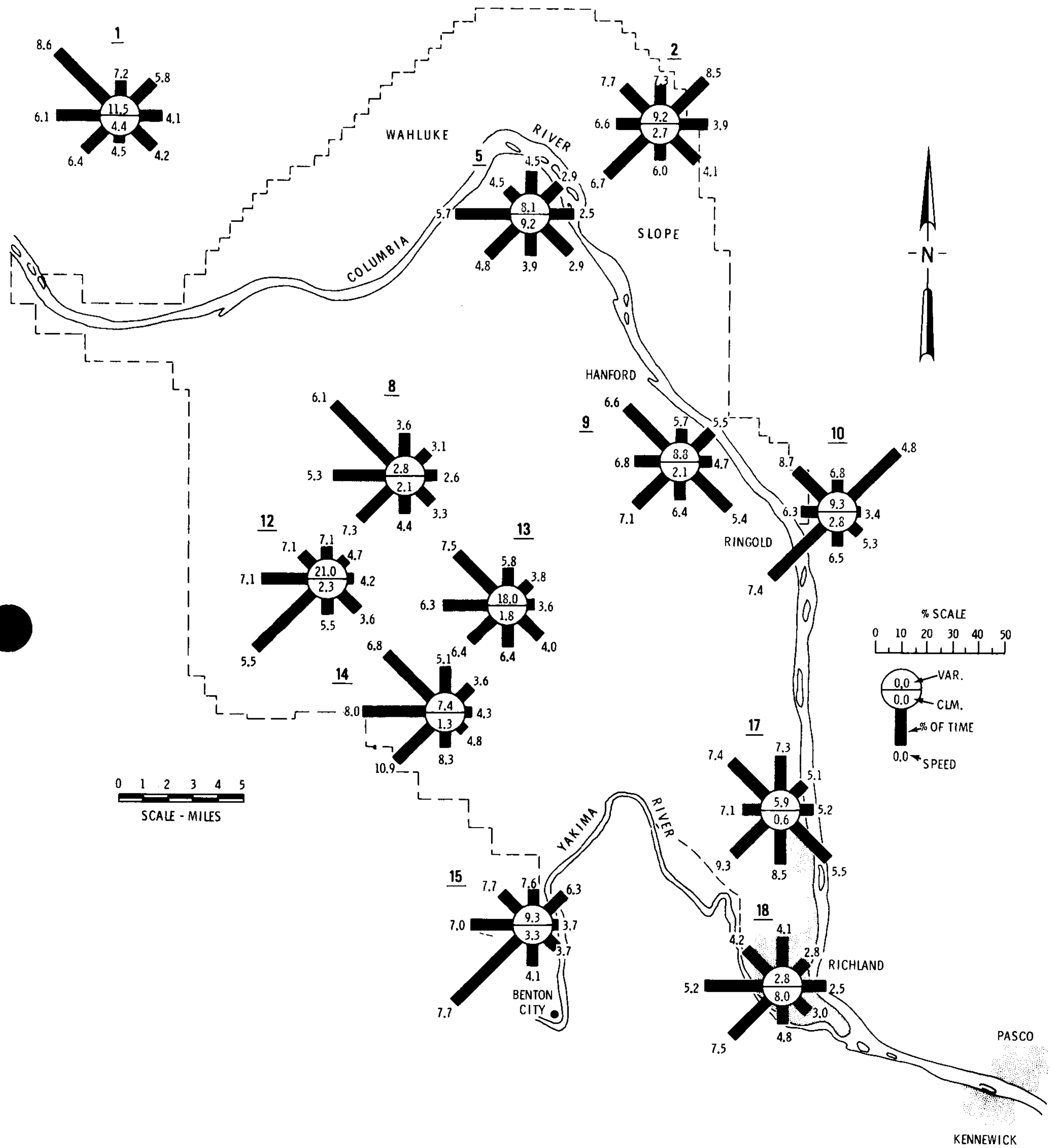
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	WIND ROSE FOR WNP-2 FOR 4-74 TO 3-75 AT 245 FT LEVEL
	FIG. 2.3-3



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	WIND ROSES FOR HANFORD STABILITY CLASSES AT WNP-2 FOR 4-74 TO 3-75 AT THE 33 FT LEVEL FIG. 2.3-4

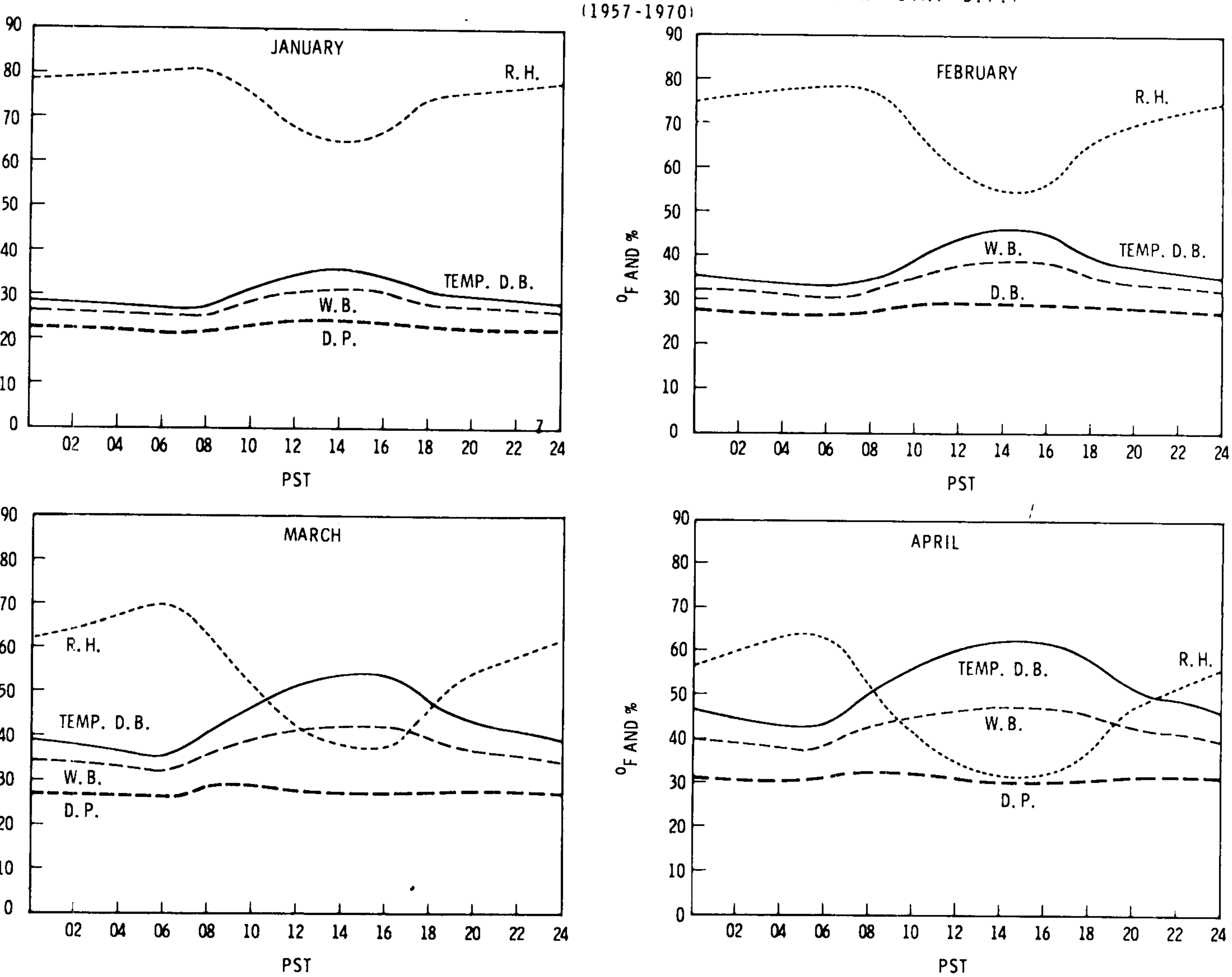


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	WIND ROSES AS A FUNCTION OF HANFORD STABILITY AND FOR ALL STABILITIES OF HMS BASED ON WINDS AT 200 FT AND AIR TEMPERATURE STABILITIES BETWEEN 3 FT AND 200 FT FOR THE PERIOD 1955 THROUGH 1970
	FIG. 2.3-5



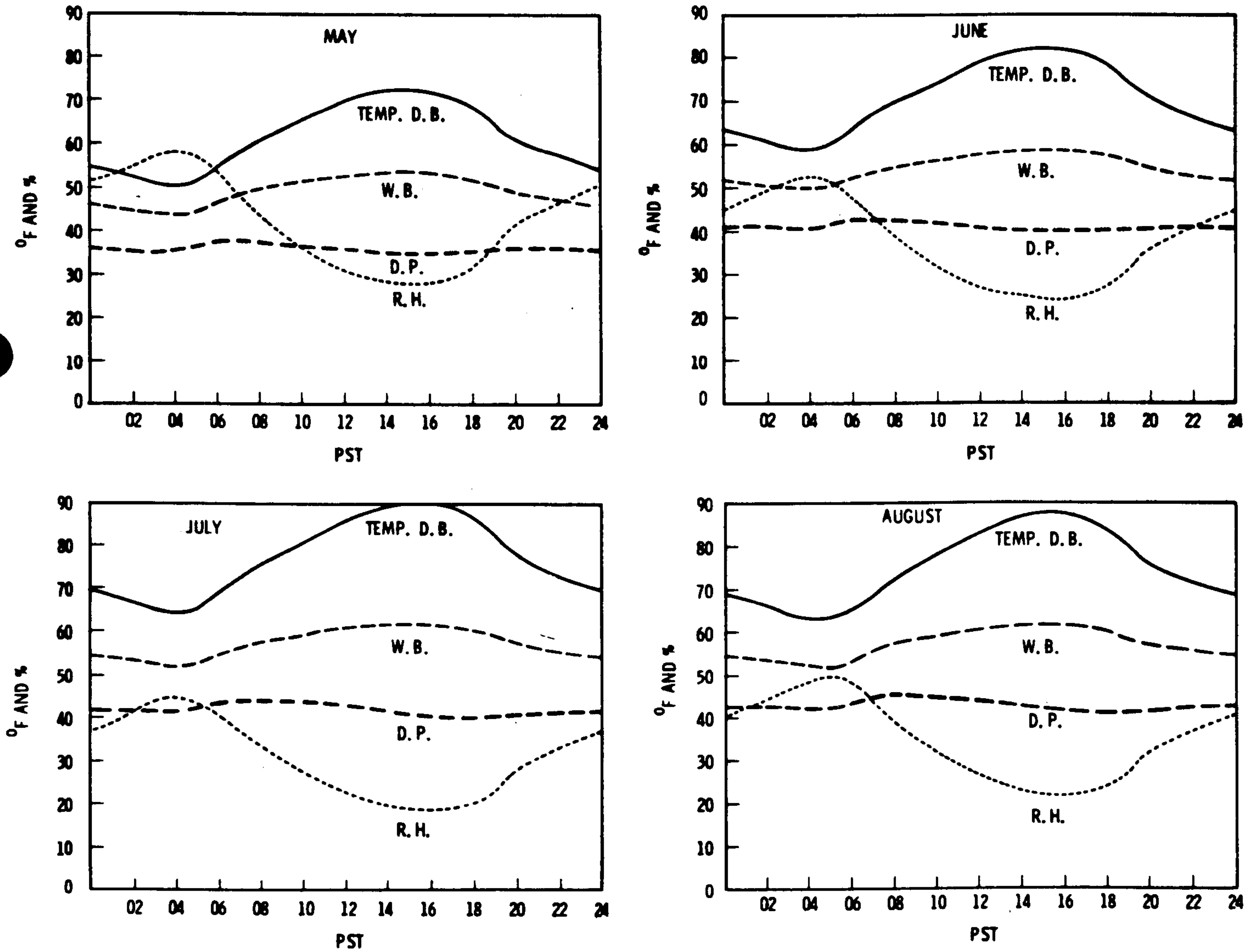
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SURFACE WIND ROSES FOR VARIOUS LOCATIONS ON AND SURROUNDING THE HANFORD SITE BASED ON FIVE-YEAR AVERAGES (1952-1956). SPEEDS ARE GIVEN IN MILES PER HOUR	FIG. 2.3-6

MONTHLY AND ANNUAL HOURLY AVERAGES OF DRY BULB (D.B.) AND WET BULB (W.B.) TEMPERATURE
RELATIVE HUMIDITY (R.H.), AND TEMPERATURE OF THE DEW POINT (D.P.)
(1957-1970)



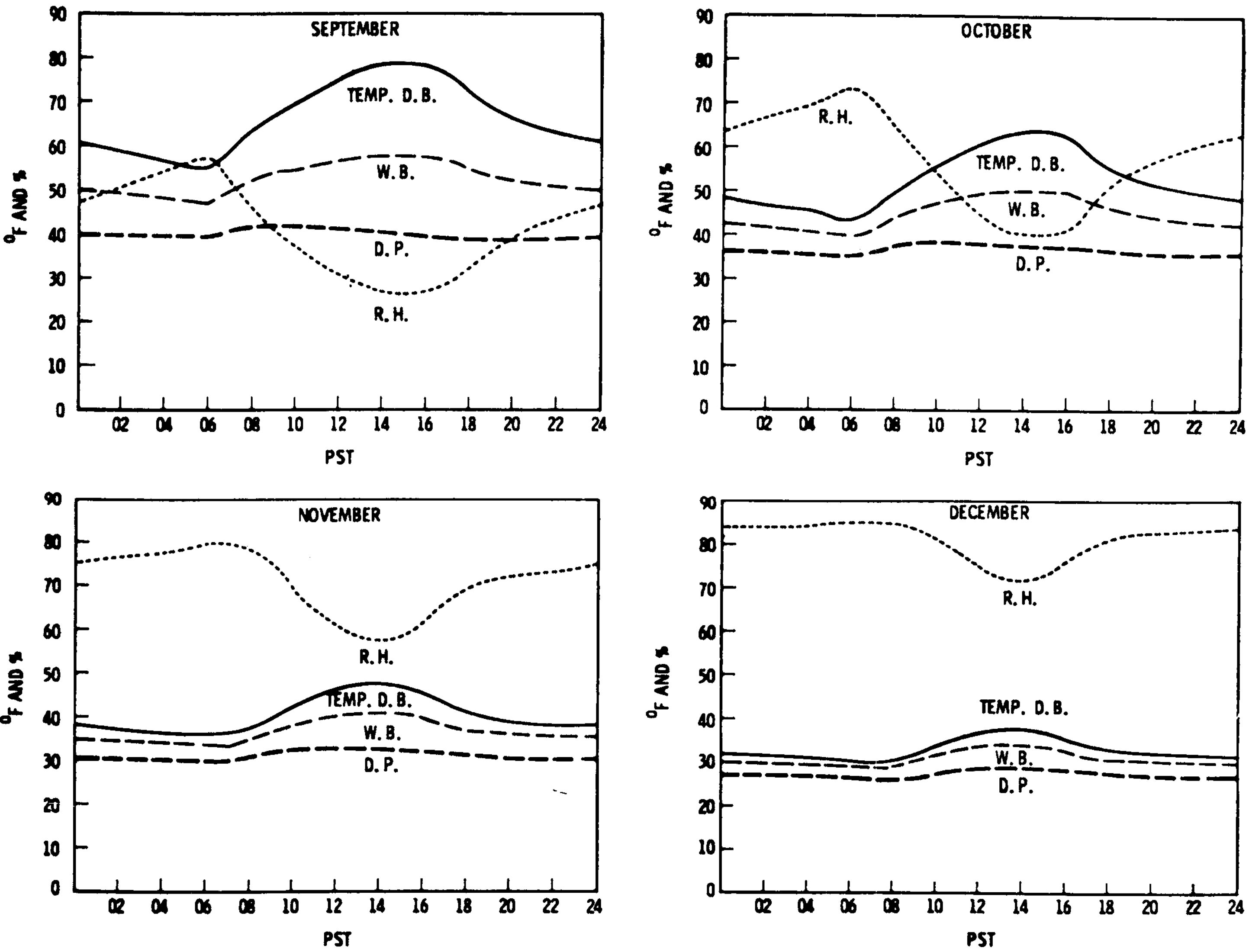
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	MONTHLY HOURLY AVERAGES OF TEMPERATURE AND RELATIVE HUMIDITY FIG. 2.3-7

MONTHLY AND ANNUAL HOURLY AVERAGES OF DRY BULB (D.B.) AND WET BULB (W.B.) TEMPERATURE
RELATIVE HUMIDITY (R.H.), AND TEMPERATURE OF THE DEW POINT (D.P.)
(1957-1970)



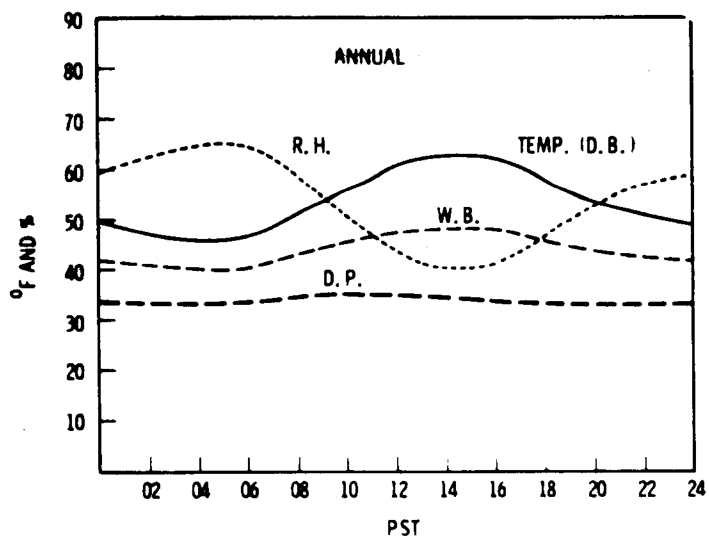
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	MONTHLY HOURLY AVERAGES OF TEMPERATURE AND RELATIVE HUMIDITY FIG. 2.3-8

MONTHLY AND ANNUAL HOURLY AVERAGES OF DRY BULB (D.B.) AND WET BULB (W.B.) TEMPERATURE
RELATIVE HUMIDITY (R.H.), AND TEMPERATURE OF THE DEW POINT (D.P.)
(1957-1970)

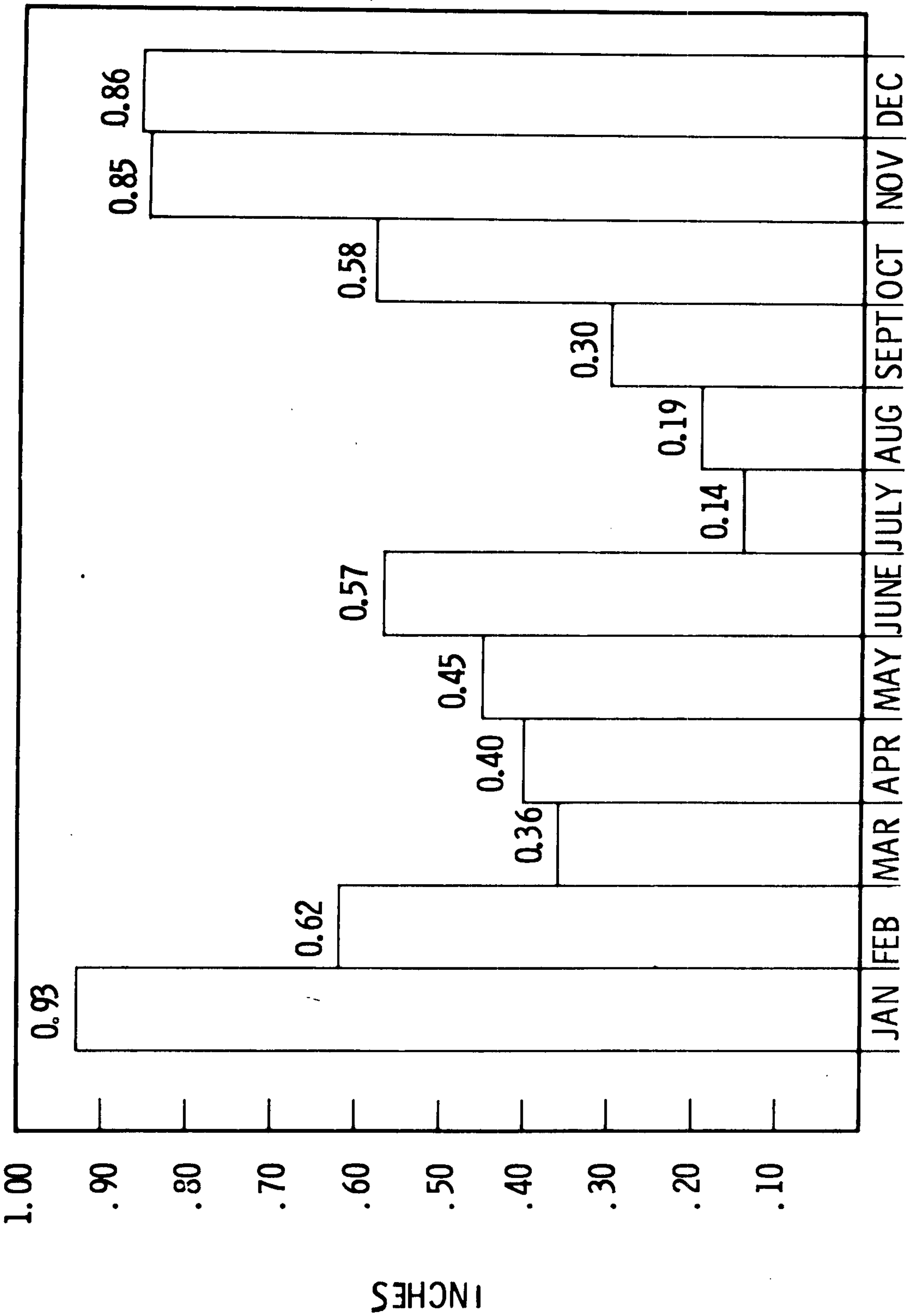


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	MONTHLY HOURLY AVERAGES OF TEMPERATURE AND RELATIVE HUMIDITY
	FIG. 2.3-9

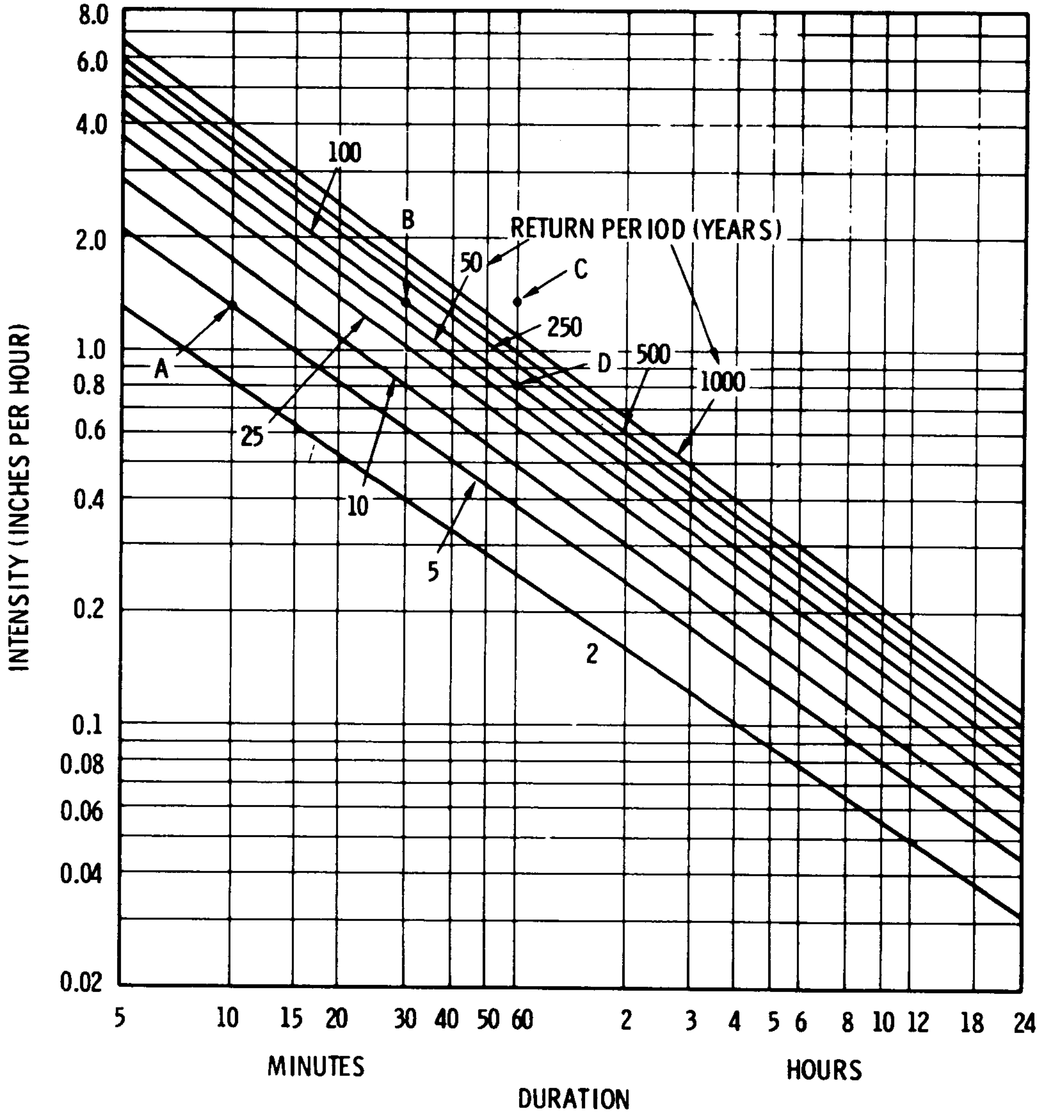
MONTHLY AND ANNUAL HOURLY AVERAGES OF DRY BULB (D.B.) AND WET BULB (W.B.) TEMPERATURE
RELATIVE HUMIDITY (R.H.), AND TEMPERATURE OF THE DEW POINT (D.P.)
(1957-1970)



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	ANNUAL HOURLY AVERAGE OF TEMPERATURE AND RELATIVE HUMIDITY
	FIG. 2.3-10



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	AVERAGE MONTHLY PRECIPITATION AMOUNTS BASED ON THE PERIOD 1912-1970 AT HMS
	FIG. 2.3-11

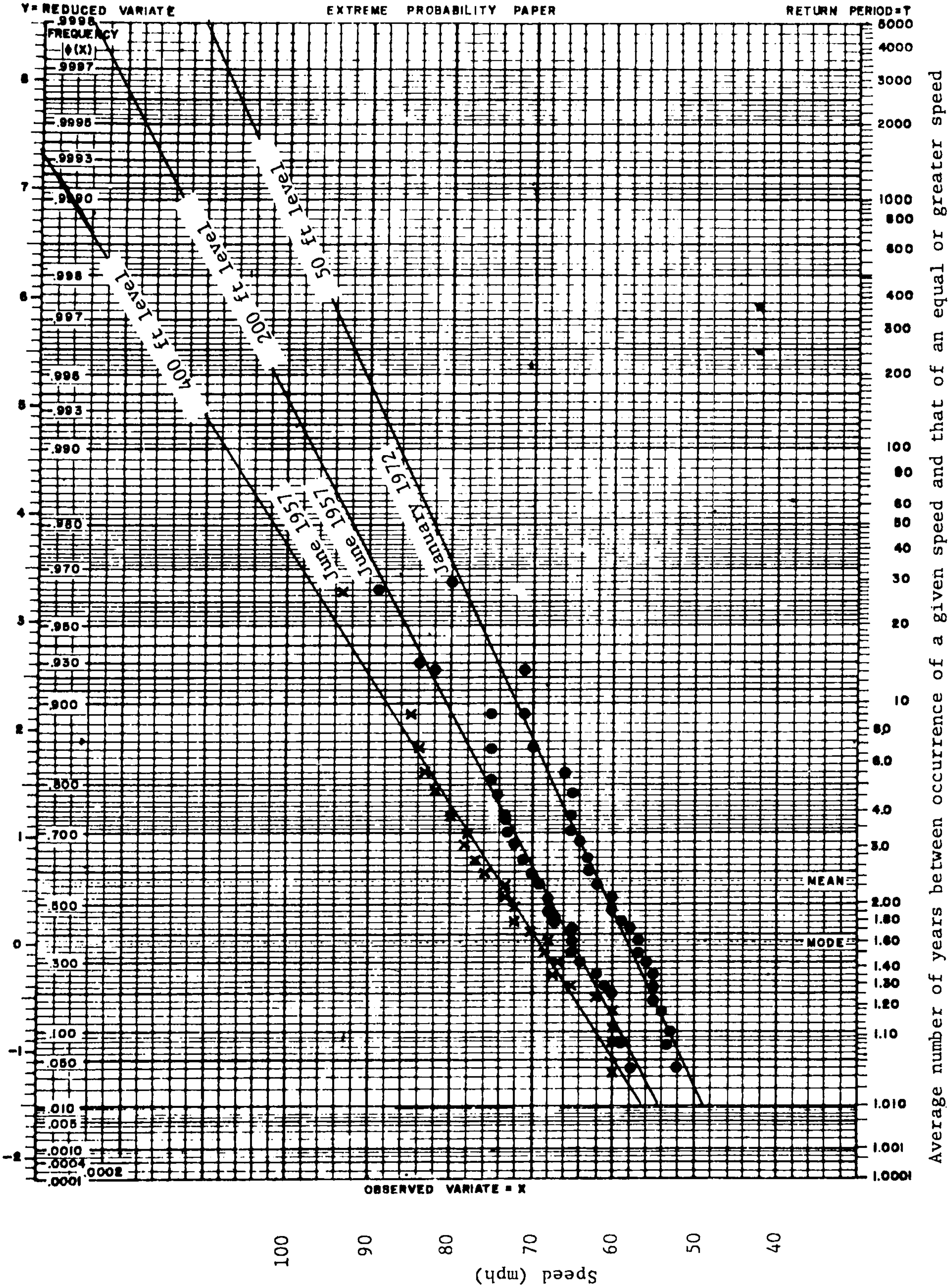


TO USE THIS CHART, SELECT ANY DESIRED RAINFALL INTENSITY AND DURATION AND READ FROM THE DIAGONAL LINES THE EXPECTED FREQUENCY OF SUCH INTENSITY AND DURATION. FOR EXAMPLE, RAINFALL INTENSITY OF 1.3 INCHES PER HOUR FOR 10 MINUTES CAN BE EXPECTED TO OCCUR, ON AVERAGE, ONCE EVERY 5 YEARS (POINT A). HOWEVER, SUCH INTENSITY CAN BE EXPECTED FOR 30 MINUTES DURATION ONLY ABOUT ONCE IN 100 YEARS (POINT B). THE RETURN PERIOD FOR THIS INTENSITY FOR 60 MINUTES DURATION IS GREATER THAN 1000 YEARS (POINT C).

THERE ARE, OF COURSE, VARIATIONS IN USE OF THE CHART. SUPPOSE, FOR EXAMPLE, IT IS DESIRED TO FIND THE "100-YEAR STORM" FOR 60 MINUTES. THIS IS 0.8 INCH (POINT D).

RAINFALL INTENSITY, DURATION, AND FREQUENCY BASED ON THE PERIOD 1947-1969 AT HMS

FIG. 2.3-12



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PEAK WIND GUST RETURN PROBABILITY DIAGRAM AT HMS
	FIG. 2.3-13

2.4 HYDROLOGY

The WNP-2 site is located at an elevation of 441 ft above mean sea level (MSL) about 3 miles west of the Columbia River at River Mile 351.75 and about 8 miles northeast of the Yakima River at Horn Rapids Dam.

The major waters that could be affected or influenced by plant operation are the Columbia River and the groundwaters of the site and the immediate environs.

2.4.1 Surface Water

2.4.1.1 Columbia River Hydrology and Physical Characteristics

The Columbia River and its tributaries are the dominant water systems in the Pacific Northwest region (Figure 2.4-1). The main stem of the Columbia River originates at Columbia Lake on the west slope of the Canadian Rockies and flows into the Pacific Ocean near Astoria, Oregon. The river drains a total area of approximately 258,000 square miles in Canada, Washington, Oregon, Idaho, Montana, Utah, Wyoming, and Nevada. The Columbia River drainage upstream of the site is approximately 96,000 square miles.[1] Since a large part of the Columbia River originates as runoff caused by snowmelt, high discharges are experienced in late spring or early summer while low discharges occur in winter.

Numerous dams and reservoirs have been constructed in the Columbia River Basin for power production, irrigation, navigation, flood control, and recreation. Table 2.4-1 lists the major Columbia River tributaries and main stem dams with their location by river mile above the Columbia River mouth.[2] The reservoirs maintain approximately 46.7 million acre-ft of active storage of which 37.5 million acre-ft are upstream of the site.[3] Arrow and Mica Dams in Canada and Grand Coulee and John Day dams in the United States are the only main stem projects providing sufficient storage for seasonal flow regulation, while the remaining main stem dams are run-of-river projects providing only daily flow control. Much of the activities of flood control and hydroelectric power production are presently controlled under the Columbia Treaty between Canada and the United States.[4]

The Columbia River is tide-affected from the mouth to Bonneville Dam (River Mile 146). The only other free flowing stretch of the river is the 49-mile reach downstream from Priest Rapids Dam (River Mile 397) to the head (approximately River Mile 348) of the reservoir behind McNary Dam. The proposed Ben Franklin hydroelectric dam site on the

Columbia River is about four miles downstream from the WNP-2 site. The planning studies for this project by the Corps of Engineers were suspended in 1969 and reinitiated in 1978 as part of the development of a management plan for the Hanford reach. While the Benton and
4 Franklin County Public Utility Districts have shown a recurring interest in revitalizing the project, previous studies have disclosed significant economic and environmental impediments.

The flows in the Columbia River in the vicinity of the site are highly regulated by Priest Rapids Dam located approximately 45 river miles upstream from the site. The momentary minimum discharge of the Columbia River at Priest Rapids was recorded to be 4120 cfs in 1936 before the construction of Priest Rapids Dam which was built in 1956. After the construction of the dam, the daily river discharge at Priest Rapids has never been below 36,000 cfs, the minimum flow administratively set by the Federal Power Commission License. The annual average discharge measured at the River Mile 394.5 (634.8 KM) just
4 downstream from the dam is 120,200 cfs.[1]

Monthly discharges below Priest Rapids Dam for the period 1928 through 1958 adjusted for 1970 conditions are presented in Table 2.4-2.[5] The listed flow values represent measured flows which were adjusted to reflect flow regulation by dams and diversions existing in 1970. Discharge duration curves derived from these values are shown in Figure 2.4-2. Because of the regulation, it is estimated that the minimum and maximum mean monthly flows will be 60,000 and 260,000 cfs in the vicinity of the site. The flow in this reach varies not only due to seasonal floods but also due to daily regulation by the power-producing Priest Rapids Dam. Flows during the late summer, fall, and winter may vary from a low of 36,000 cfs to as much as 160,000 cfs during a single day.

The four largest known floods occurred in 1876, 1894, 1948 and 1956. The 1894 flood was the maximum known flood on the Columbia River near the proposed site and had an estimated discharge of 740,000 cfs. The largest recorded flood occurred in 1948 when a flow of 692,600 cfs was recorded at Hanford. The maximum possible flood (MPF) under present regulated conditions has been estimated by the U.S. Corps of Engineers to be 1,440,000 cfs at Ringold (River Mile 357).

Figure 2.4-3 shows the exceedance frequency for annual momentary peak flows below Priest Rapids Dam derived from 1913 to 1965 records adjusted for 1970 conditions.[7] The frequency curves for both high and low flows for the period 1929-1958 adjusted for 1970 conditions are given in Figure 2.5-4. The minimum calculated 7-day average flow between 1960 and 1972 was 46,000 cfs.

River cross sections have been determined for a number of flows.[8] 4
Cross sections between River Miles 351 and 352 are shown in Figure
2.4-5.[9] The river width in the vicinity of the project varies
between 1200 and 1800 ft, depending on the flow. Figure 2.4-6 shows
the location of the WNP-2 and WNP-1/4 intake/discharge structures and
Figure 2.4-7 shows river bottom contours near the outfall. River
water surface profiles for several flows in the vicinity of the site
are shown in Figure 2.4-8.[10,11,12] Diurnal depth fluctuations 4
caused by Priest Rapids Dam regulation can be as much five feet. The
maximum velocities measured vary from less than three feet per second
(fps) to over 11 fps, again depending on the river cross section and
flow rate.

WNP-2 is at an elevation of 441 ft above MSL, which is approximately
65 ft above the water surface of the maximum recorded flood, approx-
imately 50 ft above the water surface of the maximum possible flood,
and approximately 22 ft above the water surface elevation estimated 4
for a Grand Coulee Dam failure.[10,11,12] The pumphouse for the
WNP-2 plant water intake is at an elevation of 375 ft above MSL, which
is the approximate water surface elevation of the maximum recorded
flood.

A low flow test of the Columbia River conducted on April 10, 1976 controlled the flow to 36,000 cfs for the purpose of verifying river surface elevations. Test results indicate that the river water surface elevation in the area of the WNP-2 intakes and discharge is approximately 341.7 ft MSL instead of the 343.0 ft MSL value determined from previously available data.

2.4.1.2 Columbia River Temperatures

Water temperatures of the Columbia River have been recorded both above and below the site for many years.[13-18] Tables 2.4-3 and 2.4-4 present the monthly average and extreme temperatures just below Priest Rapids Dam (1961-1974) and at Richland (1965-1974), respectively. A comparison of monthly average temperatures between the two locations is shown in Figure 2.4-9.

Monthly average temperatures at the two locations range from 1.5°C (34.7°F) to 20.2°C (68.4°F), with the lowest temperatures generally occurring in February and the highest in August. Average monthly temperatures for the 10-year period (1965-1974) range from 3.3°C (37.9°F) to 18.3°C (64.9°F) below Priest Rapids Dam and from 4.2°C (39.6°F) to 19.3°C (66.7°F) at Richland, indicating a slight warming from Priest Rapids Dam to Richland. Average daily temperatures at the two locations show a low of 0.3°C (32.5°F) and a high of 20.2°C (68.4°F) below Priest Rapids Dam and a low of 0.2°C (32.4°F) and a high of 21.5°C (70.7°F) at Richland. A diurnal variation in water temperature of about 2.2°C (4°F) in the spring and summer, and 1.1°C (2°F) in the fall and winter, can be expected to occur as a result of diurnal reservoir discharge variations from Priest Rapids Dam.

The free flowing stretch of river along the Hanford reach responds more rapidly to thermal modification from both weather and industrial inputs than impounded regions. Hence, in this stretch of river, warming in the summer and cooling in the winter occur more rapidly. Studies indicate that about 65% of the heat input in the Hanford reach of the river is dissipated by the time it reaches the Washington-Oregon border.[18] The temperature rise from natural heating along the Hanford stretch during August and September is about 0.5 to 0.75°C (0.9 to 1.35°F).

Upstream impoundments have influenced water temperatures by delaying the arrival of peak summer water temperatures, reducing summer water temperatures, and increasing winter water temperatures.[14] The change in average annual water temperatures, however, has been less than 1°C (2°F) over the past 30 years. These trends are shown in Figure 2.4-10 for the years 1938-1972 at Rocky Reach Dam. The river has not frozen over in the Hanford reach during, at least, the last 25
4 years.

The Columbia River has been thermally modified since 1944 by the operation of up to nine plutonium production reactors at Hanford. This modification was quite significant since the heat additions from man-made thermal energy sources were over 23,000 MW in 1964. A portion of the heat load was added directly to the river by reactor
4 effluents at temperatures in excess of 85°C. In addition, numerous "warm springs" were created along the plant shoreline by disposing of warm wastewater in trenches that paralleled the shore. Only one reactor, 100-N, remains in operation at present.

One-hour, 24-hour, and 7-day frequency duration curves projected for 1980 dam operations for high river water temperatures at the project site are shown in Figures 2.4-11 through 2.4-13.

4

2.4.1.3 Columbia River Water Quality

The water quality of the Columbia River is quite good.[7,19,20] The Columbia River is classified as "Class A Excellent" from its mouth to Grand Coulee Dam by the Washington State Department of Ecology. This means that the water is generally satisfactory for use as water supply (domestic, industrial, agricultural), wildlife habitat, stock watering, general recreation and aesthetic enjoyment, commerce and navigation, and fish and shellfish reproduction, rearing and harvest. Applicable water quality standards and regulations imposed by the State of Washington[21] are presented in Section 5.1 and 5.3

A summary of mean and extreme values for important water
quality parameters derived from measurements taken at
different periods between 1957 and 1973 at selected locations 1
in this region is presented in Table 2.4-5.[7,19,20] The
Columbia River shows little change in mineralization from the International Boundary at Northport, Washington (River Mile 734), to the point of its confluence with the Snake River (River Mile 324). As it enters the United States from Canada it is a calcium bicarbonate type water with an average dissolved-solids concentration of approximately 90 mg/ℓ (milligrams per liter). In samples collected daily at Northport since 1952, the dissolved-solids have ranged between 71-158 mg/ℓ. The water is moderately hard, ranging from 50-159 mg/ℓ in hardness. In the vicinity of the proposed project, the dissolved-solids have ranged between 70-154 mg/ℓ, and the hardness between 55-85 mg/ℓ.

Mean dissolved oxygen (DO) levels in all reaches of the Columbia River from Northport to Pasco have an average value of about 10 mg/ℓ; the minimum dissolved oxygen concentration reported was 6.8 mg/ℓ at Pasco. The Washington Water Quality Standards impose that no wastes be discharged into the Columbia River that cause dissolved oxygen levels to fall below 9.5 mg/ℓ above Grand Coulee Dam or 8.0 mg/ℓ below Grand Coulee Dam.

The average coliform count below Priest Rapids Dam is 131/100 mℓ which is much less than 240/100 mℓ imposed by the Washington State Water Quality Standards in this area. Turbidity in the river is very low, generally measuring less than 5 Jackson Turbidity Units (JTU). The pH is normally slightly alkaline (up to 8.6).

The passage of water over the spillways of upstream dams has caused nitrogen supersaturation in the river water. Values of dissolved nitrogen in excess of 120% of saturation have been observed below Priest Rapids Dam and in the Hanford reach of the river. It is anticipated that increased flow regulation by new upstream dams will decrease the amount of water spilled over the dam spillways, and as a consequence, decrease the nitrogen supersaturation problem.

Table 2.4-6 shows the chemical characteristics of the river water measured at 100-F Area (River Mile 374) of the Hanford Reservation.[22] A summary of water quality measurements of the river below Priest Rapids Dam (River Mile 395) for the 1972 water year is presented in Table 2.4-7.[22] Averages computed from these measurements are listed in Table 2.4-8.

Samples for chemical analyses of Columbia River are taken routinely at Priest Rapids Dam, at Vernita, the 300 Area, and Richland.[23] Several investigations studied the effect of reactor effluent on chemical quality of the water. One report[24] includes analyses of river samples taken semi-monthly at Vernita (downstream of Priest Rapids Dam but upstream from the Hanford Reservation) and within the Hanford boundaries but downstream of reactor effluent discharges. Other than hexavalent chromium, statistical comparison of the mean sample values showed no significant differences at the 90% confidence level in any of the species.

2.4.1.4 Hanford Effluents

Fourteen liquid effluent lines from Hanford facilities discharge their contents directly to the Columbia River.[25] Pertinent data for each discharge are given in Table 2.4-9, and a summary of annual amounts of the principal chemical discharges is given in Table 2.4-10.

At present, the only thermal discharges of sufficient magnitude to affect Columbia River temperatures occur either from the 100-N Reactor or from the associated WPPSS Hanford Generating Plant (HGP) when the N Reactor is operating.

The largest heated stream arising from this operation is the cooling water from the HGP (Table 2.4-9), which has a thermal capacity of 3780 MW (megawatts) and an electrical capacity of 860 MW. The cooling water flow rate is 940 to 1260 cfs depending on incoming river temperature, and is discharged at 15 to 20°C (27 to 36°F) above ambient river temperature. Surveys[26] of the thermal plume created by this discharge showed a maximum measured temperature increment in the plume of 4.5°C (8.1°F) with a river flow rate of 44,000 cfs, and a maximum increment of 2.5°C (4.5°F) at 100 yards downstream at which point the width of the plume becomes well mixed across the river width. Directly below an island some

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The largest heated stream arising from this operation is the cooling water from the HGP (River Mile 380), which has a thermal capacity of 3780 MW (megawatts) and an electrical capacity of 860 MW. The cooling water flow rate is 940 to 1260 cfs depending on incoming river temperature, and is discharged at 19 to 24°C (35 to 43°F) above ambient river temperature (Table 2.4-9). The calculated temperature
2 increment for complete mixing (about $2^1/_2$ miles downstream) at the minimum river flow rate of 36,000 cfs would be 0.6°C (1.1°F).

During operation, N Reactor, immediately downstream from HGP, discharges a cooling water stream of about 140 cfs, with a temperature up to 16°C (28.8°F) above ambient river temperature, to the river. This discharge increases the river temperature by only 0.14°C (0.25°F) at the minimum river flow rate of 36,000 cfs and 0.04°C (0.08°F) at the average river flow rate of 120,000 cfs.[25]

Chemicals are released to the Columbia River at three locations: 1) the 100-N Area, 2) the 100-K Area, and 3) the 300 Area.[25] The primary source of chemicals released to the river is the 100-N Reactor operation. The quantities of chemicals released are shown in Table 2.4-10. In addition to these chemicals, impurities removed from the river water by the treatment plants also are returned to the river. The intermittent filter backwash contains suspended solids, principally an aluminum hydroxide floc, plus an accumulation of suspended solids removed from the raw river water during 2
the filtration process. Several of the smaller effluent streams, consisting largely of treated water, may contain free chlorine at concentrations up to a maximum of 1 mg/ℓ. Other chemical concentrations in treated water are mostly the result of use of alum (aluminum sulfate) and small quantities of polyacrylamide filter aids in the water filtration plant.

While the production reactors which were cooled directly with river water have been shutdown, the Hanford reservation still has several sources of low level radioactive effluents. These include cooling water at 100-N, animal farm waste at 100-F and 300 Areas, and trituim migrating to the river with groundwater from the 200 Area disposal sites.[25]

2.4.2 Groundwater

The Hanford Reservation is underlain by three principal rock types, from top to bottom: 1) unconsolidated silts, sands, and gravels; 2) semiconsolidated lake and stream sediments (Ringold formation); and 3) dense, hard basalt which forms the bedrock beneath the area.[27] The lithologic character and water bearing properties of the several geologic units occurring in the Hanford area are summarized in Table 2.4-11. In general, groundwater in the superficial sediments occurs under unconfined conditions, while water in the basalt bedrock occurs mainly under confined conditions. In some areas the lower zone of the Ringold formation is a confined aquifer, separated from the unconfined aquifer by thick clay beds, and possesses a distinct hydraulic potential. Figure 2.5-14 shows a simplified geological cross section of the Hanford Reservation. Wells 699-9-E2, 699-10-E12, 699-14-E6, shown in this figure are located in the vicinity of the project site.

The Ellensburg Formation (beds between basalt flows) and
Ringold Formation beds are flood-plain and shallow lake 1
deposits. The glacio-fluvial sediments are largely the result of several catastrophic floods. These sediments

(actually Pasco Gravels) are about 100 times as permeable as
the Ringold Formation gravels, both of which exist at the
plant site. The average field permeabilities, determined by
a variety of methods, for the Ringold Formation gravel, the
glaciofluvial sediments (Pasco Gravels) and mixes of the two
are given in Table 2.4-12. The values were obtained on ma-
1 terials comparable to those at the FFTF and WNP-2 sites and,
of course, are appreciably higher than at sites where the
Touchet Silts and Ringold Silts and clays predominate. The
median specific yield or available porosity is estimated to
range between 4.8 to 11% and the average effective porosity
is about 9%.

From 1944 through 1972, the Hanford chemical processing plants discharged to the ground over 130 billion gallons (4×10^5 acre-ft) of wastewater and cooling water with a profound effect on the regional water table. Figure 2.4-15 shows the unconfined water table contours over the area interpreted from measurements in September 1973. It also indicates the locations of wells. As shown in this figure, the impermeable aquifer boundaries are the Rattlesnake Hills, Yakima Ridge, and Umtanum Ridge on the west and southwest sides of the Reservation. Gable Mountain and Gable Butte also impede the groundwater flow.

The current estimate of the maximum saturated thickness of the unconfined aquifer is about 230 ft. In the vicinity of the project site this thickness is approximately 100 ft to 160 ft. The depth to the water table varies greatly from place to place depending chiefly on local topography, ranging from less than one to more than 300 ft below the land surface. The ground surface is about 60 to 70 ft above the water table at the WNP-2 Site.

The groundwater flows to the Columbia River in a direction perpendicular to the contour lines shown in Figure 2.4-15. Groundwater flow near the river up to 3 miles inland is affected by seasonal river stage fluctuations.[28]

The natural recharge due to precipitation over the low lands of the Hanford Reservation is not measurable. The major artificial recharge of groundwater to the unconfined aquifer occurs near the 200 East and 200 West Areas. As is clearly shown in Figure 2.4-15, the large volumes of process water disposed to ponds at this site have caused the formation of significant mounds in the water table. 3

Upon reaching the water table, chemical and radioactive contaminants from the 200 Area disposal sites are convected in the direction of groundwater movement. Nitrate (NO_3) and tritium (^3H) ions had reached the project site in 1972.[29,30] However, the plume of gross beta emitters calculated as (^{106}Ru) does not reach the site at the present time and is not likely to do so in the future.[25]

East of the Columbia River is a very intensive 500,000 acre irrigated farming area (Columbia Basin Project area). The water table in that region is 40 to 60 ft higher than the river elevation. The water table in the region between Eltopia and Pasco has risen 40 to 60 ft since 1960[22] due to an increase in irrigation in the area. Although no specific studies have been conducted, it is apparent from the water table elevations that the flow of water is into the Columbia River. It is believed that there is a hydraulic connection between the unconfined aquifers under the Hanford Reservation and under the Columbia Basin project area. Groundwater east of the Columbia River may be contaminated by the agricultural activities. However, the Columbia River acts as a discharge boundary for the unconfined aquifers.

An underground disposal site for radioactive wastes is located immediately adjacent to the northwest corner of the WNP-2 site (Figure 2.1-3). The disposal site covers an area of 8.6 acres and was used between 1962 and 1967 to dispose of a broad spectrum of low- to high-level radioactive wastes, primarily fission products and plutonium.[31] Cartoned low-level waste was buried in trenches, and medium to high-level waste was buried in caissons or pipe facilities. The buried wastes are approximately 45 ft above the water table.

The points of groundwater withdrawal in the vicinity of the WNP-2 site are shown in Figure 2.4-16. Two on-site wells draw from the unconfined aquifer in the Ringold formation and a third well penetrates the confined aquifer in the underlying basalt flows. During construction these wells supply potable/sanitary water requirements and provide water to support construction activities (concrete, dust control, pipe flushing, fire suppression, etc.). Well water consumption for these purposes is not expected to exceed 10,000 gpd for the balance 3
of construction. For the operating phase, the wells will provide potable and service water to the plant during outages. The design is for a peak requirement of 250 gpm although average usage should be less than 20 gpm. When the plant is operating, normal water supply will be from the river and the wells will serve as a stand-by supply for service and supplemental fire protection.

TABLE 2.4-1

COLUMBIA RIVER MILE INDEX

Description	River Mile
River Mouth	0.0
Bonneville Dam	146.1
The Dalles Dam	191.5
John Day Dam	215.6
McNary Dam	292.0
Snake River	324.2
Yakima River	335.2
WNP-2 Intake and Discharge	351.75
Proposed WNP-1 and 4 Intake and Discharge	351.85
Existing Hanford Generating Plant	380.0
Priest Rapids Dam	397.1
Wanapum Dam	415.8
Rock Island Dam	453.4
Wenatchee River	468.4
Rocky Reach Dam	473.7
Chelan River	503.3
Wells Dam	515.6
Chief Joseph Dam	545.1
Grand Coulee Dam	597.6
Spokane River	638.9
United States-Canadian Boundary	745.0

TABLE 2.4-2

MEAN DISCHARGES IN CFS, OF THE COLUMBIA RIVER BELOW PRIEST RAPIDS DAM, WA

1970 Conditions

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1928										224000	109900	90900	
1929	82300	78400	101100	103000	108000	72600	85200	62000	71300	87600	97000	94300	86900
1930	87900	89800	102700	93500	90700	83100	72500	81700	90200	93800	97600	92700	90100
1931	86800	89600	100000	82200	90800	88400	74500	81700	104000	102200	99400	85800	90400
1932	87400	88700	102000	95000	109200	77800	90700	157500	156700	74600	97800	90600	102300
1933	89600	69700	102700	128800	167100	97900	118900	185900	196600	180300	121900	100200	130000
1934	100600	104200	128000	139600	203400	196700	243100	221200	168800	104500	100000	101000	150900
1935	82000	72400	109200	132100	132000	111300	117600	147500	156900	131100	99300	95900	115700
1936	90200	86200	107900	119400	79800	80400	81500	160500	123300	83400	93200	89400	99600
1937	87600	87500	105400	96600	100600	84400	63500	70400	76900	87800	102500	91500	87900
1938	89300	83100	88700	111000	124100	86800	110700	142400	146800	154100	90400	89200	109700
1939	83400	77100	91700	127200	90400	83000	108500	100000	112400	95500	96900	90800	96400
1940	85800	85400	90500	133200	98000	89200	110700	89700	101700	94100	96000	91600	97200
1941	84300	79600	92500	99400	92200	87900	137400	76900	73200	84000	91500	88700	90600
1942	96000	82700	91400	114100	119000	84600	115900	105300	148400	101400	102000	88300	104100
1943	87900	65800	86800	105600	150600	116000	132400	202600	134300	147700	101300	85900	118300
1944	81300	77200	96800	99300	110600	78700	88200	88000	69100	81200	94600	84400	87400
1945	90100	90900	103600	88500	94000	86500	77800	112800	67800	88800	99300	87400	90600
1946	86200	85700	92500	95600	117700	90800	112200	178100	170900	134500	94400	91100	112500
1947	79600	81300	93100	116000	137800	135200	155900	184400	163400	136300	89900	85500	121500
1948	94700	96000	113900	113200	202800	166700	137700	193400	257600	194700	122900	101900	149600
1949	88000	83600	97700	126000	114000	80000	123000	166400	181600	82700	92200	87800	110200
1950	79000	69500	106800	123300	155200	145400	136400	197500	200200	211900	114800	96200	136400
1951	91800	87900	102600	115400	223400	186200	195600	188800	171300	174300	110300	91700	144900
1952	94200	98800	112200	126500	155200	113300	134600	172400	135800	145100	88700	85900	121900
1953	85500	83900	103900	95500	124800	87800	98700	174000	168300	141400	99000	89200	112700
1954	83600	89800	110300	122100	153600	135200	124200	191200	224900	228400	163500	114400	145100
1955	98700	103400	126600	132400	143900	102700	110500	104300	181800	193300	111900	91000	125000
1956	95700	94500	97000	108100	206500	200600	173500	245800	212600	200400	103600	90700	152400
1957	87400	82900	109400	132100	145100	101200	113600	182700	176500	120900	89000	86900	119000
1958	77500	75200	83300	120200	123700	107300	125000	172800	172900				
Mean	87800	84700	101700	113200	132100	108600	119000	147900	147200	132800	102400	91800	114100

TABLE 2.4-3

MONTHLY AVERAGE WATER TEMPERATURE, IN °C, AT PRIEST RAPIDS DAM, WA[(a)]

Year	Month Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1961	5.4	4.7	4.7	7.4	10.4	13.7	17.3	18.9	17.8	14.9	10.4	6.6	11.0
1962	4.1	3.6	3.6	6.5	10.0	13.7	16.1	17.4	17.1	14.8	11.9	8.9	10.6
1963	5.3	3.8	4.6	6.5	10.4	14.0	16.6	18.4	18.3	16.3	11.9	7.7	11.2
1964	5.5	4.6	4.7	7.2	9.7	12.8	15.3	17.1	16.3	14.6	10.8	6.3	10.4
1965	4.4	3.3	4.1	6.6	10.0	13.3	16.1	18.4	17.3	15.3	11.9	7.8	10.7
1966	4.8	4.1	4.5	7.8	10.6	12.4	15.3	17.5	17.5	14.6	11.6	8.4	10.8
1967	5.9	5.7	5.0	6.8	10.1	13.3	16.1	18.5	18.2	15.4	11.3	7.2	11.1
1968	4.6	3.3	4.6	7.1	11.1	13.4	16.1	17.5	17.2	14.2	10.9	6.8	10.6
1969	2.4	1.5	3.4	7.2	10.8	14.6	17.1	18.2	17.7	14.8	11.5	7.6	10.6
1970	4.3	4.1	4.8	6.8	10.9	14.8	18.0	19.2	17.5	15.2	10.6	6.2	11.0
1971	4.0	3.5	3.6	6.6	10.7	12.6	15.3	18.4	17.2	15.2	11.3	6.8	10.4
1972	3.6	1.9	4.0	7.2	10.6	12.9	15.2	17.3	16.8	15.4	11.3	7.3	10.3
1973	2.3	2.9	4.8	7.7	12.5	15.4	17.6	18.8	17.8	15.2	10.3	7.7	11.1
1974	4.0	3.0	4.9	7.7	10.8	13.6	17.2	18.7	18.4	15.5	11.8	8.6	11.2
Average 1965-74	4.0	3.3	4.4	7.2	10.8	13.6	16.4	18.3	17.6	15.1	11.3	7.4	10.8
Minimum Daily	0.3	0.3	2.2	4.3	7.5	10.6	13.1	16.6	15.3	12.2	7.7	2.3	--
Maximum Daily	7.6	6.2	6.9	10.1	14.6	17.1	19.3	20.2	20.0	18.7	14.4	10.5	--

(a) Records since August 1960. Recorded values adjusted by computer-simulation to compensate for measurement errors and missing data.

TABLE 2.4-4

MONTHLY AVERAGE WATER TEMPERATURE, IN °C, AT RICHLAND, WA(a)

Year	Month												Annual Average
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1965	6.1	5.4	6.3	9.1	11.0	14.2	17.3	19.8	18.5	16.4	12.6	8.4	12.1
1966	5.9	6.2	6.8	10.3	12.1	13.5	16.2	18.8	19.4	15.6	12.6	9.5	12.2
1967	7.4	7.0	6.6	8.8	12.0	13.9	17.0	20.2	19.4	16.1	12.0	7.8	12.4
1968	5.7	5.0	6.0	8.8	12.8	14.3	17.0	18.7	18.3	15.0	11.4	7.4	11.7
1969	2.7	1.9	4.3	8.0	11.4	15.3	17.9	19.3	18.6	15.2	11.7	7.0	11.1
1970	5.3	4.9	5.7	7.9	11.7	15.4	19.0	19.9	17.5	14.9	10.6	5.9	11.6
1971	4.2	3.4	3.8	7.0	11.1	12.9	16.4	19.5	17.8	15.0	10.7	6.2	10.7
1972	3.3	2.2	3.7	7.0	11.0	13.3	15.5	18.1	16.9	14.0	10.5	6.1	10.1
1973	3.2	3.0	4.7	7.8	12.9	15.6	18.3	19.6	18.3	15.0	9.9	7.6	11.3
1974	3.2	3.2	5.2	8.2	11.3	13.7	17.4	19.4	18.8	15.4	11.5	7.9	11.3
Average 1965-74	4.7	4.2	5.3	8.3	11.7	14.2	17.2	19.3	18.4	15.3	11.4	7.4	11.4
Minimum Daily	0.2	0.7	2.4	5.1	8.6	11.2	14.2	17.3	14.6	11.1	7.7	2.4	--
Maximum Daily	8.3	8.3	8.6	12.8	15.0	17.7	20.4	21.5	21.1	18.5	15.9	11.3	--

(a) Records since June 1964.

TABLE 2.4-5

SUMMARY OF WATER QUALITY DATA FOR THE COLUMBIA RIVER AT SELECTED SITES

	D.P. (mg/ℓ)	T (°C)	Coliform MPN/ 100 mℓ	pH	Color PT-CO Units	Hard. (mg/ℓ)	Turbidity (JTU)	Ortho PO4-P (mg/ℓ)	NO3-N (mg/ℓ)
Northport, WA (River Mile 734)									
Mean	11.5	9.8	385	7.6	4	78	17	0.05	0.05
Minimum	10.2	0.0	36	6.6	0	50	0	0.00	0.00
Maximum	14.3	21.0	2,000	8.5	30	159	32	0.18	0.40
Wenatchee, WA (River Mile 471)									
Mean	11.8	11.0	310	8.0	5	66	4	0.03	0.07
Minimum	8.0	2.5	2	6.9	0	50	0	0.01	0.00
Maximum	15.5	21.6	7,300	8.6	25	112	25	0.04	0.14
Columbia River below Rock Island Dam (River Mile 451)									
Mean	12.3	10.6	691	7.8	8	82	4	--	0.10
Minimum	9.3	1.5	10	6.4	3	55	1	0.00	0.01
Maximum	15.9	19.6	8,000	8.4	30	132	32	0.07	0.73
Columbia River below Priest Rapids Dam (River Mile 395)									
Mean	11.9	11.4	131	7.7	5	69	3	0.08	0.10
Minimum	9.5	1.8	0	6.5	0	55	0	0.01	0.02
Maximum	15.9	19.2	2,000	8.5	33	81	29	0.15	1.50
Columbia River, Pasco, WA (River Mile 330)									
Mean	10.8	12.2	182	8.1	8	73	15	0.1	0.19
Minimum	6.8	3.0	1	6.8	0	40	0	0.01	0.05
Maximum	14.3	22.0	4,800	8.6	68	90	140	0.02	0.37

TABLE 2.4-6

CHEMICAL CHARACTERISTICS OF COLUMBIA RIVER WATER AT 100°F--1970 (RESULTS IN PARTS/MILLION)

Date	Mg	Fe	Cu	Ca	SO_4	PO_4	CI	Diss O_2	Phth Alk	MO Alk	Hard-ness	Solids
1/6	6.0	0.03	0.002	20.	15.	0.00	0.33	NA	2.0	68.	74.	93.
1/20	4.0	0.01	0.004	22.	15.	0.05	0.36	7.8	2.0	71.	73.	84.
2/3	5.0	0.01	0.002	21.	13.	0.06	0.33	12.	2.0	69.	72.	100
2/17	5.0	0.01	0.004	22.	19.	0.01	0.33	11.	2.0	68.	75.	100
3/3	5.4	0.02	0.002	22.	17.	0.04	0.26	8.3	1.0	65.	76.	96.
3/17	6.2	0.03	0.004	19.	17.	0.02	0.50	13.	1.0	65.	73.	81.
3/31	6.2	0.07	0.005	20.	17.	0.02	0.39	12.	2.0	69.	76.	81.
4/14	4.4	0.22	0.002	24.	20.	0.05	0.60	12.	1.0	66.	77.	100
4/28	6.3	0.12	0.005	22.	24.	0.02	0.56	12.	1.0	70.	82.	120
5/12	5.5	0.02	0.02	25.	23.	0.005	0.40	12.	2.0	72.	85.	100
6/16	4.6	0.00	0.01	22.	13.	0.04	0.29	11.	2.0	56.	68.	74.
7/21	4.2	0.09	0.007	23.	15.	0.02	0.16	9.6	1.0	61.	76.	75.
8/4	3.9	0.02	0.007	25.	17.	0.02	0.46	9.6	.1.0	70.	78.	86.
8/18	4.0	0.03	0.004	24.	13.	0.02	0.26	8.9	1.0	70.	77.	110
9/8	4.8	0.03	0.005	23.	15.	0.08	0.43	9.0	3.0	70.	77.	73.
9/22	5.3	0.02	0.002	17.	13.	0.03	0.26	9.4	2.0	63.	65.	37.
10/6	4.0	0.03	0.003	21.	20	0.02	0.66	8.2	2.0	66.	70.	99.
10/20	5.4	0.02	0.006	16.	12.	0.01	0.32	11.	0.0	92.	66.	80.
11/3	5.3	0.01	0.001	19.	18.	0.11	0.49	NA	2.0	70.	68.	80.
11/16	4.9	0.02	0.003	20.	15.	0.11	0.58	9.8	6.0	69.	70.	86.
12/1	3.8	0.01	0.002	20.	16.	0.01	0.46	NA	2.0	66.	65.	92.
12/15	6.6	0.01	0.000	18.	16.	0.11	0.53	NA	2.0	76.	73.	97.
Annual Average	5.0	0.04	0.006	22.	16.	0.04	0.40	10.	1.8	68.	74.	90.

NA Indicates there was no analysis made. Analysis was made from sing grab samples.

TABLE 2.4-7a

SUMMARY OF WATER QUALITY ANALYSES OF THE COLUMBIA RIVER BELOW PRIEST RAPIDS DAM (RIVER MILE 395) FOR 1972 WATER YEAR

DATE	TIME	INSTANTANEOUS DISCHARGE (CFS)	DISSOLVED CALCIUM (Ca) (MG/L)	DISSOLVED MAGNESIUM (Mg) (MG/L)	DISSOLVED SODIUM (Na) (MG/L)	DISSOLVED POTASSIUM (K) (MG/L)	BICARBONATE (HCO_3) (MG/L)	ALKALINITY AS $CaCO_3$ (MG/L)	DISSOLVED SULFATE (SO_4) (MG/L)	DISSOLVED CHLORIDE (Cl) (MG/L)	TOTAL KJELDAHL NITROGEN (N) (MG/L)
OCTOBER											
11	1630	106000	19	4.2	2.2	1.0	74	61	12	1.5	0.12
18	1410	91600	19	4.2	2.4	3.1	73	60	13	2.0	0.13
NOVEMBER											
08	1410	101000	19	4.4	2.3	1.1	74	61	11	0.7	0.08
15	1300	104000	19	4.0	2.7	1.5	72	59	11	2.0	0.79
DECEMBER											
13	1515	146000	21	4.7	2.0	0.7	76	62	15	1.0	0.02
27	1340	132000	20	4.5	2.1	1.1	75	62	13	1.9	0.15
JANUARY											
24	1350	132000	21	4.9	2.3	0.8	79	65	14	1.1	0.12
FEBRUARY											
07	1335	107000	22	4.8	2.0	0.8	78	64	14	1.7	0.06
21	1350	135000	21	4.7	2.4	1.1	82	67	14	1.8	0.13
MARCH											
13	1410	172000	21	4.9	2.1	1.2	80	66	14	1.2	0.30
27	1430	151000	21	4.9	2.4	1.0	77	63	16	1.2	0.31
APRIL											
10	1440	215000	20	4.8	3.0	0.9	77	63	16	0.6	0.14
24	1325	136000	21	4.9	2.4	1.4	80	66	1.6	0.19	
MAY											
08	1425	175000	20	4.9	2.5	1.0	76	62	15	0.6	0.19
22	1340	314000	19	4.4	2.7	0.7	68	56	14	0.9	0.39
JUNE											
12	1410	404000	16	3.6	1.4	0.9	64	52	9.5	1.8	0.93
26	1435	410000	17	3.7	1.8	0.8	65	53	9.8	0.7	0.37
JULY											
10	1440	241000	17	3.6	1.3	0.7	56	46	16	1.0	0.84
24	1530	197000	18	3.8	1.6	0.8	64	52	8.6	1.0	0.16
AUGUST											
07	1500	180000	18	3.7	1.6	0.7	65	53	9.6	0.3	0.24
21	1440	144000	18	3.7	1.7	0.7	67	55	9.5	0.9	0.79
SEPTEMBER											
11	1410	131000	19	3.9	2.4	0.7	69	57	9.8	1.3	0.11
25	1510	92000	18	4.2	1.9	9.0	70	57	11	0.6	0.13

TABLE 2.4-7b
(sheet 2 of 3)

DATE	DISSOLVED NITRITE (N) (MG/L)	AMMONIA NITROGEN (N) (MG/L)	DISSOLVED NITRATE (N) (MG/L)	DISSOLVED ORTHO PHOSPHORUS (P) (MG/L)	TOTAL PHOSPHORUS (P) (MG/L)	DISSOLVED SOLIDS (RESIDUE AT 180°C) (MG/L)	HARDNESS (Ca, Mg) (MG/L)	NON-CARBONATE HARDNESS (MG/L)	SPECIFIC CONDUCTANCE (MICROMHOS)	pH (UNITS)
OCTOBER										
11	0.000	0.05	0.11	0.010	0.030	82	65	4	160	7.8
18	0.000	0.06	0.07	0.010	0.020	98	65	5	140	7.8
NOVEMBER										
08	0.000	0.01	0.16	0.020	0.030	90	66	5	145	7.7
15	0.010	0.21	0.31	0.020	0.050	88	64	5	145	7.8
DECEMBER										
13	0.010	0.01	0.20	0.010	0.030	92	72	9	151	7.4
27	0.010	0.00	0.25	0.020	0.030	88	68	7	148	7.6
JANUARY										
24	0.000	0.03	0.45	0.030	0.030	90	73	8	156	7.9
FEBRUARY										
07	0.010	0.01	0.04	0.030	0.080	78	75	11	171	7.6
21	0.000	0.05	0.18	0.030	0.040	112	72	5	165	7.8
MARCH										
13	0.010	0.05	0.32	0.030	0.060	152	73	7	158	6.5
27	0.010	0.07	1.5	0.010	0.070	136	73	9	158	7.8
APRIL										
10	0.010	0.03	0.14	0.020	0.050	154	70	7	156	8.0
24	0.010	0.05	0.05	0.010	0.060	130	73	7	159	8.0
MAY										
08	0.000	0.05	0.04	0.010	0.030	154	70	8	164	8.0
22	0.000	0.05	0.07	0.010	0.050	100	66	10	370	7.8
JUNE										
12	0.010	0.30	1.1	0.000	0.080	134	55	2	128	7.6
26	0.000	0.05	0.10	0.010	0.030	112	58	4	134	7.7
JULY										
10	0.000	0.18	0.15	0.010	0.030	112	57	11	150	7.6
24	0.010	0.02	0.22	0.000	0.020	70	61	8	135	8.1
AUGUST										
07	0.010	0.04	0.08	0.000	0.020	104	60	7	144	8.2
21	0.010	0.24	0.10	0.010	0.020	104	60	5	139	7.9
SEPTEMBER										
11	0.000	0.01	0.10	0.000	0.010	82	63	7	140	8.2
25	0.010	0.03	0.30	0.010	0.030	98	62	5	139	8.5

TABLE 2.4-7c
(sheet 3 of 3)

DATE	TEMPERATURE (DEG C)	COLOR (PLATINUM COBALT UNITS)	TURBIDITY (JTU)	DISSOLVED OXYGEN (MG/L)	IMMEDIATE COLIFORM (COL. PER 100 ML)	DISSOLVED CHROMIUM (Cr) (UG/L)	DISSOLVED COPPER (Cu) (UG/L)	DISSOLVED LEAD (Pb) (UG/L)	TOTAL MERCURY (Mg) (UG/L)	DISSOLVED ZINC (Zn) (UG/L)
OCTOBER										
11	17.9	9	4	9.9	100	-	-	-	---	--
18	15.1	26	2	10.0	2000	-	2	2	0.1	0
NOVEMBER										
08	10.5	12	2	10.8	>100	-	-	-	---	--
15	11.7	5	2	10.4	50	-	-	-	---	--
DECEMBER										
13	6.2	27	2	11.7	50	-	-	-	0.3	10
27	5.2	7	1	12.5	----	-	-	-	---	--
JANUARY										
24	3.0	8	2	13.2	----	0	1	2	1.1	20
FEBRUARY										
07	1.8	7	2	13.5	30	0	6	3	0.5	30
21	3.6	12	10	13.6	50	0	2	3	0.8	20
MARCH										
13	4.7	12	4	15.4	60	0	1	4	0.3	50
27	5.1	21	7	15.9	65	0	1	9	0.1	60
APRIL										
10	7.8	17	4	14.6	250	0	1	8	0.6	80
24	10.0	13	3	11.3	100	0	1	3	0.2	50
MAY										
08	9.4	12	4	13.3	130	0	1	5	0.0	40
22	11.7	21	9	13.8	400	0	1	5	0.3	50
JUNE										
12	13.1	33	29	13.0	400	0	9	76	5.3	40
26	13.6	16	5	12.8	200	0	2	6	0.7	50
JULY										
10	15.2	18	3	12.0	400	0	2	5	0.2	20
24	17.5	12	4	11.6	1300	0	2	5	0.8	20
AUGUST										
07	19.2	13	2	11.3	110	0	0	2	0.1	10
21	18.9	9	2	11.0	120	0	2	2	0.6	30
SEPTEMBER										
11	18.7	14	1	10.1	400	0	2	4	3.3	0
25	14.8	12	1	11.0	220	0	10	1	2.5	20

TABLE 2.4-8

AVERAGE CHEMICAL CONCENTRATIONS IN THE COLUMBIA RIVER AT PRIEST RAPIDS DAM, OCTOBER 1971 TO SEPTEMBER 1972

Chemical	Concentration
Calcium	19. (mg/ℓ)
Magnesium	4.3 (mg/ℓ)
Sodium	2.1 (mg/ℓ)
Potassium	1.4 (mg/ℓ)
Chromium	0
Copper	2.6 (μg/ℓ)
Lead	8.0 (μg/ℓ)
Total Mecury	0.9 (μg/ℓ)
Zinc	32.0 (μg/ℓ)
Bicarbonate	72. (mg/ℓ)
Sulfate	13. (mg/ℓ)
Chloride	1.5 (mg/ℓ)
Kjeldahl Nitrogen	.29 (mg/ℓ)
Ammonia Nitrogen	.07 (mg/ℓ)
Nitrite Nitrogen	.006 (mg/ℓ)
Nitrate Nitrogen	.26 (mg/ℓ)
Ortho-Phosphorus	.013 (mg/ℓ)
Total Phosphorus	.037 (mg/ℓ)
Total Alkalinity	59. (mg/ℓ)
Hardness	66. (mg/ℓ)
Noncarbonate Hardness	06.8 (mg/ℓ)
Specific Conductance	158. (micro-mhos)
pH	7.8 (units)
Dissolved Solids	107. (mg/ℓ)
Color	15. (platinum - cobalt units)

TABLE 2.4-9

DISCHARGE LINES TO COLUMBIA RIVER FROM HANFORD RESERVATION

Area	Discharge Lines	Discharge Rates, cfs	or	Quantities	Use	Temperature	Other Potential Water Quality Effects
100-B/C	12-in. steel pipe			6,000 gallons	Backflush pump inlet screens	Ambient	None - untreated raw river water
100-B/C	42-in. steel pipe	2.2			Drains and filter backwash	2.8°C, above above ambient	Total Solids, Turbidity, Aluminum, Sulfate, Chloride
100-Ke and KW		1.1		5,000 gallons 3 times a year	Backflush pump inlet screens	Ambient	None - untreated river water
100-Ke and KW	Two 84-in. steel pipes	1.1			Drains, overflow and cooling water for compressors and pumps	2.8°C above ambient	Total Solids, Turbidity, Aluminum, Sulfate, Chloride, Chlorine (0.25 mg/ℓ)
100-N				75,000 gallons 3 times a day	Backflush pump inlet screens	Ambient	None - untreated river water
100-N	3- by 4-ft concrete chute	1.1			Overflow from filtered water and raw water storage tanks, condensate from medium pressure steam system, filter backwash	11 to 20°C above ambient	Total Solids, Ammonia (as well as radioactive waste) Chlorine (0.05 mg/ℓ) Turbidity
100-N	42-in. steel pipe	0.01			Filtered water overflow, and waste from floor drains	6 to 8°C above ambient	Sulfate, Chloride, Chlorine (0.05 mg/ℓ)
100-N	66-in. pipe to 12-ft concrete flume on riverbank	140			Turbine condenser cooling water and graphite heat exchanger cooling water	16°C above ambient	Aluminum, Turbidity
100-N	102-in. steel pipe	300 (extremes 140 and 410 cfs)			Steam condenser cooling water	5.5°C above ambient	Turbidity, Ammonia, Sulfate, Iron, Sodium, (occasionally 0.3 mg/ℓ orthophosphate), Chlorine - 2 to 40 ppb
WPPSS	132-in. steel pipe	940 when river <25°C 1260 when river >25°C			Steam condenser cooling water	15 to 20°C above ambient	(Same as above)
100-D/DR	12-in. steel pipe			6,000 gallons once a month	Backflush pump inlet screens once a month	Ambient	None - untreated river water
100-D/DR	Two 42-in. steel pipes	4.4 (2.2 to 22)			Filter backwash and process coolant and wash) water, hydraulic test loop water)	2.8°C above ambient	Total Solids, Turbidity, Aluminum, Sulfate, Choride, Chlorine (0.74 mg/ℓ) (maximum 2.2 mg/ℓ)
300	24-in. concrete pipe terminating as a 30-in. half-round corregated metal pipe	2.2 (average)		6 to 12/day batches of 12,000 gallons	Filter backwash (from water treatment plant)	Ambient	Total Solids, Turbidity, Aluminum, Sulfate, "Separon" (a proprietary polyacrylamide filter aid) Chlorine (0.5 mg/ℓ)
300	36-in. steel pipe	0.01			Air conditioner cooling water and floor drains	25°C above ambient	Aluminum, Sulfate, Chlorine (∿0.5 mg/ℓ)
300	12-in. steel pipe	1.1 (0.04 to 2.3)			Drainage from roof and parking lot, tanks for aquatic organisms	2 to 3°C above ambient	Total Solids, Turbidity, Organic nitrogen

TABLE 2.4-10

TOTAL ANNUAL DIRECT CHEMICAL DISCHARGE FROM HANFORD RESERVATION TO COLUMBIA RIVER

Materials	Quantity from All Facilities (tons)
Aluminum Sulfate	260
Chlorine	20
Polyacrylamide	0.8
Salt (rock)	22
Sodium Dichromate	2
Sulfuric Acid	650
Ammonium Hydroxide	60
Hydrazine	8
Morpholine	1.5
Sodium Hydroxide	230

TABLE 2.4-11

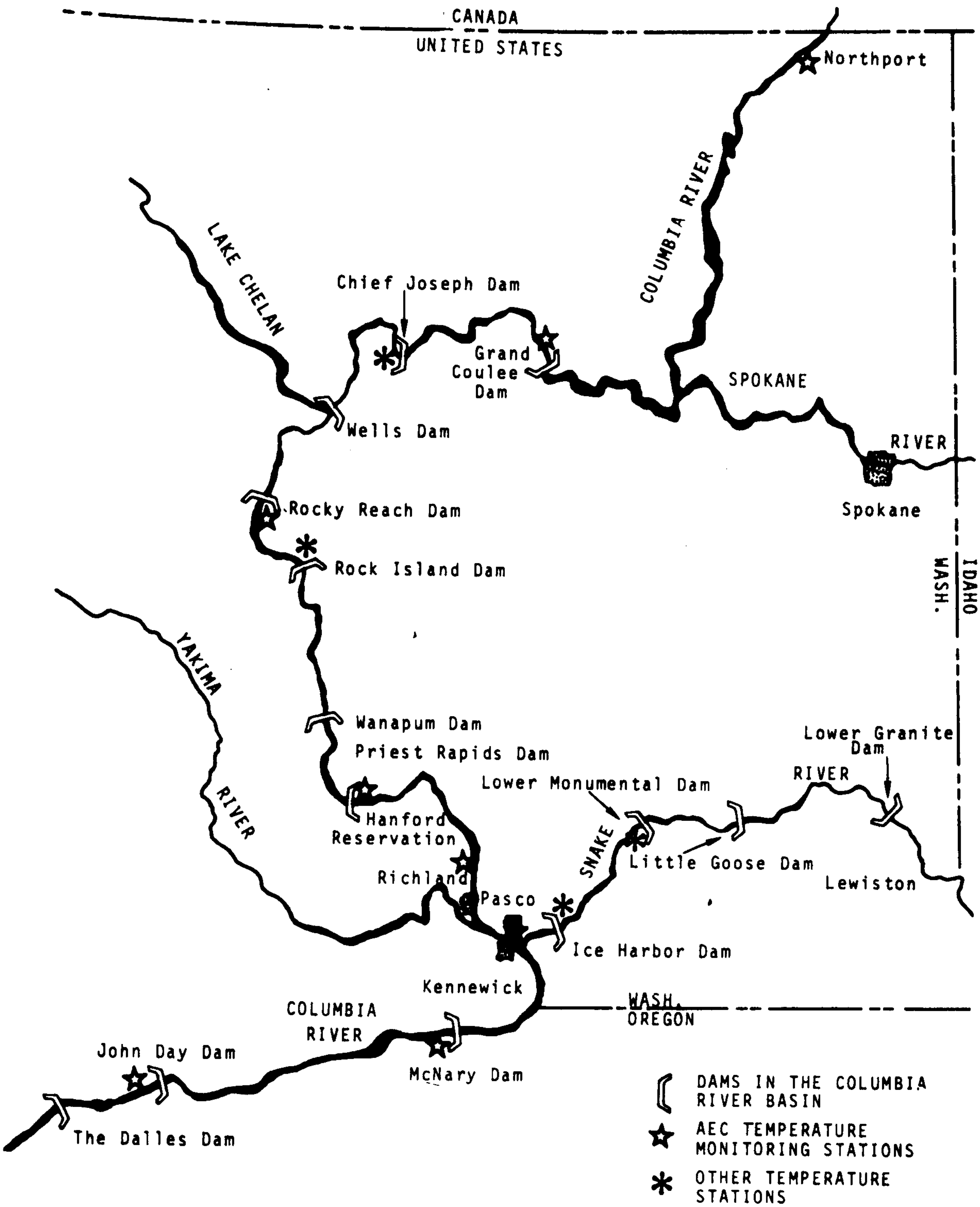
MAJOR GEOLOGIC UNITS IN THE HANFORD RESERVATION AREA AND THEIR WATER BEARING PROPERTIES

System	Series	Geologic Unit	Material	Water-Bearing Properties
		Fluviatile and glaciofluviatile sediments and the Touchet formation. (0-200 ft thick)	Sands and gravels occurring chiefly as glacial outwash. Unconsolidated, tending toward coarseness and angularity of grains, essentially free of fines.	Where below the water table, such deposits have very high permeability and are capable of storing vast amounts of water. Highest permeability value determined was 12,000 ft/day.
	Pleistocene	Palouse soil (0-40 ft thick)	Wind deposited silt.	Occurs everywhere above the water table.
Quaternary		Ringold formation (200-1,200 ft thick)	Well-bedded lacustrine silts and sands and local beds of clay and gravel. Poorly sorted, locally semi-consolidated or cemented. Generally divided into the lower "blue clay" portion which contains considerable sand and gravel, the middle conglomerate portion, and the upper silts and fine sand portion.	Has relatively low permeability; values range from 1 to 200 ft/day. Storage capacity correspondingly low. In very minor part, a few beds of gravel and sand are sufficiently clean that permeability is moderately large; on the other hand, some beds of silty clay or clay are essentially impermeable.
	Miocene and Pliocene	Columbia River basalt series. (>10,000 ft thick)	Basaltic lavas with interbedded sedimentary rocks, considerably deformed. Underlie the unconsolidated sediments.	Rocks are generally dense except for numerous shrinkage cracks, interflow scoria zones, and interbedded sediments. Permeability of rocks is small (e.g., 0.002 to 9 ft/day) but transmissivity of a thick section may be considerable (70 to 700 ft^2/day)
?	?	Rocks of unknown age, type, and structure.	Probable metasediments and metavolcanics.	?

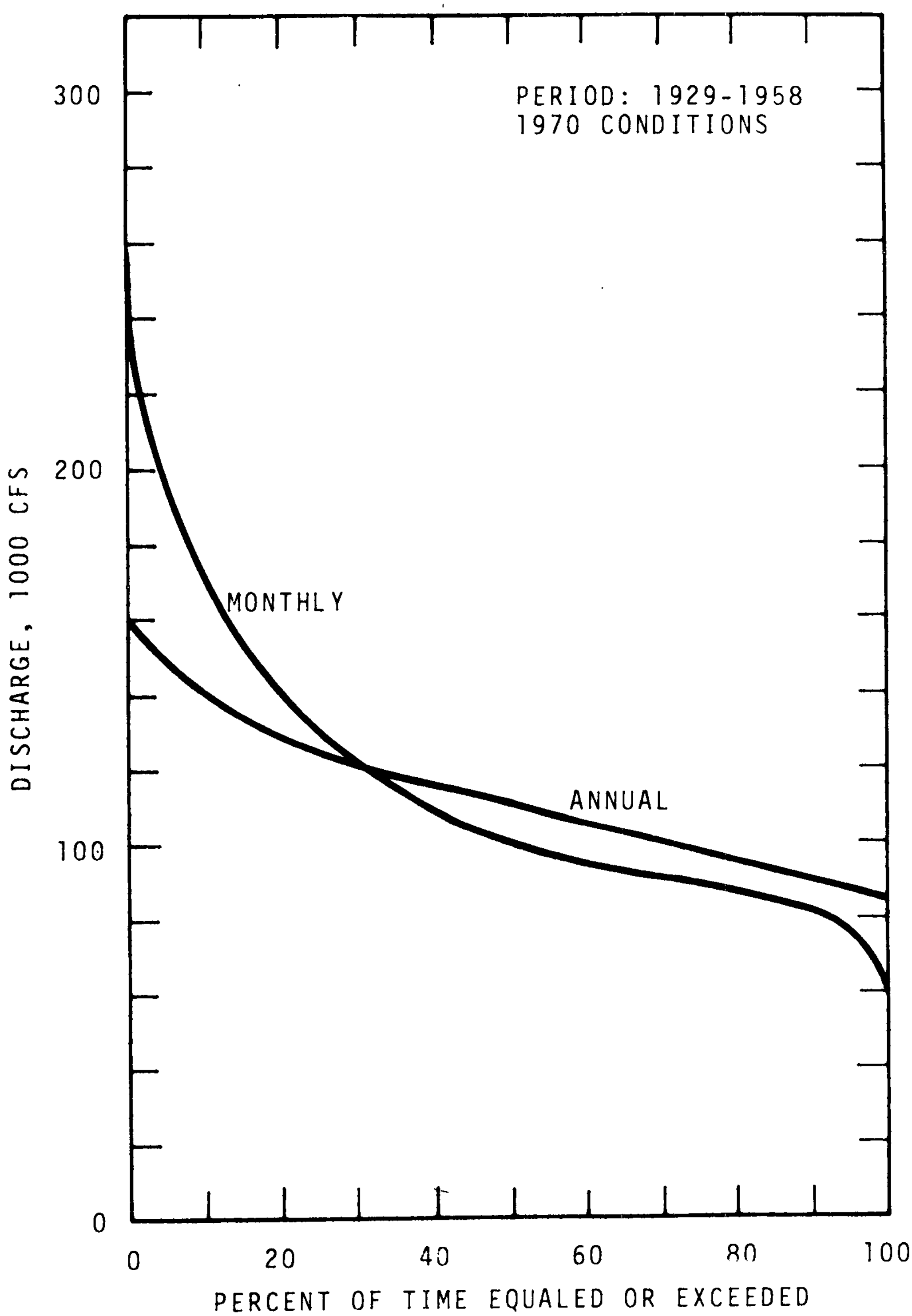
TABLE 2.4-12

AVERAGE FIELD PERMEABILITY (FT/DAY)

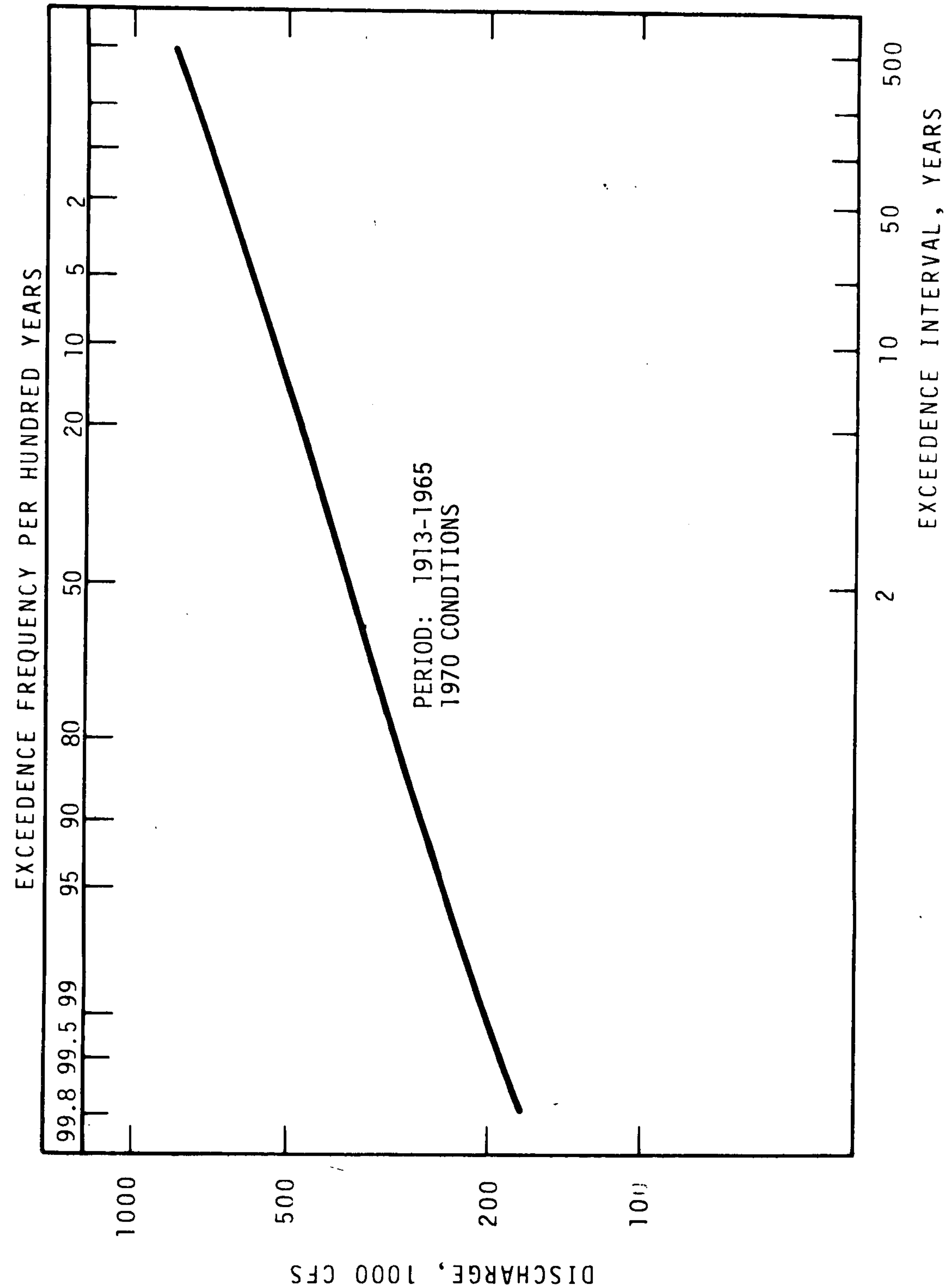
Tested	Pumping Tests	Specific Capacity Tests	Tracer Tests	Cyclic Fluctuations	Gradient Method
Glaciofluvial (gravels)	1700-9000	1300-900	8000	2200-7600	---
Glacial and Ringold (gravels)	120-670	130-530	---	130-800	---
Ringold (gravels)	1-200	8-40	---	20-66	13-40



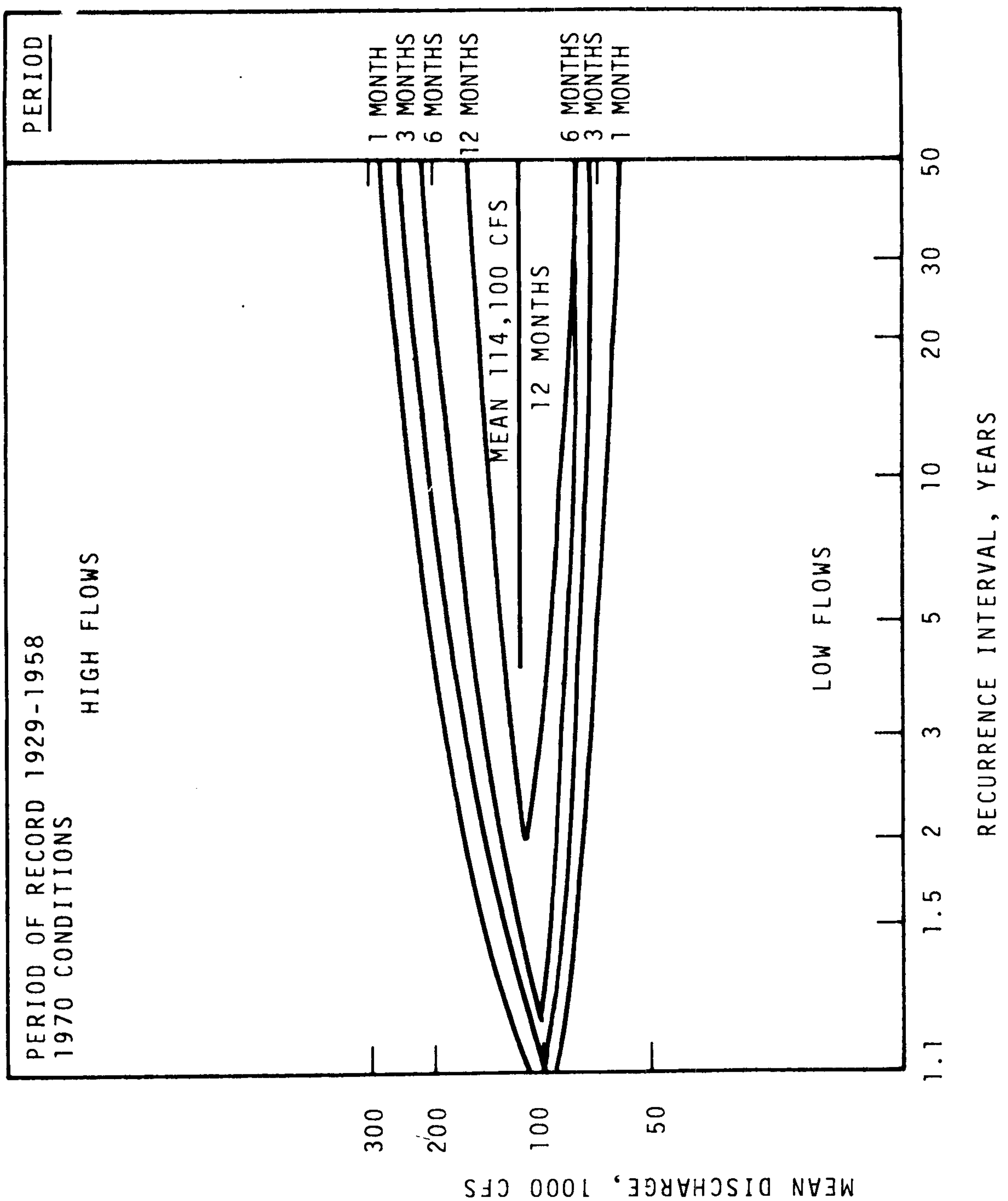
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	UPPER AND MIDDLE COLUMBIA RIVER BASIN
	FIG. 2.4-1



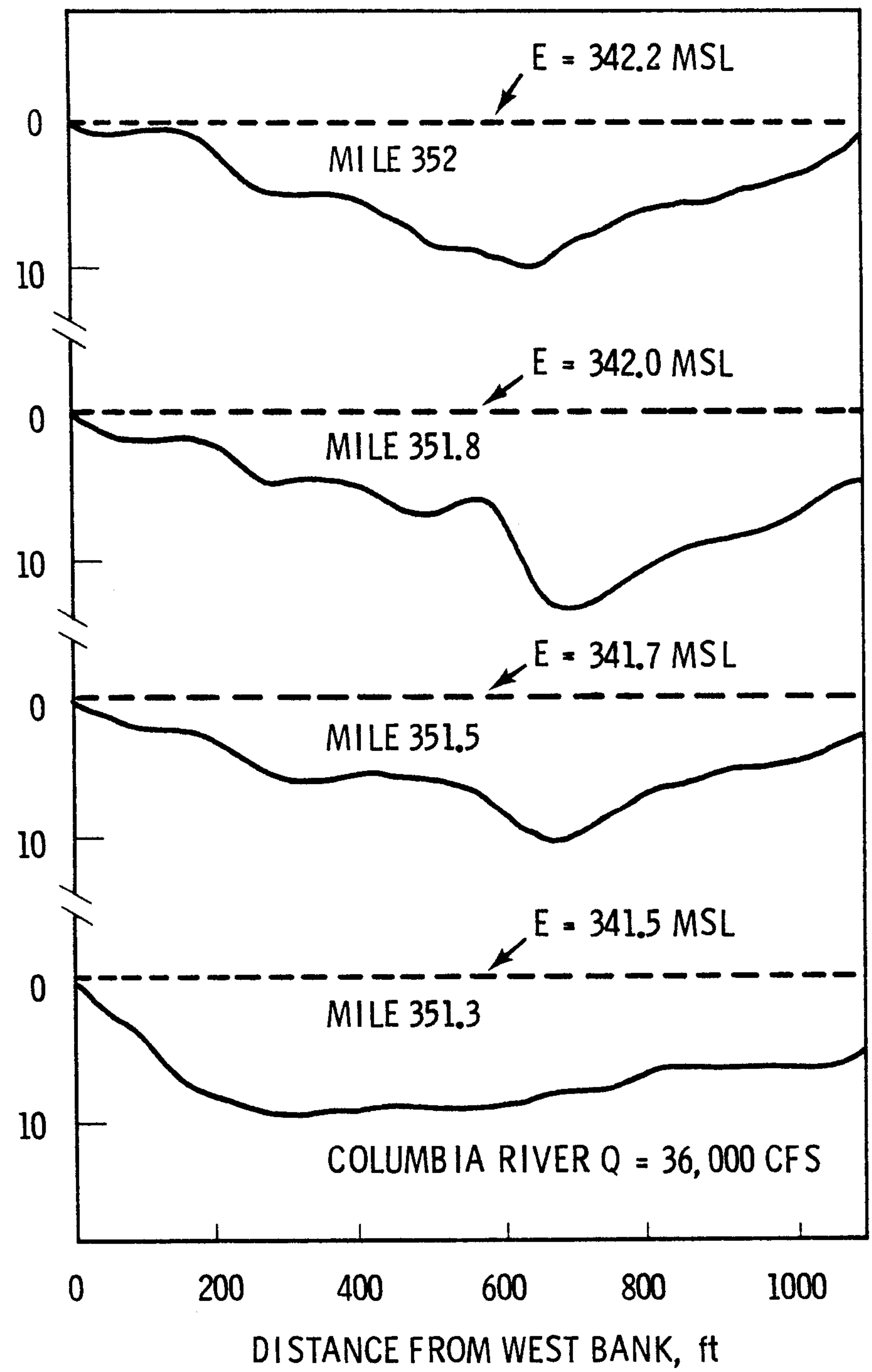
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	DISCHARGE DURATION CURVES OF THE COLUMBIA RIVER BELOW PRIEST RAPIDS DAM, WA
	FIG. 2.4-2



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FREQUENCY CURVE OF ANNUAL MOMENTARY PEAK FLOWS FOR THE COLUMBIA RIVER BELOW PRIEST RAPIDS DAM, WA **FIG.** 2.4-3

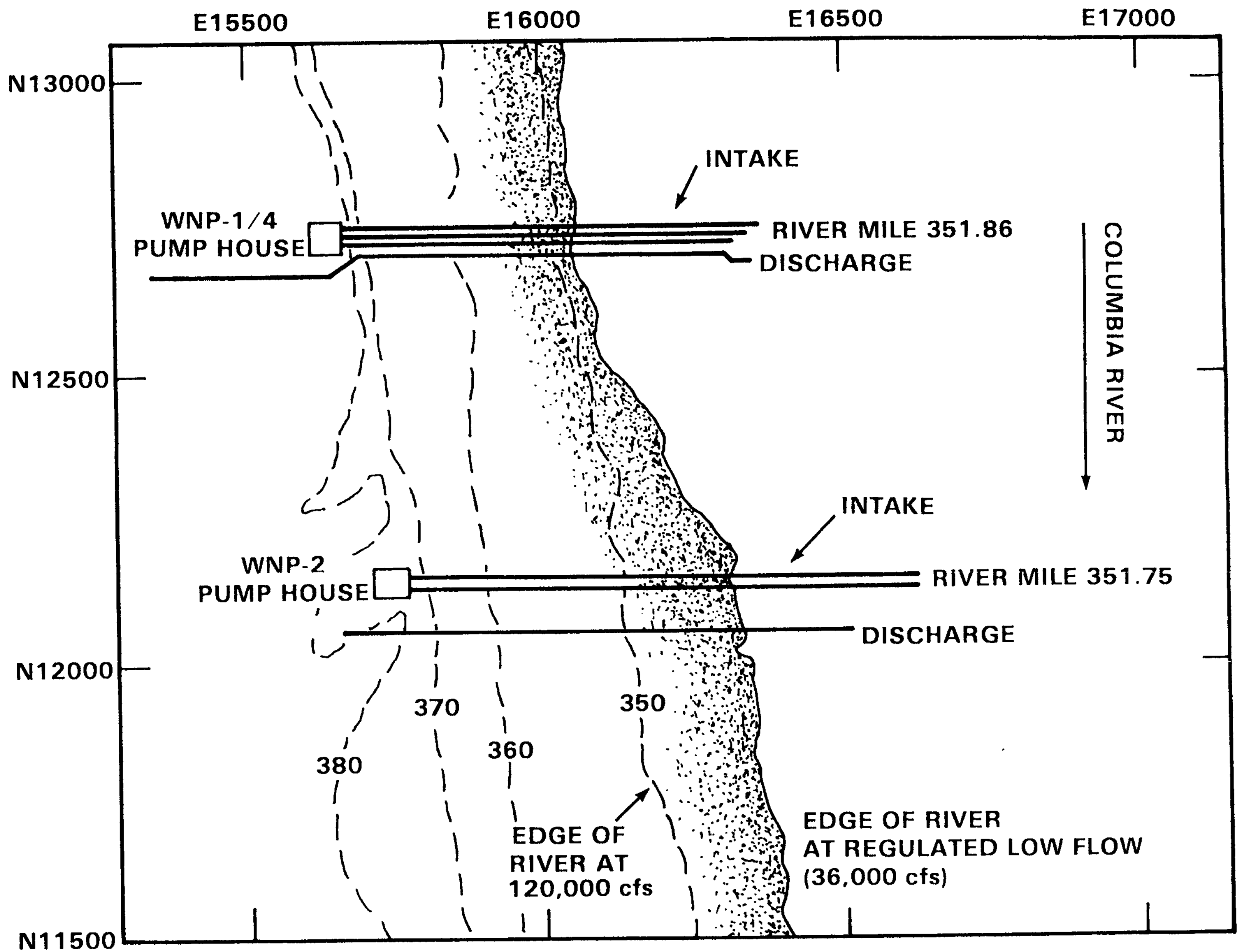


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FREQUENCY CURVES OF HIGH AND LOW FLOWS FOR THE COLUMBIA RIVER BELOW PRIEST RAPIDS DAM, WA	
		FIG. 2.4-4



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	CROSS SECTIONS OF THE COLUMBIA RIVER IN THE PLANT VICINITY FIG. 2.4-5

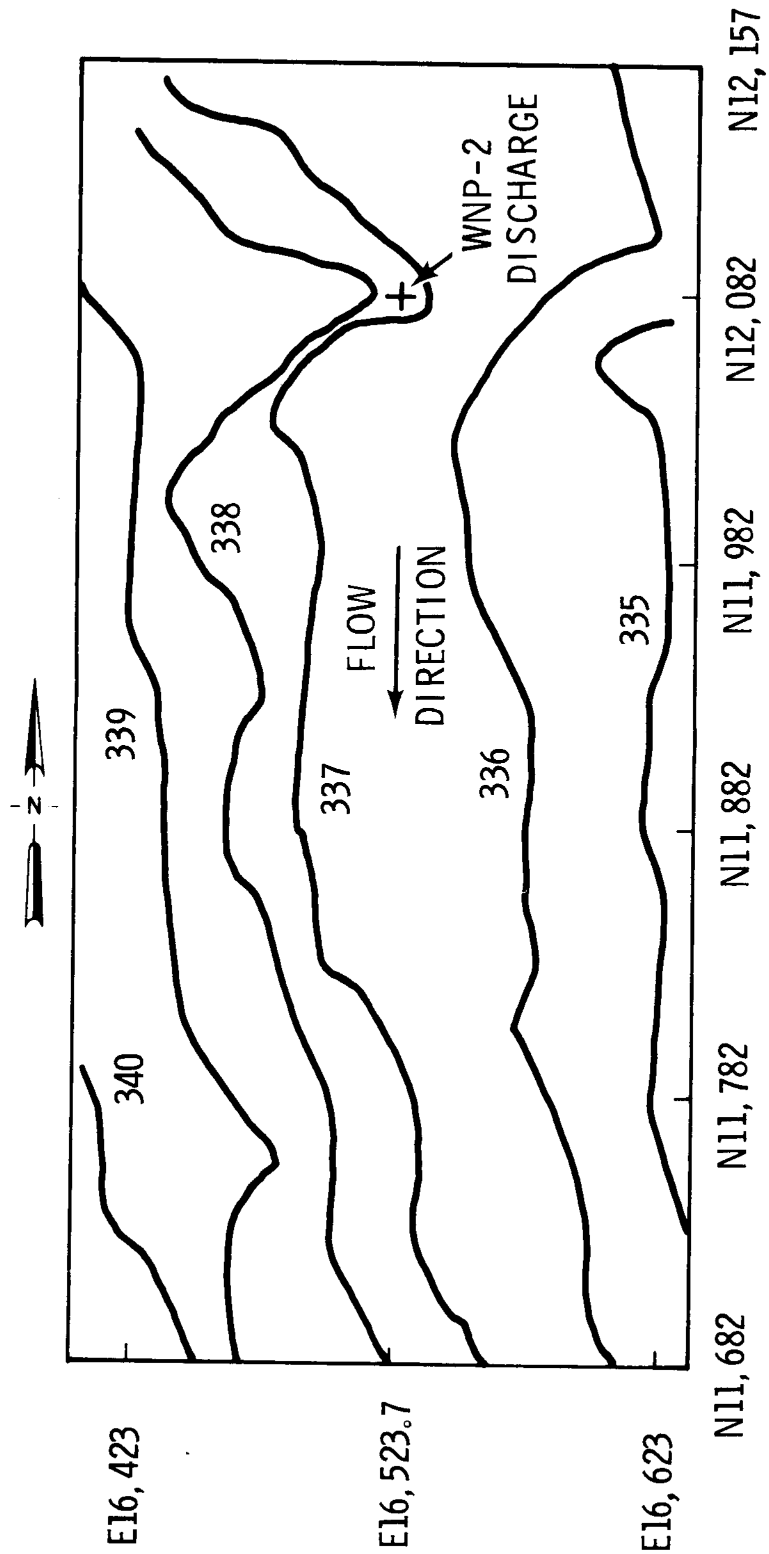
WASHINGTON PUBLIC POWER SUPPLY SYSTEM
WPPSS NUCLEAR PROJECT NO. 2
Environmental Report



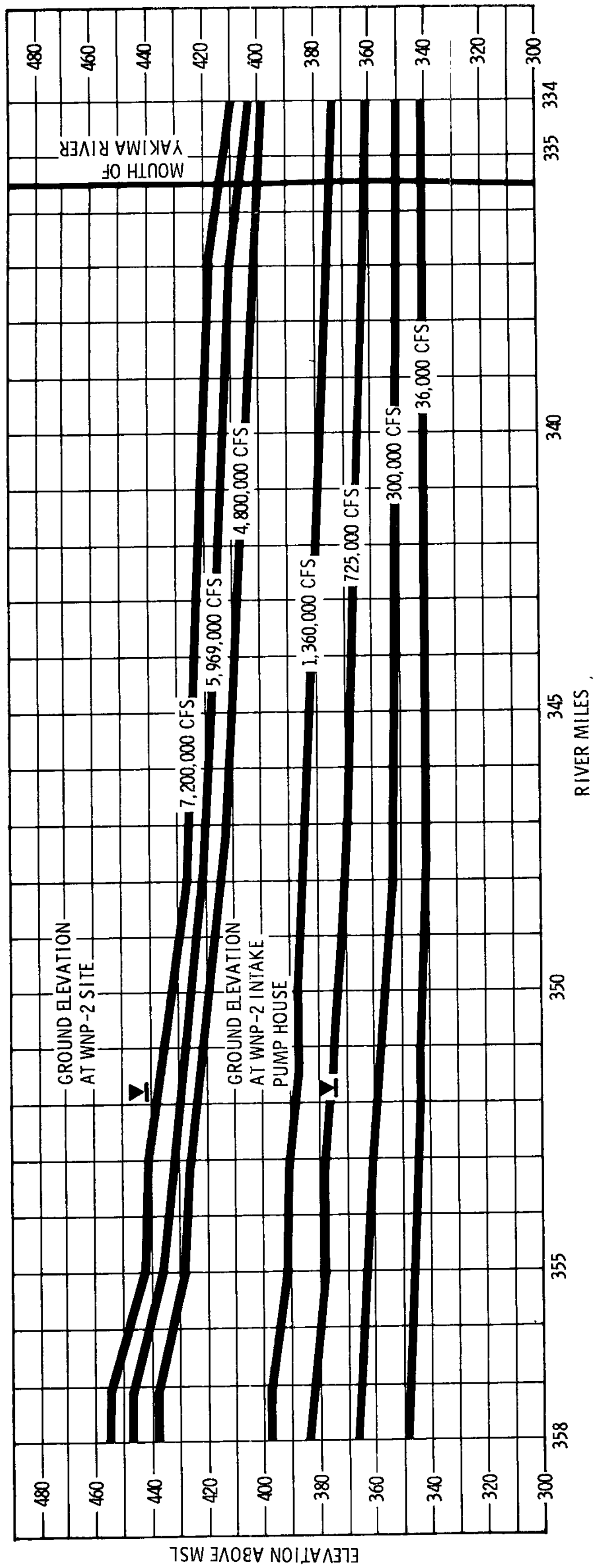
LOCATION OF INTAKE AND DISCHARGE LINES WNP-1, WNP-4, and WNP-2

FIG. 2.4-6

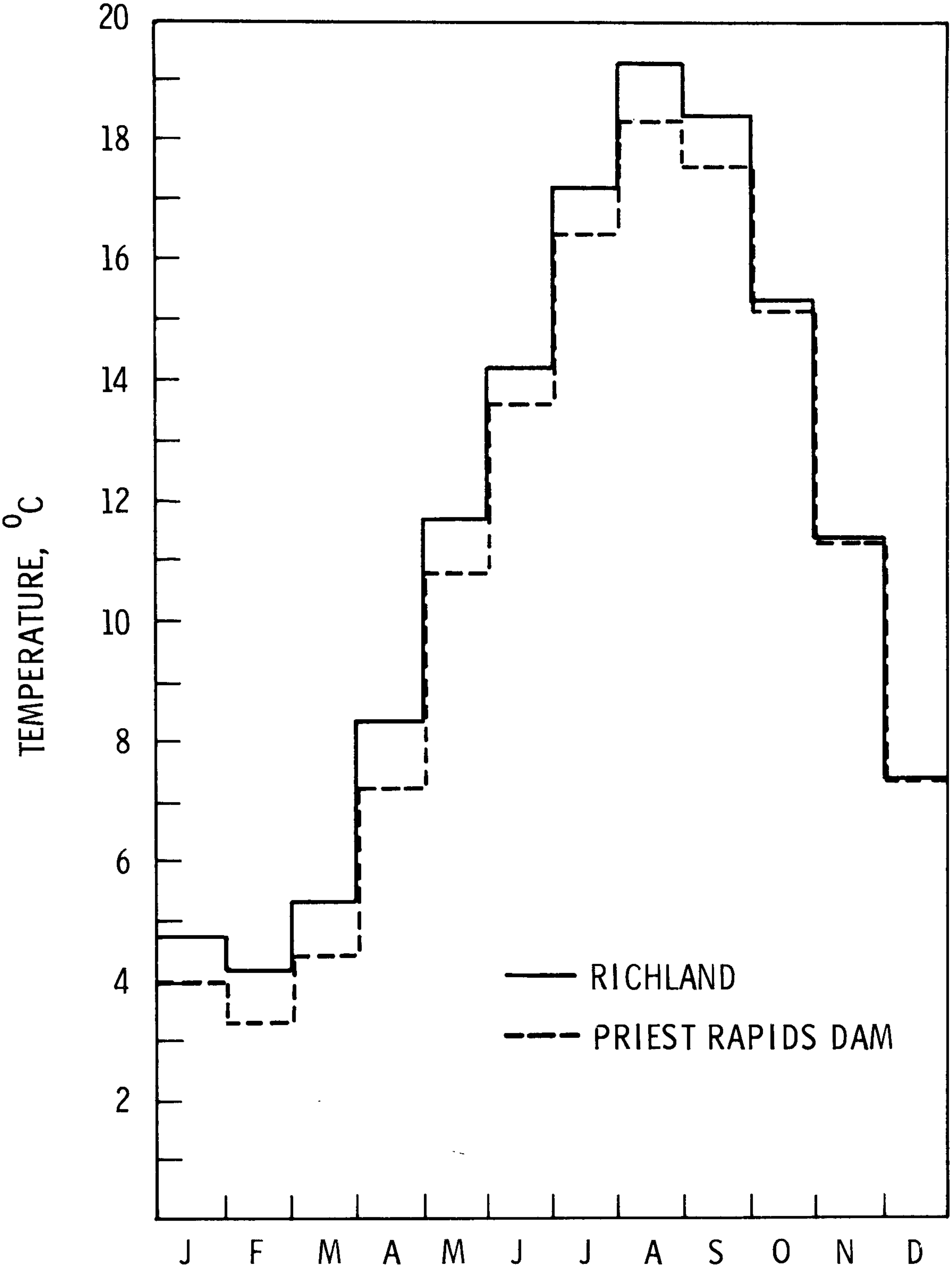
Amendment 4, October 1980



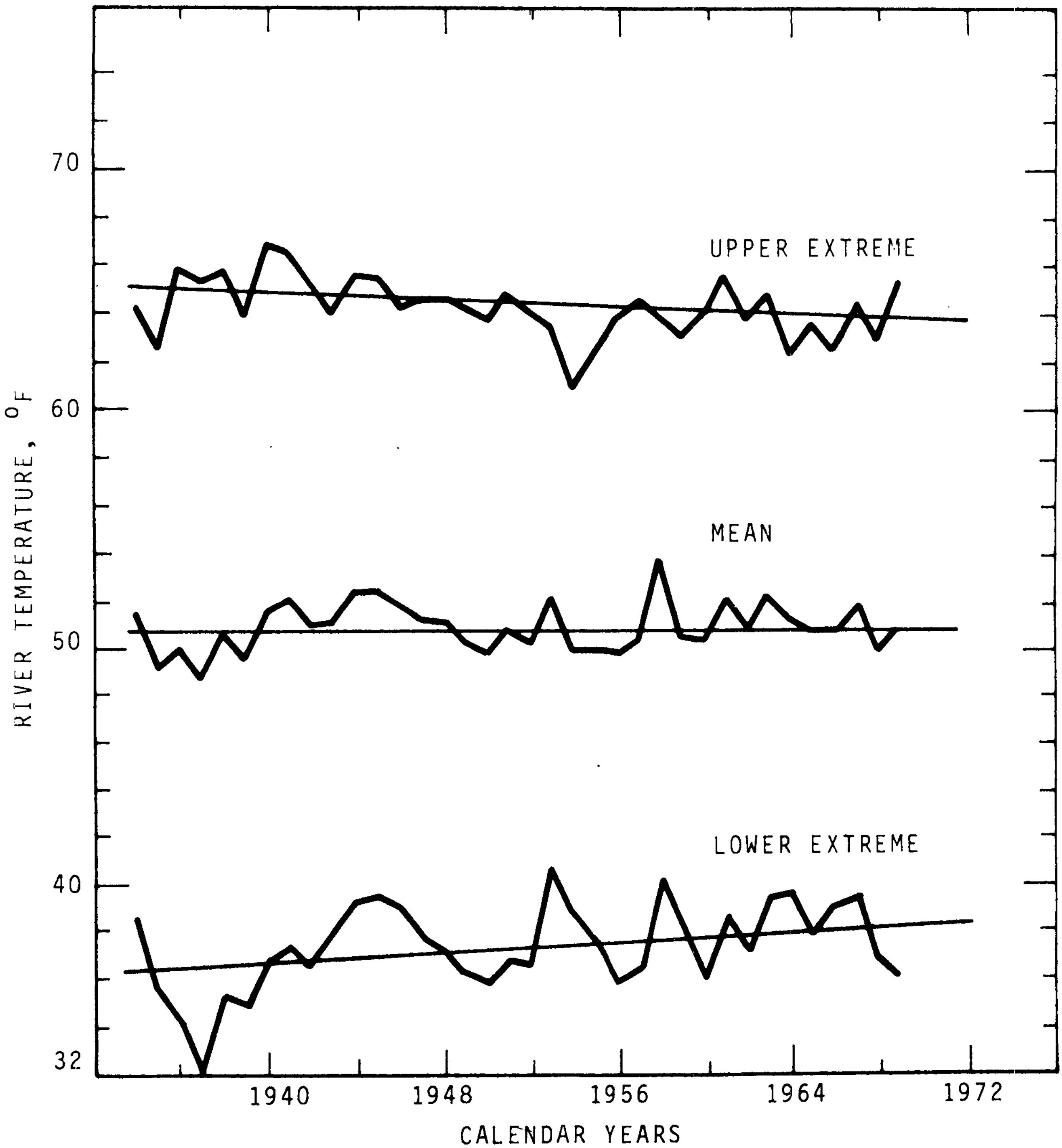
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	ELEVATION CONTOURS OF THE RIVER BOTTOM AT THE WNP-2 DISCHARGE (FEET ABOVE SEA LEVEL)
	FIG. 2.4-7



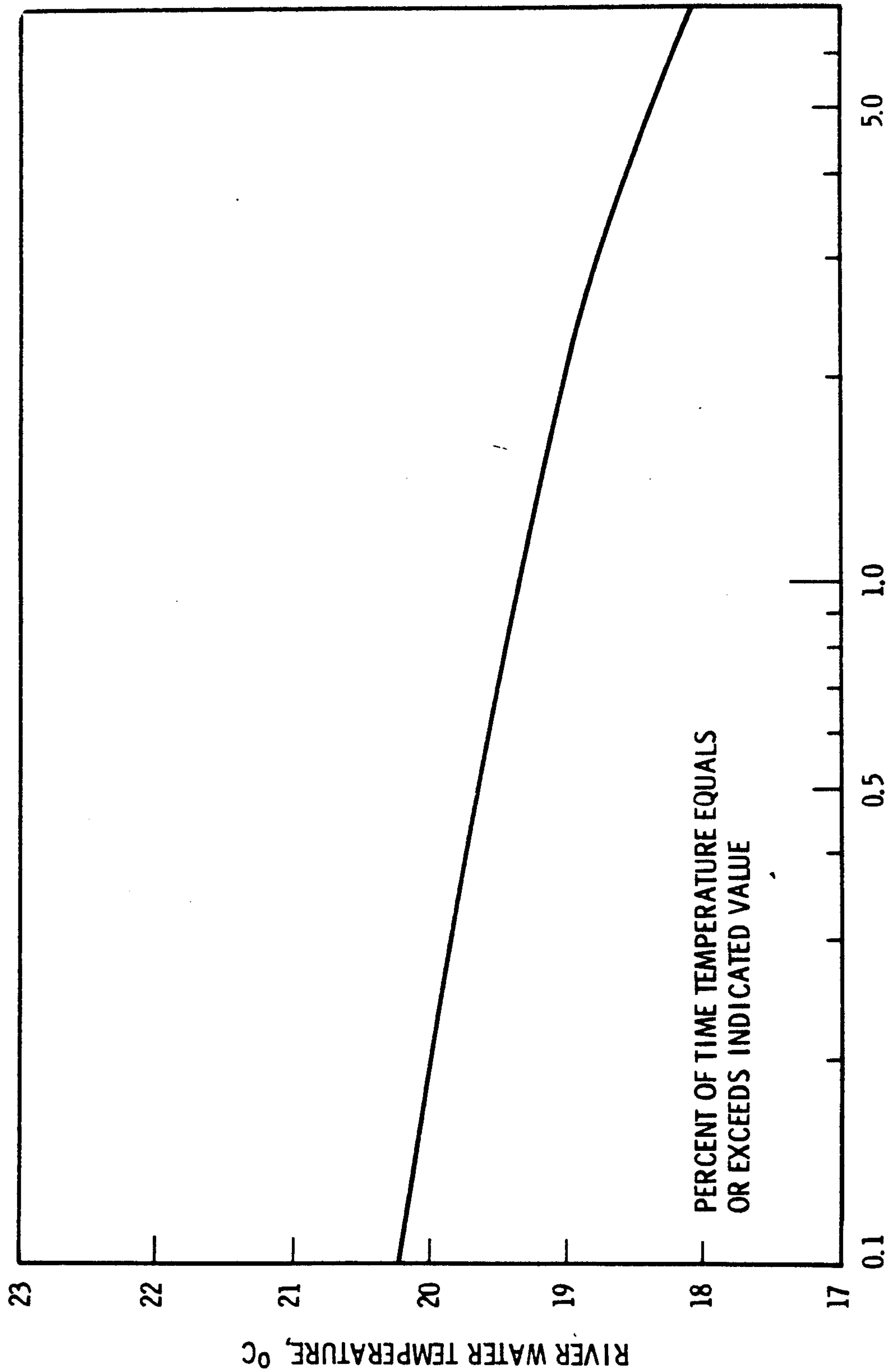
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	RIVER WATER SURFACE PROFILES FOR SEVERAL FLOW DISCHARGES IN THE VICINITY OF THE PLANT SITE FIG. 2.4-8



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	AVERAGE MONTHLY TEMPERATURE COMPARISON FOR PRIEST RAPIDS DAM RICHLAND, FOR 10-YEAR PERIOD 1965-1974
	FIG. 2.4-9

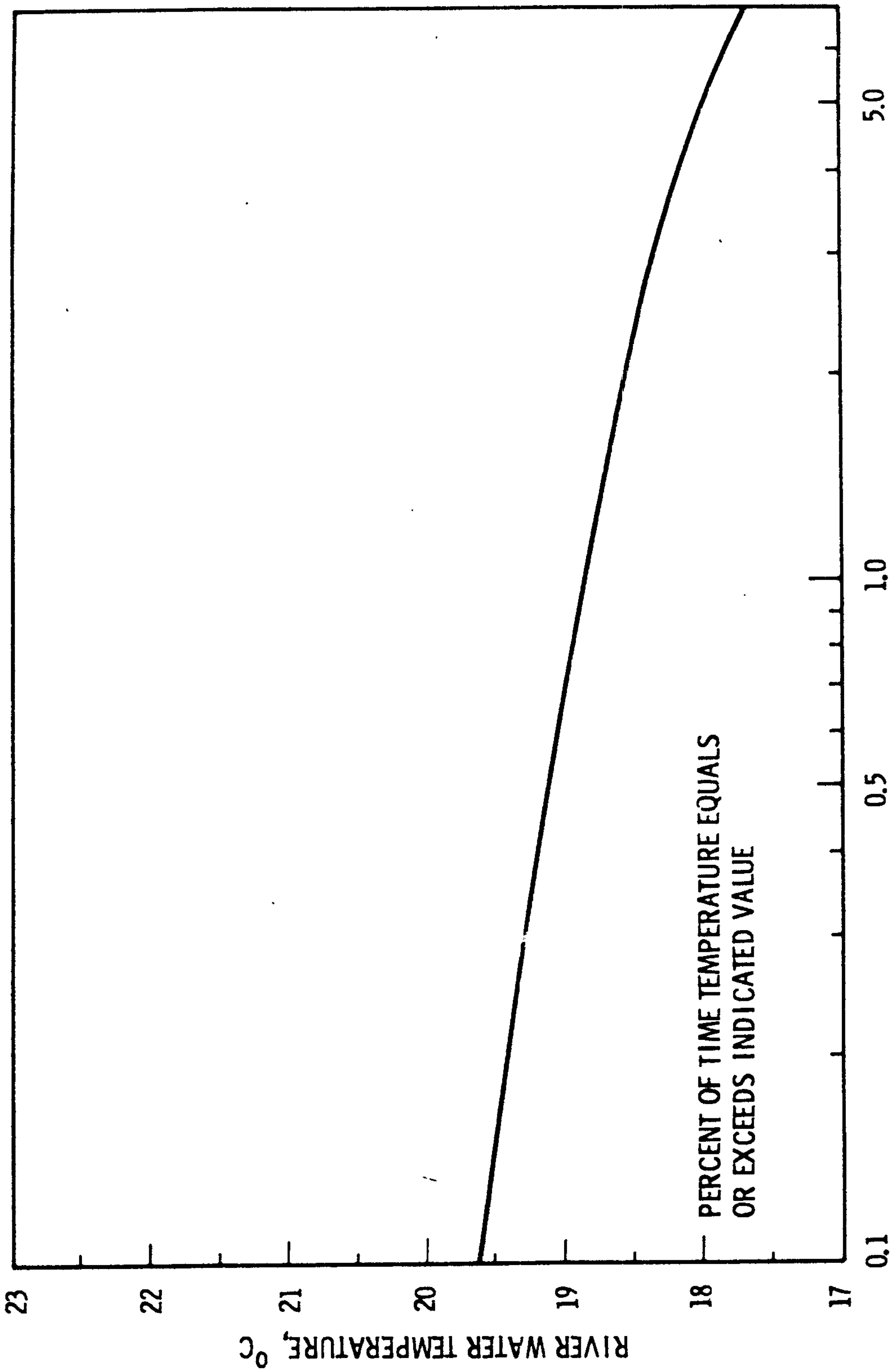


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	COMPUTED LONG TERM TEMPERATURE ON THE COLUMBIA RIVER AT ROCK ISLAND DAM (1938-1972) FIG. 2.4-10



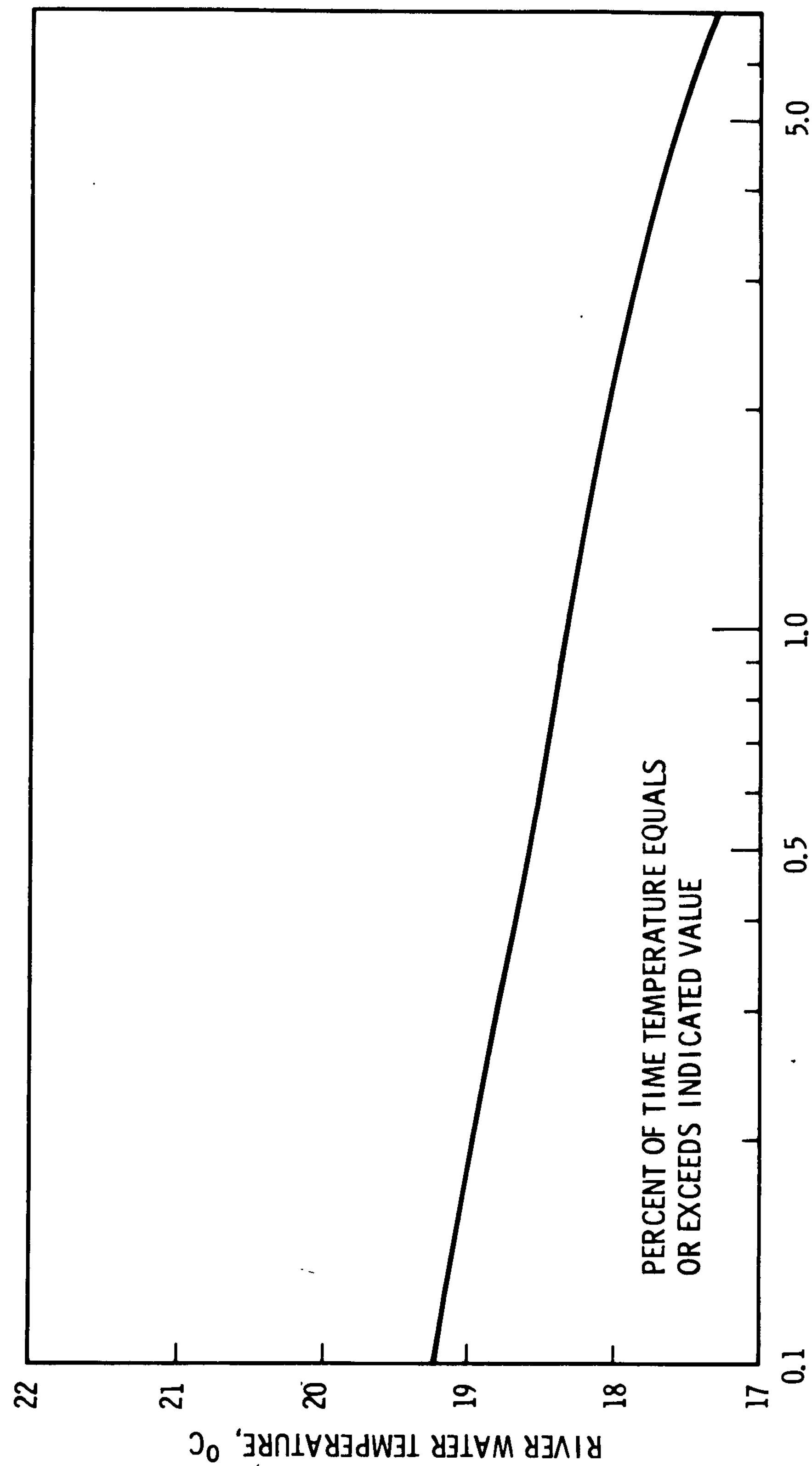
Amendment 4, October 1980

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	ONE HOUR DURATION FREQUENCY CURVE OF HIGH RIVER WATER TEMPERATURE IN THE VICINITY OF THE PROECT SITE FIG. 2.4-11

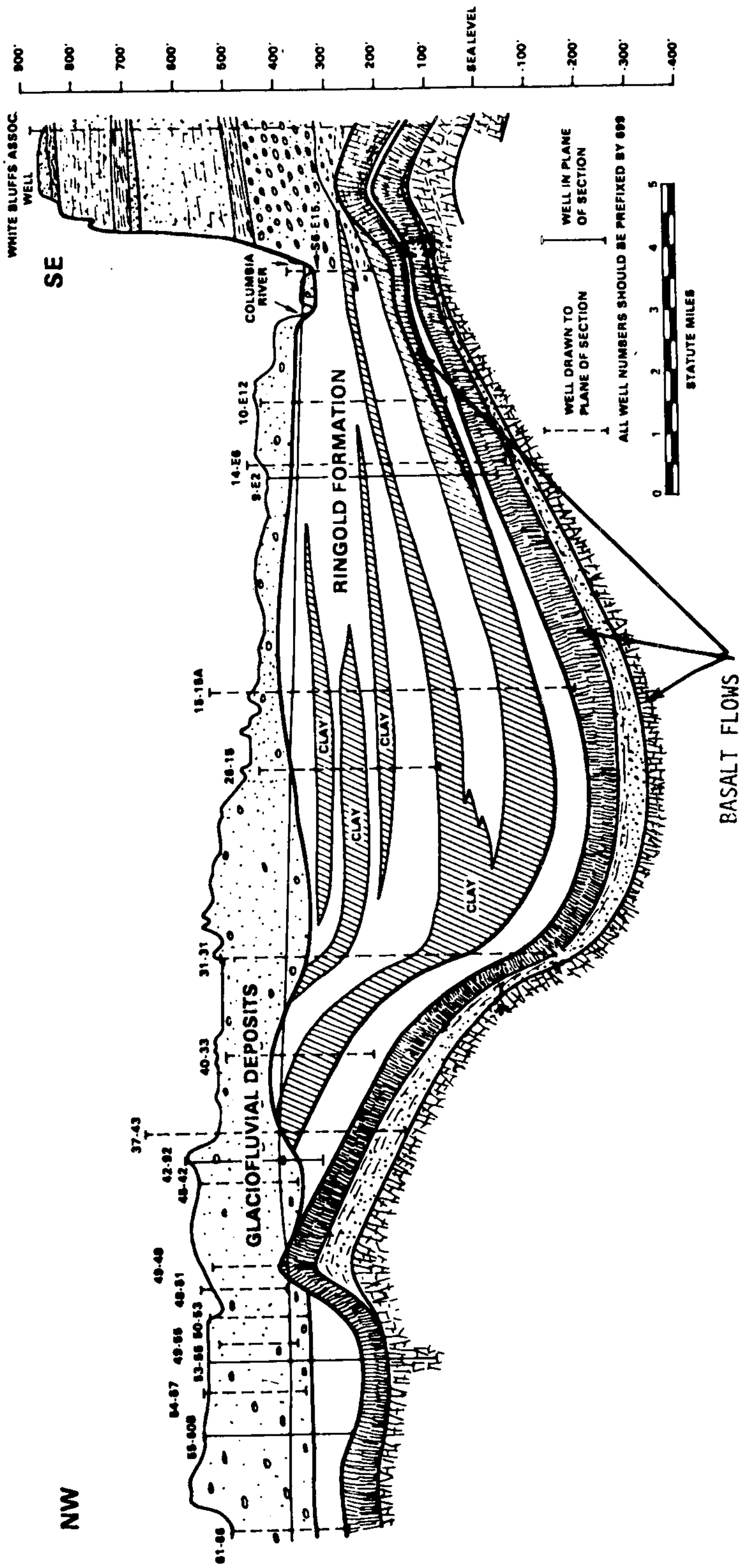


Amendment 4, October 1980

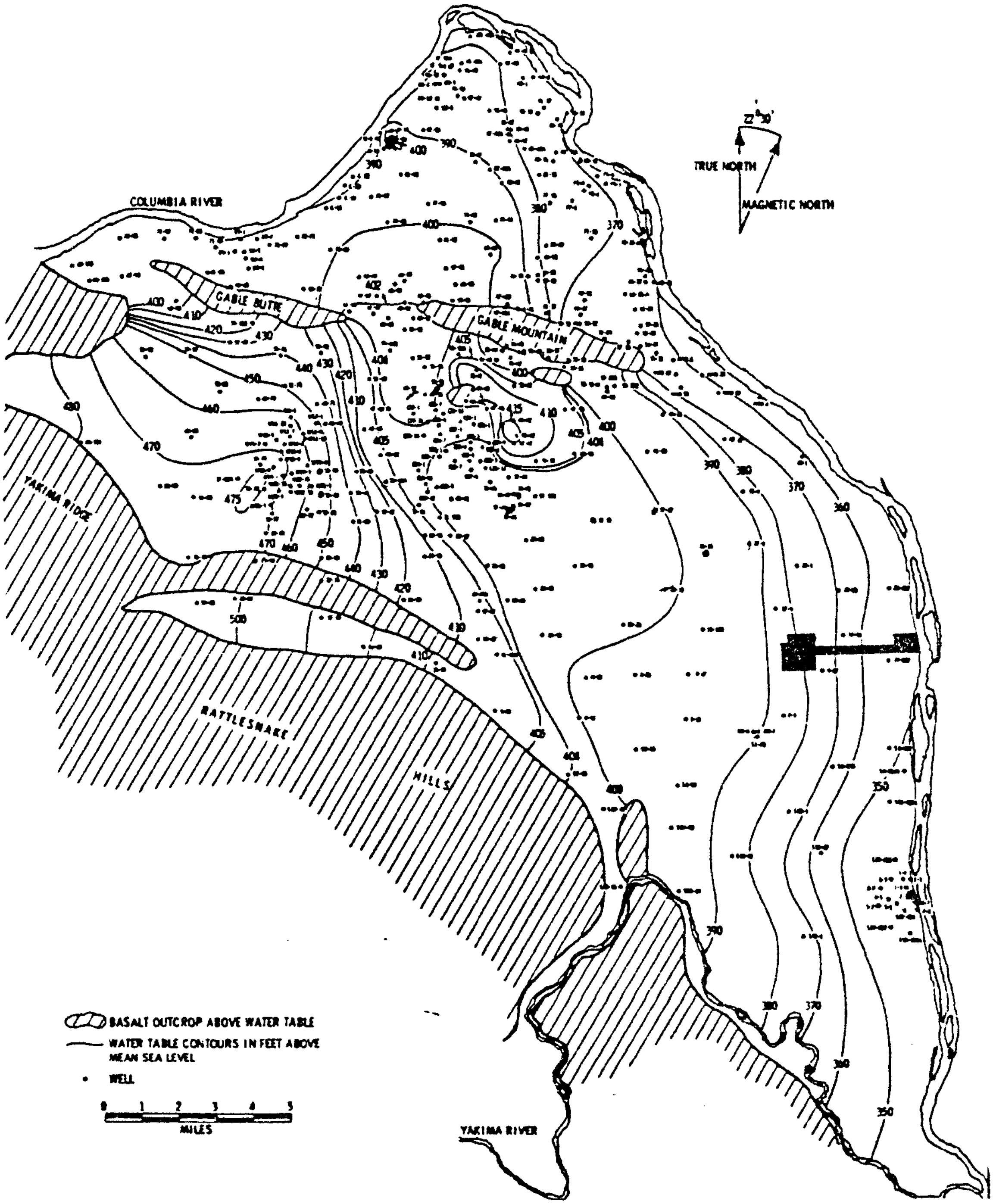
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	TWENTY-FOUR HOUR DURATION FREQUENCY CURVE OF HIGH RIVER WATER TEMPERATURE IN THE VICINITY OF THE PLANT SITE
	FIG. 2.4-12



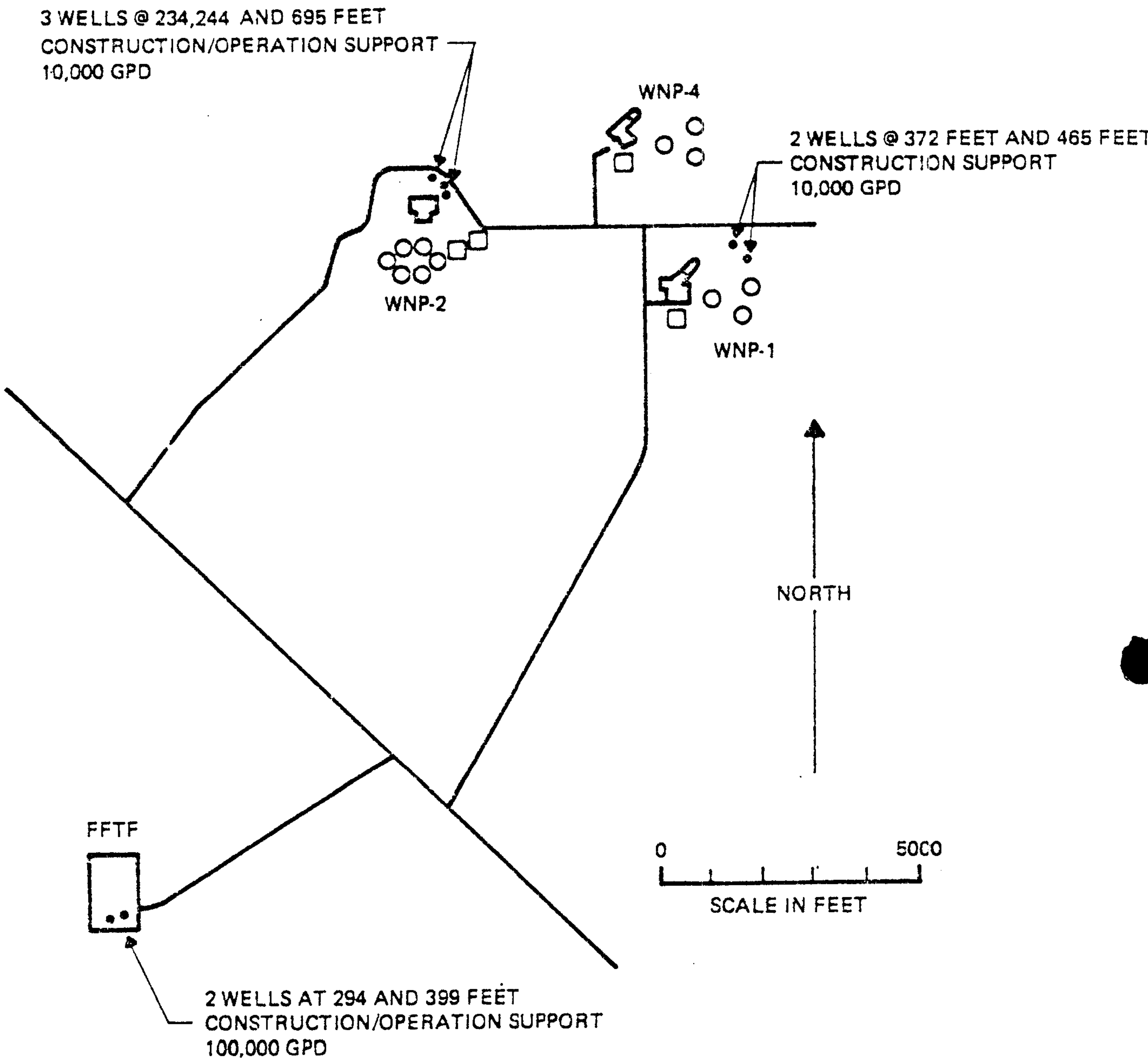
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SEVEN DAY DURATION FREQUENCY CURVE OF HIGH RIVER WATER TEMPERATURE IN THE VICINITY OF THE PROJECT SITE
	FIG. 2.4-13



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SIMPLIFIED GEOLOGICAL CROSS SECTION OF THE HANFORD RESERVATION WASHINGTON
	FIG. 2.4-14



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	GROUNDWATER CONTOURS AND LOCATIONS OF WELLS FOR THE HANFORD RESERVATION, WASHINGTON SEPTEMBER, 1973
	FIG. 2.4-15



Amendment 3, January 1979

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	POINTS OF GROUNDWATER WITHDRA[illegible] IN THE VICINITY OF WNP-2
	FIG. 2.4-16

2.5 GEOLOGY

The basic geology of the site and region was described in the AEC Final Environmental Statement (December 1972). Additional geologic and seismic studies of the site area have been conducted in support of construction and safety studies for WNP-1 and WNP-4. Applicable results are reported in the WNP-2 FSAR. These additional studies have not indicated any need to further evaluate the interface between the plant and its operation, and the geologic environment.

2.6 REGIONAL HISTORIC, SCENIC, CULTURAL AND NATURAL FEATURES

No historic places as listed in the "National Register of Historic Places"(1) occur within a 30-mile radius of the WNP-2 site. The three nearest sites on the National Register are Olmstead Place State Park, Marmes Rockshelter, and Whitman Mission National Historic Site. Olmstead Place State Park is located 70 miles northwest of the Project near Ellensberg, Washington. Marmes Rockshelter is 52 miles northeast of the Project near the confluence of the Palouse and Snake Rivers, and the Whitman Mission is 53 miles to the southeast near Walla Walla, Washington. One natural landmark listed in the National Register(1) is within a 50-mile radius of the proposed Project. This is the Ginkgo Petrified Forest State Park, approximately 47 miles to the northwest. None of these sites will be affected by the Project.

However, as of February 10, 1976, three years following the granting of permits and authorities to construct WNP-2, six properties have been determined to be eligible for inclusion on the "National Register of Historic Places" and are within a 30-mile radius of the WNP-2 site(1). These properties are entitled to the same protective measures provided for properties on the National Register pursuant to the procedures of the President's Advisory Council on Historic Preservation.

The six properties are: the Hanford Island Archaeological Site, 18 miles north of Richland; the Hanford North Archaeological District, 22 miles north of Richland; the Paris Archaeological Site, Hanford Works Reservation; the Snively Canyon Archaeological District, 25 miles northwest of Richland; the Wooded Island Archaeological District, north of Richland; and the Savage Island Archaeological District 15 miles north of Richland.

The location of all six of the properties is within the boundary of the Hanford Reservation which has provided protection to these archaeological sites from destruction by relic collectors through security procedures and restricted access. The Wooded Island Archaeological District is located about two miles south of the WNP-2 intake, and the WNP-2 pumphouse will be visible from the north end of Wooded Island. Other than this specific visual alteration, none of the six properties are anticipated to be adversely affected by WNP-2. The State Historic Preservation Officers review of the impact of plant operation on the Wooded Island site is contained in Appendix III.

The historic-ethnographic people who aboriginally occupied the stretch of Columbia River from Priest Rapids to Pasco, Washington, were the Wanapam* Indians ("River People").

Historically, the main village of the Wanapam was located at Priest Rapids,[2] approximately 43 miles upstream from the WNP-2 area. There is archaeological evidence, however, that other village sites closer to the project area were important in prehistoric times, such as the extensive village at Wahluke, located 24 miles upstream from the Project area, which was excavated in 1926-27 by the U.S. National Museum.[3]

There is no ethnographic evidence that the Wanapam people occupied the immediate Project area. The last Wanapam occupation of the Project area was in 1943 when the Hanford Reservation was established and the area evacuated. Today, remaining descendants of the Wanapam people live at Priest Rapids and on the Yakima Indian Reservation. Their recent history has been preserved by Relander.[4]

The archaeology of the middle Columbia River in South Central Washington is largely unknown. Large-scale research was conducted in the McNary Dam Reservoir area to the south in the early 1950's.[5,6,7] Upstream, approximately 69 miles, some research was conducted in the Wanapum Dam Reservoir area.[8,9] The only archaeology conducted on the Hanford Reservation since Krieger's[3] work at Wahluke was a preliminary survey and test program along the Columbia River[10] and a field and laboratory investigation near the Hanford No. 1 Generating Plant carried out by Rice[11] under contract with the Washington Public Power Supply System. This study provided a comparative collection of artifacts from an area that has not been studied for over 40 years. It also provided archaeological evidence that demonstrated aboriginal culture stability and continuity for at least 6500 years. It further demonstrated that the archaeological resource within the Hanford area is considerable and warrants further investigation and preservation.

The services of Dr. David G. Rice, Associate Professor of Anthropology, University of Idaho, a professional archaeologist with experience in the Pacific Northwest, were retained by Burns and Roe, Inc. (architect engineer for WNP-2) in order to determine whether or not archaeological and historical resources might be affected by project construction or transmission line relocation for WNP-2. Field examination of the complete Project area was conducted on August 19, 1972[12] and of the pumphouse and intake area again between January 6 and 10, 1975 and on February 3, 1975.[13]

* Students of Anthropology spell the Indian name as Wanapam. Historical references spell it Wanapum.

No archaeological features or historic structures were observed at the reactor site.[12] Geological work at the reactor site indicates that the sediments present include glacial flood gravels and associated sediments which by their nature are not likely to contain archaeological deposits. These observations also pertain to the corridor between the reactor site and the Columbia River.[14] During the 1972 field examination, evidence was observed of intermittent occupation by aboriginal people adjacent to the west bank of the Columbia River in the vicinity of the WNP-2 pumphouse and water intake. Neither surface concentrations of archaeological materials nor any accumulated depth of occupational debris were observed. Also no historical structures or features were observed. Dr. Rice recommended that no further archaeological or historical work be provided for WNP-2 except that the excavation of the pumphouse be re-examined at the time of construction for possible sub-surface evidence of aboriginal occupation.[12]

Approximately 400 to 500 ft. southeast of the intake water pumphouse area are two archaeological sites (45-BN-113 and 45-BN-114) located on the gravel beach on the west bank of the Columbia River. These sites will not be disturbed, and future access will remain unchanged.

In January 1975, Dr. Rice conducted archaeological investigations in the area of the WNP-2 pumphouse and water intake to determine whether or not subsurface evidence for aboriginal occupation existed. Scattered fire cracked rocks and three cobble implements were recovered in an area 40 feet by 30 feet. Dr. Rice's interpretation of the cultural materials observed is that the immediate project area was intermittently used as a camp site by small groups of prehistoric peoples over the last few hundred years. Their stay at these camps was evidently brief judging from the sparse accumulation of cultural material and artifacts. Since aeolian sediments overlie the cultural material and since the cultural material lies comformably upon overbank river deposits, Dr. Rice concluded that the archaeological material has been deflated by wind erosion into a single floor. The absence of organic material like bone or shell tends to corroborate this view. No earlier occupations were encountered in the sediments of the river terrace. Dr. Rice recommended that no further archaeological work be provided for the construction site of the WNP-2 pumphouse and water intake.[13]

The transmission line from the Project makes connection to the Bonneville Power Administrations 500 kV switchyard in the 100-N Area of the Hanford Reservation. (See Figure 2.1-2 for location of the 100-N Area). The 18.3 mile long by 135 ft. wide corridor goes in almost a straight line from WNP-2 to the switchyard. Since the corridor is well inland from the Columbia River it does not traverse areas likely to be rich in artifacts from earlier river-oriented tribes.

CHAPTER 3
THE PLANT

CHAPTER 3

THE PLANT

3.1 EXTERNAL APPEARANCE

Figure 2.1-4 shows the relative location of the WNP-2 plant, makeup water pumphouse, adjacent roads, railroads and transmission lines. Figure 2.1-3 shows the layout of the buildings, structures, roads, and railroads for the plant.

Figure 3.1-1 is a color oblique aerial photograph from the west of the construction site looking east with the Columbia River in the background. Shown in the photograph are the main plant buildings, spray ponds, and cooling towers. Figure 3.1-2 is an artist's conception of the finished plant (looking south-west) including the spray ponds and the cooling towers.

Two spray ponds are located approximately 600 ft. southeast of the diesel generator building. Each is 250 ft. square and 15 ft. deep.

Six round concrete mechanical (induced) draft cooling towers (See Figures 3.1-3 and 3.4-1), each 60 ft. high and 200 ft. in diameter, and the circulating water pumphouse, are located approximately 700 ft. south of the radwaste and control building.

The makeup water pumphouse (See Figures 3.1-4 and 3.1-5) is located 3 miles east of the plant on the west shore of the Columbia River Mile 352 (at an elevation of 374 ft. 6" above MSL), and will supply makeup water for WNP-2.

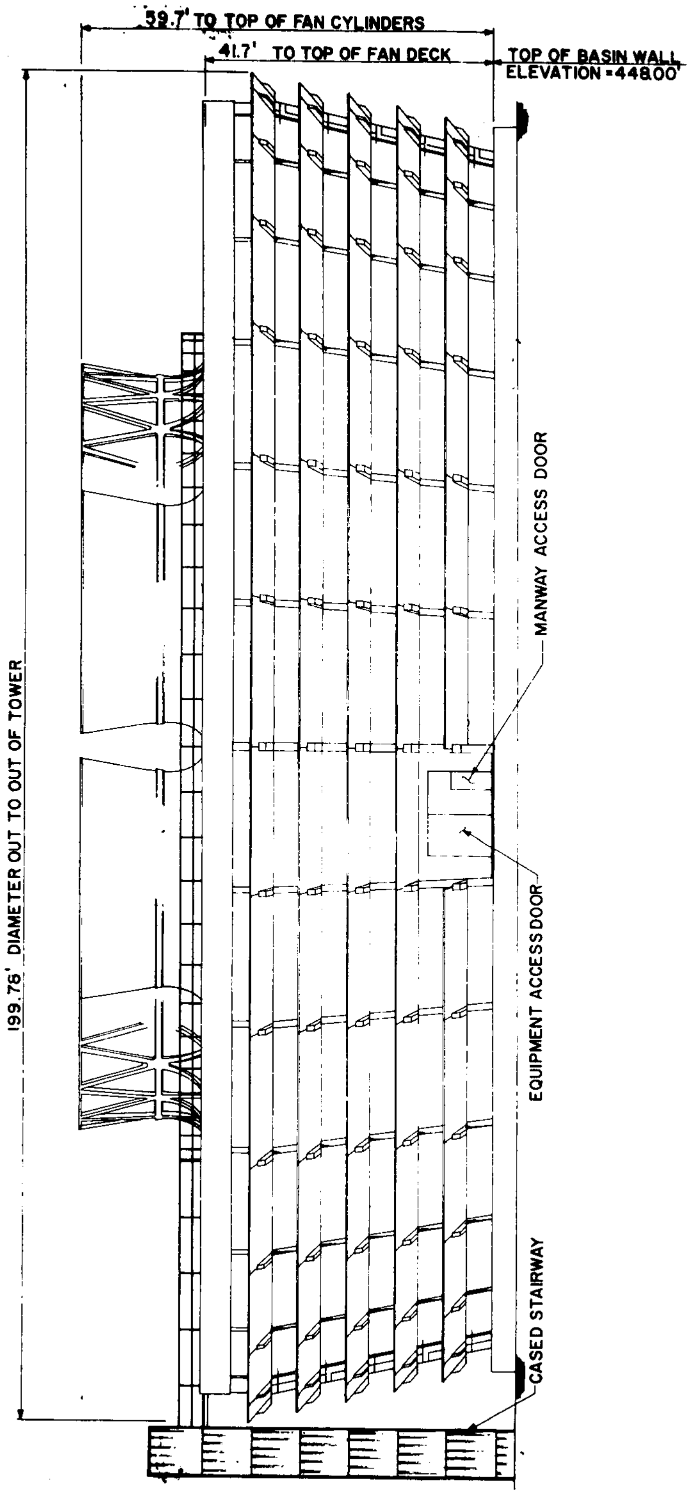
The bottle storage building, for storing hydrogen, carbon dioxide and nitrogen, is located 367 ft. north of the turbine generator building (See Figure 2.1-4).

Two 400,000 gallon, 40 ft. high condensate storage tanks are located 36 feet north of the turbine generator building. An 800,000 gallon concrete dike, surrounding the tanks, will contain any spills.

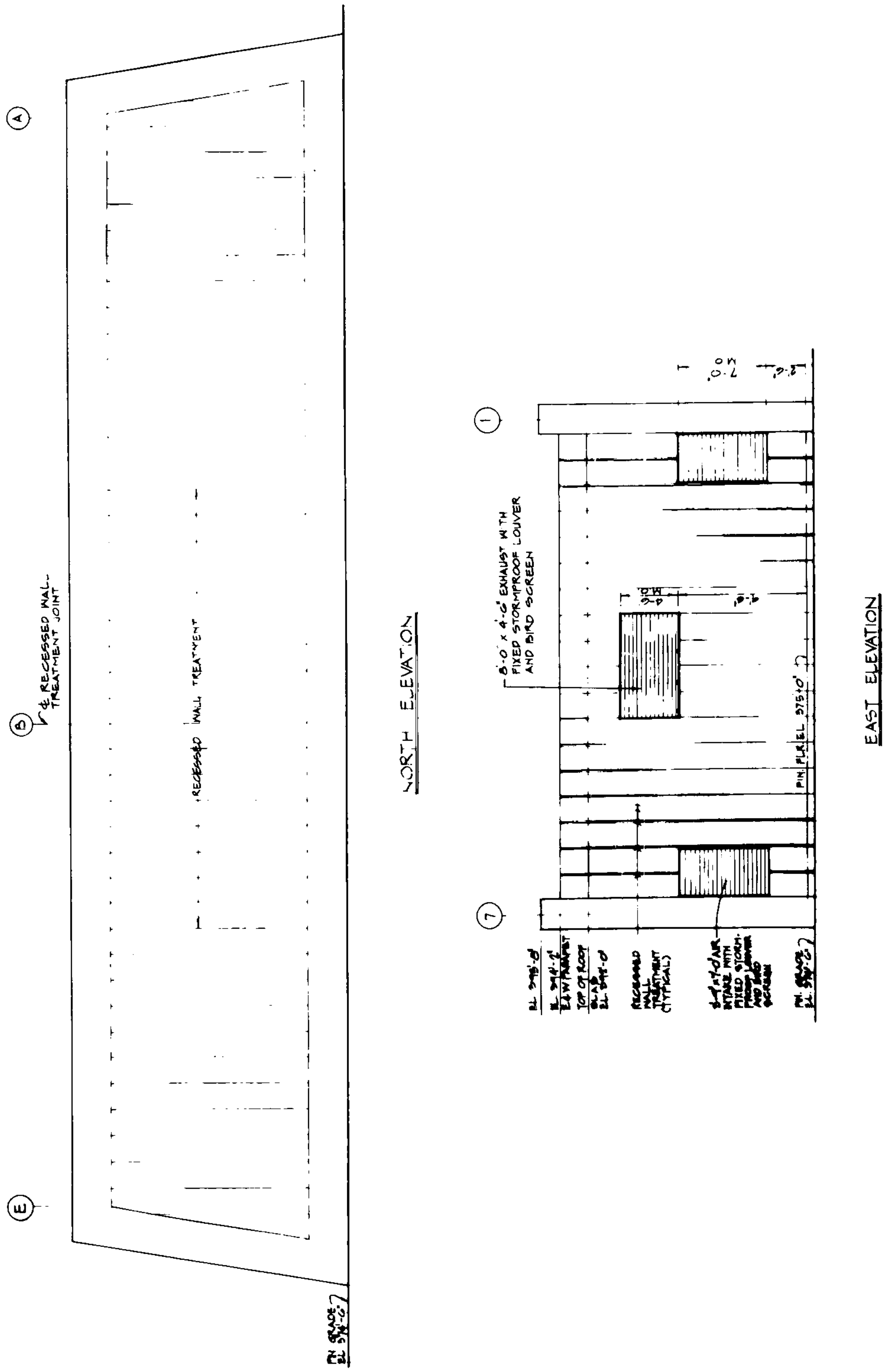
The locations and elevations of all gaseous and liquid radioactive release points are shown in Figure 3.1-6.

All of the structures are functional in design and the maximum effort has been made to achieve an esthetically pleasing appearance. Within the plant fence line, the grounds will be seeded with grass or stabilized with gravel. Unused plant property not seeded or graveled will be left in its natural state. Nothing will be allowed to grow within 20 feet of the plant security fence line.

Seclusion of the plant is achieved by it's location within the Hanford Reservation where travel by the general public is restricted. Low profile mechanical draft cooling towers and appropriate coloring of the plant, facilitate the intregation of the plant with the desert plain surrounding the site.



WASHINGTON PUBLIC POWER SUPPLY SYSTEM **WPPSS NUCLEAR PROJECT NO. 2** **Environmental Report**	MECHANICAL DRAFT COOLING TOWER ELEVATION
	FIG. 3.1-3



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	MAKE-UP WATER PUMPHOUSE ELEVATION
	FIG. 3.1-4

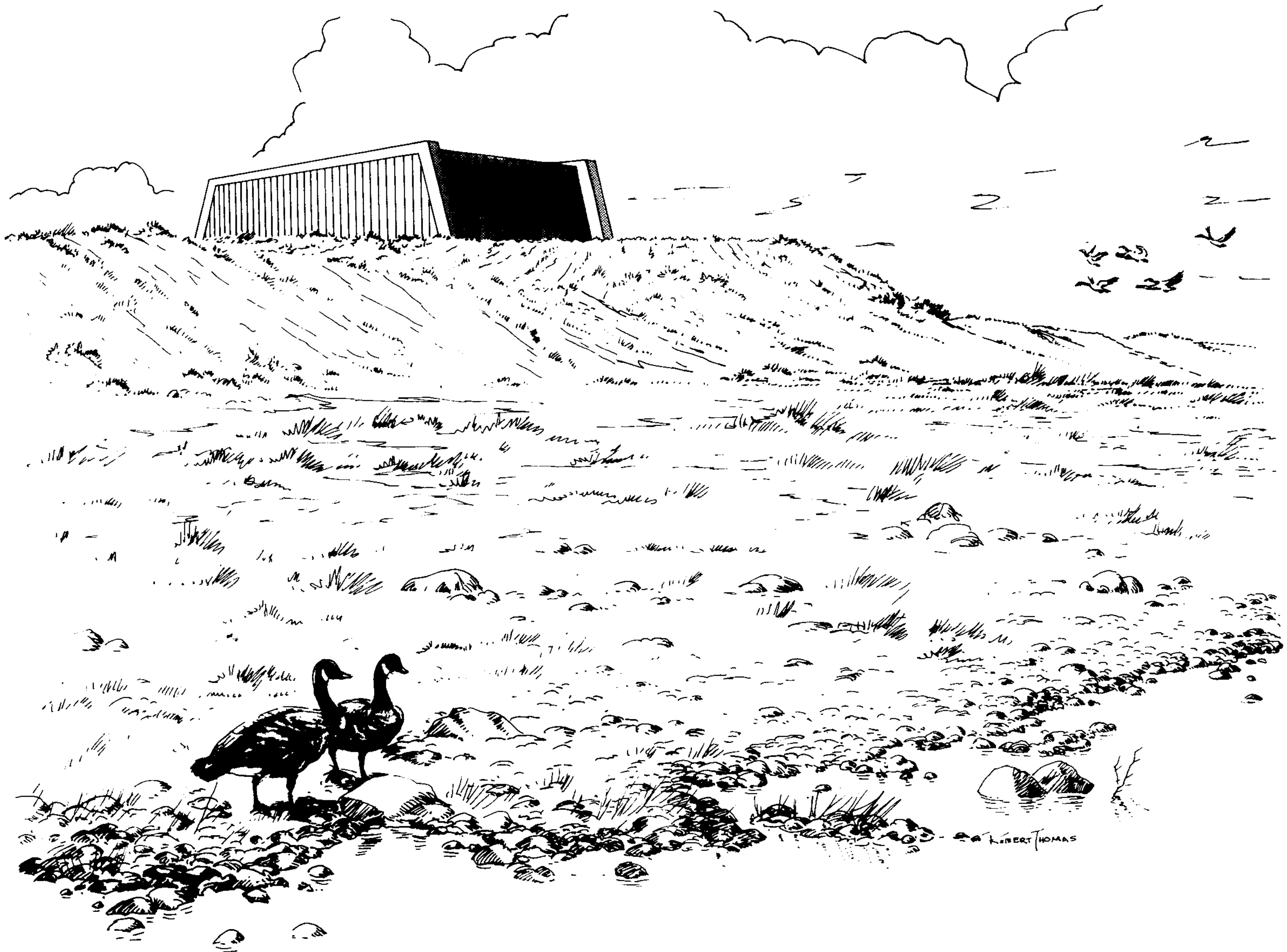
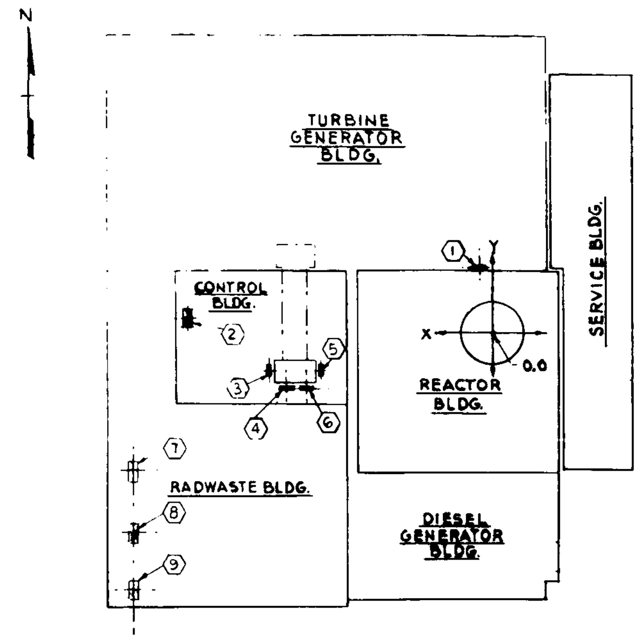


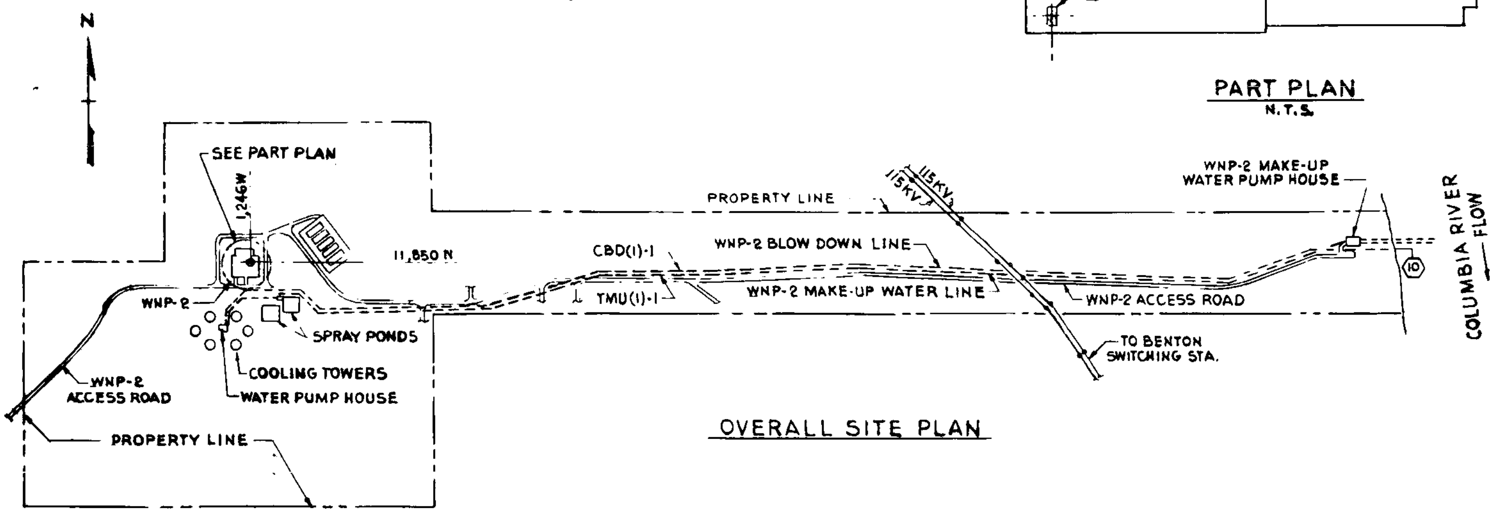
FIGURE 3.1-5
WNP-2 MAKE-UP WATER PUMP HOUSE

LEGEND

		X (Ft)	Y (Ft)	ELEV. (Ft)
①	VENT STACK – REACTOR BLDG.	5 W	65 N	671
②	VENT - CONTROL BLDG. -	204 W	25 N	545
③	EXH. PLENUM VENT - CONTROL BLDG	157 W	14 S	542
④	" " " " "	139 W	19 S	"
⑤	" " " " "	114 W	14 S	
⑥	" " " " "	127 W	19 S	"
⑦	VENT - RADWASTE BLDG.	241 W	97 S	509
⑧	" " "	"	124 S	"
⑨	" " "	"	167 S	"
⑩	BLOWDOWN RELEASE PT.	17 770 E	232 N	338



PART PLAN
N.T.S.



OVERALL SITE PLAN

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
WPPSS NUCLEAR PROJECT NO. 2
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WNP-2 EFFLUENT RELEASE POINTS

FIG. 3.1-6

3.2 REACTOR AND STEAM ELECTRIC SYSTEM

WNP-2 is a single unit nuclear electric generating plant having a nominal electric power output of approximately 1100 MWe. The plant, designed by the architect-engineer Burns and Roe, Inc., consists of a boiling water reactor, turbine generator, evaporative cooling tower system, a pumphouse which takes makeup water from the Columbia River, a 500 kilovolt transmission line leading to the Bonneville Power Administration's H. J. Ashe Substation adjacent to the site, and other associated facilities required for the generation of electric power.

3.2.1 Nuclear Steam Supply System

The Nuclear Steam Supply System (NSSS) consists of a General Electric Co. boiling water reactor and the necessary auxiliary systems required to control, contain, and service the nuclear core. The system has a guaranteed output of 3323 megawatts.

A reactor pressure vessel houses the nuclear core where nuclear fission provides the energy required to produce steam. The core contains 764 fuel assemblies, 185 control rod assemblies, and other supporting hardware. The fuel consists of uranium dioxide pellets with enrichments varying |2
from natural (0.71) to 3.0 weight percent U-235 clad with zircaloy.

The initial core will contain fuel assemblies having an average enrichment ranging from approximately 0.71 to 2.19 |2
weight percent U-235. The core average enrichment will be about 1.87% U-235 depending on initial cycle requirements. |2
Each assembly will contain between one and seven different enrichment rods. Selected rods in each assembly will, in addition, be blended with gadolinium burnable poison. The reload fuel will also contain four different enrichment rods with an average enrichment between 2.5% and 3.1% U-235. The reload fuel average enrichment will be about 2.71% U-235 depending on operating cycle requirements.

Five to seven different U-235 enrichments are used in the en- |2
riched fuel assemblies to reduce the local power peaking. Low enrichment uranium rods are used in the corner rods and in the rods nearer the water gaps; higher enrichment uranium is used in the central part of the fuel bundle. The fuel rods are equipped with characteristic mechanical end fittings to assure proper assembly preventing a higher enrichment rod to be fitted in a location of a lower enrichment rod. The general layout of the core, core cell, and fuel assembly uranium enrichment is shown in Figures 3.2-1, 3.2-2, and 3.2-3.

Cooling of the core is accomplished by boiling water which is recirculated using jet pumps located in the peripheral area around the core inside the reactor. The pumps are powered from two externally located motor driven centrifugal pumps which draw a fraction of the reactor water from the vessel and return it with increased pressure, to the jet pumps. (See Figure 3.2-4) The power level and rate of steam production is controlled by hydraulically activated control rods. The steam that is produced in the core is separated from the reactor water and dried in the top of the vessel prior to exit from the vessel. The guaranteed steam flow is 14,295,000 lbs. per hour with 985 psi absolute and 0.3% moisture outlet conditions. The thermodynamic parameters of the reactor are shown in Figure 3.2-5.

The reactor is controlled at a nearly constant pressure. During normal operations, the steam admitted to the turbine is controlled by the turbine initial pressure regulator which maintains essentially constant pressure at the turbine inlet, thus controlling the vessel pressure. The integration of the turbine pressure regulator/control system and the reactor recirculation flow control system permits the quantity of steam being produced to respond automatically to the turbine demand.

The nuclear system is supported by the specialized functions of its auxiliary systems. The major auxiliary systems used for normal operation are:

Reactor Water Cleanup System

Residual Heat Removal System

Fuel Pool Cooling and Filtering System

Cooling Water Systems

Radioactive Waste Disposal Systems

Details of these systems are described in the Final Safety Analysis Report.

Other auxiliary systems are provided as backup or emergency systems to ensure safe shutdown of the reactor during any design basis accident including those resulting from natural phenomenon such as earthquakes, tornadoes, and floods.

3.2.2 Turbine System

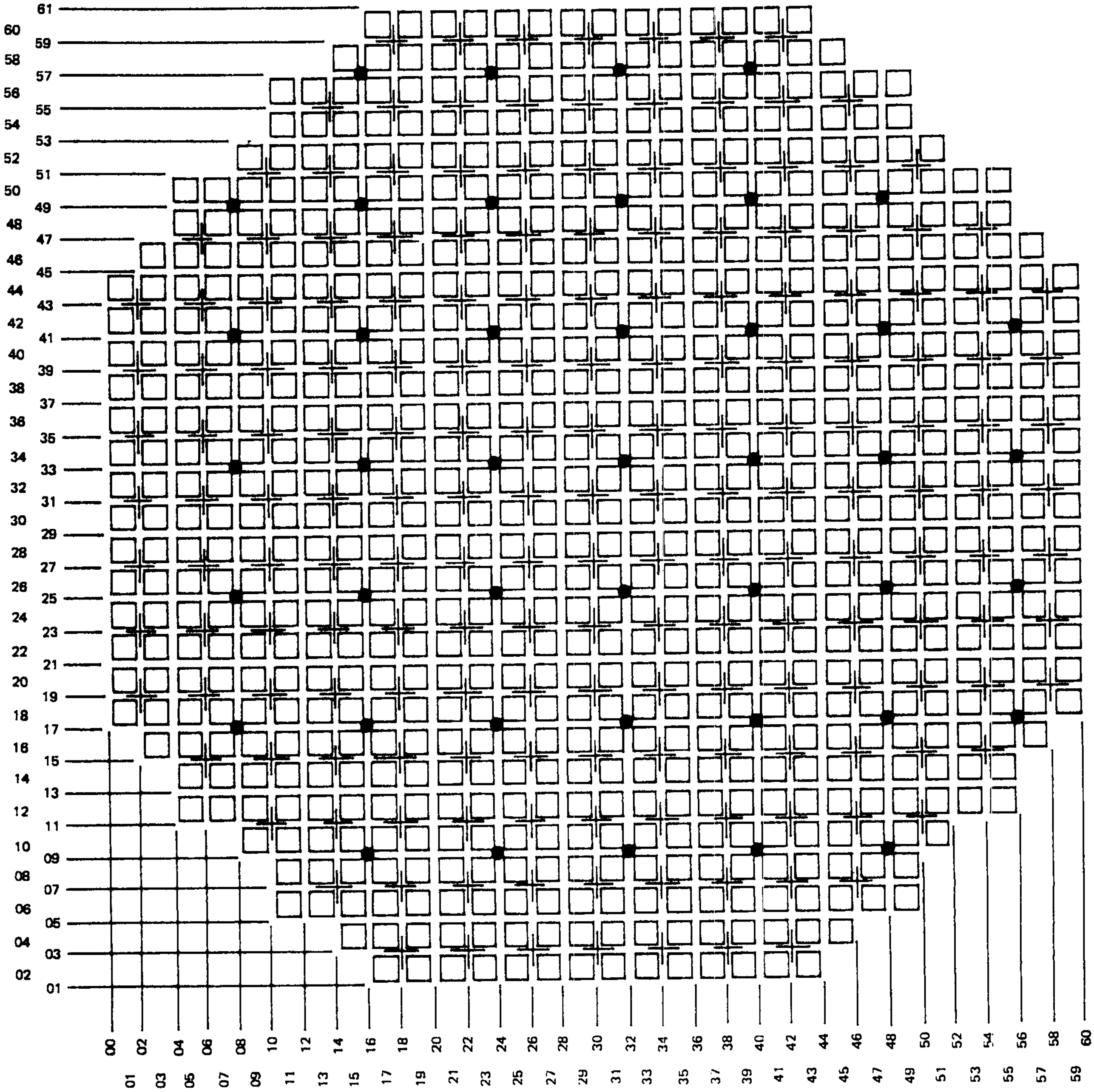
The turbine system (See Figure 3.2-6) uses the Rankine steam cycle with a closed regenerative feedwater heating cycle. Steam leaves the reactor vessel at 985 psia and enters the turbine at 970 psia with a .38% moisture content. The turbine is an 1800 rpm tandem compound turbine generator of

Westinghouse Electric Corp. manufacture having a six-flow exhaust end with 44" last stage blades. Steam is exhausted into a condenser with 792,000 sq. ft. of surface and designed for a 2.5 in. backpressure. The net plant heat rates at the backpressure variations ranging from 1" Hg to 4" Hg for maximum load at 5% overpressure, 75%, and 50% are plotted in Figure 3.2-7. Six stages of regenerative feedwater heating are provided including four from the low-pressure turbines, arranged in three parallel strings and two from the high-pressure turbine, arranged in two parallel strings. The final design feedwater temperature at normal full load is 420°F.

The power cycle includes a reheater at the high-pressure turbine exhaust. Reheating is accomplished in two stages by using steam from the reactor and from one extraction stage of the high pressure turbine. Two reheater moisture separator assemblies are used.

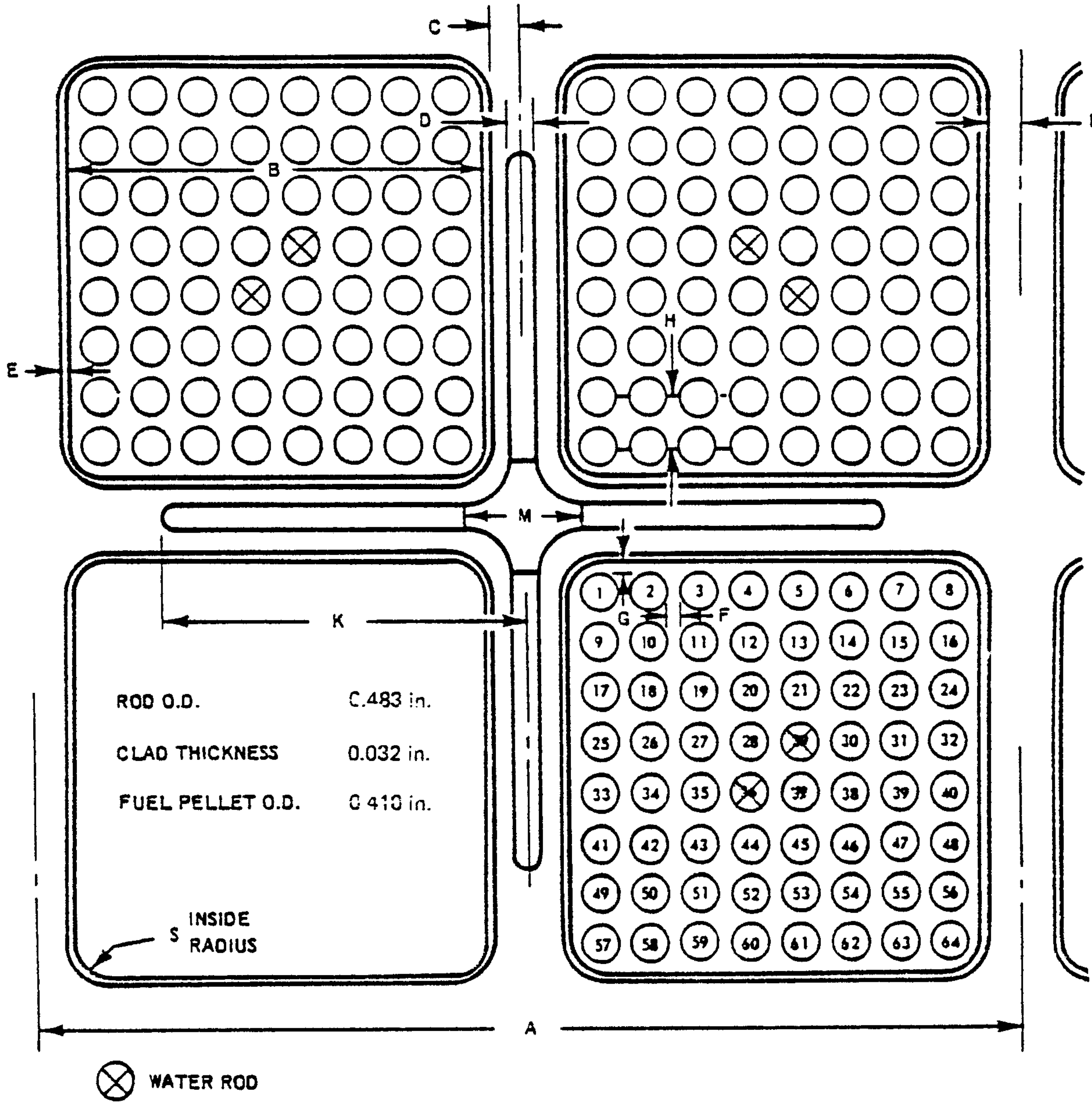
The turbine generator is guaranteed to deliver 1154 MWe, measured at the generator terminals, when operated at steam conditions listed above, associted with Nuclear Steam Supply System (NSSS) guaranteed power. In-plant electric power consumption is expected to be approximately 50 MWe resulting in an estimated net plant electrical output of approximately 1104 MWe.

The turbine building is arranged with the longitudinal axis of the turbine-generator oriented in an approximate east-west direction. The reactor building is immediately south of the turbine building (See Figure 2.1-4).



NUMBER OF FUEL ASSEMBLIES 764
NUMBER OF CONTROL RODS 185
NUMBER OF LPRM'S 43

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	CORE ARRANGEMENT FIG. 3.2-1



DIM. IDENTIFICATION	A	B	C	D	E	F
DIM. INCHES	12.0	5.278	0.261	0.260	0.100	0.157

DIM. IDENTIFICATION	K	L	M	S	G	H
DIM. INCHES	4.84	0.261	1.58	0.38	0.158	0.640

Amendment 2, October 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	TYPICAL CORE CELL FIG. 3.2-2

8 x 8 LATTICE

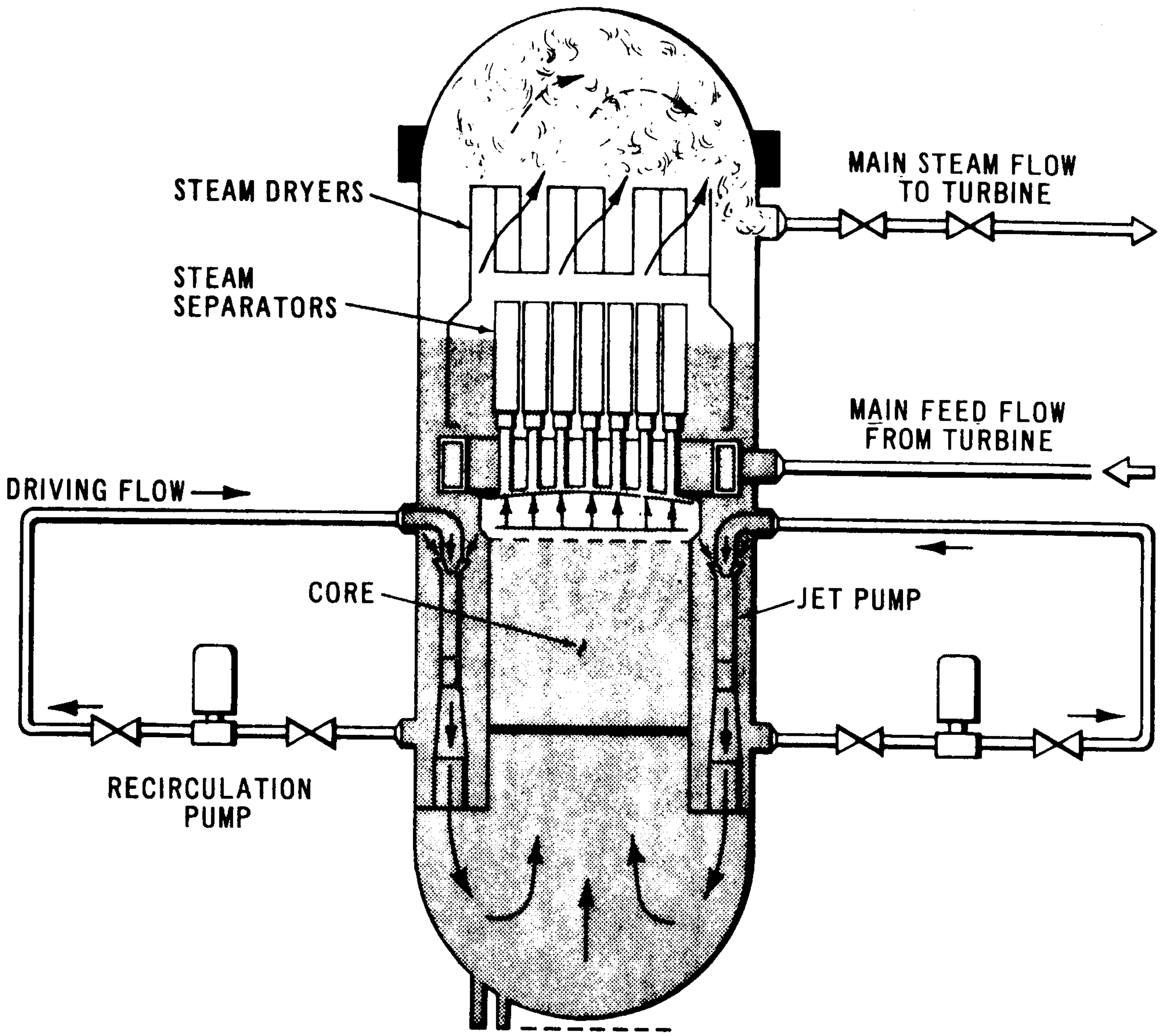
(2.19% ENRICHMENT)

6	5	4	3	3	4	5	6
5	4	2	1	1	1	3	5
4	2	1	1	1	9	1	4
3	1	1	7	10	1	1	3
3	1	1	10	8	1	2	3
4	1	9	1	1	2	2	4
5	3	1	1	2	2	4	5
6	5	4	3	3	4	5	6

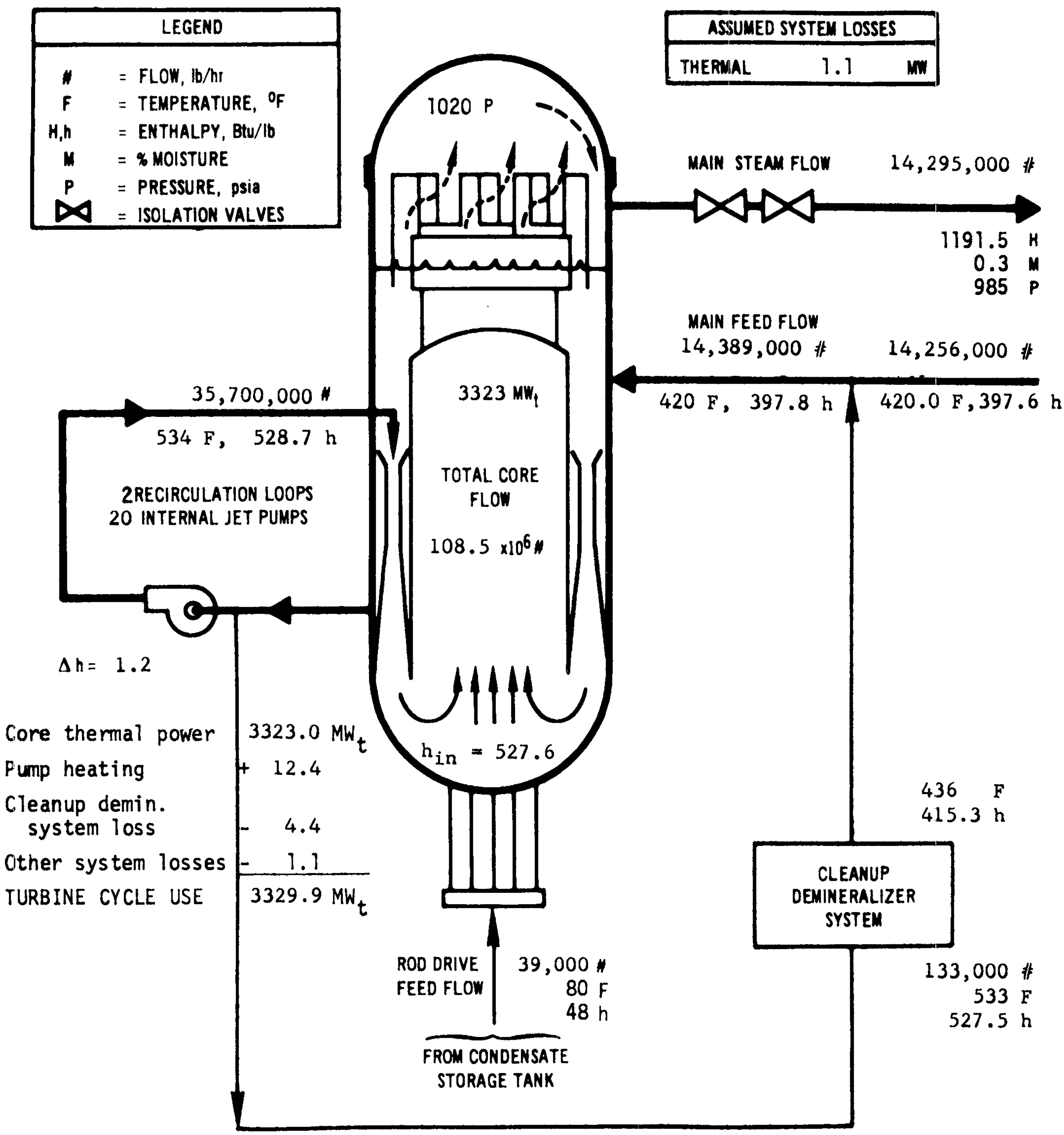
ROD TYPE	NO.	WT % U_{235}*
1	19	3.00
2	7	2.60
3	10	2.20
4	10	2.00
5	8	1.70
6	4	1.30
7	1	Gd_2O_3
8	1	Gd_2O_3
9	2	Gd_2O_3
10	2	WATER ROD

* DOES NOT INCLUDE 6 IN. OF NATURAL URANIUM AT TOP AND BOTTOM OF FUEL COLUMN.

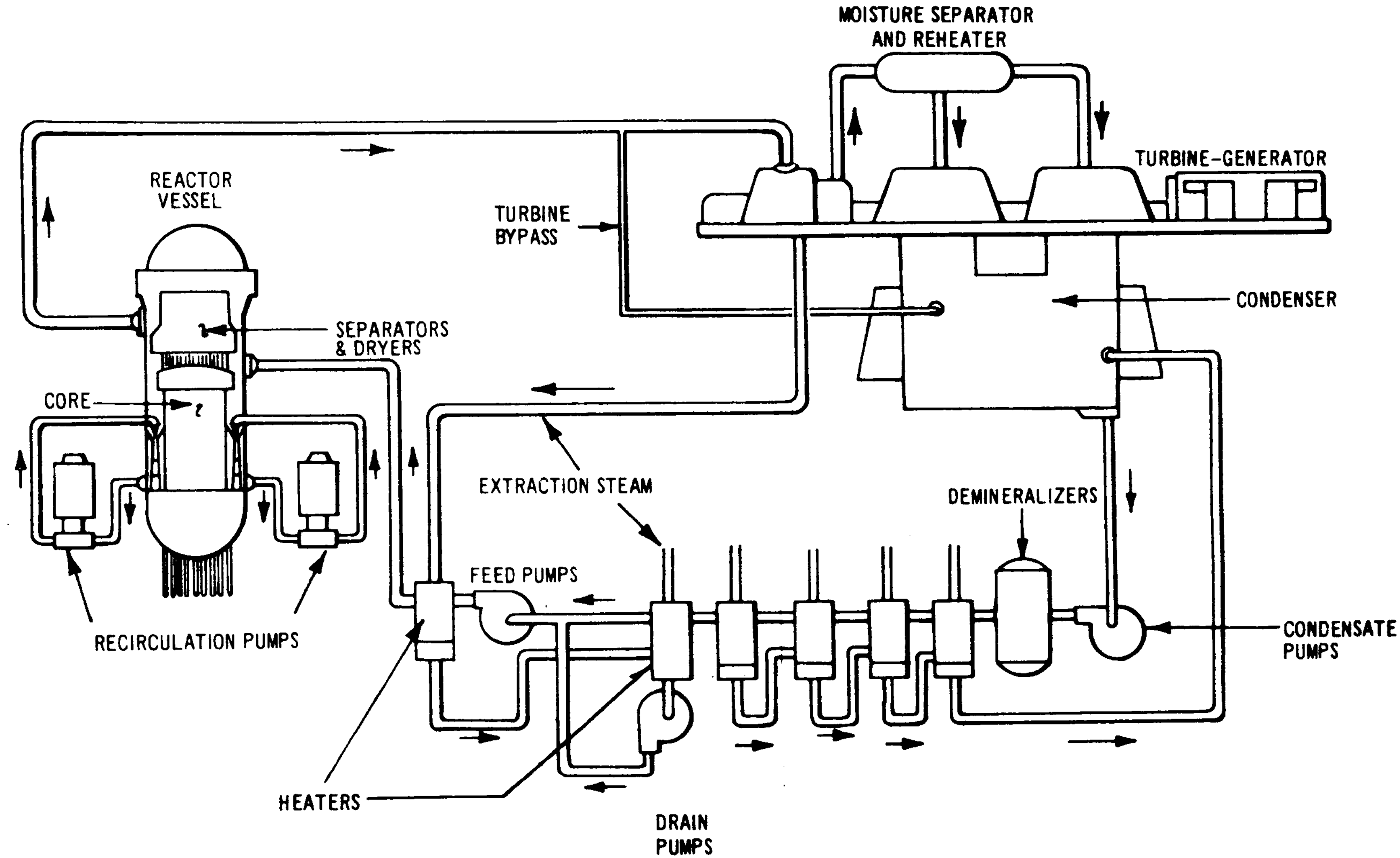
Amendment 2, October 1978



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	STEAM AND RECIRCULATION WATER FLOW PATHS FIG. 3.2-4

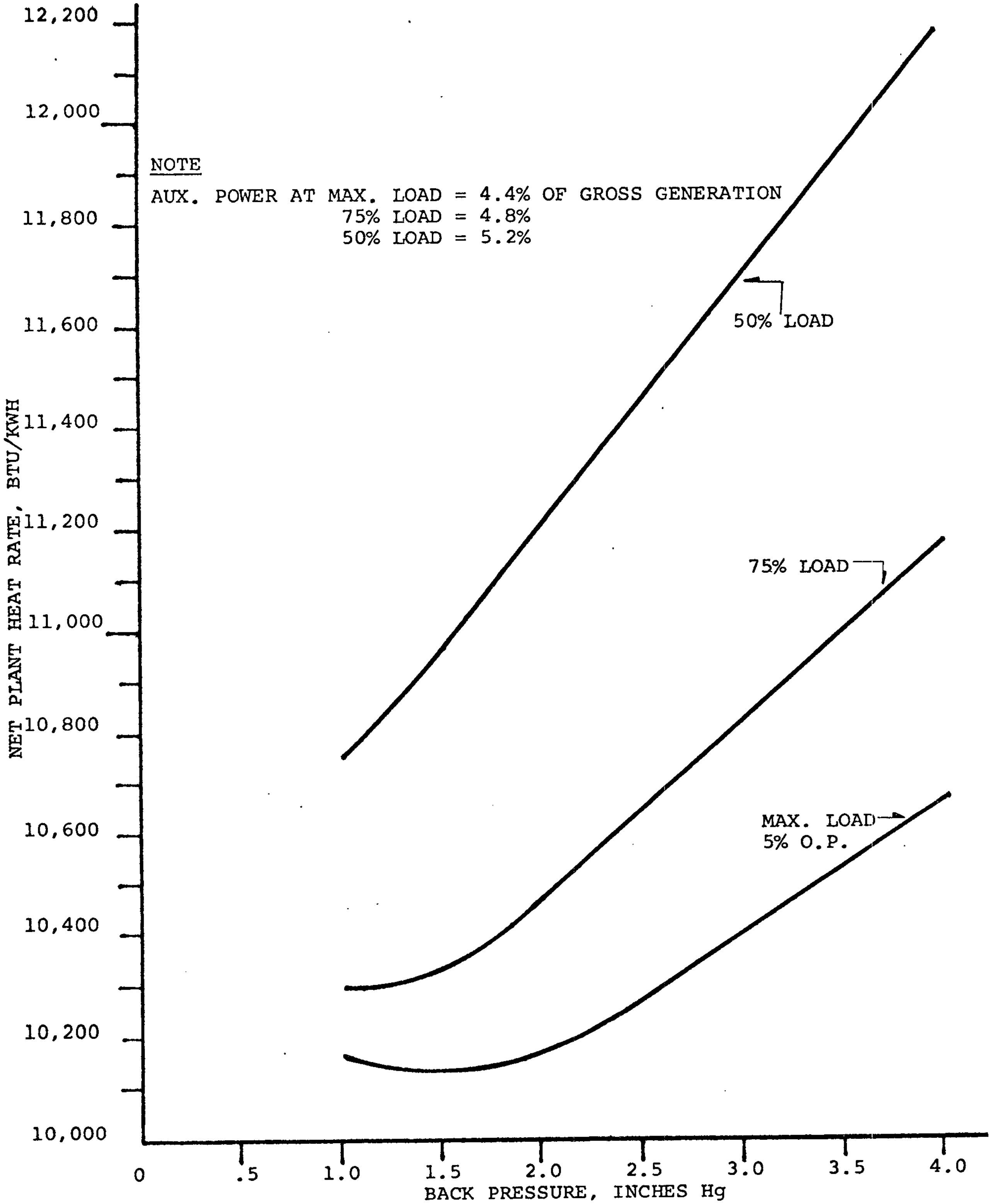


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	GE REACTOR SYSTEM HEAT BALANCE FOR RATED POWER FIG. 3.2-5



DIRECT CYCLE REACTOR AND TURBINE SYSTEM

FIG. 3.2-6



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	NET PLANT HEAT RATE VARIATIONS VS TURBINE BACK PRESSURE FIG. 3.2-7

3.3 PLANT WATER USE

3.3.1 Overall Plant

Water to meet normal operating requirements is withdrawn from the Columbia River by the cooling tower makeup pumps. Hydrological data for the river are presented in Section 2.4.1. During periods when the cooling tower makeup pumps are not operating, small quantities of makeup demineralized water and potable water may be produced using the standby well water supply. The quantity of plant makeup water withdrawn from the Columbia River is primarily dependent upon water losses from the circulating water system in the form of cooling tower evaporation, drift and blowdown. Other systems in the plant water balance include: process water treatment system, potable water and sanitary waste system, and chemical and radwaste systems.

Figure 3.3-1 is a water use flow diagram for the plant. Table 3.3-1 lists plant water use when operating at maximum power operation (expected average power operation) and temporary shutdown conditions. Average consumptive water use, that is, water withdrawn but not returned to the river, at 100% load factor, is approximately 13,000 gpm which is 0.026% of the annual average Columbia River flow and 0.08% of the minimum licensed river flow of 16,200,000 gpm.

3.3.2 Heat Dissipation System

A recirculating cooling water system with mechanical draft wet cooling towers will dissipate excess heat from the condensing steam in the main condenser and other plant auxiliary heat exchange equipment, to the atmosphere. The temperature of the closed cycle cooling water is increased by about 28°F by passing through the main condenser and other plant auxiliary heat exchange equipment. The cooling water temperature is reduced in the cooling towers by the evaporation of water and by the transfer of sensible heat to the atmosphere. The evaporation rates from the cooling towers varies with plant operation power level, ambient air temperature and humidity. A small quantity of water is entrained in the air passing through the cooling tower and is lost from the system as "drift". Drift eliminators are used in the cooling towers to minimize this loss, which will average about 285 gpm.

Dissolved and suspended solids, originally present in the river water, are concentrated in the cooling towers by the evaporation process. A small portion of the circulating water is withdrawn, by blowdown, to control the solids level as part of cooling water chemistry management. When operating at fullpower operation, it is expected that the cooling tower blowdown flow, returned to the Columbia River, will average 2580 gpm. A detailed discussion of the heat dissipation system is given in Section 3.4. Environmental effects are described in Section 5.1.

3.3.3 Process Water Treatment Systems

Process water treatment systems prepare river water for station use, potable and sanitary water use, and miscellaneous water requirements. River water, which is used for potable water, sanitary water, and demineralized water, is first treated by filtration for the removal of suspended matter. A maximum of 250 gpm of filtration capacity is provided. It is anticipated that the average operating demand for filtered water will be approximately 10 gpm.

The makeup water demineralizer provides high quality water for station use including filling and replacement of losses from the nuclear steam supply system, chemical control solution preparation, and the replacement of water lost in waste treatment processes. Virtually all liquid wastes from normal station operations are treated in the radioactive and chemical waste system and recovered to the extent possible for reuse in the primary system. The makeup water demineralizer
1 has an operating capacity of 150 gpm but is expected to operate at an average flow rate of about 6 gpm during normal operation. At times of system fill and outages, the system will operate near design capacity.

Filtered water will also be used in the potable water and sanitary waste system. This facility has a capacity of 50 gpm but is expected to operate at an average daily rate of about 2,500 gal/day.

3.3.4 Chemical and Radwaste Systems

Virtually all chemical waste from the station is processed through the radwaste system. Consumptive water use is approximately 100 gal/day. This represents the quantity of liquids lost through solid waste processes. Solidified wastes in sealed radioactive waste containers will be removed by a licensed contractor for storage at a licensed facility. A detailed discussion of the radwaste system is given in Section 3.5.

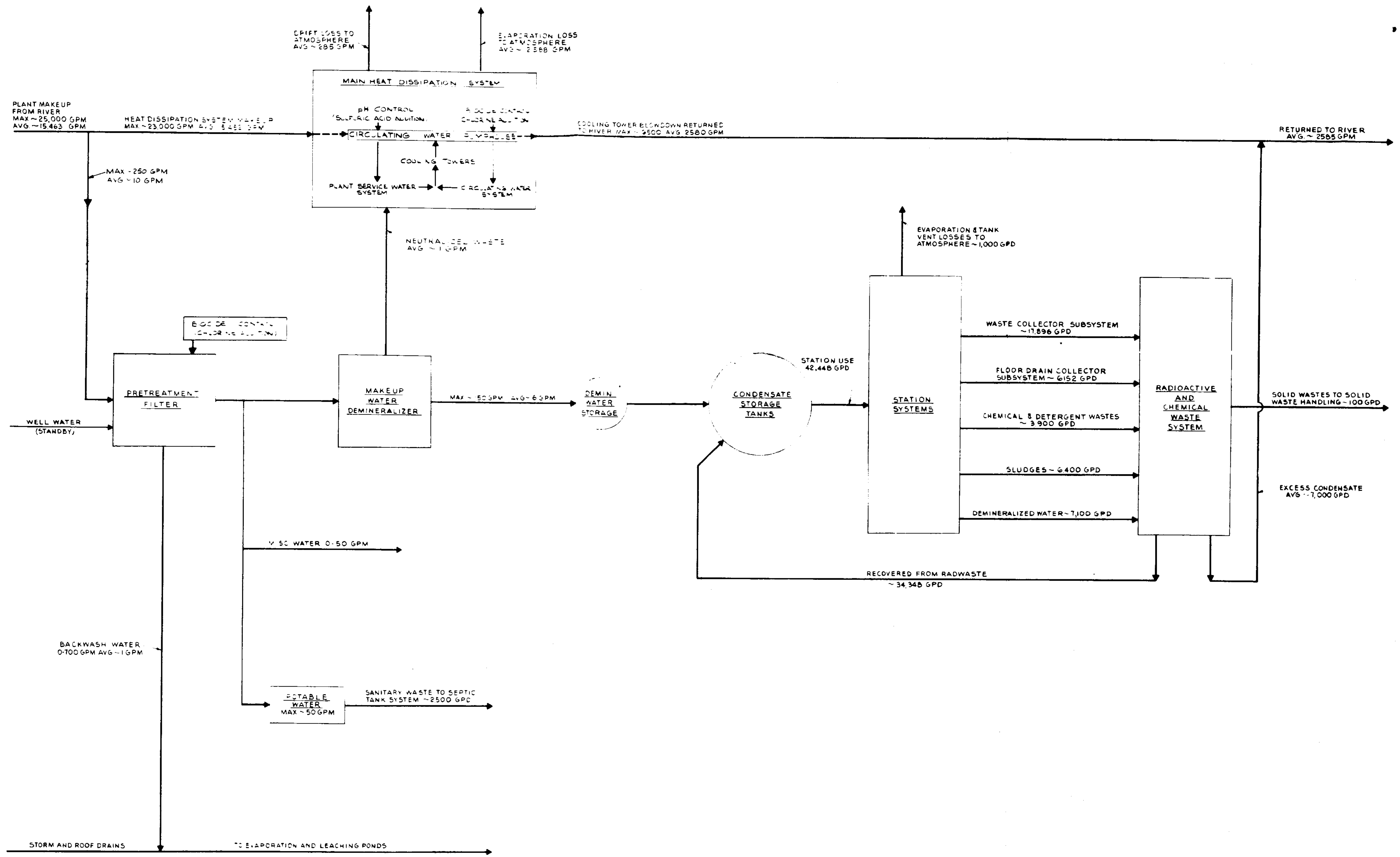
TABLE 3.3-1

PLANT WATER USE

WNP-2

	Maximum Power Operation			Temporary Shutdown		
	Total Flow (gpm)	Consumptive Use (gpm)	Returned to River (gpm)	Total Flow (gpm)	Consumptive Use (gpm)	Returned to River (gpm)
A. Circulating Water Systems						
a) Evaporation	12,588	12,588	---	368	368	---
b) Drift	285	285	---			
c) Blowdown	2,580	---	2,580			
B. Other Systems						
d) Process Water Treatment	10	4	6	10	4	6
Chemical and Radwaste*	6	1	5	6	1	5
Potable and Sanitary*	2	2	---	2	2	---
C. Total (a+b+c+d)	15,463	12,877	2,586	378	372	6

* Source - Process Water Treatment



Amendment 1, May 1973

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PLANT SYSTEMS WATER USE DIAGRAM FIG. 3.3-1

3.4 HEAT DISSIPATION SYSTEM

Heat is dissipated from the WNP-2 turbine condensers by a mechanical draft cooling tower system. Thermal impacts on the Columbia River are avoided.

A description of the heat dissipation facilities for WNP-2 is provided in the following subsections. The environmental effects due to the operation of the WNP-2 heat dissipation system are discussed in Section 5.1.

3.4.1 Mechanical Draft Cooling Towers

3.4.1.1 General

A mechanical draft tower system utilizes evaporative cooling by contacting the warm water with air. The water is cooled both by sensible and by evaporative heat transfer. Intimate contact of water with air is accomplished by introducing the warm water at the top of the tower causing flow by gravity, through fill material, crosscurrent to the air. Air is introduced into the tower through louvered side panels, flows upward through the tower fill material, passes through the drift eliminators, through the fan stack (which houses the air moving equipment) and finally discharges to the atmosphere. The cooled water is collected in basins at the base of the tower.

During this cooling process, a small percentage of the total water inventory is lost due to evaporation and drift. In addition, water is discharged from the system through system blowdown, required to limit the concentration of naturally occurring river salts in the closed cycle as a result of the evaporation process. The water makeup system, which provides the necessary water to keep the system in equilibrium, is discussed in Subsection 3.4.2.1.

3.4.1.2 Design of the Mechanical Draft Cooling Towers

In the design of the cooling tower system, the following features related to environmental matters were considered:

a. blowdown requirements including outfall structures,

b. makeup requirements,

c. meteorological effects,

d. hydrological effects, and

e. chemical and thermal effects on natural bodies of water.

The heat dissipation system is designed to cool 570,000 gpm of cooling water, rejecting 7.88×10^9 BTU/hr to the environs. The heat load for the WNP-2 cooling towers comes almost entirely from the 550,000 gpm circulating water system (with a travel time across the condenser of 15.17 seconds). The only major WNP-2 heat dissipation subsystem is the plant service water system. This system provides cooling water for most of the plants cooling coils, etc. and results in less than 4% of the heat load as provided by the circulating water system. The effect on the environment due to the added heat resulting from the plant service water system is insignificant in comparison to the heat to be dissipated by the circulating water system. As shown in Figure 3.4-1, six towers are used, with each cooling tower approximately 60 feet to the top of the fan stacks and approximately 200 feet in diameter (see Figure 3.1-3). Each tower is provided with 6-200 hp, 30 foot diameter fans used to induce the draft required to operate the tower. The discharge velocity from the fan stacks will be approximately 33 fps. Figure 3.4-2 is a cut away view of one tower and Figure 2.1-4 shows the relation of the towers with the main plant structures.

Cooling water for the condensing of the turbine exhaust system is supplied to the tube side of the condenser by circulating water pumps located in the circulating water pump house. These pumps take suction from the tower basins and are designed with sufficient head to pump through the condenser back to the cooling tower distribution system.

Design values for the cooling towers are:

Wet-bulb temperature	60°F
Approach to wet bulb	16.3°F
Range	28°F
Cold-side temperature	76.3°F

These numbers indicate that under design conditions, cooling water at 76.3°F enters the condensers where it is heated 28°F to 104.3°F. From there this hot water is pumped to the cooling tower where, in air with a wet-bulb temperature of 60°F, it is cooled to 76.3°F, which is within 16.3°F of the wet-bulb temperature. The 76.3°F water is returned to the condenser and the cycle is repeated. A cooling tower performance curve is shown in Figure 3.4-3.

Although the individual towers are designed for a 60°F wet-bulb temperature, it is necessary to provide for plant operation at less favorable conditions, so a conservative worst-case value of 70°F wet-bulb temperature was chosen for plant capacity design calculations. This is reasonable in terms of data shown in Table 2.3-22, which shows that the annual wet-bulb temperature for the WNP-2 site is such that a wet-bulb temperature between 60° and 65°F would not prevail more than 6.68% of the year and one higher than 65°F not more than 1.87% of the year.

3.4.2 Circulating Water System Balance

Water is lost from the heat dissipation system by evaporation, drift, and blowdown. To balance these losses, makeup water from the Columbia River is required.

The design values used for blowdown are based on a dissolved solids concentration factor of about five (with a range of 3-10) in the cooling tower water as compared to river water. The nominal blowdown rates calculated for normal operation vary from about 2000 to 4000 gpm. A higher rate, i.e., up to 6500 gpm, may be needed on occasion to lower the concentration of dissolved solids in the circulating water system . (The composition of the Columbia River and blowdown water is given in Table 3.6-1)

Expected values of evaporation rates, blowdown temperatures, normal river temperatures, and blowdown rates are given in Figure 3.4-4 as a function of time of year. These curves each give an expected average over the month. Actually, a range of values above and below the curves would represent conditions from expected maxima to expected minima. For example, the average blowdown water temperature is shown to be about 75°F in August. In August the range of blowdown temperature extends about 7°F above the average, to a maximum of 82°F. This is the maximum temperature expected at which water would be returned to the river. This maximum value is based on the assumption that heat transferred in the cooling towers is entirely by evaporation, with no transfer of sensible heat from the warm water, since in summer the ambient air dry-bulb temperature would be high.

The following table gives both maximum and annual average values for the heat dissipation system. Consumptive use is evaporation plus drift, where drift is taken as 0.05% of the circulating water system flow rate. Drift was determined through the use of empirical relationships determined from experimental data(1). Required makeup is evaporation plus drift plus blowdown.

	Maximum Values, gpm	Annual Average Values, gpm
Consumptive use	16,500	12,873
Blowdown	6,500	2,580
Required makeup	23,000	15,453

The actual makeup water capacity for WNP-2 is 25,000 gpm (See Section 3.4.2.1). See Figure 3.3-1 for a plant water balance chart.

3.4.2.1 Intake System

Makeup water for WNP-2 is taken from the Columbia River via a river intake which is located approximately 3 miles due east of the plant site. The intake system is made up of three parts: two perforated pipe inlets supported offshore above the bed of the river and approximately parallel to the river flow, two 36 inch diameter steel lead-in pipes approximately 900 ft. long, and the pump structure embedded into the river bank with a major portion below grade. The intake system general plan is shown in Figure 2.4-6. Figure 3.4-5 is a detailed plan and profile of the intake system.

The pump structure contains three makeup water pumps, each having a capacity of 12,500 gpm. Two pumps with a combined pumping capacity of 25,000 gpm will supply maximum plant water requirements, the third pump will be a spare. Architectural elevations and an artist's conception of the pump structure are shown in Figure 3.1-4 and 3.1-5. Plan and sections of the pump structure are shown in Figure 3.4-6. The pump house contains only the pumps, pump operating auxiliaries and flow control provisions. There are no screens or other water cleaning facilities in the structure.

Details of the "T" intake section and its connection to the two lead-in pipes are shown in Figure 3.4-7. Each "T" inlet is constructed of perforated steel pipes, with an outer 42-inch diameter pipe having 3/8-inch diameter holes covering about 40 percent of the area and an inner 36-inch diameter sleeve with 3/4-inch diameter holes covering about 7 percent of the area. The perforated pipe surface serves as the water cleaning facility. The outer sleeve is designed to prevent trash and fish entrainment and the inner sleeve is designed to provide uniform intake velocities through the outer sleeve perforations.

The inlet velocities are expected to be well below the acceptable limit required for suitable protection of small fish when water is being taken into the system. At the external screen surface under maximum operating conditions, with 12,500 gpm flowing through each "T", the velocity through the external screen openings is approximately 0.5 fps. At a distance of less than one third inch from the outer screen surface, the inlet approach velocity drops to less than 0.2 fps. Figure 3.4-8 shows the velocity profile of water approaching the inlet for two modes of circulation flow, as determined by hydraulic model testing(2). Figure 3.4-9, from the same model test series, shows the velocity distribution for 25,000 gpm through one inlet at 3/8-inch distance from the screen surface (abnormal or emergency condition). As shown in Figures 3.4-8 and 3.4-9, during normal or abnormal flow, flow velocities are low and flow distribution is even. During reduced flow, the perforated pipe intake velocity characteristics would be proportionately reduced.

Undersirable debris is not expected to pass through the outer perforations with these very low inlet velocities. A backwash system has been provided to permit low velocity flow reversal through the perforations. The perforated sleeves have been designed to reduce the potential for debris collection and to permit complete removal for periodic inspection, cleaning, repair and replacement. The frequency of backwashing and sleeve removal for the objective of minimizing biological damage will be determined from a one year monitoring program including, but not limited to visual inspections of the intake and sampling to determine fish losses.

3.4.2.2 Discharge System

The blowdown discharge system is a single pipe of varying diameter, running from the plant to the Columbia River. The layout of the discharge line is shown in Figure 2.4-6. It is buried underground and runs parallel to the makeup water line. The blowdown line in the river is located downstream of the intakes and is buried in the river bed. The exit point is a rectangular slot (See Figure 3.4-10) and is located as shown in Figure 2.4-6, about 175 feet from the river low water line. Adequate riprap has been placed around the discharge to avoid any erosion to the river bed.

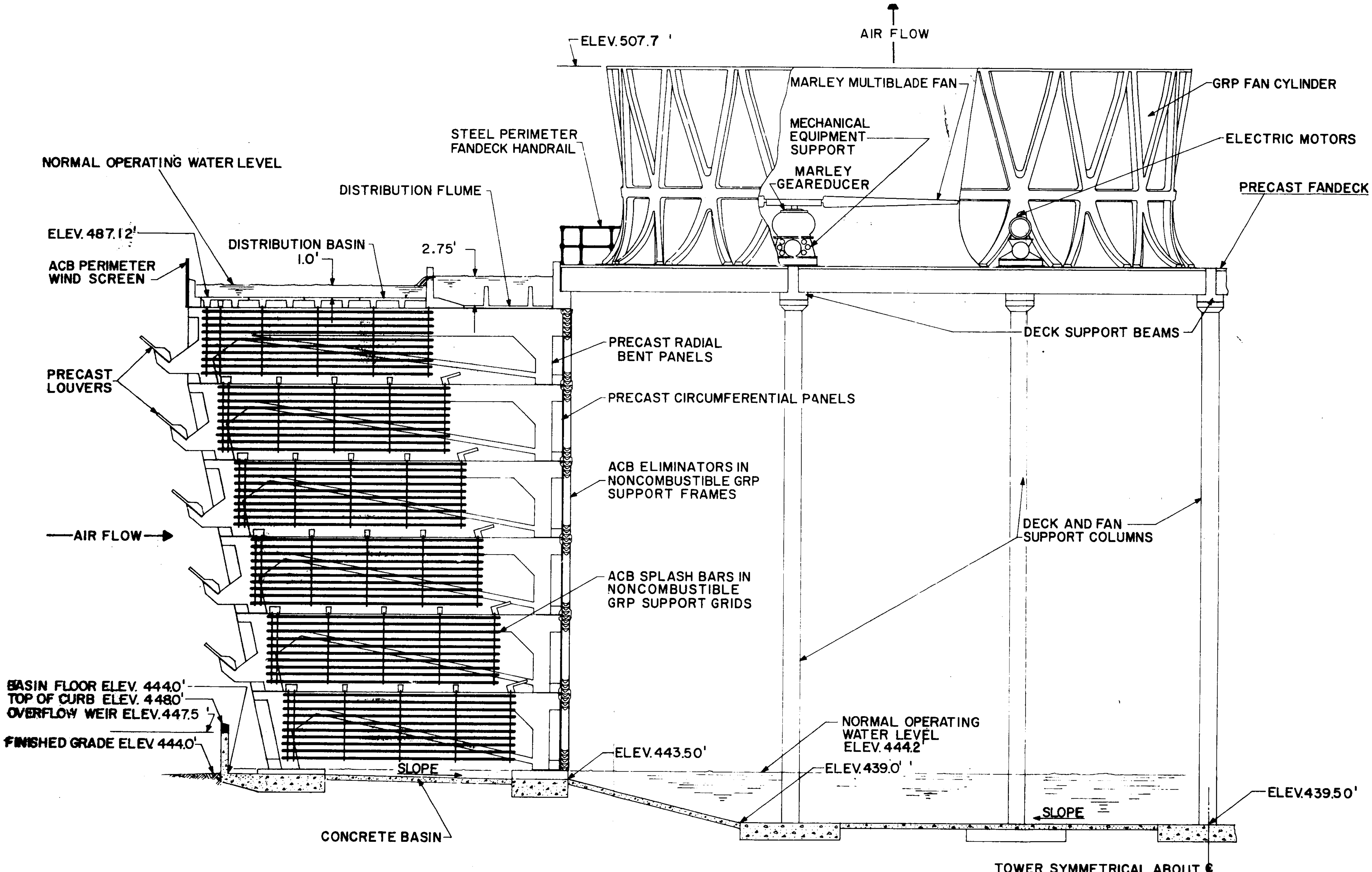
The line has been designed to accommodate a maximum blowdown rate of 6,500 gpm. However, the average blowdown will be in the range of 2,000 - 4,000 gpm. Capability has been provided for greater discharge rates, should it become desirable.

Control of slimes and algae within the circulating water system is discussed in subsection 3.6.3. Removal of any algae and slimes will be via the blowdown. Discharge of blowdown to the river will not occur during chlorination.

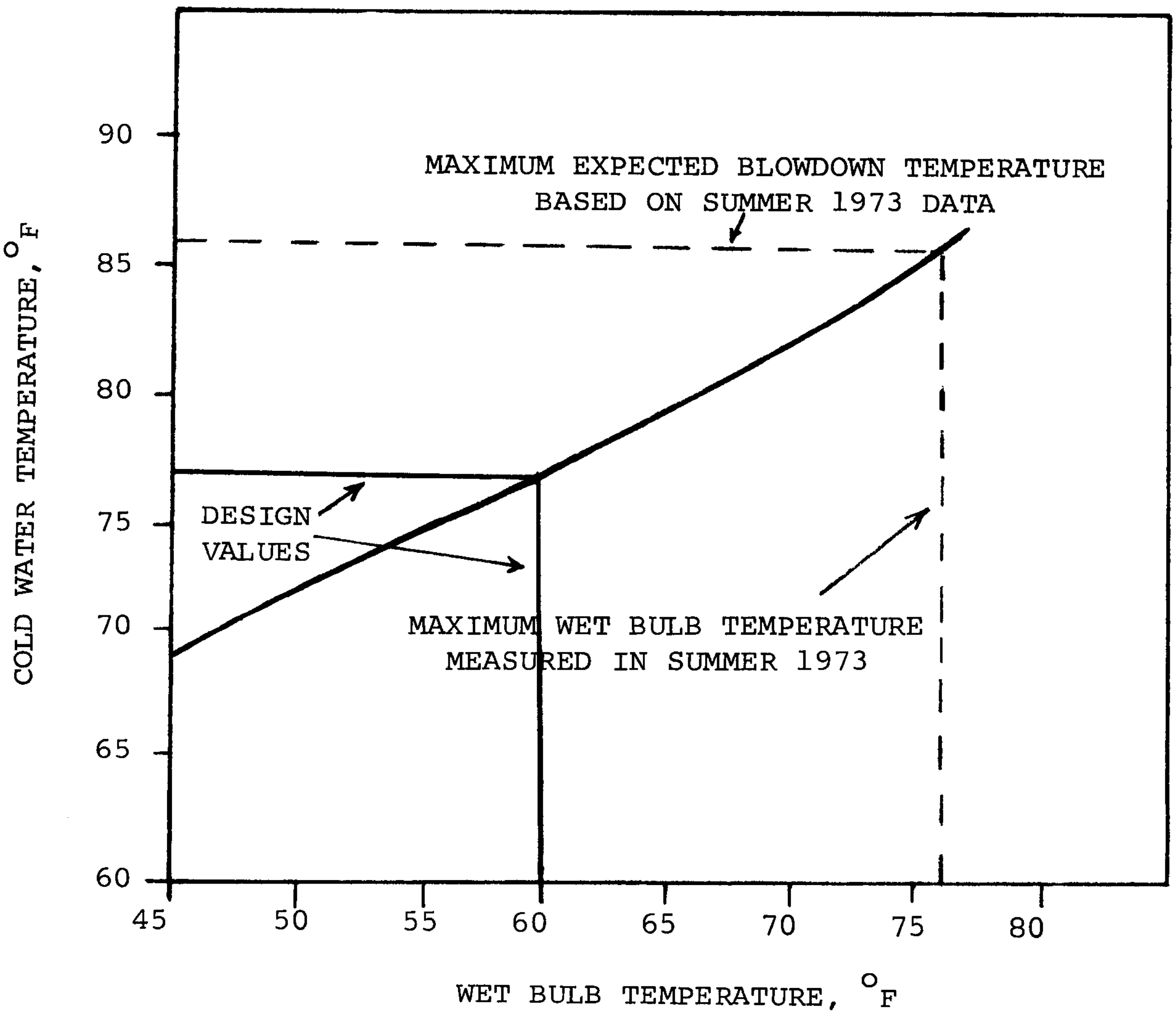
3.4.3 Spray Ponds

Two concrete basin spray ponds are provided for emergency cooling. In accordance with present requirements, the water inventory contained therein is adequate for emergency cooling for a period of thirty days. Each pond is 250 feet square with a combined surface area of 2.87 acres. Each pond is 15 feet deep, consisting of 14 feet of water and 1 foot of free board. Figure 2.1-4 shows the location of the spray ponds.

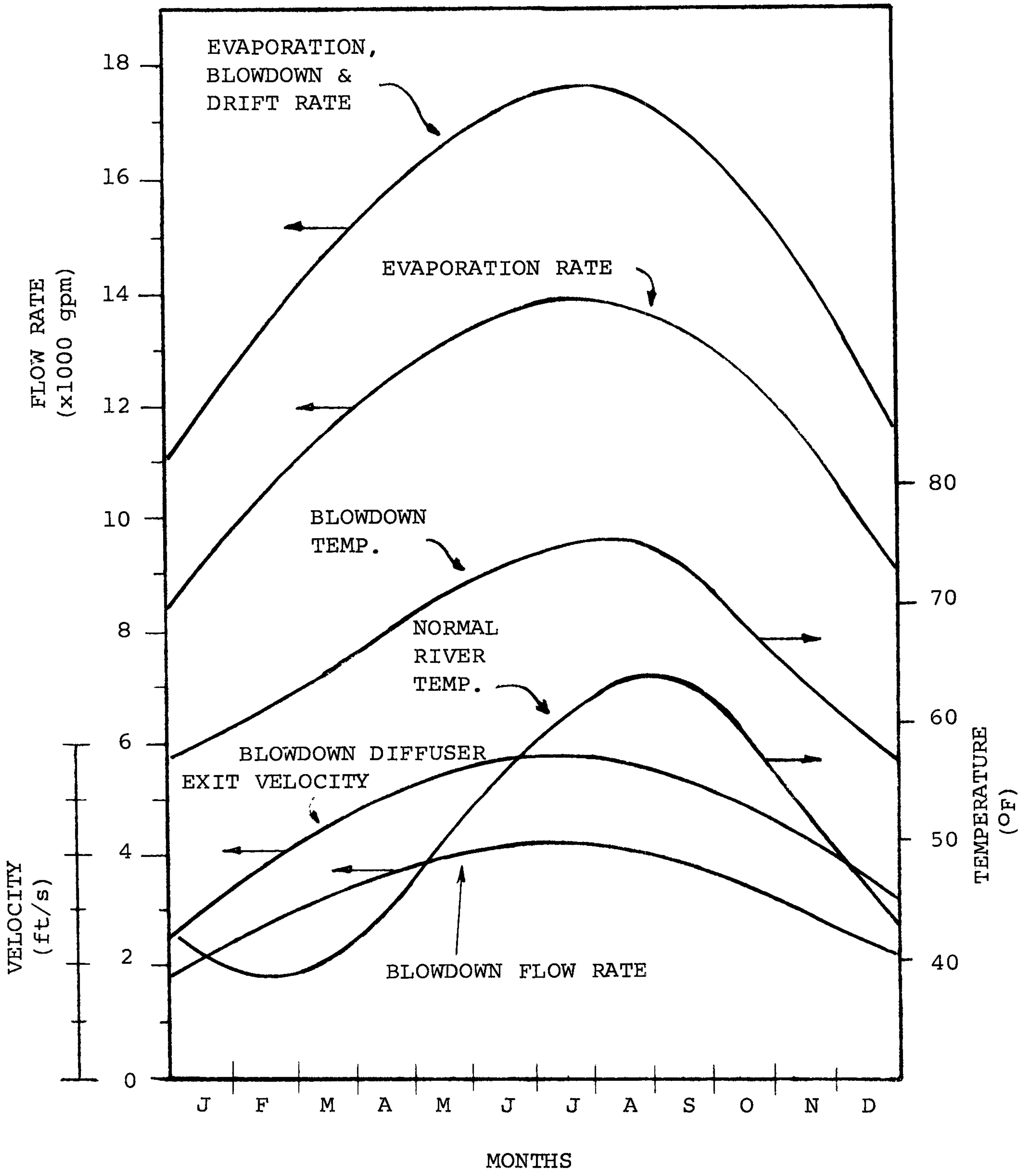
Slimes and algae in the spray ponds will be controlled with chlorine. Any discharges to the river would occur via transfer to and mixing with the cooling tower basin water.



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	TOWER CENTER SECTION THRU FILL
	FIG. 3.4-2

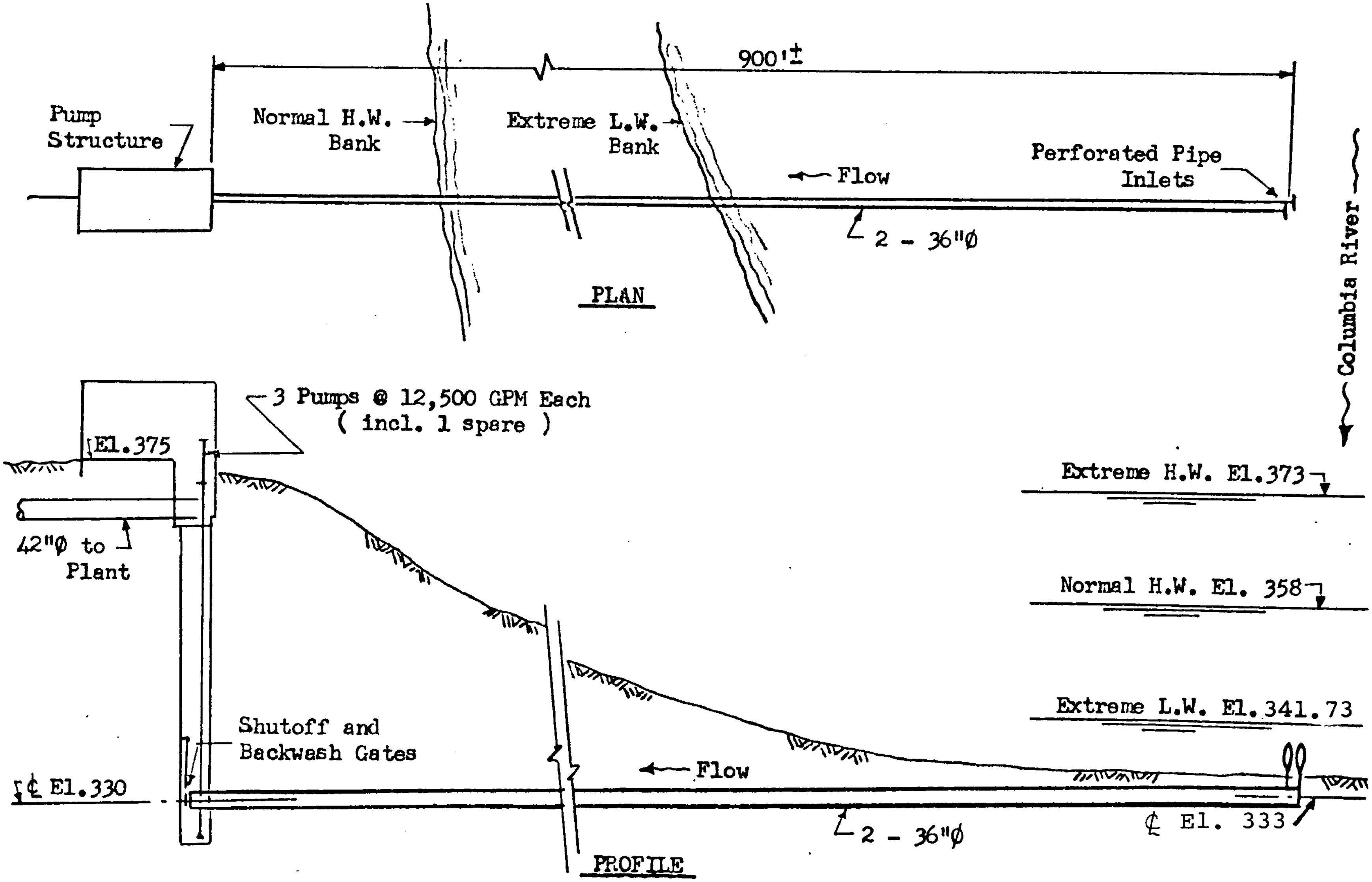


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	COOLING TOWER PERFORMANCE CURVE
	FIG. 3.4-3



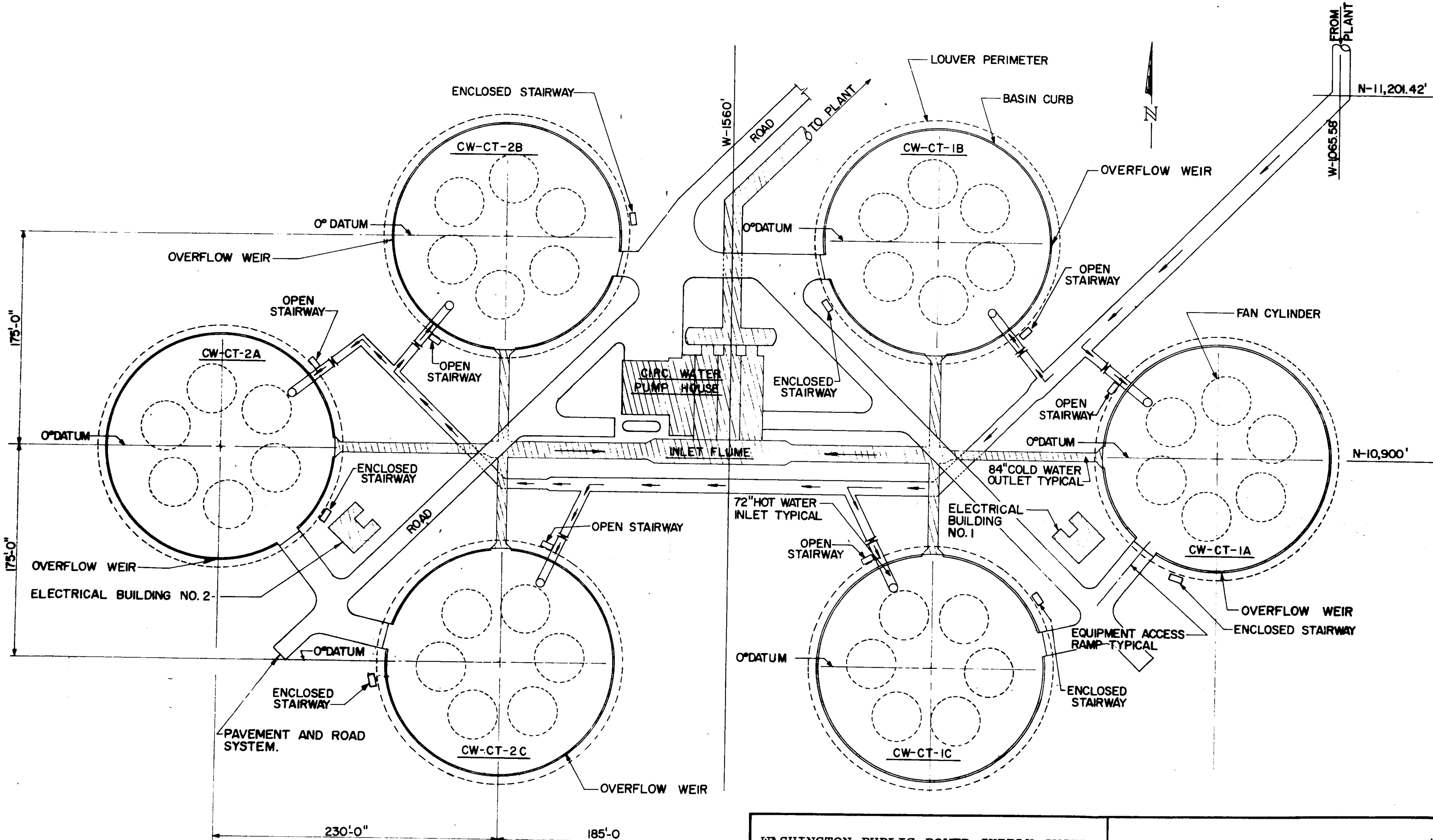
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	MONTHLY AVERAGE FLOW RATES AND TEMPERATURES FIG. 3.4-4

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
WPPSS NUCLEAR PROJECT NO. 2
Environmental Report

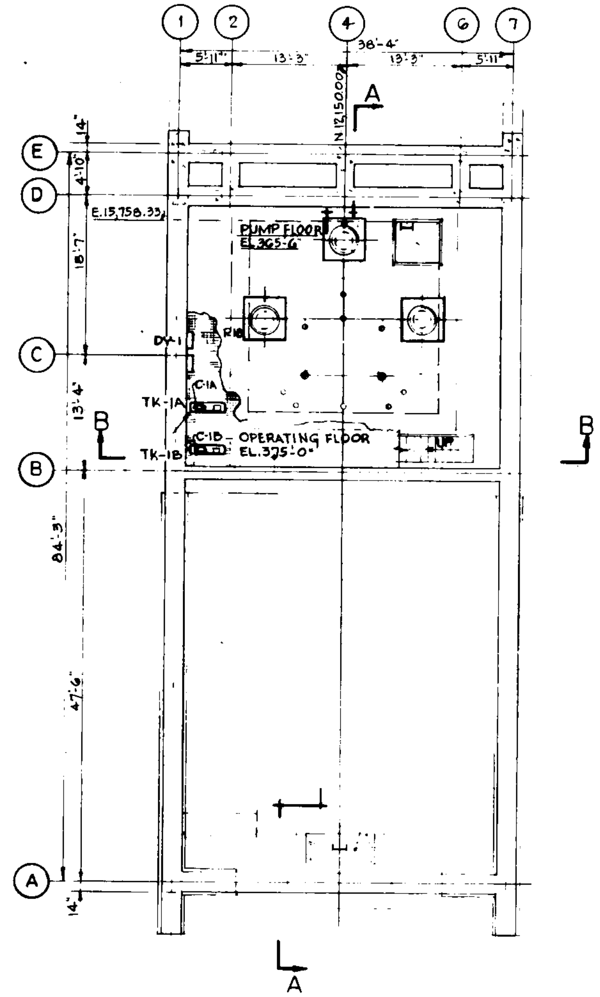


INTAKE SYSTEM
PLAN AND PROFILE

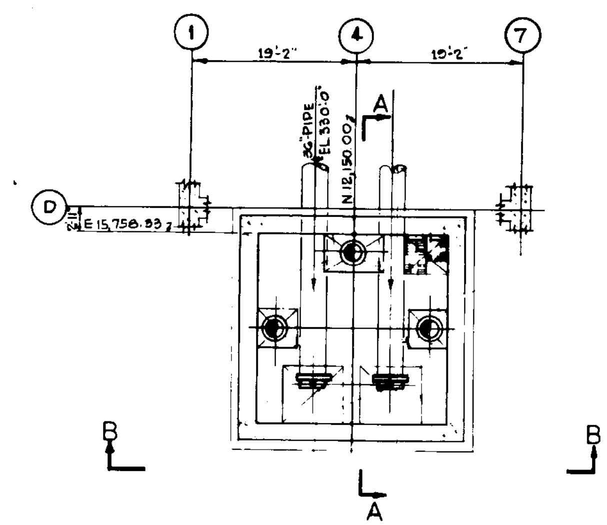
FIG. 3.4-5



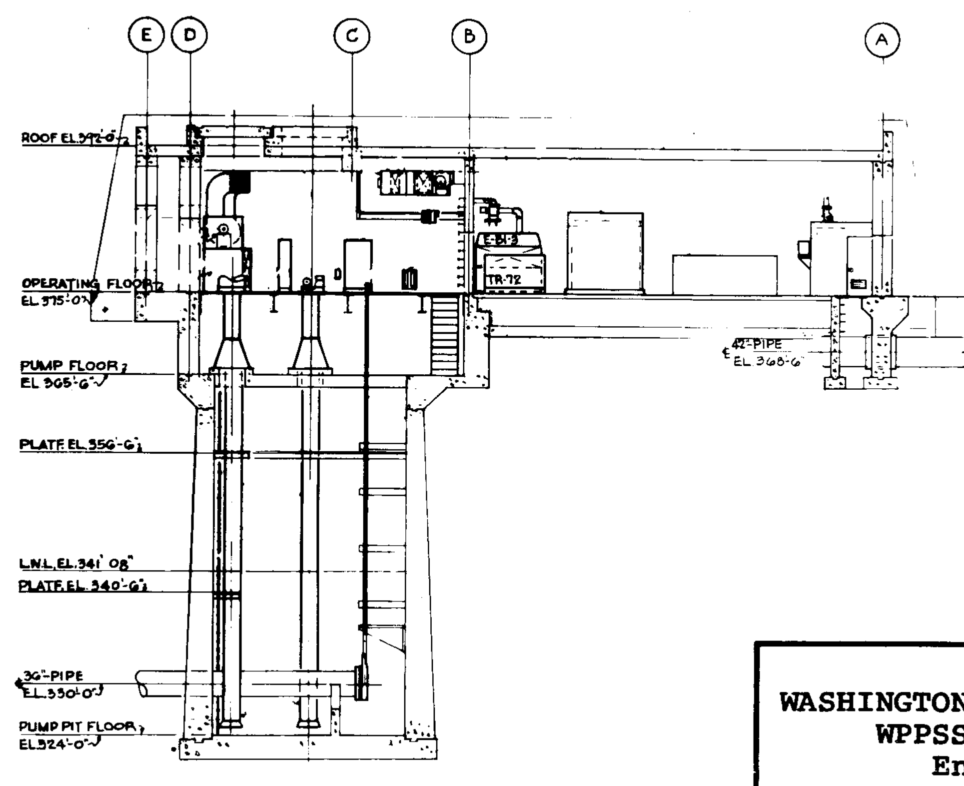
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	MECHANICAL DRAFT COOLING TOWERS PLOT PLAN FIG. 3.4-1



PLAN EL.375'-0" & BELOW

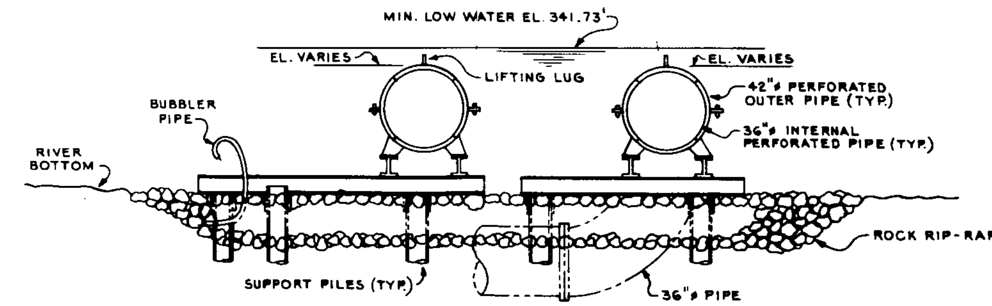


PLAN-EL.324'-0" & ABOVE

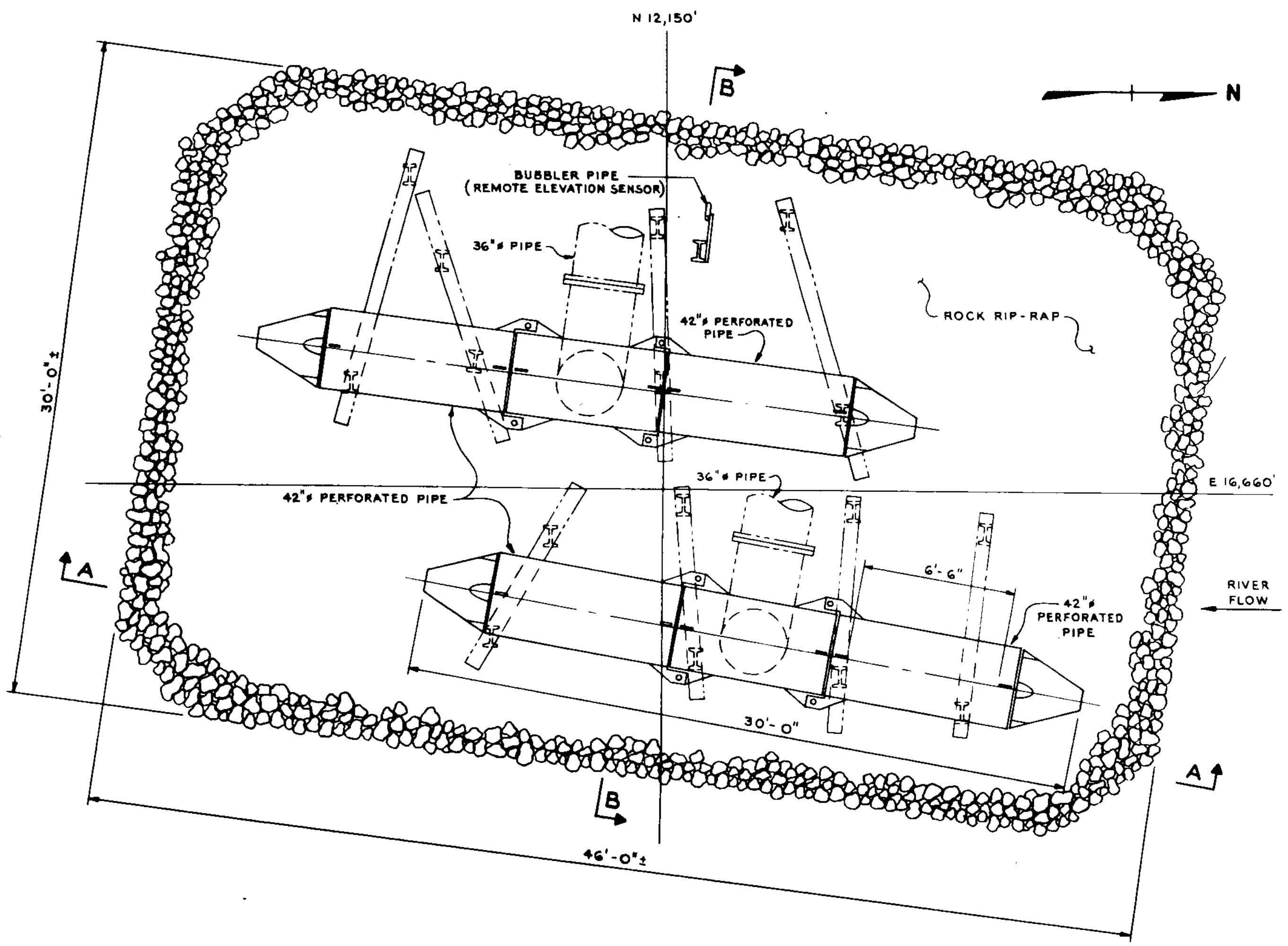


SECTION A-A

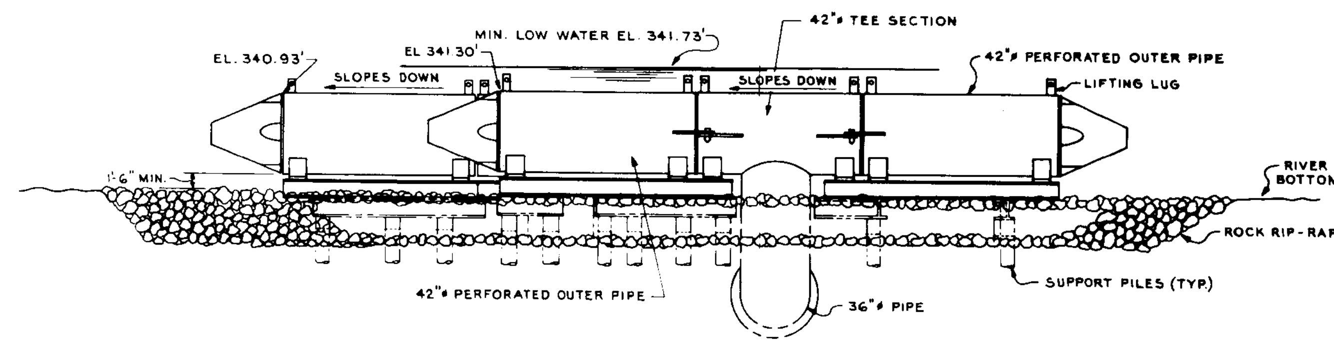
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	MAKE-UP WATER PUMPHOUSE PLAN AND SECTIONS
	FIG. 3.4-6



SECTION B-B

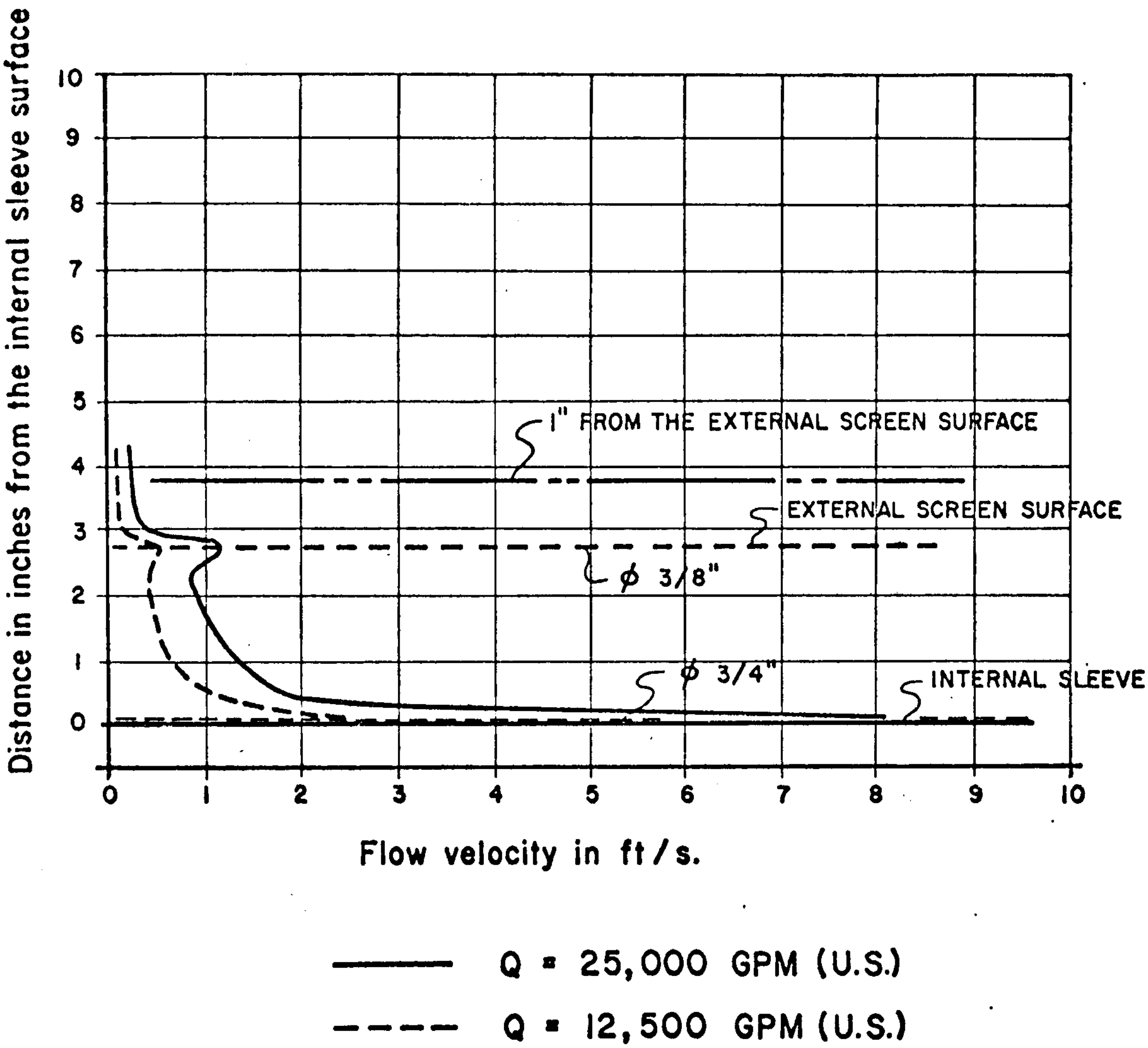


PLAN

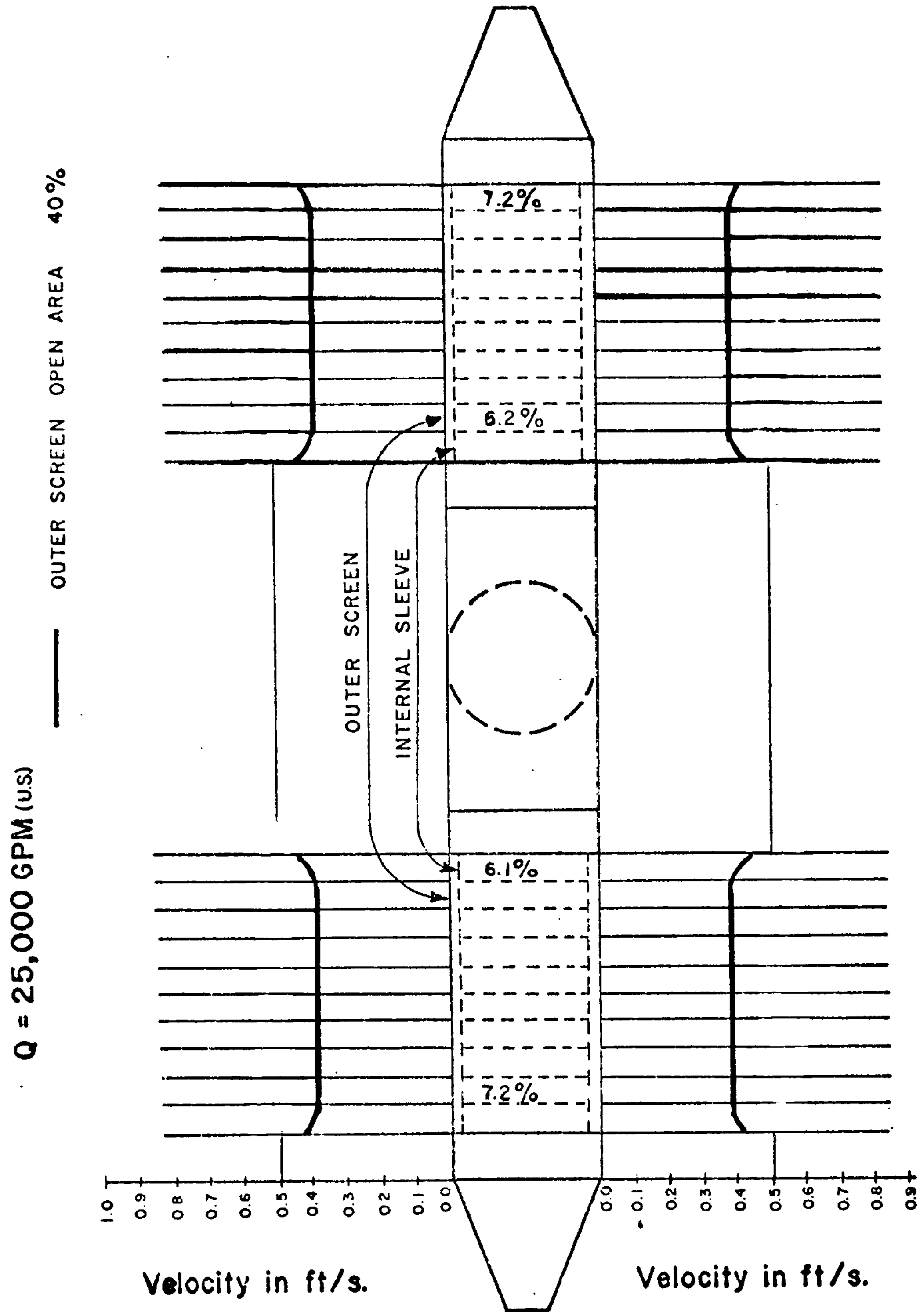


SECTION A-A

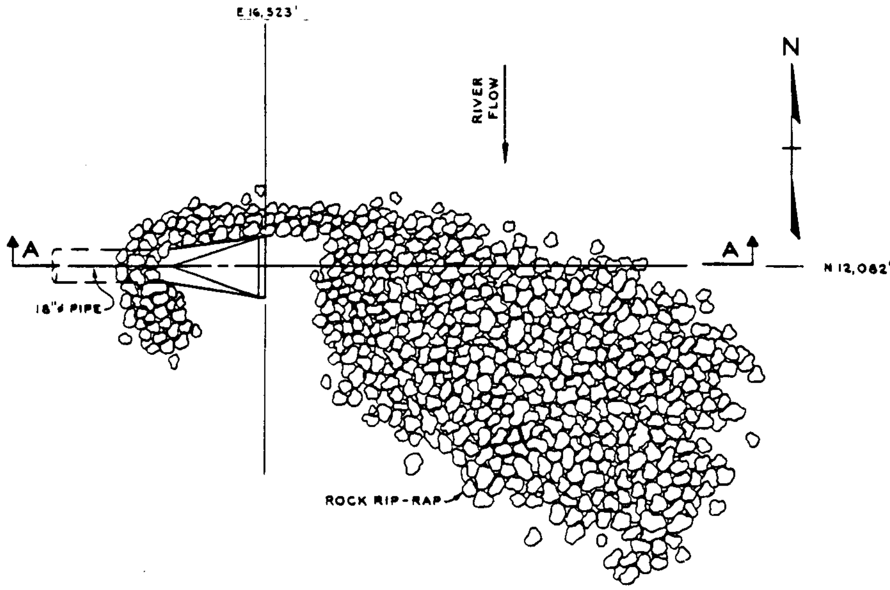
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PERFORATED INTAKE PLAN AND SECTIONS
	FIG. 3.4-7



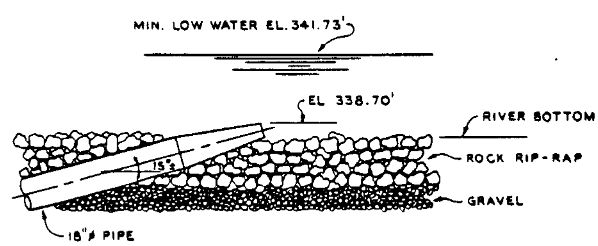
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PERFORATED PIPE INTAKE DISTANCE VS. INTAKE FLOW VELOCITIES FIG. 3.4-8



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PERFORATED PIPE INTAKE VELOCITY DISTRIBUTION 3/8" AWAY FROM SCREEN SURFACE FIG. 3.4-9



PLAN



SECTION A-A

Amendment 5, July 1981

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	RECTANGULAR SLOT DISCHARGE
	FIG. 3.4-10

3.5 RADWASTE SYSTEMS AND SOURCE TERM

3.5.1 Source Term

3.5.1.1 General

The source terms for both normal operation and anticipated operational occurrences are based on a noble gas release rate of 60,000 μCi/sec after 30 minutes decay as detailed in ANS Standard N237, "Source Term Specification."[1]

Estimates of release rates to the environment followed the guidance in the Draft Regulatory Guide "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWR's)."[2] Where guidance is not provided (e.g., fuel pool concentrations) reliance is placed on reported measurements. Improved fuel cladding integrity may result in lower releases than those indicated by measurements on early plants.

Reference is made to other subsections of Section 3.5 and to the SAR where appropriate.

3.5.1.2 Noble Gas Leakage Rates From Fuel

For normal operation, the average source terms for the environmental release are based on a total noble gas leakage rate from the fuel of 60,000 μCi/sec (after 30 min decay). This leakage rate is based on the recommendations in the proposed ANS N-237 standard on source terms.[1] Table 3.5-1 shows concentrations in units of μCi/g of steam at the reactor vessel steam nozzle, i.e., at decay time t = 0. Multiplication by the steam flow rate, 1.8×10^6 g/sec yields the release rate in μCi/sec.

Table 3.5-2 lists the calculated radionuclide release rates at t = 0 and t = 30 min decay. The latter is the rate at t = 0 multiplied by the decay factor $e^{-\lambda t}$ at t = 30 min.

3.5.1.3 Halogens

The equilibrium concentrations in the reactor water and steam at the reactor exit nozzles for computing average source terms are shown in Table 3.5-3. The iodine carryover fraction from reactor water to steam is taken as 0.02.[2]

3.5.1.4 Other Fission Products and Corrosion Products

The other fission product and corrosion product source terms are shown in Table 3.5-4 (fission products) and Table 3.5-5 (corrosion products). The carryover fraction from reactor water to the steam is taken as 0.001.[2]

3.5.1.5 Water Activation Products

The water activation products used in the source term calculations are shown in Table 3.5-6.

3.5.1.6 Tritium

In a BWR, tritum is formed from:

1. the fissioning of uranium within the fuel,

2. neutron reactions with boron in the control rods, and

3. activation of naturally-occuring deuterium in the primary coolant.

The tritium concentration in the reactor coolant is taken as 1×10^{-2} μCi/g of water or steam.(1)

The tritium released annually in liquid waste is estimated to be 0.01 μCi/ml from reference 2.

The tritium released through the building ventilation system is listed on Table 3.5-21. The principal sources are the equipment and valve leakages from the turbine and reactor buildings. The sources of leakage from individual valves, pumps and other types of equipment are each too small to detect. Release estimates are therefore based on measurements made at operating plants.

3.5.1.7 Source Terms for Fuel Pool

The 376,000 gallon fuel pool is provided with a cooling and cleanup system to minimize the release of fission products, activation products and tritium to the reactor building environment. The cleanup system, through filtration and ion exchange, removes fission and activation products from the coolant while the cooling system minimizes evaporation of the tritum bearing water. Exposure of personnel to airborne radioactive material is further reduced by the placement of ventilation exhaust ducts around the periphery of the fuel pool and reactor well.

The fuel cooling and cleanup system consists of two circulating pumps, two heat exchangers, two filter demineralizers and two skimmer surge tanks together with the required piping, valves and instrumentation. The pumps circulate the pool water in a closed loop, taking suction from the surge tanks, circulating the water through the heat exchangers and filters, and discharging it through diffusers at the bottom of the fuel pool and reactor well. The water flows from the pool surface through scuppers and skimmer weirs to the surge tanks.

The flow diagrams for the fuel pool cooling and cleanup system and the fuel pool ventilation system are Figures 3.5-13 and 3.5-9 respectively.

The Bureau of Radiological Health reports concentrations measured at Dresden 1 for normal operating conditions. These results are listed in Table 3.5-7.

Data on air conditions above the pool are limited. Since the radionuclide concentration in the air above the fuel pool is speculative, the total releases from the reactor building are taken as a better value and include the contribution from the fuel pool.

3.5.1.8 Releases from Building Ventilation Systems

Estimates of radioactive releases from ventilation systems are based on measurements of releases at operating boiling water reactors. The measurements and calculations used are those detailed in reference 2 and are summarized below.

3.5.1.8.1 Reactor and Containment Buildings

Measurements at nine boiling water reactors indicated that the average Iodine-131 release rate during normal operation was 0.11 curies per year. Measurements of Iodine-131 released from two of the plants during outages indicated an average ratio of Total I-131 released to I-131 released during normal operation of 3:1. The ratio (3:1) of total release/operating release was multiplied by the average of operating release rates (0.11 Ci/yr) to obtain the expected total I-131 release rate. Iodine-133 releases were calculated using the ratio of I-133/I-131 in the reactor coolant.

The estimated noble gas release is the average of values measured at two operating boiling water reactors.

Estimated releases of particulates are also based on measurements at operating boiling water reactors; however, the values are adjusted to reflect an 80% plant capacity factor. Of the 20% downtime, 60 days are assumed to be long term outages (one week or more) while the remaining 13 days are short term shutdowns.

Because of the differences in containment design between the measured plants and the WNP-2 design, the estimated releases were equally divided between the reactor building and containment. Appropriate decontamination factors were then assigned to the containment releases to account for the effect of the standby gas treatment system.

Estimated releases from the reactor building and containment are listed in Table 3.5-8.

3.5.1.8.2 Turbine Building

Releases of radioactive iodines, noble gases and particulates were estimated in the manner described for the reactor building. Estimated values are contained in Table 3.5-9.

3.5.1.8.3 Radwaste Building

Radwaste building releases were also based on measurements at operating plants and calculated in the manner described for the reactor building. Credit is taken, however, for HEPA filters located in the ventilation exhaust which considerably reduce the particulate releases from this source. Expected release rates are listed in Table 3.5-10.

3.5.1.9 Releases from Mechanical Vacuum Pump

Estimates of radioactive releases via the mechanical vacuum pump are based on measurements made at two operating plants as detailed in reference 2. It is assumed that the mechanical vacuum pump is operated for 24 hours during each of four shutdowns per year. Expected release rates are contained in Table 3.5-11.

3.5.1.10 Releases from Gland Seal Exhauster

Because non-radioactive steam is used in the turbine gland seal system, it is expected that particulate and noble gas releases will be less than one curie per year and that iodine released will be less than 10^{-4} curies per year.

3.5.1.11 Answers to Appendix 3 Questions

1. a. Q: Plant capacity factor
   A: 80%

   b. Q: Isotope release rates of noble gases to the reactor coolant and at 30 minutes decay, (μCi/sec)
   A: See Table 3.5-2

   c. Q: Concentration of fission products in the reactor coolant, μCi/g.
   A: See Table 3.5-4

   d. Q: Concentrations of corrosion and water activation products in the reactor coolant, μCi/g
   A: See Tables 3.5-5 and 3.5-6, respectively

e. Q: Tritium release rate
A: Annual average taken as

$$\frac{.025 \text{ Ci/MWt} \times 3300 \text{ MWt}}{3.15 \times 10^7 \text{ sec/yr}} = 2.6 \ \mu\text{Ci/sec}$$

2. Q: The maximum core thermal power (MWt) evaluated for safety considerations in the SAR
A: 3323 MWt

3. Q: The total steam flow, lb/hr
A: 1.43×10^7 lb/hr

4. Q: The mass (lbs) of primary coolant in the reactor vessel
A: 5.53×10^5 lbs at normal water level.

5. a. Q: The average flow rate through the reactor coolant cleanup demineralizer
A: 133,000 lb/hr at temperature = 533°F and enthalpy = 527.5 Btu/lb with both demineralizers in operation

b. Q: The type of resins used
A: Powdex, strong base anion and strong acid cation

c. Q: The DF's used for the cleanup demineralizer
A: Anion 10
Cs, Rb 2
Other 10

6. Q: The total mass (lb) of uranium and plutonium in an equilibrium core (metal weight)
A: For Uranium cycle, 15,000 MWD/T
U = 136.4 Tonne
Pu = 0.8 Tonne
For Plutonium cycle
U = 134.9 Tonne
Pu = 1.4 Tonne

7. Q: The percent enrichment of uranium in reload fuel
A: Uranium cycle: 2.4 - 2.8%
Plutonium cycle: 2.4%

8. Q: The percent of fissile plutonium in reload fuel
A: Uranium cycle: 0.51%
Plutonium cycle: 0.62%

9. a. Q: The regeneration frequency (days) for the condensate demineralizers
   A: These are powder type demineralizers which are backwashed every 14 days

   b. Q: The type of resins used
   A: Powdex

   c. Q: The DF's used in the evaluation for the condensate demineralizer
   A: Anion 10; Cs, Rb 2; Other 10

10. Q: The flow rate (gpm) of water used to dilute liquid waste prior to discharge
    A: 2500 - 6500 gpm

11. Q: The input sources, average flow rates and activities of the wastes processed through the high purity waste system
    A: 18,380 GPD at 0.213 x Primary Coolant Activity

12. Q: Description of the system used to process the high purity waste. The process flow diagram for the high purity waste system, indicating all decontamination factors used in the evaluation
    A: See Section 3.5.2 for description and flow diagram:
    DF for Iodine = 1000
    DF for Cesium = 20
    DF for other nuclides = 1000

13. Q: The high purity waste holdup times used in the evaluation and the fraction of the processed stream expected to be discharged over the life of the plant. The capacities (gal) of all tanks considered in calculating the holdup time
    A: See Section 3.5.2 for tank capacities:
    Collection time = 0.435 days
    Process time = 0.0617 days
    Fraction discharged = 0.01

14. Q: The input sources, average flow rates (gpd) and activities (fraction of Primary Coolant Activity) of wastes processed through the low purity waste system.
    A: 5700 GPD at 0.132 x Primary Coolant Activity

15. Q: Description of the system used to process the low purity waste. The process flow diagram for the low purity waste system, indicating all of the decontamination factors used in the evaluation

    A: See Section 3.5.2 for description and flow diagram:
    DF for Iodine = 1000
    DF for Cesium = 4
    DF for other nuclides = 1000

16. Q: The low purity waste holdup times used in the evaluation and the fraction of the processed stream expected to be discharged over the life of the plant. The capacities (gal) of all tanks considered in calculating the holdup times

    A: See Section 3.5.2 for tank capacities:
    Collection time = 1.403 days
    Process time = 0.0617 days
    Fraction discharged = 0.10

17. Q: The input sources, average flow rates (gpd) and activities (fraction of PCA) of water processed through the chemical waste system

    A: 1400 GPD at 0.02 x Primary Coolant Activity

18. Q: Description of the system used to process the chemical waste. The process flow diagram for the chemical waste system, indicating all decontamination factors used in the evaluation

    A: See Section 3.5.2 for description and flow diagram:
    DF for Iodine = 10,000
    DF for Cesium = 10,000
    DF for other nuclides = 10,000

19. Q: The chemical waste holdup times used in the evaluation and the fraction of the processed stream expected to be discharged over the life of the plant. The capacities (gal) of all tanks considered in calculating the holdup times

    A: See Section 3.5.2 for tank capacities:
    Collection time = 8.571 days
    Process time = 0.833 days
    Fraction discharged = 0.10

20. Q: The stream leakage rate (lb/hr) to the turbine building considered in the evaluation. Description of special design features used to reduce steam leakage and the fraction of iodine released. If ventilation air is treated through charcoal adsorbers, the bed depth and the iodine decontamination factor used.

A: Steam leakage estimates were not used in evaluation of turbine building releases. Release estimates are based on measurements made at operating plants as detailed in reference 2

There are no special treatment provisions for turbine building exhaust air.

21. Q: The steam flow (lb/hr) to the turbine gland seal and the source of the steam.

A: The total sealing steam flow to all turbines is 28,000 lb/hr of non-radioactive steam.

22. Q: The mass of steam (lb) in the reactor vessel

A: 21,801 lbs during operation

23. Q: The design holdup time (hrs) for gases vented from the gland seal condenser, the iodine partition factor for the condenser and the fraction of iodine released through the system vent. Description of the treatment system used to reduce the iodine releases from the gland seal system

A: There is no design holdup time for gases vented from the gland seal condenser. The gland seal steam is clean steam rather than process steam; see Question-Answer 21 above

24. Q: The primary coolant leakage rate (lb/day) to the reactor building, the temperature of the coolant and the iodine partition factor used in calculating releases from the reactor building in the evaluation

A: Coolant leakage to the reactor building is not used in evaluation of reactor building releases. Release estimates are based on measurements made at operating plants given in reference 2

25. Q: Description of the treatment provided for the reactor building ventilation air to reduce iodine prior to discharge. The decontamination factor and the bed depth of the charcoal adsorber used in the evaluation

A: See Section 3.5.3.3.2

26. Q: The holdup time (min) for off-gases for the main condenser air ejector prior to processing by the off-gas treatment system.

A: The holdup time is in excess of 10 minutes during normal operation

27. Q: Description and expected performance of the gaseous waste treatment system of the off-gases from the condenser air ejector. The expected air inleakage per condenser shell, the number of condenser shells and the iodine partition factor for the condenser.
    A: There is one condenser shell which is divided into three chambers, each at its own pressure. The total expected air inleakage is 30 cfm for the entire system. See Section 3.5.3.2 for details

28. Q: The mass of charcoal in the charcoal delay system used to treat the off-gases from the main condenser air ejector, the operating temperature of the delay system and the dynamic adsorption coefficient for Xe and Kr, based on the system design used in calculating the respective holdup times.
    A: The operating temperature is $0^{o}F$. The mass of charcoal in the system is approximately 24.6 tons. The dynamic adsorption coefficients used in calculating holdup times are 105 cm^3/g for Kr and 2410 cm^3/g for Xe

29. Q: Description of cryogenic distillation system, fraction of gases partitioned during distillation, holdup in system storage following distillation and expected system leakage
    A: Not applicable

30. Q: Inputs to the solid waste system: volumes, curie contents and sources of wastes. Principal radionuclides, on-site storage times prior to shipment. Description of solid waste processing systems
    A: See Section 3.5.4

31. Q: Sources, flow rates (gpd) and activities of detergent wastes. Description of treatment processes, volumes of holdup tanks and decontamination factors used in the evaluation
    A: See Section 3.5.4. Note: No on-site laundry

32. Q: Process and instrumentation diagrams for liquid, gaseous and solid radwaste systems and all other systems influencing the source term calculations.
    A: See Figures 3.5-1 to 3.5-11.

33. Q: Process and instrumentation diagrams for fuel pool cooling and purification systems and for fuel pool ventilation system. Provide the volume of the fuel pool and refueling canals, identify the sources

of makeup water and describe the management of water inventories during refueling. Provide an analysis of the concentration of radioactive materials in the fuel pool water following refueling and calculate the releases of radioactive materials in gaseous effluents due to evaporation from the surface of the fuel pool and refueling canals during refueling and during normal power operation. Provide the basis for the values used

A: See Section 3.5.1.7

3.5.2 Liquid Radwaste System

3.5.2.1 General

The liquid radwaste system is composed of a group of subsystems designed to collect, control, process, handle, store, recycle and dispose of liquid radioactive wastes generated as a result of normal operation and anticipated operational occurrences. These subsystems and the classification of wastes that these systems process are as follows:

a. Equipment drains subsystem - processes high purity wastes. These wastes have a normal conductivity level less than 50 μmho/cm and a radioactivity level less than 10^{-2} μCi/cc.

b. Floor drain subsystem - processes intermediate purity wastes. These wastes typically have a higher conductivity level than equipment drains but have a lower radioactivity level on the order of 10^{-7} to 10^{-3} μCi/cc.

c. Chemical waste subsystem - processes low purity wastes. These wastes are of such high conductivity so as to preclude treatment by ion exchange. The radioactivity concentrations are variable and substantially affected by chemical cleaning and decontamination solutions.

These systems are discussed in Subsections 3.5.2.2 through 3.5.2.5, respectively.

The water that is generated from liquid waste processing is recycled for plant reuse to the maximum extent practical. Excess water is discharged from the plant to maintain an overall plant water balance. Excess water is discharged to the cooling tower blowdown line which is, in turn, discharged to the river. Table 3.5-12 lists the estimated radionuclide concentrations that are discharged to the river cooling tower blowdown line. The concentrations listed were estimated using the methods and parameters of the GALE Code detailed in reference 2. The parameters used in this evaluation are not necessarily the same values used for design.

Design basis values for the equipment decontamination factors are listed in Table 3.5-13. These factors are defined as the ratio of the input radioactivity concentration to the output concentration.

The liquid radwaste system equipment is designed for a maximum of 150 psig and 150^{o}F operation. Collection and storage tanks are vented to the radwaste building exhaust system. The mixed bed demineralizers, precoat filters and concentrators are contained within pressure vessels. The quality classification for the system is in accordance with Regulatory Guide 1.26.

The liquid radwaste system is essentially a manual-start, automatic stop process. Process and radiation instrumentation allows for the initiation of batch processing from the Radwaste Control Room area or local operation areas. Inputs to the various subsystems originate from both occasional unscheduled sources such as sumps and from scheduled events such as process equipment flushing.

The portions of the radwaste and control building which are Seismic Category I are the radwaste area for El. 437'-0" to El. 467'-0" and the vertical portion of the building encompassing the area of the control room. The remainder of the building is Seismic Category II.

A process flow diagram, Figure 3.5-1, together with process data, Table 3.5-14, shows the tank capacities, system flow rates, design capacities of components, holdup times and total radionuclide inventories for the various radwaste subsystems.

Piping and instrumentation drawings of the subsystems with collection and discharge piping are shown in Figures 3.5-2 through 3.5-4.

3.5.2.2 <u>Equipment Drain Subsystem Description</u>

The equipment drain subsystem collects and treats wastes from the following sources:

a. Drywell equipment drain sump

b. Reactor building equipment drain sump

c. Radwaste building equipment drain sump

d. Turbine building equipment drain sump

e. Reactor water cleanup system

f. Residual heat removal system

g. Cleanup phase separators (Decant water only)

h. Fuel pool seal rupture drains

i. Condensate phase separators (Decant water only)

Table 3.5-15 lists the quantity from each of the above sources that are processed in this system.

The wastes from these sources are pumped or drained into the waste collector tank. The waste collector tank contents are pumped through the waste collector filter and waste demineralizer to the waste sample tanks where the liquid is monitored prior to release to the condensate tanks or the cooling tower blowdown line or recirculated for further processing. (See Figure 3.5-2)

In the event of a component malfunction within the equipment drain subsystem, sufficient crossties are provided to the floor drain collector subsystem to permit continued processing of the wastes. Sufficient capacity is provided in the equipment to handle such conditions.

3.5.2.3 Floor Drain Subsystem Description

The floor drain subsystem collects and treats wastes from the following sources:

a. Drywell floor drain sump

b. Reactor building floor drain sumps

c. Radwaste building floor drain sumps

d. Turbine building floor drain sumps

e. Waste sludge phase separator

The wastes from these sources are pumped into the floor drain collector tank. Table 3.5-16 lists the quantity from each of the above sources that is processed by this system. The floor drain collector tank contents are pumped through the floor drain collector filter and the floor drain demineralizer to the floor drain sample tank. Here the fluid is sampled prior to discharge to the condensate storage tank or the cooling tower blowdown line. (See Figure 3.5-3)

Similar to the equipment drain subsystem, the floor drain subsystem normlly functions as an independent process string. Intersystem crossties are provided with the equipment drain subsystem to allow continued processing of floor drain wastes.

3.5.2.4 Chemical Waste Subsystem Description

The chemical waste subsystem collects and treats wastes from the following sources:

a. Detergent drains

b. Shop decontamination solutions

c. Reactor, turbine and radwaste building decontamination drains

d. Low purity wastes from either the equipment or floor drain subsystems

e. Chemical cleaning solutions from filter demineralizer units

f. Battery room drains

g. Chemical system overflows and tank drains

h. Laboratory drains

i. Chemical waste sump (radwaste building)

The quantities from the above sources are listed in Table 3.5-17. These wastes are collected in the chemical waste tank. The contents of this tank are recirculated through a mixing eductor in the tank. During recirculation, the fluid is sampled and a neutralizing solution is added as required from one of the chemical addition tanks.

Samples are taken and if a neutral solution is indicated, the liquid is pumped to the decontamination solution concentrator. The concentrator bottoms are blown to one of the decontamination solution concentrated waste tanks. From here, the concentrator bottoms are pumped to the decontamination solution concentrator waste measuring tank. This tank admits a pre-determined quantity of wastes for processing through the solidification system.

The concentrator distillate is condensed in the decontamination solution condenser and stored in the distillate tanks The distillate is sampled and if the radioactivity level and water quality is acceptable, the distillate is pumped to the condensate storage tanks. If the radioactivity level or water quality is unacceptably high, the distillate is processed through the distillate polishing demineralizers or reprocessed through the decontamination solution concentrators. It is resampled, and if acceptable, it is pumped to the condensate storage tanks. As with the other subsystems, when condensate storage is not available, the purified liquid is sent to the cooling tower blowdown line (See Figure 3.5-4 for an illustration of this system).

Equipment reduncancy is provided in the chemical waste processing system to allow bypassing of any failed component. Sufficient capacity is provided in the equipment to handle such conditions.

3.5.2.5 Detergent Wastes

Detergent wastes are collected in the detergent drain tanks. These wastes consist of primarily laboratory and decontamination solutions which contain detergent and laboratory wastes. Because of a tendency to foul ion exchange resins, these liquid radwastes are treated separately. They are filtered through the detergent drain filter prior to discharge to the chemical waste system for cleanup and recycling.

3.5.2.6 Sludges

Expended filter demineralizer ion exchange resins are removed when necessary by backwashing. Condensate filter demineralizer resins are backwashed to the condensate backwash receiving tank and pumped to the condensate phase separator tanks for processing. Reactor water cleanup system sludges are collected in the RWCU phase separators where excess backwash water is decanted to the waste collector tank. The remaining sludge is processed through the radwaste solids system.

The fuel pool filter demineralizer, waste collector and floor drain filters are backwashed to the waste sludge phase separator tank. The accumulated resins and sludges are processed through the solid radwaste system after a suitable decay period. The processing system for these sludges and resins is described in Section 3.5.4.

3.5.3 Gaseous Radwaste System

3.5.3.1 General

The gaseous radwaste system is designed to process and control the release of gaseous radioactive effluents to the site environs so that the radiation dose to off-site persons is "as low as practicable" as defined in 10CFR50, Appendix I.

Gaseous effluents that are released to the off-site environs emanate from the following sources:

a. effluent released from the off-gas treatment system,

b. effluent released from the ventilation system in the various buildings, and

c. effluent released from the mechanical vacuum pump.

3.5.3.2 Off-Gas Treatment System

3.5.3.2.1 General

The off-gas system can be divided into the following subsystems:

a. Recombiner subsystem

b. Condensing-moisture separator subsystem

c. Cooler condenser-glycol subsystem

d. Filter subsystem

e. Desiccant dryer regeneration system

f. Activated carbon refrigeration-adsorption subsystem

Each of these are discussed in Subsections 3.5.3.2.2 to 3.5.3.2.7.

The source of radioactive gases is the steam jet air ejectors which remove main condenser noncondensible gases during plant operation. The condenser off-gas contains both fission product gases which leak through the reactor fuel element cladding as well as the coolant activation gases. The activation gases result from the irradiation of reactor coolant as it passes through the neutron field in the fuel portion of the core in the reactor vessel. The production of these gases is dependent upon the reactor power level rather than the amount of leakage in the fuel cladding. Condenser off-gas activity is principally due to N-16, 0-19 and N-13. The N-16 and 0-19 have very short half-lives (secs) and decay rapidly, whereas N-13, with a ten (10) minute half-life, is only present in small amounts. The condenser off-gas contains radioactive noble gases including daughter products of these nuclides. The concentration of noble gases depends on the amount of tramp uranium present and any fuel element defects which exist.

The source terms for the off-gas treatment system are based on the average noble gas release rate of 60,000 μCi/sec after 30 minutes decay (See Subsection 3.5.1). The system has a design basis of 100,000 μCi/sec with the capability of processing 300,000 μCi/sec of noble gases activity without affecting the delay time of the noble gases. Based on a condenser air inleakage of 30 scfm, the charcoal system will present a residence time delay for krypton of at least 46 hours and a xenon residence delay time of at least 42 days.

The off-gas system's first processing function is to catalytically recombine radiolytically produced hydrogen and oxygen. The off-gas is then cooled to approximately 130°F to remove condensibles, and in the process, reduce the mass of gas per unit volume. The remaining non-condensible gas, which consists primarily of air plus trace concentrations of krypton-xenon, is delayed in the ten (10) minute holdup system. The gas is cooled to 45°F and filtered through a high efficiency particulate air (HEPA) filter. The gas is then passed through a desiccant dryer that reduces its dewpoint to -90°F and then is chilled to 0°F. Charcoal adsorption beds, operating in a refrigerated vault at about 0°F, selectively adsorb and delay the trace quantities of xenon and krypton in the bulk carrier gas. The refrigeration system of the charcoal adsorber vault is designed with sufficient flexibility to maintain the vault temperature down to -40°F. After this delay, the gas is then passed through a HEPA filter and then discharged to the environment through the reactor building elevated release point.

Radioiodine is present in reactor steam and, to a small extent, carries over through the condensation and filtration stages of the off-gas system. Removal of off-gas train iodine, however, is virtually complete in passage of the process gas through granular activated carbon. Thus, the radioactive noble gases control the release rate of gaseous wastes from the off-gas system.

Figure 3.5-5 shows a schematic of the process flow diagram for the system. Table 3.5-18 lists the process data which apply to this system. The process and instrumentation diagrams are given in Figures 3.5-6 and 3.5-7.

The release rate of the noble gas isotopes into the atmosphere are listed in Table 3.5-20.

3.5.3.2.2 Recombiner Subsystem

During plant operation, the steam jet air ejector removes the non-condensible gases from the main condenser, provides the motive pressure at the inlet to the off-gas system, and dilutes the hydrogen present in the off-gas with steam to maintain the maximum hydrogen concentration less than four percent by volume at all power levels. The actual hydrogen concentration in the effluent gas to and from the recombiner is much below the four percent level.

The off-gas effluent from the air ejectors is directed to the recombiner preheater. Of these, there are two 100 percent capacity units, with one of the units on standby service.

The recombiner preheater raises the off-gas temperature to approximately 350°F to allow efficient catalytic recombiner operation In the recombiner, the gas temperature increases up to 850°F due to the heat of formation of water and this further improves recombiner efficiency. At the outlet of the recombiner, a hydrogen analyzer monitors the hydrogen concentration and inititates alarms at abnormal hydrogen levels.

3.5.3.2.3 Condensing Subsystem

The off-gas condenser is utilized to cool and condense the recombiner effluent and reduce entrained water vapor from the off-gas stream. The effluent noncondensible gases are then directed to the water separator where additional entrained water droplets are removed. From the water separator, the off-gas is routed to the holdup line, which is designed to provide lag storage of the off-gas for at least ten (10) minutes at the design flow rate. From here the off-gas stream is routed to one of the two 100 percent capacity cooler condensers. The second unit remains on standby service. In the cooler condenser, the off-gas is further cooled to a lower dewpoint temperature to remove more condensibles. Upon leaving the cooler condenser, the off-gas stream is discharged to one of the moisture separators. There are two 100 percent units with one unit on standby service. In the moisture separator, additional entrained moisture is removed. From here the off-gas stream is routed to the filter-dryer subsystem.

3.5.3.2.4 Filter-Dryer Subsystem

The off-gas stream effluent from the moisture separator is directed to one of the two 100 percent capacity HEPA pre-filters. These filters are of the high efficiency absolute type particulate filters which remove particulate form radio-nuclides. Based on DOP tests, the filter elements remove at least 99.97 percent of particles larger than 0.3 micron in diameter. Gas leaving the prefilter is directed through a disiccant dryer to further reduce the dewpoint level to reduce the competition of water for adsorption sites on the charcoal beds. There are four desiccant dryer units arranged in two independent trains as described in Subsection 3.5.3.2.7. Thus, while regeneration is being performed on one of the trains, the dryers in the second train are available in the process system, one of which acts as a standby unit. Each of the four dryers is capable of drying the process gas stream to -90°F dewpoint. From the dryer train, the off-gas stream is directed to the refrigerated adsorption subsystem.

3.5.3.2.5 Refrigerated Adsorption Subsystem

Off-gas effluent from the desiccant dryers under normal operation flows through one of the four off-gas coolers which are each designed to cool the process gas stream to 0°F. From the cooler the gas passes to one of the two banks of charcoal adsorbers. There are four adsorber vessels in each of the banks. From two of the coolers, the gas stream is directed to the first vessel of each bank of adsorbers. The remaining two coolers are arranged so that one of the coolers feeding each bank of adsorbers can bypass the first adsorber in each bank in the event of the presence of excess moisture in that adsorber vessel. The gas stream effluent from the last unit of each bank is routed to one of the two afterfilters. Each of the afterfilters is capable of treating 100 percent of the normal process gas flow, thus one unit is in the standby condition. The afterfilters are of the HEPA high efficiency moisture resistant absolute particulate type. Particulate daughter products and charcoal fines are removed by the afterfilter before the gas is monitored for radiation level prior to being directed to the reactor building elevated release point and then is released to the atmosphere. This type of filter has better than 99 percent efficiency for particulates larger than 0.3 microns based on DOP tests.

The charcoal adsorbers provide selective adsorption of the xenon and krypton isotopes from the bulk gas (air) in the off-gas stream. Selective adsorption permits a major fraction of xenon and krypton isotopes to decay in place, thereby reducing activity releases to the atmosphere. The holdup time at design flow is in excess of 42 days for xenon and 46 hours for krypton gases as mentioned earlier.

The Kr and Xe holdup time is closely approximated by the following equation:

$$t = \frac{K_d M}{F}$$

Where:

t = holdup time of a given gas, (sec)

K_d = dynamic adsorption coefficient for the given gas, (cm^3/sec)

M = weight of charcoal, (g)

F = flow rate, (cm^3/sec)

Dynamic adsorption coefficient values for xenon and krypton have been reported by several authors, including Browning.[5]

The off-gas charcoal adsorber vault is maintained at 0°F during normal plant operation by two independent, full capacity, closed loop, brine refrigeration systems. The refrigeration system has been designed with sufficient flexibility to maintain the vault temperature down to -40°F. The off-gas charcoal adsorber vault refrigeration system is schematically shown in Figure 3.5-8.

During normal plant operation, one refrigeration system operates with the second system in standby mode. Each system consists of a rotary screw type liquid chiller, a centrifugal pump, two refrigeration fan coil units and associated piping, distribution ductwork and accessories.

3.5.3.2.6 Glycol Subsystem

This subsystem consists of three refrigeration machines through which a closed-type glycol system is fed. The cold glycol solution is pumped to the off-gas process stream's two cooler condensers described in Subsection 3.5.3.2.3 and the desiccant dryer's regenerative dryer chillers described in Subsection 3.5.3.2.7.

3.5.3.2.7 Desiccant Dryer Regeneration Subsystem

This subsystem consists of four desiccant beds in two independent trains, each train having a full set of regeneration equipment. The regeneration cycle uses only captive air from the off-gas process stream which is cooled in the dryer chiller, circulated by the regenerative blower and heated and dried by the dryer heater before being directed through the desiccant dryer being regenerated. Under normal operating conditions, a desiccant unit can be regenerated in a 12-hour period including cooldown.

The desiccant dryer regeneration system is also piped to allow its use in supplying relatively dry (45°F dewpoint), heated (250°F) air at the rate of 250 cfm to be used in defrosting and drying the charcoal adsorber beds during the annual refueling outage, should gross moisture be present. Service air is utilized for this purpose and circulated through the regeneration system prior to being circulated through the charcoal adsorber beds.

3.5.3.3 Building Ventilation

3.5.3.3.1 General

The Heating, Ventilation and Air Conditioning (HVAC) systems that service the reactor, radwaste and turbine building are designed to the following performance objectives:

a. To provide fresh air and maintain appropriate temperature and humidity conditions for plant personnel and equipment.

b. Control and monitor all potentially radioactive airborne releases from the plant to within the objectives of 10CFR50, Appendix I.

c. Control and limit airborne contaminants within the plant structures by inducing air flow from areas of low radiation potential to areas of high radiation potential.

d. Maintain the various buildings at a negative pressure with respect to the atmosphere. This prevents the exfiltration of radioactive material.

Details of the HVAC system used in each building are discussed in the following paragraphs.

3.5.3.3.2 Reactor Building

The reactor building heating and ventilating system is schematically shown in Figure 3.5-9.

The system is basically a push-pull heating and ventilation system providing once-through air flow with no recirculation. It consists of the following subsystems which can potentially release radioactive effluents.

Supply Air System

The supply air system consists of a ventilation unit, air distribution ductwork, two isolation butterfly dampers on the fresh air intake and the associated controls. During normal plant operation and shutdown, the supply air system isolation dampers are open and the ventilation system operates continuously. This provides 100% outdoor air throughout the building.

The reactor building supply air system also provides makeup air to the primary containment during a primary containment purge. During purging, isolation valves in the supply purge duct to the primary containment are opened, and air is blown from the supply air system into the primary containment.

In the event of a reactor building isolation signal, the supply system ventilating unit stops and the two isolation dampers on the fresh air intake close. The signals which cause reactor building isolation are as follows:

a. reactor vessel low water level,

b. high drywell pressure, and

c. high radiation level in the reactor building exhaust ventilation system.

Exhaust Air System

The reactor building exhaust system draws air from all areas with radiation contamination potential and discharges it to the elevated release point. The elevated release point is located on the roof of the reactor building.

In the event of a primary containment purge, the exhaust air is discharged through the reactor building exhaust system or through the standby gas treatment system. Ducts connect the primary containment drywell and wetwell with reactor building exhaust system and standby gas treatment system. The reactor building exhaust system is normally used.

The standby gas treatment system is used to process building exhaust during an accident to maintain reactor building under negative pressure. It consists of two independent, full-size systems. Each system contains a demister which removes excess moisture, a prefilter which removes particulate matter present in the effluent, and electric heating coil to reduce the relative humidity of the air, a high efficiency particulate air filter (HEPA) which is capable of removing 99.97% of all particulate matter which is 0.3 micron or larger in size, two activated charcoal iodine filters which remove 99% of the iodine and an afterfilter. This equipment is listed in the order of air treatment. See Subsection 6.5 of the FSAR for further details.

Sump Vent Exhaust Filter System

All potentially radioactive liquid leaks and/or spills in the reactor building are channeled to the euqipment or floor drain system. In order to minimize the release of radioactive contaminants from the building, the drain system sumps and drain headers are maintained at a negative pressure and are vented through a filter system. The sump vent exhaust system is composed of two full-capacity, 1000 cfm filter units, each consisting of moisture separator, electric heater, HEPA filter, charcoal filter and fan. The units which draw air from the sumps and drain headers pass it through filters and discharge it into the main reactor building exhaust system upstream of the radiation monitoring instruments.

3.5.3.3.3 Radwaste Building

The radwaste building heating and ventilating system is schematically shown in Figure 3.5-10. The main system is a push-pull heating and ventilating system providing once-through air flow with no recirculation. In addition, individual air conditioning units are provided for all rooms which personnel will normally occupy for extended periods of time.

The main radwaste building supply air system consists of a supply ventilation unit and distribution ductwork. During normal plant operation, the supply unit operates continuously. This provides fresh air throughout the building via the supply duct distribution system.

The radwaste building exhaust system is composed of three 50% capacity exhaust filter units. Only two of these units are in operation at any one time. Each exhaust unit fan is provided with an automatic air operated inlet vane for volume control. The inlet vanes are controlled by differential pressure controllers set to maintain the tank enclosures in the lower level of the radwaste building at a negative pressure with respect to the atmostphere.

All radwaste building exhaust air is processed by the exhaust units and monitored by radiation detectors prior to discharge. The release point for the ventilation exhaust is located on the roof of the radwaste building. All exhaust air is passed through HEPA filters prior to discharge, thus minimizing the release of radioactive particulates.

3.5.3.3.4 Turbine Generator Building

The heating and ventilation systems of the turbine generator building are schematically shown in Figure 3.5-11. The primary system is a push-pull heating and ventilating system. It consists of the following subsystems which can potentially release radioactive effluent.

Main Supply System

The turbine generator building supply air system is composed of four supply ventilation units and distribution ductwork. The units are operated in pairs, with one pair discharging into a common supply duct system servicing the west side of the building. The other pair supplies the east side of the building.

Each ventilation unit contains a centrifugal fan. This fan is furnished with automatic inlet vanes for fan capacity and control. These are used to control the air flow and to maintain the turbine building at a negative pressure with respect to the atmosphere.

Automatic dampers are provided on the intake of each ventilation unit that permit the unit to draw either 100% outdoor air or 100% recirculation air from the turbine building. Recirculation is only performed in the event of a plant outage, when airborne contamination potential does not exist, to reduce building heating requirements.

Main Exhaust System

The main exhaust system consists of four roof-mounted centrifugal fans, all of which draw air from a central exhaust duct system. Three of the exhaust fans normally operate continuously with one fan as standby. Air flow through the operating fans is maintained at a constant rate by automatic volume dampers on the fan discharges.

Almost all exhaust air is drawn from the shielded areas of the turbine building where the potential for airborne radioactive contamination is highest. This induces flow from the cleaner areas. All exhaust air is monitored for radioactive contamination prior to discharge.

In the event that supply air to the turbine generator building is reduced, as during a plant outage, only one or two exhaust fans may be operated. Motor operated shut-off dampers are provided in all main branches of the exhaust duct system so that exhaust can be stopped on an area-by-area basis. Automatic volume dampers are provided in the exhaust system so that full exhaust flow can be drawn from the shielded equipment vaults on the lower level of the turbine building when the exhaust system is operating at full capacity. These vaults house equipment with higher contamination potential such as the air ejectors and the off-gas system hydrogen recombiners.

3.5.3.3.5 Effluent Released from Building Ventilation

Flow rate, elevation, heat content and description of the three release points are listed on Table 3.5-19.

Reactor Building

The reactor building ventilation system supplies fresh air to the reactor building and exhausts air through the elevated release point. Table 3.5-21 lists the radionuclide concentration in the reactor building effluent; basis for these values are discussed in 3.5.1.8.1.

The reactor building sumps are vented through a bank of HEPA and activated charcoal filters; however, no credit is taken for this sump vent treatment system when calculating releases.

Turbine Building

The turbine building ventilation system supplies fresh air to the various building areas and exhausts air to the atmosphere. Table 3.5-21 lists the radionuclide concentration in the turbine building effluent. These values are based on measurements at operating plants as discussed in 3.5.1.8.2.

The turbine building sumps are vented through the ventilation system directly to the atmosphere. The contribution to the total building ventilation effluent is included in Table 3.5-21 values.

Radwaste Building

Sources of gaseous radioactivity in the radwaste building include:

a. Air ejector off-gas system leakage

b. Liquid leakage to the radwaste building

c. Hydropneumatic transfer of resins

Leakage of radioactive gases from the off-gas treatment system is limited by the use of welded piping connections where possible and bellows stem seals or equivalent for valving. The system operates at a maximum of 7 psig during startup and less than 2 psig during normal operation so that the differential pressure to cause leakage is small.

Liquid leakage, which is at ambient temperature, is retained in trenches, cells and concrete rooms and returned to the system for additional processing.

Any radioactivity displaced from filter precoats and bed resins during processing is routed to the building ventilation exhaust system and high efficiency filters.

Estimated radioactive material releases from the radwaste building ventilation exhaust are listed in Table 3.5-21.

3.5.4 Solid Radwaste System

3.5.4.1 General

The solid radwaste system collects, monitors, processes, packages and provides temporary storage facilities for radioactive solid wastes for off-site shipment and permanent disposal. The following describes the design basis for the solid radwaste system.

a. The solid radwaste system is designed such that the solid radwaste collected and prepared for off-site shipment does not result in radiation exposure in excess of the limits set in 10CFR20.

b. The solid radwaste system is designed to package radioactive solid wastes for off-site shipment and burial in accordance with applicable regulations including 49CFR170-178.

c. The solid radwaste system is designed to prevent the release of significant quantities of radioactive materials to the environs so as to restrict the overall exposure to the public within the limits of 10CFR50, Appendix I.

d. Shielded casks are provided as necessary which conform to applicable federal regulations.

The solid waste processing system processes both wet and dry solid wastes. Wet solid wastes include backwash sludge and spent resins from the reactor water cleanup system, the condensate filter demineralizer system, the fuel pool filter demineralizers, the floor drain filter, the waste collector filter, the floor drain demineralizer, the waste demineralizer, the decontamination solution concentrator and the distillate polishing demineralizer. Dry solids wastes include rags, paper, small equipment parts, solid laboratory wastes, etc. The processing of these wastes is discussed in Subsections 3.5.4.4 and 3.5.4.5.

The input of the various radioactive solid waste inputs are shown on the radwaste process diagram, Figure 3.5-1. The expected frequency of solid waste input, the quantities of solids generated and the radioactivity level in the solids after accumulation are listed on Table 3.5-22. Figure 3.5-12 shows the waste packaging portion of the solid radwaste system.

The radionuclide inventory in the streams that serve as input into the radwaste is listed in Table 3.5-23.

3.5.4.2 Radwaste Disposal System Descriptions

3.5.4.2.1 Radwaste Disposal System for Reactor Water Cleanup Sludge

The purpose of the radwaste system for cleanup sludge is to process the highly radioactive backwash waste which is discharged from the reactor water cleanup system.

The reactor water cleanup system includes two filter-demineralizer units, each of which are precoated with powdered ion exchange resin (powdex), which is retained on a permanent stainless steel septum. These filter demineralizer units remove, by filtration and ion exchange, the suspended and dissolved solids from the recirculating primary reactor coolant. These solids consist of radioactive and stable elements. Upon exhaustion of either its filtration or ion exchange capability, the cleanup filter demineralizer is taken out of service. Then it is backwashed and precoated.

The backwash waste discharged from a cleanup demineralizer consists of a slurry which has a suspended solids content of about 0.5% by weight. This slurry is accumulated in one of the two cleanup phase separators.

Each backwash batch received by the working phase separator is allowed to settle and the resulting decantate is pumped to to the waste collector tank. The bottoms, or sludge, is stored in the phase separator, and when sufficient sludge has accumulated, the working phase separator is isolated for a period of one to two months to permit additional time for radionuclide decay. At the end of this decay period, water is added to the sludge until about 5% solids content by weight is reached and it is then pumped to the centrifuges for dewatering. See Subsection 3.5.4.4 for a description of the centrifuges.

3.5.4.2.2 Radwaste Disposal System for Condensate Demineralizer Sludge

The purpose of this system is to process the radioactive backwash waste which is discharged from the condensate filter demineralizer system.

The condensate filter demineralizer system consists of six filter demineralizer units which are precoated with powdered ion exchange resin (powdex). Five of these are in continuous operation and one is in a standby mode. These filter demineralizer units remove, by filtration and ion exchange, the suspended and dissolved solids from the reactor steam condensate. These solids consist primarily of corrosion products and trace radionuclides. Upon exhaustion of either its filter or ion exchange capability, the exhausted demineralizer is taken out of service and is backwashed and precoated.

The backwash waste discharged from a condensate demineralizer consists of a slurry which has a suspended solids content of aoubt 0.5% by weight. This discharge is collected in the condensate backwash receiving tank. After collection, the waste is transferred by pumping to one of the two condensate phase separators for processing.

Operation of the condensate phase separators is similar to that for the cleanup phase separators (See Subsection 3.5.4.2.1). Backwash sludge is received by the phase separators at a suspended sludge concentration of 0.5% by weight. The slurry is retained to allow setting and is then decanted to the waste collector. The sludge fraction is routed to the centrifuges for dewatering and solid waste packaging.

3.5.4.2.3 Radwaste Disposal System for Fuel Pool, Floor Drain and Waste Collector Filter Sludge

The purpose of this system is to collect backwash sludge wastes from the floor drain filter, waste collector filter and fuel pool filter demineralizers. These wastes, which have a solids content of about 0.5% by weight, are drained by gravity to the waste sludge phase separator. The waste sludge phase separator decants the wastes to a solids content of 5% by weight. The resulting decantate is pumped to the floor drain collector tank.

When a predetermined quantity of waste sludge has been accumulated, water is added to it until a solids content of 5% by weight is reached. Then the sludge is pumped to the centrifuges for dewatering.

3.5.4.2.4 Radwaste Disposal System for Spent Resin

The purpose of this system is to collect spent resin from the floor drain, waste collector and distillate polishing demineralizers. These wastes are hydropneumatically transferred to the spent resin tank. The spent resin tank is designed to accept one batch of resins from any of the aforementioned demineralizers plus resin transfer water plus free board. Each batch of the spent resin is transferred, in slurry, to the centrifuges for dewatering.

3.5.4.3 Radwaste Disposal System for Concentrated Solutions

The purpose of this system is to process wastes from the decontamination solution concentrators which are discharged to the concentrator waste tanks. These wastes consist of radioactive chemical wastes, detergent wastes and excess inventory floor drain wastes whose chemical content is too high to permit economical purification by ion exchange. These wastes are concentrated in the decontamination solution concentrator.

The waste solution from the decontamination solution concentrator is blown down with steam to one of two decontamination solution concentrated waste tanks. Each concentrated waste tank is sized to handle half of a batch of concentrated waste solution from each concentrator.

From the concentrated waste tank, the concentrated solution is pumped to the decontamination solution concentrator waste measuring tank. From here, the solution is fed into the solids waste processing system for solidification and disposal. Note that these wastes are not pumped to the centrifuges prior to disposal.

3.5.4.4 Radwaste Solids Handling System

The purpose of this system is to process the waste sludge slurries from the cleanup phase separators, the condensate phase separators, the waste sludge phase separators, the spent resin tank and the concentrated solutions from the decontamination solution concentrator waste measuring tank. The system dewaters the bulk volume of the solid water slurries and prepares the dewatered concentrated waste for off-site shipment in disposable containers. The system also reclaims the water from the wet solid wastes for reuse within the plant. Concentrator waste solutions can be solidified in disposable containers for off-site shipment. In addition, the system has the capability for solidifying all dewatered solid wastes in disposable containers compatible for off-site shipment.

Two processing trains are provided for processing the solid waste slurries. Each processing train consists of a centrifuge, hopper, controls and piping to dewater and concentrate the solid waste slurries. In addition, one processing train contains equipment for solidifying the dewatered solid wastes. This equipment consists of a waste processing pump, static mixer and associated polymer storage tanks, polymer day tank, catalyst tanks and pumps to deliver predetermined amounts of polymer and catalyst for solidification.

Sludge and resin wastes are pumped from the cleanup phase separators, the condensate phase separators, the waste sludge phase separator or the spent resin tank and are reduced in volume by dewatering in either one of the two centrifuges. Water effluent from the centrifuges is transferred to the waste sludge phase separator tank for decanting, reprocessing and reuse in the station. The dewatered solid wastes are discharged from the centrifuges by gravity into their respective hoppers, which are used for filling 50 cubic foot containers for disposal.

If solidification is required, the solidification processing train is used and the hopper is filled to a predetermined level with dewatered solids from the centrifuge. The required amount of water is then added to each hopper.

An empty disposable container is placed on the transfer dolly and the transfer dolly and container are then moved to the filling station underneath the hopper. The hopper discharge valve is opened, which permits the flow of wastes to the waste processing pump. A set of hopper augers forces the wastes into the discharge bin and a conveyor transports the waste to the throat of the pump. The speed of the waste processing pump, polymer processing pump and the amount of catalyst are set to achieve the proper ratio of solids, polymer and catalyst required for proper solidification of the mixture. The processing pumps are started and pump the mixture through the static mixer where the solids, catalyst and polymers are well mixed. Then, the mixture is discharged into a disposable container from the static mixer.

An identical process to the above is used to solidify decontamination solution concentrator wastes. The concentrator waste measuring tank discharges directly to the waste processing pump. The speed of the waste processing pump, polymer processing pump and catalyst processing pump are set to achieve the proper ratio of concentrate, polymer and catalyst required for solidification of the mixture. The processing pumps are started and pump the mixture into the static mixer where mixing occurs; then the mixture is discharged into a disposable container.

Dewatered solid wastes are packaged in 50 cu. ft. disposable containers that meet the requirements established in 49CFR170-178. The containers are brought into the processing area and loaded on the dolly and the dolly is moved to the filling station where dewatered waste is added. The quantity of wastes packaged in the container is measured by a level indicator.

The filled container is moved to the container capping station where it is remotely capped by the operator. After capping, the container is moved to the smear and washdown station and decontaminated prior to being sent to the storage area station.

The storage area is capable of storing up to seventy-two 50 cubic foot containers. High radioactivity containers can be stored for periods of up to, and in excess of, six months to allow for additional decay prior to shipment.

3.5.4.5 Miscellaneous Solid Waste System

Dry waste consists of air filter media, miscellaneous paper, rags, etc. from contaminated areas. It also consists of contaminated clothing, tools and equipment parts which cannot be effectively decontaminated, and solid laboratory wastes. The radioactivity level of much of the waste is low enough to permit direct handling by personnel. These wastes are collected in containers located in appropriate zones around the plant as dictated by the volumes of wastes generated during operation and maintenance. The filled containers are sealed and moved to a controlled access area for temporary storage. Compressible wastes are compacted into 55-gallon steel drums in a hydraulic press-baling machine to reduce their volume.

The compressed solid wastes are stored temporarily near the truck loading area in the radwaste building. Non-compressible solid wastes are packaged manually in similar 55-gallon steel drums. Because of its low radioactivity level, this waste can be stored until enough is accumulated to permit economical transportation to an off-site burial ground for final disposal.

3.5.5 Process and Effluent Monitoring

The locations and elevations of all radioactive release points are shown in Figure 3.1-6.

Table 3.5-24 lists all radioactive effluent monitoring and control points. Indicated are those monitors that automatically terminate effluent discharges upon alarm or those monitors, upon alarm, which automatically actuate standby or alternative treatment systems or which automatically divert streams to holdup tanks.

TABLE 3.5-1

NOBLE GAS CONCENTRATION IN THE REACTOR STEAM

NUMERICAL VALUES - CONCENTRATIONS IN PRINCIPAL FLUID

(μCi/gm)

ISOTOPE	REACTOR STEAM[(a)]
Kr 83 m	1.1 E-3
Kr 85 m	1.9 E-3
Kr 85	6.0 E-6
Kr 87	6.6 E-3
Kr 88	6.6 E-3
Kr 89	4.1 E-2
Kr 90	9.0 E-2
Kr 91	1.1 E-1
Kr 92	1.1 E-1
Kr 93	2.9 E-2
Kr 94	7.2 E-3
Kr 95	6.6 E-4
Kr 97	4.4 E-6
Xe 131 m	4.7 E-6
Xe 133 m	9.0 E-5
Xe 133	2.6 E-3
Xe 135 m	8.4 E-4
Xe 135	7.2 E-3
Xe 137	4.7 E-2
Xe 138	2.8 E-2
Xe 139	9.0 E-2
Xe 140	9.6 E-2
Xe 141	7.8 E-2
Xe 142	2.3 E-2
Xe 143	3.8 E-3
Xe 144	1.8 E-4

(a) The reactor steam concentration is specified at the nozzle where reactor water leaves the reactor vessel; similarly, the reactor steam concentration is specified at time 0. These values are ANSI N237 Table V values multiplied by 0.6 to convert from the 100,000 μCi/sec - 30 minute mixture design basis case to the 60,000 μCi/sec normal operating basis suggested by ANSI N237 and subsequently by NRC Regulatory Guide 1.70.27 references.

TABLE 3.5-2

AVERAGE NOBLE GAS RELEASE[a]

RATES FROM FUEL

ISOTOPE	HALF-LIFE	LEAKAGE RATE AT t = 0 (μCi/s)	LEAKAGE RATE AT t = 30m (μCi/s)
Kr 83 m	1.86 h	2.0 E3	1.7 E3
Kr 85 m	4.4 h	3.4 E3	3.1 E3
Kr 85	10.74 y	1.1 E1	1.1 E1
Kr 87	76. m	1.2 E4	9.1 E3
Kr 88	2.79 h	1.2 E4	1.1 E4
Kr 89	3.18 m	7.4 E4	7.4 E1
Kr 90	32.3 s	1.6 E5	-
Kr 91	8.6 s	2.0 E5	-
Kr 92	1.84 s	2.0 E5	-
Kr 93	1.29 s	5.2 E5	-
Kr 94	1.0 s	1.3 E4	-
Kr 95	0.5 s	1.2 E3	-
Kr 97	1. s	7.9 E0	-
Xe 131 m	11.96 d	8.5 E0	8.4 E0
Xe 133 m	2.26 d	1.6 E2	1.6 E2
Xe 133	5.27 d	4.7 E3	4.7 E3
Xe 135 m	15.7 m	1.5 E3	4.0 E2
Xe 135	9.16 h	1.3 E4	1.3 E4
Xe 137	3.82 m	8.5 E4	3.4 E2
Xe 138	14.2 m	5.0 E4	1.2 E4
Xe 139	4.0 s	1.6 E5	-
Xe 140	13.6 s	1.7 E5	-
Xe 141	1.72 s	1.4 E5	-
Xe 142	1.22 s	4.1 E4	-
Xe 143	.96 s	6.8 E3	-
Xe 144	9. s	3.2 E2	-
	TOTALS	1.4 E6	5.6 E4

(a) NRC Draft Reg. Guide (Ref. 2)

TABLE 3.5-3

CONCENTRATIONS OF HALOGENS IN REACTOR COOLANT AT REACTOR VESSEL EXIT NOZZLES (μCi/gm)[a]

ISOTOPE	REACTOR WATER	REACTOR STEAM
Br 83	3 E-3	6 E-5
Br 84	5 E-3	1 E-4
Br 85	3 E-3	6 E-5
I 131	5 E-3	1 E-4
I 132	3 E-2	6 E-4
I 133	2 E-2	4 E-4
I 134	7 E-2	1 E-4
I 135	2 E-2	4 E-4

(a) Values from ANSI N237 Table 5

TABLE 3.5-4

CONCENTRATIONS OF FISSION PRODUCTS IN REACTOR COOLANT AT REACTOR VESSEL EXIT NOZZLES (μCi/gm)[a]

ISOTOPE	REACTOR WATER	REACTOR STEAM
Rb 89	5 E-3	5 E-6
Sr 89	1 E-4	1 E-7
Sr 90	6 E-6	6 E-9
Sr 91	4 E-3	4 E-6
Sr 92	1 E-2	1 E-5
Y 91	4 E-5	4 E-8
Y 92	6 E-3	6 E-6
Y 93	7 E-6	7 E-9
Zr 95	7 E-6	7 E-9
Zr 97	5 E-6	5 E-9
Nb 95	7 E-6	7 E-9
Nb 98	4 E-3	4 E-6
Mo 99	2 E-3	4 E-6
Tc 99 m	2 E-2	2 E-5
Tc 101	9 E-2	9 E-5
Tc 104	8 E-2	8 E-5
Ru 103	2 E-5	2 E-8
Ru 105	2 E-3	2 E-6
Ru 106	3 E-6	3 E-9
Ag 110 m	1 E-6	1 E-9
Te 129 m	4 E-5	4 E-8
Te 131 m	1 E-4	1 E-7
Te 132	1 E-5	1 E-8
Cs 134	3 E-5	3 E-8
Cs 136	2 E-5	2 E-8
Cs 137	7 E-5	7 E-8
Cs 138	1 E-2	1 E-5
Ba 139	1 E-2	1 E-5
Ba 140	4 E-4	4 E-7
Ba 141	1 E-2	1 E-5
Ba 142	6 E-3	6 E-6
La 142	5 E-3	5 E-6
Ce 141	3 E-5	3 E-8
Ce 143	3 E-5	3 E-8
Ce 144	3 E-6	3 E-9
Pr 143	4 E-5	4 E-8
Nd 147	3 E-6	3 E-9
W 187	3 E-4	3 E-7
Np 239	7 E-3	7 E-6

(a) Values from ANSI N237 Table 5

TABLE 3.5-5

CONCENTRATIONS OF CORROSION PRODUCTS IN REACTOR COOLANT AT REACTOR VESSEL EXIT NOZZLES (μCi/gm)[a]

ISOTOPE	REACTOR WATER	REACTOR STEAM
Na 24	9 E-3	9 E-6
P 32	2 E-4	2 E-7
Cr 51	5 E-3	5 E-6
Mn 54	6 E-5	6 E-8
Mn 56	5 E-2	5 E-5
Fe 55	1 E-3	1 E-6
Fe 59	3 E-5	3 E-8
Co 58	2 E-4	2 E-7
Co 60	4 E-4	4 E-7
Ni 63	1 E-6	1 E-9
Ni 65	3 E-4	3 E-7
Cu 64	3 E-2	3 E-5
Zn 65	2 E-4	2 E-7
Zn 69 m	2 E-3	2 E-6

(a) Values from ANSI N237 Table 5

TABLE 3.5-6

CONCENTRATIONS OF WATER ACTIVATION PRODUCTS IN REACTOR COOLANT AT REACTOR VESSEL EXIT NOZZLES ($\mu Ci/gm$)[a]

ISOTOPE	REACTOR WATER	REACTOR STEAM
N 13	5 E-2	7 E-3
N 16	6 E-1	5 E-1
N 17	9 E-3	2 E-2
O 19	7 E-1	2 E-1
F 18	4 E-3	4 E-3

(a) Values from ANSI N237 Table 5

TABLE 3.5-7

RADIONUCLIDE CONCENTRATIONS IN FUEL POOL[a]

RADIONUCLIDE	RADIONUCLIDE CONCENTRATION $\mu Ci/mL$
I 131	$<1 \times 10^{-6}$
H 3	8.8×10^{-4}
Mn 54	6×10^{-6}
Co 58	1.8×10^{-5}
Co 60	7.4×10^{-5}
Sr 89	2.0×10^{-6}
Sr 90	1.8×10^{-5}
Cs 134	3.1×10^{-4}
Cs 137	7.6×10^{-4}
Ba 140	1.5×10^{-5}

(a) Radiological Surveillance Studies at a Boiling Water Nuclear Power Reactor, BRH/DER 70-1, February 1971.

TABLE 3.5-8

ESTIMATED RELEASES FROM DRYWELL AND REACTOR BUILDING VENTILATION SYSTEMS[(a)]

	REACTOR BUILDING Ci/yr	CONTAINMENT BUILDING Ci/yr
Kr 85 m	3	3
Kr 87	3	3
Kr 88	3	3
Xe 133	66	66
Xe 135 m	46	46
Xe 135	34	34
Xe 138	70	70
I 131	0.17	1.7×10^{-2}
I 133	0.68	6.8×10^{-2}
Cr 51	3×10^{-4}	3×10^{-6}
Mn 54	3×10^{-3}	3×10^{-5}
Fe 59	4×10^{-4}	4×10^{-6}
Co 58	6×10^{-4}	6×10^{-6}
Co 60	1×10^{-2}	1×10^{-4}
Zn 65	2×10^{-3}	2×10^{-5}
Sr 89	9×10^{-5}	9×10^{-7}
Sr 90	5×10^{-6}	5×10^{-8}
Zr 95	4×10^{-4}	4×10^{-6}
Sb 124	2×10^{-4}	2×10^{-6}
Cs 134	4×10^{-3}	4×10^{-5}
Cs 136	3×10^{-4}	3×10^{-6}
Cs 137	5×10^{-3}	5×10^{-5}
Ba 140	4×10^{-4}	4×10^{-6}
Ce 141	1×10^{-4}	1×10^{-6}

(a) Based on NRC GALE Code (Ref. 2)

TABLE 3.5-9

ESTIMATED RELEASES FROM TURBINE BUILDING VENTILATION[a]

	Ci/yr
Kr 85 m	68
Kr 87	190
Kr 88	230
Xe 133	280
Xe 135 m	650
Xe 135	630
Xe 138	1400
I 131	0.19
I 133	0.76
Cr 51	1.3×10^{-2}
Mn 54	6×10^{-4}
Fe 59	5×10^{-4}
Co 58	6×10^{-4}
Co 60	2×10^{-3}
Zn 65	2×10^{-4}
Sr 89	6×10^{-3}
Sr 90	2×10^{-5}
Zr 95	1×10^{-4}
Sb 124	3×10^{-4}
Cs 134	3×10^{-4}
Cs 136	5×10^{-5}
Cs 137	6×10^{-4}
Ba 140	1.1×10^{-2}
Ce 141	6×10^{-4}

(a) Based on NRC GALE Code (Ref. 2)

TABLE 3.5-10

ESTIMATED RELEASES FROM RADWASTE BUILDING[a]

	Ci/yr
Xe 133	10
Xe 135	45
I 131	5.0×10^{-2}
I 133	1.8×10^{-1}
Cr 51	9.0×10^{-5}
Mn 54	4.5×10^{-4}
Fe 59	1.5×10^{-4}
Co 58	4.5×10^{-5}
Co 60	9.0×10^{-4}
Zn 65	1.5×10^{-5}
Sr 89	4.5×10^{-6}
Sr 90	3.0×10^{-6}
Zr 95	5.0×10^{-7}
Sb 124	5.0×10^{-7}
Cs 134	4.5×10^{-5}
Cs 136	4.5×10^{-6}
Cs 137	9.0×10^{-5}
Ba 140	1.0×10^{-6}
Ce 141	6.0×10^{-5}

(a) Based on NRC GALE Code (Ref. 2)

TABLE 3.5-11

ESTIMATED RELEASES FROM MECHANICAL VACUUM PUMP[a]

	Ci/yr
Xe 133	2300
Xe 135	350
I 131	3×10^{-2}
Cs 134	3×10^{-6}
Cs 136	2×10^{-6}
Cs 137	1×10^{-5}
Ba 140	1.1×10^{-5}

(a) Based on NRC GALE Code (Ref. 2)

TABLE 3.5-12

ANNUAL RELEASES OF RADIOACTIVE MATERIAL AS LIQUID

	NUCLIDE	HALF-LIFE (DAYS)	CONCENTRATION IN PRIMARY COOLANT (MICRO CI/ML)	HIGH PURITY (CURIES)	LOW PURITY (CURIES)	TOTAL LWS (CURIES)	ADJUSTED TOTAL (CI/YR)*	TOTAL (CI/YR)
	CORROSION AND ACTIVATION PRODUCTS							
	NA 24	6.25E-01	8.38E-03	0.00034	0.00041	0.00075	0.00656	0.00660
	P 32	1.43E 01	1.96E-04	0.00001	0.00002	0.00003	0.00026	0.00026
1	CR 51	2.78E 01	4.90E-03	0.00026	0.00050	0.00077	0.00671	0.00670
	MN 54	3.03E 02	5.89E-05	0.00000	0.00001	0.00001	0.00008	0.00008
	MN 56	1.07E-01	4.08E-02	0.00050	0.00032	0.00081	0.00712	0.00710
	FE 55	9.50E 02	9.82E-04	0.00005	0.00010	0.00016	0.00136	0.00140
1	FE 59	4.50E 01	2.94E-05	0.00000	0.00000	0.00000	0.00004	0.00004
	CO 58	7.13E 01	1.96E-04	0.00001	0.00002	0.00003	0.00027	0.00027
	CO 60	1.92E 03	3.93E-04	0.00002	0.00004	0.00006	0.00055	0.00055
	NI 65	1.07E-01	2.45E-04	0.00000	0.00000	0.00000	0.00004	0.00004
	CU 64	5.33E-01	2.77E-02	0.00106	0.00122	0.00228	0.02000	0.02000
1	ZN 65	2.45E 02	1.96E-04	0.00001	0.00002	0.00003	0.00027	0.00027
	ZN 69M	5.75E-01	1.85E-03	0.00007	0.00009	0.00016	0.00139	0.00140
	ZN 69	3.96E-02	0.0	0.00008	0.00009	0.00017	0.00146	0.00150
	W 187	9.96E-01	2.84E-04	0.00001	0.00002	0.00003	0.00027	0.00027
	NP 239	2.35E-00	6.77E-03	0.00034	0.00057	0.00090	0.00792	0.00790
	FISSION PRODUCTS							
	BR 83	1.00E-01	2.31E-03	0.00003	0.00002	0.00004	0.00037	0.00037
	BR 84	2.21E-02	3.50E-03	0.00000	0.00000	0.00000	0.00003	0.00003
	RB 89	1.07E-02	3.43E-03	0.00001	0.00002	0.00002	0.00021	0.00021
1	SR 89	5.20E 01	9.81E-05	0.00001	0.00001	0.00002	0.00014	0.00014
	SR 91	4.03E-01	3.64E-03	0.00012	0.00013	0.00025	0.00222	0.00220
	Y 91M	3.47E-02	0.0	0.00008	0.00008	0.00016	0.00139	0.00140
1	Y 91	5.88E 01	3.93E-05	0.00000	0.00001	0.00001	0.00007	0.00007
	SR 92	1.13E-01	8.20E-03	0.00011	0.00007	0.00017	0.00152	0.00150

TABLE 3.5-12 (Cont'd)

	NUCLIDE	HALF-LIFE (DAYS)	CONCENTRATION IN PRIMARY COOLANT (MICRO CI/ML)	HIGH PURITY (CURIES)	LOW PURITY (CURIES)	TOTAL LWS (CURIES)	ADJUSTED TOTAL (CI/YR)*	TOTAL (CI/YR)
	Y 92	1.47E-01	5.04E-03	0.00020	0.00015	0.00036	0.00313	0.00310
	Y 93	4.25E-01	3.65E-03	0.00013	0.00013	0.00026	0.00230	0.00230
	NB 98	3.54E-02	2.96E-03	0.00001	0.00000	0.00001	0.00008	0.00008
	MO 99	2.79E-00	1.94E-03	0.00010	0.00017	0.00027	0.00233	0.00230
	TC 99M	2.50E-01	1.76E-02	0.00051	0.00051	0.00102	0.00893	0.00890
	TC101	9.72E-03	6.25E-02	0.00000	0.00000	0.00000	0.00002	0.00002
	RU103	3.96E+01	1.96E-05	0.00000	0.00000	0.00000	0.00003	0.00003
2	RH103M	3.96E-02	0.0	0.00000	0.00000	0.00000	0.00003	0.00003
	TC104	1.25E-02	5.60E-02	0.00000	0.00000	0.00001	0.00006	0.00006
	RU105	1.85E-01	1.72E-03	0.00004	0.00003	0.00006	0.00055	0.00055
	RH105M	5.21E-04	0.0	0.00004	0.00003	0.00006	0.00056	0.00056
1	RH105	1.50E 00	0.0	0.00001	0.00001	0.00002	0.00018	0.00018
	TE129M	3.40E 01	3.92E-05	0.00000	0.00000	0.00001	0.00005	0.00005
	TE129	4.79E-02	0.0	0.00000	0.00000	0.00000	0.00003	0.00003
1	TE131M	1.25E 00	9.54E-05	0.00000	0.00001	0.00001	0.00010	0.00010
	TE131	1.74E-02	0.0	0.00000	0.00000	0.00000	0.00002	0.00002
1	I131	8.05E 00	4.87E-03	0.00026	0.00047	0.00073	0.00643	0.00640
	TE132	3.25E 00	9.71E-06	0.00000	0.00000	0.00000	0.00001	0.00001
	I132	9.58E-02	2.30E-02	0.00024	0.00015	0.00039	0.00345	0.00350
	I133	8.75E-01	1.84E-02	0.00080	0.00110	0.00190	0.01667	0.01700
	I134	3.67E-02	5.01E-02	0.00010	0.00006	0.00016	0.00144	0.00140
1	CS134	7.49E 02	2.95E-05	0.00008	0.00077	0.00085	0.00741	0.00740
	I135	2.79E-01	1.69E-02	0.00048	0.00042	0.00090	0.00788	0.00790
1	CS136	1.30E 01	1.95E-05	0.00005	0.00049	0.00054	0.00473	0.00470
	CS137	1.10E 04	6.87E-05	0.00019	0.00179	0.00197	0.01730	0.01700
	BA137M	1.77E-03	0.0	0.00017	0.00167	0.00184	0.01618	0.01600
	CS138	2.24E-02	7.00E-03	0.00021	0.00062	0.00083	0.00724	0.00720
	BA139	5.76E-02	7.71E-03	0.00004	0.00002	0.00006	0.00053	0.00053
1	BA140	1.28E 01	3.92E-04	0.00002	0.00004	0.00006	0.00053	0.00053
	LA140	1.67E-00	0.0	0.00000	0.00001	0.00001	0.00011	0.00011
	LA141	1.62E-01	0.0	0.00001	0.00001	0.00002	0.00017	0.00017
1	CE141	3.24E 01	2.94E-03	0.00000	0.00000	0.00000	0.00004	0.00004

TABLE 3.5-12 (Cont'd)

NUCLIDE	HALF-LIFE (DAYS)	CONCENTRATION IN PRIMARY COOLANT (MICRO CI/ML)	HIGH PURITY (CURIES)	LOW PURITY (CURIES)	TOTAL LWS (CURIES)	ADJUSTED TOTAL (CI/YR)*	TOTAL (CI/YR)
LA142	6.39E-02	3.89E-03	0.00003	0.00002	0.00004	0.00036	0.00036
CE143	1.38E 00	2.87E-05	0.00000	0.00000	0.00000	0.00003	0.00003
PR143	1.37E 01	3.92E-05	0.00000	0.00000	0.00001	0.00005	0.00005
ALL OTHERS		1.32E-02	0.00000	0.00000	0.00001	0.00007	0.00007
TOTAL (EXCEPT TRITIUM)		4.11E-01	0.00685	0.01246	0.01931	0.16931	0.17000

TRITIUM RELEASE - - - 12 Curies per year -

*Adjusted total includes an additional 0.15 ci/yr with the same isotopic distribution as the calculated source term to account for anticipated occurrences such as operator errors resulting in unplanned releases.

TABLE 3.5-13

RADWASTE OPERATING EQUIPMENT DESIGN BASIS

EQUIPMENT	DESIGN BASIS DECONTAMINATION FACTOR
Deep Bed Demineralizers	
Conductivity	20
Radioactivity	Soluble 100 Insoluble 50
Precoat Filters	
Suspended Solids	Equipment Drains 20 Floor Drains 100
Radioactivity	Soluble 1 Insoluble 2
Evaporators	
Concentration (Input/Bottom)	2/25
Radioactivity	1000

TABLE 3.5-14

RADWASTE SYSTEM

PROCESS FLOW DIAGRAM DATA

(sheet 1 of 11)

EQUIPMENT DRAIN SUBSYSTEM

Flow Path	1	2	3	4	5	6
Batches/Day (Normal)	8.5	4.1	1.1	6.3	1.0/3.4	4.0/7.4
Batches/Day (Maximum)	63.4	15.8	1.1	6.3	1.0	4.0/2.0
Volume/Batch (gal)	455	909	909	909	2430	13,500
Normal Daily Volume (gal)	3,860	3,755	1,000	5,725	-	-
Normal Activity (uCi/cc)	4.92E-2	1.24E-2	6.84E-5	1.82E-5	1.52E-2	6.84E-6
Max. Daily Volume (gal)	28,800	14,400	1,000	5,725	2,430	27,000
Max. Activity (uCi/cc)	1.72E-0	4.32E-1	2.39E-3	1.26E-2	5.32E-1	3.59E-4
Flow Rate (gal/min)	50	50	50	50	50	450
Daily Activity (uCi/day)						
Normal	7.19E5	1.76E5	2.59E2	3.94E2	-	-
Maximum	2.51E7	6.14E6	9.05E3	2.73E5	4.89E6	3.67E4

See page 9 of Table for notes, definitions and explanation of entries.

TABLE 3.5-14

(sheet 2 of 11)

EQUIPMENT DRAIN SUBSYSTEM (Cont.)

Flow Path △	8	9	33	12	14
Batches/Day (Normal)	1.0/30.0	1.0	1.0	1.0	1.0
Batches/Day (Maximum)	1.0/30.0	7.0	7.0	7.0	7.0
Volume/Batch (gal)	11,250	15,000	15,000	15,000	15,000
Normal Daily Volume (gal)	-	15,000	15,000	15,000	15,000
Normal Activity (uCi/cc)	8.79E-7	1.11E-2	5.54E-3	1.11E-4	1.11E-4
Max. Daily Volume (gal)	11,250	104,825	104,825	104,825	104,825
Max. Activity (uCi/cc)	3.08E-5	3.59E-1	3.53E-1	3.53E-3	3.53E-3
Flow Rate (gal/min)	Batch	190	190	190	190
Daily Activity (uCi/day)					
Normal	-	6.28E5	3.12E5	6.28E3	6.28E3
Maximum	1.31E3	4.9E7	4.82E7	4.82E5	4.82E5

TABLE 3.5-14

(sheet 3 of 11)

FLOOR DRAIN SUBSYSTEM

Flow Path △	17	18	19	20	21
Batches/Day (Normal)	1.5	2.2	1.1	2.2	.3
Batches/Day (Maximum)	63.4	16.5	1.1	2.2	1.3
Volume/Batch (gal)	455	909	909	909	19,305
Normal Daily Volume (gal)	700	2,000	1,000	2,000	6,615
Normal Activity (uCi/cc)	6.84E-6	1.00E-6	1.37E-5	6.84E-7	9.53E-5
Maximum Daily Volume (gal)	28,800	12,000	1,000	2,000	52,062
Maximum Activity (uCi/cc)	6.84E-2	1.00E-3	4.78E-4	2.39E-5	1.08E-2
Flow Rate (gal/min)	50	100	50	50	190
Daily Activity (uCi/Day)					
Normal	1.81E1	7.57E0	5.18E1	5.18E0	2.39E3
Maximum	1.81E5	7.57E3	1.61E3	1.81E3	5.40E5

TABLE 3.5-14

(sheet 4 of 11)

FLOOR DRAIN SUBSYSTEM (Cont.)

Flow Path	23	107	108
Batches/Day (Normal)	.3	.3	.3
Batches/Day (Maximum)	1.3	1.3	1.3
Volume/Batch (gal)	19,305	19,305	19,305
Normal Daily Volume (gal)	6,615	6,615	6,615
Normal Activity (uCi/cc)	4.76E-5	9.53E-7	9.53E-7
Maximum Daily Volume (gal)	52,062	52,062	52,062
Maximum Activity (uCi/cc)	1.08E-2	1.08E-4	1.08E-4
Flow Rate (gal/min)	190	190	190
Daily Activity (uCi/Day)			
Normal	1.19E3	2.39E1	2.34E1
Maximum	5.40E5	5.40E3	5.40E3

TABLE 3.5-14

(sheet 5 of 11)

WASTE SURGE SUBSYSTEM

Flow Path △	104	37
Batches/Day (Normal)	1.0/yr	1.0/yr
Batches/Day (Maximum)	1.0	1.0
Volume/Batch (gal)	56,720	56,720
Normal Daily Volume (gal)	-	-
Normal Activity (uCi/cc)	6.84E-6	6.84E-6
Maximum Daily Volume (gal)	56,720	56,720
Maximum Activity (uCi/cc)	3,59E-4	3.59E-4
Flow Rate (gal/min)	Batch	190

TABLE 3.5-14

(sheet 6 of 11)

CHEMICAL WASTE SUBSYSTEM

Flow Path	27	109	120	121	122
Batches/Day (Normal)	1.0	-	-	-	-
Batches/Day (Maximum)	2.0	1.0	1.0	1.0	3.0
Volume/Batch (gal)	1,000	24,305	24,305	760	230
Normal Daily Volume (gal)	1,000	-	-	-	-
Normal Activity (uCi/cc)	1.0E-5	2.63E-3	2.58E-3	1.45E-2	1.45E-2
Maximum Daily Volume (gal)	2,000	24,305	24,305	760	760
Maximum Activity (uCi/cc)	1.0E-5		2.67E-3	1.50E-2	1.50E-2
Flow Rate (gal/min)	25	190	10	Batch	30

TABLE 3.5-15

(sheet 7 of 11)

WASTE SLUDGE SUBSYSTEM (Condensate Backwash)

Flow Path △	56	58	60	6
Batches/Day (Normal)	4.0/7.4	4.0/7.4	1/18.5	4/7.4
Batches/Day (Maximum)	4.0	4.0	1	4.0
Volume/Batch Solids (lbs)	330	330	3300	-
Liquids (gal)	13,500	13,500	7527	13,500
Normal Daily Volume (gal)	13,500	13,500		
Normal Activity Solids (uCi/Batch)	2.10E6	2.10E6	1.20E7	-
Liquids (uCi/cc)	6.84E-6	6.84E-6	6.84E-6	6.84E-6
Maximum Daily Volume (gal)	54,000	54,000	7527	27,000
Maximum Activity Solids (uCi/Batch)	5.26E7	5.26E7	2.67E7	
Liquids (uCi/cc)	3.59E-4	3.59E-4	3.59E-4	3.59E-4
Flow Rate (gal/min)	2,500	450	20	450

TABLE 3.5-14

(sheet 8 of 11)

WASTE SLUDGE SUBSYSTEM (Radwaste Filter Backwash)

Flow Path △	61	63	62	7	65
Batches/Day (Normal)	1.0	1.0/3.4	1.0/5.2	-	1.0/3.4
Batches/Day (Maximum)	2.9	1.0	1.0/5.2	1.0	1.1
Volume/Batch Solids (lbs)	41.36	41.36	59.4	-	219
Liquids (gal)	1692	1692	2430	28,800	527
Normal Daily Volume (gal)	1692	-	-	-	-
Normal Activity Solids (uCi/Batch)	3.15E4	8.03E1	1.40E4		4.64E4
Liquids (uCi/cc)	6.84E-6	6.84E-6	6.84E-6	varies	6.84E-6
Maximum Daily Volume (gal)	4906	1692	-	28,800	527
Maximum Activity Solids (uCi/Batch)	3.15E4	8.03E1	1.41E6	-	7.33E5
Liquids (uCi/cc)	3.59E-4	3.59E-4	3.59E-4	varies	9.88E-4
Flow Rate (gal/min)	376	376	540	20	20

TABLE 3.5-14

(sheet 9 of 11)

WASTE SLUDGE SUBSYSTEM (Cleanup Backwash)

		54	59	5
Flow Path △				
Batches/Day (Normal)		2.0/3.4	1.0/60	2.0/3.4
Batches/Day (Maximum)		2.0	1.0/60	2.0
Volume/Batch	Solids (lbs)	29.7	1048	-
	Liquids (gal)	1215	2391	-
Normal Daily	Volume (gal)	1215		1215
	Solids (uCi/Batch)	2.43E7	2.25E8	
Normal Activity		1.52E-2	1.52E-2	1.52E-2
Maximum Daily Volume (gal)		2430	2391	2430
Maximum Activity	Solids (uCi/Batch)	7.68E8	3.59E8	
	Liquids (uCi/gal)	5.33E-1	5.53E-1	5.33E-1
Flow Rate (gal/min)		270	20	53

TABLE 3.5-14

(sheet 10 of 11)

WASTE SLUDGE SUBSYSTEM (Spent Resin)

Flow Path △	64	119	69	71
Batches/Day (Normal)	1.0/66	1.0/67	1.0/25	
Batches/Day (Maximum)	1.0/29	1.0/49	1.0/22	
Volume/Batch Solids (lbs)	1539	1539	1863	1539
Liquids (gal)	746	746	930	3210
Normal Activity Solids (uCi/Batch)	2.28E6	5.86E3	1.56E2	-
Liquids (uCi/gal)	6.84E-6	6.84E-6	6.84E-6	6.84E-6
Maximum Activity Solids (uCi/Batch)	2.74E7	2.34E5	1.72E2	-
Liquids (uCi/gal)	3.59E-4	3.59E-4	3.59E-4	3.59E-4
Flow Rate (gal/min)	37	37	47	20

TABLE 3.5-14

(sheet 11 of 11)

NOTES:

a. The following definitions are used for this data:

Normal Volume - Expected flow during steady state normal operation.
Maximum Volume - Maximum expected flow during unsteady state operation such as startup, shutdown, etc.
Normal Activity - Activity level expected during operation with no fuel leaks and corrosion product reactor water activity concentration of 0.1 uCi/cc.
Maximum Activity - Activity level expected during operation with fuel leak rate equivalent to reactor water activity concentration of 2.3 uCi/cc and total noble gas stock release rate of 100,000 uCi/sec (corrosion and fission products present).
Maximum volume and maximum activity are not necessarily concurrent.

b. For Activity Values: E-1 = number x 10^{-1}; E1 = number x 10^{1}
E-4 = number x 10^{-4}; E4 = number x 10^{4}

c. Fractional values on tables denote the number of items per occurrence divided by the number of days between each occurrence (i.e., 1/30 batches/day means one batch processed every 30 days).

d. Waste system input activities are based on a reactor water-to-steam decontamination factor of 1.OE-3.

TABLE 3.5-15

EQUIPMENT DRAIN SUBSYSTEM SOURCES

Source	Startup Flows (GPD)	Regular Daily Flows (GPD)	Irregular Flows (GPD)	Maximum Flows (GPD)
Equipment Drains				
Drywell	3,800	3,800		28,800
Reactor Bldg.	3,800	3,800		14,400
Turbine Bldg.	5,700	5,700		5,700
Radwaste Bldg.	1,000	1,000		1,000
Reactor Hydrotest & Thermal Expansion Water	56,700	0		0
Suppression Pool Drain	11,300	0	11,300 (4)	0
RHR System Flush Water			4,000 (5)	0
Condensate Demin. Backwash	27,000		13,500 (1)	40,500 (3)
Cleanup Demin. Backwash	2,400		2,400 (2)	
Water Inleakage to Condenser	0	0		14,400
	111,700	14,300		104,800

1. Under normal operating conditions, one condensate filter demineralizer would be precoated every four days.

2. Under normal operating conditions, each cleanup demineralizer would be precoated every 3.4 days.

3. The maximum daily flow is based on a condenser inleakage of 10 gpm, which corresponds to two condensate demineralizer precoats daily and maximum leak and drain inflows. Higher condenser inleakage rates can be accommodated up to a maximum of 36 gpm. This requires precoating of one condensate demineralizer every three hours. This leakage rate would result in overloading the equipment drain subsystem but could be tolerated for short periods of time during location and repair of the leak.

TABLE 3.5-15 (Cont'd)

4. Once every thirty days during testing of reactor emergency core coolant systems.

5. Occurs every shutdown prior to placing the RHR system in operation for shutdown cooling.

TABLE 3.5-16

FLOOR DRAIN SUBSYSTEM SOURCES

Source	Regular Daily Flows (GPD)	Irregular Flows (GPD)	Maximum Daily Flows (GPD)
Floor Drains			
Drywell	700		7,200
Reactor Building	2,000		12,000
Radwaste Building	1,000		1,000
Turbine Building	2,000		2,000
Waste Sludge Phase Separator Decant	0	8,400[(1)]	8,400
	5,700	8,400	31,200

(1) Under normal operating conditions, the waste sludge phase separator tank is decanted every 3.4 days.

TABLE 3.5-17

CHEMICAL WASTE SUBSYSTEM SOURCES

Source	Regular Daily Flows (GPD)	Irregular Flows (GPD)	Maximum Daily Flows (GPD)
Detergent Drains/Shop			
Decontamination Solutions	1,000		2,000
Laboratory Drains	400		400
Decontamination			
Drains Reactor &			
Turbine Buildings		1,000	1,000
From Floor Drain or			
Equipment Drain			
Subsystem		20,000	20,000
Filter Demineralizer			
Chemical Cleaning		Infrequent	2,000
Solutions		2,000	
Battery Room Drains		Infrequent	100
		100	
Chemical System Overflow		Infrequent	
& Tank Drains			
	1,400		25,000

TABLE 3.5-18

OFF-GAS SYSTEM PROCESS DATA

The information contained in this table is proprietary and will be transmitted separately with other FSAR proprietary information as Sheet 761E918AD.

TABLE 3.5-19

RELEASE POINT DATA

	Reactor Bldg	Radwaste Bldg	Turbine Bldg
Height of release point above grade	230'-8"	65'	107'
Annual average total air flow from release point	95,000	82,000	261,000 cfm
Annual average heat content flow from release point	15.09×10^6	41.46×10^6	13.02×10^6 BTU/Hr
Type and size of release point	DUCT 45" x 120"	3 LOUVER HOUSES 54" x 96" x 30"	4 DUCTS 57" x 79"

TABLE 3.5-20

NOBLE GAS RELEASE RATE

INTO ATMOSPHERE FROM OFF-GAS SYSTEM

Isotope	Avg. Release Rate (Ci/yr)
Kr 85 m	2
Kr 85	270
Xe 131 m	5
Xe 133	22
Total	299

TABLE 3.5-21

ESTIMATED ANNUAL AVERAGE RELEASES OF RADIOACTIVE MATERIALS

FROM BUILDING VENTILATION SYSTEMS, GLAND SEAL AND MECHANICAL VACUUM PUMPS

		GASEOUS RELEASE RATE (CURIES PER YEAR)					
NUCLIDE	COOLANT CONC. (MICROCURIES/G)	DRYWELL	TURBINE BLDG	REACTOR BLDG	RADWASTE BLDG	GLAND SEAL	MECH VAC PUMP
Kr 83 m	1.100E-03	0.0	0.0	0.0	0.0	0.0	0.0
Kr 85 m	1.900E-03	3.0E 00	6.8E 01	3.0E 00	0.0	0.0	0.0
Kr 85	6.000E-06	0.0	0.0	0.0	0.0	0.0	0.0
Kr 87	6.600E-03	3.0E 00	1.9E 02	3.0E 00	0.0	0.0	0.0
Kr 88	6.600E-03	3.0E 00	2.3E 02	3.0E 00	0.0	0.0	0.0
Kr 89	4.100E-02	0.0	0.0	0.0	0.0	0.0	0.0
Xe 131 m	4.700E-06	0.0	0.0	0.0	0.0	0.0	0.0
Xe 133 m	9.000E-05	0.0	0.0	0.0	0.0	0.0	0.0
Xe 133	2.600E-03	6.6E 01	2.8E 02	6.6E 01	1.0E 01	0.0	2.3E 03
Xe 135 m	8.400E-04	4.6E 01	6.5E 02	4.6E 01	0.0	0.0	0.0
Xe 135	7.200E-03	3.4E 01	6.3E 02	3.4E 01	4.5E 01	0.0	3.5E 02
Xe 137	4.700E-02	0.0	0.0	0.0	0.0	0.0	0.0
Xe 138	2.800E-02	7.0E 00	1.4E 03	7.0E 00	0.0	0.0	0.0
Total Noble Gases							
I 131	3.449E-03	1.7E-02	1.9E-01	1.7E-01	5.0E-02	0.0	3.0E-02
I 133	1.477E-02	6.8E-02	7.6E-01	6.8E-01	1.8E-01	0.0	0.0
Tritium Gaseous Release			68 Curies/Yr				

"0.0" Appearing in the table indicates release is less than 1.0 Ci/Yr for noble gas and less than 0.0001 Ci/Yr for Iodine.

TABLE 3.5-21 (Cont'd)

ESTIMATED ANNUAL AVERAGE RELEASES OF RADIOACTIVE MATERIALS

FROM BUILDING VENTILATION SYSTEMS, GLAND SEAL AND MECHANICAL VACUUM PUMPS

	AIRBORNE PARTICULATE RELEASE RATE (CURIES PER YEAR)				
NUCLIDE	CONTAINMENT BLDG	TURBINE BLDG	REACTOR BLDG	RADWASTE BLDG	MECH VAC PUMP
Cr 51	3.0E-06	1.3E-02	3.0E-04	9.0E-05	0.0
Mn 54	3.0E-05	6.0E-04	3.0E-03	4.5E-04	0.0
Fe 59	4.0E-06	5.0E-04	4.0E-04	1.5E-04	0.0
Co 58	6.0E-06	6.0E-04	6.0E-04	4.5E-05	0.0
Co 60	1.0E-04	2.0E-03	1.0E-02	9.0E-04	0.0
Zn 65	2.0E-05	2.0E-04	2.0E-03	1.5E-05	0.0
Sr 89	9.0E-07	6.0E-03	9.0E-05	4.5E-06	0.0
Sr 90	5.0E-08	2.0E-05	5.0E-06	3.0E-06	0.0
Zr 95	4.0E-06	1.0E-04	4.0E-04	5.0E-07	0.0
Sb 124	2.0E-06	3.0E-04	2.0E-04	5.0E-07	0.0
Cs 134	4.0E-05	3.0E-04	4.0E-03	4.5E-05	3.0E-06
Cs 136	3.0E-06	5.0E-05	3.0E-04	4.5E-06	2.0E-06
Cs 137	5.5E-05	6.0E-04	5.5E-03	9.0E-05	1.0E-05
Ba 140	4.0E-06	1.1E-02	4.0E-04	1.0E-06	1.1E-05
Ce 141	1.0E-06	6.0E-04	1.0E-04	6.0E-05	0.0

TABLE 3.5-22

EXPECTED ANNUAL PRODUCTION OF SOLIDS

	50 Ft^3 *Containers/yr	Normal Activity μCi/Container	Maximum Activity μCi/Container
Cleanup Filter Demineralizer Sludge	10	1.39×10^8	2.23×10^8
Condensate Filter Demineralizer Sludge	100	2.47×10^6	5.5×10^6
Waste, Floor Drain & Fuel Pool Filter Demineralizer Sludge	36	1.37×10^5	2.16×10^6
Distillate Demineralizer Resin	26	$.96 \times 10^2$	1.05×10^2
Waste Demineralizer Resin	7	1.78×10^6	2.14×10^7
Floor Drain Demineralizer Resin	7	4.56×10^3	1.82×10^5
Concentrated Waste Solution	11	2.05×10^4	2.12×10^4

*50 cubic foot containers

TABLE 3.5-23

SIGNIFICANT ISOTOPE ACTIVITY ON WET SOLIDS AFTER PROCESSING

Stream	Clean Up Sludge	Waste Sludge	Distillate Resin	Waste Resin	Floor Drain Resin	Condensate Sludge	Concentrated Waste
Batch Solid Production	1048 lbs/ 60 days	219 lbs/ 3.4 days	1863 lbs/ 25 days	1539 lbs/ 66 days	1539 lbs/ 67 days	3300 lbs/ 18.5 days	690 lbs/ 3 days
Isotopes			Ci/50 Cubic Foot Container				
Mo 99	----	0.3	5.3×10^{-6}	1.07	9.1×10^{-3}	----	1.3×10^{-3}
Sr 89	40	0.15	1.1×10^{-5}	2.14	1.8×10^{-2}	1.16	1.1×10^{-3}
Sr 90	11	0.015	1.1×10^{-6}	0.21	1.8×10^{-3}	0.11	8.5×10^{-5}
Cs 134	6.7	0.006	5.3×10^{-7}	0.11	9.1×10^{-4}	0.11	6.4×10^{-5}
Cs 137	11	0.015	1.1×10^{-6}	0.21	1.8×10^{-3}	0.17	8.5×10^{-5}
Ba 140	4.5	0.35	1.1×10^{-5}	2.14	1.8×10^{-2}	0.66	2.3×10^{-3}
Np 239	----	----	5.1×10^{-5}	10.3	8.7×20^{-2}	----	1.1×10^{-2}
I 131	0.67	0.76	1.1×10^{-5}	2.14	1.8×10^{-2}	0.44	2.5×10^{-3}
I 133	----	0.39	3.2×10^{-6}	0.64	5.5×10^{-3}	----	----
Co 58	116	0.15	1.6×10^{-5}	2.14	1.8×10^{-2}	2.26	1.9×10^{-3}
Co 60	29	0.015	1.6×10^{-6}	0.21	1.8×10^{-3}	0.44	2.1×10^{-4}
Cr 51	4.5	0.015	1.6×10^{-6}	0.11	9.1×10^{-4}	0.17	2.1×10^{-4}

TABLE 3.5-24

SUMMARY OF RADIOACTIVE EFFLUENT

MONITORING AND CONTROL POINTS

RELEASE POINT	LOCATION OF DETECTOR OR SAMPLE PROBE	TYPE OF MONITOR	ALARM OR SHUTDOWN FUNCTION	RELEASE POINT AS SHOWN ON FIG 3.1-6	REMARKS
Reactor Bldg. Vent Stack	Probe at Elev. 650' In Stack	Continuous Noble Gas Detector (Gamma), Iodine and Particulate Sampler Cartridge	High Radiation Alarm	1	Effluent Monitor
"	Probe in Off-Gas Line from Outlet of Charcoal Adsorbers to Reactor Bldg. Vent Stack	Dual Continuous Noble Gas Detector GM Tubes (Gamma), Iodine and Particulate Sampler Cartridge	High Radiation Alarm Automatically Isolates Off-Gas from Vent Stack		Process Monitor D17-5011
"	Detector in Line from (Condenser) Mechanical Vacuum Pumps to Vent Stack	Continuous GM Tube (Gamma) Detector	High Radiation Alarm, Automatically Shuts Down Vacuum Pumps and Gland Seal Exhauster		Process Monitor RE-21
"	Four (4) Detectors in Reactor Bldg. Ventilation Exhaust Plenum (Discharge to Vent Stack)	Continuous GM Tube (Gamma) Detector	High Radiation Alarm, Automatically Trips Valves to Isolate HVAC Exhaust from Vent Stack, Closes Containment Vent Valves and Initiates Standby Gas Treatment System		HVAC Monitor D17-N009A, B, C, D

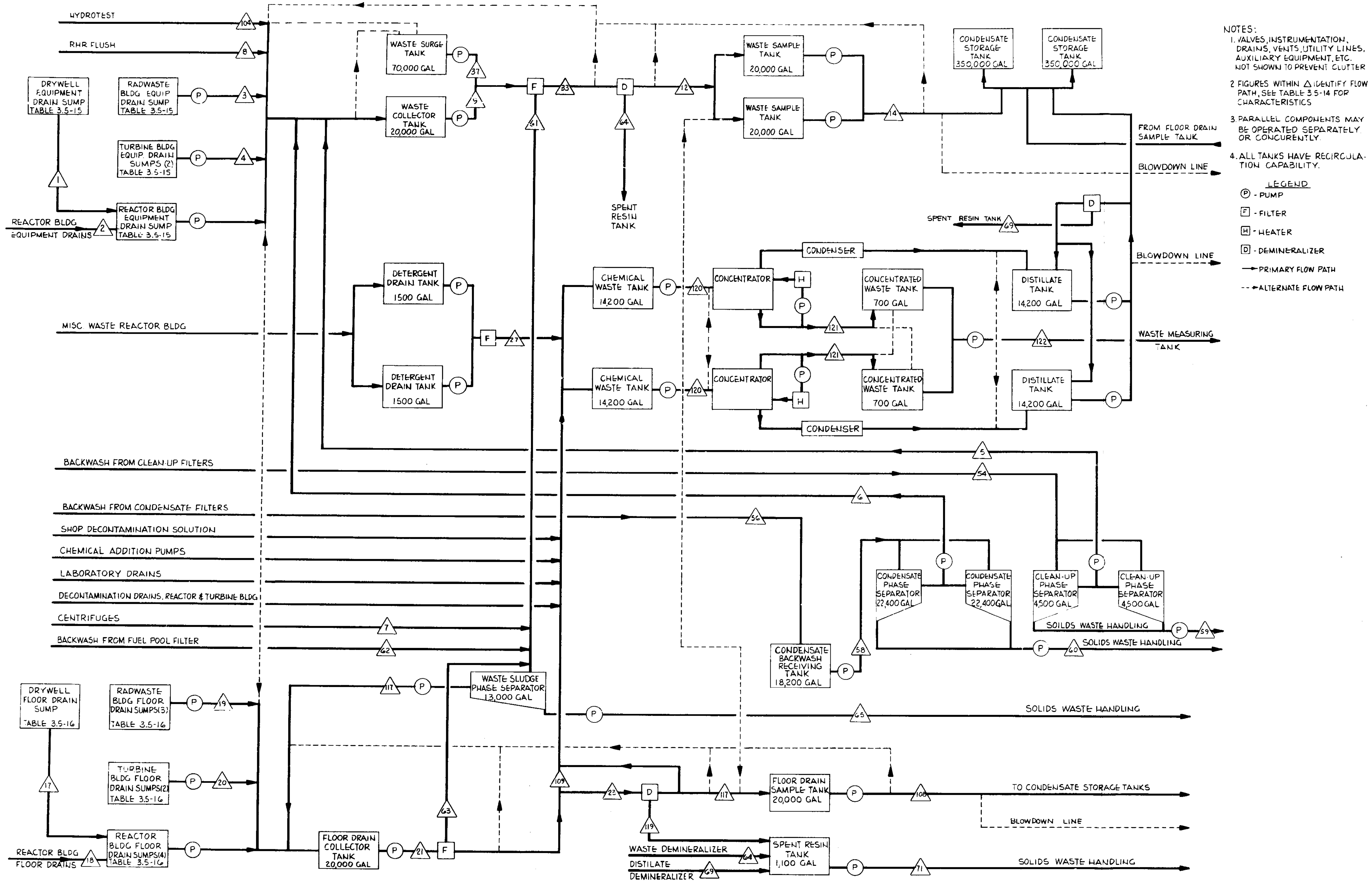
TABLE 3.5-24 (Cont'd)

SUMMARY OF RADIOACTIVE EFFLUENT

MONITORING AND CONTROL POINTS

RELEASE POINT	LOCATION OF DETECTOR OR SAMPLE PROBE	TYPE OF MONITOR	ALARM OR SHUTDOWN FUNCTION	RELEASE POINT AS SHOWN ON FIG 3.1-6	REMARKS
Turbine Bldg. HVAC Exhaust	Probe at Elev. 551' In Duct Bet. Col. 11 & 12 7'-6" North of Col. K	Continuous Noble Gas Detector (Gamma), Iodine and Particulate Sampler Cartridge	High Radiation Alarm	3 4 5 6	Effluent Monitor
Radwaste Bldg. (HVAC Exhaust) Vent	Probes in Bldg. (HVAC Exhaust) Vent Fan Discharges	Continuous Noble Gas Detector (Gamma), Iodine and Particulate Sampler Cartridge	High Radiation Alarm	7 8 9	Effluent Monitor, Probe in Each of the three Fan Set Discharges
Plant Blowdown Line CBD (1)-1	Detector in Blowdown Line 24" CBD (1)-1	Continuous Liquid Radiation Detector In Line, Gamma Scintillation	High Radiation Alarm	10	Effluent Monitor, D17 RE N008
"	Detector in Line 4" FDR (7)-1 Discharging to Blowdown Line 36" CBD (1)-1	Continuous Liquid Radiation Detector in Line Gamma Scintillation	High Radiation Alarm, Automatically Isolates Radwaste Discharge		Process Monitor, D17-RE-N006

1



WASHINGTON PUBLIC POWER SUPPLY SYSTEM
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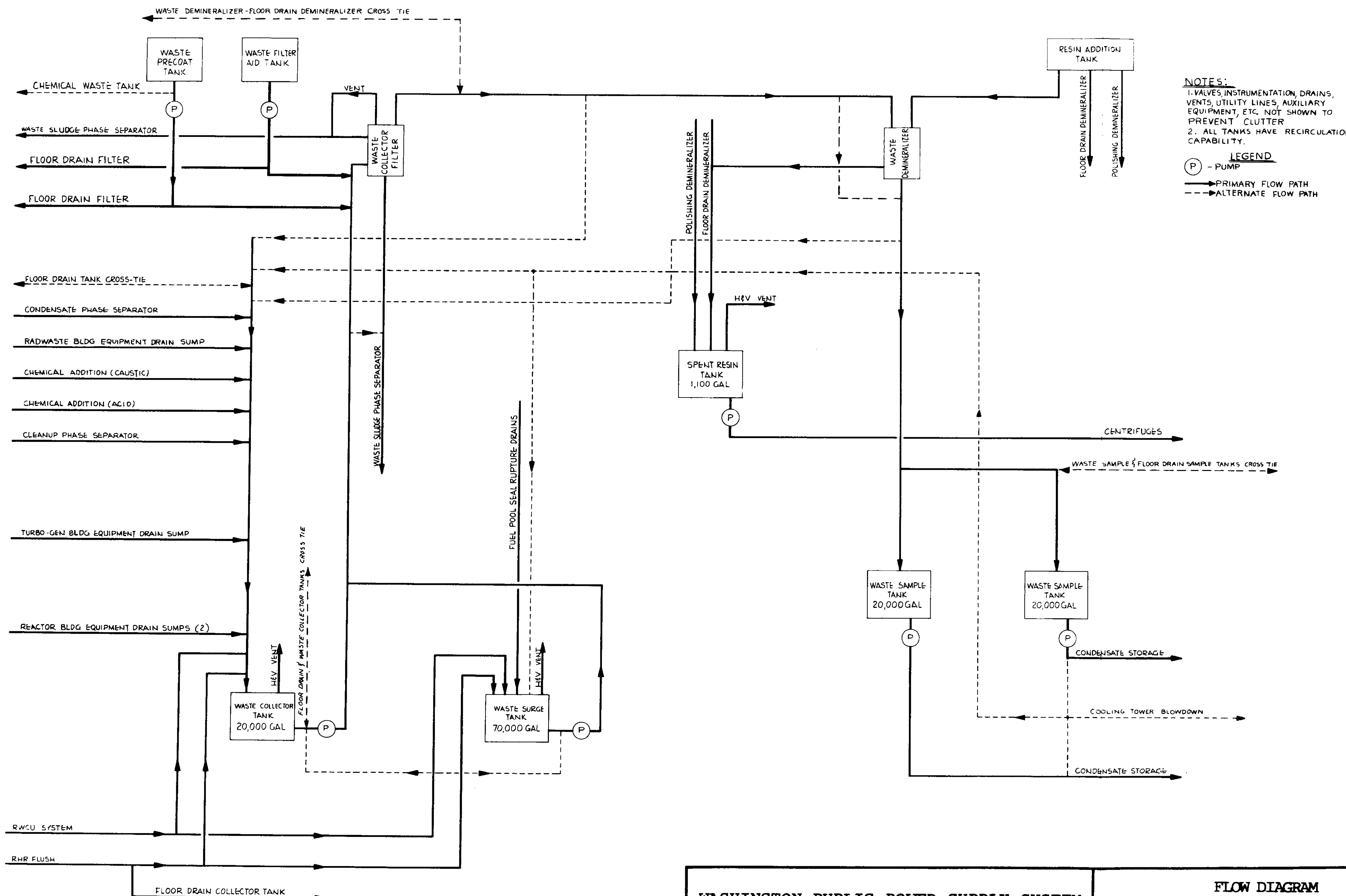
Environmental Report

FLOW DIAGRAM
PROCESS FLOW DIAGRAM LIQUID

FIG. 3.5-1



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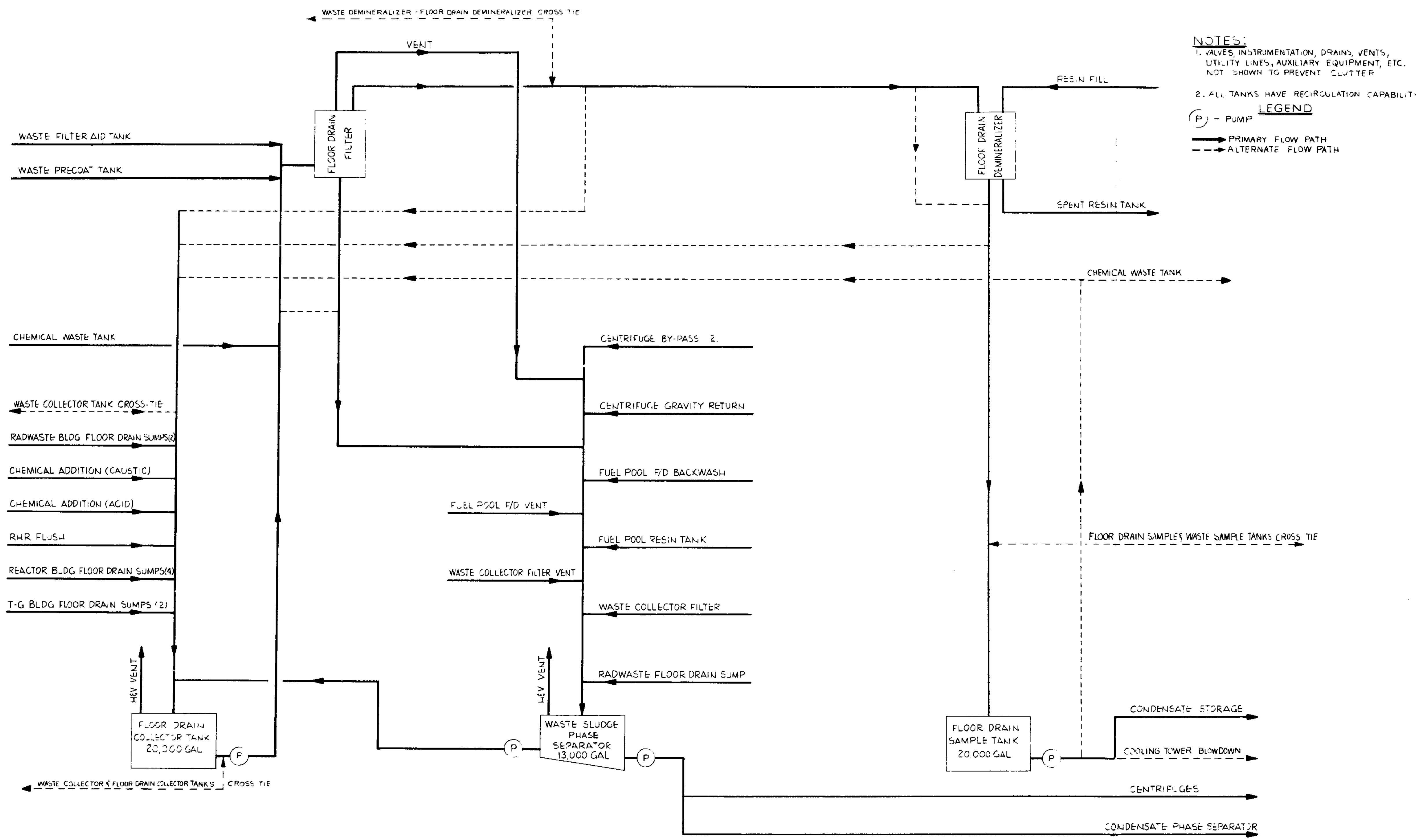
FLOW DIAGRAM
RADIOACTIVE WASTE SYSTEM
EQUIPMENT DRAIN PROCESSING

FIG. 3.5-2



WASHINGTON PUBLIC POWER SUPPLY SYSTEM
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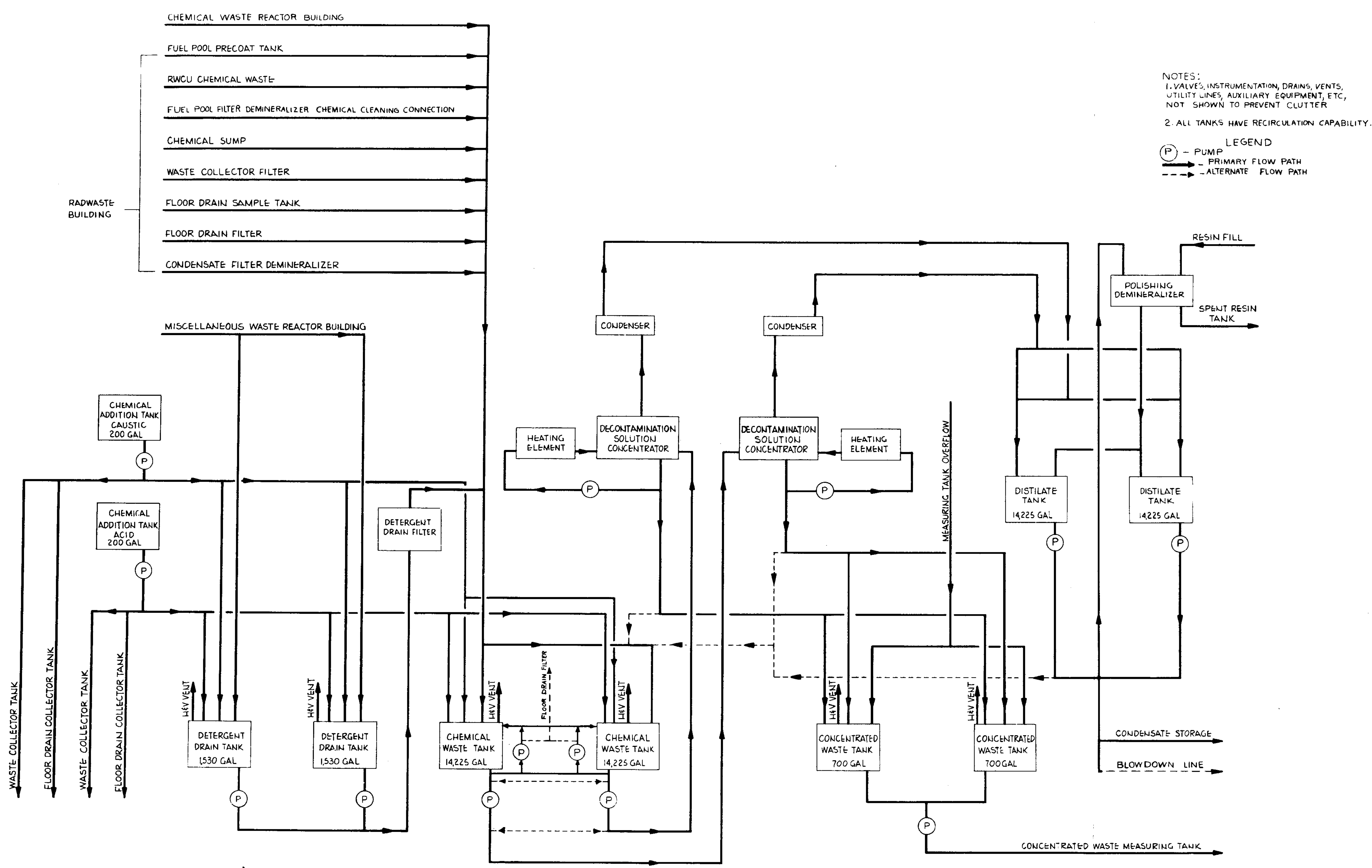
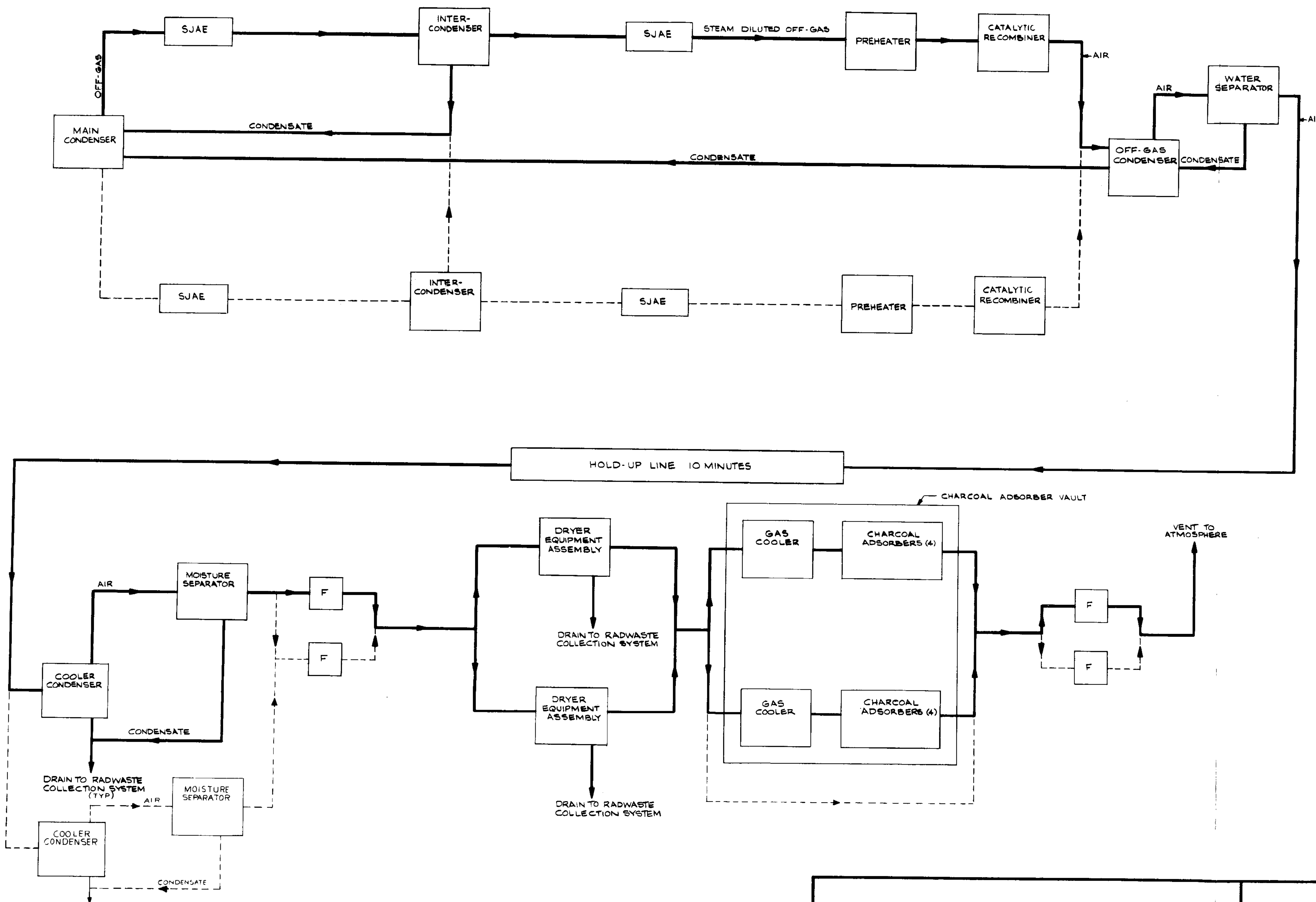
Environmental Report

FLOW DIAGRAM
RADIOACTIVE WASTE SYSTEM
FLOOR DRAIN PROCESSING

FIG. 3.5-3



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM CHEMICAL WASTE PROCESSING
	FIG. 3.5-4



NOTES

1. VALVES, INSTRUMENTS, CONDENSATE DRAINS, MAINTENANCE DRAINS, UTILITY LINES, ETC. NOT SHOWN TO PREVENT CLUTTER

2. FOR PROCESS FLOW CHARACTERISTICE SEE TABLE 3.5-10

LEGEND

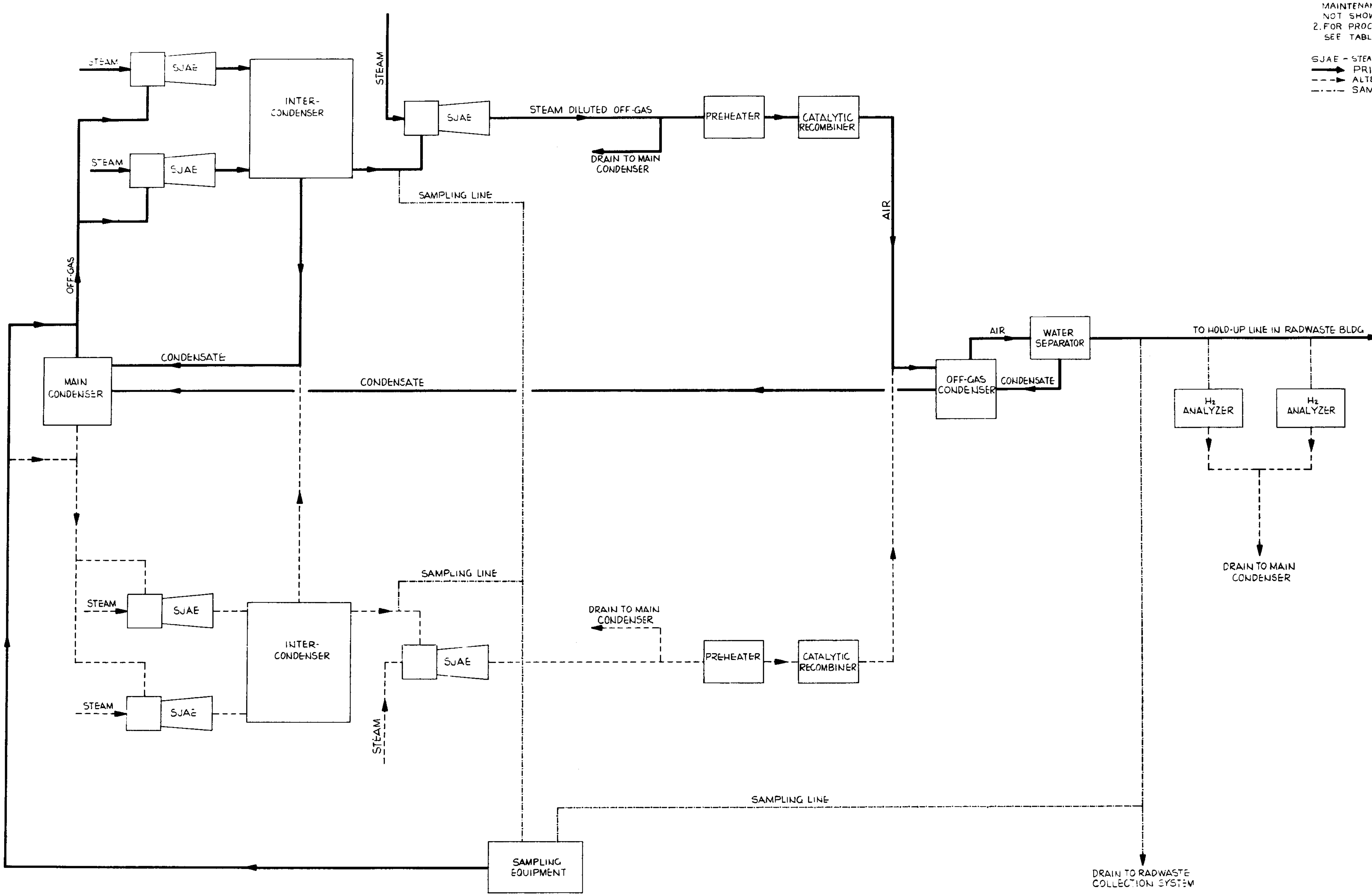
SJAE - STEAM JET AIR EJECTOR

F - FILTER

— PRIMARY FLOW PATH

- - ALTERNATE FLOW PATH

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM PROCESS OFF-GAS SYSTEM LOW TEMPERATURE N-67-1020
	FIG. 3.5-5

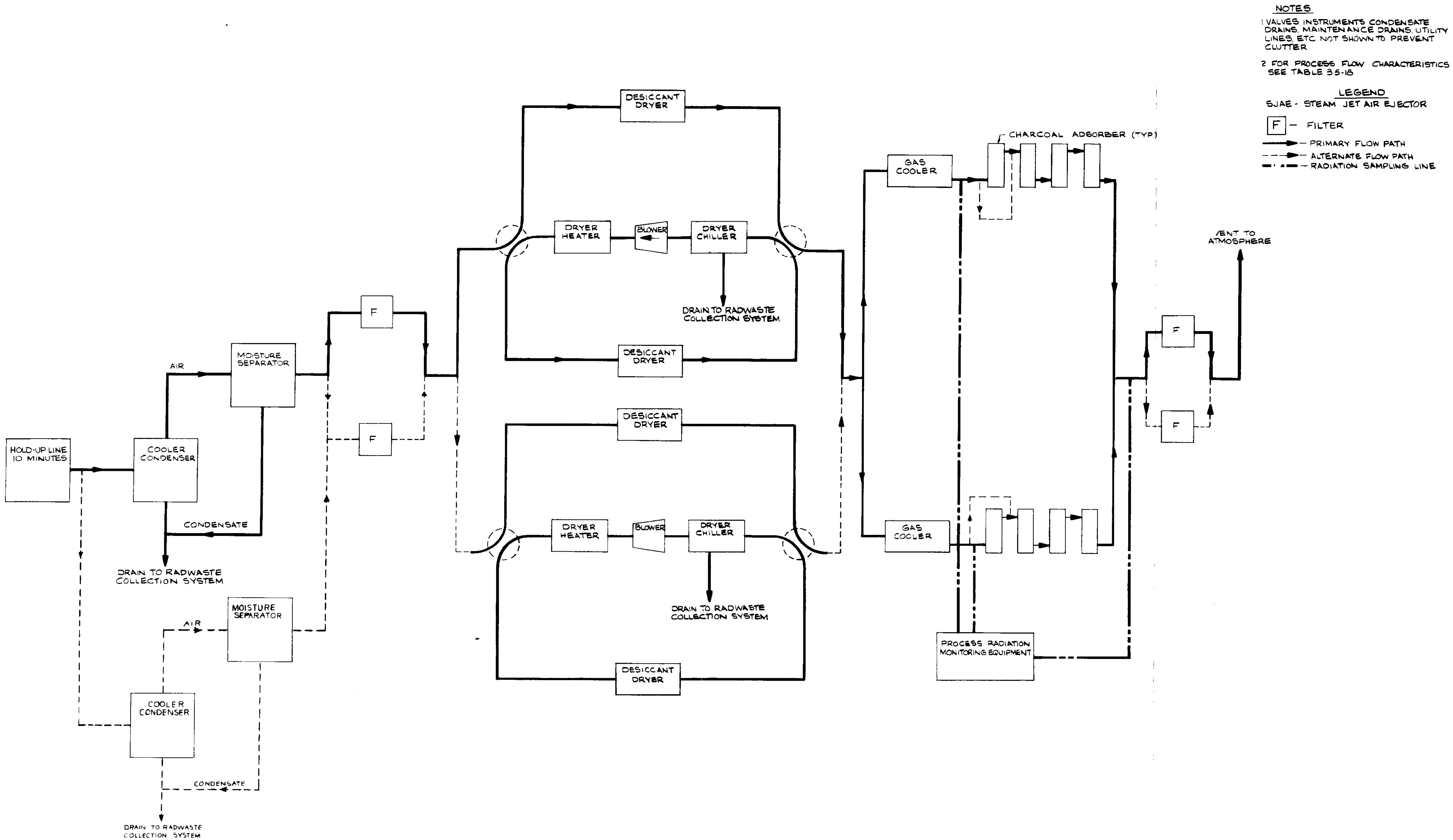


NOTES:
1. VALVES INSTRUMENTS CONDENSATE DRAINS, MAINTENANCE DRAINS, UTILITY LINES, ETC NOT SHOWN TO PREVENT CLUTTER
2. FOR PROCESS FLOW CHARACTERISTICS SEE TABLE 3.5-18

LEGEND

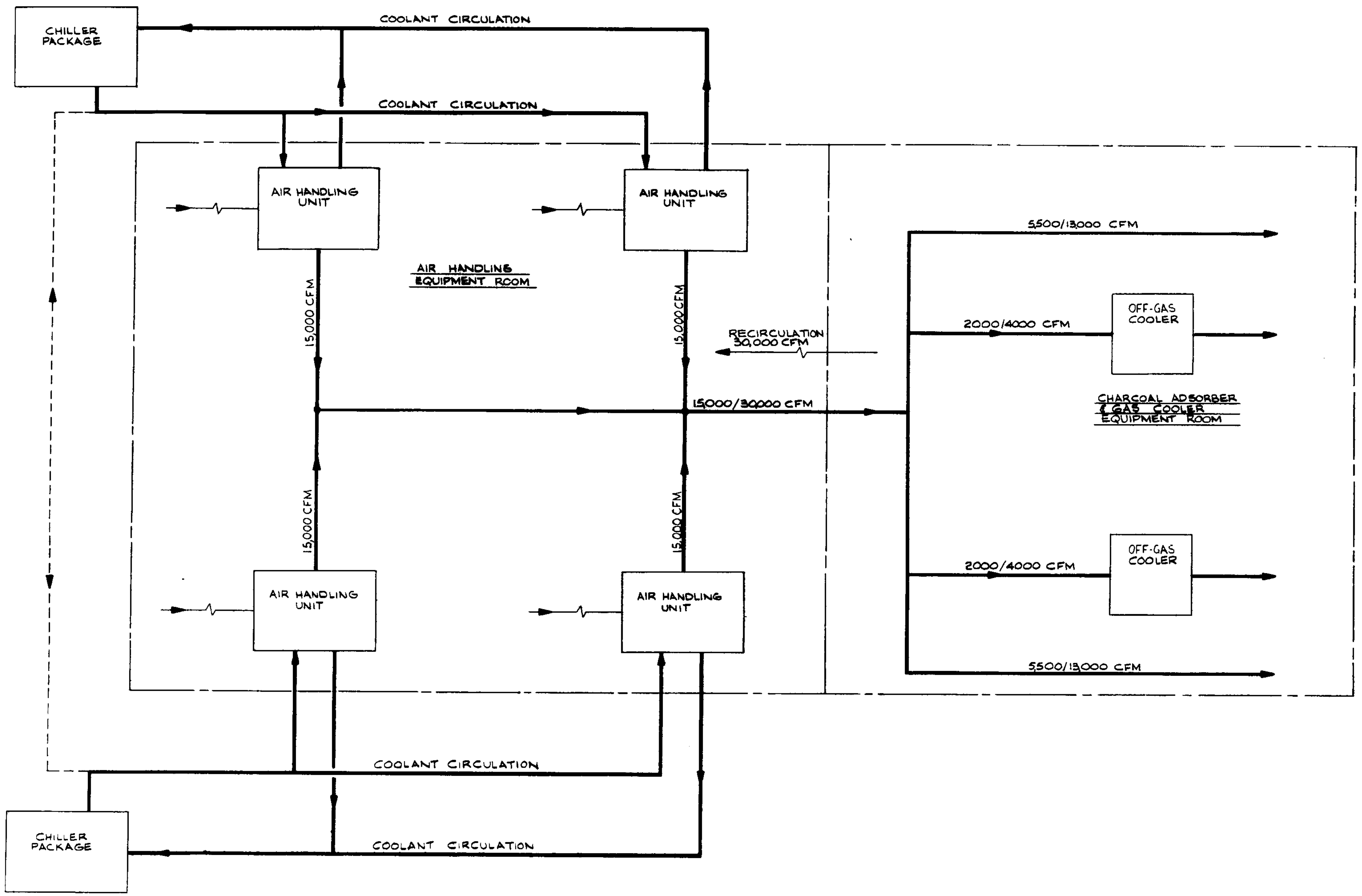
SJAE - STEAM JET AIR EJECTOR
PRIMARY FLOW PATH
ALTERNATE FLOW PATH
SAMPLING LINE

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM OFF-GAS PROCESSING TURBINE BUILDING FIG. 3.5-6

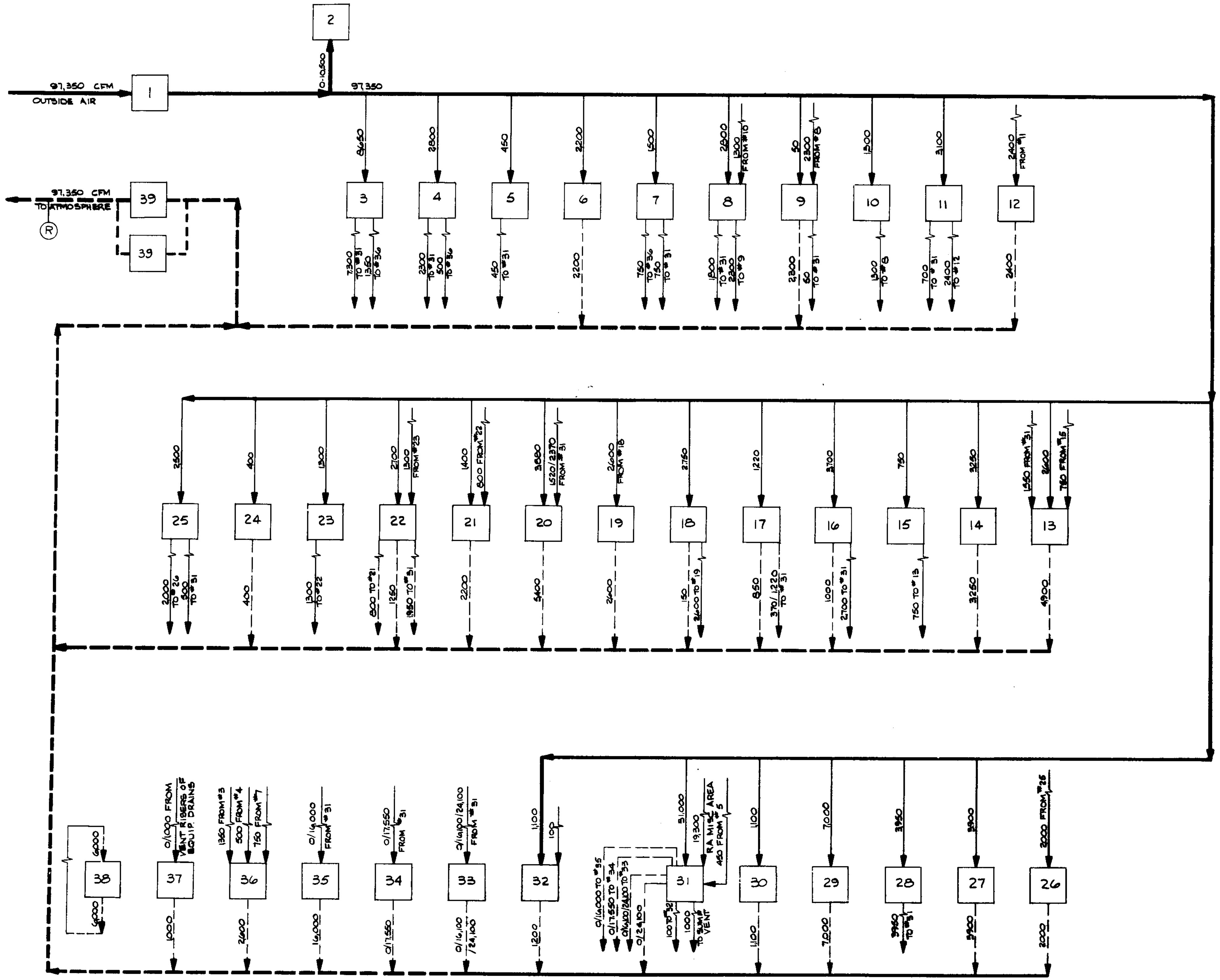


WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM OFF-GAS PROCESSING SYSTEM RADWASTE BUILDING
	FIG. 3.5-7

NOTES
1. VALVES, INSTRUMENTATION, DRAINS, UTILITY LINES, ETC. NOT SHOWN TO PREVENT CLUTTER
2. TWO SYSTEMS SHOWN IN PARALLEL. NORMALLY ONE SYSTEM IS OPERATING THE OTHER IN STANDBY



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM HVAC-O.G. CHARCOAL ADSORBER VAULT RADWASTE BUILDING FIG. 3.5-8



LEGEND

1. HEATING & VENTILATION UNIT INCLUDING ROUGHING FILTER, STEAM HEATING COIL, AIR WASHER, OPERATING SUPPLY AIR FAN & STAND-BY FAN.
2. DRYWELL & SUPPRESSION CHAMBER PURGE SUPPLY
3. EQUIPMENT ACCESS AREA.
*4. H_2 RECOMBINER MCC ROOMS (DIV. I & II) (WITH TWO EMERGENCY COOLING SYSTEMS)
5. COLLIMATOR AREA & STORAGE ROOM
6. FUEL POOL HEAT EXCHANGER & PUMP ROOM
7. GENERAL AREA WEST
8. CRD MODULES WEST
9. A.C. UNIT IN ACCESS AREA & ELECTRONICS ROOM
*10. AIR HANDLING UNIT OF DIV. I MCC ROOM (WITH ONE EMERGENCY COOLING SYS)
11. GENERAL AREA WEST
12. SHUT DOWN COOLING SUPPLY AREA, CRD EQUIPMENT LOCK & SHUT DOWN COOLING LOOP "B" AREA
13. NORTH & SOUTH VALVE ROOMS (GENERAL AREA)
*14. RHR PUMP ROOMS #1, 2 & 3 (WITH THREE EMERGENCY COOLING SYSTEMS)
*15. DC MCC ROOM (DIV. I) (WITH ONE EMERGENCY COOLING SYSTEM)
16. STAND BY LIQUID CONTROL SYSTEM AREA GENERAL AREA SOUTH & PIPE SPACE
*17. (SAMPLING & ANALYZER ROOM IA) & ANALYZER ROOM IB (WITH TWO EMERGENCY COOLING SYSTEMS)
18. GENERAL & GAS TREATMENT AREA NORTH & NEW FUEL STORAGE VAULT
19. RHR HT EXCHANGER ROOM 'A'
20. REGEN. & NON REGEN. HEAT EXCHANGER AREA, EQUIP. ACCESS AREA & PIPE SPACE
21. RWCU PUMP ROOMS "A" & "B" & ACCESS AREA
22. CRD MODULES EAST & PIPE SPACE
*23. DIV II MCC ROOM (AIR HANDLING UNIT) (WITH ONE EMERGENCY COOLING SYSTEM)
24. CRD REPAIR ROOM
25. GENERAL AREA & NEUTRON MONITORING DRIVE MECHANISM AREA
26. TIP ROOM SHUTDOWN COOLING LOOP 'A' AREA & VALVE ACCESS AREA
*27. RHR PUMP RM #4, LPCS PUMP RM #5 & HPCS PUMP RM #6 (WITH THREE EMERGENCY COOLING SYSTEMS)
28. GENERAL AREA
29. CRD PUMP ROOM & AUXILIARY COND. PUMP ROOM
30. ELEVATOR MACHINE ROOM #1
31. EQUIPMENT ACCESS AREA
32. ELEVATOR MACHINE ROOM #2 & TOILET
33. FUEL POOL
34. REACTOR WELL
35. DRYER SEPARATOR POOL
36. RHR HT EXCHANGER ROOM 'B'
37. SUMP VENT EXHAUST FILTER SYSTEMS (ONE OPERATING & ONE STAND BY SYSTEM) EACH SYSTEM INCLUDES A DEMISTER, AN ELECTRIC HEATING COIL, A ROUGHING FILTER, HEPA FILTER CHARCOAL FILTER WITH DELUGE VALVE ASSEMBLY & EXHAUST FAN.)
38. MAIN STEAM TUNNEL COOLED BY TWO AIR HANDLING UNITS EACH 3000 CFM
39. EXHAUST AIR FANS (ONE FAN OPERATING & ONE FAN STAND BY)

(R) RADIATION MONITORS & INDICATORS (FOUR RADIATION DETECTORS & FOUR RADIATION MONITORS & INDICATORS & 2 PEN RECORDERS)

* INDICATES THAT SPACE IS SERVED BY REACTOR BUILDING EMERGENCY COOLING SYSTEMS

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
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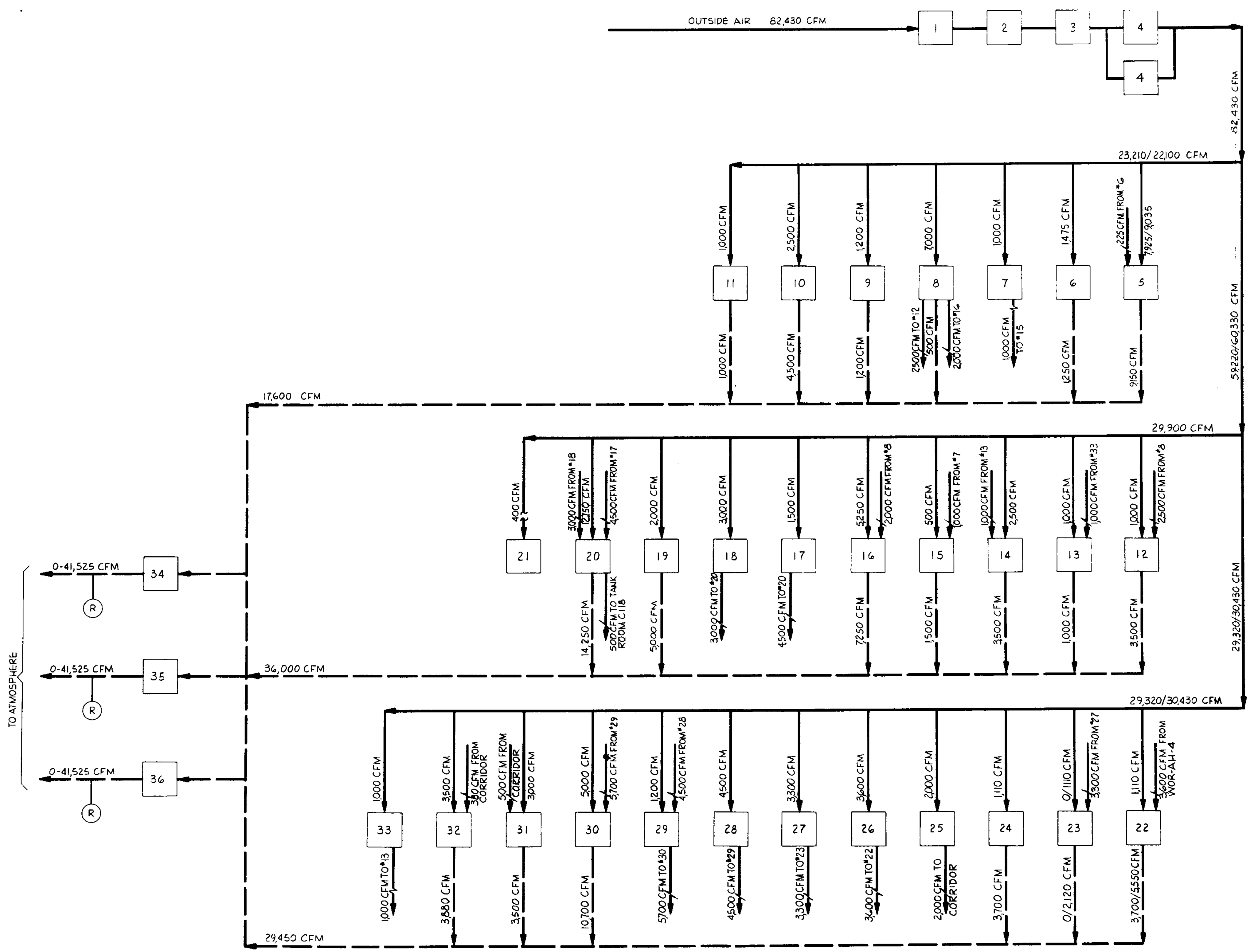
FLOW DIAGRAM
HEATING & VENTILATION SYSTEM
REACTOR BUILDING

FIG. 3.5-9



LEGEND

1. ROUGHING FILTER
2. STEAM HEATING COIL
3. AIR WASHER
4. CENTRIFUGAL FANS (ONE OPERATING & ONE STAND-BY)
5. FILTER EXHAUST AREA
6. AIR HANDLING UNIT SERVING: OFFICE, MENS/LOCKER ROOM/ HOT & COLD SHOWERS & TOILET, WOMENS LOCKER ROOMS, HOT & COLD SHOWERS & TOILET (HEALTH PHYSICS AREA)
7. OFF-GAS EQUIPMENT ROOM.
8. OFF-GAS EQUIPMENT REMOVAL AREA
9. ELEVATOR MACHINE ROOM
10. FILTER VALVE & PUMP ROOM
11. CORRIDOR BETWEEN VALVE AREA-ACCESS AREA
12. ACCESS-AREA, CENTRIFUGE ROOMS & MWR TANK
13. CORRIDOR OUTSIDE PRECOAT ARE & CONTAMINATION ROOM.
14. PRECOAT ROOM
15. VESTIBULE & OFF-GAS FILTER ROOM.
16. EQUIPMENT ACCESS AREA INCLUDING TRUCK AREA, DRUM/CASK, OPERATING & STORAGE AREAS, DECONTAMINATION AREA & HOPPER MIXER ROOM
17. TANK CORRIDOR
18. REFRIGERATION EQUIPMENT AREA
19. DRYER EQUIPMENT ROOMS, VESTIBULE VALVE ROOM, COOLER & MOISTURE EQUIPMENT ROOM
20. PUMP AREAS & TANK ROOMS
21. DIESEL GENERATOR CABLE CORRIDOR

*22. AIR CLEANING UNITS IN RADIO-CHEM. LABORATORY

*23. AIR CLEANING UNIT IN SAMPLE ROOM

*24. AIR CLEANING UNIT IN MECHANICAL EQUIPMENT AREA

25. AIR HANDLING UNIT/COUNTING ROOM
26. AIR HANDLING UNIT/RADIOCHEMICAL LABORATORY
27. AIR HANDLING UNIT/SAMPLE ROOM
28. EQUIPMENT AREA
29. CORRIDOR
30. DEMINERALIZATION REMOVAL ROOM

*31. AIR HANDLING & AIR CLEANING UNITS HOT INSTRUMENT SHOP

32. HOT MACHINE ROOM
33. AIR HANDLING UNIT/RADWASTE CONTROL ROOM

*34. AIR CLEANING UNIT "A" WITH DELUGE VALVE ASSEMBLY

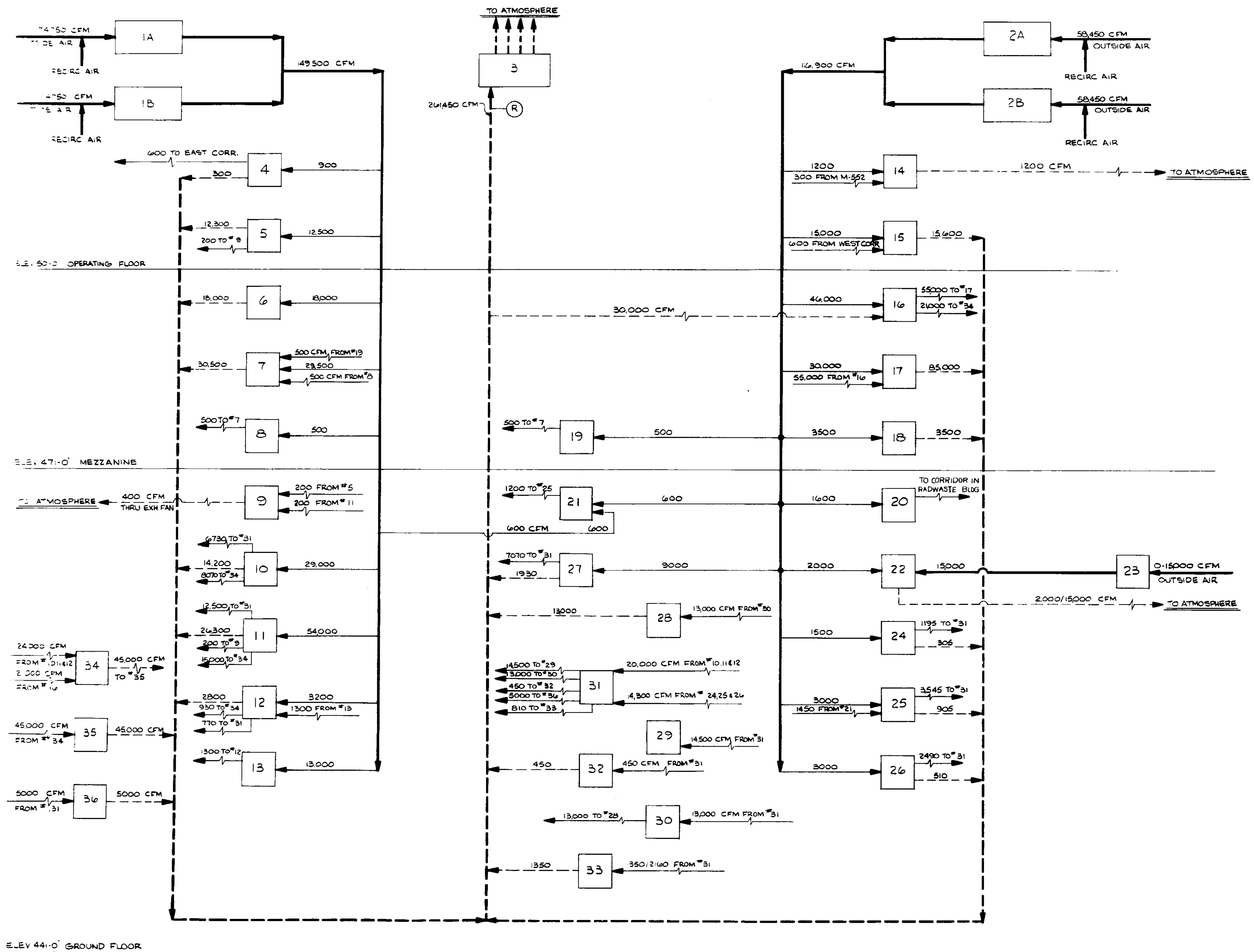
*35. AIR CLEANING UNIT "B" WITH DELUGE VALVE ASSEMBLY

*36. AIR CLEANING UNIT "C" WITH DELUGE VALVE ASSEMBLY

(R) RADIATION MONITOR

* - AIR CLEANING UNITS CONSISTING OF ROUGHING FILTER, HEPA FILTER, AND EXHAUST FAN

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM RADWASTE BUILDING HEATING AND VENTILATION SYSTEM FIG. 3.5-10



LEGEND

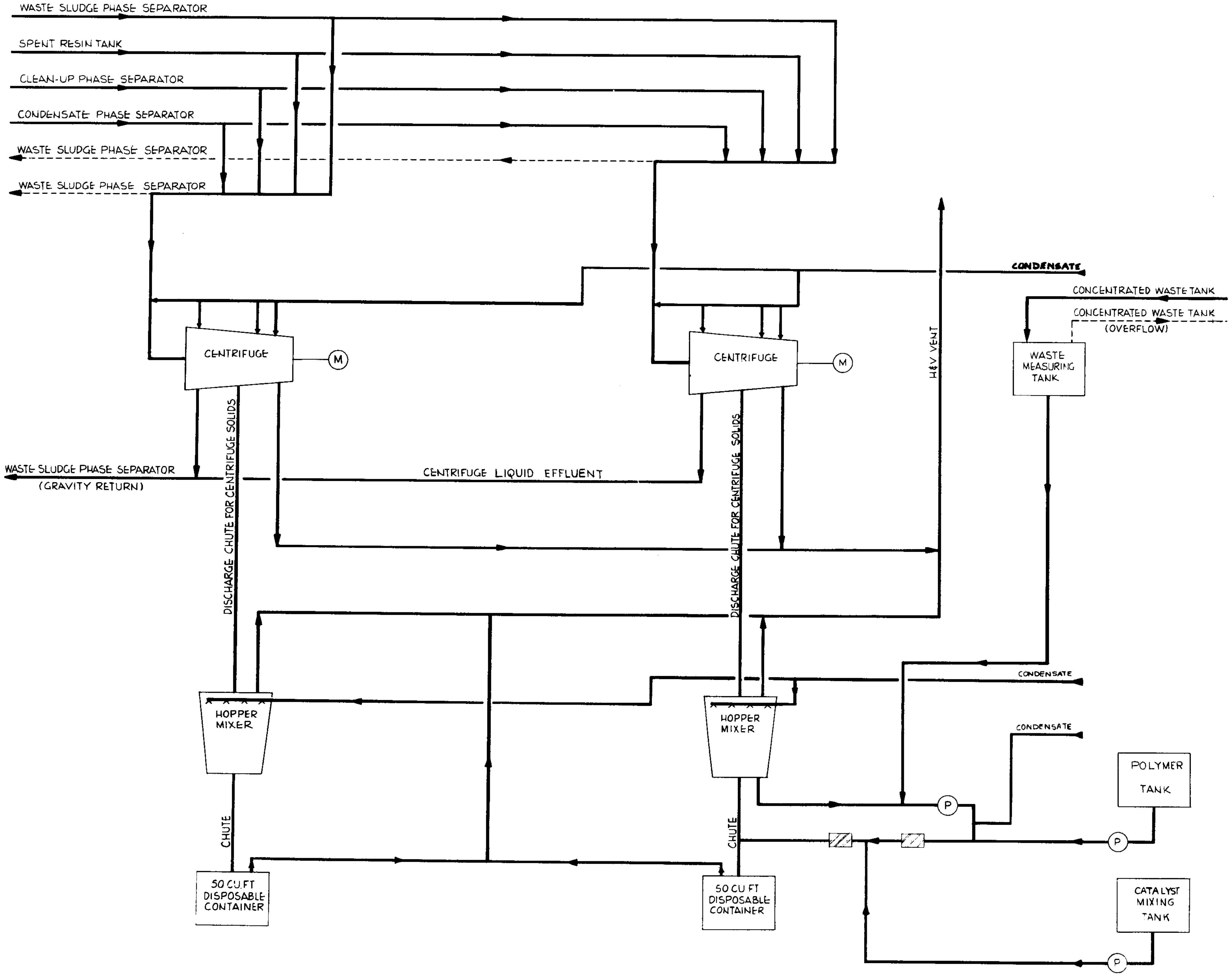
1A & 1B. AIR WASHER SYSTEM CONSISTING OF (ROUGHING FILTER, HEATING COIL & WATER SPRAY SECTIONS & SUPPLY AIR FAN)

2A & 2B. SAME AS A & B EXCEPT FOR CAPACITIES

3. EXHAUST PLENUM IS EXHAUSTED BY THREE OPERATING FANS & ONE STAND BY FAN
4. CORRIDOR ELEV 50-0
5. GENERATOR & EXCITER AREA & MEN'S TOILET
6. BUS DUCT AREA
7. SWITCHGEAR AREA
8. CORRIDOR ELEV 471-0"
9. MEN'S TOILETS (EL.50-0' & EL.441-0")
10. CONDENSATE PUMPS AREA
11. CONDENSATE BOOSTER PUMPS AREA & MEN'S TOILET
12. GENERAL WEST AREA (EL.441-0")
13. H_2 SEAL OIL ROOM
14. ELEVATOR EQUIPMENT ROOM
15. GENERAL EAST AREA (EL.50-0' & EL.471-0")
16. CONDENSER AREA
17. HEATERS AREA
18. TURBINE OIL RESERVOIR
19. CORRIDOR (EL.471-0)
20. N-W CORRIDOR
21. E-W CORRIDOR
22. BOILER ROOM
23. AIR HANDLING UNIT
24. TURBINE OIL TREATMENT AREA
25. GENERAL EAST AREA
26. AIR COMPRESSOR AREA
27. TRANSFORMER ROOMS
28. AIR EJECTOR AREAS 'A & B
29. REACTOR FEED PUMP AREA 'A & B
30. VACUUM PUMP AREA
31. CORRIDOR
32. HYDROGEN ANALYZER ROOM
33. SAMPLE ROOM (FILTERING UNIT & AIR COND. UNIT)
34. CONDENSER GRADE
35. PIPE TUNNEL
36. OFF GAS RECOMBINER AREA

(R) RADIATION MONITOR

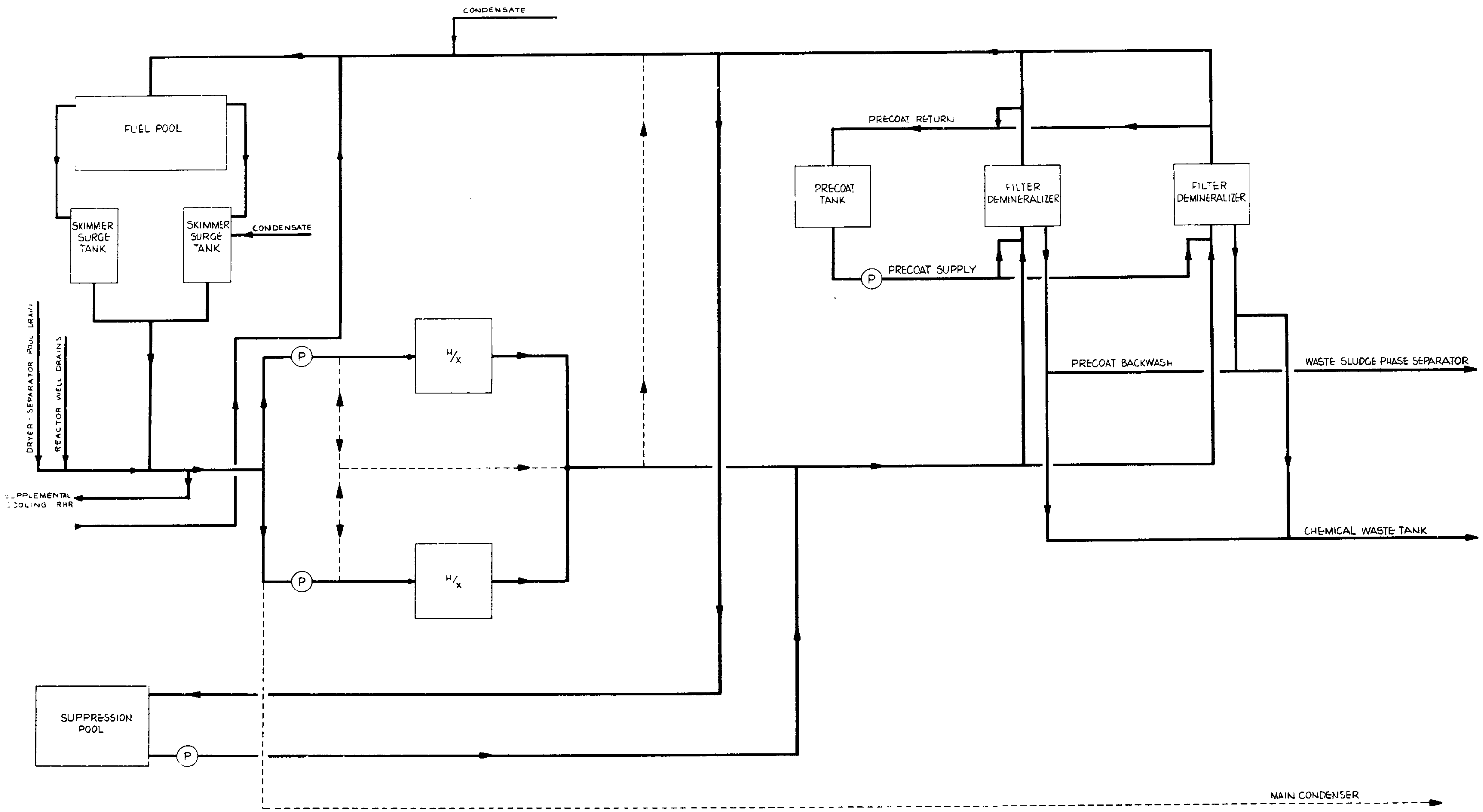
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM HEATING & VENTILATING SYSTEM TURBINE BUILDING
	FIG. 3.5-11



NOTES.
1. VALVES, INSTRUMENTATION, OVERFLOW DRAINS, MAINTENANCE DRAINS, UTILITY LINES, ETC. NOT SHOWN TO PREVENT CLUTTER

LEGEND
P - PUMP
M - MOTOR
→ PRIMARY FLOW PATH
- - → ALTERNATE FLOW PATH
- STATIC MIXER

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM RADIOACTIVE WASTE DISPOSAL SOLID HANDLING
	FIG. 3.5-12



NOTES

1 VALVES, INSTRUMENTATION, OVERFLOW DRAINS, MAINTENANCE DRAINS, UTILITY LINES, ETC. NOT SHOWN TO PREVENT CLUTTER.

2 PARALLEL COMPONENTS MAY BE OPERATED SEPARATELY OR CONCURRENTLY

LEGEND

P - PUMP

H/X - HEAT EXCHANGER

PRIMARY FLOW PATH

ALTERNATE FLOW PATH

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	FLOW DIAGRAM FUEL POOL COOLING AND CLEANUP SYSTEM FIG. 3.5-13

3.6 CHEMICAL AND BIOCIDE WASTES

3.6.1 General

Waste waters discharged to the Columbia River will meet the requirements given in 40 CFR Part 423 "Effluent Limitations, Guidelines and Standards for the Steam Electric Power Generating Point Source Category", issued by the Environmental Protection Agency, October 8, 1974. Waste water streams actually and potentially containing radionuclides will be processed in the liquid radwaste system as described in Section 3.5.2.

3.6.2 Chemical Waste Treatment System

The makeup water demineralizer produces low dissolved solids makeup water by ion exchange, for plant use. Periodically, the makeup water demineralizing equipment requires regeneration to restore the ion exchange capacity. The regeneration process requires a maximum of approximately 180 lbs of 66° Be sulfuric acid and 192 lbs of 100% sodium hydroxide. Excess regenerant chemicals are collected along with rinse waters from the regeneration cycle, neutralized and tested before discharge to the heat dissipation system.

The total volume of waste water produced by one demineralizer regeneration cycle, is approximately 9100 gallons, with a typical composition as shown in column D, Table 3.6-1. When operating on average composition river water, the makeup water demineralizer will produce approximately 110,000 gallons of demineralized water to service, per cycle. Normal operating plant demand will require on the order of 5 gallons per minute of demineralized water makeup, so that the regeneration of this equipment will be infrequent.

The total plant is being built "clean" so that conventional chemical cleaning prior to start-up is not anticipated. In the future, if chemical cleaning is required, cleaning wastes will not be discharged to the Columbia River.

3.6.3 Heat Dissipation System

The removal facilities are discussed in Section 3.4. The evaporation of water in the cooling towers will cause solids concentrations in the circulating water to increase as discussed in Section 3.3. Control of the cooling water chemistry is required to preclude reductions in plant efficiency and service life. This includes adjustment of the pH of the circulating water to maintain a non-scaling and non-corrosive condition; intermittent chlorination to control biological growths such as slimes, algae and fungi; and the blowdown or withdrawal of a portion of the circulating water to control the dissolved solids concentration. Typical composition of the Columbia River water used for cooling makeup, is shown on Table 3.6-1, (columns A, B, C). The composition of the water in the heat dissipation system which will be the same as the cooling tower blowdown is shown on Table 3.6-1 (columns E, F, G).

Sulfuric acid is added to the circulating water to maintain the circulating water pH in the range of 6.5-8.5, for scale and corrosion control. The anticipated sulfuric acid consumption will be in the range of 1700-3400 lbs/day. If the pH of the circulating water, hence the cooling tower blowdown water, should fall below 6.5 or rise above 8.5, operating alarms within the plant will alert the operating personnel who will initiate corrective action.

It is anticipated that adequate corrosion control in the heat dissipation system can be maintained by pH control by means of the addition of sulfuric acid and the control of the dissolved solids in the system by the means of blowdown. No other corrosion or scale inhibitors are to be used.

2 Condenser tubing is 94% admiralty and 6% 70-30 copper-
nickel. Erosion/corrosion of the tubes is expected to
1 contribute a copper concentration of 35 to 110 micrograms
per liter to the cooling tower blowdown effluent at ten (10)
cycles of concentration.

Wood has not been used in the construction of the cooling tower or as a fill material. Therefore, chemical preservatives will not be extracted and discharged to the river.

The cooling tower fill material is corrugated asbestos
cement strips, 3/16" thick, supported by fiberglass re-
inforced polyester grids. The fill is 18% asbestos by
1 weight. Based on conservative estimates of erosion rates
the concentration of asbestos in blowdown is expected to be
less than 0.02 ppm.

Biological growths on heat transfer surfaces result in fouling and a loss of efficiency. Also, algae, slimes and bacterial growths can cause an increase in the corrosion rate of metal surfaces. Therefore, biological activity in the heat dissipation system will be controlled by chlorination. It is anticipated that about 240 lbs/day of chlorine will be injected, intermittently into the circulating water line upstream of the main condenser.

Chlcrine dosage will be automatically controlled so that a concentration of about 0.5 ppm will be present after the condenser, in the water going to the cooling tower, during periods of chlorinator operation. A small portion of this will be dispersed to the atmosphere and the remainder effectively consumed by the small quantities of organic matter present in the circulating water. During the time the chlorine is added, the cooling tower blowdown valve will closed. It will remain closed until the total residual chlorine concentration has been at or below 0.1 mg/l for 15 minutes. 1
The total cumulative operating time of the chlorination system will not exceed 2 hrs/day. Interrupting the blowdown flow during periods of chlorinator operation and for a short period afterwards, assures compliance with the NPDES Permit 3
(see Appendix IV).

The anticipated composition of the cooling tower blowdown is given in Table 3.6-1. This discharge flow will be essentially continuous during normal operation, except during periods of chlorinator operation and for a brief period afterwards.

A small portion of the circulating water will be lost from the cooling towers in the form of small droplets. This "drift" is of the same composition as the circulating water containing some dissolved and suspended solids (Table 3.6-1). Drift eliminators are incorporated in the design of the cooling towers so as to limit the drift to a maximum of 285 gpm, as discussed in Section 3.4. The total solids contained in the drift would amount to about 1,425 lbs per day under 3
full load conditions (assuming a drift rate of 0.05%). The deposition of drift in the vicinity of the cooling towers is discussed in Section 5.1.4.

TABLE 3.6-1

WATER COMPOSITION
COLUMBIA RIVER, DEMINERALIZER WASTE, COOLING TOWER BLOWDOWN

	A	B	C	D	E	F	G
	Columbia River			Demineralizer Waste	Cooling	Tower	Blowdown
	Avg.	Max.	Min.		Avg.	Max.	Min.
Calcium, Ca^{++} ppm	23	32	18	309	116	160	90
Magnesium, Mg^{++} ppm	4	7	2	52	21	34	10
Sodium, Na^{+} ppm	2	5	0	1466	12	24	0
Bicarbonate, HCO_3^- ppm	72	80	50	514	92	92	92
Carbonate, $CO_3^=$ ppm	2	6	0	-	0	0	0
Sulfate, $SO_4^=$ ppm	15	28	10	3495	236	415	109
Chloride, Cl^- ppm	1	2.6	0.2	56	5	13	1
Nitrate, NO_3^- ppm	0.24	0.62	0	32	1.24	3.1	0
Phosphate, $PO_4^=$ ppm	0.03	0.13	0	5	0.06	0.63	0
Total Hardness ppm $CaCO_3$	74	88	64	988	375	540	265
Total Alkalinity ppm $CaCO_3$	63	76	41	422	150	150	150
pH	8.7	9.1	8-8.5	8.3	7.5	8.5	6.5
Silica, SiO_2 ppm	6	9	3	76	30	45	15
Dissolved Soilds, ppm	87	115	72	6022	435	600	360

3.7 SANITARY AND OTHER WASTES

3.7.1 Sanitary Waste

A septic tank/drain field system was originally selected for treatment and disposal of sanitary wastes. The installed system was designed for plant operation on the basis of 100 persons at 25 gallons per capita per day. Construction phase wastes were treated in temporary septic tank/tile fields or hauled offsite to a sewage lagoon. With the buildup of a construction force at WNP-1 and WNP-4, concurrently with the construction activity at WNP-2, the Supply System chose to build a central waste treatment system to serve the three plants and the Emergency Response/Plant Support Facility. This system will also provide treatment during maintenance/refueling outages when much larger than normal work forces 5
are on site.

The sanitary waste treatment system uses aerated lagoons in series with lined facultative stabilization ponds. Flow from the ponds is dosed to four percolation/evaporation beds with a combined area of about two acres. The percolation beds are located about 45 feet above the water table and there is no discharge to a surface water course. Wastes are delivered to the treatment plant via a gravity collection system. The treatment system is sized (0.17 mgpd) to accommodate the largest anticipated combined construction/operation work force for the three nuclear plants. During normal power plant operation, when the flow will average 0.05 mgpd, the aerated lagoons can be bypassed. The location of the facility and arrangement of the ponds are shown in Figure 3.7-1.

3.7.2 Storm Water and Roof Drains

Storm water and roof drains will be collected in a separate drain system and routed to an evaporation/leach area located at about N12600, W325 (see Figure 2.1-4).

3.7.3 Filter Backwash Water

Periodically, filter backwash water from the makeup demineralizer sys- 1
tem, is routed to the evaporation/leach area. The filters accumulate and store backwash water that is released at a flow rate of up to 525 gpm for a period of about 5 minutes per week.

3.7.4 Gaseous Wastes

During plant shutdown and outages, a diesel oil fired auxiliary boiler furnishes auxiliary steam and heating. In addition, three standby diesel generators will operate on an infrequent, intermittant basis.

The three standby diesel engine driven generators will be test run for about one (1) hour monthly. Also, each generator set will be operated at full load for 24 hours at least once during an 18 month period. Two of the units consume 340 gph of fuel, each at full load, while the third will use 170 gph at full load. Assuming full load operation, with a fuel oil sulfur content of 0.4%, this equipment will exhaust about 1400
1 lbs of SO_2, 980 lbs of NO_X and 34 lbs of particulates per year.

The heating boiler provides building heat and supplies steam to the radwaste system, when needed. It is expected that the equivalent of only three months at 25% of full load operation, will be required annually. The heating boiler, consuming No.2 fuel oil, containing 0.4% sulfur will produce approximately 13,650 lbs of SO_2, 9,800 lbs of NO_X, and 340 lbs of particulates per year.

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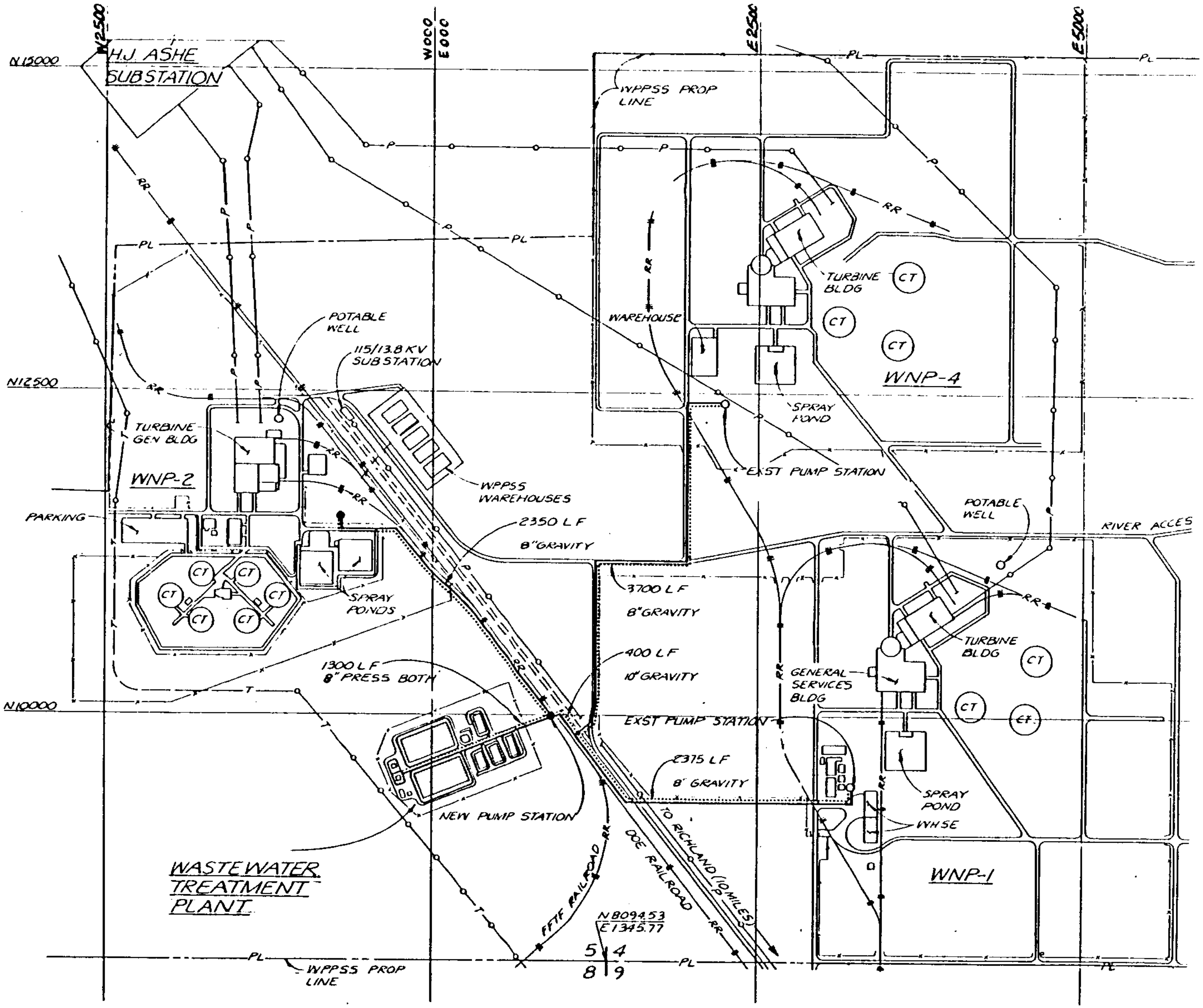


SANITARY WASTE TREATMENT SYSTEM

FIG. 3.7-1

3.8 REPORTING OF RADIOACTIVE MATERIAL MOVEMENT

Generation of electrical energy in a nuclear power plant requires periodic shipment of new fuel assemblies to the plant, spent fuel assemblies to a fuel reprocessing or storage facility, and packaged low level radioactive materials to licensed waste burial grounds. The shipments are made in compliance with federal and state requirements pertaining to the proper packaging and transportation of the materials. 2

3.8.1 New Fuel

3.8.1.1 Description

New fuel for the WNP-2 plant is made of slightly enriched uranium dioxide ceramic fuel which has been compacted and sintered to form very dense pellets having high strength and high melting point. The pellets are about 0.41 inch in diameter, 0.41 inch long, and are stacked in Zircaloy-2 tubing to provide an active fuel length of 150 inches with a plenum left at the top end to provide for collection of gas generated during the fission process. The tubes are welded shut at both ends and are subjected to rigorous quality control to ensure their integrity. 2

Sixty-two fuel rods and two water rods (tubes of Zr-2 cladding without UO_2 fuel) are assembled in an eight-by-eight array to form a fuel bundle. Each fuel bundle will contain fuel rods of either five or seven different enrichments, whose average bundle enrichments will be approximately 1.8 or 2.2 percent U-235 for the first core. The reload fuel will have average bundle enrichments in the range of 2.4 to 3.0 percent U-235. 2

A fuel assembly consists of a fuel bundle weighing approximately 615 pounds and a fuel channel weighing 83 pounds. The fuel channel is used to control coolant flow within the reactor core. Normally the channel will be reused and assembled at the plant site with a new fuel bundle. The reactor core will contain a total of 764 fuel assemblies. 2

3.8.1.2 New Fuel Shipment

Prior to shipment, plastic spacers are inserted between the rows of rods in the fuel assembly to provide protection for the fuel against the normal shock and vibration during transport and to assure that, when the fuel is placed into the reactor, the proper spacing has been maintained between the fuel rods for heat transfer purposes. New fuel assemblies are enclosed in a plastic bag and placed in a metal container which provides insulation for fire protection and which supports the fuel assembly along its entire length during the course of transportation. This metal container also provides necessary impact protection to meet drop test requirements provided for in NRC regulations. The metal container is gasketed and bolted shut, then placed into an outer wooden box. The fuel properties and a typical description of the fuel shipping containers follows:

NEW FUEL PROPERTIES AND CONTAINER DESCRIPTION

Fuel Properties	Container Description
1) No radioactive fission products	1) Metal container in wooden box
2) Non radioactive gases	2) Dimensions:
3) High melting point, insoluble	Metal container, 11" x 18 1/2" x 182" long
	Wooden box, 33" x 32" x 207" long
	3) Capacity - two BWR assemblies
	4) Weights:
	Empty - 1400 pounds Loaded - 2800 pounds

There are no components of the package or its contents which are subject to chemical reaction in the normal transportation environment. The package connot be opened inadvertently, uses no coolant, and has no lifting devices or tie-down attachments. During normal transport conditions, containment integrity and nuclear safety are not significantly affected by ambient temperatures, $\pm$0.5 psi pressure differntials or road vibrations.

3.8.1.3 Method and Frequency of Shipments

The General Electric Company is responsible for shipment of the initial core fuel assemblies from its fabrication plant at Wilmington, North Carolina, to the WNP-2 reactor site, a distance
2 of about 3000 miles. This fuel will be shipped by truck in quantities of up to 16 shipping containers per load, each containing two fuel assemblies, thereby providing a maximum of 32 fuel assemblies per truck shipment. About 24 shipments will be received at the plant for the initial core.

Reload fuel assemblies will be shipped from the Exxon Nuclear Company plant located less than ten miles from the WNP-2 plant site. About 180 fuel assemblies will be required annually.

3.8.2 Spent Fuel

3.8.2.1 Description

Inherent in the generation of power by a nuclear reactor is the fact that fissionable isotopes in the nuclear fuel are depleted to the extent that they need to be replaced with new fuel. However, the spent fuel, which has essentially the same weight as fresh fuel, still contains fissionable uranium and plutonium. Although these materials could be recovered in a fuel reprocessing facility and re-used in fabricated fuel assemblies, current policy is to indefinitely defer commerical reprocessing and recyling of the plutonium produced in the U.S. nuclear power programs. The Supply System will continue to closely monitor both government policy and development concerning spent fuel disposition, reprocessing, and plutonium recycle.

Present planning calls for storage of the spent fuel in the plant spent fuel pool until at least 1988. Because of the installation of additional spent fuel storage capacity, loss of full core discharge capability should not occur prior to 1993 for WNP-2, and the pool should have sufficient capacity for reloads until at least 1998. In is anticipated, however, that by the 1990's the ultimate disposition of the spent fuel, whether it will be temporarily stored and later withdrawn for reprocessing, or whether it will be regarded as waste and ultimately disposed of in a pemanent repository, will be known. 2

Spent fuel removed from the reactor during annual refueling contains, on a weight basis, in excess of 99.99 percent of the fission products formed inside the fuel. These fuel assemblies are temporarily stored in the spent fuel pool at the plant after removal from the reactor core. This spent fuel is covered by about ten feet of water at all times which serves as a radiation shield and coolant while the short-lived fission products decay. During this period, the fuel assemblies are monitored to identify "leaking" fuel elements so that they may be canned prior to insertion in shipping casks, thereby reducing even further the remote likelihood of a release of fission products. The temporary storage period will be a minimum of 180 days to allow for decay of short-lived fission products.

The planned average fuel bundle burnup over the plant lifetime will be approximately 27,500 megawatt days per metric ton (MWD/tonne). It is expected, however, that the burnups could vary from 10,000 MWD/tonne to 35,000 MWD/tonne for individual discharges.

3.8.2.2 Spent Fuel Shipment

The NRC and U.S. Department of Transportation (DOT) regulations specify both normal and accident conditions against which a package designer must evaluate any radioactive material packaging.

These conditions are intended to assure that the package has the required integrity to meet all conditions which may be encountered during the course of transportation. The normal shipping conditions require that the package be able to withstand conditions ranging from -40°F to 139°F and to withstand the normal vibrations, shocks, and wetting that would be incident to normal transport. In addition, the packages are required to withstand specified test conditions with the release of no radioactivity except for slightly contaminated coolant and up to 1,000 curies of radioactive noble gases. The test conditions for which the package must be designed include, in sequence, a 30-foot free fall onto a completely unyielding surface, followed by a 40-inch drop onto a six-inch diameter pin, followed by 30 minutes in a 1475°F fire, followed by eight hours immersion in three feet of water.

Prior to use, the proposed container design and transport system are reviewed and approved by NRC and DOT, and transportation is authorized by an NRC license. Lincense provisions include adequate quality assurance and testing programs to assure the equipment is constructed and used in accordance with approved desgins and procedures. After loading, containers are decontaminated and carefully surveyed and inspected to assure that they have been properly prepared for shipment and are in full compliance with license provisions governing transportation. The container is also labeled in accordance with federal regulations.

2| 3.8.2.3 Method and Frequency of Shipment

There is presently a considerable diversity of shipping methods proposed for the very heavy irradiated fuel containers, ranging from legal weight truck shipments which will ship approximately two BWR fuel assemblies at a time to large rail casks which will
2| ship as many as thirty BWR fuel assemblies at a time.

Shipment of 200 spent fuel assemblies from the WNP-2 plant would annually involve about 100 truck shipments or ten rail shipments. Since the plant will have rail access, it is expected that spent fuel will be shipped exclusively by rail. Truck shipments are planned only for those few assemblies left over from rail shipments.

2| 3.8.3 Radwastes

3.8.3.1 Description

A variety of radioactive wastes will be shipped by truck or rail to duly licensed burial locations for disposal. Radioactive wastes shipped off-site during normal operation will be in the form of solids or solidified liquids in amounts as shown in Table 3.8-1. These wastes will include (activities are given in Table 3.5-22):

a. RWCU filter demineralizer spent resins

b. Condensate filter demineralizer spent resins

c. Fuel pool demineralizer spent resins

d. Radwaste demineralizer spent resins

e. Radwaste filter sludges

f. Evaporator bottoms

g. Miscellaneous solid wastes

The miscellaneous solid wastes include spent control rods and fuel channels, small pieces of contaminated instruments and instrument cable, filter cartridges, contaminated tools, and compressible radioactive solid waste. The compressible radioactive solid waste will include contaminated clothing, paper, and rags. Processing of these miscellaneous solid wastes prior to shipment off-site is discussed in Section 3.5.4.

3.8.3.2 Radioactive Waste Shipment

Fifty and one-hundred cubic foot steel containers will be utilized for packaging the majority of the solid wastes to be shipped for off-site disposal. Off-site shipment of packaged material will be contracted to a firm specializing in the transportation of solid wastes. This specialist will hold the necessary permits and licenses and be responsible for the shipment in transit. In conformance with Federal Regulations, the Supply System will be responsible to assure that the site packaged containers are sealed and labeled properly.

The low activity compressible waste will generally be packaged for shipment in steel drums. Spent fuel radioactive equipment and other solid waste components will be shipped by contract with a specialist in the field who will provide the necessary containers, such as modified spent fuel casks.

3.8.3.3 Method and Frequency of Shipment

The expected quantities of radiactive waste materials to be shipped from the WNP-2 plant are shown on Table 3.8-1 and are detailed in Section 3.5, Radwaste Systems and Source Term. It is expected that all low-level radioactive waste will be buried on the licensed burial site on the Hanford Reservation - a distance of about ten miles from the WNP-2 plant site.

Demineralizer resins, filter sludges, and evaporator bottoms are collected in the plant and dewatered and solidified into fifty and one-hundred cubic foot containers. The packaged wastes are then stored as necessary to allow decay of short lived isotopes.

Storage area is provided for a minimum of 60 days decay time. The waste containers will be placed in shielded shipping casks as required to comply with the limitations of 49 CFR and placed on flatbed trucks for shipment to the burial site.

Compressible low-level wastes in 55-gallon drums will also be shipped by truck to the burial site. It is not expected that additional shielding will be required for these wastes.

Radioactive equipment components will be stored in the spent fuel pool until a sufficient amount is accumulated for a shipment. They will be shipped by contract with a specialist in the field who will provide the necessary containers.

3.8.4 Summary of Radioactive Material Movement

A summary of the principal shipments of radioactive materials, type of transportation systems and the estimated distance involved in shipment of radioactive materials to and from the WNP-2 site appears as Table 3.8-1.

TABLE 3.8-1 RADIOACTIVE MATERIAL MOVEMENT SUMMARY

Radioactive Material	Transportation Mode	Material Quantity	Shipment Distance (1)	Quantity Per Shipment	Year	Vehicle Miles Per Year
New Fuel						
Initial Core	Truck	764 Assemblies	3000 Mi.	32 Assemblies	0	72,000
Reloads	Truck	180 Assemblies Per Yr.	10 Mi.	32 Assemblies	1	0
					2	60
					3	60
					4	60
					5	60
2 Spent Fuel	Rail	200 Assemblies Per Yr.	Unknown (3)	18 Assemblies	1	0 (2)
					2	0
					3	0
					4	0
					5	0
Radwastes Sludges & Resins	Truck	9850 Ft^3/Yr. or 100 Containers	10 Mi.	3 Containers	1	420
					2	420
					3	420
					4	420
					5	420
Miscellaneous Solids	Truck	100 Drums	10 Mi.	50 Drums	1	20
2					2	20
					3	20
					4	20
					5	20

(1) One-way distance

(2) No fuel discharge from spent fuel pool anticipated until at least 1988.

2 (3) Ultimate disposition of spent fuel as yet unknown. Refer to discussion in paragraph 3.8.2.1.

3.9 TRANSMISSION FACILITIES

3.9.1 General Description of Facilities

The Bonneville Power Administration is planning, designing, and constructing the 500 KV transmission and 230 KV start-up lines and the H. J. Ashe Switching Station for WNP-2. BPA has submitted an environmental statement[1] concerning these facilities. The information in this Section is taken from that report.

To provide power for the construction of WNP-2, a 115 KV line was erected in 1972. This line comes from the Bonneville Power Administration's Benton Switching Station utilizing a 115 KV line that extends from Section 3, Township 11 North, Range 28 East. The interconnecting line to WNP-2 is slightly over 1 mile in length and requires a 90 foot right-of-way. After plant start-up, the 115 KV line will be used as an emergency back-up power source for WNP-2. This is an existing line, and will not be considered in the following sections.

3.9.1.1 500 KV Transmission Line

This transmission line will be the primary transmission line originating at WNP-2 (See Figure 3.9-1). It travels 1/2 mile making connection to the BPA Ashe Substation, then 18 miles northwest to the 500 KV Hanford switchyard. The entire line is within the Hanford Reservation and will be approximately 18.3 miles in length, requiring a 125 foot right-of-way (See Route "A", Figures 10.9-1 and 10.9-2).

Lattice steel, single circuit, delta configuration, 500 KV towers will be used on this line (See Figure 3.9-2). The towers will average 123 feet in height and 44 feet in width. The average spacing between towers will be 1,150 feet. Three conductors will be used for this line with the average conductor ground clearance being 51 feet. Land requirements for each tower will average 400 square feet. See Table 3.9-1 for this line's electrical characteristics.

3.9.1.2 230 KV Start-Up Line

This three conductor transmission line (A-HEW#3) will extend from the existing Bonneville Power Administration 230 KV grid connection, located in Section 32, Township 13 North, Range 27 East, East Williamette Meridian to the H. J. Ashe substation. This interconnection is approximately 10.1 miles long and will require a 125 foot right-of-way (See Figures 3.9-3 and Route "A" 10.9-1).

Lattice steel, single circuit, flat configuration, 230 KV towers will be used on this line (See Figure 3.9-2). Steel from existing towers, taken from a BPA line to be removed, will be used for the towers of this line. The towers will average approximately 80 feet in height with a base 28 feet square and a span length between towers averaging 1,150 feet. Three conductors will be used for this line with the average conductor ground clearance being 47 feet. See Table 3.9-1 for this line's electrical characteristics.

3.9.1.3 Howard J. Ashe Substation

The H. J. Ashe substation, as shown in Figure 3.9-4, is being built by BPA to handle the WNP-2 500 KV transmission line and 230 KV start-up line. As shown in Figure 2.1-3, the Ashe substation is approximately 1/2 mile due north of WNP-2. The substation requires about 37 acres of land and an access road about 2,000 feet long for a total land requirement of about 38 acres. Construction on the Ashe substation was completed in May, 1976.

3.9.2 Environmental Parameters

3.9.2.1 Non-Electrical

A total of 648 acres will be required for the right-of-way for the 500 KV and 230 KV lines. The land to be crossed by the transmission lines is shown in Figures 10.9-3 and 10.9-4. A detailed discussion of the 500 KV and 230 KV routes impact on land, vegetation, wild life and their crossings of highways, railways, water-bodies, areas of acheological, historical and recreational interest are discussed in Section 10.9.2.1. Alternative right-of-ways and the rationale for the selection of the proposed rights-of-way is given in Section 10.9.

3.9.2.2 Electrical

Radiated electrical interference is insignificant beyond 1000 feet from the rights-of-way and no receptors are anticipated within this range due to the land classification. Radiated acoustic noise is insignificant on lines with voltages below 345 KV. The 500 KV lines will be designed to minimize acoustic noise.

Ground currents, in normal operation, both induced and conducted are insignificant. The magnitude of such currents depends on the magnitude and balance of the load current in the conductors. Procedures for grounding metal structures and equipment, along with other precautions used by BPA substantially eliminates the possible hazard and nuisance from these sources. Under phase to ground fault conditions the current can reach 23 KA in the immediate vicinity for a maximum of one half second until the line protection devices operate.

The magnitude of induced currents beneath the transmission lines can be estimated from BPA design criteria. One design criterion is that the electric field strength, as measured one meter above the ground, not exceed 9 kv/m under typical maximum operating conditions. It is additionally specified that the field strength at the edge of the right-of-way not exceed 5 kv/m. In such a field, the short-circuit current under the lines could be 0.14 mA in a person and about 5 mA for a large trailer truck. No short- or long-term effects on humans in fields of this magnitude have been documented.[3] 1

High voltage transmission lines exhibit corona discharge which is associated with the formation of ozone. Because corona discharge represents a power loss, transmission lines are designed to minimize this loss for economic reasons.

The ozone formation per three-phase mile of 500 KV transmission line would be approximately 0.9 lb/day, and will be considerably less for the 230 KV line. The effects of this ozone formation are difficult to evaluate since the natural formation rate is high in comparison. Over the rights-of-way the natural ozone generation is one or two orders of magnitude above that caused by corona discharge from transmission lines. Field measurements of ozone concentrations in the vicinity of transmission lines have failed to record any increases that were attributable to the power lines. For these reasons, ozone formation is expected to cause no significant environmental effect.

TABLE 3.9-1

500 KV AND 230 KV LINE ELECTRICAL CHARACTERISTICS (2)

500 KV Ashe Hanford #1 Transmission Line:

Conductor type: ACSR CHUKAR

Capacity/conductor: I at 50°C rise over 25°C ambient with sum = 1458 amps

AC Resistance:

°Centigrade	25	50	75	80	100
ohms/mile	.0560	.0609	.0659	.0670	.0709

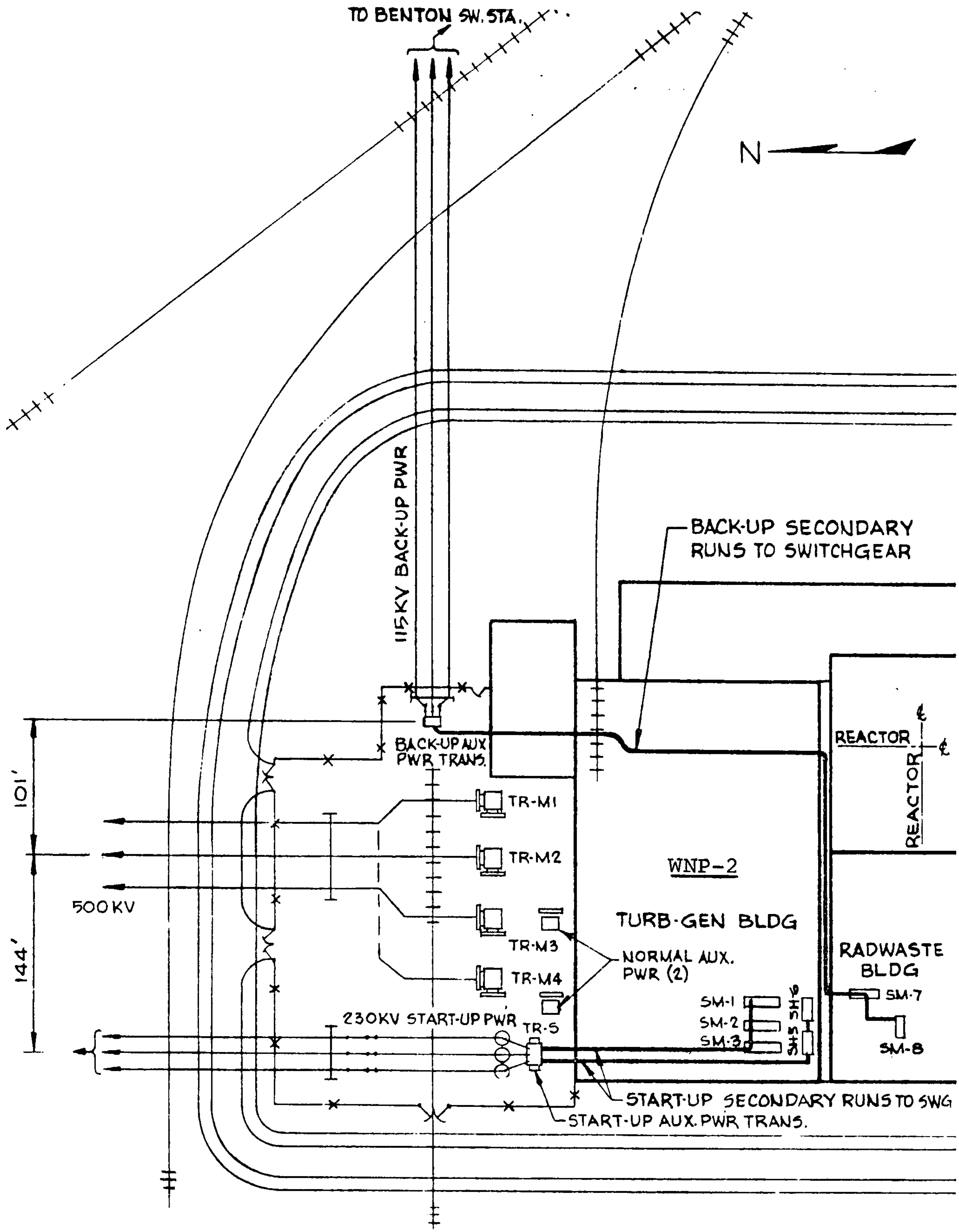
230 KV Ashe HEW #3 Startup Line:

Conductor type: ACSR DRAKE

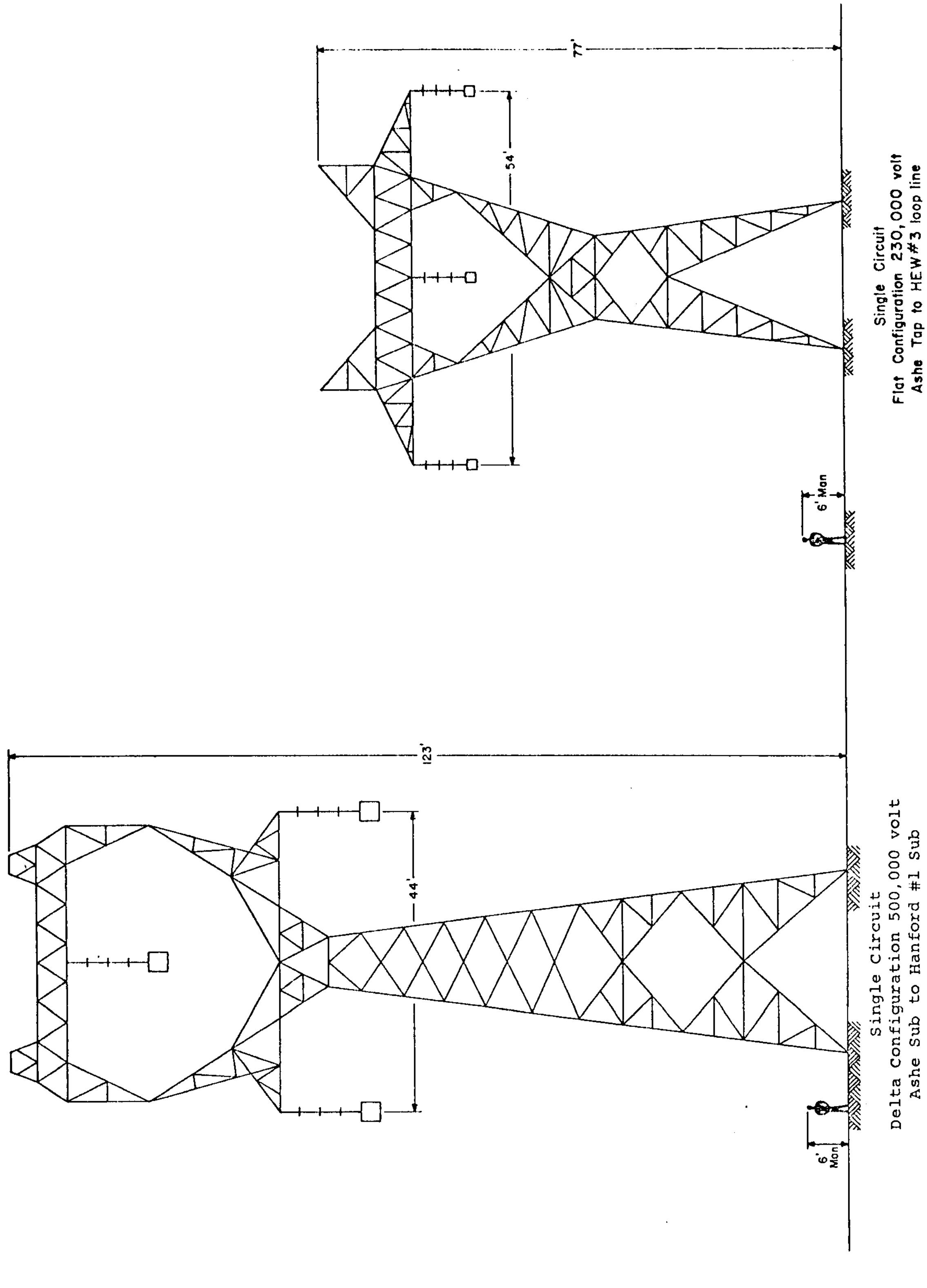
Capacity/conductor: I at 50°C rise over 25°C ambient with sum = 906 amps

AC Resistance:

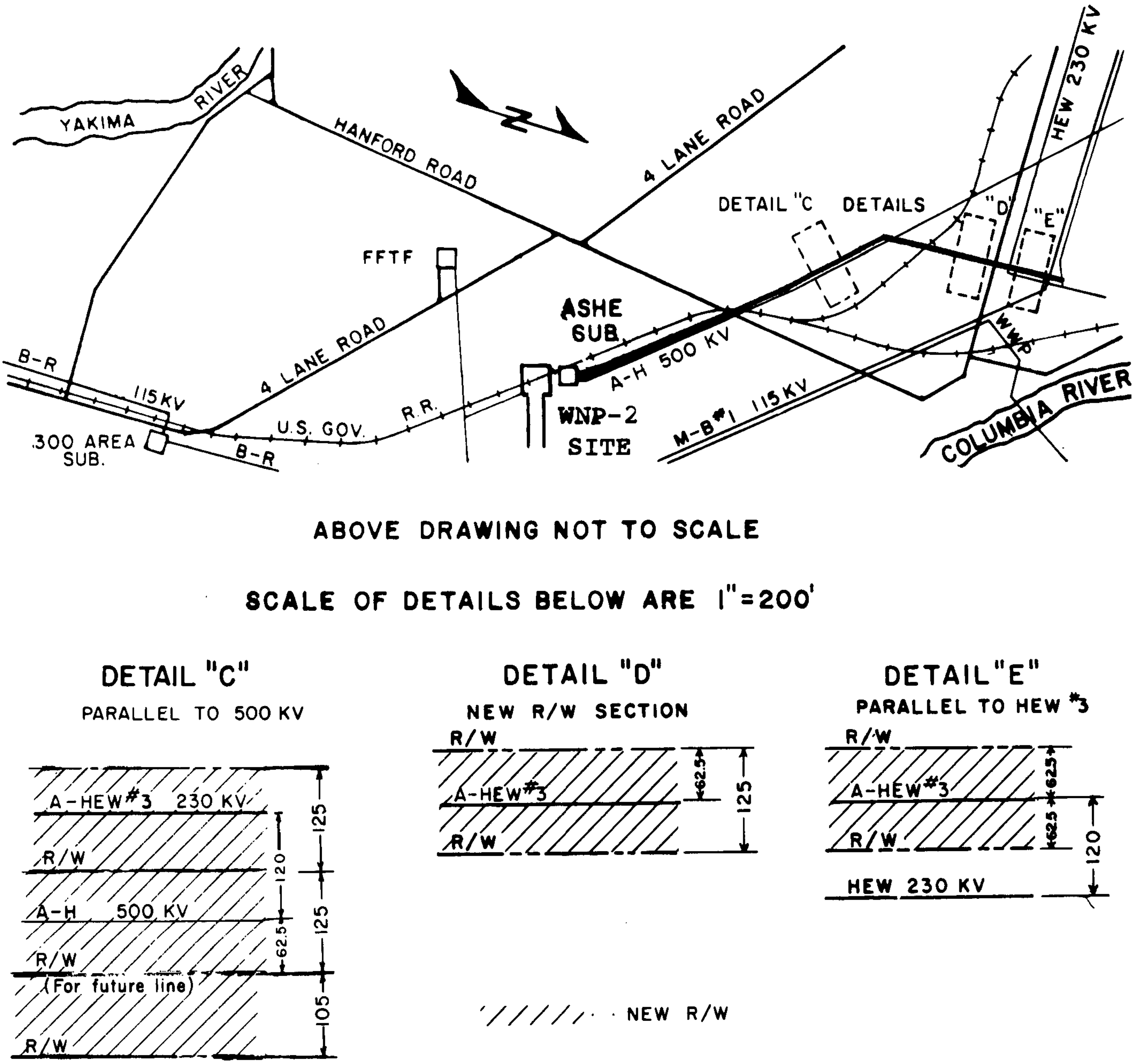
°Centigrade	25	50	75	80	100
ohms/mile	.1177	.1293	.1408	.1431	.1523



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	500 KV, 230 KV, 115 KV Power Layout
	FIG. 3.9-1



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	CONFIGURATIONS OF BPA TRANSMISSION TOWERS (1)
	FIG. 3.9-2



//////	·	NEW R/W
FFTF	· · ·	FAST FLUX TEST FACILITY
R/W	· · ·	RIGHT OF WAY
A-H	· · ·	ASHE – HANFORD #1
A-HEW#3	·	ASHE TAP TO HEW#3
B-R	·	BENTON – RICHLAND
HEW	· · ·	HANFORD ENERGY WORKS
M-B	· ·	MIDWAY – BENTON
WWP	· · ·	WASHINGTON WATER POWER

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	230 KV RIGHT OF WAY DETAIL MAP (1) FIG. 3.9-3

FIGURE 3.9-4
BONNEVILE POWER ADMINISTRATION'S H. J. ASHE SUBSTATION

CHAPTER 4
ENVIRONMENTAL EFFECTS OF
SITE PREPARATION

CHAPTER 4

ENVIRONMENTAL EFFECTS OF SITE PREPARATION, PLANT AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

Total construction activities associated with the WNP-2 project encompass approximately 353 acres of land entirely within the boundaries of WPPSS's leased property or the Hanford Reservation. The following is an approximate breakdown of the construction acreage required by the WNP-2 project.

Construction Activity	Approximate Acres
On WPPSS's leased property(1):	
Plant structures	4
Makeup water pumphouse + parking lot	16
Makeup water and blowdown pipe lines	15
Access road to makeup water pumphouse	11
Cooling towers and spray ponds	25
Other (parking lots, temporary buildings, etc.)	131
TOTAL	202
On Hanford Reservation (off of WPPSS property)(2):	
Ashe Substation + access road	51
500 KV line and access roads	63
230 KV line and access roads	37
TOTAL	151

Only a small percentage of the land area supporting the shrub-steppe vegetation types common to the Hanford Reservation will be disturbed.

Figure 4.1-1 is the WNP-2 construction schedule showing key dates of construction activities concerning major structures and auxiliary facilities. Figure 4.1-2 is a combined actual and estimated schedule of the WNP-2 construction work force.

4.1.1 Impacts on the Local Population

There is widespread public acceptance of nuclear installations within the communities surrounding the Reservation. Figure 2.1-9 shows the proximity of permanent population. These communities consist of a high percentage of people skilled in the engineering, construction, and operation of a wide variety of nuclear facilities. The construction of WNP-2 affects the local communities in a positive way by providing jobs for people living in the local communities (approximately 78.4% of the construction work force is from the Tri-Cities region[3]) and the prevention of displacement of the construction workers to other regions.

As shown in Figure 2.2-1 and Figure 3.1-1, the WNP-2 site is characterized by a sagebrush-bitterbrush vegetation and is designated as "unclassified." A letter[4] from the Benton County Office of the County Engineer states: "the use of that area, "WNP-2 site, "for the construction and operation of a nuclear generating project is consistent with zoning ordinances prepared by the Benton County Planning Commission."

The construction activities are far removed from inhabited areas, public roads, and from the FFTF site. There has been no measurable noise (except from the movement of trucks to and from the site) upon anyone other than the work force. Therefore, with the exception of localized construction and the normal dust and traffic problems associated with any large construction activity, the ecology of the area surrounding the site has not and is not expected to be significantly changed by construction. Upon completion of the work, a landscaping program will be implemented for the purpose of improving the aesthetics and preventing erosion at the site.

Specific discussions on past, present and future construction impacts on local land and water uses is discussed in the following subsections.

4.1.2 Construction Impacts on the Environment

4.1.2.1 Land Use

4.1.2.1.1 Past and Present Impacts

In July 1970, a lightning originated fire effectively removed the greater portion of the pristine vegetation on the site, leaving only a sparse ground cover with little wildlife present. Due to the relatively barren condition of the land, the construction of the WNP-2 plant has had minimal effects on land usage. Environmental effects relating to water usage have also been considered during all phases of site preparation and plant construction, and will be discussed in Section 4.1.2.2.

The construction site is in the early state of recovery from
the fire and provides limited food and cover for resident
wildlife. Construction activities, destroying the habitats
of small mammals (of which the pocket mouse is the dominant
species), has not had any measurable effect on the transitory
wildlife of the large shrubsteppe. The pocket mouse population 1
near the construction site has been monitored for three
years as part of the monitoring program for WNP-1/4.[6,7]
There has been virtually no change in the population during
that time. It appears that the pocket mouse is impacted
only if directly within the disturbed construction area.
The major disturbance and displacement of fauna in the area
occured as a result of the fire. The more productive shrub-
steppe and riparian habitats are remote from the site, and
construction appears to have had little influence on the
wildlife associated with these habitats.

Several temporary vegetation recovery study areas near WNP-2
are under investigation for grass and sagebrush regrowth.
(Nineteen thousand acres of its vegetative cover was burned
in July 1970.) These study areas (two burned and three
unburned plots) are located approximately within a mile of
the site in west, south, and east quadrants (see Figure
6.1-2). Knowledge from these studies applies to construction 3
impacts because the 1970 fire was extremely hot, destroying
virtually all plant life and all seeds which would have
normally germinated the next year. As with construction
areas, revegetation of these areas depends on new seeds
blowing in from unburned areas. Information on these plots
is contained in Section 6.1.4.3.

Following the range fire in 1970, the construction site had a sparse cover of annual vegetation in early successional stages, which has partially stabilized the soil and provides only a marginal habitat for resident wildlife. The exposed area is subjected to wind erosion and consequently blowing dust occurs frequently. Since the construction activities are not visible to the general public, they have no aesthetic impact with the possible exception of an incremental dust burden to the air.

Rainfall at the Hanford Reservation averages 6.25 inches per year. The surface soils are very permeable and minimal natural surface runoff occurs. Erosion control has been successfully accomplished by proper grading and terracing.

No known historical or archaeological sites are located within the WNP-2 site or the transmission corridors. During the construction period a competent archaeologist is employed and his expertise has been utilized during excavation activities. Archaeological sites south of the WNP-2 lease area along the river bank were roped off to avoid disturbance. A discussion of findings is presented in Section 2.6.

Sanitary wastes have been and will continue to be disposed of through septic tanks and tile fields supplemented by temporary chemical toilets. The chemical toilets are serviced, when necessary, by an outside contractor. This is in compliance with State of Washington Department of Labor and Industries Safety Standards for Construction Work, WAC 296-40-055 - Sanitary Facilities.

Separate wash facilities are housed in a heated building, and the waste water is disposed of through a drainage tile field. Waste flow from these facilities is estimated at 15-30 gallons per day per person. No adverse affects on the environment have been experienced.

Combustible construction scraps were initially burned in a burn pit approximately 1/4 mile east of the main plant but are currently being buried. Petroleum wastes have been accumulated in drums and disposed of off-site. Chemical wastes have been and will be accumulated in drums and returned to the manufacturer for disposal or otherwise disposed of in a manner determined to adequately protect the environment.

4.1.2.1.2 Future Construction Effects

Future work, off of WPPSS's property, includes the completion and erection of the transmission lines and their associated access roads. Section 4.2 describes their construction effects. Major construction still to be completed at the site includes those major items listed in Figure 4.1-1. Future work at the WNP-2 site will continue to be controlled by the Construction Impact Control Program (see section 4.5).

3

4.1.2.2 Water Use

4.1.2.2.1 Past and Present Impacts

In accordance with the site certification agreement with the
Thermal Power Plant Site Evaluation Council (TPPSEC), con-
struction activities involving work in the Columbia River
was to be limited to the period from July 31 thru October
15, 1975. During those months the river level and velocity
and migrant fish levels were low and construction impacts
would be minimal. However, additional work to return the
river bed to its natural contours required TPPSEC notifica-
tion and rip rap repair in the vicinity of the intake "T"'s
and the cooling tower blowdown line. This repair was performed
3 during February 11 to March 15, 1976. To reduce possible
biotic and water quality impacts during initial work and
repair work, the small gravel used for pipeline bedding was
screened and rip rap was placed by a clam shell. An assessment
3 of the construction effects is given in Reference 6.1-7.

The water used during construction has been pumped from on-site wells at an average withdrawal rate of approximately 25 gpm. This withdrawal rate has had no measurable effect on the ground-water profile, since ample recharge of the aquifer is available. 3

4.1.2.2.2 Future Construction Effects

There is no further construction or excavation scheduled to take place in the Columbia River. Well water withdrawal is not expected to exceed 10,000 gallons per day, and as experience has shown, no adverse environmental effects are expected. 3

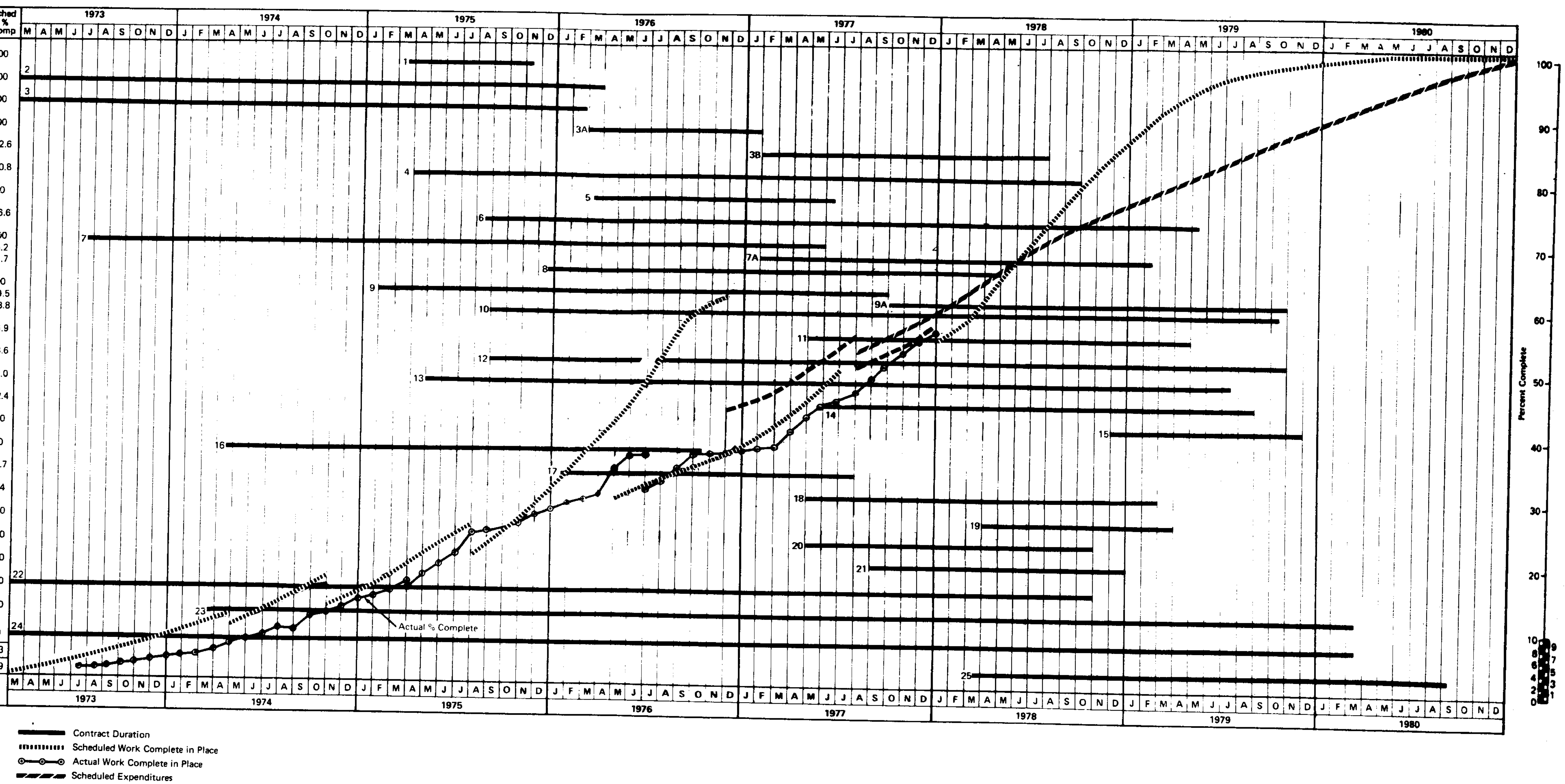
4.1.3 Final Site Construction and Restoration

Landscaping will serve both a functional and an aesthetic purpose. Suitable grasses and hedges will be planted to facilitate erosion and dust control plus the added benefits of the aesthetic appeal. Landscaping will integrate excess excavated materials (spoils) with the site contours to ensure runoff away from all buildings and auxiliary structures. In compliance with the WNP-2 security program, no landscaping is to be provided within an isolation area extending 20 feet on either side of the perimeter security line. Figures 3.1-2 and 3.1-5 are an artist's conception of the finished plant and makeup water pumphouse showing the landscaping and plant facilities.

BURNS AND ROE, INC.
CONSTRUCTION PROGRESS SUMMARY
WPPSS NUCLEAR PROJECT NO. 2

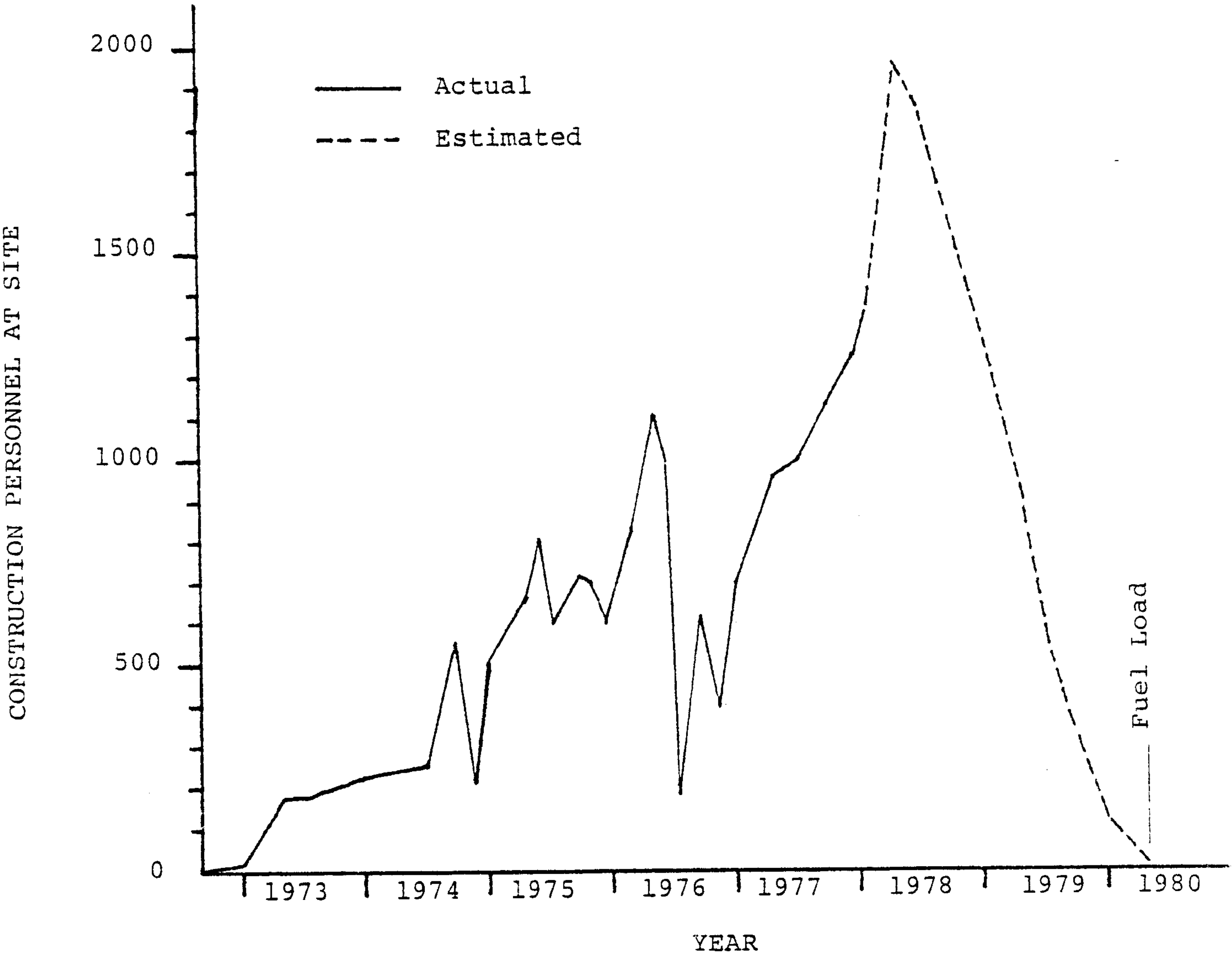
Status as of: December 23, 1977

Item No.	Contract Number/Description	Rel. Weight	Act % Comp	Sched % Comp
1	204 Field Fabricated Tanks	.0011	100	100
2	205, 208, 221, 224, 226, 230, 232 Complete	.0151	100	100
3	206 General Construction	.1452	100	100
3A	C6426 (250) General Construction (Interim)	.0399	100	100
3B	206A (251) General Construction (Final)	.0063	54.8	62.6
4	207 Structural Steel	.0029	50.8	50.8
5	209 Rigging of Reactor Pressure Vessel	.0027	100	100
6	210 Architectural Construction	.0151	61.2	66.6
7	213 Primary Containment Vessel	.0180	99.8	100
7A	213A Containment Vessel Retrofit	.0192	18.6	15.2
8	214 Turbine Generator Installation	.0208	81.6	91.7
9	215 Mechanical Equip. Install. & Piping	.1159	100	100
9A	215 Fit Mech. Equip. Install & Piping	.2222	8.2	9.5
10	216 HVAC & Plumbing Installation	.0315	39.7	43.8
11	217 Fire Protection System	.0031	7.9	6.9
12	218 Electric Installation	.1728	39.3	43.6
13	219 Special Coatings	.0036	42.4	46.0
14	220 Instrumentation Installation	.0164	2.5	2.4
15	222 Final Site Work	.0058	0.0	0.0
16	223 Cooling Towers	.0153	100	100
17	225 Make-Up Water Pumphouse	.0072	99.4	99.7
18	228 Communications Systems	.0015	1.0	5.4
19	229 Finish Painting	.0014	0.0	0.0
20	231 Security Systems	.0019	0.0	0.0
21	233 Spray Pond Piping	.0019	0.0	0.0
22	36 Production & Delivery of Concrete	.0061	98.0	98.0
23	74 Maintenance & Misc. Future	.0087	68.0	68.0
24	Project Contingency	.0420	0.0	0.0
	TOTALS	1.00	56.1	58.3
25	Startup Support – 550 000 Manhours		53.8	55.9



Amendment 1, May 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	CONSTRUCTION PROGRESS SUMMARY
	FIG. 4.1-1



Amendment 1, May 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	WNP-2 CONSTRUCTION PERSONNEL(5)
	FIG. 4.1-2

4.2 TRANSMISSION FACILITIES CONSTRUCTION

The effects of clearing the rights-of-way and installing transmission towers and conductors, on the environs and the people living in the adjacent area, are discussed in this section.

Bonneville Power Administration is constructing the Howard J. Ashe Substation and the WNP-2 500 KV transmission line and 230 KV start-up line entirely within the Hanford Reservation. Access to the Hanford Reservation is partially restricted and any construction activities by BPA will not have an effect on the general public.

BPA has submitted an environmental statement[1] discussing the Howard J. Ashe Substation and the 500 KV and 230 KV lines. The information for the following sections was taken from that document. Work on the 230 KV line took place from November 1975 to March 1976. Work on the 500 KV line is scheduled from January 1977 to January 1978. Work on the H. J. Ashe Substation was intiated during November 1975 with the substation to be energized in September 1976.

4.2.1 Clearing the Rights-of-Way and the Substation Site

4.2.1.1 Techniques

For construction purposes, sagebrush will be removed from the rights-of way only at the tower sites in an area of about 20 feet square for the 500 KV towers, 28 feet square for the 230 KV towers, and on main access roads. The total construction land requirements for the 500 KV and 230 KV lines amounts to approximately 100 acres. Sagebrush will be removed at tower sites to facilitate tower erection. Grass will be left growing on all portions of the rights-of-way to the extent possible. Construction of the substation will remove approximately 51 acres of sagebrush-bunchgrass/cheatgrass vegetation and associated wildlife habitat. The site is essentially level except for some local microrelief and only minimal grading will be required.

4.2.1.2 Impacts

A description of the standard mitigation measures that will be used during construction operations to mitigate impacts to the natural, cultural, and socioeconomic resources can be found in the BPA General Construction and Maintenance Program statement [2]. In addition to the General Construction and Maintenance Program statement, the publication entitled, "Environmental Criteria for Electric Transmission Systems" jointly published by the Departments of Agriculture and Interior, summarizes the measures that will be used to lessen visual impacts of transmission lines.

Where required, clearing will be by bulldozer; no spraying will be used to clear the rights-of ways. Section 4.2.4.3 discusses the effects of construction on identified endangered species, and Section 4.1 gives an estimate of land requirements during construction.

The corridors do not cross any streams or come near the Columbia River and the substation will be located approximately 3000 feet north of WNP-2 and 3 miles east of the Columbia River. Therefore, no environmental impacts on the river or streams will occur.

Clearing the transmission routes and the substation site will not create noise noticeable to the general public.

Erosion is discussed in Subsection 4.2.4.

4.2.2 Method for Erecting Transmission Line Structures

Construction of transmission lines involves establishment of temporary construction access roads for movement of materials and heavy erection machinery to construction areas; clearing vegetation, structures, and other obstructions on the rights-of-way that might interfere with construction of the transmission lines; burning or otherwise disposing of cleared vegetation; leveling areas necessary for tower sites and tower steel storage and staging areas; excavating for and installing tower footings; erecting transmission towers; stringing and tensioning conductors; construction of permanent maintenance access roads on and off the rights-of-way as dictated by terrain and other factors; and reseeding or otherwise revegetating disturbed soil areas where appropriate.

4.2.3 Access and Service Roads

A total of 16.4 miles of new access and service roads will be constructed. Ten and one-half miles of access roads will be on the rights-of-way, 5.5 miles will be off the rights-of-way, and 0.4 miles will be for the substation.

With the total length of the corridors being 20.9 miles, the remainder of the access roads will be comprised of existing access roads from other transmission lines and service roads from existing telephone lines. For example, through the sand dunes area, approximately 3 miles of an existing gravelled telephone access road will be utilized. Short spur roads to the individual tower sites will be necessary.

4.2.4 Environmental Effects

4.2.4.1 Erosion

Wind erosion potential of the sandy loam soil in this dry climate is extremely high. When vegetative cover is removed and soil is disturbed during construction and clearing of access roads and tower sites, wind erosion can be severe. In most areas, the fall germination of cheatgrass will re-stabilize the area in a few years. Blowouts, dunes, and other wind produced features found widely scattered across the area, however, attest to the chronic erosion potential in the absence of control measures.

The lines cross 3 miles of sand dunes. Some sand dunes are not stable due to lack of vegetation cover and construction will impact on these as well as on stabilized dunes with a high potential for additional erosion. Sand dunes are up to 30 feet high and capable of moving eastward at a rate of up to 1 foot per year.

In order to minimize wind erosion caused by construction as many existing roads as possible will be used and gravel will be used to cover the principal new access roads. If possible, spur roads will not be graded. Existing roads that are well gravelled seem to be very stable with little wind erosion. It has also been found that in a disturbed area such as temporary access roads, grass will establish itself within 1 to 2 years and again be capable of minimizing wind erosion.

3 4.2.4.2 Loss of Agricultural Productivity

The Hanford Reservation is owned and controlled by the Energy Research and Development Administration. The 500 KV and 230 KV transmission lines will be entirely within the boundaries of the Reservation. Most of the land (excepting Gable Mountain) is a shrub steppe with no other productive (agricultural and other) uses planned by ERDA. Therefore construction activities will have no foreseeable affect on agricultural productivity.

4.2.4.3 Fish and Wildlife and Endangered Species 2

Adverse effects upon resident wildlife including the sage grouse will be largely limited to the construction period. The routes do not cross any streams, therefore, aquatic life will not be affected.

Due to clearing of sagebrush from main access roads and tower sites, song birds, birds of prey, and upland birds within the vicinity will be temporarily disturbed and some habitat will be lost.

Sage grouse, although few in number, have been able to survive on the reservation due to the presence of exclusion areas and the lack of hunting.

The Bald Eagle is the only threathened animal species (Federal designation) to occur in the WNP-2 Site Area. The population on the Hanford DOE Site has increased over the years from five (5) birds in the 1960's to over 15 birds in the late 1970's. Eagles generally arrive during mid-November with a peak abundance occuring in late November through early February and begin to depart in mid-February. They do not nest in the area. There are no other Federally designated threatened or endangered animals or plants living in the WNP-2 Site area. The following threatened wildlife species 2
may at times appear along the corridors although their exact ranges are not known.

Species	Federal Status
Bald Eagle (*Haliaeetus leucocephalus*)	Threatened
American peregrine falcon (*Falcon peregrinus anatum*)	Endangered

4.2.4.4 Water Quality

The transmission routes do not cross any streams or rivers and the water table of the Hanford Reservation is well below ground level, therefore, construction activities will have no affect on the local water quality.

4.2.4.5 Noise

Due to the isolation of the transmission routes and the substation, construction will create no noise impacts upon the general public.

4.2.4.6 Historical and Archeological Sites

Neither the lines nor the substation is near any historical or archeological sites.

4.3 RESOURCES COMMITTED

The portion of the Hanford Reservation affected by WNP-2 consists of land mostly covered with sagebrush and desert grasses. This land is not currently being used for any productive purpose. In general, the land has no agricultural value without irrigation.

Approximately 30 of the 1,089 acres originally leased by WPPSS for WNP-2 will be utilized for plant operation. An additional 80 acres on the Reservation will be used as tower sites for power transmission lines, access roads and for a substation's land requirements.

Except for concrete (which would be considered lost for anything but sanitary landfill or similar use), much of the uncontaminated materials used for WNP-2 could be salvaged after decommissioning the unit. However, the cost of retrieving these materials would in some instances, far exceed the purchase price of new materials. Some components of the facility will have become radioactive through activation and/or contamination and thus, will essentially be irretrievably lost. Upon the inevitable decommissioning of WNP-2, the area (approximately 3.5 acres) occupied by the reactor facilities may be placed on permanent restricted use because of the residual concentrations of radioactivity that would result from operating the plant.

Air and water are resources which, during the construction of this project, will also be affected, but consumption will be minimal. Small quantities of liquid and gaseous effluents will be dispersed into, and diluted by, these two natural resources. Neither of these forms of effluents will render the the air and water unsuitable for additional use by man. In addition, capital resources were committed prior to and during construction. This resource should be totally recovered assuming the facility is operated throughout its planned lifetime. Some additional disturbance of the site has been necessary to accommodate materials, construction equipment, and temporary buildings during construction. This has been kept to a minimum consistent with appropriate safety, reliability, and environmental criteria. These disturbances do not represent an irreversible commitment of resources since the temporarily disturbed area will revert to its natural vegetative state within several years when these facilities are removed. The characteristics of the land for the site are representative of much of the adjacent underdeveloped land which is covered with sagebrush, bitterbrush, other alien weeds, and desert grasses. The land is not considered unusual, and in all probability would otherwise be undeveloped for many years. Thus, the use of this site involves no area of limited supply or unique potential. Construction of WNP-2 is having no significant impact on wildlife.

Native forms of wildlife, which may once have been present in this small area, have not been destroyed; rather they have been displaced to the vast expanses of the Hanford Reservation, much of which has remained essentially in its natural condition. Thus no net reduction in either the numbers or diversity of wildlife species has resulted from the construction of WNP-2.

4.4 RADIOACTIVITY

The scheduled fuel load for WNP-2 is March 1980. WNP-1 and
WNP-4 are scheduled for fuel loading during June 1982 and
December 1983, respectively. DOE's Fast Flux Test Facility
(FFTF), located approximately three miles from WNP-2 in a
southwesterly direction, is scheduled for fuel load in June
1979. It has been estimated that operation of this facility
1 will contribute a dose of about 10^{-3} mrem per year to individuals
at WNP-2.[3] Based on the projected construction force for
the last year of construction, the total dose to site personnel
would be on the order of 0.5×10^{-3} man-rem per year.

No past or future adverse effects of radioactivity from other nuclear power plants has, or is anticipated to affect the WNP-2 construction workers.

4.5 CONSTRUCTION IMPACT CONTROL PROGRAM

4.5.1 Controls

WNP-2 is located in a shrub steppe region, consisting of several shallow rolling hills, with the eastern extremity having a general slope to the river. Surface drainage is good due to the open and dry nature of the area (average rainfall is 6.25 inches per year) and sandy soil types.

During construction, contractors are required to maintain proper drainage and erosion control around the construction areas and especially in areas of excavation or fill. Controls are being employed to insure proper embankment slopes. These slopes were further recommended not to be cut steeper than one vertical on one and one half horizontal[1].

Borrow pits are prepared by grading to minimize wind and water erosion and to conform, where possible, to the natural topography. Any accumulation of precipitation within the excavation area are allowed to infiltrate into the permeable soils.

Site roadways are watered by sprinkler trucks as necessary to decrease the impact of windblown soil. Because of the remote location, there are no off-site impacts from dust and noise. 3

Combustible construction scraps are buried on site. Petroleum wastes are accumulated in drums and disposed off-site. Salvageable non-combustible materials (scrap metal, etc.) are accumulated and removed periodically from the site for recycling.

Sanitary wastes are disposed of through septic tanks and tile fields supplemented by temporary chemical toilets. The chemical toilets are serviced, when necessary, by outside contractors.

Landscaping and final site construction will serve to both control dust and improve the site aesthetics. Landscaping will integrate excess excavated material (spoils) with the site contours to ensure runoff away from all buildings and auxiliary structures. 3

4.5.2 Nature of Control Implementation

Control of the environmental quality protection requirements are implemented and maintained via two main methods:

a. written direction to contractors through specifications and correspondence; and

b. routine inspection of the site by a con-
3 struction management representative.

Construction activity impacts are controlled by the Site Certification Agreement between the State of Washington and WPPSS, the U. S. Army Corps of Engineers Construction Permit,
3 the U. S. Nuclear Regulatory Commission Construction Permit (No. EPPR-93), the Department of Energy, and the State Environmental Policy Act. The requirements of these legal entities and documents are implemented by the Supply System through auditable contractual agreements between WPPSS and contractors. Construction management personnel inspect construction activities to ensure contract adherence,
3 and the Supply System in turn audits the construction activities through periodic on-site inspection.

CHAPTER 5
ENVIRONMENTAL EFFECTS OF PLANT OPERATION

CHAPTER 5

ENVIRONMENTAL EFFECTS OF PLANT OPERATION

5.1 EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM

5.1.1 Effluent Limitations and Water Quality Standards

The Water Quality Standards of the State of Washington(1) classify the Columbia River from its mouth to Grand Coulee Dam (River Mile 595) as "Class A Excellent". Different water temperature standards are formulated for various reaches of the river. Since the WNP-2 plant is not expected to affect the water temperature of the Columbia River downstream of the Washington-Oregon border (River Mile 309), only the standards applicable for the reach from that point to Priest Rapids Dam (River Mile 397) are described here.

The standards specify that water temperatures, outside a specified mixing zone, shall not exceed 20°C (68°F) due in part to measurable (0.3°C) increases resulting from human activities and that temperature increases from human activities at any time shall not exceed $t = 34/(T+9)$, where t is the permissible increase and T is the water temperature in °C due to all causes combined. 2

Applicable guideline of 40 CFR Part 432.25(2) state that there shall be no discharge of heat from the main condensers; however, heat may be discharged in blowdown from recirculated cooling water systems or cooling ponds. This is allowed if the temperature of the blowdown water does not exceed the lowest temperature of the recirculated cooling water prior to the addition of the makeup water.

Discharges from WNP-2 to the river are controlled by the National Pollutant Discharge Elimination System Waste Discharge Permit (No. WA-002515-1) issued by the State of Washington in compliance with Chapter 155, Laws of 1973 (RCW 90.48) as amended and the Federal Water Pollution Control Act Amendment of 1972 (PL 92-500). The above incorporates by reference State of Washington Water Quality Criteria contained in Washington Administrative Code 173-201. The mixing zone specified extends from 50 ft upstream to 300 ft downstream of the discharge with lateral boundaries separated by 100 ft. Vertically the mixing zone extends from the surface to the river bottom. The discharge from WNP-1/4, located approximately 650 feet upstream, has a mixing zone of the same dimensions. 4

5.1.2 Physical Effects

5.1.2.1 Summary System Description

The heat dissipation system is discussed in detail in Section 3.4 and the thermal/flow characteristics of the blowdown and receiving stream are presented in Figure 3.4-4. Only a few of the operating parameters which determine the environmental effects of operation will be summarized in this section.

The waste heat generated by WNP-2 will be dissipated to the environment by two paths: 1) heat transfer to air through the use of mechanical draft wet cooling towers and 2) cooling tower blowdown discharged to the Columbia River.

The components of the cooling system which might have some effect on the environment are: 1) the intake structure, 2) the blowdown water discharge system, and 3) the cooling tower vapor plume. The environmental effects of these are discussed in the following subsections. Figure 2.4-6 depicts the
4 location of intake and discharge lines.

5.1.2.2 Intake Effects

The intake for the makeup water of the cooling system of WNP-2 will consist of two 42 in. diameter perforated pipes placed parellel to the river flow above the river bottom. The top of the pipes will be submerged below the water surface for the lowest regulated flow of 36,000 cfs. The maximum pumping rate will be 25,000 gpm (55.6 cfs) which is about 0.15% of the lowest regulated flow and 0.05% of the average river flow (120,000 cfs). The average makeup
4 water requirement will be about 15,500 gpm (34.4 cfs).

Detailed hydraulic model studies of the intake structure were done by Lasalle Hydraulic Laboratory.[3] These studies concluded that the perforated pipe inlet with an internal sleeve would give uniform flow distribution and would offer maximum protection to small fish during all operating conditions. At the maximum withdrawal rate of 12,500 gpm at each intake, the maximum inlet velocity at the external screen surface will be approximately 0.5 fps, but at
4 a distance of one (1) inch from the outer screen surface the velocity will be approximately 0.1 fps. It is noted that intake velocities will generally be below these values since the normal withdrawal rate will be approximately 7,730 gpm at each intake. Undesirable debris is not expected to pass through the outer perforations with these low velocities. A backwash system will permit low-velocity flow reversal. Riprap protection of the river bed has been provided to prevent scour around the intake. A buoy has been placed outboard of the intake to warn boaters and prevent damage to the boats and the intake structure. A previous evaluation of alternate intake systems concluded that perforated pipes placed above the river channel bed would provide the best alternative water intake system for a nuclear power plant on the central Columbia River considering potential environmental impacts and costs for construction, operation, and maintenance.[4]

5.1.2.3 Blowdown Discharge Effects

The blowdown discharge pipe is buried in the river bottom and has a 8 x 32 in diffuser outlet discharging perpendicular to the river flow direction and at an upward angle of 15° from the horizontal. The exit flow velocity will be
4 approximately 8.5 fps at the maximum blowdown rate of 6500 gpm and 3.5 fps at the average blowdown rate of 2585 gpm. Riprap has been placed around the discharge to prevent riverbed erosion.

River velocities were measured during 1972 near the location of the WNP-2 4
outfall. Surface velocities varied between 2.5 and 3.3 fps for river flows varying from 36,000 to 50,000 cfs. A river velocity transect was also made during March 1974, in which current meter measurements were made at three depths for four cross-river locations. Based on the Ringold gauging station, river flow during the survey was estimated at 130,000 cfs. Measurements in the vicinity of the proposed discharge for WNP-1 and WNP-4 indicated the river velocity to be about 4.2 fps and to be near constant with depth. Measurements made in December 1979 at the WNP-2 discharge location showed velocities of about 5 fps at a flow of 135,000 cfs.[5]

Mathematical predictions of the blowdown plume dispersion were conducted for a combination of conditions which are considered representative of a "worst case" situation.[6] The river flow was taken as 36,000 cfs, the minimum regulated flow. While this flow may be attained for short durations at Priest Rapids Dam, it will rarely, if ever occur, at the discharge site 45 miles downstream. Depth and velocity at the discharge are 4 feet and 2.5 fps, respectively. The ambient river temperature was assumed to be 20°C (68°F), the baseline maximum specified by water quality standards. Maximum blowdown, 6500 gpm, was assumed with a temperature of 28.8°C (82°F). This temperature corresponds to a wet bulb of 21.1°C (70°F). Historically, wet bulbs greater than 70°F have an annual frequency of occurrence of about 0.05% although such events occurred with a much greater frequency in 1975 (see Section 2.3.3).

To consider the additive effects of the future blowdown from WNP-1/4 it was 4
assumed that these units were discharging at the maximum combined rate of 15,500 gpm. The point of discharge is about 650 feet upstream from the WNP-2 outfall. It was also assumed that the WNP-1/4 plume centerline was carried directly over the WNP-2 discharge. A description of the thermal plume model and its assumptions is given in Subsection 6.1.1.1. Calculations are based on an eddy diffusivity of 4 ft^2/sec which was derived from a review of data from a dye dispersion study at the outfall site.[6]

Results of the mathematical simulations are shown in Figures 5.1-1 to 5.1-3. Under the assumed critical conditions, the temperature increase 300 feet downstream of the WNP-2 discharge is estimated to be 0.1°C (0.2°F) in the absence of a discharge from WNP-1 and WNP-4. Within 15 feet the temperature excess is 0.6°C (1°F). With the concurrent maximum discharge from WNP-1/4, the temperature increase at the end of the WNP-2 mixing zone is estimated to be 0.3°C (0.5°F), the limit specified by the water quality standards. The 1°F temperature excess is attained about 30 feet from the discharge. As shown in Figure 5.1-3, temperature increases of more than 0.3°C (0.5°F) are confined to a distance of about 20 feet on either side of the plume centerline.

The above predictions are for a combination of extreme conditions most likely to occur in late summer. Seasonal variation of meteorological and hydrological conditions will result in greater initial temperature excesses (blowdown temperature minus river temperature) at other times of the year (see

Figure 3.4-4). These higher initial temperature differentials would, however, be offset by the greater plume dilution associated with the higher river flow. Generally, at distances beyond the point of complete vertical mixing, the predicted excess temperature at a point downstream will vary directly with initial excess temperature and discharge flow and inversely with river depth and square root of river velocity.

4

Absolute river temperatures downstream from the discharge would be less than for the critical condition which was modeled. The maximum combined thermal load from WNP-2 and WNP-1/4 is expected to be less than 75,000 Btu/sec. This heat load would raise bulk river temperature less than 0.033°F at minimum river flow and by about 0.01°F under average flow conditions.

5.1.3 Biological Effects

5.1.3.1 Effects of Intake Structure

The effects of the intake structure upon aquatic biotic populations are expected to be insignificant. Only those small fish that cannot escape the approximate maximum intake velocity of 0.5 fps at the 3/8-in intake screen openings will probably be impinged and lost. Essentially all of the drifting biota occurring in the water column (phyto- and zooplankton, drifting insects, 4 fish fry or larvae) which are drawn into the intake structure will be killed. This loss, however, will be so slight in comparison to the total populations of these organisms in the river water passing the site that the loss will not 4 significantly affect the ecosystem. As noted in Subsection 5.1.2.2, the maximum water withdrawal will be less than 0.15% of the river volume at the lowest regulated flow of 36,000 cfs.

Sports and commercial fish species which may be affected are the whitefish (Prosopium williamsoni), steelhead trout (Salmo gairdneri), and salmon (Oncorhynchus sp.). The whitefish deposit adhesive eggs, thus only the drifting larvae may encounter the intake structure. Juvenile salmonids emerging from the gravel upstream from the intake structure may also be vulnerable to impingement; again, however, the fact that such a small volume is impacted renders the total impact minimal. The fact that most young salmon pass through the area of the intake structure during the spring runoff when flows are high further decreases their susceptibility to impingement.

The WNP-2 intake structure was inspected for fish impingement in December 1978 and May through December 1979. No fish were observed on the intake screens during the inspections.[5] Also, a fish entrainment study was conducted on 4 the WNP-2 intake system in May 1979 through May 1980. Analysis of 69 entrainment samples revealed no fish eggs or fish larvae.[5] During these tests the makeup water pumps were operated in a manner that approximated actual plant operating conditions.

5.1.3.2 General Effects of Thermal Effluents

Thermal effects of the WNP-2 blowdown discharge are expected to be negligible from either a thermal increase effect or from "cold shock". Thermal effects involve two factors: 1) the change in water temperature above or below ambient and 2) the duration of exposure of the organisms to the change in temperature. Because of its direct and/or indirect effects, temperature is a principal factor determining the suitability of a habitat for aquatic organisms. The introduction of heated water into an aquatic ecosystem will cause some biological changes with effects on metabolism, development, growth and reproduction, and mortality documented in the literature.[8,9] The tolerance of organisms to any thermal increment is species specific, depending on the magnitude of the thermal increment and the duration of the exposure, as well as previous temperature acclimation.

5.1.3.3 Thermal Effects on Periphyton

Periphyton communities in the Hanford reach of the river are typically at a subclimax level of growth, with turbulent riverflow and seasonally low water temperatures being factors limiting the biomass in the main channel.[10] In both the periphyton and phytoplankton populations, diatoms are the dominant forms. The discharge of heated water may cause an increase in the growth of periphyton in the immediate vicinity of the outfall in an area within the 2.5^{o}F isotherm, but such an effect is expected to be small and negated by loss from turbulent river flow. In Columbia River studies by Coutant and Owens,[11] thermal increments of 18^{o}F increased the standing crop of periphyton only during a short period in winter, with the domination by diatom species persisting. Patrick[12] reported that water temperatures less than 50 to 59^{o}F limited the growth and reproduction of phytoplankton populations dominated by diatom forms, while higher temperatures increased the biomass until the temperature of the water reached 84.2 to 86^{o}F. Temperatures exceeding 86 to 93.2^{o}F caused a measurable decrease in the number of species and population size as compared to that between 64.4 to 72.2^{o}F.

5.1.3.4 Thermal Effects on Benthos

The upper temperature limits for the majority of benthic organisms reported to occur in the Hanford reach of the river (see Subsection 2.2.2.5) appear to be in the range of 85 to 92^{o}F, with tolerance dependent somewhat on the species, stage of development, and acclimation temperature.[9] Curry[15] found the upper thermal tolerance of several families of aquatic dipterans to be temperatures between 86 and 91.4^{o}F. Caddisfly larvae, and stonefly and mayfly nymphs acclimated to 50^{o}F had a 96-hour median tolerance to temperatures ranging from 70 to 87^{o}F, with mayflies being the most sensitive species.[16] Becker[17] reported that caddisfly larvae acclimated to a river temperature of 67.1^{o}F had a 50% mortality (^{LD}50) after a 68-hour exposure to an 18^{o}F increment, whereas, mortality to temperatures 13.5^{o}F above ambient were insignificant. Thermal increase up to a temperature differential of 18^{o}F resulted in well-defined increases in growth for all of the species tested,[17] and Coutant[18] has reported a 2-week earlier emergence in heated zones as compared to ambient temperatures in the Columbia River.

5.1.3.5 Thermal Effects on Plankton

Although prolonged exposures to elevated temperatures have been reported to
affect the growth rate and species composition of phytoplankton and zoo-
plankton in the area of thermal discharges, the time interval in which
plankton will be entrained in the thermal plume is considered too brief to
4 cause significant changes. During low flow and with a 24°F temperature
differential at the point of blowdown, the time intervals in which organisms
would be exposed to temperatures greater than 2.5°F above ambient in the
4 WNP-1/4 plume and WNP-2 plume would be approximately 12 and 4 seconds,
respectively. These exposures are below those reported to have measurable
effects.(9,12,19)

The ecological consequences of thermal discharges on planktonic and benthic
organisms are expected to be negligible, with lethal effects, if realized,
being restricted to sessile benthic organims in an area of the initial mixing
(within 15 ft of the outfall), and any sublethal effects(18,20) to the small
area within the 2.5°F isotherm. Such changes would have no measurable
effect on the abundance and composition of food organisms in the stream drift,
and no impact on the fish resources.

5.1.3.6 Thermal Effects on Fishes

Temperature, through both direct and indirect action, is one of the important
parameters influencing the fishery resources in the Columbia River. The
anadromous fish, particularly the salmonids, are the fish with the greatest
4 sport and commercial value. A review of the tolerance and thermal require-
ments of fish indicates that, in the Hanford reach of the river, salmonids
are the species most sensitive to and directly affected by thermal dis-
charges.(21)

The Hanford reach of the Columbia River is used extensively as a spawning and
rearing area by chinook salmon and steelhead trout, as well as a major
migration route for other adult and juvenile salmonids. A description of the
salmon activities in the Hanford reach of the river is shown in Table 5.1-1.
Steelheads are essentially present throughout all periods of the year, with
spawning activity commencing from late March to June.(22) The optimum
temperatures most conducive to salmonid activities have been reported as: 45
to 60°F for migration, 45 to 55°F for spawning areas, and 50 to 60°F for
rearing areas.(19) The ambient water temperatures in the Hanford reach are
typically below the preferred levels in March and April during the initial
emergence of chinook fry, while temperatures during May and June are within
those levels reported optimum and the preferred temperature of juvenile
salmonids. The most critical period is during the months of July through
4 September, when temperatures rise into the upper zone of salmonid thermal
tolerance.

The thermal plume from the discharge of cooling tower blowdown does not
intersect with any reported spawning areas.(23) The nearest potential
4 salmonid spawning areas are approximately 3/4 mile downstream and 1000 ft east

of the plume centerline and the thermal increment in the river after mixing is expected to have no measurable effect on spawning or on the growth and development of egg and larval stages in these areas. In a study on the effects of temperature on varying developmental stages of salmon eggs and fry, no adverse effects were noted when the thermal increments were less than 2.9°F and only a slight increase in mortality was noted when temperatures averaged 4.9°F above a 5-year mean ambient water temperature in the Hanford reach of the Columbia River.[24] If minimum flow were to occur during the spring spawning period concurrently with the maximum initial temperature excess of 24°F, a differential of 1.2°F would occur approximately 100 ft 4
downstream of the outfall in an area where no spawning or rearing would be anticipated because of water turbulence and cobble substrate. The thermal increment at the nearest potential chinook and steelhead redds, as well as in areas within approximately 200 ft of the western shoreline, will be less than 0.05°F.

During movement in the main channel, juvenile salmonids could be involuntarily carried through the effluent plume, with their downstream velocity assumed to be essentially that of the riverflow, e.g., 2.5 to approximately 5 fps, during minimum and average flow rates. Figure 5.1-9 summarizes the average monthly thermal increment at the point of discharge and after initial mixing with respect to ambient river temperatures and the thermal requirements and tolerance of juvenile salmonids.[19,25] During May through September the temperatures of the receiving water will be above the upper incipient lethal temperature (69.8°F) at the point of discharge. However, even under worst-case conditions (periods of low flow, an ambient river temperature of 68°F, an effuent temperature of 82°F, and simultaneous discharges from WNP-1 and 4
WNP-4), temperatures in the receiving water would be below the upper incipient lethal temperature after a time interval of a very few seconds.

The preferred temperatures for juvenile salmonids are reported as 41 to 62.6°F.[22] Temperatures above 68°F are considered to be adverse for juvenile salmonids,[19] and 69.8°F is the upper incipient lethal temperature[25] (i.e., that temperature which will kill a stated fraction of the population when brought rapidly to it from a lower temperature, within an indefinite prolonged exposure). Brett reported that juvenile salmonids (five species of the genus Oncorhynchus), when acclimated to temperatures of 41 to 75.2°F, had a preferred temperature range of 53.6 to 57.2°F and avoided temperatures above 59°F except under conditions of feeding stimuli.[25] In the same study, the ultimate incipient lethal temperature was 74.8 to 77.2°F with juvenile chinook and coho exhibiting the greater thermal resistance. Figure 5.1-10 shows the geometric mean time for loss of equilibrium and death when juvenile chinook are exposed to temperatures above the ultimate incipient lethal temperature.[26] A minimum of 5.4°F below the ultimate incipient temperature has been recommended as the maximum allowable for juvenile salmonids "to avoid significicant curtailment of activity," with temperatures near 62.6°F considered the upper optimum temperature.[19] Mean survival time curves, based on a review of experimental data on the thermal tolerance of juvenile salmonid to variable temperature as a function of exposure duration and acclimation, have been summarized in a 1971 report.[19] Snyder and Blahm[27] reported that juvenile chinook salmon acclimated at 55°F exhibited no mortality within a 72-hour observation period after being suddenly exposed to a temperature of 70°F for 1 hour, while fish exposed to 80°F exhibited the first mortality after 100 sec of exposure. Juvenile chum salmon acclimated at higher temperatures (60°F) had no mortality when subjected to temperatures of 75°F; at a temperature of 80°F the first mortality was observed after a 44-min duration.

The recent study by Bush, Welch, and Mar[28] presents data relating preferred and suboptimal temperatures to the expected effects of increasing water temperatures upon Columbia River fishes. These data indicate that temperatures of 24°C (75.2°F), if present continuously, would erradicate the salmon species in the Columbia River and that temperatures of 32°C (89.6°F) would eliminate the remaining salmonids.

4 Although the temperature increments in the plume at the determined exposures are less than those reported to cause direct lethal effects, indirect effects have been reported to occur at sublethal thermal doses. In preliminary studies by Schneider[29] juvenile rainbow trout acclimated at 59°F were exposed to temperatures ranging from 68.8 to 86°F to determine the effect of sublethal thermal exposures on the vulnerability of juvenile to predation. Exposure to an elevated temperature of 69.8°F had no effect on the susceptibility of juveniles to predation. At temperatures of 71.6 to 73.4°F an exposure duration of 12 min was required to increase the vulnerability of juveniles above the control, while exposures for 2.5 to 4 min were required when temperatures were 80.6 to 82.4°F. In another study, the thermal dose (temperature and exposure duration) that first initiated differential predation was about 10 to 11% of that reported for the median dose for loss of equilibrium.[30] There was no evidence of an enhanced incidence or infection of C. columnaris disease in fish in areas below the thermal discharges from the early Hanford reactors as compared to areas not influenced by the thermal plumes.[30]

4 During periods of migration, adult anadromous fish would be expected to avoid the thermal plume and the potentially lethal temperatures associated with the areas of initial mixing. Ambient water temperatures which exceed 70°F are reported to impede or block adult salmonid migration.[19] During the periods of peak adult salmonid migration, the maximum cross sectional area of
4 the river which would experience thermal increases greater than 1°F, and would be expected to evoke an avoidance response, is less than 3% of the main channel during worst-case conditions, and assures free passage of adult migrants. Temperatures between 50 and 70°F were reported to cause no avoidance or blockage of migration near the confluence of the Snake and Columbia Rivers, whereas when the ambient temperatures exceeded 70°F, migration preference was in the lowest temperature zone.[19,27] In a study on the Hanford reach of the river, adult salmonid demonstrated a general preference for migration along the eastern shoreline (across the river from WNP-2 outfall) from Priest Rapids Dam downstream to Richland.[30] The study also indicated that the thermal discharges from the early Hanford reactors had no significant effects on migration.

From the above discussion, it is evident that temperatures considered to have lethal or sublethal effects on Columbia River fish will occur only very briefly in time and space in the area downstream from the WNP-2 discharge. From predictions of the near-field temperatures and incremental additions to the bulk river temperature (including the WNP-1/4 discharge), it is concluded that thermal effects upon the Columbia River ecosystem will be insignificant. 4

"Cold shock" is an additional concern at some nuclear power stations utilizing natural bodies of water as cooling sources. Cold shock problems stem from the sudden cessation of thermal discharge upon plant shutdown, since the thermal plume issuing from power plants acts as an attractant to aquatic organisms, particularly fishes. These organisms reside in the artificially heated waters for long periods, becoming acclimated to the elevated temperatures and, in fact, dependent on them for survival. Fish mortalities have occurred at a few plants following shutdowns and much effort has recently gone into devising ways to eliminate these fish kills. Cold shock is never expected to occur at WNP-2 because of its location on a swiftly flowing reach of the Columbia River. For fish to become acclimated to the warmer temperatures of the plume they would have to occupy these waters for several days, which is not expected to happen in the strong river currents. Fish populations downstream from the mixing zone, i.e., where the river has become thermally homogeneous, will experience temperatures that are essentially natural.

The only other aquatic community that might have a continuous exposure to the effluent and thus become acclimated to the higher temperatures is the benthic community. However, any impact on this population from cold shock would be minimal in terms of the aquatic community in the vicinity of the site since the potentially affected area is so small.

5.1.4 Effects of Heat Dissipation Facilities

5.1.4.1 Physical Description of Cooling Tower Plumes

The operation of mechanical draft evaporative cooling towers at the WNP-2 site will produce visible plumes of liquid water droplets under certain atmospheric conditions. These plumes will extend from the cooling towers to varying distances dictated by prevailing meteorological conditions.

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The models and assumptions used in assessment of the impact of cooling tower plumes are outlines in Subsection 6.1.3.2 and are presented in detail in Reference 31. These models and assumptions are conservative and overestimate the potential impacts discussed below.

Length of Elevated Plumes. Table 5.1-2 contains summaries of the annual percent persistence of plume length for operating mechanical draft cooling towers at the present site. The plumes are predicted to extend to distances on the order of 30 km on rare occasions. The highest frequencies occur between SE and SW, and between NNW and NNE.

Table 5.1-3 summarizes the persistences of plume lengths when the ambient air temperature is at freezing or below. This represents the total potential for icing by the elevated visible plume. Actual ice accumulation will be much less than these summaries indicate because of solar and artificial heating of surfaces.

The monthly persistences of plume lengths are given in Table 5.1-4 for all plumes and plumes during freezing conditions. The winter months clearly have the longest and most persistent plumes predicted. The shortest plumes are predicted for summer. In August the longest plume extends only to 8 km, compared to beyond 30 km in January.

Average predicted visible plume widths are given as a function of month and downwind distance in Table 5.1-5. The widest plumes occur in winter. The vertical dimension of the visible plume will generally be of the same order of magnitude as the width near the site, and as much as an order of magnitude smaller than the width at the longer distances.

Ground Level Effects. The frequencies of ground level interaction were calculated to evaluate the potential imapcts. Table 5.1-6 summarizes the results of these calculations. The only ground level interactions predicted were on the high bluffs agricultural area on the east side of the Columbia River (7 to 8 km NE to ENE of the plant). A 1 km wide arc receives 1 hour and 0.5 hour of fogging and icing, respectively. Such results may be sensitive to the assumptions used in the calculation. The effects of varying the plume rise and reflection factor terms were studied. These results are discussed in Reference 31.

Effect of Fogging and Icing on Commercial Operations. No ground level interactions of the visible plume were predicted at local airports. A few hours per year of elevated plume occurrence over the Richland and Kennewick airports were predicted. No elevated or ground fogging was predicted for the Pasco airport (known as the Tri-Cities Airport). The persistences at the Richland airport (18 km south) show no ground fogging and 14 hours of elevated plume occurrences in the annular segment containing the airport. If the impact in the sector is apportioned to the 2 km square area bounding Richland airport operations, then about 4 and 1 hours per year of elevated fogging and icing are predicted, respectively. Hence the actual interference is expected to be relatively small.

At distances as great as the Kennewick and Pasco airports, the direction estimates cannot be expected to be necessarily accurate, so it is reasonable to interpret the results as predicting several hours of fogging out to 30 km, which may or may not hit these targets.

The potential impact on local agricultural operations by the invisible plume was assessed. The atmospheric cooling tower plume is assumed visible out to the point where the lowest possible saturation point is reached. The further mixing with ambient air results in the concentrations within the plume being reduced towards the ambient air concentrations. The invisible plume consists of incremental increases in heat and moisture. Considering the very dry conditions indigenous to the summer season in this region (Table 2.3-1), any incremental effect of increased moisture is expected to have a positive effect on plant growth. The only exception to this is during the grain harvesting when low humidities are desired for drying the crops.

The invisible plumes from WNP-2 were considered in detail during the month of June. Later months tend to have lower humidities and June was considered a conservative choice of summer months. The evaluation considered plumes every 4 hours in the direction sectors clockwise between 45° and 135° at distances of 8 and 10 km. These represent the closest impact areas on the top of the bluff on the east side of the Columbia River.

The plumes considered represented about 1/4 of the total plumes. The maximum plume centerline change in humidity was at 8 km at 0400 PDST. This is given in terms of ambient humidities in Table 5.1-7. Even for this highest centerline value in the analysis, the increase at high humidities is only slight. The average centerline value of all cases is also given. Realistically a certain amount of wandering of the plume can be expected and these centerline values are considered conservative estimates. Hence, the increase in moisture is not believed to be a potential problem. Based on these results, the impact on local agriculture is expected to be small. The harvesting period of mid-July to the end of August has lower relative humidities and higher temperatures than any other time of the year. The above estimates show that even the maximum impact of the plume is only slight. Therefore, except in rare and very localized situations, the plume from the plant cannot be expected to interfere with harvesting operation.

Effect of Fogging and Icing on Traffic. The nearest public highway to the site is State Highway 240, which runs about 10 km southwest of the site. In this sector, no fogging or icing at ground level is expected to occur.

Other roads closer to the site are on the Hanford Reservation and access by the public is controlled. Workers traveling the project road to the FFTF site, to the Hanford operations, and to the WNP-1 and WNP-4 site will rarely if ever encounter ground level fogging or freezing.

Effect of Chemical Interaction. The WNP-2 cooling tower plumes are not expected to have any significant interaction with other pollutant sources. There are no major single pollutant sources in this region. The Hanford operation has several small fossil-fuelled plants serving specific Hanford facilities. Their impact on the region is very small as
1 evidenced by very low levels of ambient sulfur and nitrogen oxides. The fact that those sources are widely dispersed and mostly 9 to 18 miles from the the site indicates that the probability of the plumes interacting at any significant concentrations is extremely small. The small probability when coupled with the small probability of the plumes contacting the ground makes the likelihood of a surface impact insignificant.

5.1.4.2 Cooling Tower Drift Deposition

The potential impact from the cooling tower drift was estimated using methods and assumptions described in Subsection 6.1.3.2. Table 5.1-8 presents the results obtained. The first column lists distance from the cooling tower. The second column presents the gross salt deposition rate per year assuming the wind blows equally as often from all directions. (The salt deposition in this table refers to salts naturally occurring in the Columbia River water which is used as makeup water. The contribution of plant additives is small by comparison. The third and fourth columns contain estimates of deposition rates based on the observed maximum wind direction frequencies at the WNP-2 site and at the HMS site. The maximum wind direction frequency at WNP-2 was 9% from the south (drift to the north). The measurement elevation was 23 ft. At an elevation of 400 ft at HMS, the maximum direction frequency was 20% from the northwest (drift to the southeast).

The maximum direction frequency observed at the HMS 50-ft elevation (17%) is smaller than that at the HMS 400-ft elevation (20%), but is considerably larger than that at the WNP-2 23-ft elevation (9%). Since maximum salt deposition would be directly proportional to direction frequency, use of the HMS 400-ft data might be expected to yield an excessively conservative (high) estimate of salt deposition. In contrast, since plume heights were presumed to be between 330 and 1300 ft, use of the 400-ft direction frequencies is more reasonable than use of those measured at lower elevations.

The deposition rates in Table 5.1-8 are put into perspective by comparison to the amount of salt which could be added to soil through irrigation as shown in the last three columns. Locally, 48 in. of water is a reasonable annual average irrigation requirement.

The relatively high drift deposition at the 0.25- and 0.3-mile distances as compared to greater distances is due to wintertime high humidities which permit the larger diameter drift droplets to intersect the surface before significant evaporation takes place.

Patterns of salt deposition on the surrounding region were estimated using the wind direction frequencies from the onsite meteorology tower. These are given in Figures 5.4-11 and 5.4-12.

5.1.4.3 Effects of Heat Dissipation Systems, Salt Deposition, and Accumulation in Soil

The operation of cooling towers is expected to increase the concentration of salts in the soil profile. The salts originate in cooling tower drift droplets that are expected to be deposited on the soil surface, mostly in the near vicinity of the cooling tower. Due to low rainfall, salts are expected to remain in the root zone and with time their concentrations may build up to the point deleterious to the growth of plants.

The operational activities of the WNP-2 station are expected to have little effect upon game bird and mammal populations. However, the operation of the cooling towers may have an impact on nesting populations of shrub-steppe birds, especially the horned lark, western meadow lark, and the would occur from salt drift released from the mechanical draft cooling towers, especially from salt buildup in soils which in time may build up in the soil profile in concentrations of sufficient strength to prevent the growth of cheatgrass which presently provides the main vegetative cover.

The loss of cheatgrass and other vegetative cover probably would make the habitat unsuitable for the nesting of these birds. It is likely that vegetation loss, if it occurs, would be a gradual process and effects would not be noticeable during the early years of operation. The impacted acreage is likely to be relatively small, but extending beyond the limits of construction damaged habitat. If the postulated impact were detected it could be mitigated by temporary irrigation to flush salts below the root zone. The loss of habitat acreage associated with cooling tower drift, if it occurs at all, would affect the food chain described in Section 2.2.1 in a deleterious fashion. The magnitude of the impact is likely to be closely related to the number of acres affected.

TABLE 5.1-1

TIMING OF SALMON ACTIVITIES IN THE COLUMBIA RIVER NEAR HANFORD FROM L. O. ROTHFUS TESTIMONY IN TPPSEC 71-1 HEARINGS (Exhibit 62)

		Month											
Species	Fresh-Water Life Phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Spring Chinook	Upstream migration				X	X	X						
	Spawning												
	Intragravel development												
	Fresh-water rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Downstream migration			X	X	X	X						
Summer - Fall Chinook	Upstream migration						X	X	X	X	X		
	Spawning									X	X	X	
	Intragravel development	X	X	X						X	X	X	X
	Fresh-water rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Downstream migration				X	X	X	X	X	X			
Coho	Upstream migration								X	X	X		
	Spawning												
	Intragravel development												
	Fresh-water rearing	X	X	X	X	X	X	X	X	X	X	X	X
	Downstream migration				X	X	X	X					
Pink	Upstream migration												
	Spawning												
	Intragravel development												
	Fresh-water rearing												
	Downstream migration												
Chum	Upstream migration												
	Spawning												
	Intragravel development												
	Fresh-water rearing												
	Downstream migration												
Sockeye	Upstream migration						X	X	X				
	Spawning												
	Intragravel development												
	Fresh-water rearing												
	Downstream migration				X	X	X	X	X	X			

TABLE 5.1-2

ESTIMATED ANNUAL PERCENT PERSISTENCE OF ELEVATED VISIBLE PLUME LENGTHS

Direction	Distance (km) 1	2	4	6	8	10	14	18	24	30
N	3.79	3.68	2.62	1.75	0.63	0.21	0.12	0	0	0
-	3.12	2.75	1.50	0.43	0.13	0.02	0	0	0	0
NE	1.53	1.28	0.90	0.38	0.07	0	0	0	0	0
-	1.03	0.90	0.46	0.22	0.11	0	0	0	0	0
E	0.88	0.73	0.41	0.15	0	0	0	0	0	0
-	1.85	1.42	0.73	0.41	0.11	0	0	0	0	0
SE	2.74	2.18	1.51	0.87	0.35	0.23	0.06	0	0	0
-	4.11	3.65	2.59	1.14	0.26	0.04	0.04	0.04	0	0
S	3.78	3.32	2.36	1.19	0.51	0.17	0.17	0.17	0.09	0.06
-	3.32	2.96	1.87	1.37	0.48	0.02	0.02	0.02	0.02	0
SW	3.34	2.95	1.63	1.08	0.38	0	0	0	0	0
-	1.04	0.74	0.45	0.30	0.05	0	0	0	0	0
W	0.91	0.59	0.45	0.25	0.09	0	0	0	0	0
-	1.42	1.11	0.59	0.29	0.08	0	0	0	0	0
NW	1.45	1.22	0.88	0.42	0.06	0.06	0.06	0	0	0
-	3.67	3.09	2.20	1.10	0.28	0.06	0.06	0	0	0
Total	38.0	32.5	21.1	11.3	3.6	0.81	0.52	0.23	0.12	0.06

TABLE 5.1-3

ESTIMATED ANNUAL PERCENT PERSISTENCE OF
ELEVATED VISIBLE PLUME LENGTHS WITH THE AIR TEMPERATURE 0°C OR LESS

Direction	Distance (km) 1	2	4	6	8	10	14	18	24	30
N	0.72	0.72	0.69	0.69	0.41	0.12	0.12	0	0	0
-	0.10	0.10	0.10	0.10	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0	0
-	0.12	0.12	0.12	0.06	0.06	0	0	0	0	0
E	0	0	0	0	0	0	0	0	0	0
-	0	0	0	0	0	0	0	0	0	0
SE	0.42	0.42	0.41	0.41	0.29	0.23	0.06	0	0	0
-	0.28	0.28	0.28	0.17	0.12	0.04	0.04	0.04	0	0
S	0.77	0.73	0.73	0.54	0.37	0.17	0.17	0.17	0.09	0.06
-	1.16	1.03	0.81	0.63	0.20	0.02	0.02	0.02	0.02	0
SW	0.98	0.92	0.27	0.15	0.06	0	0	0	0	0
-	0.07	0.07	0.07	0	0	0	0	0	0	0
W	0.09	0.09	0.09	0	0	0	0	0	0	0
-	0	0	0	0	0	0	0	0	0	0
NW	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0	0	0
-	0.32	0.32	0.30	0.30	0.12	0.06	0.06	0	0	0
Total	5.09	4.86	3.93	3.12	1.68	0.69	0.52	0.23	0.12	0.06

TABLE 5.1-4

MONTHLY ELEVATED VISIBLE PLUME LENGTHS PERCENT PERSISTENCES

Month	Distance (km) for All Plumes 1	2	4	6	8	10	14	18	24	30
Jan	46.2	43.9	34.5	22.8	10.5	5.26	3.51	1.75	1.17	0.59
Feb	37.8	33.1	19.6	13.5	5.41	0.68	0	0	0	0
Mar	46.7	40.0	31.7	19.2	6.67	1.67	0	0	0	0
Apr	39.4	33.1	23.2	12.0	2.82	0	0	0	0	0
May	31.0	25.6	16.3	8.5	1.55	0	0	0	0	0
Jun	33.1	25.0	14.7	7.35	1.47	0	0	0	0	0
Jul	26.5	21.0	11.6	4.42	0	0	0	0	0	0
Aug	29.9	22.0	8.5	1.22	0	0	0	0	0	0
Sep	42.2	36.4	20.8	11.0	1.30	0	0	0	0	0
Oct	41.6	34.3	24.1	13.1	4.38	0	0	0	0	0
Nov	29.0	26.1	20.3	8.7	2.90	0	0	0	0	0
Dec	60.6	58.7	34.9	17.4	7.3	1.84	0.92	0.92	0	0
AVERAGE	38.0	32.5	21.1	11.3	3.6	0.81	0.52	0.23	0.12	0.058

Month	Distance (km) for Freezing Plumes 1	2	4	6	8	10	14	18	24	30
Jan	21.1	20.5	18.13	14.0	7.6	4.68	3.51	1.75	1.17	0.59
Feb	6.08	5.41	5.41	4.73	3.38	0.68	0	0	0	0
Mar	5.83	5.83	5.83	5.83	3.33	1.67	0	0	0	0
Apr	2.8	2.8	2.8	2.8	1.4	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	0	0	0
Oct	2.2	2.2	2.2	1.5	0.73	0	0	0	0	0
Nov	0.7	0.7	0.7	0.7	0.7	0	0	0	0	0
Dec	25.7	23.9	12.8	8.3	2.8	0.92	0.92	0.92	0	0
AVERAGE	5.1	4.9	3.93	3.12	1.68	0.69	0.52	0.23	0.12	0.058

TABLE 5.1-5

PREDICTED VISIBLE PLUME WIDTHS
IN METERS AS A FUNCTION OF MONTH AND DOWNWIND DISTANCE*

Month	Distance (m) 1000	2000	6000	14000	24000
Jun	120	130	185	0	0
Jul	110	125	155	0	0
Aug	105	115	110	0	0
Sep	130	150	180	0	0
Oct	130	170	260	0	0
Nov	175	200	275	0	0
Dec	165	175	310	(320)	0
Jan	180	200	305	350	(385)
Feb	170	195	265	0	0
Mar	155	185	270	(270)	0
Apr	145	170	230	0	0
May	125	150	215	0	0

* Values are averages of all nonzero values. Values in parentheses are based on three or less cases.

TABLE 5.1-6

SUMMARY OF FOGGING IMPACT ESTIMATES

Location	Distance Direction Height**	Average Plume Frequency* (Hours km) All	Average Plume Frequency* (Hours km) Ice	Average Plume Width (km) All	Average Plume Width (km) Ice
Richland Airport	20 km S				
	Groundlevel	0	0	0	0
	Plume centerline	1.6	1.6	0.38	0.38
Tri-Cities Airport (Pasco)	29 km SE				
	Groundlevel	0	0	0	0
	200 feet	0	0	0	0
	All plumes	0	0	0	0
Kennewick Airport	29 km S				
	Groundlevel	0	0	0	0
	All plumes	0.44	0.44	0.3	0.3
Top of Red Mountain	20 km SSW	0	0	0	0
Rattlesnake Hills High Areas	20 km WSW-SW	0	0	0	0
Rattlesnake Hills Slopes	11-17 km WSW	0	0	0	0
Bluffs Area on East Side of Columbia River	11 km N-NE	0	0	0	0
	7-8 km NE-ENE	1.0	0.5	0.2	0.2
	8-9 km E	0	0	0	0
	9 km ESE	0	0	0	0
	9 km SE	0	0	0	0
	10 km SE	0	0	0	0
FFTF	5 km SSW-SW	0	0	0	0
State Highway 240	10 km SW	0	0	0	0
300 Area Buildings	11 km SSE	0	0	0	0
Project Highways	3 and 6 km NW-WNW	0	0	0	0
Exxon Facility	14 km SSE	0	0	0	0
200 Area West Buildings	23 km WNW	0	0	0	0
200 Area East Buildings	14 km WNW	0	0	0	0
Top of Federal Building	20 km SSE	0	0	0	0
Gable Mountain	20 km NW	0	0	0	0
Top Hanford Meteorology Tower	20 km WNW	0	0	0	0

* Frequencies are given as the number of hours that fog was computed for 1 km arcs within the sectors. These arcs are defined as 1 km sections of circles with centers at the cooling tower and radii of the specified distances to the cooling towers.

** Groundlevel unless specified.

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TABLE 5.1-7

INCREASE IN RELATIVE HUMIDITY AT POINTS OF MAXIMUM POTENTIAL IMPACT

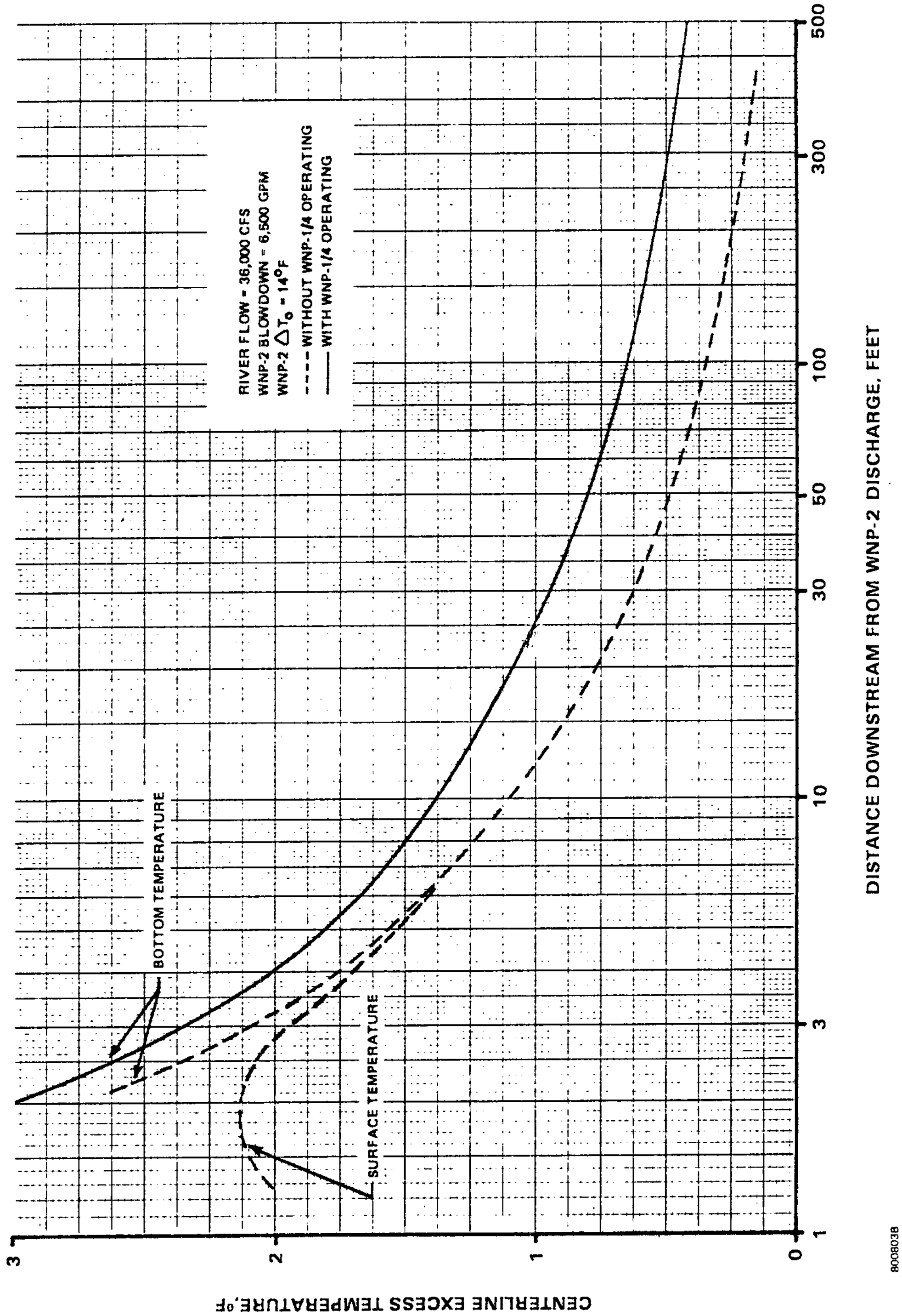
Ambient	0400 8 km	0400 10 km	All Hours 8 km	All Hours 10 km
90%	91.7	90.8	90.6	90.3
80	83.4	81.6	81.1	80.6
60	66.8	63.2	62.3	61.1
40	50.2	44.8	43.4	41.7
20	33.6	26.4	24.6	22.2

TABLE 5.1-8

SALT DEPOSITION RATE VERSUS DISTANCE

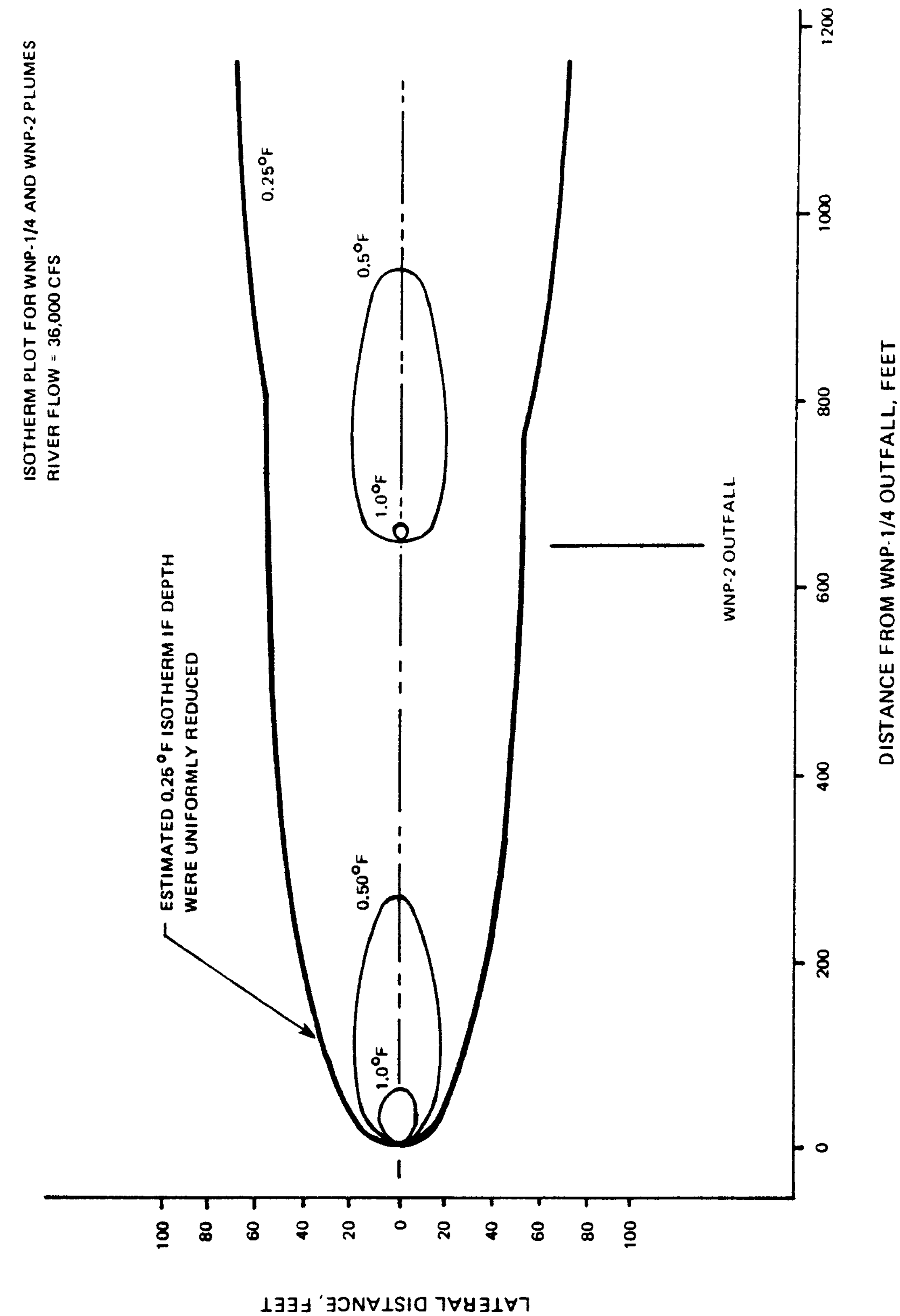
Distance from Tower (miles)	Salt Deposition (lb/acre yr)			% of Normal 48 in. of Irrigation		
	Equal Direction Frequency	9%(a) from Single Direction	20%(b) from Single Direction	Equal Direction Frequency	9% from Single Direction	20% from Single Direction
0 to 0.22	nil	nil	nil	nil	nil	nil
0.22 to 0.28	271.0	390.0	867.0	29.0	42.0	93.0
0.28 to 0.33	166.0	239.0	531.0	18.0	26.0	58.0
0.33 to 0.6	0.4	0.6	1.3	0.04	.06	0.13
0.6 to 3	0.7	1.0	2.2	0.07	0.10	0.22
3	0.7	1.0	2.2	0.07	0.10	0.22

(a) 16-point compass presumed. Maximum wind direction frequency observed at WNP-2 site was 9%. Measurement elevation was 23 ft.
(b) 16-point compass presumed. Maximum wind direction frequency observed at HMS site was 20%. Measurement elevation was 400 ft.



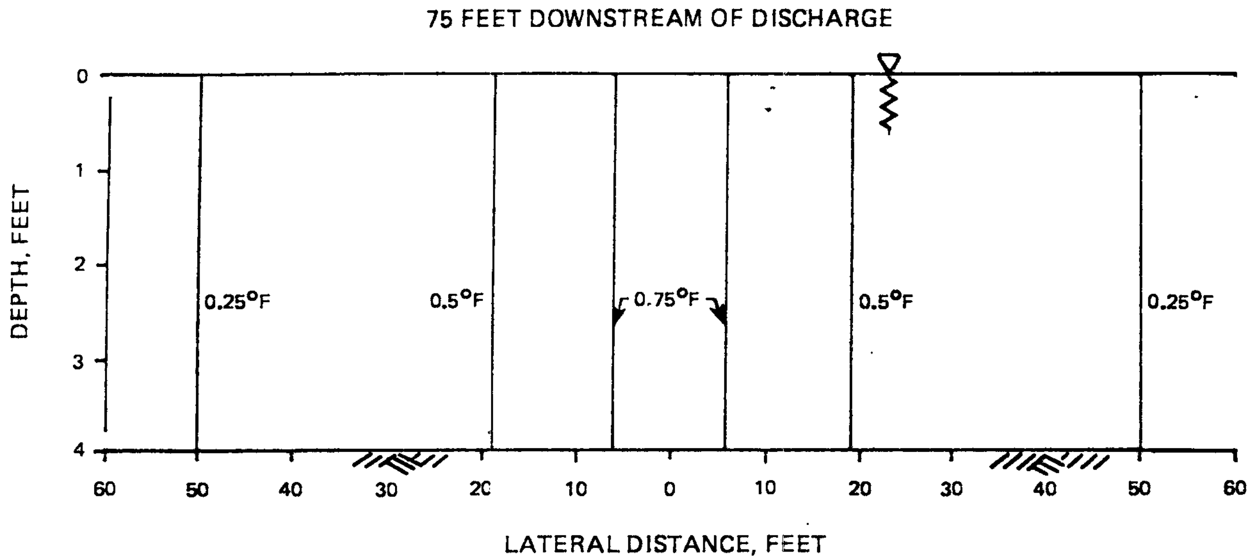
Amendment 4, October 1980

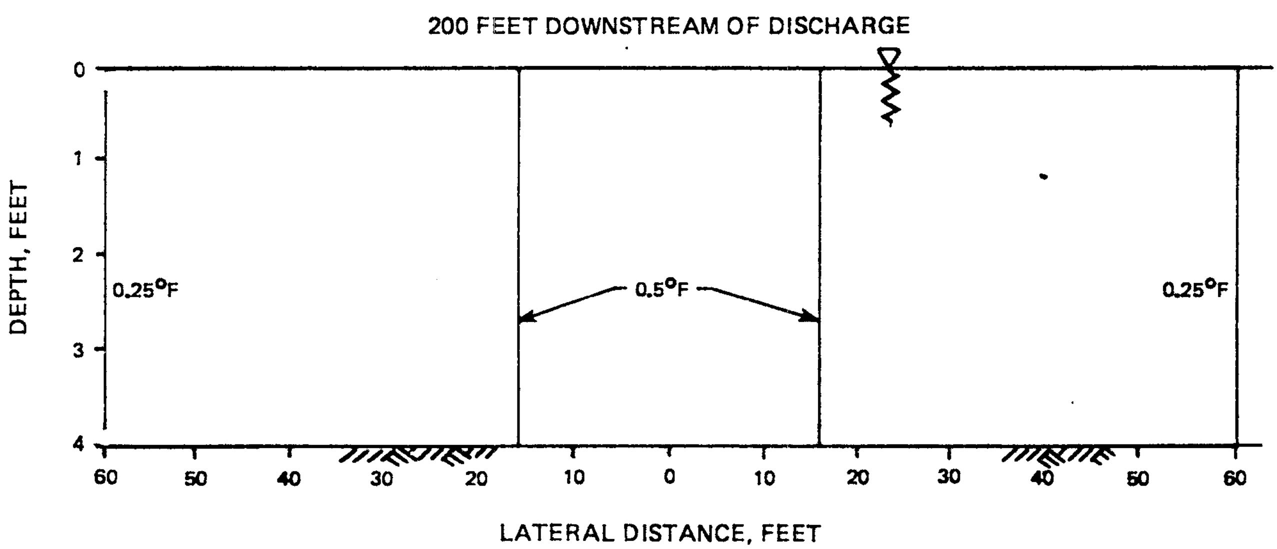
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	BLOWDOWN PLUME CENTERLINE TEMPERATURES
	FIG. 5.1-1



Amendment 4, October 1980

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PLAN VIEW OF WNP-2 & WNP-1/4 BLOWDOWN PLUME ISOTHERMS
	FIG. 5.1-2





Amendment 4, October 1980

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	CROSS-SECTION OF WNP-2 BLOWDOWN PLUME ISOTHERMS FIG. 5.1-3

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HINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report		
		FIG. 5.1-4

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WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report		
		FIG. 5.1-5

FIGURE DELETED

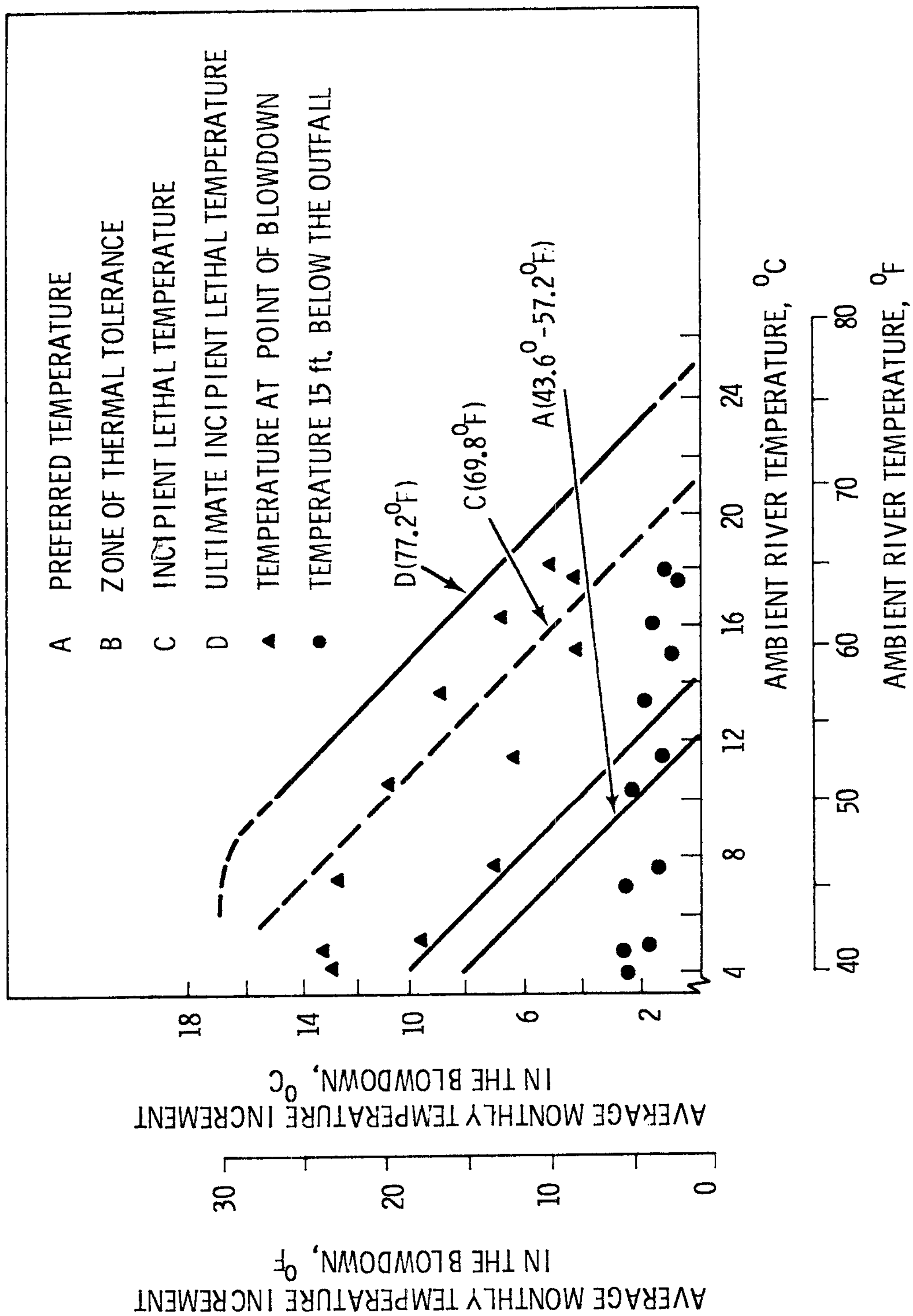
SHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report		
		FIG. 5.1-6

FIGURE DELETED

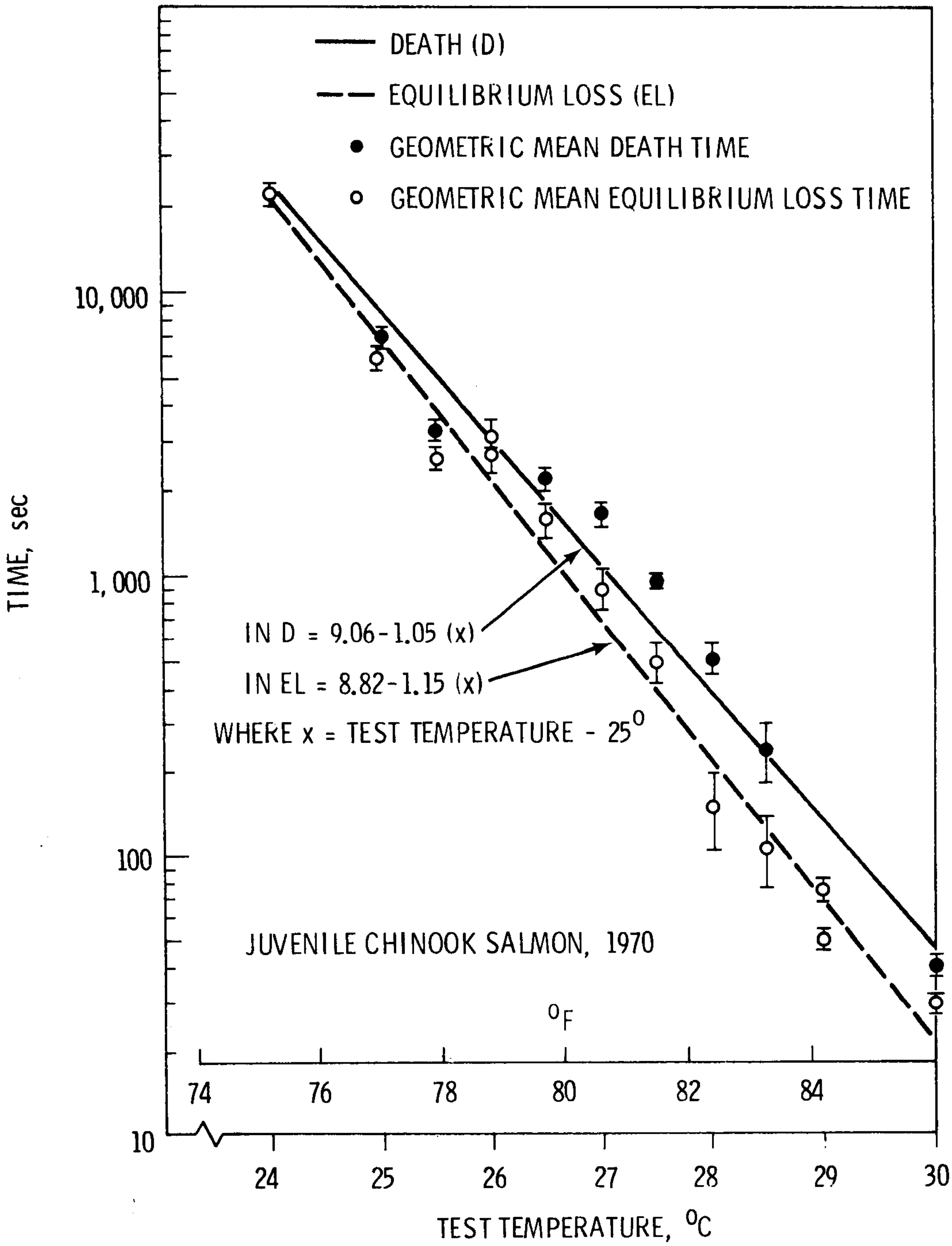
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report		
		FIG. 5.1-7

FIGURE DELETED

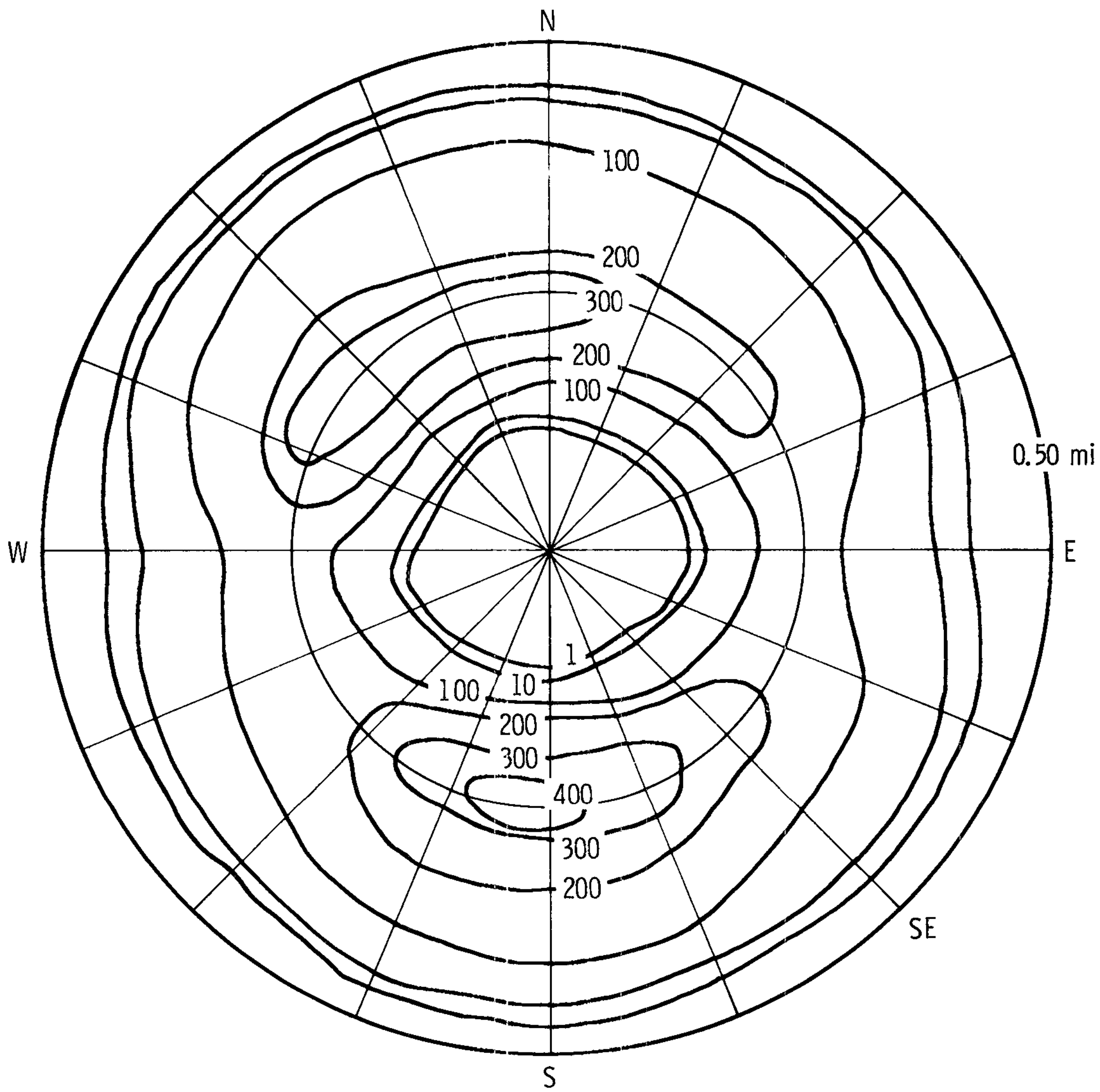
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report		
		FIG. 5.1-8



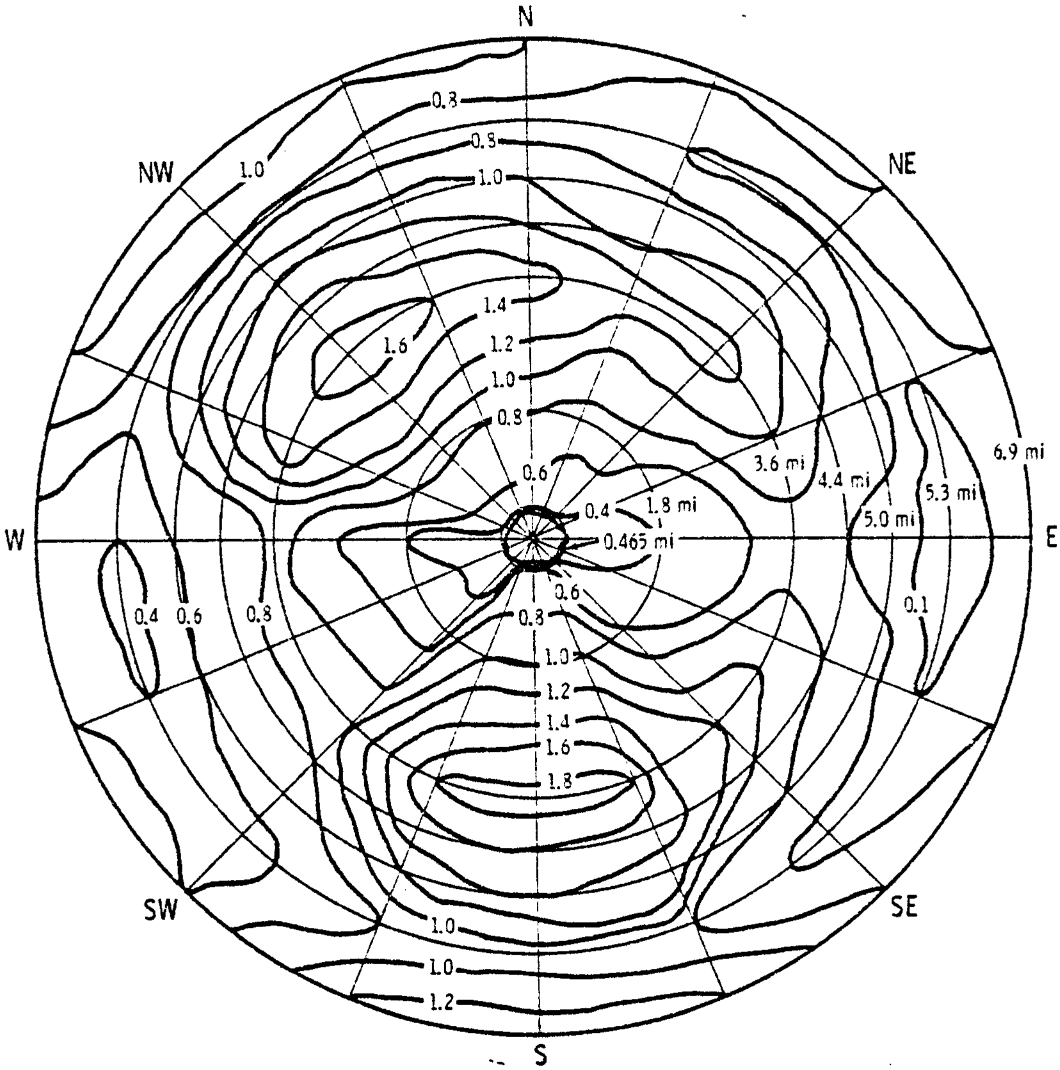
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SUMMARY OF TEMPERATURE EXPOSURE AND THERMAL TOLERANCE OF JUVENILE SALMONIDS
	FIG. 5.1-9



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	EQUILIBRIUM LOSS AND DEATH TIMES AT VARIOUS TEMPERATURES FOR JUVENILE CHINOOK SALMON R. E. Nakatani, Exhibit 49, TPPSEC 71-1 hearings
	FIG. 5.1-10



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SALT DEPOSITION PATTERNS OUT TO 0.5 MILE (lb/acre/yr)
	FIG. 5.1-11



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	SALT DEPOSITION PATTERNS OUT TO 6.9 MILE (lb/acre/yr)
	FIG. 5.1-12

5.2 RADIOLOGICAL IMPACT FROM ROUTINE OPERATION

During normal operation of any nuclear plant, radioactive material is generated. Regardless of the effectiveness of the advanced liquid and gas treatment systems it is a prudent design practice and an NRC design requirement that potential release paths be identified and any offsite effects evaluated. Details of the radwaste system and design assumptions regarding overall plant performance are described in Section 3.5 based on conservative[a] assumptions regarding fuel failures and system leakage. The system is designed to meet the requirements of Appendix I to 10 CFR 50 and applicable sections of 10 CFR 20. Radiological impact calculations have been performed in accordance with Regulatory Guide 1.109 or
3 models developed by Battelle Pacific Northwest Laboratories.

5.2.1 Exposure Pathways

The potential release paths considered in the design of this nuclear plant include releases to the atmosphere as a gas or vapor and release to the river. Radionuclides released to the atmosphere would be primarily noble gases, which would not be taken up by vegetation or animals. However, any radioiodine and particulates released may be deposited on or taken up by vegetation, from which they may enter into a food chain ending in man or other biota.

Radionuclides in liquid effluents would be available for uptake in algae and other water plants, fish, clams, and crustaceans living in the river. Radionuclides may be accumulated by these organisms to concentrations greater than in the surrounding water. Predators of the more simple organisms, such as small animals, fish and birds, may concentrate these nuclides still further. In addition, some radionuclides may be deposited with the silt on the river bottom and shoreline and lead to external exposure of biota; Figure 5.2-1 shows the exposure pathways to biota from WNP-2.

Radionuclides released into the plant liquid effluents reach man through a variety of pathways, involving both external exposure and internal exposure. Pathways of external exposure include such activities as swimming, boating and skiing on waters downstream from the plant, also hiking, fishing, etc., along the river shore. Pathways leading to internal exposure include the consumption of drinking water, fish and waterfowl from the river, produce from gardens irrigated

(a) In this context, "conservative" assumptions are those which will increase the expected release of radioactive material.

with river water, and animal products such as meat, eggs and milk from animals who eat irrigated feed or pasture grass.

Exposure via the airborne pathways includes both external exposure to skin and total body from the noble gases and internal exposure from inhalation of tritium, radioiodines and particulates released from the plant. Also, internal exposures may be received from the consumption of foods produced from vegetation on which radionuclides of plant origin may be deposited. Such foods include fresh leafy vegetables from local gardens and milk from cows foraging on pasture grass. In addition, direct exposure may be received from the transportation of fuel and radioactive wastes outside the plant boundary and from the plant itself. Figure 5.2-2 shows the exposure pathways to man from WNP-2.

5.2.2 Radioactivity in the Environment

Table 5.2-1 lists the amounts of radionuclides and the associated concentrations in a blowdown flow of 5.76 cfs. 1
A few feet downstream from the discharge point, the effluent will be diluted to 10% of its original concentration, while a few miles downstream the effluent will be entirely mixed in the river with a dilution of 1:20,000, assuming an average river flow of 120,000 cfs.

Table 5.2-2 lists the amounts of radionuclides that may be released to the atmosphere from WNP-2. Also listed in Table 5.2-2 are the associated concentrations in the effluent of WNP-2 which are discharged to the atmosphere. The effluent is then diluted further by prevailing meteorological conditions. Table 5.2-3 lists the annual average atmospheric dilution factors ($\overline{\chi}/Q'$) derived from 1 year of meteorological data collected at the site (see Section 6.1 for a discussion of the methodology and release point assumptions used to determine the χ/Q values).

Effluents from WNP-1 and -4 used to calculate radiation doses from those plants in this report were taken from Section 5.3 3
of the Environmental Report for WNP-1 and -4.

Table 5.2-4 lists concentrations of several radionuclides in various environmental media and foodstuffs. The nuclides listed were chosen because they may be important in terms of radiation dose to man.

3

5.2.3 Dose Rate Estimates for Biota Other Than Man

3 Using the source terms and assumptions in Tables 5.2-5, 5.2-6, 5.2-7, and models in Appendix II, doses were estimated for organisms living in or close to the water such a fish, clams, and crustacea which derive an internal dose from sorption of the water in which they live and from consumption of plankton.

External doses are received from the surrounding water and sometimes from the mud on the river bottom. Animals and birds, which prey on these smaller creatures, derive an internal dose from the radionuclides contained in their diet and external doses from air, water, and shoreline. Some geese reside near the Hanford Reservation most of the year. These birds do not consume aquatic food and so receive most of their radiation dose from external exposure to contaminated water or shoreline. Animals such as deer, coyotes, and field mice that do not consume aquatic food or spend much time at the river bank, will receive their dose through direct radiation from the plant's gaseous effluent plume, ingestion of terrestrial vegetation and external doses due to exposure to contaminated ground. The dose from inhalation of radionuclides and consumption of terrestrial vegetation will be small. Animals such as deer may receive an external dose rate of less than 1 mrad/yr from WNP-2 if near the plant boundary 50% of the time. A slight additional dose may be received by such animals due to grazing. Table 5.2-8 lists dose rates to biota associated with airborne and waterborne releases of radioactive material from WNP-2.

Numerous investigations have been made on the effects of radioactivity on biota. No effects have been observed at dose rates as low as those associated with the proposed WNP-2 effluents. Investigations of Chironomid larvae, bloodworms, living in bottom sediments near Oak Ridge, Tennessee, where they were irradiated at the rate of about 230 to 240 rad/yr for more than 130 generations, have shown no decrease in abundance, even though a slightly increased number of chromosome aberrations have occurred.[1]

Studies have shown that irradiation of salmon eggs and larvae from the Columbia River at a rate of 500 mrad/day did not affect the number of adult fish returning from the ocean or their ability to spawn.[2] Previously, when all the Hanford reactors were operating, studies were made on the effect of their released radionuclides on spawning salmon. These studies have shown that these salmon have not been affected by dose rates in the range of 100 to 200 mrad/week.[3]

Since the estimated doses to Columbia River biota from the radioactive effluents released by WNP-2 will be many times less than those mentioned in the above studies, no perceptible effect on the biota in the environs is expected.

5.2.4 Dose Rate Estimates for Man

Using the source terms and assumptions in Tables 5.2-5, 5.2-6, 5.2-7 and the models in Appendix II, doses were estimated for individuals living near the plant and for the population within 50 miles of the plant. Tables 5.2-9 and 5.2-10 summarize the annual radiation doses to an individual which could be attributed to WNP-2 only, and in combination with WNP-1 and WNP-4. 3

5.2.4.1 Liquid Pathway

People may be exposed to the radioactive material released in the liquid effluent from WNP-2 by drinking water, eating fish, eating irrigated farm products and by participating in recreational activities on or along the Columbia River.

Drinking Water

The population within 50 miles of the site utilizing Columbia River water for drinking includes the cities of Pasco and Richland. The city of Kennewick utilizes groundwater drawn from collectors placed along the Columbia River. Historically, the Kennewick city water has contained significantly lower concentrations of radionuclides of Hanford origin than the water in the Pasco municipal system immediately across the river. The water table slopes toward the river from the Kennewick highlands, channeling uncontaminated water into the aquifers adjacent to the river.

The cities of Richland and Pasco have efficient alum-floc water treatment plants capable of removing a significant fraction of the radionuclides in the incoming water. Samples of the water entering and leaving these two water treatment plants were collected and analyzed for several years under the AEC environmental monitoring program at Hanford. Results of these measurements have been used to define the removal efficiencies for specific radionuclides during the years 1960 through 1968. These data, which represent the fraction passing through the treatment plant, are summarized in Table 5.2-11 along with estimated[4] values for chemically similar nuclides not measured.

The Hanford Reservation 300 Area utilizes Columbia River water for drinking purposes also. This intake is located approximately seven(7) miles downriver from the WNP-2 discharge. The 300 Area also has an alum-floc water treatment plant which removes a fraction of the radionuclides. The water from the 3

plant is mixed with a significant portion of well water
3 prior to consumption. The concentration of radionuclides in
the river water used here is not expected to be significantly
different than that used in Richland or Pasco.

When estimating radiation doses, the radionuclide content of drinking water in the cities of Pasco and Richland was calculated from the annual releases (given in Table 5.2-1) diluted in the average river flow. The resulting concentrations in the river were then reduced by the factors in Table 5.2-11 and decayed for 24 hours travel time from the effluent discharge point downriver and through the water plant to the consumer.

Assuming a consumption rate of 2.0 ℓ/day of water, a typical
3 adult would receive a total-body dose rate of 1.7×10^{-5}
mrem/yr from this source. The total estimated population of
consumers in 2020 (75,000) drinking an average of 1.2 ℓ/day
3 would receive an integrated total-body dose rate 7.7×10^{-4}
man-rem/yr. The radiation dose rate to the individual adult
thyroid from consumption of 2.0 ℓ/day of drinking water was
3 estimated to be 9.0×10^{-5} mrem/yr.

Radiation doses due to consumption of river water were not
calculated for workers in the 300 Area of the Hanford Reservation
since they are not considered to be a critical group. These
individuals are in a restricted area where occupational dose
3 limits are applicable. Effluents from the WPPSS site could
contribute only a very small fraction of the occupational
exposure limits. Since most individuals working in the 300
Area live within 50 miles of the site, population dose
estimates due to plant effluents include these people when
they are not on the Hanford Reservation.

When WNP-1 and WNP-4 begin operation, the calculated radiation
dose to a typical adult in Richland or Pasco would be 1.8×10^{-3}
mrem/yr to the total-body. The calculated population total-
3 body dose is 8.0×10^{-2} man-rem/yr.

Fish and Waterfowl

Because fish will concentrate most radionuclides from the water they inhabit, the potential radiation dose from consumption of Columbia River fish was estimated for both the individual and the population within 50 miles of the plant. There is some waterfowl hunting around the perimeters of the Hanford Reservation. Some of these waterfowl could conceivably derive part of their diet from fish or aquatic plants from water downstream of the plant, but most waterfowl eaten by people (i.e., ducks and geese) consume primarily grains.

Based on the assumptions found in Table 5.2-6[5] the internal dose rate to the individual fisherman would be 2.2 mrem/yr to his total body due to effluents from WNP-2. Integrated dose rate to the population would be 3.9×10^{-4} man-rem/yr from fish consumption. After WNP-1 and WNP-4 have begun operation, the fisherman would receive a total-body dose of 2.3 mrem/yr. The total-body dose rate to the population would be 4.3×10^{-4} man-rem/yr. The radiation dose to an individual due to consumption of waterfowl will be insignificant.

Water Recreation

Aquatic recreation is a popular pastime in the stretch of the Columbia River below the plant site. Swimming, boating, water skiing and picnicking along the shore or on islands could result in small incremental doses to the local population.[6] Using the assumptions listed in Table 5.2-6 the total-body dose rate to an individual from external exposure would total about 9.3×10^{-2} mrem/yr. The population dose received during water recreation activities[6] can be estimated on the basis of the assumptions listed in Table 5.2-6. Under these conservative assumptions, the integrated population dose rate from water sports would be 3.0×10^{-4} man-rem/yr, principally from exposure to the contaminated shoreline.

No detectable increase in radiation dose will result from this pathway when WNP-1 and WNP-4 begin operation.

Irrigated Farm Products

Estimates were made of doses derived from consuming food products produced on farms and gardens downstream from the plant using irrigation water from the river. It was assumed the individual will eat food that will be grown directly under such irrigation plus eggs, milk, and meat from animals consuming feed grown under irrigation. Table 5.2-12 lists the food paths considered along with some typical parameters used in the calculation of the dose to the individual. The dose to the population was estimated using these assumptions, except that the consumption rates were reduced by one-half. The holdup is the period between the release of the radionuclides and deposition on the ground or on plants plus any time periods between harvest and consumption. In the case of eggs, beef or pork, when the animal will eat grain, the holdup also includes the time between the grain harvest and its consumption by the animal as well as the time between the slaughter of the animal (or egg laying) and consumption of the animal product by an individual. For the forage-milk pathway, the holdup includes the time between irrigation of plants and consumption by the cow as well as the time between milking and consumption of milk by an individual. The dose rate estimated to the total-body of an individual from the consumption of all 13 food types which are irrigated is 5.9 $\times 10^{-5}$ mrem/yr. 3

At the present time, the nearest point at which Columbia River water is withdrawn for irrigation of farm products downstream of the site is at the Taylor Flat area, approxi-
3 mately 4.2 miles ESE of the plant. A second point of withdrawal is the Riverview District of Pasco. Other irrigation water used either adjacent to the site or in the Kennewick area comes from the Grand Coulee Dam area or the Yakima River. Water use at Taylor Flat is for irrigation of an estimated
3 300 acres of hay crops. The total land available for irrigation in the Riverview District is about 5300 acres.[7] It is doubtful that this amount of land could produce food for more than a few thousand people. Since some additional irrigation occurs near Burbank using Columbia River water, it was conservatively assumed that a maximum of 10,000 persons could consume irrigated food products for this population dose estimate. The point at which water is taken from the river for irrigation in the Riverview District is about 12 miles from the plant outfall. This coupled with the fact that there are several islands between the outfall and the point of withdrawal will give complete mixing of all effluents in the river. From these assumptions the annual whole-body dose to the population from irrigated food products is estimated to be 1.6×10^{-4} man-rem. When WNP-1 and WNP-4 begin operation, the radiation dose to an individual from this pathway will be 2.3×10^{-3} mrem/yr to the total-body. The annual total-body population dose would be 8.0×10^{-3} man-rem/yr.

5.2.4.2 Gaseous Pathways

People may be exposed to radioactive material released to the atmosphere by WNP-2 via inhalation, air submersion and ingestion of farm products.

Air Submersion

Maximum offsite exposures occur in the southeast sector. An
3 individual located 0.5 miles from the plant could recieve a total-body dose rate of 6.7×10^{-4} mrem/hr while his skin dose would be 1.2×10^{-3} mrem/hr. However, since the location is now on Federally-owned land (the Hanford Reservation), the general public would not ordinarily be allowed access. A more probable location for occupancy by the general public
3 would be a point just offshore from the plant about 3.5 miles ESE, where a fisherman might fish from a boat. Here the atmospheric dilution factor at the shoreline is the greatest, 3.0×10^{-7} sec/m^3. The external total-body dose rate to the fisherman at this point is estimated to be 5.4×10^{-5} mrem/hr.
3 An avid fisherman remaining here 500 hr/yr would receive an annual total-body dose of 2.7×10^{-2} mrem; his skin dose would be approximately 4.8×10^{-2}.

At present the closest point to the plant at which people reside is across the river at Ringold Flat, approximately 4 miles ENE of WNP-2. However, the atmospheric dilution

factor is greater at the second closest residence across the
river at Taylor Flat. Airborne radiation doses were estimated
for an individual occupying this location (Taylor Flat) all
year. The atmospheric dilution factor was estimated to be
2.6×10^{-7} sec/m^3 at this location. The total-body and skin
dose rates from external radiation were estimated to be 0.14
mrem/yr and 0.28 mrem/yr, respectively. When WNP-1 and 3
WNP-4 begin operation, the individual at Taylor Flat would
receive 0.17 mrem/yr to the total-body and 0.69 mrem/yr to
the skin.

The annual total-body air submersion dose to the estimated
2020 population residing within a 50-mile radius of the
plant was estimated. Table 5.2-13 shows that the estimated
270,000 persons living within the region in 2020 would
receive an annual external dose of only 1.6 man-rem from the
radioactive gaseous effluents released into the atmosphere
by WNP-2. With the later addition of WNP-1 and WNP-4, a
total-body dose would increase to 2.1 man-rem/yr.

Inhalation

An individual residing at Taylor Flat would receive a dose
to the total-body of 8.1×10^{-4} mrem/yr due to inhalation of 3
radioiodines and particulates and absorption of tritium
through the skin. The radiation dose to the thyroid of this
individual would be 7.8×10^{-2} mrem/yr. The fisherman
located 3.5 miles from the plant for 500 hours during the 3
year would receive a total-body dose of 5.1×10^{-5} mrem/yr
via this pathway. The annual total-body radiation dose to
the population within 50 miles of WNP-2 due to inhalation/
transpiration would be 2.3×10^{-2} man-rem.

When WNP-1 and WNP-4 begin operation, an individual at
Taylor Flat would receive a total-body dose of 4.4×10^{-3}
and a thyroid dose of 9.5 x 10-2 mrem/yr. At that time, the
annual total-body radiation dose to the population would be 3
0.10 man-rem/yr.

Farm Products

Estimates were made of radiation doses received from consum-
ing farm products produced in the vicinity of the plant
which might be affected by airborne effluents. Table 5.2-12
lists the 14 food items considered along with some typical
parameters used in the calculation of dose to the individual.
The dose to the population within 50 miles of the site was
estimated using these same assumptions, except that the
consumption rates were reduced by one-half. The dose rate
from this pathway for an individual residing at Taylor Flat
would be 8.9×10^{-3} mrem/yr to the total-body and 1.8 mrem/yr 3
to the thyroid.

For the population dose estimate, it was assumed that all land not on the Hanford Reservation or in an urban area could be used for agriculture and that the entire population within 50 miles (270,000) might eat food grown in this area. Using these assumptions, the annual total-body dose to the
3 population from this pathway would be 6.9×10^{-2} man-rem/yr.

When WNP-1 and WNP-4 begin operation, an individual at Taylor Flat would receive a dose rate to the total body of
3 4.4×10^{-2} mrem/yr and 2.2 mrem/yr to the thyroid. The total-body dose rate to the population at that time would be 0.27 man-rem/yr.

Milk

The air→grass→cow→milk pathway, which for some nuclear plants is quite critical because of milk cows actually pastured on or near the fenceline, is of less importance for these projects because cows are not pastured very close to the plant. Since the plant is on DOE property and natural pasture is sparse, it is very unlikely that milk cows would be pastured at the fenceline in the foreseeable future.

The closest point at which a milk cow is now pastured is
3 across the river 4.3 miles southeast of the site at Taylor Flat. The atmospheric dilution factor at this location is estimated to be 2.6×10^{-7} sec/m^3. The estimated thyroid dose rate to
3 an infant consuming 1 ℓ of milk each day from cows pastured 9 months of the year at this farm would be 9.0 mrem/yr. The dose rate to an adult consuming the same amount of milk
3 would be 1.2 mrem/yr.

When WNP-1 and WNP-4 begin operation, these doses would
3 increase to 11 mrem/yr to an infant's thyroid and 1.4 mrem/yr to an adult's thyroid.

5.2.4.3 Direct Radiation From Facility

Radiation From Facility

Wastes from WNP-2 will be stored in tanks within concrete buildings so that radiation levels to workers within the plant boundaries will be below applicable standards. In addition, tanks containing low levels of activity will be situated and shielded to reduce dose rates at the site boundary to very small levels. Since the plant is located inside the Hanford Reservation it is not expected that the general public will be close to the plant site long enough to receive any measurable radiation exposure from turbine shine.

Construction workers at WNP-1 and WNP-4 will receive some radiation dose due to the operation of WNP-2. If an individual were to work 0.5 miles from WNP-2, he would receive a total-body dose of 2.5 mrem/yr from N-16 turbine shine.[10] This worker would also receive about 0.7 mrem/yr due to the airborne release of radioactive material from WNP-2. When WNP-2 begins operation, approximately 3200 construction workers will be building WNP-1 and WNP-4. If these workers are located an average of 1 mile from WNP-2, the total-body radiation dose to those workers would be 4.4 man-rem/yr.

Transportation of Radioactive Materials

Since the locations of fuel fabrication plants, reprocessing plants and waste disposal facilities have not been determined, transportation routes have not been decided. However, a generic study[8] has estimated that radiation dose rates to the general public from transportation of radioactive materials will not exceed 5 man-rem/yr per 3
unit. It is expected that the value estimated from the actual routing of the plant's radioactive material transport will be lower than this since much of the route will be through sparsely populated regions of the western United States or the waste may not be transported outside of the Hanford Site. 3

5.2.5 Summary of Annual Radiation Doses

Table 5.2-14 lists the annual radiation doses received by individuals residing near the site from the major pathways. It is conceivable that one individual residing at Taylor Flat could be exposed simultaneously via several pathways. If this individual were an avid fisherman, drank milk from the nearest cow and ate farm products affected by plant effluents (liquid and airborne), he might receive a total-body radiation dose of 2.3 mrem/yr, a thyroid dose of 2.4 mrem/yr and a bone dose of 1.8 mrem/yr. 3

The estimated annual doses to the population affected by the operation of the WNP-2 and the combined operation of WNP-2, WNP-1 and WNP-4 are given in Table 5.2-15.[a] The total population dose estimate includes 5
the transportation of radioactive materials (spent fuel and wastes) from the plants as well as the doses received via the air and water pathways. The dose to the population from the direct radiation from the

(a) The population doses presented in the preceding subsections and in Tables 5.2-13 and -15 are based on population estimates documented in Ref. 6.1-47. These estimates were revised (see Section 2.1, Amendment 5) by Ref. 2.1-2, however, the doses were not recalculated because approximately 75% of the population dose is associated with radioactive material shipment and because the changes in projected population would not greatly change the dose from the liquid and gaseous pathways. 5

plants is assumed negligible, since the closest point to the site continuously occupied is more than 3 miles away from any one plant, and the point occupied intermittently by a fisherman is more than 2 miles.

The annual population dose from all sources attributable to all three plants operating simultaneously is 18 man-rem. By comparison the background radiation dose rate from natural sources in this region is approximately 105 mrem/yr,[a] resulting in an annual dose of 28,000 man-rem to the same population. Therefore, routine operations of the WNP-1, WNP-2 and WNP-4 operating simultaneously at this site, will contribute a very small increment to the total-body dose already received as a result of the natural background radiation.

3

(a) Approximately 80 mrem/yr from external sources and 25 mrem/yr from internal sources (mostly K-40).[8]

TABLE 5.2-1

RELEASE RATES AND CONCENTRATION OF RADIONUCLIDES IN LIQUID EFFLUENTS FROM WNP-2

	Isotope	Release (Ci/y)	Concentration in Plant Effluents (pCi/ℓ)
	H-3	12.0	2.3E+3
	Na-24	6.6E-3	1.3
	P-32	2.6E-4	5.1E-2
	Cr-51	6.7E-3	1.3
	Mn-54	8.0E-5	1.6E-2
	Mn-56	7.1E-3	1.4
	Fe-55	1.4E-3	2.7E-1
	Fe-59	4.0E-5	7.8E-3
	Co-58	2.7E-4	5.2E-4
	Co-60	5.5E-4	1.1E-1
	Ni-65	4.0E-5	7.8E-3
	Cu-64	2.0E-2	3.9
	Zn-65	2.7E-4	5.2E-2
	Zn-69m	1.4E-3	2.7E-1
	Zn-69	1.5E-3	2.9E-1
	Br-83	3.7E-4	7.2E-2
	Br-84	3.0E-5	5.8E-3
1 |	Rb-89	2.1E-4	4.1E-2
	Sr-89	1.4E-4	2.7E-2
	Sr-90	7.0E-5	1.4E-2
	Sr-91	2.2E-3	4.3E-1
	Sr-92	1.5E-3	2.9E-1
	Y-90	7.0E-5	1.4E-2
	Y-91m	1.4E-3	2.7E-1
	Y-91	7.0E-5	1.4E-2
	Y-92	3.1E-3	6.0E-1
	Y-93	2.3E-3	4.5E-1
	Mo-99	2.3E-3	4.5E-1

TABLE 5.2-1
(sheet 2 of 2)

Isotope	Release (Ci/y)	Concentration in Plant Effluents (pCi/ℓ)
Tc-99m	8.9E-3	1.7
Tc-101	2.0E-5	3.9E-3
Ru-103	3.0E-5	5.8E-3
Ru-105	5.5E-4	1.1E-1
Rh-105	1.8E-4	3.5E-2
Te-129m	5.0E-5	9.7E-3
Te-129	3.0E-5	5.8E-3
Te-131m	1.0E-4	1.9E-2
Te-131	2.0E-5	3.9E-3
Te-132	1.0E-5	1.9E-3
I-131	6.4E-3	1.2
I-132	3.5E-3	6.8E-1
I-133	1.7E-2	3.3
I-134	1.4E-3	2.7E-1
I-135	7.9E-3	1.5
Cs-134	7.4E-3	1.4
Cs-136	4.7E-3	9.1E-1
Cs-137	1.7E-2	3.3
Cs-138	7.2E-3	1.4
Ba-139	5.3E-4	1.0E-1
Ba-140	5.3E-4	1.0E-1
La-140	1.1E-4	2.1E-2
La-141	1.7E-4	3.3E-2
La-142	3.6E-4	7.0E-2
Ce-141	4.0E-5	7.8E-3
Ce-143	3.0E-5	5.8E-3
Pr-143	5.0E-5	9.7E-3
W-187	2.7E-4	4.7E-2
Np-239	7.9E-3	1.5

1

TABLE 5.2-2

RELEASE RATES AND CONCENTRATIONS OF RADIONUCLIDES IN THE AIRBORNE EFFLUENTS FROM WNP-2

Isotope	Release Rate (Ci/y)	Concentration in Plant Effluent (pCi/m^3)	Isotope	Release Rate (Ci/y)	Concentration in Plant Effluent (pCi/m^3)
H-3	68	8.3	Sb-124	5.0E-4	6.1E-5
Cr-51	1.3E-2	1.6E-3	I-131	4.6E-1	5.6E-2
Mn-54	4.1E-3	5.0E-4	I-133	1.7	2.1E-1
Fe-59	1.1E-3	1.4E-4	Xe-131m	5.0	6.1E-1
Co-58	1.3E-3	1.6E-4	Xe-133	2700	3.3E+2
Co-60	1.3E-2	1.6E-3	Xe-135m	740	9.1E+1
Zn-65	2.2E-3	2.7E-4	Xe-135	1100	1.4E+2
Kr-85m	76	9.3	Xe-138	1400	1.7E+2
Kr-85	270	3.3E+1	Cs-134	4.4E-3	5.4E-4
Kr-87	200	2.5E+1	Cs-136	3.6E-4	4.4E-5
Kr-88	240	2.9E+1	Cs-137	6.3E-3	7.7E-4
Sr-89	6.1E-3	7.5E-4	Ba-140	1.1E-2	1.4E-3
Sr-90	2.8E-5	3.4E-6	Ce-141	7.6E-4	9.3E-5
Zr-95	5.1E-4	6.2E-5			

TABLE 5.2-3

ANNUAL AVERAGE ATMOSPHERIC DILUTION FACTORS ($\overline{X}/Q'$)

Direction from Source	Range (mile) .5 MI	1.5 MI	2.5 MI	3.5 MI	4.5 MI	7.5 MI	15 MI	25 MI	35 MI	45 MI	TOTALS
N	3.04E-06	8.04E-07	4.30E-07	2.83E-07	2.07E-07	1.08E-07	4.40E-08	2.22E-08	1.40E-08	9.92E-09	4.97E-06
NNE	2.65E-06	6.72E-07	3.54E-07	2.31E-07	1.67E-07	8.65E-08	3.45E-08	1.72E-08	1.08E-08	7.59E-09	4.23E-06
NE	2.10E-06	5.47E-07	2.90E-07	1.90E-07	1.38E-07	7.16E-08	2.85E-08	1.41E-08	8.82E-09	6.18E-09	3.39E-06
ENE	2.04E-06	5.36E-07	2.85E-07	1.86E-07	1.36E-07	6.99E-08	2.78E-08	1.38E-08	8.60E-09	6.03E-09	3.31E-06
E	1.98E-06	5.10E-07	2.69E-07	1.75E-07	1.27E-07	6.48E-08	2.54E-08	1.25E-08	7.79E-09	5.45E-09	3.17E-06
ESE	3.33E-06	8.73E-07	4.63E-07	3.03E-07	2.20E-07	1.13E-07	4.45E-08	2.20E-08	1.37E-08	9.58E-09	5.39E-06
SE	3.82E-06	1.03E-06	5.50E-07	3.38E-07	2.64E-07	1.37E-07	5.50E-08	2.75E-08	1.72E-08	1.21E-08	6.24E-06
SSE	3.61E-06	9.56E-07	5.13E-07	3.38E-07	2.47E-07	1.29E-07	5.21E-08	2.61E-08	1.64E-08	1.16E-08	5.90E-06
S	3.11E-06	8.33E-07	4.49E-07	2.98E-07	2.18E-07	1.15E-07	4.68E-08	2.35E-08	1.48E-08	1.04E-08	5.12E-06
SSW	2.38E-06	6.52E-07	3.55E-07	2.37E-07	1.74E-07	9.25E-08	3.79E-08	1.91E-08	1.21E-08	8.49E-09	3.97E-06
SW	2.13E-06	6.01E-07	3.31E-07	2.22E-07	1.64E-07	8.75E-08	3.62E-08	1.83E-08	1.16E-08	8.17E-09	3.61E-06
WSW	1.85E-06	5.08E-07	2.77E-07	1.84E-07	1.36E-07	7.19E-08	2.94E-08	1.48E-08	9.32E-09	6.56E-09	3.08E-06
W	1.38E-06	3.81E-07	2.08E-07	1.30E-07	1.02E-07	5.39E-08	2.20E-08	1.10E-08	6.92E-09	4.87E-09	2.30E-06
WNW	1.66E-06	4.33E-07	2.30E-07	1.50E-07	1.10E-07	5.69E-08	2.27E-08	1.12E-08	7.01E-09	4.91E-09	2.69E-06
NW	1.75E-06	4.47E-07	2.36E-07	1.54E-07	1.12E-07	5.74E-08	2.28E-08	1.13E-08	7.08E-09	4.97E-09	2.80E-06
NNW	2.65E-06	7.11E-07	3.82E-07	2.52E-07	1.84E-07	9.67E-08	3.92E-08	1.98E-08	1.25E-08	8.82E-09	4.36E-06
TOTALS	3.95E-05	1.05E-05	5.62E-06	3.67E-06	2.71E-06	1.41E-06	5.69E-07	2.85E-07	1.79E-07	1.26E-07	6.45E-05
CUM TOTL	3.95E-05	5.00E-05	5.56E-05	5.93E-05	6.20E-05	6.34E-05	6.39E-05	6.42E-05	6.44E-05	6.45E-05	6.45E-05

WNP-2
ER

TABLE 5.2-4

CONCENTRATIONS OF IMPORTANT RADIONUCLIDES IN VARIOUS ENVIRONMENTAL MEDIA

Nuclide	River Water at Point of Irrigation (pCi/ℓ)	Air at Taylor Flats (pCi/m³)	Sediment at outfall (pCi/kg)	Soil at Taylor Flats (pCi/kg)	Fish at Outfall (pCi/kg)	Coots (pCi/kg)	Drinking Water at Richland (pCi/ℓ)	Vegetation at Taylor Flats (pCi/kg)	Milk from Nearest Cow (pCi/ℓ)	Eggs at Taylor Flats (pCi/kg)	Meat at Taylor Flats (pCi/kg)
H-3	1.1E-1	5.6E-1	--	7.0E+0	2.1E+3	2.1E+3	1.1E-1	6.4E+1	3.1E+1	1.3E+1	3.0E+1
Na-24	--	0	--	--	1.3E+2	1.3E+2	5.5E-5	--	--	--	--
P-32	2.4E-6	0	--	0	1.5E+1	1.5E+1	--	0	0	0	0
Mn-56	--	0	--	--	5.5E+2	5.5E+2	3.3E-5	--	--	--	--
Co-60	5.1E-6	1.1E-4	1.9E+0	1.1E-1	5.4E+0	5.4E+0	1.0E-7	3.1E-2	--	--	--
Kr-87	0	1.6E+0	0	0	0	0	0	0	0	0	0
Kr-88	0	1.9E+0	0	0	0	0	0	0	0	0	0
Sr-89	1.3E-6	5.0E-5	--	1.4E-3	8.2E-1	8.2E-1	2.6E-7	1.2E-2	9.4E-4	--	--
Sr-90+D	6.5E-7	2.3E-7	--	7.0E-4	4.1E-1	4.1E-1	1.3E-7	2.0E-4	--	7.4E-6	2.9E-6
I-131	6.0E-5	3.8E-3	--	1.7E-1	1.9E+1	1.9E+1	4.8E-5	3.7E+0	2.1E+0 (a)	1.5E-1	1.2E-1
I-132	--	0	--	--	1.0E+1	1.0E+1	2.6E-5	--	--	--	--
I-133	--	1.4E-2	--	6.7E-2	5.0E+1	5.0E+1	1.3E-4	1.1E+0	3.1E-1 (a)	2.1E-2	--
I-135	--	0	--	--	2.3E+1	2.3E+1	5.9E-5	--	--	--	--
Xe-135	0	9.0E+0	0	0	0	0	0	0	0	0	0
Xe-138	0	1.2E+1	0	0	0	0	0	0	0	0	0
Cs-134	6.9E-5	3.6E-5	9.6E+0	1.5E-2	2.9E+3	2.9E+3	6.3E-5	1.0E-2	2.6E-3	--	1.6E-3
Cs-136	4.4E-5	--	--	--	1.8E+3	1.8E+3	3.9E-5	--	--	--	--
CS-137	1.6E-4	5.2E-5	1.4E+2	1.6E-1	6.6E+3	6.6E+3	1.4E-4	1.5E-2	3.8E-3	2.7E-4	3.0E-3
Cs-138	--	--	--		2.8E+3	2.8E+3	6.1E-5	--	--	--	--
Ba-140	4.9E-6	9.4E-5	--	6.7E-4	4.1E-1	4.1E-1	2.0E-6	1.3E-2	--	--	--

(a) This would be a factor of 1.2 times higher if goats' milk is consumed.

TABLE 5.2-5

ASSUMPTIONS USED FOR BIOTA DOSE ESTIMATES

Fish, Clam, Crustacea

- In equilibrium with 10% plant effluent
- Effective radius = 2 cm
- Bioaccumulation factors listed in Appendix II

Muskrat

- Spends 33% of time in 10% plant effluent; 33% in riverbank den; 33% on land
- Effective radius = 6 cm
- Body mass = 1 kg
- Consumes 100 g/day aquatic vegetation growing in 10% plant effluent

Raccoon

- Spends 25% of time on shoreline washed with 10% plant effluent
- Effective radius = 14 cm
- Body mass = 12 kg
- Consumes 20 g/day fish living in 10% plant effluent (10% of total diet). (The other 90% of his diet is assumed to be free of radionuclides of WNP-2 origin.)

Coot

- Spends 50% of time floating in 10% plant effluent and 50% of time on shoreline washed with 10% plant effluent
- Effective radius = 5 cm
- Body mass = 1 kg
- Consumes 100 g/day aquatic vegetation living in 10% plant effluent

Heron

- Spends 33% of time standing in 10% plant effluent; 33% on riverbank washed with 10% plant effluent
- Effective radius = 11 cm
- Body mass = 4.6 kg
- Consumes 600 g/day fish living in 10% plant effluent

Goose

- Spends 50% of time floating in 10% plant effluent and 50% of time on shoreline washed with 10% plant effluent
- Effective radius = 10 cm
- Body mass = 3 kg
- Consumes 500 g/day of grain

External dose to muskrat, coot and heron from gaseous effluents are received at shoreline 3.5 mi ESE of the containment building.

External dose to racoon from gaseous effluents are received at shoreline (25%) and at a location 0.5 mi SE (75%). 3

TABLE 5.2-6

ASSUMPTIONS USED IN ESTIMATING DOSES FROM THE LIQUID PATHWAY

Drinking Water

- Liquid effluent diluted by annual average river flow (120,000 cfs)
- 24 hours delay between release of radionuclides and consumption of water (plus holdup in water plant)
- Fractions of radionuclides passing through water plant were those given in Table 5.2-11
- Consumption rate of 2.0 ℓ/day (730 ℓ/yr) for maximum individual and 1.2 ℓ/day (440 ℓ/yr) for the average individual.
- Total population consuming drinking water downstream from the plant is approximately 75,000

Fish

- Fish caught in waters containing plant effluent diluted by a factor of 0.1 for maximum individual and by annual average river flow for population average.
- One-day delay between harvest of fish and consumption for population and 1 hour for maximum individual.
- Consumption rate of 40 kg/yr for maximum individual[3] and 1.4×10^4 kg/yr (edible weight) for population living in the 50-mile radius of the plant. (The approximate edible weight of sportfish harvested from the river between Ringold and Boardman.[5])
- No losses in preparation of fish.

RECREATIONAL ACTIVITIES

Maximum Individual

- Recreation in or near waters containing 10% effluent.
- 0.1 hour delay between release and location of shoreline activity, swimming and boating.
- 500 hrs/yr shoreline activities.[(b) 6]
- 100 hrs/yr swimming (complete immersion)[6]
- 100 hrs/yr boating or water skiing (surface)[6]

Average Individual Members of the Population

- Recreation in or near waters containing plant effluent fully diluted in the annual average river flow.[(a)]
- 4 hours delay between release of radionuclides and location of recreation.
- 17 hrs/yr shoreline activities[(b) 6]
- 10 hrs/yr swimming (complete immersion)[6]
- 5 hrs/yr boating and water skiing (surface)[6]
- Total population using Columbia River downstream from the plant for recreation is approximately 193,000.[(c)]

Irrigated Food Products

- Irrigation water contains effluent nuclides diluted with annual average river flow.
- Radionuclide buildup period in soil is 30 years.
- 25% of radionuclide which falls out is retained on crops.
- All radioiodine released is in inorganic form.
- Environmental half-life of deposition on plants is 14 days.
- Holdups, Individual Consumptions, Irrigation Rates, Yields, and Growing Periods are listed in Table 5.2-12
- Average member of population is assumed to eat 1/2 of consumptions listed in Table 5.2-12
- Population consuming irrigated foods assumed to be 10,000.

(a) The dilution offered by the Snake River below Pasco, and the decay during river travel time to southwest Benton County was ignored. The majority (over 50%) of the exposed population resides in the vicinity of the Tri-Cities, (Pasco, Kennewick, and Richland).
(b) Receptor assumed 3 ft above infinite plane. Resulting dose decreased by factor of 0.2 to account for finite width of shoreline.
(c) The population within 50 miles of the site in the sectors between the NNE and the SW directions, inclusive, are the persons who travel to the Columbia River downstream of the plant for their aquatic recreation. This population is estimated to total 192,710 persons in 2020.

TABLE 5.2-7

ASSUMPTIONS USED IN ESTIMATING DOSES FROM THE GASEOUS PATHWAY

- For external beta dose 2π geometry used.
- For external gamma dose 2π geometry used.
- Ground level release with wake correction.
- 2020 population distribution.

TABLE 5.2-8

ANNUAL DOSE RATES TO BIOTA
ATTRIBUTABLE TO THE WNP-2 NUCLEAR PLANT (mrad/yr)

Organism	Air Submersion	Water Immersion	Shoreline, or Bottom Sediment	Contaminated Ground	Internal	Total
Fish	--	2.0E-4	--	--	1.3E+1	1.3E+1
Clam	--	2.0E-4	2.6E-2	--	2.1E+2	2.1E+2
Crustacean	--	2.0E-4	2.6E-2	--	2.1E+2	2.1E+2
Muskrat	2.3E-1	6.6E-5	8.5E-3	7.9E-3	7.1E+1	7.1E+1
Raccoon	3.9E+0	--	6.5E-3	1.4E-1	1.4E+0	4.9E+0
Coot	3.3E-1	5.0E-5	1.3E-2	--	6.9E+1	6.9E+1
Heron	3.3E-1	3.3E-5	8.5E-3	--	1.4E+2	1.4E+2
Goose	3.3E-1	5.0E-5	1.3E-2	--	1.5E-4	2.9E-1
Deer	9.6E-1	--	--	4.5E-2	2.7E-4	8.5E-1
Cattle	1.6E-1	--	--	7.8E-3	2.7E-4	1.5E-1

TABLE 5.2-9

ESTIMATED ANNUAL DOSES TO AN INDIVIDUAL FROM THE LIQUID AND GASEOUS EFFLUENTS OF WNP-2

	Pathway	Annual Exposure	Location	Dilution Factor or χ/Q	Annual Doses (mrem) to an Adult				
					Skin	Total Body	GI-LLI	Thyroid	Bone
	LIQUID								
3	Drinking Water	730 ℓ	Richland	1/20,000	--	1.7E-5	1.1E-5	9.0E-5	6.7E-6
	Fish	40 kg	Near Outfall	1/10	--	2.2	2.0E-1	2.5E-1	1.6
	Water Recreation	(a)	Near Outfall	1/10	1.1E-1	9.3E-2	(9.3E-2)	(9.3E-2)	(9.3E-2)[c]
	Irrigated Food Products:								
	Produce	(b)	Riverview Area	1/20,000	--	2.7E-5	1.1E-5	6.5E-5	2.5E-5
	Eggs	(b)	Riverview Area	1/20,000	--	5.4E-7	4.1E-7	2.7E-6	5.4E-7
	Milk	(b)	Riverview Area	1/20,000	--	2.4E-5	5.0E-6	1.6E-4	1.9E-5
	Meat	(b)	Riverview Area	1/20,000	--	7.6E-6	1.6E-6	4.9E-6	6.3E-6
	Ground Contamination	4,400 h	Riverview Area	1/20,000	2.2E-4	1.9E-4	(1.9E-4)	(1.9E-4)	(1.9E-4)
	AIR								
	Air Submersion	8,766 h	Taylor Flat	2.6×10^{-7}	2.8E-1	1.4E-1	(1.4E-1)	(1.4E-1)	(1.4E-1)
	Inhalation/Transportation	7,300 m^3	Taylor Flat	2.6×10^{-7}	--	8.1E-4	8.6E-4	7.8E-2	2.3E-4
3	Food Products:								
	Produce	(b)	Taylor Flat	2.6×10^{-7}	--	5.6E-3	5.3E-3	6.0E-1	1.7E-3
	Eggs	(b)	Taylor Flat	2.6×10^{-7}	--	5.9E-5	5.2E-5	8.9E-3	2.1E-5
	Milk (cow)	(b)	Taylor Flat	2.6×10^{-7}	--	3.0E-3	2.1E-3	1.2[d]	2.6E-3
	Meat	(b)	Taylor Flat	2.6×10^{-7}	--	2.7E-4	2.3E-4	1.6E-2	5.6E-5
	Ground Contamination	4,400 h	Taylor Flat	2.6×10^{-7}	4.2E-3	3.4E-3	(3.4E-3)	(3.4E-3)	(3.4E-3)

(a) See Table 5.2-6 for exposure rates for water recreation.
(b) See Table 5.2-12 for consumption rates for farm products.
(c) Parentheses around a number indicate that the radiation dose to an internal organ is due to an external source and is estimated to be equal to the external total-body dose.
3 (d) This would be a factor of 1.2 times higher if goats' milk is consumed.

TABLE 5.2-10

ESTIMATED ANNUAL DOSES TO AN INDIVIDUAL FROM THE LIQUID AND GASEOUS EFFLUENTS OF WNP-2, WNP-1 AND WNP-4

	Pathway	Annual Exposure	Location	Annual Doses (mrem) to an Adult: Skin	Total Body	GI-LLI	Thyroid	Bone
	LIQUID							
3	Drinking Water	730 ℓ	Richland	--	1.8E-3	1.8E-3	1.9E-3	6.7E-6
	Fish	40 kg	Near Outfall	--	2.3	2.6	3.1E-1	1.6
	Water Recreation	(a)	Near Outfall	1.1E-1	9.3E-2	(9.3E-2)	(9.3E-2)	(9.3E-2) [c]
	Irrigated Food Products:							
	Produce	(b)	Riverview Area	--	1.3E-3	1.3E-3	1.3E-3	2.5E-5
	Eggs	(b)	Riverview Area	--	6.9E-5	6.9E-5	6.9E-5	5.4E-7
	Milk	(b)	Riverview Area	--	6.6E-4	6.5E-4	8.1E-4	1.9E-5
	Meat	(b)	Riverview Area	--	2.3E-4	2.2E-4	2.3E-4	6.3E-6
	Ground Contamination	4,400 h	Riverview Area	2.2E-4	1.9E-4	(1.9E-4)	(1.9E-4)	(1.9E-4)
	AIR							
	Air Submersion	8,766 h	Taylor Flat	6.9E-1	1.7E-1	(1.7E-1)	(1.7E-1)	(1.7E-1)
	Inhalation/Transportation	7,300 m^3	Taylor Flat	--	4.4E-3	4.5E-3	9.5E-2	2.6E-4
3	Food Products:							
	Produce	(b)	Taylor Flat	--	3.4E-2	3.3E-2	7.4E-1	2.0E-3
	Eggs	(b)	Taylor Flat	--	3.2E-4	3.1E-4	1.1E-2	2.5E-5
	Milk (cow)	(b)	Taylor Flat	--	9.1E-3	8.0E-3	1.4 [d]	3.1E-3
	Meat	(b)	Taylor Flat	--	1.6E-3	1.5E-3	2.1E-2	6.3E-5
	Ground Contamination	4,400 h	Taylor Glat	5.3E-3	4.1E-3	(4.1E-3)	(4.1E-3)	(4.1E-3)

(a) See Table 5.2-6 for exposure rates for water recreation.
(b) See Table 5.2-12 for consumption rates for farm products.
(c) Parentheses around a number indicate that the radiation dose to an internal organ is due to an external source and is estimated to be equal to the external total-body dose.
3 (d) This would be a factor of 1.2 times higher if goats' milk is consumed.

TABLE 5.2-11

FRACTION OF RADIONUCLIDE PASSING THROUGH WATER TREATMENT PLANTS[4]

Element	Fraction	Element	Fraction
H	1.0	Mo	0.9
Na	0.9	Tc	0.7
P	0.4	Ru	0.5
Cr	0.9	Rh	0.5
Mn	0.5	Te	0.8
Fe	0.2	I	0.8
Co	0.2	Cs	0.9
Ni	0.2	Ba	0.4
Cu	0.6	La	0.2
Zn	0.4	Ce	0.2
Br	0.8	Pr	0.2
Rb	0.9	W	0.9
Sr	0.2	Np	0.7
Y	0.2		

TABLE 5.2-12

ASSUMPTIONS FOR ESTIMATING DOSES FROM CROPS AND ANIMAL FODDER SUBJECT TO DEPOSITION OF RADIOACTIVE MATERIALS RELEASED BY THE PLANT

Food Types	Holdup (day)	Consumption[a] (kg/yr or ℓ/yr)	Irrigation Rate[b] ($\ell/m^2/mo$)	Atomspheric Dilution (s/m^3)	Yield (kg/m^2)	Growing Period (day)
Produce						
Leafy Vegetables	1	30	200	$2.6x10^{-7}$	1.5	70
Beans, Peas, Asparagus	1	30	160	$2.6x10^{-7}$	0.4	70
Potatoes	10	110	180	$2.6x10^{-7}$	5	100
Other Root Vegetables	1	72	150	$2.6x10^{-7}$	5	70
Berries	1	30	180	$2.6x10^{-7}$	2.7	60
Melons (water)	1	40	180	$2.6x10^{-7}$	1.4	100
Orchard Fruit	1	265	180	$2.6x10^{-7}$	2.1	90
Wheat	10	80	0[c]	$2.6x10^{-7}$	0.72	70
Other Grain (sweet Corn)	1	8.3	150	$2.6x10^{-7}$	1.4	100
Eggs	2	30	150	$2.6x10^{-7}$	0.66	130
Milk	2	274	200	$2.6x10^{-7}$	1.3	30
Meat						
Beef	15	40	160	$2.6x10^{-7}$	2.0	130
Pork	15	40	150	$2.6x10^{-7}$	0.69	130
Poultry	2	18	140	$2.6x10^{-7}$	0.66	130

(a) Consumptions are for maximum individual. Average population member is assumed to eat one-half of those quantities.
(b) Typical irrigation rates for the region.
(c) No irrigation of wheat.

TABLE 5.2-13

CUMULATIVE POPULATION, ANNUAL POPULATION DOSE, FROM SUBMERSION IN AIR CONTAINING RADIONUCLIDES FROM THE WNP-2 AND COMBINED RELEASES OF WNP-2 AND WNP-1 AND -4[a]

Radius (miles)	Cumulative Population (2020)	Cumulative Annual Population Dose (man-rem)		Annual Average Dose (mrem)	
		WNP-2	Combined	WNP-2	Combined
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	130	0.0086	0.010	0.066	0.078
10	12,650	0.44	0.56	0.035	0.045
20	108,060	1.3	1.8	0.012	0.016
30	157,760	1.5	2.1	0.0093	0.013
40	201,270	1.5	2.1	0.0075	0.010
50	267,790	1.6	2.2	0.0058	0.0081

(a) Population estimates in Section 2.1 were revised by Amendment No. 5. These revisions reflect a projection of 380,000 people in the year 2020 living within 50 miles. However, because all the increases are beyond 10 miles, the cumulative population dose is not expected to increase significantly and is, therefore, not recalculated. See also note on P.5.2-10.

TABLE 5.2-14

ANNUAL DOSES RECEIVED VIA MAJOR PATHWAYS FOR WNP-2 AND FOR WNP-2, WNP-1 AND -4 COMBINED

	Annual Dose (mrem)			
	WNP-2	WNP-1 & -4	Combined	Appendix I Limits per Reactor
AIR PATHWAY				
Air Submersion[(a)]				
Total Body	0.47	0.38	0.85	5
Skin	0.84	0.60	1.4	15
Infant's Thyroid[(b)]	9.1	1.8	11	15
Nearest Resident[(c)]				
Thyroid	2.0	0.37	2.4	15
Total Body	0.15	6-8E-2	0.22	10
LIQUID PATHWAY				
Drinking Water				
Total Body	1.7E-5	1.8E-3	1.8E-3	3
Fish Consumption				
Total Body	2.2	6.2E-2	2.3	3
Bone	1.6	4.0E-8	1.6	10
Nearest Resident[(d)]				
Total Body	0.10	2.9E-2	0.13	3
All Others	<0.10	<3.0E-3	~0.1	10
AIR DOSE (mrad/yr)[(e)]				
Gamma Air Dose	2.9	-	-	10
Beta Air Dose	1.9	-	-	20

3

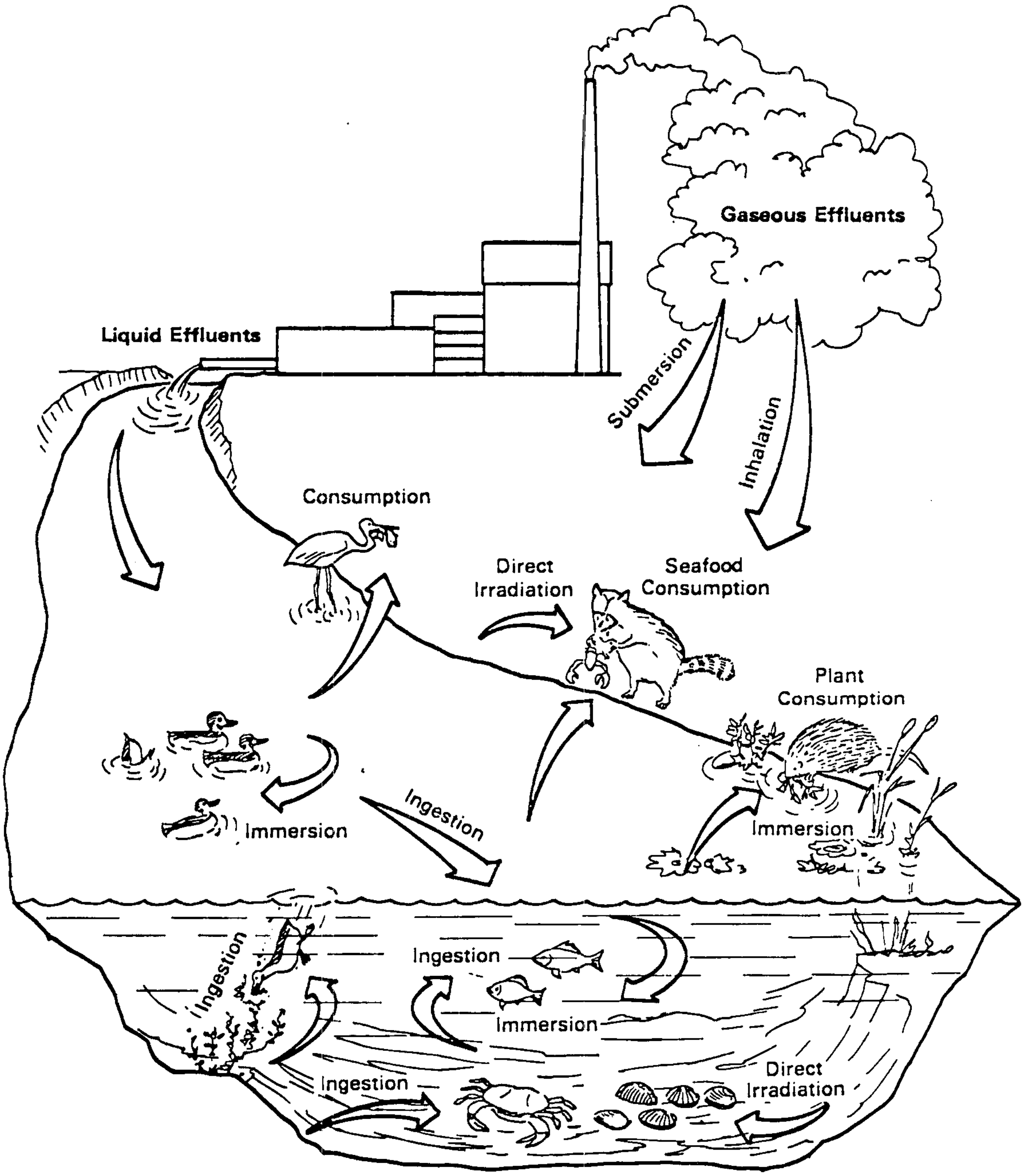
(a) Located 3.5 miles ESE of WNP-2.
(b) Milk and inhalation at nearest residence.
(c) Inhalation, air submersion, ingestion of farm products, contaminated ground.
(d) Swimming, boating, shoreline, ground contamination, ingestion of farm products.
(e) At a location 0.5 miles southeast of the plant.

TABLE 5.2-15

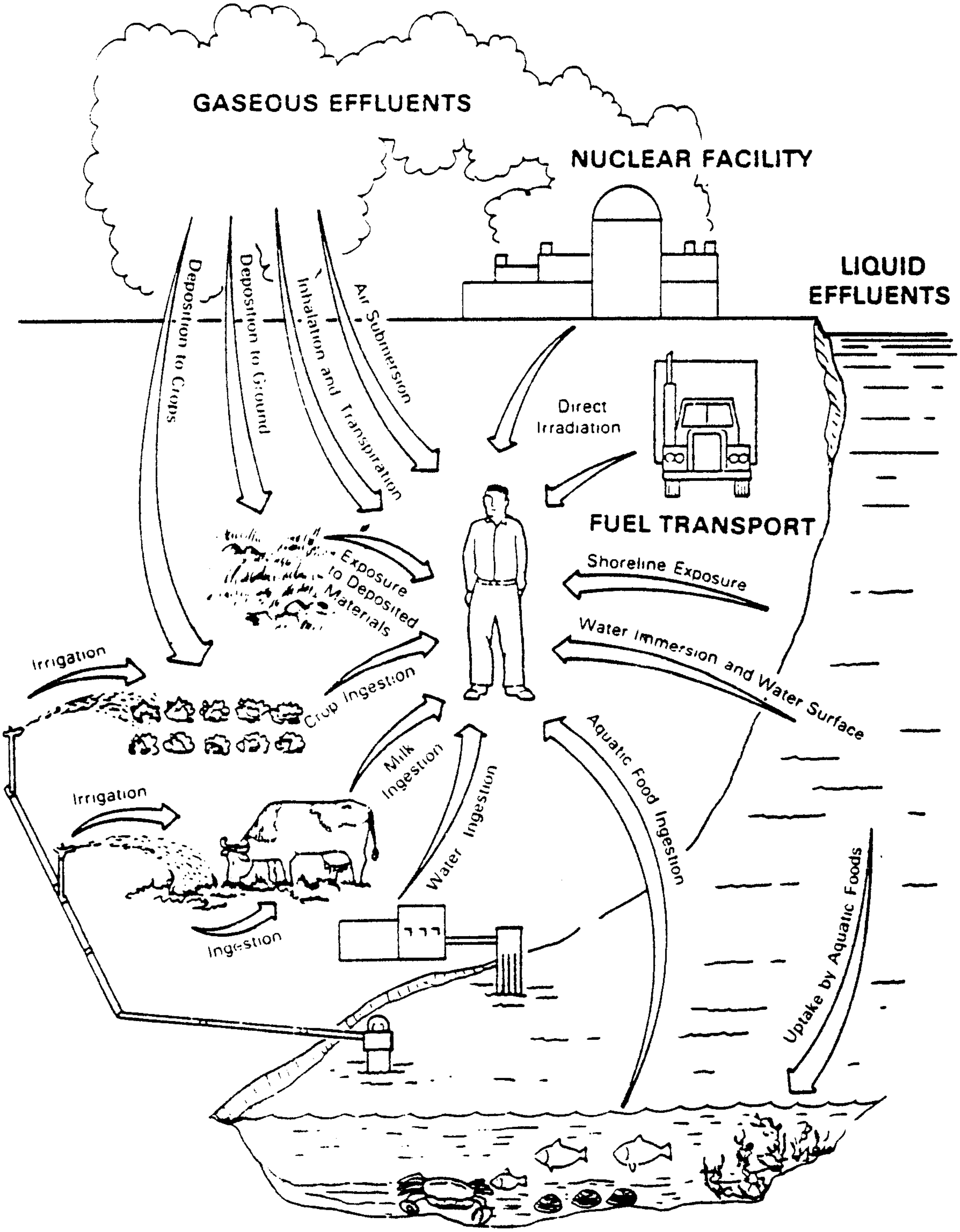
ESTIMATED ANNUAL POPULATION DOSES ATTRIBUTABLE AT WNP-2 AND COMBINED RADIONUCLIDE RELEASES OF WNP-1, WNP-2 AND WNP-4 [(a)]

Pathway	Total Body Dose Man-Rem WNP-2	Total Body Dose Man-Rem Combined	Remarks
AIR			
Submersion in Cloud	1.6	2.1	No credit taken for shielding.
Direct Radiation	--	--	
Inhalation/Transpiration	2.3E-2	1.0E-1	
3 Farm Products	6.9E-2	2.7E-1	
WATER			
Fish Consumption	3.9E-4	4.3E-4	Complete mixing in river was assumed.
3 Drinking Water	7.7E-4	8.0E-2	Complete mixing in river was assumed.
Water Recreation	3.0E-4	3.0E-4	Complete mixing in river was assumed.
Irrigated Farm Products	1.8E-4	8.0E-3	
TRANSPORTATION OF RADIOACTIVE MATERIALS	5	15	From reference 8.

5 (a) See notes on Page 5.2-10 and Table 5.2-13



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	EXPOSURE PATHWAYS FOR ORGANISMS OTHER THAN MAN
	FIG. 5.2-1



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	EXPOSURE PATHWAYS TO MAN
	FIG. 5.2-2

5.3 EFFECTS OF CHEMICAL AND BIOCIDE DISCHARGES

5.3.1 Liquid Discharges

The expected impacts of chemical and biocide discharges were presented in the AEC Final Environmental Statement (December 1972) as prepared at the construction permit stage. The basic data and conclusions presented in that statement have not changed and are included herein by reference. However, supplemental discussion follows.

WNP-2 liquid effluent discharges will comply with the conditions of the Site Certification Agreement Between the State of Washington and the Washington Public Power Supply System for Hanford No. 2 (May 17, 1972) as amended (September 25, 1975). This incorporates a National Pollutant Discharge Elimination System Waste Discharge Permit (in compliance with the provisions of Chapter 90.48 RCN as amended and the Federal Water Pollution Control Act Amendment of 1972, Public Law 92-500) and applicable State of Washington Water Quality Criteria or Standards contained in Washington Administrative Code 173-201.

The State criteria or standards appear in Chapter 12. Since the construction permit application, the requirement that total dissolved gas not exceed 110% of saturation has been added. Nitrogen and oxygen are considered the gases of potential biological concern. The equilibrium concentrations of these gases in water are controlled by the temperature and the dissolved gas concentration in blowdown effluents
1 will comply with the supersaturation limitation. Even though the concentration of gases in the blowdown will be subsaturated with respect to the river at the discharge point, the State dissolved oxygen stand-ard will be met within a few feet of the discharge due to rapid dilution with the river water which normally has an oxygen content ranging from 9.5 to 14.0 mg/ℓ.

The NPDES permit (No. WA-002515-1) is contained in Appendix IV wherein discharge and monitoring conditions are given.

Table 5.3.1 lists the maximum potential increase of chemical concentrations of the Columbia River water which could result from the WNP-2 discharges. The basic information is not changed from that reported at the construction permit stage, but is presented in a format that more directly defines the impact on river concentrations. The maximum potential change was computed assuming a maximum chemical waste stream of 150 gpm and a maximum blowdown of 6,500 gpm, and complete mixing with the minimum regulated Columbia River flow of 36,000 cfs. The table indicates that the increases in river concentrations are very small in comparison to ambient concentrations.

Storm water, roof drains, and makeup demineralizer backwash
waters will be collected in a separate sewer system and 1
forwarded to an evaporation/leach area noted in Sections
3.7.2 and 3.7.3. No rad-waste, chemical wastes, or sanitary
wastes, will enter this system.

Trash and solid nonradioactive wastes generated by the plant will be disposed of offsite by an independent contractor.

The environmental concentrations and effects of cooling 1
tower drift are discussed in Section 5.1.4.

TABLE 5.3-1

MAXIMUM POTENTIAL CHANGE IN COLUMBIA RIVER WATER QUALITY RESULTING FROM WNP-2 CHEMICAL DISCHARGES

	Maximum Concentrations Change in River	Maximum Concentrations in River Upstream of WNP-2
Calcium, ppm Ca^{++}	0.066	32
Magnesium, ppm Mg^{++}	0.014	7
Sodium, ppm Na^{+}	0.01	5
Bicarbonate, ppm HCO_3^-	0.038	80
Sulfate, ppm SO_4^{--}	0.171	28
Chloride, ppm Cl^-	0.005	2.6
Nitrate, ppm NO_3^-	0.0012	0.62
Phosphate, ppm PO_4^{---}	0.003	0.13
Total Hardness, ppm $CaCO_3$	0.222	88
Total Alkalinity, ppm $CaCO_3$	0.062	76
Silica, ppm SiO_2	0.019	9
Dissolved Solids, ppm	0.247	115

5.4 EFFECTS OF SANITARY WASTE DISCHARGES

The amount of sanitary wastes processed at the central sanitary waste
treatment facility is small relative to the capacity of the soil to ac-
commodate these wastes. During peak loading an average of 100 gpm will
be percolated to the soil while long term operation will result in 25
gpm or less. The treatment system is efficient at removing BOD and sol-
ids. Approximately 45 feet of soils will provide disinfection of resi-
dual bacteria before the liquids enter the unconfined groundwater. Nu-
trients (principally nitrogen and phosphorus) which may eventually reach
the Columbia River (three miles east) will have no measurable effect on
water quality or biota. The nearest water supply wells are 3000 feet
from the percolation beds. Because of the limited zone of potential
contamination and the limited use of groundwater at the site, the opera-
tion of the treatment facility will have no measurable effect on ground- 5
water resources. There is no discharge to surface waters.

The ponds may attract waterfowl, however, they will not be adversely affected; the lagoons will not receive wastes which present a toxicity problem. The facility will be fenced to preclude entry by deer which could damage the pond liner with hooves. During normal operation, the aerobic process will not be a source of odors.

In summary, the waste treatement system, utilizing oxidation and photosynthesis, will have no significant or lasting environmental effect. The sanitary waste treatment facility was designed according to criteria of the State of Washington Department of Ecology and its construction was subject to approval by the State Energy Facility Site Evaluation Council.

5.5 EFFECTS OF OPERATION AND MAINTENANCE OF THE TRANSMISSION SYSTEM

Effects of operating and maintaining the transmission lines are expected to be as described in the FES for the construction permit stage. However, the H. J. Ashe substation which is being constructed by the Bonneville Power Administration to handle the WNP-2 500 KV transmission line and 230 KV start-up line has not been described and assessed previously. The Ashe substation is located about 1/2 mile due north of WNP-2. The substation requires about 37 acres of land with a 2000-ft long access road requiring about 1 acre. The Ashe substation is scheduled to be completed just prior to the startup of WNP-2. NEPA requirements for the construction and operation of the Ashe substation and transmission lines serving WNP-2 are being addressed by the Bonneville Power Administration.(1)

5.6 OTHER EFFECTS

All known effects of plant operation except noise are discussed in other sections. The effects of noise caused by the operation WNP-2 are expected to be as described in the FES for the construction permit stage.

5.7 RESOURCES COMMITTED

The estimated irreversible and irretrievable commitments of resources due to the operation of WNP-w have not changed significantly since evaluated in the AEC Final Environmental Statement (December 1972) except as noted below in an updated discussion of fuel utilization.

5.7.1 Uranium Resources

Operation of WNP-2 will require the initial loading of 139
metric tons (MT) of uranium as uranium dioxide with and average
isotopic enrichment of 1.87% ^{235}U. This initial loading required
605 short tons of U_3O_8 of natural isotopic composition. This
2 corresponds to obtaining 288,300 short tons of ore containing
0.21% U_3O_8, which is a very small fraction of the estimated
domestic uranium ore reserves.

The enrichment of uranium for the initial loading of WNP-2
2 required about 289 MT separative work units which is 1.8% of
the annual separative work capacity of the three DOE gaseous
diffusion plants if fully loaded.

DOE had indicated it may be necessary to increase the opertional tails assay in the future.

Fuel requirements for continued operation of WNP-2 will depend on the fuel management practices adopted and the use made of the plant to meet power requirements. Under equilibrium conditions, and an average output from the plant of 711 MWe, the plant will require about 31 MT/year of uranium enriched to 2.71% ^{235}U; this corresponds to the utilization of 220 short tons of natural U_3O_8 and 88 MT separative work units annually. This would require 22 MWe of power, which would be 2.8% of the average power produced by WNP-2.

If the plutonium generated in WNP-2 is recycled, the ^{235}U content of the fuel can be lowered to about 2.4%. Under these conditions annual requirements for natural uranium would decrease by 14%, and for separative work would be decreased by 19%.

5.8 DECOMMISSIONING AND DISMANTLING

The necessity for complete dismantling of the reactor complex and return of the site to its former appearance may be both unnecessary and impractical.

The site selection process for these projects has a long, continuous history which dates back to January 1943 when the Manhattan District of the Corps of Engineers selected the Hanford area for nuclear development. Among considerations in the selection of Hanford were the isolation of the area; the number of residents to be displaced; the general nature of the area; and abundant sources of electric energy and cooling water.

In considering the future following the useful life of WNP-2, the site within the Hanford Reservation originally selected for its isolation, ecological simplicity and abundant cooling water coupled with its historical "reinforcement" and connections to important transmission networks, will become even more viable than it is today. Therefore, it would likely be a logical site for the installation of future power stations, whether nuclear or fossil, a site too valuable to abandon.

5.8.1 Scope of Dismantling

As a possibility it might be considered desirable to:

a. Remove the structural steel framing and metal siding of the turbine-generator building, salvage the crane and all equipment, leave the nonremovable parts of the turbine-generator foundation and block all entrances.

b. Salvage the equipment as practicable in the general services building, raze the structural walls and block the entrances. The disposition of other auxiliary structures will depend on future use of the site.

c. Remove all fuel, control rods and accessories in the containment and fuel storage area, and salvage the cranes and other equipment. For these buildings, detailed plans will have to be established immediately preceding the decommissioning to allow maximum reuse of site land areas while eliminating any radioactive hazard. The degree of building demolition, the extent of practicable decontamination, the possible reuse of certain equipment or structures, and the subsequent use to be made of the site must be evaluated in establishing these plans.

In the above operations, equipment would be decontaminated where necessary and practicable or transported with suitable precautions.

5.8.2 Impact on the Environment

Dismantling the plants would have many of the same impacts on the environment as the original site preparation and station construction. Cars, trucks and rail traffic will increase, as would the noise level. Some land would have to be used for laydown area.

5.8.3 Radiological Impact on the Environment

The dismantling of the reactor buildings would have radiological impact characteristic of transporting irradiated fuel and radioactive wastes from the site. After dismantling is complete, however, it is expected that the proposed action would have no further significant radiological impact on the environment.

5.8.4 Dismantling Plan

An overall work plan, including cost estimates, may be prepared near the end of the reactor's useful life. The dismantling operations would be conducted in accordance with detailed procedures, specifications and schedules. The specifications would define the scope, methods and sequence of accomplishing major tasks. When required to supplement the specifications, detailed work procedures would be developed to meet the existing field conditions, state-of-the-art technology and shipping and burial ground requirements. All procedures would be reviewed with NRC.

All spent fuel will be withdrawn and transported to a licensed nuclear fuel processing plant. Steam generators and other components likely to be contaminated by "detectable radioactivity" would be decontaminated, cut if necessary, or shipped whole with protective coverings. The cutting of radioactive components would be done within containment and with monitoring. Immediate work areas would be enclosed within a contamination control envelope to prevent release of activity to the environment.

Tanks, machines and other components capable of being decontaminated would be so treated and shipped to salvage dealers. Solid wastes will be properly packaged in approved containers which will be sealed and thoroughly surveyed for external contamination before they are removed.

The subgrade levels of all buildings would be decontaminated and sealed. Provisions would be made so that any leakage of groundwater can be detected.

5.8.5 Systems To Be Utilized During Dismantling

Typical plant systems which would likely need to be kept activated during dismantling are: demineralizer, gaseous waste disposal, fuel element storage well system, ventilation, air conditioning and heating, service water, emergency electrical, service air and plant communication systems, as well as radwaste systems.

5.8.6 Preparatory Work

Prior to dismantling, certain preparatory work would be initiated. This includes:

a. preparation of detailed plans and accumulation of tools and equipment,

b. selection and qualification (if required) of necessary personnel,

c. maintaining security precautions to keep out unauthorized personnel,

d. construction of an enlarged change room and personnel decontamination area,

e. space for storage areas for contaminated and uncontaminated wastes,

f. establishing personnel and area radioactivity monitoring procedure for the additional personnel and areas involved.

5.8.7 Post-Dismantling Survey

After program completion, but prior to any backfitting operations, a thorough radiation survey of the plant site would be performed to verify that any detectable radioactivity does not represent a source of contamination and is within established regulatory limits.

5.8.8 Routine Inspection and Maintenance

After completion of the dimantling or securing of the reactor building, it would be inspected at appropriate intervals to insure that the secured building remains sealed. Minimal maintenance is expected.

5.8.9 Costs of Dismantling and Decommissioning

Preliminary estimates of costs to decommission WNP-2 in 1979 dollars and at 1979 costs are given in Table 5.8-1. Cost estimates are for entombment and dismantling although the existence of the plant on the ERDA Hanford Reservation may result in other options.

TABLE 5.8-1

PRELIMINARY ESTIMATES OF
DISMANTLING AND DECOMMISSIONING COSTS
(1979 Dollars and 1979 Costs)

	Entombment	Dismantling
Program Scope	$ 270,000	$ 270,000
Licensing Activity	510,000	490,000
Facility Preparation	420,000	420,000
Equipment Removal	2,700,000	8,300,000
Building Removal	--	5,500,000
Seal Bio. Shield	460,000	--
Shipping, Disposal, Burial	1,100,000	10,000,000
Radiation Protection Equipment and Grounds Improvement	210,000	340,000
Fee (7%)	400,000	1,800,000
Contingency (25%)	1,500,000	6,900,000
TOTAL	$7,570,000	$34,020,000

CHAPTER 6
EFFLUENT AND ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

CHAPTER 6

EFFLUENT AND ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

6.1 PREOPERATIONAL ENVIRONMENTAL PROGRAM

6.1.1 Surface Water

6.1.1.1 Physical and Chemical Parameters

Previous Studies. Numerous studies have been conducted for approximately 35 years in connection with the Hanford Project activities concerning the physical and chemical characteristics of the Columbia River in the vicinity of WNP-2 and WNP-1/4. These studies have included both general observations and detailed analyses of the effects on the river of effluents from the plutonium production reactors. These reports, which were reviewed, evaluated, and summarized by Becker and Waddel[1] and Neitzel[2], provide an accurate and comprehensive historical picture of the river. 4

Measurements by Others. Stage and discharge of the Columbia River are measured continuously at the U.S. Geological Survey gaging station below Priest Rapids Dam, 45 miles upstream of the project site.[3] The USGS also routinely monitors river temperatures and water chemistry at the Vernita bridge six miles below the dam and at the intake of the City of Richland water supply treatment plant about 11 miles downstream of the project site. Samples for chemical analyses of the Columbia River have been taken at Priest Rapids Dam, Vernita, the 300 Area, and Richland by Battelle-Northwest and the Hanford Environmental Health Foundation under a contract with the Energy Research and Development Administration.[4] 4

Measurements by Applicant. Dye dispersion studies and velocity measurements have been performed by the Supply System to determine hydraulic characteristics of the Columbia River in the vicinity of the project site. Four dye releases were made on February 26, 1972, at RM 351.75 in 5 to 7 ft of water off the west bank of the river, the location of the cooling tower blowdown discharge.[5] River flows were low during the releases and ranged from 36,000 to 50,000 cfs. The studies showed that complete vertical mixing occurs rapidly at this location, and that dye releases made from the river bottom mix more rapidly than releases from mid-depth and the surface. For all releases, complete vertical mixing occurred within 250 ft downstream of the release point. Velocities ranging from 2.5 to 3.3 fps were measured at the water surface during these tests.

River velocities were also measured by the Supply System on March 14, 1974, at four locations and three depths at each location at a river transect just upstream of the WNP-2 intake.[6] Three of these locations were in the right (west and main) channel, and the fourth location was in the middle of the left (east and secondary) channel. The river flow at the time of the measurements was about 130,000 cfs, and measurements were made between 3.3 ft and 19.7 ft from the water surface in the right channel and between 3.3 ft and 13.1 ft in the left channel. The velocities near the water surface ranged from 4.2 to 4.6 fps in the right channel and were 0.8 fps in the left channel.

Velocities in the vicinity of the WNP-2 discharge were also measured in
4 December 1979 when the river flow was about 135,000 cfs and the depth was about 20 ft. Velocities varied from 3 1/2 fps near the bottom to 7 fps near the surface.[16f]

Measurements of suspended sediment concentrations and turbidity were performed at various locations upstream and downstream from the outfall structures during excavtion of the river bed and installation of the intake and outfall structures.[7] The purpose of these measurements was to assure that the construction activities required to install the intake and outfall minimized scour, erosion, runoff and turbidity. The measurements were conducted daily during excavation activities in the river. Sediment concentrations were measured by a conventional suspended sediment sampler.

A low flow test of the Columbia River on April 10, 1976 controlled the flow to 36,000 cfs for the purpose of verifying river surface elevations. It was con-
4 cluded that the water surface is about 1.3 ft lower than was indicated by previous data. Subsequently, river bottom elevations in the vicinity of the WNP-2 discharge were surveyed by the Supply System to obtain more accurate flow depths than were available from previous surveys by others.

<u>Modeling of Blowdown Plume Temperatures</u>. A mathematical model was used to estimate the hydrodynamic and water temperature regime of the cooling tower blowdown plume in the Columbia River under different blowdown and river discharge conditions.[8] The model was selected on the basis of its applicability to thermal plume behavior in general and observed conditions in the Columbia River in particular.

The basic equations available for the computation of thermal plumes are the equations of state, continuity, energy, and momentum. However, these equations are extremely difficult to solve in their more general, nonsteady and three-dimensional formulations. Various assumptions are therefore necessary to simplify the equations to develop practical numerical solutions. Simplifications may involve the assumption of steady-state, reduction of a three-dimensional problem into fewer dimensions (if possible with symmetry), and the division of a complex problem into smaller sequential problems.

For a submerged discharge of effluent entering a swiftly moving turbulent river in a direction perpendicular to the mainstream current, three regimes of flow can be defined:

1. the very near field, where the momentum of the effluent jet causes intensive mixing resulting in rapid reduction in maximum effluent concentration;

2. a region (loosely termed the intermediate field) where the effluent stream has been turned and is moving along with the current, almost like a part of the mainstream, and is diffusing laterally and vertically predominately due to river turbulence and some buoyant action; and

3. the far field, defined here as the region where the effluent is moving downstream passively, fully mixed in the vertical dimension with river turbulence dominating lateral diffusion.

These definitions of the conceptual regimes are based on observations made during dye studies on a test stretch of the Columbia River [5] and on stream data collected during operation of the now decommissioned Hanford production reactors[9] and the existing Hanford Generating Plant (HGP)[10] These measurements indicated that a downstream heated plume will be vertically well-mixed in the test stretch even at low flow conditions.[11]

Regime 1 encompasses a region extending from the point of discharge downstream to a location where cross-stream velocity is no longer significant. This flow regime is extremely complex because of the strong interaction between the jet and ambient streams. Numerous analytical and experimental studies concerning similar problems have been conducted in recent years.[12,13]

A simplified analytical approach is through similarity analysis, in which the governing three-dimensional partial differential equations are reduced to ordinary differential equations by assuming experimentally determined profiles for velocity and temperature (or concentration). Unfortunately, similarity approaches are strictly applicable only to discharges to semi-infinite water bodies. Hence, similarity theory cannot be applied with a great deal of confidence to discharge flow behavior which is modified by a confining free surface or riverbed.

The blowdown effluents from WNP-2 and WNP-1/4 are categorized as severely confined discharges because at low flow the discharge orifice size is of the same order of magnitude as the water depth. Therefore a similarity solution would not be expected to yield accurate results. Additionally, it is doubtful that the jet will detach from the river bottom because of the expected rapid dilution of the buoyancy, the jet-induced turbulence, and the intense river turbulence.

The confining nature of the stream (surface and bottom) is a factor which tends to decrease jet dilution compared with predicted discharge to a semi-infinite ambient. Conversely, turbulence in the Columbia River as in other swiftly-moving streams, is very intense and since similarity theory does not provide for ambient turbulence, this factor tends to cause greater dilution than theory would predict.

Because of these limitations in applying the theory to the blowdown discharge, dilution for the very near field cannot be predicted very accurately. However, the theory is valuable for predicting the approximate trajectory of the plume and thus the point where cross-steam velocities become insignificant. These simulations can indicate the importance of the initial jet behavior and the point at which the intermediate zone solution can confidently be started.

4 The very near-field dynamic behavior and dilution has little influence on downstream conditions (i. e., at distances greater than 20 jet diameters downstream) in cases of discharge to swiftly moving streams.

The effluent in Regime 2 is flowing downstream with a velocity equal to that of the river flow. However, both lateral and vertical diffusion processes are important and buoyant forces may need to be considered. In this case, the advection-diffusion transport equation for heat or other constituents can be applied.

The downstream river velocity is assumed to be known a priori from river velocity transect data, and secondary (transverse and vertical) flow effects are masked by mainstream turbulence. In accordance with the definition of this regime, downstream velocity perturbations caused by the discharge effluent are also assumed to be insignificant compared to the mainstream flow.

Considerable simplification may be achieved if the turbulent behavior of the mainstream dominates buoyant effects. This behavior is typical of shallow, swiftly moving streams such as the river reach which will receive the WNP-2 and WNP-1/4 blowdown discharges. Also, steady flow can be assumed for the analysis of selected blowdown and river flow conditions which do not vary rapidly with time. The advection-diffusion equation for Regime 2 can then be written:

$$\frac{\partial T}{\partial x} = K_y \frac{\partial^2 T}{\partial_y{}^2} + K_z \frac{\partial^2 T}{\partial_z{}^2}$$

where

$$K_y = \frac{k_y}{u_r}$$

$$K_z = \frac{k_z}{u_r}$$

and

T = temperature
x = downstream coordinate
y = cross-stream coordinate
z = vertical coordinate
u_r = downstream velocity component
k_y, k_z = eddy diffusivities for heat in the y and z directions, respectively

In this equation downstream diffusion has been eliminated because the contribution is small compared to downstream advection.

The following summarizes assumptions used in deriving the advection-diffusion equation: 4

1. The downstream velocity distribution, u_r, is known a priori from field data.

2. Buoyancy effects are insignificant.

3. Vertical and lateral velocity components are insignificant.

4. Eddy diffusivities are homogeneous, but possibly anisotropic.

5. Downstream diffusion is insignificant compared to downstream advection.

6. The flow is steady in time (i.e., $\partial T/\partial t = 0$).

7. Atmospheric effects are insignificant.

4 The advection-diffusion equation has the form of the classical transient heat conduction equation and may be easily solved for any desired boundary condition using well-tested numerical techniques. For application to WNP-2 and WNP-1/4, an alternating direction implicit finite difference solution was used.

Regime 3 is identified as the far field, where the effluent is moving downstream passively and is fully mixed in the vertical dimension. Atmospheric effects, i.e., heat transfer across the air-water interface may become significant. The approximate beginning of this region is ascertained by the calculation procedure outlined for Regime 2. Regime 3 was not modeled since Regime 2 assumptions were adequate to encompass the mixing zone.

6.1.1.2 Ecological Parameters - Aquatic

4 Studies at the Hanford Site for more than 35 years have resulted in a substantial amount of qualitative and quantitive information useful for impact assessment. In addition, the Supply System has conducted a preliminary program including literature studies (1, 2) and field studies of the Columbia River from 1973 - 1980.[15, 16a-16f] (See Section 2.2.2 also.) These historic and preoperational studies have resulted in the knowledge of the composition, structure, and function of the aquatic ecosystem and provided a basis for the design of the operational monitoring program.

The preoperational program concentrated on obtaining baseline data from which impacts of plant operation can most probably be measured if they should occur. Accordingly, the portion of the river immediately adjacent to the plant site received the most attention as did the biota most likely affected. Monitoring of those aquatic populations unlikely to be affected by plant operation was retained in the program, but with a lower level of effort. The major preoperational monitoring program tasks included benthic biota, fish, and plankton monitoring.

The preoperational program was curtailed in March 1980 with the concurrence of the Washington Energy Facility Site Evaluation Council (EFSEC).[52] These studies provide a continuous data series on the natural variations in the sea- 4
sonal occurrence and abundance of important aquatic species near the WNP-2 and WNP-1/4 sites from 1973 through early 1980. This knowledge of the extent of natural variations permits evaluation of changes in the abundance of important aquatic species in the vicinity of the projects before and after operation. A comparison of changes in species abundance in the vicinity of the intake and discharge in relation to changes in control areas outside the influence of the plant will be made before and after operation.

Benthic Organisms. Alterations of the Columbia River aquatic biota due to the influence of the plant effluent should be most readily indicated by changes in the structure of the benthic community in the immediate vicinity of the dis-
charges. The Supply System's aquatic ecological[15, 16a-16f] program has 4
characterized the composition, density and seasonal abundance of the benthic fauna near WNP-2 and WNP-1/4. The preoperational benthic program focused on 4
the benthic flora and fauna in the area of expected discharge impact.

Figure 6.1-1 indicates sampling locations for the aquatic biota program. Station 1 above and Station 8 below the area influenced by the discharge plume and Stations 7 and 11 in the plume were utilized. These stations were sampled four times per year (March, June, September, and December) to establish baseline information on community composition and abundance. For benthic fauna, rock-filled baskets were incubated on the bottom for three months. On recovery, species composition, biomass and commuinity dominance were determined. For benthic flora, glass microscope slides were incubated at the same sites as the rock-filled baskets and sampled on the same frequency. Qualitative species analysis, chlorophyll-a and biomass measurements were made. Replicate benthic flora and fauna samples were taken to allow for statistical analysis of community changes.

Fish. Identification of the species present in the Hanford stretch of the river is essentially complete. The Supply System's program has examined the spatial, and temporal distribution, species relative abundance, age structure and feeding habits of fish found near the site. In the preoperational program, emphasis was placed on fish found in the immediate vicinity of the intake and the discharge plume. Species and numbers of fish residing seasonally near the plant were examined with particular attention given to anadromous outmigrants. Samples were obtained using one or more of the following sampling methods: hoop-nets, electroshocking, gill netting or beach seining. Sampling locations for each of these methods are shown in Figure 6.1-1. A tag
and release program was used in an attempt to determine population size and 1
time of residence within the study area.

Fish sampling was conducted at least monthly, February through October. Table 4
6.1-2 provides the sampling frequency by method.

4

Plankton. Some fraction of the river's plankton will be drawn into the plant
with the cooling water and another fraction will be exposed to the effects of
entrainment in the discharge plume. The numbers so affected are an extremely
small fraction of the population passing the plant. Studies conducted by the
Supply System on the Columbia River indicate that planktonic algae and micro-
4 crustaceans in the aquatic system near WNP-2 and WNP-1/4 do not have a major
role in energy transfer pathways. No significant impact on the plankton com-
munity is expected because of the small volume of water withdrawn by WNP-2,
and the small volume influenced by the discharged water compared to the total
river flow. Nonetheless, phyto and zooplankton studies were conducted, on a
limited basis. Investigations by the Supply System indicate that samples
representative of the river plankton population may be obtained from any one
4 1 station and depth.(15, 16a) Therefore, during the preoperational program
monthly plankton samples were taken at one station (Station 1, Figure 6.1-1)
and one depth. These samples were used to determine phyto and zooplankton
species relative abundance and baseline biomass. This program provided a con-
tinuous indicator of changes in the plankton population.

6.1.2 Groundwater

The Department of Energy (DOE) through its contractors has drilled about 1,500
wells on the Hanford Reservation.(17) More than 20 wells are located within
1 5 miles of the project site and 6 wells are installed in the immediate vicin-
ity of the site;(18) see Figure 2.4-15.

Extensive environmental monitoring programs concerning the physical, chemical
and radiological characteristics of groundwater have been conducted under the
4 DOE auspices(18a). These monitoring programs and investigations have al-
ready accumulated quite comprehensive information on groundwater character-
istics and are expected to be continued routinely as part of the DOE program.

The Supply System has no plans to monitor non-radiological groundwater quality
1 parameters during the preoperational phase.

6.1.3 Air

6.1.3.1 Local Meteorology

Onsite meteorological data were collected at the WNP-2 site from April 1, 1974
1 through May 31, 1976. The meteorological data collection system consisted of
a 245-ft tower, an auxiliary 7-ft instrument mast, sensors with associated
electronics and recording devices, and a meteorological building.

A temporary meteorological system began collecting data at the same location
1 in March 1972 and was discontinued (September 1974) once the satisfactory op-
eration of the new system was verified. The temporary meteorological system
consisted of a 23-ft mast with an aerovane wind sensor. Data was recorded on
chart paper. Air temperature and relative humidity were recorded by use of a
hygrothermograph in an adjacent weather screen.

The permanent meteorological system consists of a primary tower 240-ft high with an extending 5-ft mast. The primary tower is triangular in shape and of open lattice construction to minimize tower interference with meteorological measurements. Wind and temperature measurements on the main tower were made at the 245-ft and 33-ft levels. At the 33-ft level the instruments (wind, temperature, and dewpoint) were mounted on an 8-ft horizontal boom extending west-northwest of the tower.

Wind and temperature measurements were also made at the top of the 7-ft mast which is located approximately 80 ft to the southwest of the 240-ft tower. Wind speed measurements were made using conventional cup anemometers (Climet Instruments, Model 01101 Wind Speed Transmitter). The instruments have a response threshold of about 0.6 mph and an accuracy of ± 1% or 0.15 mph (whichever is greater) over a range of 0.6 to 90 mph. The instruments were calibrated at speeds between approximately 5 and 20 mph. 4

Wind direction measurements were made using lightweight vanes (Climet Instruments, Model 012-1 10 Wind Direction Transmitter). The response threshold of these vanes is about 0.75 mph, and their damping ratio and distance constant are approximately 0.4 and 3.3 ft, respectively. Dual potentiometers in the wind direction transmitter produce an electrical signal covering 540° in azimuth with an accuracy of within ± 2°.

In addition, electronics have been included to provide signals which are proportional to the standard deviation ($\sigma\theta$) of the wind direction fluctuations at each level.

Temperature instrumentation provided measurements of both the ambient air temperature at the 245, 33, and 7-ft levels and the temperature differences between these levels. The ambient air temperature and the temperature difference sensors are independent of each other to provide reliability. All temperature measurements for both systems are made in aspirated temperature shields (Climet Instruments Model 016-1 or -2) using platinum resistance temperature devices (Rosemount Engineering Co., Model 104 MB6ABCA). These instruments
1 provide an ambient temperature range from $-30^{\circ}F$ to $+130^{\circ}F$ and a temperature difference range of $\pm 15^{\circ}F$. The accuracy of the instruments exceeds $\pm 0.9^{\circ}F$ in the measurement of temperatures and $\pm 0.18^{\circ}F$ in the measurement of temperature differences.

The dewpoint temperature was measured at the 33-ft level of the tower using a lithium chloride dewpoint sensor (Climet Instruments, Model 015-1 12) housed in an aspirated temperature shield (Climet Instruments, Model 016-2). The accuracy of this measurement in the normal range of measurement is better than $\pm 0.9^{\circ}F$.

Precipitation was measured at ground level using a tipping bucket rain gage (Meteorology Research, Model 302) located about 40 ft west of the main tower. This instrument is accurate to within $\pm 1\%$ at rainfall rates up to 3 in./hr and has a resolution of 0.01 in.

The instrument building provided a climate-controlled environment near the tower to house the instrument electronics and record the data. Both digital magnetic tape and analog strip chart recorders were used providing redundant data recording capability. The primary data recording system is a 7-track digital magnetic tape recorder (Kennedy, Model 1600) that uses 1/2-in. tape. Logarithmically, time-averaged wind speed, wind direction, temperature, temperature difference, and dewpoint temperature signals were recorded at 5-minute intervals. The time constant of the averaging process is 5 to 15 minutes. The standard deviation of wind direction fluctuations during the preceding 5 minutes at each level and the total precipitation were recorded along with the wind and temperature information. All data, except the wind direction standard deviations, were recorded on strip

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charts. Besides enhancing data retrievability, the strip chart records provided a rapid means of identifying instrument malfunctions and were useful in system calibration. Strip charts and magnetic tapes were changed weekly.

In summary, the total system (sensor, recorder, analysis, etc.) accuracies for the measured meteorological parameters meet or exceed the following specifications:

air temperature	$\pm 0.5^{\circ}C$	
temperature difference	$\pm 0.2^{\circ}C$	
humidity (dew point)	$\pm 0.5^{\circ}C$	
wind speed	± 0.5 mph	1
wind direction	$\pm 5^{\circ}$	

These are verified by the end-to-end calibrations. Data recovery was better than 90%.

To ensure the quality of the meteorological data collected by the monitoring system, an extensive quality assurance program was instituted. This program covered all phases of meteorological monitoring from the initial instrument acquisition through the analysis of data. Periodic checks and calibration of the instrument systems and individual components were instituted. These periodic checks ranged from daily inspection of the strip charts to semiannual calibration of the complete system.

Calibrations were performed at three-month intervals during the duration of data collection (April 1, 1974 - May 31, 1976). Full system (system electronics and sensors) calibrations were performed (dated) July, October 1974, April, October 1975, and April 1976. Calibrations of just the system 1
electronics were performed at the intervals between. Prior to April 1, 1974 the system was calibrated by the vendor. The final calibration, prior to shutdown, was an electronics calibration during June 1976.

All checks, calibrations, and maintenance were fully documented including traceability of test and calibration equipment to the National Bureau of Standards where necessary. These calibrations and routine daily and weekly inspections demonstrated that the meteorological system remained electronically stable in terms of obtaining data of sufficient quality to meet the requirements of Regulatory Guide 1.23. Corrections 1
to the data have been applied per the quarterly calibration findings and all data have been summarized in the form of monthly reports.

The data, once collected, were protected from loss to the maximum extent possible. The digital tapes were examined to identify possible instrumentation malfunctions. The data were then copied onto two master tapes. The original weekly tape and one master tape were stored in vaults. The second master tape was used in the preparation of data summaries.

Finally, to ensure proper operation of computer hardware and software, all computer programs used to summarize or analyze the data were checked quarterly. These checks were performed using a standard data input. The computer output from these tests was saved to document computer operation.

6.1.3.2 Models

Dispersion Estimates. Short-term diffusion estimates were made in accordance with applicable documents[19-22] using data from the 245-ft meteorology tower at the WNP-2 site. The basic Gaussian diffusion model for a groundlevel release is employed using lateral (σ_y) and vertical (σ_z) spread parameters determined experimentally at Hanford.[22]

For long-term diffusion estimates, the Hanford speed parameters are used in the Gaussian diffusion model for a groundlevel release. Assumptions in the calculation are reflection of the plume at the ground, no plume depletion by surface deposition or washout, and uniform occurrence of the plume within each sector. The appropriate form of the Gaussian model is

$$\frac{\chi}{Q} = \frac{2n}{(2\pi)^{3/2}\sigma_z \bar{u}} \qquad (2)$$

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where

$\frac{\chi}{Q}$ = normalized air concentration
$\underline{n}$ = number of sectors
$\bar{u}$ = mean wind speed

Sixteen sectors were used. The values of σ_y and σ_z used for stable atmospheric conditions were determined experimentally at Hanford and are given by:[22]

$$\sigma_y^2 = At - \frac{A^2}{2(\sigma_\theta \bar{u})^2} \quad 1-\exp \quad - \frac{2(\sigma_\Theta \bar{u})^2 t}{A} \tag{3}$$

$$A = 13.0 + 232\sigma_\Theta \bar{u} \tag{4}$$

$$\sigma_z^2 = a \quad 1-\exp(-k^2 t^2) \quad + bt \tag{5}$$

$$t = x/\bar{u} \tag{6}$$

where

t = time
x = downwind distance
σ_θ = horizontal wind-direction standard deviation

and the coefficients are given as:

	Moderately Stable	Very Stable
a	97 m^2	34 m^2
b	0.33 m^2/sec	0.025 m^2/sec
k^2	2.5 x 10^{-4} sec^{-2}	8.8 x 10^{-4} sec^{-2}

For neutral and unstable atmospheric conditions the Sutton formulations

$$\sigma_y^2 = \frac{C_y^2}{2} x^{(2-m)} \tag{7}$$

$$\sigma_z^2 = \frac{C_z^2}{2} x^{(2-m)} \tag{8}$$

used where the coefficients for a groundlevel release are given as:

	Wind Speed m/sec	Unstable	Neutral
C_y	$0.10 \leq \bar{u} \leq 2.0$	0.35	0.21
	$2.0 < \bar{u} \leq 7.0$	0.30	0.15
	$7.0 < \bar{u}$	0.28	0.14
C_z	$0.22 \leq \bar{u} \leq 2.0$	0.35	0.17
	$2.0 < \bar{u} \leq 7.0$	0.30	0.14
	$7.0 < \bar{u}$	0.28	0.13
m		0.20	0.25

For the purpose of comparison, the ΔT stability classification that has been used in diffusion studies at Hanford, and which has been used here, is compared with the ΔT/Δz Pasquill classes identified in the AEC Regulatory Guide 1.23 (where ΔT = change in air temperature and Δz = change in vertical distance):

Regulatory Guide 1.23		Definition for Hanford Diffusion Parameters	
Pasquill Class	ΔT/Δz (°F/200 ft)	Class	ΔT/Δz (°F/200 ft)
A	<-2.1	Unstable	<-1.5
B	-2.1 to -1.9		
C	-1.9 to -1.6	Neutral	-0.5 to -1.5
D	-1.6 to -0.6		
E	-0.6 to 1.6	Moderately Stable	3.5 to -0.5
F	1.6 to 4.4		
G	>4.4	Very Stable	≥3.5

The above described model is consistent with standard methods with the exception that the plume growth rates used are those determined to be most appropriate for the Hanford area based upon many diffusion experiments at Hanford.

To demonstrate the effect of dilution in the building wake cavity on estimates of sector-averaged values (crosswind integrated), σ_z was replaced by

$$\left(\sigma_z^{2} + \frac{cB}{\pi}\right)^{1/2} \qquad (9)$$

where

c = empirical coefficient, conservatively taken as 0.5
B = cross-sectional area of building normal to wind

Hourly 30-minute averages of σ_θ and ΔT were used to determine the plume growth parameters, as discussed above, and χ/Q for each hour of the year for each sector and selected distances. For calm wind conditions, a speed of 0.22 mph was assumed (threshold of the instrument); for σ_θ less than 1°, a value of 1° was assumed.

The straight-line Gaussian diffusion model using empirically
derived diffusion coefficients based on Hanford experimental
data is expected to provide the best estimate of transport
and dispersion for the WNP-2 site. The Hanford dispersion
parameters described above are particularly applicable,
since they are based on the results of numerous field tracer
studies over local terrain representative of the terrain
1 downwind of WNP-2 out to the distances where the maximum
individual doses and population doses are computed. Based
on available information, the inherent transport assumptions
of the straight-line Gaussian methodology will not cause a
substantial underestimate of individual or population doses.
Additional discussion of the adequacy of the Gaussian diffusion
model is given in Section 2.3.5.2 of the FSAR.

<u>Methods Used for Modeling Cooling Tower Atmospheric Plumes</u>.
A computer program, utilizing diffusion and cumulus cloud
models was used to estimate the environmental effects of the
circular mechanical draft evaporative cooling tower. Because
1 the cooling tower analysis preceded the availability of data
from the permanent onsite meteorological system, one year of
onsite hourly data from the temporary meteorological system
was combined with hourly stability data from the Hanford
meteorology tower for the analysis. Individual plume
characteristics are calculated and the results summarized in
monthly and annual tables.

The plume rise from the circular mechanical draft cooling towers of WNP-2 are calculated using a modified heat input term in the Briggs plume rise equations.[23] This heat input term was calculated based on the Weinstein and Davis[24,25] cumulus cloud model at 0400 and 1600 hours each day. The cumulus cloud model and the Briggs model predictions were compared and correction factors calculated for the heat input to the Briggs model. The correction factors were then linearly interpolated for other hours and applied to the Briggs model predictions for those hours.

The plume rise estimates were used to define the centerline of the plume, while the prevailing wind direction defined the direction of movement.

It was assumed that for a given set of design and meteorological conditons, vapor leaving a cooling tower diffuses outward from the center of a plume according to the Gaussian plume formula regardless of whether some of the vapor condenses to fog. The criteria for visible plume formation and subsequent dissipation were based on a comparison of the calculated water vapor concentration of the plume and the corresponding value from a curve of saturation vapor pressure as a function of temperature. Whenever the latter was the greater quantity, the plume was assumed to be no longer visible.

If ground fog is predicted to be present at a given distance, the width of the plume at groundlevel is determined by the relationship,

$$Y = \partial(\sigma_y)^2 \ln (\chi_{max}/\chi)^{1/2} \tag{10}$$

When Y is the plume width, χ_{max} is the maximum value of χ along the centerline, and χ is the minimum humidity associated with fogging based on ambient conditions.

The analysis was performed for an entire year of data. The results of visible plume lengths, widths, and ground interactions as a function of distance and direction were tabulated for all conditions, and for freezing conditions. The results are given in Section 5.1.4.

Although this model is a combination of a number of physical processes for which experimental verification is available, an overall verification of the plume estimates with field data has not been performed. The impact estimates can be expected to be generally conservative as a result of the choice of conservative assumptions relative to plume rise and water source term. A more detailed discussion of the model, assumptions, and results is contained in Reference 26.

Drift Impact Model. The drift estimates are based upon the graphical method of estimating deposition rates of salts from evaporative cooling towers developed by Hosler et al.[27] They describe the problem as follows: "Drift drops are carried by the plume updraft up to a certain height and then they fall to the ground while traveling with the wind. The surface over which this salt will be distributed depends on the wind speed and the time the drops will spend in the air. This time depends on the maximum height the drop reaches and the drop fall velocity. The fall velocity of the drift drops is reduced with time because of evaporation. The rate and extent of evaporation depends on: 1) salt concentration, which regulates vapor pressure, 2) size of the droplet, and 3) ambient relative humidity. For the same environmental conditions, drops of different sizes may or may not achieve the same degree of evaporation before reaching the ground. To simplify the problem only three degrees of evaporation were considered: 1) no evaporation, 2) evaporation to saturated solution, and

3) evaporation to dry salt particles. A graph was constructed for each degree of evaporation. These graphs can be used to determine the surface to be covered by the salt, from the knowledge of the drift mass distribution as a function of drop size, the salt concentration, the maximum height of the drop, and the wind speed.[28]

Data Input. The following values were used as input into the cited model:

18.2 m	Height of tower
610,000 gpm	Water circulated per unit time[b]
4.2×10^{-4}	Mass of salt per mass of circulating water[a]
310 gpm	Drift (0.05% of circulated water)[c]
36 fps	Stack exit velocity

Table 6.1-1 lists the mass size distribution of drift droplets. Based on long-term climatological records at the Hanford Meteorological Station (HMS), the year was divided into two primary classes: 1) summer (April through September), when relative humidities averaged 40% and 2) winter (October through March), when relative humidities averaged 78%.

Plume height was allowed to vary with atmospheric stability. The heights used were based on estimates made by Woodruff et al.[29] for mechanical draft cooling tower plumes. Presumptions were that the plume would rise to a height of 1000 ft above stack top during summer neutral and unstable atmospheres, and to 330 ft during summer stable atmospheres. During winter the comparable heights for neutral/unstable and for stable situations were 1300 ft and 430 ft, respectively.

Hosler et al. [27] found minimal differences in deposition rates calculated by using mean wind speeds and by using observed wind speed distribution. Mean speeds observed at the 400-ft

(a) This value is five times the average of dissolved constituents of the Columbia River during 1969-70. The additional concentration is presumed to account for "distillation" in the cooling tower evaporation process. There is an additional mass of salts added to the river water as it enters the cooling system, but this addition amounts to only 1/610 of that contributed by the raw river water, and thus is ignored in the calculations.
(b) Larger than final design value of 570,000 gpm.
(c) Final design value is 285 gpm.

elevation at the Hanford Meteorological Station were used in the calculations. It was assumed that the period 0600 to 1800 hours daily was thermally unstable or neutral, and that the nighttime period, 1800 to 0600 hours, experienced stable atmospheres. Mean 400-ft wind speeds associated with these periods were 9.5 mph for winter days, and 10.9 mph for winter nights.

Roffman and Van Vleck[28] show that the state-of-the-art of predicting the salt deposition from drift droplets is such that the values obtained by various methods vary by a factor of ± 10. The present estimates are considered a maximum as a result of the choice of generally conservative assumptions for the calculation.

6.1.3.3 Air Quality

As a result of the small quantities of nonradiological air pollutants to be released, the Applicant does not propose to initiate a nonradiological preoperational air quality monitoring program. An independent system is operated by the Hanford Environmental Health Foundation. This program includes measurement at several locations in the Hanford area of airborne particulates, SO_2 and NO_2. These measurements as well as other air quality aspects of the site have been discussed in the PSAR (Section 2.3.1).

6.1.4 Land

Much applicable land-monitoring information related to the WNP-2 site has been collected over the years by ERDA.[17] Research field studies, particularly of soils and terrestrial ecology, were carried out on the Hanford Reservation by ERDA contractors. Thus, the data base in this case is substantial with regard to land monitoring information.

6.1.4.1 Geology and Soils

The Hanford Project, including the WNP-2 site, has been the object of many geologic studies, mainly of a topical nature. McHenry[30] characterized the chemical and physical properties of soils of the project from drilling samples collected from approximately 40 wells spaced about the project. Hajek[31] classified the soils of the project on an agricultural basis.

Earlier topical geology studies, related primarily to aspects of radioactive waste disposal, included subsurface geology of the Hanford area, identification of stratigraphic units, correlation of volcanic flows, and aquifer descriptions.[32-37]

Additional and detailed information on geologic studies, soil boring patterns, and analytical and testing methods used are contained in the Final Safety Analysis Report.

Although research studies have been carried out over a number of years concerning terrestrial ecology on the Hanford Reservation, none of these studies have been aimed at assessing impacts of cooling tower drift. Cooling tower drift will be a new kind of environmental stress for Hanford Reservation ecosystems.

The vegetative cover growing in the near vicinity of the cooling towers consists primarily of cheatgrass, Bromus tectorum. This grass provides the main biotic protection against soil erosion. Because the climate is dry, salt dissolved in drift droplets is expected to accumulate in the soil profile. Salt accumulation is expected to be most concentrated near the base of the cooling tower and rapidly decrease with increasing distance from the tower. The longer the cooling towers are operational, the more intense the salt accumulation.

Although it is expected that cheatgrass will be tolerant of moderate increases in soil salt and pH values, there are no data presently available to judge the magnitude of increased soil salt concentrations needed to significantly impair the germinability of cheatgrass seeds. This is an important point because cheatgrass is an annual grass and the stand originates from seed each year and there is no known plant that is as successful in this habitat as is cheatgrass.

A preoperational monitoring program to detect and assess significant changes
in soil chemistry in the vicinity of WNP-1/4 and WNP-2 caused by salt drift
will be initiated prior to plant operation. Soil samples will be collected at
study plots located at distances bracketing the area of expected maximum im-
pact in the predominant downwind directions (N and SE). A control plot in
similar soil, but removed from influence of the cooling tower plumes, will be
1 selected. Each study plot will be marked so that the same plot can be exam-
ined during post-operational monitoring. Less than optimum locations may have
to be selected to avoid undisturbed soil and working areas.

At each study plot, composite samples will be taken to a depth of approxi-
4 mately six (6) inches below the surface. Samples will be analyzed for salt
content, electrical conductivity, and pH. Chemical analyses will be for the
dominant ions in the cooling tower drift and in the soil: the cations Ca, Mg,
Na, and K and the anions CO_3, HCO_3, SO_4, and Cl.

6.1.4.2 Land Use and Demographic Surveys

Land use in the immediate vicinity of the WNP-2 site is under the control of Department of Energy (previously ERDA), 1 and the staff of the Richland Operations Office provided the source material required for land use descriptions of Hanford Project facilities. Additional information related to off-project land uses was obtained primarily from the Bureau of Reclamation Regional Office, which is responsible for much of the land development in surrounding areas, from the Soil Conservation Service, and from the Washington State Department of Agriculture. Some information was provided by the County Planning Offices in adjacent counties; however, this was generally related to county zoning rather than actual current land use. The collected published data were supplemented with information obtained from personal conversation with county planning and other local, county, State and Federal agency officials and through reconnaissance surveys of those areas where missing or questionable data were concerned.

Demographic data for the latest census year (1970) were obtained from Bureau of the Census publications. Information for population projections was available from the Washington State Office of Program Planning and Fiscal Management,[39] the Portland State University Center for Population Research and Census,[40] the Bonneville Power Administration,[41] the Pacific Northwest River Basins Commission,[42] Pacific Northwest Bell,[43] and the Tri-City Nuclear Industrial Council.[44] Rural population trends were based also on estimates developed for the Columbia Basin Development League.[45] Information from these sources were used by the Applicant to project population for future census years over the expected life of the plant.[46,47]

In conjunction with the construction of WNP-1 and -4, the Applicant is conducting a program to monitor the socioeconomic effects. The results of this study will be partially applicable to WNP-2. The purpose of the study is to document, assess, and project the primary and secondary socioeconomic effects and impacts of construction and operation of WNP-1 and -4. Two phases are defined in implementing the study. The first phase will emphasize measurement and documentation of socioeconomic effects into the peak of construction of 1 the WNP-1 and WNP-4 projects. Preliminary reports will be on an annual basis for each of these years. The second phase of the study will be to prepare a final report which will: 1) make an evaluation of the accuracy of a previously conducted impact projection report and 2) make new projections, if found necessary, independent of the previous study, based on updated information developed in the preliminary reports.[46,47]

The important socioeconomic factors expected to be studied in detail are listed below:

- o in-migrant workers and families
- o resident workers and families
- o the relationship between contract construction on WNP-1 and -4 and secondary employment
- o economic conditions in the study area
- o schools
- o housing
- o government services and facilities
- o traffic flow and transportation
- o social and health services
- o police and fire protection

6.1.4.3 Terrestrial Ecology

The important local flora and fauna are being identified to the species level,
1 and the relationships of the fauna to the vegetation and to the salient cli-
4 matic and soil features of the local environment are being described (48-51).
The Bald Eagle is the only threatened animal species to occur in the area. No
2 other Federally designated threatened or endangered animals or plants live in
the area. Recommendations will be made to preserve special habitats necessary
for the continued protection of such species should they occur. The important
shrub-steppe food chains are also being identified.

The preoperational monitoring program will focus on establishing a baseline
1 for evaluating cooling tower drift effects.

Aerial Photography. Aerial photographs in natural and infrared color of the
site and adjacent area were made by the Supply System to provide a basis for
mapping the extent of existing plant communities between the plant site and
the Columbia River. Photography is not believed to be sophisticated enough to
detect incipient changes due to cooling tower drift.[48] Future terrestrial
5 1 impact assessment will rely on analysis of vegetation study plots and soil
chemistry data (Section 6.1.4.1) but not aerial photography.[53]

Vegetational Analyses. A program to establish a data base for terrestrial
ecosystems in the vicinity of WNP-1, 2, and 4 was initiated in 1974.[48] 4
Vegetation study areas were established at five locations within approximately
one mile of the site. Two of these plots are located within an area burned by
wildfire in 1970 and three are in areas that escaped the fire. Figure 6.1-2
shows the location of terrestrial ecology study sites. Knowledge from these
studies will apply to construction impacts because the 1970 fire was extremely
hot, destroying virtually all plant life and all seeds which would have normally germinated the next year. As with construction areas, vegetation of
these areas depends on new seeds blowing in from unburned areas.

Species composition and relative abundance of seed plants at the five study
plots were measured according to a canopy cover method of vegetational analysis developed for shrub-steppe and meadow-steppe vegetation.[38] The percent of canopy (ground) cover provided by various botanical categories for
1975 through 1978 is shown in Figure 6.1-4.

The dominant species in burned and unburned areas is cheatgrass (Bromus
tectorum) which comprises almost all the annual grass category. The primary
productivity (grams of dry matter produced per square meter per year) of the 4
Hanford bitterbush-cheatgrass ecosystem is similar to other United States arid
land ecosystems.[51] The data presented in Figure 6.1-5 reflects that primary productivity varies from year to year depending upon the weather and
other environmental variables.

The preoperational monitoring program will include continued analyses of plant
communities on the five (5) previously established study plots. Field examination of these plots and a control will be conducted yearly at the time of 1
peak flowering. Primary productivity, canopy cover, and frequency of occurrence will be obtained.

The emphasis of preoperational studies will be to establish a baseline for
assessing impacts on indigenous vegetation caused by cooling tower drift.
Vegetation study plots are established adjacent to the soil sampling plots
discussed in Section 6.1.4.1. Litterfall sampling was performed in 1979 and
1980. Due to the extreme variability seen in the collection it is questionable whether this method could be used to detect changes in shrub productivity 5
over time. Accordingly, the Supply System, with the concurrance of
EFSEC[53], has deleted this approach from the terrestrial monitoring programs.

Animal Studies. Studies have focused on censuses of mammals and birds in the
vicinity of the site. Small mammal populations were sampled using a live
trap-mark-release-recapture technique in two contrasting plant communities.
One is a burned community, dominated by cheatgrass, and the other is an unburned, shrub-dominated community (Figure 6.1-2). Trapping is done periodically throughout the year to obtain information concerning the seasonal appearance of young animals. The weights, age, sex, general health, and the
occurrence of external parasites are recorded before release.

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The small mammal population is dominated by one species, the Great Basin Pocket Mouse. The pocket mouse population varies greatly according to the season of the year. The largest population normally occurs in late summer with the addition of young animals. A comparison of pocket catches in burned and unburned study plots is shown below:

	Unburned		Burned	
Year	Spring	Summer	Spring	Summer
1974	--	46	--	29
1975	36	27*	27	13*
1976	52	53	8	2
1977	43	30	7	14
1978	15	56	1	5
1979	64		9	
	42	42	10	13

*Trapping session conducted in July

1 These data indicate that a large population of pocket mice resides in the unburned plot and only a small population resides on the burned plot. It is not known if the small population on the burned plot is a result of the burning or whether some other factors are involved (i.e., predation). Analysis of the 1974-1979 pocket mice data indicates that about one-half percent of the total
5 pocket mouse habitat on the Hanford Site may be already effected by construction of WNP-2 and WNP-1/4. Based on the low level of impact and the project that future impacts would not be more severe, pocket mice studies were deleted from the environmental monitoring program in 1981.(53)

An aerial census of larger mammals, i.e., deer and coyote, was made once in winter to obtain an estimate of the use of the local areas. A land census of
5 deer and rabbits was initiated in 1981.(53) The pellet group count technique will be performed semiannually on sample plots to obtain an estimate of use of the WNP-1, 2 and 4 site by these animals.

Bird surveys have been taken on a twenty (20) acre study plot near WNP-2. Only three resident species were spotted during a three-day period in June 1976. The total was fourteen (14) Western Meadowlarks, six (6) Horned Larks, and two (2) Shrikes. The 1977 and 1978 results are similar to those of 1978.(51) In 1981, four new 20 acre sample plots were established in shrub
5 and river habitats.(53) Species composition and density of birds will be determined during spring and fall censuses.

Studies to date have revealed no detrimental effects of plant construction on
4 the indigenous animal and bird populations. Plant operation is expected to be less disruptive and detrimental than plant construction.

6.1.6 Radiological Monitoring

The preoperational program is designed to provide measurements of radiation and radioactive materials in those exposure pathways, and for those radionuclides, which are expected to lead to the highest radiation exposures of individuals from the operation of WNP-2. The preoperational program will begin two (2) years prior to the fuel loading of WNP-2, and follow the duration specified in the schedule below:

Two years of sampling for:
- Direct radiation
- Fish
- Vegetation
- Sediment

One year of sampling for:
- Airborne particulate
- Milk (except iodine)
- River water
- Drinking water
- Ground water

Six (6) months of sampling for:
- Airborne iodine 1
- Milk (iodine)

The preoperational program objectives are to measure background levels and their variations in exposure pathways surrounding the site; to train personnel; and to evaluate procedures, equipment, and techniques. 4

Table 6.1-3 describes the sample type, approximate location, sample collection, and analyses to be performed on each sample. Analytical techniques will be used such that the detection capabilities in Table 6.1-5 are achieved. Figure 6.1-3 shows the approximate location of the stations, and Table 6.1-4 shows the samples to be obtained at each station.

Airborne sample stations have been chosen based on the projected population distribution around the site, adjacent land use, and meterorological data presented in Chapter 2. Airborne measurements will be obtained from the vicinity of a residence which has the highest calculated atmospheric dilution factor. In selecting the locations, special attention was given to the zone within a ten mile radius of the site, especially areas in the prevailing down-wind direction.

Consideration was also given to existing facilities on the Hanford Reservation in selecting these stations.

In the terrestrial monitoring part of this program (vegetation and farm products), the area within a ten-mile radius of the site is of concern, and attention is given to the area of Franklin County which uses Columbia River water for irrigation and is in the previling downwind direction. Samples collected will be those primary food chain components available which lead to man. Milk samples will be obtained from farms or individual milk animals which are located in sectors with the higher calculated annual average atmospheric dilution factors.

Aquatic sampling locations have been chosen based on the
need to determine the WNP-2 impact on the aquatic environs
separately from other facilities on the Hanford Reservation.
The intake water will be sampled to identify the isotopes and
concentrations present prior to use by WNP-2. The water from
the discharge line will be sampled prior to dilution by the
Columbia River, and analysis will identify the isotopes and their
concentrations which may be due to WNP-2 operation. Similar
samples will be taken from the WNP-1/4 intake and discharge when
those units begin operation. The Columbia River will be sampled at
the first downstream user which is the Department of Energy (DOE)
300 Area. The water will be sampled,prior to any treatment or
1 mixing, in the vicinity of the river water intake. The City of
Richland drinking water will be sampled at the Municipal Water
Treatment Plant. This will be representative of the
water consumed and not of that withdrawn from the river. Ground
water will be obtained from wells on the site which are being used
to provide drinking water for construction workers. Fish will
be obtained from the area of the plant discharge and,since there
is no commerical fishing in this area of the river, the species
selected will be those which are seasonally available. Due to
the velocity of the Columbia River in area of the site, sedimen-
tary deposits are minimal and will be obtained from available
areas above and below the discharge.

The type of analysis to be performed for the various media was chosen to provide measurements of radionuclides from which the population doses may be estimated or verified to be below that specified in Appendix I, 10CFR50. In some cases, the analysis provides a trend indicator, and will signal the need to perform additional specific analyses of individual samples.

The frequencies selected are those expected to minimize the effect of day-to-day variations, and provide an adequate quantity of sample to meet minimum sensitivity requirements of Table 6.1-5. The samples will provide statistically valid data which is used to compare to subsequent results, and detect changes from expected values.

TABLE 6.1-1

MASS SIZE DISTRIBUTION
OF DRIFT DROPLETS

(Mechanical Draft Tower)

Diameter, μm	Percent of Mass
0- 50	11
50-100	20
100-150	21
150-200	16
200-250	13
250-300	8
300-350	11

TABLE 6.1-2

FISH SAMPLING FREQUENCY BY STATION AND METHOD[a]

Month	Frequency Per Month	Beach Seine	Hoop Net	Gill/[c] Trammel	Electro-Shocking
January	1	no sample	no sample	4 stations	no sample
February	1	6 stations	no sample	4 stations	no sample
March	1	6 stations	no sample	4 stations	b
April	2	6 stations	no sample	4 stations	b
May	2	6 stations	4 stations	4 stations	b
June	2	6 stations	4 stations	4 stations	b
July	1	6 stations	4 stations	4 stations	b
August	1	6 stations	4 stations	4 stations	b
September	1	6 stations	4 stations	4 stations	b
October	1	6 stations	4 stations	4 stations	b
November	1	no sample	no sample	4 stations	no sample
December	1	no sample	no sample	4 stations	no sample

[a]See Figure 6.1-1 for sample sites

[b]Twice monthly

4 [c]Gill net sampling was terminated in July 1979 per EFSEC Resolution No. 157

TABLE 6.1-3

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Sample Type	Location[1]	Sampling and[1] Collection Frequency	Type and Frequency[11] of Analysis
Airborne Particulate and Radioiodine	1.2 miles S of WNP-2 1.5 miles NNE of WNP-2 2.0 miles SE of WNP-2 9 miles SSE of WNP-2 7 miles SE of WNP-2 8 miles S of WNP-2 3 miles WNW of WNP-2 4.2 miles ESE of WNP-2 30 miles WSW of WNP-2	Continuous Sampling Weekly Collection	Particulate: Gross β[2] Gamma isotopic[3] on quarterly composite (by location) Radioiodine: Gamma for I-131 weekly
Direct Radiation[4]	1.2 miles S of WNP-2 1.5 miles NNE of WNP-2 2.0 miles SE of WNP-2 9 miles SSE of WNP-2 7 milses SE of WNP-2 8 miles S of WNP-2 3 miles WNW of WNP-2 4.2 miles ESE of WNP-2 30 miles WSW of WNP-2 3 miles E of WNP-2 3 miles ENE of WNP-2 7 miles NNW of WNP-2 13 stations at $22\frac{1}{2}^{\circ}$ sectors	Quarterly, Annually	Gamma Dose
River Water	Intake WNP-1/4[5] Discharge WNP-1/4[5] Intake WNP-2 Discharge WNP-2	Composite Aliquots[6] for month	Gamma isotopic[3] Tritium[7]

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TABLE 6.1-3 (Continued)

Sample Type	Location[1]	Sampling and[1] Collection Frequency	Type and Frequency[11] of Analysis
Drinking Water	7 miles ERDA 300 Area 11 miles Richland Water Treatment Plant	Composite aliquots[6] for month	Gamma isotopic[3] Tritium[7]
Ground Water[8]	#1 well WNP-2 #2 well WNP-2 well WNP-1 well WNP-4	Quarterly	Gamma isotopic[3] Tritium
Sediment	∿1 mile upstream ∿2 miles downstream	Semi-annually	Gamma isotopic[3]
Milk[9]	Closest milk animal Farm SE ∿7 miles SE Farm SE ∿8 miles ESE Control, 30 miles WSW	Semi-monthly grazing season Monthly at other times	Gamma isotopic[3] Iodine - 131
Fish	4 in vicinity of discharge 1 control Snake River	Semi-annually	Gamma isotopic[3]
Fruit and Vegetables[10]	Within 10 mile radius	Monthly during growing season	Gamma isotopic[3]

[1] Deviation may be required if samples are unobtainable due to hazardous conditions, seasonal availability, malfunction of automatic sampling equipment, or other legitimate reasons. All deviations will be documented in the annual report.

[2] Particulate sample filters will be analyzed for gross Beta after at least 24 hours decay. If gross Beta activity is greater than 10 times the mean of the control sample, gamma isotopic analysis should be performed on the individual sample.

[3] Gamma isotopic means identification and quantification of gamma emitting radionuclides that may be attributable to the effluents of the facility.

TABLE 6.1-3 (Continued)

[4] Thermoluminescent Dosimeter (TLD) badges which contain 3-5 chips will be used. Each station will have two badges; one will be changed each quarter and one will be changed annually. The badges in each $22\frac{1}{2}^{o}$ sector will be placed at the exclusion areas of the plants.

[5] Sampling of the river water from the intake and discharge of WNP-1/4 will begin at least 60 days prior to the fuel loading for WNP-1.

[6] Composite samples will be collected with equipment which is capable of collecting an aliquot at time intervals which are short relative to the compositing period.

[7] Tritium analysis will be performed on a quarterly composited sample.

[8] Wells sampled will be those which are being used to provide drinking water for construction personnel at each of the plants.

[9] Milk samples will be obtained from farms or individual milk animals which are located in sectors with the higher calculated annual average ground-level $^{D}/Q$'s. If Cesium-134 or Cesium-137 is measured in an individual milk sample in excess of 30 pCi/l, then Strontium 90 analysis should be performed.

[10] Fruit and vegetables will be obtained from farms or gardens which use Columbia River water, if possible, for irrigation and different varieties will be obtained as they are in season. One sample each of root food, leafy vegetables, and fruit should be collected each period.

[11] Frequency of analysis will be as collected or as stated in these footnotes for special cases.

Note

In addition to above guidance for operational monitoring, the following material is supplied for the preoperational programs.

The monitoring program defined will be instituted 2 years prior to the fuel loading of WNP-2. The preoperational program should follow the duration specified in the schedule below.

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TABLE 6.1-3 (Continued)

Two Years	One Year	Six Months
direct radiation	airborne particulate	airborne iodine
fish	milk (except iodine)	milk (iodine)
vegetation	river water	
sediment and soil	drinking water	
	ground water	

The Preoperational Radiological Monitoring Program objectives are to measure background levels and their variations along anticipated critical pathways surrounding the Supply System site, to train personnel, and to evaluate procedures, equipment, and techniques.

TABLE 6.1-4

KEY FOR FIGURE 6.1-3

Station Number	Sample Type
1 through 7	Particulate Radioiodine Direct Radiation
8	Particulate Radioiodine Direct Radiation Milk Fruit and/or Vegetables
9	Particulate Radioiodine Direct Radiation Milk Fruit and/or Vegetables
10 through 25	Direct Radiation
26	River Water
27 and 28	River Water Fish
29 and 30	Drinking Water
31 through 34	Ground Water
35 and 36	Sediment
37 and 38	Milk

TABLE 6.1-5

MAXIMUM VALUES FOR THE LOWER LIMIT OF DETECTION (LLD)[a, b]

	Analysis	Water (pCi/1)	Airborne Particulate or Gas (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/1)	Vegetation (pCi/kg, wet)	Sediment (pCi/kg, dry)
4	gross beta	4	1×10^{-2}				
	^{3}H	2000					
	^{54}Mn	15		130			
	^{59}Fe	30		260			
	$^{58,60}Co$	15		130			
	^{65}Zn	30		260			
	^{95}Zr	30					
	^{95}Nb	15					
	^{131}I	1[c]	7×10^{-2}		1	60	
4	^{134}Cs	15	5×10^{-2}	130	15	60	150
	^{137}Cs	18	6×10^{-2}	150	18	80	180
	^{140}Ba	60			60		
	^{140}La	15			15		

[a]Acceptable detection capabilities for thermolominescent dosimeters used for environmental measurements are given in Regulatory Guide 4.13.

TABLE 6.1-5 (Continued)

[b]Table 6.1-5 indicates acceptable detection capabilities for radioactive materials in environmental samples. These detection capabilities are tabulated in terms of the lower limits of detection (LLDs). The LLD is defined, for purposes of this guide, as the smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66\ s_b}{E \cdot V \cdot 2.22 \cdot Y\ \exp(-\lambda \Delta t)}$$

where

LLD is the lower limit of detection as defined above (as pCi per unit mass or volume)

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

E is the counting efficiency (as counts per disintegration)

V is the sample size in units of mass or volume)

2.22 is the number of disintegrations per minute per picocurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

Δt is the elapsed time between sample collection and counting

The value of s_b used in the calculation of the LLD for a particular measurement system should be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicted variance. In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background should include the typical contributions of other radionuclides normally present in the samples (e.g., potassium-40 in milk samples).

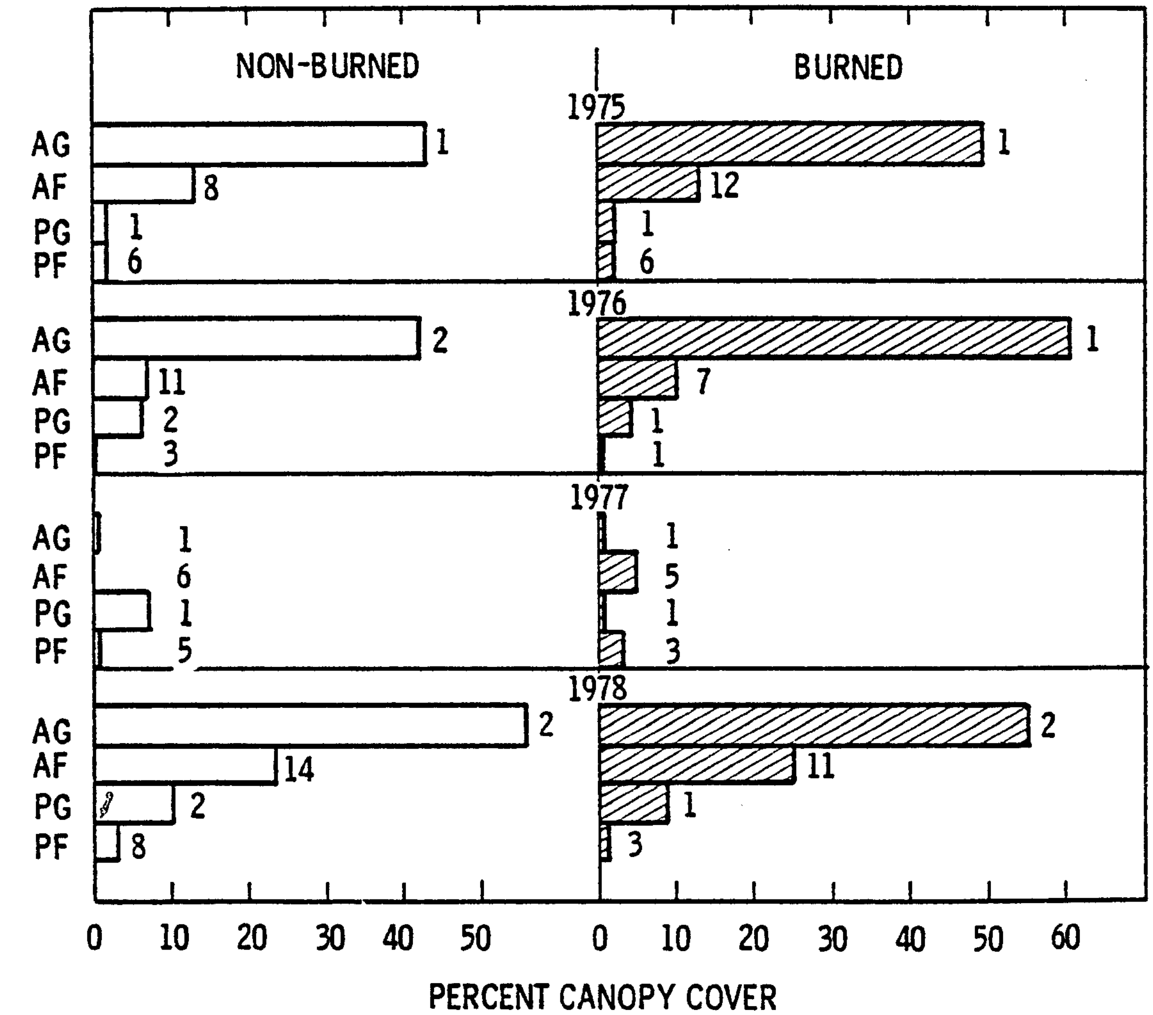
TABLE 6.1-5 (Continued)

b (Continued)

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors will be identified and described in the Annual Radiological Environmental Operating Report.

c LLD for drinking water.

4

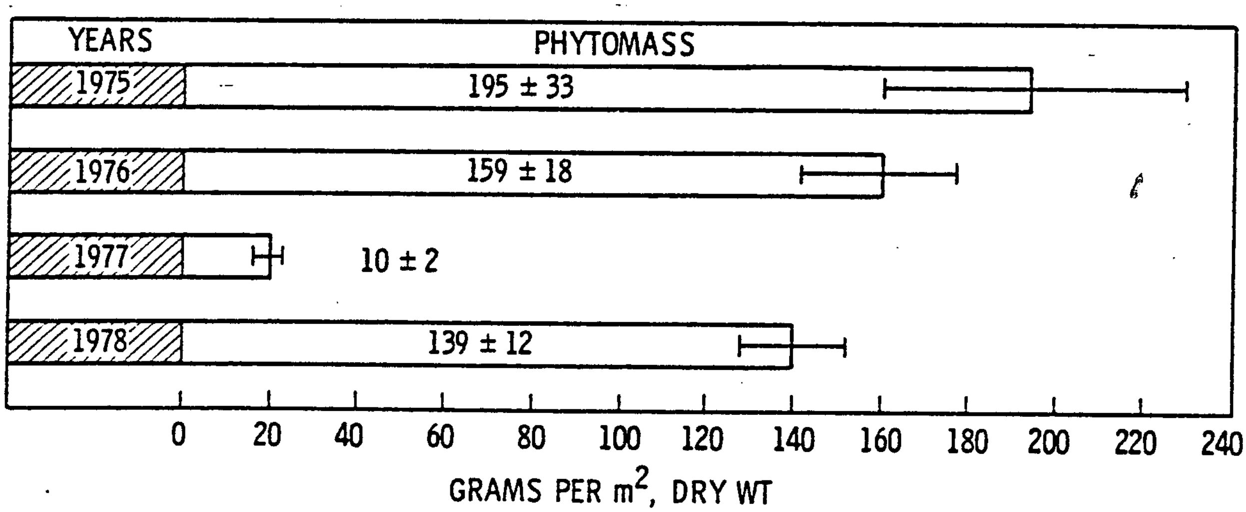


AG=ANNUAL GRASS AF=ANNUAL FORB PG=PERENNIAL GRASS PF=PERENNIAL FORB

Numerical Values Indicate the Number of Species in Each Botanical Category

Amendment 4, October 1980

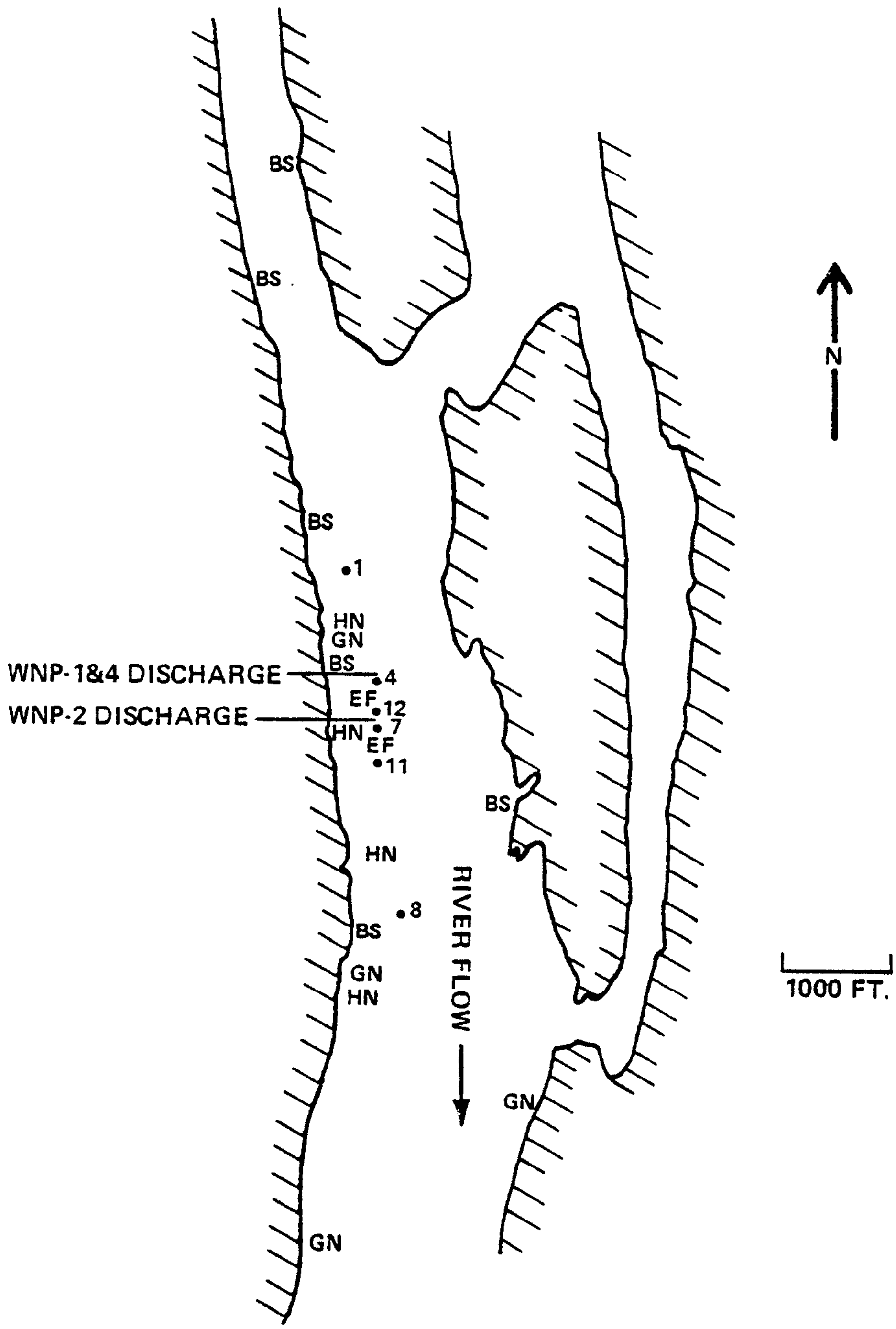
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PERCENT CANOPY COVER OF HERBS IN VICINITY OF WNP-2 FIG. 6.1-4



Average Live Aboveground Herb Phytomass ± One Standard Error

Amendment 4, October 1980

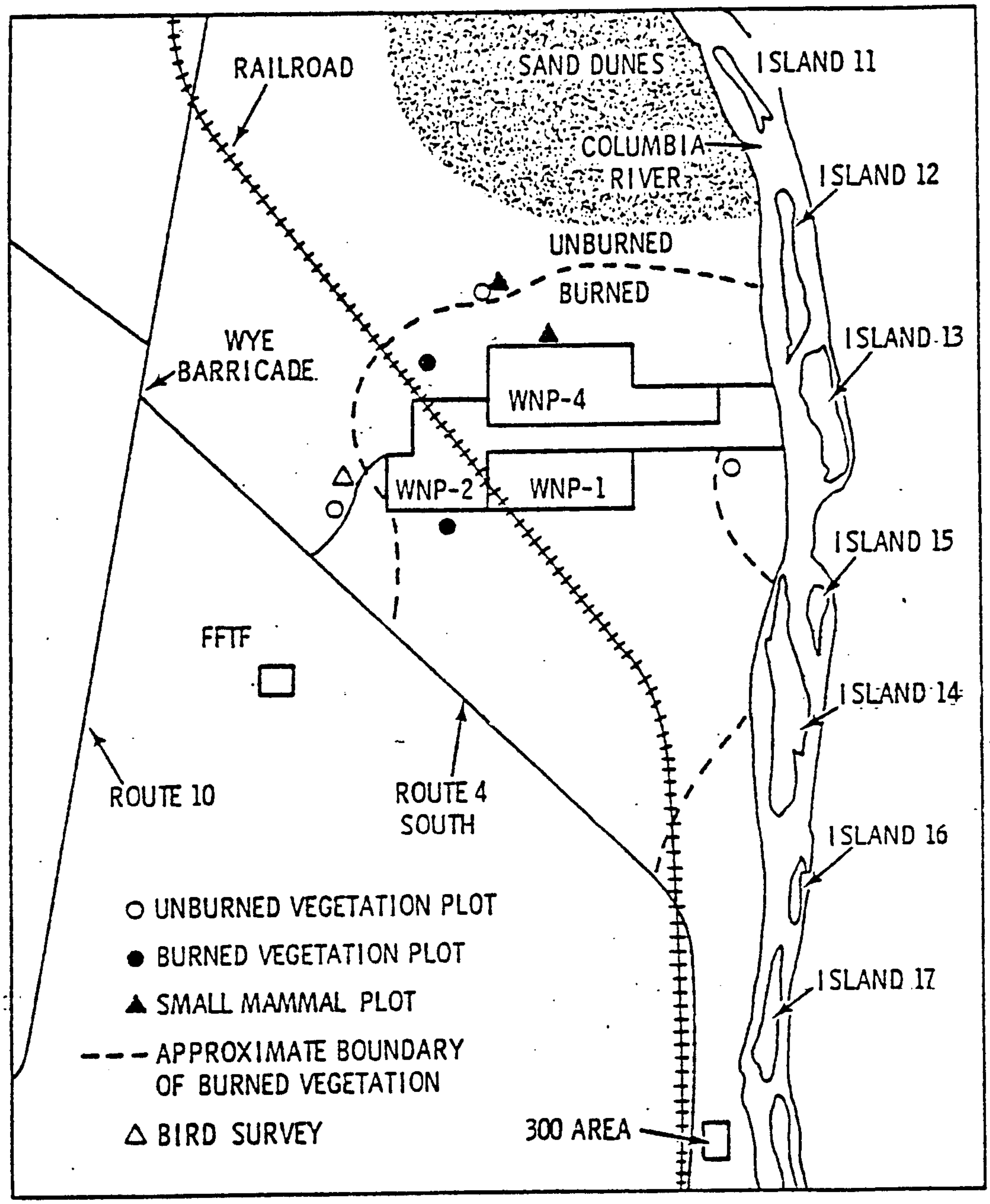
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	AVERAGE HERB PRIMARY PRODUCTIVITY IN VICINITY OF WNP-2
	FIG. 6.1-5



BS - BEACH SEINE SITES
HN - HOOP NET SITES
GN - GILL NET SITES
EF - ELECTROFISH AREAS
• - SAMPLING STATIONS FOR PLANKTON, BENTHOS, & WATER QUALITY

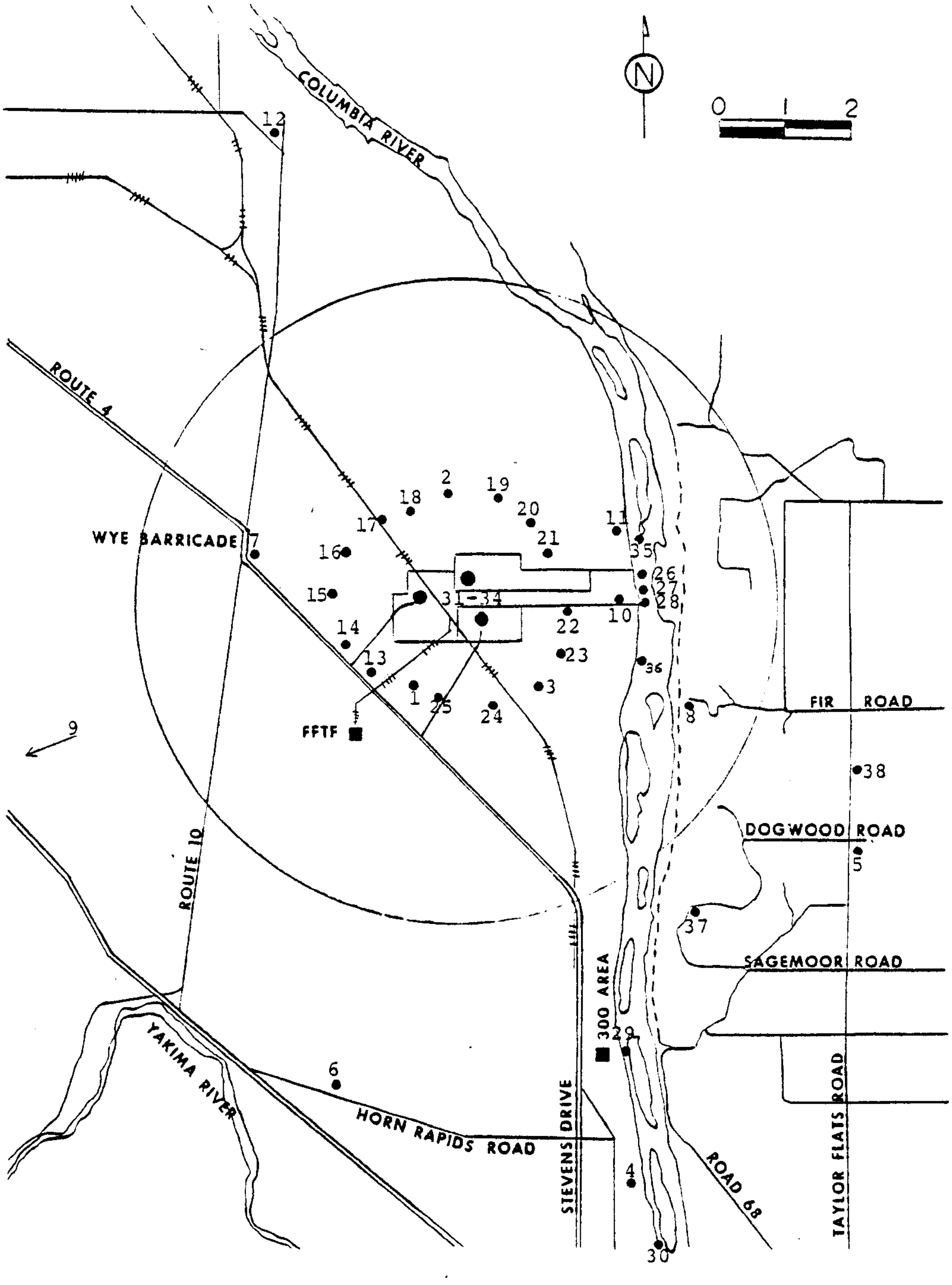
Amendment 2, October 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	AQUATIC BIOTA AND WATER QUALITY SAMPLING STATIONS NEAR WNP-1, 2, AND 4. FIG. 6.1-1



Amendment 1, May 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	TERRESTRIAL ECOLOGY STUDY SITES IN THE VICINITY OF WNP-2
	FIG. 6.1-2



Amendment 1, May 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	RADIOLOGICAL SAMPLE STATION LOCATIONS
	FIG. 6.1-3

6.2 OPERATIONAL ENVIRONMENTAL PROGRAM

The scope and general content of the operational environmental monitoring program and special topical studies are described in the following subsections. In all cases these programs may be modified based on the results of the preoperational programs and the first year of operational data. Program details, including administrative controls and reporting plans, are contained in the Environmental Technical Specifications in Appendix I.

6.2.1 Water Quality

The planned operational phase water quality monitoring program is described by Table 6.2-1. Continuous recordings will be made of the temperature of the blowdown and the makeup water. These mesurements will be made in the circulating water pumphouse and in the makeup water pumphouse, and will be representative of blowdown discharge temperatures and ambient river temperatures near the intake. Temperatures in the intake pumphouse will not be representative of ambient river conditions when makeup water is not being withdrawn. 1

Total residual chlorine will be measured every fifteen minutes during chlorination and for two hours after blowdown commences, or until it reaches undetectable levels.

Chlorination requirements will be studied during the first year to determine the minimum daily discharge duration of free available and total residual chlorine which will allow the plant to operate efficiently. 1

6.2.2 Aquatic Environment

The operational aquatic monitoring program will be designed based upon results of the preoperational program described in 6.1.1.2. The programs will be similar in scope.

4

6.2.3 Radiological

The operational radiological monitoring program will be the
same as the preoperational program described in Section
1 6.1.5 for the first year of operation. The scope of monitoring
in subsequent years will be determined based upon the results
of the two-year preoperational program and the first year's
operational program.

6.2.4 Meteorological

The operational monitoring program will include wind speed,
1 direction and temperature measurements made at the 245 and
33 foot levels, and dewpoint measurements at the 33 foot
level. Rainfall amounts and intensities will also be measured.
Real-time wind speed, direction and stability data will be
available in the control room.

6.2.5 Land

The first year operational program will continue the preoperational programs described in 6.1.4 unless preoperational results indicate changes are necessary.

TABLE 6.2-1

WATER QUALITY MONITORING PROGRAM

Measured Items	Station 1*	WNP-2 Discharge	Station 11*	Station 8*	Wells in vicinity of Plant Site
Quantity (flow)	-	C	-	-	-
Temperature	M	C	M	M	-
Dissolved Oxygen	M	-	M	M	-
pH	M	C	M	M	Q
Turbidity	M	-	M	M	-
Total Alkalinity	M	M	M	M	Q
Filterable Residue (Total Dissolved Solid)	M	M	M	M	-
Nonfilterable Residue (Suspended Solids)	M	M	M	M	-
Conductivity	M	M	M	M	-
Iron (Total)	M	M	M	M	-
Copper (Total)	M	M	M	M	-
Nickel (Total)	M	M	M	M	-
Zinc (Total)	M	M	M	M	-
Sulfate	M	M	M	M	-
NH_4+ Nitrogen	M	M	M	M	-
NO_3- Nitrogen	M	M	M	M	Q
Ortho Phosphorus	M	M	M	M	Q
Total Phosphorus	M	M	M	M	Q
Oil and Grease	M	W	M	M	-
Chlorine, Total Residual	-	C	M	M	-

Symbols Key

C = Continuous
W = Weekly
M = Monthly
Q = Quarterly

* Refer to Figure 6.1-1 for station location

Amendment 1
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6.3 RELATED ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

Currently, a number of related studies are being carried out in the vicinity of the WNP-2 site by the Applicant and by or under sponsorship of several State and Federal agencies. Some of these studies are of a continuing nature and date back 20 or more years, particularly those associated with assessment of effluent releases from the operation of the Hanford Production reactors.

6.3.1 Hydrological and Water Quality Studies in Progress

Agency	Program
U.S. Geological Survey, Tacoma District Office	Continuous water stage and discharge measurements of the Columbia River below Priest Rapids Dam (RM 394.5).[1]
U.S. Geological Survey, Tacoma District Office	Continuous water temperature measurements of the Columbia River at the City of Richland water supply treatment plant (RM 338) and at Vernita (RM 391).[2,3]
U.S. Energy Research and Development Administration, Richland Operations Office	Weekly pH, turbidity, dissolved oxygen, biochemical oxygen demand, and coliform sampling of the Columbia River at the City of Richland water supply treatment plant (RM 338), 300 Area (RM 345), and Vernita (RM 391), by Battelle-Northwest.[4]
U.S. Energy Research and Development Administration, Richland Operations Office	Weekly coliform, fluoride and nitrate sampling of Columbia River at City of Richland water supply treatment plant (RM 338), 300 Area (RM 345), and 100 Areas (to RM 384), by Hanford Environmental Health Foundation.[5]
U.S. Energy Research and Development Administration, Richland Operations Office	Monthly to annual groundwater depth and water quality measurements for observation wells on Hanford Reservation, by Battelle-Northwest and Atlantic Richfield Hanford Company.[4,6]

Agency	Program
U.S. Energy Research and Development Administration, Division of Reactor Research and Development	Studies by Battelle-Northwest related to environmental aspects of the potential establishment of a nuclear energy center at the Hanford Reservation.(7)
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Studies by Battelle-Northwest on sediment and radionuclide transport in Columbia River below Priest Rapids Dam.(3)
U.S. Army Corps of Engineers, North Pacific Division	Review of Columbia River and tributaries water resources.(8)
Washington State Department of Ecology	Water temperature, dissolved oxygen, conductivity, color, pH, turbidity, total coliform bacteria and fecal coliform bacteria sampling in the Columbia River at Highway 24 bridge near Vernita (RM 338.1) (semimonthly during water year 1972, quarterly during water year 1975, semimonthly since October 1975), and at the Port of Pasco public dock (RM 328.4) (semimonthly December 1971 - September 1972), and occasional biochemical oxygen demand and streamflow determinations at both sites. Sampling of additional 21 parameters at Vernita bridge during water year 1972.(9)
U.S. Environmental Protection Agency	Miscellaneous water quality measurements in STORET data system for period 1957 to present at following Columbia River locations between McNary and Priest Rapids Dams: RM 292.0 (McNary Dam), 292.4, 292.5, 293.0 324.9 (above mouth of Snake River), 326.3, 328.0 (Kennewick-Pasco railroad bridge), 328.3, 329.0, 330.0 (Kennewick-Pasco State Highway 12 bridge), 334.7

Agency	Program
	(below mouth of Yakima River), 388.1 (Vernita State Highway 24 bridge), 388.5, 395.5, 395.6, 397.0 (Priest Rapids Dam).

6.3.2 Ecological Parameters - Aquatic Studies in Progress

Agency	Program
Washington Public Power Supply System	Studies by Battelle-Northwest in the Columbia River in the vicinity of WNP-2 to systematically collect baseline ecological data on the plankton, benthos, and fish. This program constitutes the proposed operational monitoring program for WNP-1 and WNP-4, and the preoperational studies for WNP-2.
Washington Public Power Supply System	Studies by Battelle-Northwest of the preoperational baseline data and operational effects of the Hanford Generating Plant near the 100-N Reactor. Current efforts on operational effects are assessing the loss of fish by impingement on the intake screens.[11,12]
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Annual (since 1947) census of the fall chinook salmon spawning population in the Columbia River between Richland and Priest Rapids Dam, by Battelle-Northwest. Weekly aerial observations have provided data to evaluate the fluctuations in the spawning populations in this section of the river and to examine the relationships between the numbers and perturbations in the river.[13]
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Investigations by Battelle-Northwest on the combined effects of heat and chemical pollutants on warm and cold water fishes and on fish food

Agency	Program
	organisms. These studies are intended to quantify the combined effects of thermal insult and chemical stress on the physiology of fish and fish food organisms.[14]
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Studies by Battelle-Northwest on the physiological effects of rapid temperature decline on warm and cold water fish and crayfish. The objective of cold shock studies is to define the interactions between biota and the varying hydrographic regimes occurring in thermal mixing zones following cessation of heated discharges.[14]
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Investigations by Battelle-Northwest on the effects of thermal discharge on fish behavior and sensory physiology including sublethal effects that might impair the capacity of a fish to function effectively in its environment.[14]
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Studies by Battelle Northwest on the effect of thermal discharges on aquatic organisms. This project addresses mainly two specific impacts of thermal discharges and their effects: gas bubble disease and effects of fatigue on thermal tolerance.[15]
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Studies by Battelle-Northwest on fish behavior in waters whose quality has been altered by various perturbations. Emphasis in this work makes use of radio-tracking telemetry to examine the response of fishes encountering such conditions.[14]

Agency	Program
U.S. Army Corps of Engineers, Grant County PUD, Chelan County PUD	Studies of upstream adult migrant fish passing Columbia River dams. These fish counts are generally made from April to October each year.
National Marine Fisheries Service	Research on the enhancement of downstream passage of juvenile salmonids at Priest Rapids Dam and other PUD dams on the Columbia River.

6.3.3 Ecological Parameters - Terrestrial Studies in Progress

Agency	Program
Washington Public Power Supply System	Studies by Battelle-Northwest including characterization of small mammal populations in burned and unburned shrub-steppe plant communities, avifauna of shrub-steppe plant communities, ecological characterization of burned and unburned shrub-steppe plant communities, primary production of cheatgrass, and aerial photography of shrub-steppe plant communities.
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	A small mammal trapping study by Battelle-Northwest is on the WYE burial ground located immediately west of the WNP-2 site. This study has been in progress for 2 years and yields information on abundance, age, weight, and sex ratios of great basin pocket mice.(14)
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Extensive ecological studies by Battelle-Northwest concerning plant and animal communities have been conducted on the Arid Lands Ecology (ALE) Reserve since 1968. The ALE Reserve is located about 10 miles west of the WNP-2 site.(14)

Agency	Program
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Mule deer fawns have been tagged by Battelle-Northwest along the Columbia River for a number of years to determine mule deer movements beyond the Hanford Reservation. A nesting survey of the Columbia River Canada goose population has been conducted for nearly 30 years.[14]
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Radiotracking of coyotes and breeding ecology of raptors and long-billed curlews are currently being studied by Battelle-Northwest on the Hanford Reservation.[14]

6.3.4 Meteorological Monitoring Programs in Progress

Agency	Program
Washington Public Power Supply System	Meteorological data collection at the WNP-2 site by Battelle-Northwest from March 1972 to September 1974 with temporary system and from April 1974 to June 1976 with permanent system. Temporary system measurements included wind speed on 23-ft mast, air temperature and relative humidity. Permanent system measurements included wind speed and air temperature at top of 7-ft mast and at 33-ft level and top of 245-ft tower, dewpoint temperature at the 33-ft level, and precipitation at ground level.
U.S. Energy Research and Development Administration, Richland Operations Office	The Hanford Meteorological Station, 14 miles west-northwest of the WNP-2 site, is operated for ERDA by Battelle-Northwest. This station is manned by an observer-forecaster 24 hours per day. Complete surface weather observations are made hourly. Wind and temperature profiles from the surface

Agency	Program
	to 400 ft are monitored continuously.[17] In addition a network of nine telemetered wind and temperature stations is operated on the Hanford Reservation including the WNP-2 site, and assists in definition of airflow patterns. Micrometeorological and climatological records dating from 1944 are available from the Hanford Meteorological Station.[18]
U.S. Energy Research and Development Administration, Division of Biomedical and Environmental Research	Climatological measurements of maximum and minimum temperature, humidity, and precipitation are currently being made on ERDA's Arid Lands Ecology Reserve (ALE) by Battelle-Northwest.[19] The ALE Reserve lies to the west of WNP-2
U.S. Energy Research and Development Administration, Division of Production and Waste Management	Wind speed and direction are being measured at the site of the ERDA's Fast Flux Test Facility, 3 miles west of WNP-2 Measurements have been at this location since 1971.
U.S. Energy Research and Development Administration	Wind speed, direction and temperature have been measured at the surface and at the 50 200, and 300-ft levels on a meteorological tower operated by United Nuclear Industries near the N-reactor approximately 19 miles northwest of the WNP-2 site.[20] This data is not presently collected on a routine basis.

6.3.5 Radiological Monitoring Programs in Progress

Agency	Program
U.S. Energy Research and Development Administration	A comprehensive radiological monitoring program for the Hanford plant and surrounding environs is carried out by

Agency	Program
	Battelle-Northwest to evaluate the disposition and translocation of Hanford plant-released radionuclides (continuous since before 1960). Table 6.3-1 provides a summary of the program, taken from reference 21, and Figures 6.3-1 and 6.3-2 show sampling locations. Annual reports provide surveillance program details[21] and results.[22,23]
Washington State, Division of Social and Health Services	A state-wide radiological surveillance program is carried out by the Radiological Control Unit.[24] Samples of Columbia River water, air, milk and shellfish are obtained at a number of locations relevant to WNP-2 are shown in Table 6.3-2 and Figure 6.3-3. Results are reported to the Environmental Protection Agency and are published annually.

TABLE 6.3-1

ROUTINE ENVIRONMENTAL RADIATION SURVEILLANCE SCHEDULE - 1979
U. S. DEPARTMENT OF ENERGY

Type of Sample	Type of Analysis	W	BW	M	BM	Q	SA	A
WATER								
Columbia River Water	Radioactivity		2	2				
	Dose Rate			2				
	Chemical	2						
	Biological			2				
Sanitary Water	Radioactivity	1		3		9		
	Chemical	2[(a)]						
Groundwater Wells	Radioactivity					340	36	
	Chemical					255	40	35
AIR:								
Filters	Radioactive Particulates		44					
Molecular Sieves	Tritium		6					
Charcoal Cartridge	Radioiodines		10	34				
OTHER:								
Radiation Level	Dose Rate			61				
Shoreline Survey	Dose Rate			11				
Waste Site Survey	Radioactivity					3	66	3
Road Survey	Radioactivity			6		3		
Aerial Survey	Radioactivity							1
Railroad Survey	Radioactivity					3		2
Milk	Radioactivity		9					
Fish (Columbia River)	Radioactivity			1	1		4	
Wild Fowl	Radioactivity			2		5		9
Mammals	Radioactivity				10			
Soil	Radioactivity							21
Vegetation	Radioactivity							21
Foodstuffs: Meat	Radioactivity					1	1	1
Produce	Radioactivity			5	1			6

(a) Samples routinely analyzed and reported by the Hanford Environmental Health Foundation.

TABLE 6.3-2

ENVIRONMENTAL RADIATION SURVEILLANCE NETWORK
WASHINGTON STATE DEPARTMENT OF SOCIAL AND HEALTH SERVICES
HEALTH SERVICES DIVISION, JUNE 1978

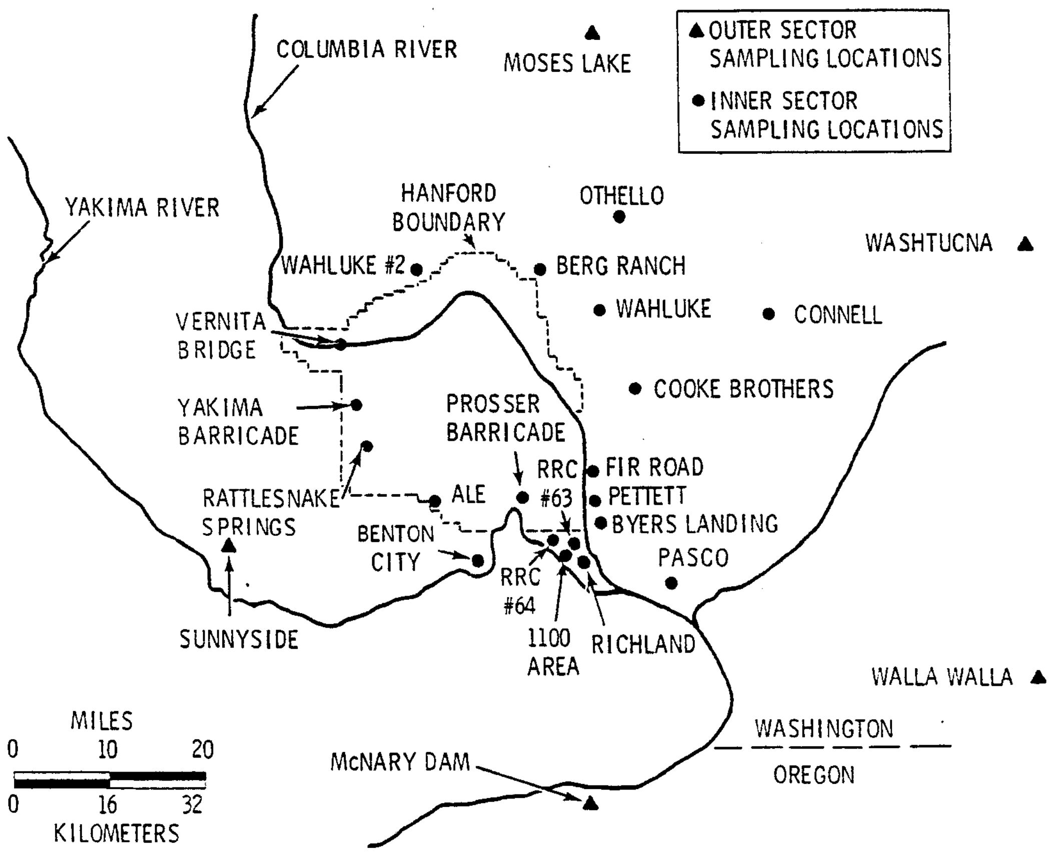
Station Code	Location	Sample Type
Puget Sound		
PS 0101	Seattle - Smith Tower	Air
0102	Seattle - Boeing Field	TLD*
0201	Cedar River - Lansberg	Surface Water
1302	Puyallup River - Puyallup	Surface Water
1702	Puget Sound - Bangor	Oyster, Sediment
1704	Puget Sound Naval Shipyard - Bremerton	Sediment
3201	Olympia	TLD
3301	Edmonds	TLD
3401	Bremerton	TLD
3501	Bangor	TLD
3601	Pack Forest - Lt. Br. of Spring	Ground Water
3602	Pack Forest - Rt. Br. of Spring	Ground Water
3603	Pack Forest - Ditch below Spring	Ground Water
3604	Pack Forest - Ditch 200' Uphill	Ground Water
Coastal Peninsula		
CP 1801	Elma	TLD
2401	Port Angeles	TLD
Southwest		
SW 0301	Kalama River - Kalama	Surface Water
0904	Columbia River - Longview	Surface Water
0905	Cottonwood Island - Columbia River	Sediment
0906	Columbia River - East Shore, Trojan	Sediment
1100	Kalama - Sewage Treatment Plant	TLD, Soil
2002	Woodland	Milk
2100	Kelso - Vision Acres	TLD, Soil
3100	Longview, Ocean Beach Substation	TLD, Soil
4100	Trojan Plant - Meteorology Tower	TLD
Northwest		
NW 0204	Skagit River - Concrete	Surface Water
0501	Skagit County - General Area	Milk
1501	Bellingham	TLD
1601	Lyman	TLD
Southcentral		
SC 0202	Yakima River - Yakima (Parker)	Surface Water
Northcentral		
NC 0103	Okanogan River - Malott	Surface Water
0701	Wenatchee - Sewage Treatment Plant	TLD

*Thermoluminescent Dosimeter

TABLE 6.3-2 (Cont.)

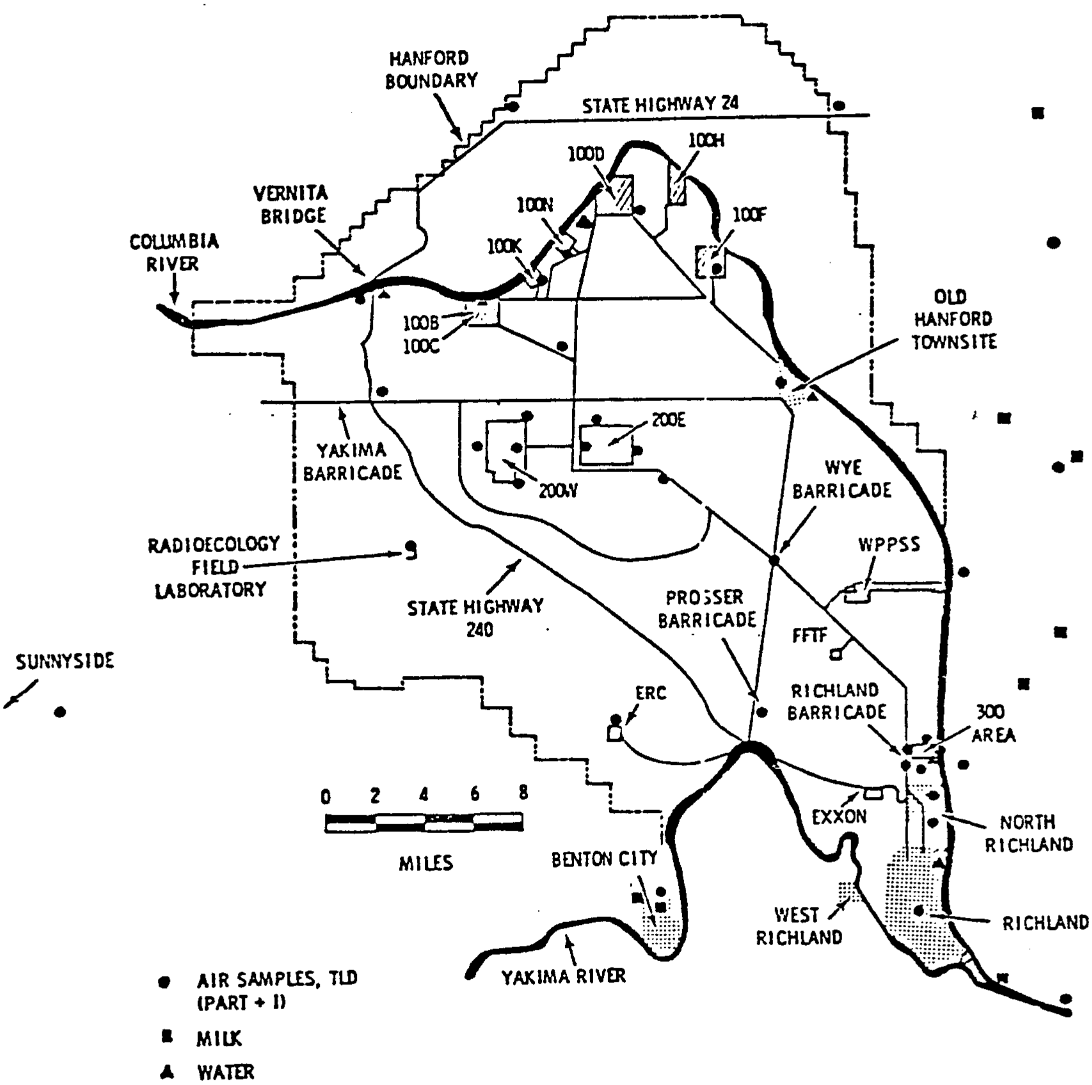
Station Code	Location	Sample Type
Southeast		
SE 0011	Hanford - Well 699-17-5	Ground Water
0012	Hanford - Well 699-9-E2	Ground Water
0013	Hanford - Well 699-2-3	Ground Water
0104	Columbia River - Richland Water Treatment Plant	Surface Water
0601	Benton County - General Area	Milk
0701	Franklin County - General Area	Milk
1101	Richland	TLD*
1201	Hanford - NECO Burial Site - NE Corner	TLD, Soil
1202	Hanford - NECO Burial Site - NW Corner	TLD, Soil
1203	Hanford - NECO Burial Site - SW Corner	TLD, Soil
1204	Hanford - NECO Burial Site - SE Corner	TLD, Soil
3201	WPPSS-2 - Station 1	TLD, Soil
3202	WPPSS-2 - Station 2	TLD, Soil
3203	WPPSS-2 - Station 3	TLD, Soil
3204	WPPSS-2 - Station 4	TLD, Soil
3208	WPPSS-2 - Station 8	TLD, Soil
3235	WPPSS-2 - Station 35	Sediment
3236	WPPSS-2 - Station 36	Sediment
Northeast		
NE 0101	Spokane - City Hall	Air
0102	Chattaroy - 20 miles north of Spokane	TLD
0103	Spokane	TLD
1101	Deer Park - General Area	Milk
2101	Sherwood U. Mill - Station A	Soil, Air
2103	Sherwood U. Mill - Station C	Soil, Air, TLD
2105	Sherwood U. Mill - Station E	Air, TLD
2106	Sherwood U. Mill - Station F	Air
2107	Sherwood U. Mill - Station G	Soil, Air, TLD
2109	Sherwood U. Mill - Rajewski Ranch	Soil, Air, TLD
2121	Sherwood U. Mill - Station L1	Sediment
2122	Sherwood U. Mill - Station L2	Sediment
2123	Sherwood U. Mill - Station L3	S. Water,Sediment
2124	Sherwood U. Mill - Blue Creek	S. Water
2131	Sherwood U. Mill - Station S1	Ground Water
2132	Sherwood U. Mill - Station S2	Ground Water
2133	Sherwood U. Mill - Station S3	Ground Water
2134	Sherwood U. Mill - Station MW1	Ground Water
2135	Sherwood U. Mill - Station MW2	Ground Water
2136	Sherwood U. Mill - Station MW3	Ground Water
2138	Sherwood U. Mill - Station MW5	Ground Water
2139	Sherwood U. Mill - Station MW6	Ground Water

*Thermoluminescent Dosimeter



Amendment 4, October 1980

WASHINGTON PUBLIC POWER SUPPLY SYSTEM **WPPSS NUCLEAR PROJECT NO. 2** **Environmental Report**	HANFORD ENVIRONMENTAL AIR SAMPLING LOCATIONS **FIG.** 6.3-1

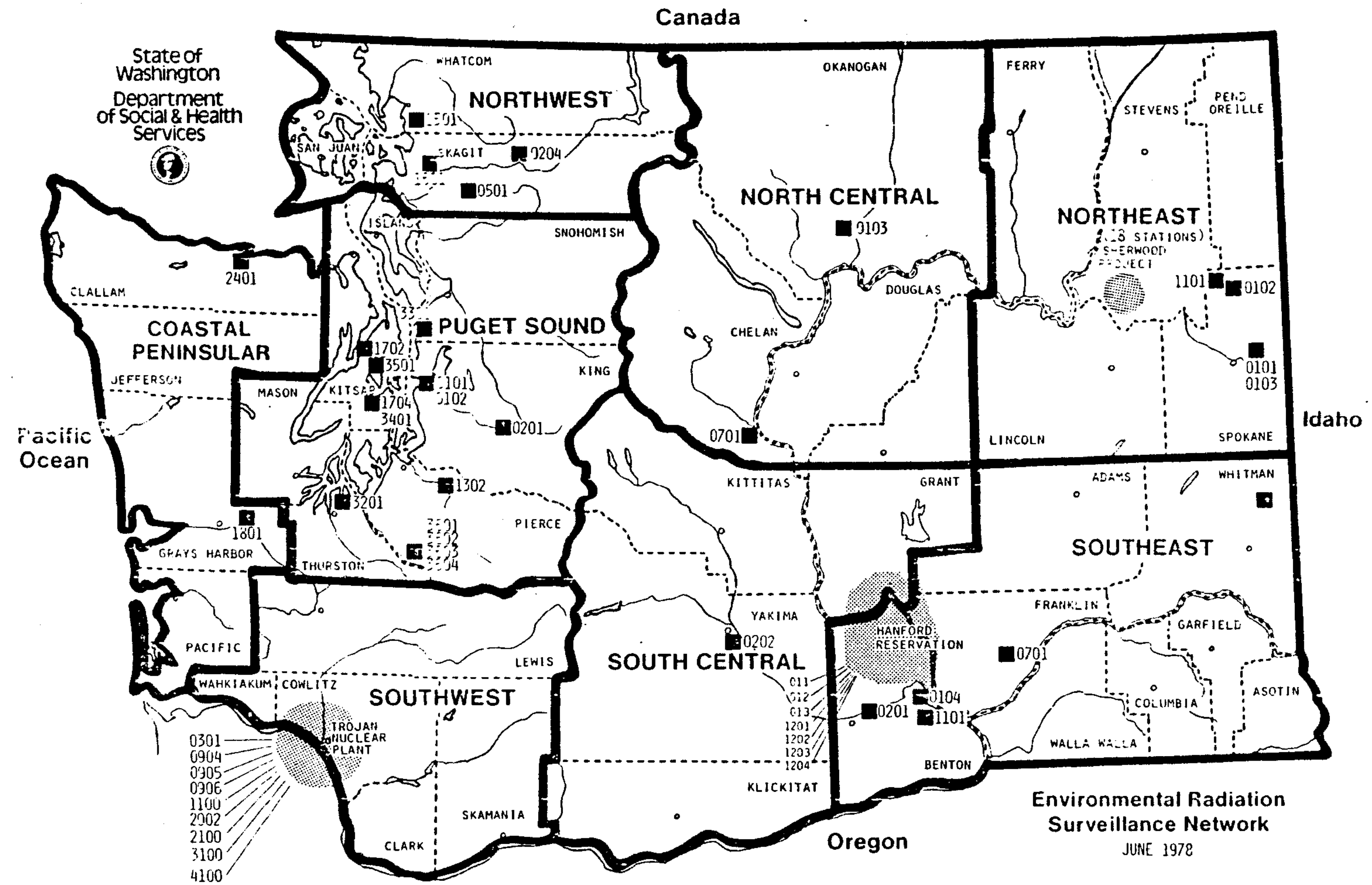


Amendment 1, May 1978

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	RADIOLOGICAL MONITORING STATIONS AT HANFORD OPERATED BY DOE
	FIG. 6.3-2

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
WPPSS NUCLEAR PROJECT NO. 2
Environmental Report

Amendment 4, October 1980



STATEWIDE SAMPLING LOCATIONS

FIG. 6.3-3

6.4 Preoperational Environmental Radiological Monitoring Data

The data below represents results of samples taken from March, 1978 through June, 1980.

Sediment

Sample Date	Station Number	Isotope (pCi/g) Co-60	Cs-137	Other Gamma
5-17-78	35	0.59±0.21	0.36±0.13	<0.15
5-17-78	36	0.32±0.11	0.38±0.09	<0.15
11-27-78	36	0.38±0.11	0.49±0.09	<0.15
12-21-78	35	<0.15	0.22±0.05	<0.15, Zn-65 = 0.37±0.11
7-10-79	35	0.13±0.06	0.31±0.07	<0.15
7-10-79	36	0.46±0.12	0.42±0.08	<0.15
11-19-79	35	0.13±0.06	0.31±0.06	<0.15
11-19-79	36	0.61±.11	0.48±0.07	<0.15
5-08-80	35	<0.15	0.20±0.03	<0.15

Soil

Sample Date	Station Number	Isotope (pCi/g) Cs-137	Zn-65	Fe-59	Other Gamma
5-08-78	1	0.5±0.1	<0.15	<0.26	<0.15
5-08-78	2	<0.15	<0.15	<0.26	<0.15
5-08-78	3	0.7±.1	<0.15	<0.26	<0.15
5-08-78	7	0.50±0.07	<0.15	<0.26	<0.15
5-08-78	9	0.14±0.04	<0.15	<0.26	<0.15
5-10-79	1	<0.15	-	-	<0.15
5-10-79	2	0.55±0.07	-	-	<0.15
5-10-79	3	0.14±0.03	-	-	<0.15
5-10-79	7	<0.15	-	-	<0.15
5-10-79	9	<0.15	-	-	<0.15
5-08-80	1	1.65±0.14	-	-	<0.15
5-08-80	2	<0.15	-	-	<0.15
5-08-80	3	1.12±0.12	-	-	<0.15
5-08-80	7	1.88±0.14	-	-	<0.15
5-08-80	9	<0.15	-	-	<0.15

Natural K-40 in the soil ranged from 7-14 pCi/g with an average of 10 pCi/g for the ten (10) samples.

Garden Produce

Sample Type	Collection Site	Collection Date	Gamma Emitters pCi/g Wet
Chard	Pasco	6/20/78	<0.08
Chard	Pasco	6/20/78	<0.08
Carrots	Grandview	6/20/78	<0.08
Apricots	Pasco	7/24/78	<0.08
Onions	Pasco	7/24/78	<0.08
Cabbage	Pasco	7/24/78	<0.08
Apricots	Grandview	7/24/78	<0.08
Onions	Grandview	7/24/78	<0.08
Beans	Grandview	7/24/78	<0.08
Chard	Pasco	8/21/78	<0.08
Carrots	Pasco	8/21/78	<0.08
Apples	Pasco	8/21/78	<0.08
Onions	Grandview	8/21/78	<0.08
Apples	Grandview	8/21/78	<0.08
Chard	Pasco	9/25/78	<0.08
Carrots	Pasco	9/25/78	<0.08
Grapes	Pasco	9/25/78	<0.08
Chard	Grandview	9/25/78	<0.08
Carrots	Grandview	9/25/78	<0.08
Tomatoes	Grandview	9/25/78	<0.08
Chard	Pasco	10/23/78	<0.08
Carrots	Pasco	10/23/78	<0.08
Tomatoes	Pasco	10/23/78	<0.08
Comfrey	Grandview	10/23/78	<0.08
Carrots	Grandview	10/23/78	<0.08
Tomatoes	Grandview	10/23/78	<0.08
Comfrey	Grandview	5/22/79	<0.08
Lettuce	Pasco	5/22/79	<0.08
Onion	Pasco	5/22/79	<0.13
Strawberry	Pasco	5/22/79	<0.08
Carrots	Grandview	6/25/79	<0.08
Comfrey	Grandview	6/25/79	<0.08
Cherries	Grandview	6/25/79	<0.08
Chard	Pasco	6/25/79	<0.08
Carrots	Pasco	6/25/79	<0.08
Cherries	Pasco	6/25/79	<0.08

Garden Produce (Cont.)

Sample Type	Collection Site	Collection Date	Gamma Emitters pCi/g Wet
Apples	Pasco	7/29/79	<0.08
Carrots	Pasco	7/29/79	<0.08
Peppers	Pasco	7/29/79	<0.08
Chard	Grandview	7/29/79	<0.08
Carrots	Grandview	7/29/79	<0.08
Apples	Grandview	7/29/79	<0.08
Carrots	Pasco	8/21/79	<0.08
Cabbage	Pasco	8/21/79	<0.08
Apples	Pasco	8/21/79	<0.08
Tomatoes	Grandview	8/21/79	<0.08
Comfrey	Grandview	8/21/79	<0.08
Apples	Pasco	9/18/79	<0.08
Cabbage	Pasco	9/18/79	<0.08
Carrots	Pasco	9/18/79	<0.08
Tomatoes	Grandview	9/18/79	<0.08
Chard	Grandview	9/18/79	<0.08
Carrots	Grandview	9/18/79	<0.08
Turnip Tops	Pasco	5/08/80	<0.08
Onion	Pasco	5/08/80	<0.08
Comfrey	Grandview	5/08/80	<0.08
Onion	Grandview	5/08/80	<0.08
Swiss Chard	Pasco	6/23/80	<0.08
Beets	Pasco	6/23/80	<0.08
Comfrey	Grandview	6/23/80	<0.08
Beets	Grandview	6/23/80	<0.08

Fish

Station	Sample Date	Species	pCi/g (wet)				
			Co-60	Cs-137	Fe-59	Zn-65	Other Gamma
Columbia	4/26/78	Sucker	<0.13	<0.13	0.26	<0.26	<0.13
Snake	4/26/78	Trout	<0.13	<0.13	0.26	<0.26	<0.13
Columbia	4/26/78	Squawfish	<0.13	<0.13	0.26	<0.26	<0.13
Columbia	4/26/78	Salmon	<0.13	<0.13	0.26	<0.26	<0.13
Columbia	4/26/78	Carp	<0.13	<0.13	0.26	<0.26	<0.13
Snake	10/24/78	Trout	<0.13	<0.13	0.26	<0.26	<0.13
Columbia	10/20/78	Salmon	<0.13	<0.13	0.26	<0.26	<0.13
Columbia	10/20/78	Salmon	<0.13	<0.13	0.26	<0.26	<0.13
Columbia	10/20/78	Salmon	<0.13	<0.13	0.26	<0.26	<0.13
Columbia	10/20/78	Catfish	<0.13	<0.13	0.26	<0.26	<0.13
Columbia	4/25/79	Salmon	<0.13	<0.13	-	<0.13	<0.13
Columbia	4/25/79	Salmon	<0.13	<0.13	-	<0.13	<0.13
Columbia	4/25/79	Trout	<0.13	<0.13	-	<0.13	<0.13
Columbia	4/25/79	Trout	<0.13	<0.13	-	<0.13	<0.13
Snake	4/25/79	Trout	<0.13	<0.13	-	<0.13	<0.13
Columbia	10/29/79	Whitefish	<0.13	<0.13	-	<0.13	<0.13
Snake	10/30/79	Steelhead	<0.13	<0.13	-	<0.13	<0.13
Columbia	4/23/80	Whitefish	<0.13	<0.13	-	<0.13	<0.13
Columbia	4/23/80	Whitefish	<0.13	<0.13	-	<0.13	<0.13
Columbia	4/23/80	Whitefish	<0.13	<0.13	-	<0.13	<0.13
Columbia	4/23/80	Whitefish	<0.13	<0.13	-	<0.13	<0.13
Snake	4/21/80	Steelhead	<0.13	<0.13	-	<0.13	<0.13

Well Water

Station	Sample Date	pCi/1 Tritium
WNP-2 Well #3	11/19/78	380±340

Direct Radiation

Direct radiation measurements were made during this period using thermoluminescence dosimeters (TLD) at twenty-five (25) stations around the site. The results of these measurements were 0.25±0.03 mrem/day.

CHAPTER 7
ENVIRONMENTAL EFFECTS OF ACCIDENTS

CHAPTER 7

ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.1 STATION ACCIDENTS INVOLVING RADIOACTIVITY

The postulated accidents discussed in this chapter are also found in the Safety Analysis Report. In keeping with the overall objective of the Environmental Report, the assumptions used to analyze these accidents are conservative but more realistic than the very conservative assumptions utilized in the Safety Analysis Report. In this chapter credence is given to the correct design, manufacture and operation of the reactor safeguards system. Both the probability of occurrence and the consequences of the postulated accidents are reviewed.

The spectrum of accidents, ranging in severity from trivial to very serious, is divided into classes. These classes are shown in Table 7.1-1. Each class is characterized by an occurrence rate and a set of consequences.

To determine the resultant doses from each accident, the annual average atmospheric dispersion parameter, χ/Q was calculated using one year of onsite meteorological data. The χ/Q values as a function of distance and sector are shown in Table 5.2-3.

The analytical models used to calculate the doses for each of the accidents found in this chapter are discussed in detail in Reference 1.

7.1.1 Class 1 - Trivial Incidents

These incidents are included and evaluated under routine releases in Section 5.2.

7.1.2 Class 2 - Small Release Outside Containment

These incidents are included and evaluated under routine releases in Section 5.2.

7.1.3 Class 3 - Radwaste System Failure

Events identified for consideration in this category are those resulting from inadvertent pumping of a liquid radwaste storage tank to the blowdown line (considered an operator error) as well as failure of the drain seal on the offgas system. While these events do not result in appreciable offsite exposures they typify events and consequences which may be expected to occur infrequently as a consequence of normal operation. More serious failures of the radwaste systems are postulated and described under Class 8 events.

7.1.3.1 Liquid Radwaste System Leakage

A radwaste tank is assumed to be inadvertently pumped to the blowdown line as a result of one of the following single operator errors:

1. the operator commences pumping without taking a batch sample;

2. a batch sample is misinterpreted or the results are incorrectly communicated to the operator; or

3. the operator, notified of an acceptable batch sample pumps the wrong tank.

However, when this occurs, the high radiation alarm on the liquid effluent monitor will signal the valve on the discharge to close if concentrations are in excess of those allowed by technical specifications; thus any release is controlled to levels allowed during normal operation.

7.1.3.2 Offgas System Leakage (OGSL)

Examination of the offgas system equipment indicates that the most likely source of potential release, other than the normal effluent path, is leakage through the drain lines. These drain lines are close to the inlet and outlet of the holdup pipe and normally have a water seal to prevent gaseous leaks. For this case, it is assumed that the water seal for the inlet drain is lost.

7.1.3.2.1 Estimated Release

A 60,000 μci/sec off-gas release rate at 30 minutes is equivalent to 270,000 μci/sec at 2 minutes. Correlating the ratio of drain line to holdup pipe diameters to flow rates results in approximately 4.0% of the 2 minute old mix (10,800 μci/sec) being released. This release continues for 4 hours until the leak is sensed by radiation monitors and corrected by operator action. The resultant total release is 155 curies.

7.1.3.2.2 Estimated Dose

The dose calculation for this event is shown in Table 7.1-2.

7.1.3.2.3 Probability Considerations

The water seal is a passive device which holds water and is inherently simple and reliable. Three failure modes have been identified:

1. the water can evaporate,

2. the water seal can be overpressurized,

3. the water can leak through a faulty drain.

Although the failure of the water seal is unlikely, it is nevertheless placed in the upset category (Section 7.1.11).

7.1.4 <u>Class 4 Fission Products to Primary System</u>

Events which lead to the release of activity into the primary system are a result of transitory stress which exceeds the mechanical properties of the cladding material.

7.1.4.1 <u>Fuel Cladding Defects</u>

Random cladding defects are allowed for in design and are included and evaluated in Section 5.2.4.2 under normal operation.

7.1.4.2 <u>Offdesign Transients that Induce Fuel Failures Above Those Expected</u>

The plant design criteria includes the requirement that any anticipated transient event concomitant with a single equipment malfunction or single operator error must not result in a minimum critical power ratio (MCPR) less than 1.06 for any normal plant operating mode. Since the design basis correlation[3] used in determination of the CP is conservatively 1
selected with a large margin between predicted and observed CP, fuel which experiences a MCPR of 1.06 is not likely to have cladding failure. It is, therefore, concluded that there are no offdesign transients other than the control rod drop accident identified in section 7.1.8.3, which induce fuel failure above that normally expected.

7.1.5 <u>Class 5 - Fission Products to Secondary System</u>

In the direct cycle BWR, "secondary system" is interpreted to mean the secondary side of heat exchangers whose primary side contains primary system coolant. The BWR system has several heat exchangers in this category:

1. main turbine condenser,

2. RHR heat exchangers,

3. drywell cooler heat exchanger,

4. spent fuel storage heat exchanger.

All of these heat exchangers are operated in a mode or employ an intermediate heat exchanger which precludes the release of activity to the environment. The main condenser is protected during plant operation by the normal vacuum. The drywell, and spent fuel heat exchangers are protected by being cooled with a closed cooling loop, the RHR heat exchangers are protected by being cooled by the cooling towers or spray pond. In addition during shutdown cooling the cooling water side is maintained at a higher pressure to prevent any out leakages to the Cooling System.

7.1.6 Class 6 - Refueling Accidents (FUHA)

The fuel bundle is the heaviest object which could be dropped onto the core during normal refueling operations. The fuel bundle drop is postulated to occur as a result of equipment failure during the refueling process and occurs within the reactor cavity above the core.

7.1.6.1 Estimated Release

The following parameters are used to determine the amount of activity released to the environment.

1. The accident occurs four days after shutdown.

2. 8 fuel rods are damaged.

3. A water partition factor of 10^3 is used for iodine.

4. SGTS filter efficiency is 99.9% for all forms of iodine and 0% for noble gases.

5. The volumetric leak rate from the reactor building is 100%/day.

7.1.6.1.2 Estimated Dose

The dose calculated for this accident is shown in Table 7.1-2.

7.1.6.1.3 Probability Considerations

See subsection 7.1.7.1.3.

7.1.7 Class 7 - Spent Fuel Handling Accident

Spent fuel handling accidents are of two essential types: dropping a fuel bundle onto the fuel in the fuel storage area, and dropping a spent fuel cask. The fuel bundle drop accident is a design basis accident; the cask drop accident is not expeated to result in fuel damage.

7.1.7.1 Fuel Assembly Drop in Fuel Storage Pool (FUHA)

This accident is postulated to occur while a fuel bundle is being transferred or suspended over the spent fuel storage pool.

7.1.7.1.1 Estimated Releases

The following parameters are used to determine the amount of activity released to the environment.

1. The accident occurs four days after shutdown.
2. 8 fuel rods are damaged.
3. A water partition factor of 10^3 is used for iodine.
4. SGTS filter efficiency is 99.9% for all forms of iodine and 0% for noble gases.
5. The volumetric leak rate from the reactor building is 100%/day.

7.1.7.1.2 Estimated Dose

The dose calculated for this accident is shown in Table 7.1-2.

7.1.7.1.3 Probability Considerations

For this accident to occur, either the hoist must go out of control or one of the supporting components must fail. For the hoist to go out of control, the limit switch must fail to decelerate the bundle's falling rate. The probability of either of these events occurring would constitute a fault condition (see Section 7.6.11). A random failure of the cable grapple, handle, or tie rod would be no more likely than an emergency condition and is probably closer to a fault condition. Since there is less than one chance in four that such a failure could occur while the fuel is at the maximum height above the core, the combined event is no more likely than a fault condition for each bundle transferred. Assuming that one-fourth of the core is transferred each year, the likelihood of the event becomes that of an emergency condition. (See Section 7.1.11)

7.1.7.2 Fuel Cask Drop (FCDA)

Design of the fuel storage pool and cask transfer hatch precludes the cask from being moved over the fuel storage pool. Consequently, the worst accident occurs when a fully loaded spent fuel cask becomes detached from its lifting mechanism and falls a distance of 99 feet onto the yielding surface of a railroad flatcar. The rail car is in position under the cask while it is being lowered thus providing a yielding type of impact surface. (The 10CFR 71 cask drop accident is 30 feet onto a non-yielding impact surface.)

7.1.7.2.1 Estimated Release

The cask is loaded with a maximum of 24 fuel bundles which have been out of the reactor for at least 90 days. The cask closure head will remain intact upon impact with the yielding surface of the rail car. No fuel damage or fission preduct release is expected. However, for the purpose of analysis, it is assumed that 1000 Ci of nobile gas are released as per 10CFR 71 criteria.

7.1.7.2.2 Estimated Dose

The dose calculated for this accident is shown in Table 7.1-2.

7.1.7.2.3 Probability Considerations

By inferring a frequency of occurrence from other crane accidents, the cask drop accident should be placed in the emergency category (Section 7.1.11).

7.1.8 Class 8 - Accident Initiation Events Considered in Design-Basis Evaluation in the Safety Analysis Report

These events are described in chapter 15 of the Safety Analysis Report and are briefly outlined in the following paragraphs. Included are the inside containment loss-of-coolant accident (recirculation pipe break) the outside containment loss-of-coolant accident (steam line break), and the reactivity excursion accident (control rod drop). Two non-design-basis accidents (catastrophic failures of a liquid radwaste tank and of the offgas holdup system) are also treated here.

The design-basis refueling accident falls in Class 7 and is reviewed in 7.1.7.1.

7.1.8.1 Loss of Coolant Accident (LOCA)

A sudden circumferential break is assumed to occur in a recirculation line, permitting the discharge of coolant into the primary containment from both sides of the break. Concurrent with this failure, a single active component failure is assumed to occur. This additional failure can occur to the HPCS diesel generator or the standby diesel generator.

7.1.8.1.1 Estimated Release

To calculate a realistic core heatup following a LOCA, the results of parametric studies were applied to the standard core heatup models currently in use [4].

The approach in the thermal-hydraulic analysis was to select realistic values for those key assumptions normally used in the Safety Analysis Report in which very conservative estimates are made. Other assumptions which are of lesser significance use values as described in the SAR or in NRC regulatory guides. Where parameters are not specifically mentioned, NRC assumptions, whose inherent conservatism has been well documented, have been employed. Peak clad temperatures were calculated for a spectrum of break sizes.

The realistic analysis shows no heatup of fuel into the perforation range. The parameters used to predict the activity released to the environment are:

1. no fuel rods are damaged,

2. fission products released are a result of coolant activity and spiking activity from reactor shutdown,

3. primary containment leak rate is 0.5% per day,

4. reactor building leak rate is 100% per day,

5. plateout and condensation effects are assumed to reduce the source term by a factor of 4,

6. standby gas treatment system filter efficiency is 99.9% for I_2 and CH_3I and 0% for noble gases.

7.1.8.1.2 Estimated Dose

The dose calculated for this accident is shown in Table 7.1-2.

7.1.8.1.3 Probability Considerations

Based on estimates of pipe failure rates contained in the literature and on the number of pipes that satisfy the conditions for a large break design basis accident, the probability of a large break is within the range of an emergency condition (See Section 7.1.11.)

The probability that an HPCS diesel generator will be unable to start when desired should also fall within the range of an emergency condition based on an analysis using failure rates from references 5, 6, and 7 considering anticipated downtime and the interval between HPCS diesel tests.

Since each probability is low and the outcomes are not critically interdependent, the joint probability of pipe break and HPCS failure is expected to be very low so as to place this event in the fault condition. (See Section 7.1.11).

7.1.8.2 Steam Line Break Accident (SLBA)

The postulated accident is a sudden circumferential severance of one main steam line outside the containment. This results in steam being released to the steam tunnel and the turbine building.

7.1.8.2.1 Estimated Release

The mass of coolant released during the 4 second isolation valve closure time is 23,000 pounds of steam. Because there is no fuel damage during this accident, the iodine released to the turbine building is proportional to the amount of steam released.

Based on past BWR operating experience, the I-131 coolant
5 activity is assumed to be 0.005 μci/gm with corresponding amounts of I-132 and I-135.

7.1.8.2.2 Estimated Dose

The dose calculated for this accident is shown in Table 7.1-2.

7.1.8.2.3 Probability Considerations

The design basis main steam line break accident postulated complete severance of one of the main steam lines while the reactor is at power followed by total isolation of the break within four seconds. The probability of this event is essentially the probability of the severance. Based upon estimates of pipe failure rates contained in the literature[8] and considering the number of locations where the rupture could occur in the main steam system, the probability of pipe severance should be well within the "emergency category" (See Section 7.1.11.)

7.1.8.3 Control Rod Drop Accident (CRDA)

The postulated accident is a reactivity excursion caused by accidental removal of a control rod from the core at a rate more rapid than can be achieved by the use of the control rod drive mechanism. In the CRDA, a fully inserted control rod is assumed to fall out of the core after becoming disconnected from its drive and after the drive has been removed to the fully withdrawn position. The design of the control rod velocity limiter limits the free fall velocity to 3 ft/sec. Based on this velocity and assuming the reactor is at full power, the maximum rod worth is approximately 1%, resulting in the perforation of less than 10 rods.

The activity released from the 10 rods is insufficient to cause a radiation level high enough to trip the main steam line isolation valves. However, it is high enough to cause isolation of the offgas system For the purpose of evaluating the consequences of this accident, it is assumed that 100% of the noble gases and 1% of the iodine activity released from the failed fuel rods is transferred to the condenser. Since the offgas system and ultimately the reactor vessel are isolated, it is assumed that the condenser activity achieves an equilibrium condition between the condensate and the free volume and is released unfiltered to the environment at a rate of 0.25% of the condenser free volume per day.

7.1.8.3.2 Estimated Dose

The dose calculated for this accident is shown in Table 7.1-2.

7.1.8.3.3 Probability Consideration

For a rod drop accident to occur the control rod must first become detached from the drive, remain lodged in position while the drive is fully withdrawn from the core, and then, become disloged and fall freely. This complex series of events is offset by the many annunciators and procedures that are meant to avoid such an event, for example: rods are tested weekly, thus providing many opportunities for a uncoupled rod to be detected.

Actual experience has been good. However, conservative judgement indicates that this event should be assigned as an emergency condition (See Section 7.1.11).

7.1.8.4 Liquid Radwaste Tank Accident (LRTA)

The postulated accident is assumed to occur as a result of a catastrophic failure of the waste storage tanks. The design of the radwaste building precludes the release of liquid radwaste. The liquid contents of the tanks will be contained by an unlined 18-inch high concrete dike around the radwaste tank area. This dike can contain in excess of 80% of the total liquid inventory of all the tanks. 1

7.1.8.4.1 Estimated Releases

The liquid radwaste tanks are not pressurized nor are they kept at a high temperature. Nevertheless, because of evaporation, it is assumed that 0.5% of the iodines become airborne and are released to the environment.

7.1.8.4.2 Estimated Dose

The resultant doses for this accident are shown in Table 7.1-2.

7.1.8.4.3 Probability Considerations

Although the below grade liquid radwaste tanks are unpressurized accumulators, they are designed in accordance with the appropriate ASME codes. There are no other parts other than piping attached to the tanks. Therefore, the probability of a radwaste tank failure is so low as to place it in the fault category (See Section 7.1.11).

7.1.8.5 OffGas System Accident (OGSA)

The postulated accident for this category is the failure of a charcoal tank in the offgas system. The tank with the largest noble gas inventory is assumed to fail and spill the contents of the tank.

7.1.8.5.1 Estimated Release

The activity inventories of the offgas system are based on an offgas release rate of 60,000 microcuries per second for noble gas and on a reactor water coolant concentration of .005 microcuries per gram for I-131, with 2% steam carry over, and a condenser decontamination factor of 7.2×10^{-3}. It is also assumed that 5% of the noble gas inventory and 0.5% of the iodine inventory are released.

These release fractions are based on evaluation of the retention characteristics of charcoal for spillage of the entire contents of the tank.

7.1.8.5.2 Estimated Dose

The dose calculated for this accident is shown in Table 7.1-2.

7.1.8.5.3 Probability Consideration

The offgas system is designed and constructed in accordance with appropriate ASME codes. In the unlikely event that the tank fails only a small fraction of the contents would be released to the environment. The probability of such an occurrence is so low as to classify a release to the environment in the fault category (See Section 7.1.11).

7.1.9 Transportation Accidents

Accidents in this category have no significant impact on the environment, however, they are discussed for the purpose of completeness of this report.

7.1.9.1 Shipment of Spent Fuel

An evaluation by the AEC of the frequency of accidents involving the shipment of high level radioactive wastes shows that, on the average, approximately 0.05 accidents may occur in transportation during the lifetime of a light water reactor[9]. In addition to the very low occurrence rate of accidents, the consequences of an accident involving radioactive material are mitigated by the procedures which carriers are required to follow[10]. These procedures include: separation of persons from packages or materials and immediate notification of the shipper and DOT in case of an accident, fire, or leaking package. Therefore, in the unlikely event an accident occurs, the radiological exposures will be limited to a relatively small number of persons and does not present any concern to the general population.

7.1.9.2 Low Level Radwaste Shipments

The only time a radiological exposure could be received in radwaste shipment is for the case of an accident involving the solid waste containers. These containers usually contain | 1
a very "stiff" or viscous slurry or are actually mixed with polymer and catalyst to form a solid. Such exposures would be minor and would be limited to those workers involved in any necessary cleanup following the accident. The effect to the population is judged to be insignificant.

7.1.9.3 New Fuel Shipment

New fuel is normally shipped by rail in containers designed to protect them from physical damage due to the normal handling and vibration of transportation. Because new fuel contains practically no fission products or radioactive gases, the results for an accident, even if the fuel should be damaged, would be limited to an economic loss.

7.1.10 Summary of Radiological Effects of Accidents

The radiological effects of each of the accidents evaluated in Chapter 7 are shown in Table 7.12. Also shown for the purpose of comparison, is the average normal background and man made radiation exposures. When compared to background and manmade exposure it is clear that the exposure received by the population as a result of postulated accident is extremely small.

7.1.11 Probability Assessment

In Reference 11, the Commission requires that "in the consideration of the environmental risks due to postulated accidents, the probabilities of their occurrence must . . . be taken into account."

Consideration of the yearly probabilities of abnormal conditions is necessary to an assessment of environmental risk for the obvious reason that such conditions are not expected to occur as often as once a year or even once in a plant lifetime. Comparison of accident exposures with the man-rems per year fully expected from natural sources and normal operation of the plant operation of the plant requires that the former be weighted by their annual frequencies in order to predict an average annual effect. It will be noted, however, that the forgoing analyses have concentrated principally on prediction of exposures given the occurrence of the accident and have factored in the probability of the event in the overall dose affect. The reason for this treatment is two-fold.

1. It emphasizes the fact that radiological exposures due to the accidents are in fact exceedingly low in themselves, without additionally complicating the issue with probabilities;

2. The "classes" of accidents tend to be less homogeneous in their probabilities than in their releases; thus, to propose a two-significant figure probability as "typical" of a class would be not only inaccurate but misleading as well.

7.1.11.1 Probability Categories

To alleviate the problem of inhomogeneity mentioned above, the probability of occurrence of each "class" of accidents and incidents has been placed in a broad probability category about two decades wide. The system chosen for this categorization is derived from Section III of the ASME Boiler and Pressure Vessel Code. These classes are used by the General Electric Company in design safety analyses and have appeared in safety analysis reports for several stations. A brief semi-quantitative description of each class is given below.

7.1.11.1.1 Normal Condition ($P = 1$)

A normal condition is any planned and scheduled event that is the result of deliberate plant operation according to prescribed procedures.

7.1.11.1.2 Upset Condition ($1 > P > 2.5\times10^{-3}$)

An upset condition is a deviation from normal conditions that has a moderate probability of occurring during a 40 - year plant lifetime. These conditions typically do not preclude subsequent plant operation.

7.1.11.1.3 Emergency Condition ($2.5\times10^{-3} > P > 2.5\times10^{-5}$)

An emergency condition is a deviation from normal plant operation that has a low probability of occurring during a 40-year plant lifetime. Emergency condition events are typified by transients caused by a multiple valve blowdown of the reactor vessel or a pipe rupture of an auxiliary system.

7.1.11.1.4 Fault Condition ($2.5x10^{-5} > P > 2.5x10^{-8}$)

A fault condition is a deviation from normal conditions that has an extremely low probability of occurring during a 40-year plant lifetime. These postulated events include, but are not limited to, the most drastic that must be designed against (the limiting design bases).

7.1.11.2 Basis for Probability Estimation

The occurrences described in this analysis are of such a nature that their frequencies cannot be derived from historical data. The nuclear industry is too young to have accumulated much information even on the most frequent events. The events with the more serious consequences are not likely to occur and historical data is not possible.

As a result, probabilities on most events must be inferred from our knowledge of other events. Table 7.1-3 is a listing of event descriptions and their associated probabilities as reported in the literature. These findings, reinforced by individual modeling studies of the postulated events specified in this analyses, lead to the assignment of each occurrence to one of the four probability categories described in Section 7.1-3. As a point of reference, Table 7.1-4 is included which gives some mortality statistics experienced in the U.S.A.

It must be emphasized that the probability assignment is one of judgement and can never be proven. However, the broad classification of probability ranges and the assignment of each event to a category does quantify the best that is known about the relative frequency of occurrence of many events and is informative and useful on a comparative basis.

TABLE 7.1-1

REACTOR FACILITY

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

NO. OF CLASS	DESCRIPTION	AEC EXAMPLE(S)	PLANT DESIGN-ANALYSES
1	Trivial Incidents	Small spills Small leaks inside containment	None
2	Misc. Small Releases Outside Containment	Spills Leaks and Pipe breaks	Reactor Coolant leaks (below or just above allowable tech spec limits) outside primary containment or plant boundary
3	Radwaste System Failures	Equipment Failure Serious malfunction or human error	Any Single Equipment Failure or Any Single Operator Error
4	Events that Release Radioactivity into the Primary System	Fuel Failures during normal operation Transients outside expected range of variables	Fuel Failures during transients outside the normal range of plant variables but within expected range of protective equipment and other parameter operation
5	Events that Release Radioactivity into Secondary System	Class 4 and Heat Exchanger Leak	Primary Coolant loop to auxiliary cooling system Secondary side of heat exchanger leak
6	Refueling Accidents Inside Containment	Drop fuel element Drop heavy object onto fuel Mechanical malfunction or loss of cooling in transfer tube	Dropping of fuel assembly on reactor core, spent fuel rack, or against pool boundary

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TABLE 7.1-1 (continued)

NO. OF CLASS	DESCRIPTION	AEC EXAMPLE(S)	PLANT DESIGN-ANALYSES
7	Accidents to Spent Fuel outside Containment	Drop Fuel element Drop heavy object onto fuel Drop shielding cask - loss of cooling to cask Transportation accident on site	Dropping of fuel assembly on spent fuel in refueling storage pool Dropping of spent fuel shipping cask on site
8	Accident Initiation Events considered in Design-Basis evaluation in the Safety Analysis Report	Reactivity Transient Rupture of Primary piping Flow Decrease - Steam-line break	a. Reactivity Transient b. Loss of Reactor Coolant inside or outside primary containment

TABLE 7.1-2

RADIATION EXPOSURE SUMMARY

DISTANCE (MILES) / SOURCE	EA-REM* 1.2	INTEGRATED WHOLE BODY EXPOSURE,** PERSON-REM 5.0	10.0	20.0	30.0	40.0	50.0
1) NATURAL (PER YEAR)	1.4E-01	1.8E 01	1.8E 03	1.5E 04	2.2E 04	2.8E 04	3.7E 04
2) MANMADE*** (PER YEAR)	1.0E-01	1.3E 01	1.3E 03	1.1E 04	1.6E 04	2.0E 04	2.7E 04
3) EVENT CLASS							
OGSL 3	3.1E-06	5.3E-05	2.5E-03	8.5E-03	9.7E-03	1.0E-02	1.0E-02
FUMA 6/7	5.3E-07	1.6E-05	1.2E-03	5.5E-03	6.5E-03	7.0E-03	7.6E-03
FCDA 7	1.4E-07	4.2E-06	3.1E-04	1.5E-03	1.8E-03	1.9E-03	2.2E-03
LOCA 8	1.8E-07	5.3E-06	3.7E-04	1.1E-03	2.3E-03	2.4E-03	2.6E-03
SLBA 8	2.5E-07	6.2E-06	3.2E-04	1.1E-03	1.2E-03	1.3E-03	1.4E-03
CRDA 8	5.4E-10	1.6E-08	1.2E-06	5.6E-06	6.4E-06	7.3E-06	8.0E-06
LRIA 8	4.4E-09	1.1E-07	6.1E-06	2.0E-05	2.1E-05	2.2E-05	2.4E-05
OGSA 8	1.1E-06	5.0E-05	1.9E-03	8.4E-03	9.8E-03	1.0E-02	1.0E-02

* Exclusion Area (EA) Individual Dose For Duration of Event

** Integrated over year 2020 population estimate (see Table 2.1-1) for each area; ie: 0-5 mile radius, 0-10 mile radius, etc.

*** Refers to that manmade background radiation not associated with WNP-2 (medical, television, industry, etc.).

TABLE 7.1-3

TABLE OF EVENT PROBABILITIES

EVENT	PROBABILITY	SOURCE
Reactivity Fault at Power	10^{-2}/year	12
Emergency Injection System Failure	10^{-2}/demand	13
Reactor Bldg. Atmosphere Washing and Cooling System Failure	10^{-2}/demand	13
Core Spray System Failure	$2.1x10^{-3}$ to $5.2x10^{-2}$/demand	12
Operator Error	10^{-2} to 10^{-3}/operation	14
Diesel Generator Unavailability	0.004 years/year	15
Loss of Load	$>10^{-3}$/year	16
Excessive Load Increase	$>10^{-3}$/year	16
Loss of One Feedwater Pump	$>10^{-3}$/year	16
Loss of Flow (one pump)	$>10^{-3}$/year	16
Primary System Pipe Rupture	10^{-3}/year	13
Failure to Isolate Containment	10^{-3}/year	15
Core-Flooding System Failure	10^{-3}/demand	13
Operator Error	10^{-2} to 10^{-4}/trial	17
Reactivity Fault at Startup	10^{-4}/year	12
Instrument Part Rupture	$5x10^{-4}$/year	12
Pipe Severence Rate	$6.3x10^{-4}$/year/plant	18
Reactor Shutdown System Failures	10^{-5}/demand	13
Failure to Trip Reactor	$7x10^{-5}$/demand	15
Emergency Power Unavailability	$2x10^{-5}$years/year	15
Large Aircraft Crashing into Reactor > 5 mi. from Airport	$2.4x10^{-6}$/year	18
Failure to Trip Reactor	$2x10^{-7}$/demand	16
Truck Accident Rate (severe)	$5x10^{-7}$/mile	14,18

TABLE 7.1-4

SOME U.S. ACCIDENTAL DEATH STATISTICS
FOR 1971 (Ref. 21)

ACCIDENT	TOTAL DEATHS	PROBABILITY DEATH/PERSON/YR
Motor vehicle	54,700	2.7×10^{-4}
Falls	17,900	8.7×10^{-5}
Fire	6,700	3.2×10^{-5}
Drowning	7,300	3.5×10^{-5}
Poisoning	5,100	2.5×10^{-5}
Firearms	2,400	1.2×10^{-5}
Cataclysm*	155	8.0×10^{-7}
Lightning*	110	5.5×10^{-7}

* Reference 21 (1966 statistics)

7.2 OTHER ACCIDENTS

The environmental effects of accidents not related to the release of radioactive materials are considered in this section. Accidents which fall into this category include the spill or leakage of chemicals (caustic or acid), gaseous releases (hydrogen or chlorine), fires within the plant fenceline, and fuel oil spillage from oil storage or transfer operations. The probability of accidents of this nature happening is small and the Supply System will take all necessary actions to prevent the occurrence of such accidents. The proper training of operating personnel, the specification of detailed procedures to be used in handling the materials and the proper design of equipment are all positive steps to be used by the Supply System in preventing such accidents. In addition, these same steps will assist in mitigating the effects of an accident if it does occur.

The primary environmental impact to be considered is the effect on the Columbia River. Other areas of possible impact are the groundwater, land, and air in the vicinity of the plant. The environmental effects of the postulated accidents on each of these areas are discussed below.

7.2.1 Liquid Chemical Spill Accidents

The only two chemicals which are used in reasonably large quantities in the plant are caustic (sodium hydroxide) and acid (sulphuric acid).

The caustic and acid will be transported to the site in chemical tank trucks which conform to applicable Department of Transportation regulations. The chemicals will be pumped via an outside hose connected to phenolic lined steel storage tanks in their respective buildings. The acid is stored in a 6,000 gallon tank in the circulating water pump house (for neutralizing the circulating water alkalinity) and in a 5,000 gallon tank in the service building (for regeneration of the make-up demineralizers). The caustic is also stored in a 5,000 gallon tank in the service building for use in regeneration of the demineralizers. Two 200 gallon tanks, one in the reactor building and one in the radwaste building contain acid for general neutralizing uses. The radwaste building also has a 200 gallon tank of caustic for general neutralizing uses. The 200 gallon tanks will be filled from smaller containers which are transported to the buildings by hand pulled carts.

Any spillage of the chemicals during storage or transfer operations in the buildings are collected in sumps, neutralized and disposed of harmlessly through the normal chemical waste treatment process stream (see Section 3.6).

Hence, the loss of these chemicals will not have an adverse impact on the environment.

7.2.2 Gaseous Release Accidents

The only two gases which are stored in sufficient quantities to have an effect on the environment are hydrogen and chlorine. Hydrogen is used in the generator cooling system and chlorine is used for water purification and as a biocide.

Hydrogen will be transported to the site in standard gas bottles, each containing 140 standard cubic feet (scf). Eight bottles of hydrogen are stored in the bottle storage building 367 feet north of the turbine generator building and 563 feet north of the reactor building. The hydrogen is piped to the turbine generator building via an underground pipe. The gas transfer pipe is contained in a larger shielding pipe to insure the integrity of the transfer pipe. In the event of an explosion, any resulting fire would not spread since the fenced plant area is devoid of flammable material (see Subsection 7.2.3).

Liquefied chlorine is transported to the site in one ton and 150 lb bottles. Ten one ton bottles are stored in the chlorine storage room in the circulating water pumphouse building with all of the bottles hooked up to the manifold, however, only one bottle outlet valve will be opened at a time in order to minimize the amount of released chlorine in the event of a break in the piping. Three 150 lb bottles are stored in the chlorine storage room in the service building. In case of a chlorine release in either of the chlorine storage rooms, the gas, which is heavier than air, would be taken out of the buildings by floor level vents and exhausted from the top of the respective building to the atmosphere. A fourth 150 lb bottle is located on the exterior of the warehouse building. If failure of this exterior bottle occurs, chlorine would be released directly to the atmosphere.

A chlorine release inside the circulating water pumphouse could result in the emission of a maximum of 2000 lbs of chlorine to the environment. Calculations performed for the most restrictive dispersive conditions which could result in maximum offsite chlorine gas concentrations (no cooling tower interference with the chlorine cloud and extremely stable (light wind) atmospheric conditions), show that the magnitude of chlorine concentrations in amounts considered to be "dangerous in 30 minutes to one hour", [1] could be experienced by persons at the site boundary. However, in order for this level of chlorine concentrations to be available, this extreme case requires a chlorine cloud translation speed of approximately 1.7 mph. Due to this low cloud translation speed and resultant small cloud size, there would be a personnel alert time of over 40 minutes for persons at the site boundary and an associated total chlorine exposure time of only 17 minutes. The same calculations show that chlorine concentrations at the nearest population zone (3.6 miles) would be less than the "least amount required to cause irritation of throat"[1] and gives an alert time of over 2 hours. Since a decreased alert time is only possible due to an increased wind speed, and the approximate proportional decrease in chlorine concentrations (due to the greater atmospheric turbulent dilution), the possible worst case environmental impacts would be the loss of some vegetation (due to chlorine poisoning) and the resultant slight loss of land cover. When realistically considering the possible interaction of the chlorine cloud and the cooling towers coupled with the long alert time, the possible adverse chlorine affects are reduced substantially.

7.2.3 Fire Prevention and Effects

The occurrence of a major fire at any of the plant site buildings is improbable. If one does occur the effect of the fire on the environment would be limited to the smoke produced. Because of the low density of people (see Section 2.1.3), crops, and wildlife in the vicinity of the plant the smoke would produce no measurable effects on the environment. A fire located in the area of the main plant buildings would be a minimum of 100 feet from the site fence. Since no readily combustible material will exist between the fenceline and the fire location, the fire could not spread to the surrounding vegetation beyond the site fence unless windblown.

The effect of fires on the Hanford Reservation has been studied in the past.[2] The primary fuel for fires in the vicinity of WNP-2 is the litter accumulated from the crop of annuals. The areas affected by fire are naturally reseeded relatively quickly with various annuals. The return of other plants such as sagebrush is normally slower.

Fire prevention measures which will be taken include instruction of plant personnel on the possible sources of fire, on the various aspects of fire prevention and on the proper actions to be taken if a fire does occur. In addition, the plant is designed to reduce both the probability of starting a fire and the extent and effects of a fire should one occur.

7.2.4 Fuel Oil Accidents

Fuel oil (No. 2 and diesel) is required in the plant for the auxiliary boiler and the diesel engines. The diesel engines consist of two plant emergency diesel generators (4650 kW each) one HPCS diesel generator (2600 kW), two diesel driven air compressors (15 hp each), and one diesel driven fire pump (250 hp).

Fuel oil for the auxiliary boiler is stored in one 50,000 gallon underground storage tank just to the east of the diesel generator building. Oil supply to the boiler is directly from this tank.

Diesel oil is stored in three underground storage tanks partly underneath the diesel generator building (two of 60,000 gallon capacity and one of 50,000 gallon capacity), and three day tanks (3,000 gallons each), one located in each of the three rooms of the diesel generator building. Diesel oil for the fire pump engine is stored in a 280 gallon above ground, outdoor storage tank to the rear of the circulating water pumphouse. The four underground and day tanks are Seismic Category I, Quality Class I tanks.

Oil is delivered to the site by truck and is transferred to the four primary storage tanks. Oil delivery personnel present during the tank filling operation can stop the filling operation prior to overflowing the storage tanks. The three diesel generator day tanks are each filled from their respective storage tanks. This operation is accomplished by controls which automatically start and stop the supply pumps mounted on the storage tanks. The day tanks are each located in an individual room which is "diked" off to retain any tank leakage. The diked volume exceeds the capacity of the day tank.

The detection of oil leaks is carried out by routine inspection of oil storage and transfer facilities by the monitoring of oil flow lines and by accurate inventory of all oil on hand. Should a loss of oil be detected action will be taken immediately to isolate and repair the faulty equipment and to take the appropriate steps to remove excess oil and effect cleanup.

To reduce the probability of a fire due to the ignition of fumes, all rooms where the fuel oil is kept have intake and exhaust vents equipped with fire arresters. In addition, the large storage tanks are buried.

7.2.5 Nearby Industrial, Transportation, and Military Facilities

The possible accidents effects caused by nearby industrial, transportation and military facilities effects are discussed in the Final Safety Analysis Report, Section 2.2.

CHAPTER 8
ECONOMIC AND SOCIAL EFFECTS

CHAPTER 8

ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

8.1 BENEFITS

8.1.1 Primary Benefits

The primary benefits of WNP-2 are those inherent in the value of the generated electricity which will be delivered by Bonneville Power Administration (BPA) to 27 municipalities, 22 public utility districts, and 45 electric cooperatives, collectively called the Participants, located principally in Washington, Oregon, Idaho, Montana, and California and each of whom is a statutory preference customer of BPA. The Participants' shares of the WNP-2 output range from approximately 15 percent to 0.005 percent. An aggregate of approximately 22.5 percent of the output is shared by 64 of the Participants each of whom has a share of less than 1 percent.

8.1.1.1 Electric Energy

As explained in Section 1.0.2, projections for electrical energy demands and resources in the Northwest are based on the West Group Forecast. This forecast assumes the project supplies 688 MW (average) of energy (6.0 billion kW-hr) in its first full year of commercial operation (1981-82).* 1
The following year, and each year thereafter, it is scheduled to supply 825 MW (average) of energy (7.2 billion kW-hrs.), according to the projections in the West Group Forecast. As part of Phase I of the Hydro Thermal Power Program, the plant is expected to supply base load energy to the Pacific Northwest while peaking requirements will be met increasingly by hydro facilities.

The demand for electric energy from the Project is expected to be similar to that experienced in the West Group Area in 1970. The estimated contribution of each class of consumer to the West Group Area coincidental electric power peak and the share of electric energy consumed by each, based on available data for 1970, is as follows:[1]

	1970 Peak	1970 Energy
Residential	50.0%	31.4%
Commercial	21.3%	13.4%
Industrial	28.0%	50.2%
Other	0.7%	5.0%
TOTAL	100.0%	100.0%

*The West Group Forecast uses a water year calendar which runs from July 1 to the following June 30.

For 1990 the contribution of each class of consumer to the West Group Area coincidental peak and the percentage of energy consumed are estimated as follows:[1]

	1990 Peak	1990 Energy
Residential	50.0%	30.9%
Commercial	24.0%	15.3%
Industrial	25.0%	48.1%
Other	1.0%	5.7%
TOTAL	100.0%	100.0%

Actual and estimated electric power requirements in the West Group Area are shown on Table 8.1-1. A lower annual average growth rate is expected for the period from 1976 to 1990 than was experienced in the period from 1950 to 1976. This change is the result of consumer and producer efforts to conserve energy, higher nonpromotional electric rates, more efficient electrical appliances, electrical appliance saturation, and a leveling off of population.

8.1.1.2 Benefits of Averting Electrical Shortages

The probability of electrical shortage with and without the Project on schedule is discussed in Section 1.1.3.2 in regards to effects on capacity reserves and the magnitude of a deficit to meet firm energy requirements. In the West Group Forecast of Power Loads and Resources, July 1978-June 1987, dated March 1, 1978, the expected date of commercial operation for WNP-2 is May 1981. Based on that date, the forecast states the cumnlative probability of meeting total energy load through June 1982 with the Project on schedule is 26.6 percent and of meeting firm energy load is 69.7
1 percent. With all projects, including WNP-2, on schedule, the probability of meeting total energy loads in any year through 1989 ranges from 87 to 60 percent. Similarly, the probability of meeting firm energy loads ranges from 98 to 82 percent. Without WNP-2 the probability of meeting total energy loads decreases about 10 to 12 percent and the probability of meeting firm energy loads decreases about 4 to 17 percent.

Long term shortages of electricity would result in severe social and economic impacts since two-thirds of all electric energy is used in commerce and industry in the Pacific Northwest. An inadequate energy supply for industry means reduced capital investment, fewer jobs, decreased payrolls, less production, and lower living standards. Unemployment would increase demands on governments for welfare and unemployment assistance at the same time that the tax bases financing governments would be declining, and tend to increase social and sociopolitical stresses.

The Northwest Power Pool has drafted an emergency plan for curtailing loads in the event of long term power shortages. This plan is discussed in Section 1.3.1. The voluntary level one curtailment portion of the plan was utilized in the winters of 1972 - 1973 and 1973 - 1974 when low flow and adverse hydro conditions were experienced; firm power requirements were met but some interruptible power utilized by industrial customers was curtailed. The costs of these cutbacks are not known but are clearly substantial.

As the probability for meeting total and firm energy loads in all periods of 1978 to 1989 decreases, the need for 1
projects, such as WNP-2, being available as scheduled becomes greater with the hope that, if a deficit occurs, only the voluntary portions of the emergency plan will need to be utilized.

8.1.1.3 Beneficial Uses of By-Product Heat

The Supply System as a condition of the Site Certification Agreement with the State of Washington, is cooperating in a project to demonstrate the beneficial use of condenser cooling water. WNP-2 will be the warm water source for studies on the response of crops and trees to warm water irrigation. Other possible areas of study include aquaculture, soil heating, and greenhouse and animal enclosure environment control. During operation, 4,000 GPM of water, taken from the hot leg between the plant and the cooling towers will be available to the warm water agricultural project. Cold water will be utilized when warm water is not available. 1

The project is coordinated by the Board of Directors of the Hanford Warm Water Utilization Laboratory (HWWUL) composed of representatives of Washington State University, Oregon State University, University of Idaho, the state governments of Washington, Oregon, and Idaho, the U. S. Department of Energy (DOE) and the Supply System. DOE has leased approximately 900 acres to HWWUL for the research project. A pilot study of tree growth on the leased area funded by the Pacific Northwest Regional Commission was initiated in 1976. Funding for expanded studies involving the use of the WNP-2 warm water has not yet been secured.

8.1.2 Other Social and Economic Benefits

8.1.2.1 Payrolls and Employment

Construction began in September 1972 and is expected to extend through March 1980, with a total construction payroll outlay of about $300 million, an average of approximately 1
$3.3 million per month over the entire period. In 1978, the anticipated year of peak employment of approximately 1850

construction workers, peak payroll outlays will be about $8.0 million per month. These payrolls represent an addition to the regional income as the labor force is primarily drawn from the Pacific Northwest, much of it resides in the greater Tri-City area.

During the 40 year operation period beginning in 1980, 104 permanent operation staff will be employed plus an additional WPPSS support staff of approximately 25 workers. The annual payroll outlay for these employees is estimated to be approximately $2.4 million.

8.1.2.2 Tax Revenues

During the construction of the Project, approximately $32 million in sales taxes will be paid to state and local government. During operation the Project will pay sales taxes in excess of $72 million. Since the Project is entirely owned by WPPSS, a joint operating agency and public utility, no real estate taxes will be levied.

During the operation period, the Supply System is required by law to pay a "privilege tax" as imposed by RCW 54.28, which is one and one half percent of the wholesale power cost. Over the life of the plant, it is estimated that approximately $72 million will be paid in privilege taxes,
1 with approximately $36 million of this figure to go to Benton county and a number of other taxing districts within a 35-mile radius of the plant.

In addition to this privilege tax, the Supply System is making payments during the construction period to local school districts experiencing increased enrollment as a result of the Project. In addition to the maintenance and operation payments prescribed by RCW 54.36, (which are approximately $400 per project pupil year), the Supply System has voluntarily entered into an agreement with the school districts in the Tri-Cities area to provide funds for capital construction purposes. Upon meeting minimal eligibility requirements, the districts are immediately eligible to draw upon their allotted share of these funds.

8.1.2.3 Public Facilities

During plant construction, visitors have access to a temporary outdoor display located outside the security fence near the southwest gate. With regard to a permanent visitor facility, the Supply System is planning to construct an information center at its central office facility approximately nine miles South of the WNP-2 and WNP-1&4 sites. Present plans are for a 5,000 sq. ft. building which will include archaeological and energy - related displays and demonstrations.

TABLE 8.1-1

ELECTRIC POWER REQUIREMENTS BY MAJOR
CONSUMER CATEGORIES IN THE PACIFIC NORTHWEST
(West Group Area)

	Actual				Estimated		
	1950	1960	1970	1976	1980	1990	1995
Population (000) 1/	4,675	5,490	6,435	7,016	7,414	8,498	8,977
No. Domestic Consumers (000)	1,073	1,407	1,986	2,394	2,620	3,260	3,575
No. Commercial Consumers (000)	140	177	242	276	302	362	392
KWh Per Consumer							
Domestic	5,112	9,841	13,831	15,742	17,000	20,500	22,000
Commercial	16,799	29,143	50,035	63,088	71,500	95,000	107,800
Energy Sales (billions kWh)							
Domestic	5.5	13.8	27.5	37.7	44.5	66.8	78.6
Commercial	2.4	5.2	12.1	17.4	21.6	34.4	42.1
Industrial	11.1	22.3	44.1	51.0	65.3	93.4	113.8
Irrigation	.1	1.0	2.6	3.9	4.6	6.3	7.6
Other	.6	.8	1.4	2.1	2.5	4.3	5.1
Total	19.7	43.1	87.7	112.1	138.5	205.2	247.2
Losses	3.1	4.7	9.6	11.0	13.2	19.5	22.9
Total Requirements	22.8	47.8	97.3	123.1	151.7	224.7	270.1
Ten Year Annual Growth Rates		7.7%	7.4%		4.5%	4.0%	

1/ States of Washington, Oregon, Idaho, and western Montana.

Source: BPA Requirements Section, March 6, 1978

TABLE 8.2-1

COST COMPONENTS OF WNP-2

Direct Costs

a.	Land and land rights	$ 68,000
b.	Structures and site facilities	138,840,000
c.	Reactor (boiler) plant equipment	111,529,000
d.	Turbine plant equipment	102,926,000
e.	Heat rejection system (cooling towers)	11,590,000
f.	Electric plant equipment	58,473,000
g.	Miscellaneous plant equipment	42,257,000
h.	Spare parts allowance	4,876,000
i.	Contingency allowance	111,065,000
	Subtotal	$581,624,000

Indirect Costs

a.	Construction facilities, equipment and services	$ 28,857,000
b.	Engineering and construction management services	116,439,000
c.	Other costs	222,315,000
d.	Interest during construction*	35,103,000
	Escalation during construction	92,662,000
	Total capitalized Plant Cost, at start of commercial operation	$1,077,000,000(1)

*Does not include debt service on bonds issued for plant construction between the date (September 1977) when payments are to commence under net billing agreements with Bonneville Power Administration and the scheduled commercial operation date (December 1980). This amount is currently estimated to be $199,908,000. 2

TABLE 8.2-2

INFORMATION REQUESTED BY NRC

WNP-2

1.	Interest during construction	6.68%/year[a]
2.	Length of construction work week	40 hours
3.	Estimated site labor requirement	9.82 manhours/KWe
	Total manhours of construction effort	10.8 million
4.	Average site labor pay rate (including fringe benefits) effective at month and year of NSSS order	$12.00/hour[b]
5.	Composite escalation rates for 1978	7.7%/year
	Composite escalation rates for 1979	7.6%/year
	Composite escalation rates for 1980	7.2%/year
6.	Total plant cost at start of commercial operation	$1,077,000,000

[a] Weighted average effective interest rate.

[b] NSSS was ordered in April 1971 before site construction began. The $12.00/hour represents average site labor pay rate for March 1976, the delivery date for NSSS. In January 1978 the average labor cost was $14.23/hour.

The occurrence of the rapid increase in population projected by Woodward-Clyde Consultants is substantiated by the numbers of new residential telephone hookups experienced by General Telephone in 1974 through 1977, and the expansion of the residential housing market in the Tri-City area. The residential population increase is scattered among the Tri-Cities and outlying communities.

The association of WNP-2 to the total residential population increase can be estimated from the results of a survey of WNP-2 workers in February 1975 performed as part of the socioeconomic study by Woodward-Clyde Consultants. It was found that 65 percent of the workers surveyed (about 70 percent of 550 workers) lived in the Tri-City area before construction on WNP-2 began and that about 80 percent of the workers surveyed lived in the Tri-Cities.[3] At the time of the survey in February 1975, approximately 1200 construction workers were employed on the FFTF Project. In making projections of total population growth in the Tri-City area, Woodward-Clyde Consultants assumed that 40 percent of the peak construction work force on WNP-2 in 1977 or 660 workers would be new residents.

It is significant that the demand for workers on WNP-1 and WNP-4 will be increasing to about 3300 workers from 1975 to 1980. It is also significant to note that FFTF and WNP-2 will have been completed by then, or will be near the end of the downside of their manpower curves. Since the mix and magnitude of building trades workers is similar on these projects, it is expected that the new resident workers on FFTF and WNP-2 will remain in the Tri-City area to work on WNP-1 and 4. An attempt to confirm this hypothesis began in February 1978, when a question on "place of previous employment" was included on the revised "1st Day Worker Survey" for WNP-1/4 workers. This questionnaire is one of several data sources developed for the socioeconomic monitoring effort required by the State of Washington Site Certification Agreement for WNP-1/4. 1

As construction activities on WNP-1/4 peak and are completed between 1979 and 1983, construction population growth in the Tri-City area is expected to decline; however, the expansion occuring in other local industries and irrigation agriculture is expected by 1982 to take up the slack in population growth caused by a decline in construction industry employment. It is likely that other construction projects related to energy research and development will occur in the Tri-City area during the 1980-1989 decade.

The increase in population from 1974 to 1978 is anticipated to have certain adverse effects related to the increased burden of new residents on community services and facilities.

Although conceived as adverse effects in the short-term, the act of increasing community services and facility capacities during the late 1970's will be a benefit in the 1980's as the area population stabilizes at a higher permanent level. The anticipated effects of short-term population growth on community services and facilities are summarized on Table 8.2-6.

The housing requirement noted in Table 8.2-6 is being met by the number of new homes and apartments which have been and are being constructed. The local residential housing market sector seems capable of responding to the short-term need which is anticipated.

The effects of population growth on school enrollments is a problem in the Tri-City area which is being met by intra-
1 district busing and the construction of new facilities.

The Supply System has negotiated an agreement with school districts effected by WNP-1 and 4 to make financial assistance payments for construction of new facilities. Also included in the agreement is a procedure for compensating for enrollment increases caused by WNP-2 and WNP-1/4. The conditions of the agreement are consistent with WPPSS authority as a public agency and are detailed to ensure a fair and equitable distribution of funds when and where need exists.

Local hospitals are not expected to be impacted by the anticipated short-term population increase. In fact, Table
1 8.2-6 depicts a condition of excess capacity in all three local hospitals. However, need for increased fire and police protection is anticipated.

The various public Works Departments in the Tri-Cities are aware of the general pressures of growth, and have adopted a policy of meeting the overall area growth as part of their normal functions. Quantity and pressure within water systems is not a problem, except during those weather abnormalities when there are more than two weeks of temperatures in excess of 100°F. Almost all of the communities
1 are planning or building significant increases in water supply and/or pressure systems to come on line during the 1979-1982 period. Increases in the size and capabilities of sewage treatment and collector systems are also being planned or constructed, although none of the public works departments would even characterize the peaks under current conditions as "critical".

Traffic congestion associated with workers traveling to the Hanford Reservation through the City of Richland is a problem on George Washington Way and the By-Pass Highway during peak periods during the morning and afternoon. However, progress is being made towards placement of two additional lanes on the By-Pass. Planning and design for the project will be carried out in 1978 and early 1979, and the project has top priority for construction during Washington's 1979-81 budgetary biennium. Barring any major budget surprises from the 1979 Legislative Session, the project will be constructed during June through September, 1979. These improvements, coupled with a decrease in construction personnel from FFTF and WNP-2, will greatly ease congestion on this highway. 1

Since the WNP-2 site is located on the DOE Hanford Reservation, twelve miles north of the City of Richland and two miles west of the Columbia River, noise and temporary aesthetic disturbances on residential populations are expected to be negligible. In addition, the acquisition of land for WNP-2 did not cause any affect on local residents because the land is leased from DOE and has not had residents since 1943 when it was acquired by the Manhattan Project of the Army Corps of Engineers.

8.2.2.2 Long-Term External Costs

Long-term external costs are those associated with the operation of WNP-2 beginning in 1980 for approximately 40 years.

The operation of the Project will not impair recreational values, deteriorate aesthetic values, or degrade or restrict access to areas of scenic, historical, or cultural interest.

The Project is located 12 miles north of the City of Richland on the DOE Hanford Reservation and, as such, is not anticipated to create locally adverse meteorological conditions or noise.

The increased costs to local governments for services required by the permanently employed plant workers and their families are expected to be compensated for by local taxes paid by individual workers who become permanent residents. In addition, the project will provide abundant tax revenues to the area taxing districts from the privilege (generation) tax ($36 million) and from the sales tax on fuel reloads (approximately $7.2 million) during plant operation. (WNP 1 and 4, also in the Tri-Cities area, will also be providing $126 million from the generation tax and $33.4 million in sales taxes to local governments during approximately the same time period as WNP-2.) 1

There is no known economic incentive for heavy industry to be attracted to the WNP-2 site area. There are no electric rate incentives or deterents to influence the growth of residential or commercial customers in the WNP-2 site area. Therefore, no long-term external costs are anticipated with respect to further industrial development in the area.

TABLE 8.2-1

COST COMPONENTS OF WNP-2

Direct Costs

a.	Land and land rights	$ 68,000
b.	Structures and site facilities	138,840,000
c.	Reactor (boiler) plant equipment	111,529,000
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a.	Construction facilities, equipment and services	$ 28,857,000
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d.	Interest during construction*	35,103,000
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	Total capitalized Plant Cost, at start of commercial operation (September 1980)	$1,077,000,000(1)

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TABLE 8.2-2

INFORMATION REQUESTED BY NRC

WNP-2

1.	Interest during construction	6.68%/year[a]
2.	Length of construction work week	40 hours
3.	Estimated site labor requirement	9.82 manhours/KWe
	Total manhours of construction effort	10.8 million
4.	Average site labor pay rate (including fringe benefits) effective at month and year of NSSS order	\$12.00/hour[b]
5.	Composite escalation rates for 1978	7.7%/year
	Composite escalation rates for 1979	7.6%/year
	Composite escalation rates for 1980	7.2%/year
6.	Total plant cost at start of commercial operation	\$1,077,000,000

[a] Weighted average effective interest rate.

[b] NSSS was ordered in April 1971 before site construction began. The \$12.00/hour represents average site labor pay rate for March 1976, the delivery date for NSSS. In January 1978 the average labor cost was \$14.23/hour.

TABLE 8.2-3

ESTIMATED COST OF ELECTRICITY FROM WNP-2

Fixed Costs	Annual Cost	mills/kilowatt hour
Interest and Amortization	$ 80,526,000	13.20
Insurance	2,259,000	.37
Payment to Reserve and Contingency Fund	8,053,000	1.32
Operation and Maintenance (fixed)	12,183,000	2.00
Administration and General	6,977,000	1.14
Subtotal	109,998,000	18.03
Less: Surplus of Prior Year's Payment to Reserve and Contingency Fund	5,305,000	-.87
Interest Earnings	2,712,000	-.44
Total Fixed Cost	$101,981,000	16.72
Variable Costs[a]		
Nuclear Fuel Cycle[b]		
Cost of U_3O_8 (yellow cake)		.97
Cost of shipping		.23
Cost of conversion and enrichment		2.69
Cost of conversion and fabrication		.70
Cost of reprocessing		.00
Carrying charge on fuel inventory		.10
Cost of waste disposal		.73
Credit for plutonium, U-233 or U-235		.00
Total cost for fuel	$ 33,055,000	5.42
Taxes	1,971,000	.32
Total Variable Cost	35,026,000	5.74
Net Annual Cost	$137,007,000	22.46

(a) All variable costs are calculated at 63 percent plant factor.

(b) Mills/kWh derived from data developed for the 1978 Fuel Management Plan by B. M. Moore, WPPSS. The cost is levelized over a 15 year period and is escalated.

TABLE 8.2-4

POPULATION DATA FOR THE TRI-CITY AREA

	1940	1950	1960	1970	1971*	1972*	1973*	1974	1975	1976	1977
Benton County	12,053	51,370	62,070	67,540	67,700	67,800	68,200	69,800	73,300	78,700	84,500
Franklin County	6,307	13,563	23,342	25,816	26,000	26,000	26,000	26,200	26,700	27,500	28,300
TOTALS	18,360	64,933	85,412	93,356	93,700	93,800	94,200	96,000	100,000	106,200	112,800
Kennewick	1,918	10,106	14,244	15,212	15,400	15,580	16,200	16,800	18,253**	21,301**	23,638**
Pasco	3,913	10,228	14,522	13,920	13,920	14,000	14,050	14,100	14,450	14,618	15,500
Richland	247	21,809	23,548	26,290	26,300	26,350	26,600	28,000	28,600	30,009**	31,040
West Richland	--	--	1,347	1,107	1,143	1,159	1,225	1,247**	1,477**	1,561**	2,024**
TRI-CITY TOTALS	6,078	42,143	53,661	56,529	56,763	57,089	58,075	60,147	62,780	67,489	72,202

*Estimates from Tri-City Chamber of Commerce and the Washington State Office of Program and Fiscal Management.

**Actual Census.

Source:

Socioeconomic Study: WPPSS Nuclear Projects Nos. 1 and 4, by Woodward-Clyde Consultants, April 1975, Tables 4.3-1 and 4.3-2.

1974-1976 "Washington Information Report; State of Washington, Population Trends, 1976", Population Studies Division, Office of Program Planning and Fiscal Management, Olympia, August 1976.

1977, Preliminary Estimates, yet to be certified, unpublished data, Benton-Franklin Council of Governments.

TABLE 8.2-5

PROJECTED SHORT-TERM POPULATION GROWTH IN TRI-CITY AREA

	Yearly Change	Population
Actual		
1974	--	108,026
1975	+ 4,332	112,358
1976	+ 6,667	119,025
Projected		
1977	+ 7,500	126,525
1978	+ 6500	130,500
1979[a]	- 1000[a]	129,500
1980	- 1500	128,000
1981	+ 500	128,500
1982	+ 1500	130,000

[a]After 1978 changes will depend upon new major construction.

Sources: Socioeconomic Study: WPPSS Nuclear Projects Nos. 1 and 4, April 1975

"Washington State Information Report - State of Washington Population Trends, 1976," Population Studies Division of the Office of Program Planning and Fiscal Management, Olympia, Washington, August 1976.

TABLE 8.2-6

SUMMARY OF REGIONAL GROWTH INDICATORS

	Richland					Kennewick					Pasco				
	1974	1975	1976	1977	1978	1974	1975	1976	1977	1978	1974	1975	1976	1977	1978
Population	28,000	28,600	30,009	31,040	32,050	16,800	18,253	21,301	23,638	24,000	14,100	14,450	14,618	15,500	16,400
Population Increases*	-	600	1,409	1,031	725	-	1,453	3,048	2,337	362	-	350	168	882	900
Housing Required	-	200	470	345	242	-	485	1,020	780	120	-	120	36	295	300
School Enrollment**	7,648	7,843	7,979	8,080	8,016	7,632	7,839	8,517	8,842	9,000	4,825	4,782	5,033	5,473	5,955
Increases	-	195	136	101	80	-	207	678	325	158	-	(43)	251	440	482
Water Requirements (MGD)															
Plant Capacity	36	36	36	36	36	13.5	14.0	14.0	14.0	19.5	20	20	20	20	20
Average Use	13.7	13.7	13.8	13.8	13.9		4.5	4.8	5.2	5.4	5.5	5.5	5.5	5.6	5.7
Peak Use	35.0	35.1	35.2	35.2	35.3		9.1	11.0	13.1	13.5	15.5	14.5	14.8	14.9	15.0
Sewage Disposal Use (MGD)															
Plant Capacity	6	6	6	6	6	8.0	8.0	8.7	8.7	8.7	12.7	12.7	12.7	12.7	12.7
Average Use	3.4	3.5	3.7	3.8	3.8	3.4	3.5	3.7	3.8	3.8	1.3	1.6	1.6	1.8	1.9
Peak Use	5.0	5.1	5.2	5.2	5.3	5.0	5.1	5.2	5.2	5.3	3.2	2.3	2.8	2.8	2.9
Policemen	35	35	35	40	40	20	27	30	30	32	24	27	27	28	29
Firemen	37	37	38	38	39	26	29	30	30	32	22	24	24	24	25
Hospital Beds															
Available	135	135	135	135	135	60	60	60	60	60	80	80	80	80	80
Average Use	91	93	90	90	90	40	36	34	32	32	55	54	53	52	51

NOTES: 1974 through 1976 data source - The agencies providing the service or facility.
1977 through 1978 estimates based on projections and/or per capita demand.

*Excluding 1977-78 annexations
**For 1977, May 1, 1977 only

CHAPTER 9
ALTERNATIVE ENERGY SOURCES AND SITES

CHAPTER 9

ALTERNATIVE ENERGY SOURCES AND SITES

9.1 ALTERNATIVES NOT REQUIRING THE CREATION OF NEW GENERATING CAPACITY

At the time of application for a Construction Permit for WNP-2, it was concluded that the projected power requirements of the region could best be met by addition of a new base load thermal plant. This conclusion is still valid; and according to the latest West Group Forecast, the power output of the unit will be fully utilized when it commences operation. An updated evaluation of the need for power was presented in Chapter 1.

9.2 ALTERNATIVES REQUIRING THE CREATION OF NEW GENERATING CAPABILITY

Several alternate energy sources were given consideration during the early planning stages of WNP-2. There have been no changes in the technology or economics of any of these alternatives that would indicate that the project should be abandoned in favor of an alternative generation method.

9.3 SELECTION OF CANDIDATE AREAS

The selection of the site for WNP-2 has been fully discussed in previous documents of public record. No new information has come to light as a result of construction activities or environmental monitoring programs that would indicate in any way that the selected site is unsuitable for the project.

9.4 COST-BENEFIT COMPARISON OF CANDIDATE SITE PLANT ALTERNATIVES

There is no alternative plant-site combination that would afford a better balance of economic, social, and environmental factors than the proposed project. This situation has not changed since the original analysis was made.

CHAPTER 10
PLANT DESIGN ALTERNATIVES

CHAPTER 10

PLANT DESIGN ALTERNATIVES

10.1 COOLING SYSTEM ALTERNATIVES

10.1.1 Range of Alternative Cooling Systems

The cooling system for dissipating the waste heat from WNP-2 is described in Section 3.4, "Heat Dissipation System." At the time of application for a Construction Permit for WNP-2, the Supply System investigated the following alternative heat dissipation methods: variations of mechanical draft cooling towers, natural draft wet cooling towers, spray ponds, once-through cooling, and a cooling pond (1,2).

The selection of the WNP-2 heat dissipation system was based on: determining what systems were available, selection and analysis of realistic alternatives, and optimization of the selected type of system.

Analyses considering environmental and economic factors were performed for the various alternatives. Rectangular mechanical draft (induced) wet cooling towers were selected to provide the best combination of characteristics for WNP-2 as shown in the WNP-2 Construction Permit Stage Environmental Report.

Since that document, further advances in mechanical draft cooling tower technology has resulted in round concrete mechanical draft cooling towers as an alternative to the rectangular design. No technological advances in any of the other alternatives looked into in the Construction Permit Stage Environmental Report has resulted (to date) in an improvement over mechanical draft cooling towers.

A cost-benefit comparison performed in 1972 resulted in the decision to construct round mechanical draft cooling towers (see Figure 3.1-3). An environmental and economical costs-benefits comparison between round and rectangular cooling towers, if done today, would not be expected to result in a different conclusion, especially when considering the associated sunk environmental and economical costs. However, it is relevant to show how the selection of the round cooling towers over the rectangular cooling towers was made. Therefore, the following is a summary of the evaluation of these two types of mechanical towers performed by the Supply System in December 1972 to determine which tower exhibited better economical and environmental characteristics.

10.1.1.1 General

Both of the alternate cooling systems are based upon the evaporative cooling process. Thus it is appropriate to discuss the evaporation of water to a moving air stream, the rate controlling properties, the limits of the process and other phenomena inherent in the process.

The heat transfer process involves a latent heat transfer due to change in state of a small portion of the water from liquid to vapor and a sensible heat transfer due to the difference in temperature of the water and air. Approximately 1000 Btu are required to evaporate one pound of water. The properties which control the rate of evaporation are the degree of saturation of the air and the difference between the "wet-bulb" temperature and the cold water temperature. This temperature difference is called the "approach to the wet-bulb" or simply the "approach". The degree of cooling; ie, the temperature difference of the water entering and leaving the cooling system is called the "range".

When water is evaporated, the chemicals, minerals and dirt which were in the water either as dissolved solids or suspended solids remain behind. Thus, if the water evaporated is simply replaced by an equal amount (makeup) the concentration of dissolved solids in the system would continue to increase. This can cause corrosion or scaling of the system components. The increase of dissolved solids in the system is controlled by adding more makeup water than is evaporated, and intentionally returning the excess (blowdown) from the system back to the river.

The pH is controlled by chemically treating the water, in this case by adding sulfuric acid until the pH is between 6.5 and 8.5.

The location and orientation of cooling towers with respect to nearby buildings, electrical structures, and prevailing winds is important from the standpoint of noise, fog, and icing conditions created by the saturated air discharge, and interference with the free movement of air into the tower intakes. These factors are balanced with piping and power transmission costs and site related installation factors.

The air flow designs used in both mechanical draft tower alternatives is induced draft, where fans are located in the air outlet. Heated water entering the tower is broken into drops increasing water surface area and facilitating evaporation. Release of the latent heat of vaporization to the air, which is expelled from the tower by the fans, cools the water droplets which are collected and recirculated back through the plant condenser.

10.1.1.2 Selected Cooling System Optimization

A system of conventional mechanical draft (induced) cooling towers (MDCT) is considered the optimal design to minimize environmental and economic costs. Upon selection of the conventional MDCT, the Supply System conducted a series of indepth studies of MDCT designs. As a result, six, round concrete MDCT's were selected as the cooling system for WNP-2.

The round mechanical draft cooling towers were determined to have a number of advantages over the conventional (rectangular) mechanical draft cooling towers. The following information comes from the study made by the Supply System in 1972.

10.1.2.1 Comparison of Designs

Item	Rectangular Towers	Round Towers
No. of towers	4	6
Total Land required	19.5 acres	9.2 acres
Design wet-bulb	60°F	60°F
Cold side temp	76.5°F	76.3°F
Approach to wet-bulb	16.5°F	16.3°F
Range	28°F	28°F
Turbine back press.	Base	Same
Fan horsepower	200 hp	200 hp
No. of cells	36	6
No. of fans	36	36

10.1.3 Power Consumption

Table 10.1-1 compares the relative energy requirements of the two tower systems in terms of 1972 capitalized energy consumption (turbine back pressure was taken as equal for both systems).

10.1.4 Effect on Capacity Factor

Neither alternative would have an effect on the capacity factor.

10.1.5 Monetized Costs

As shown in Table 10.1-2, evaluated 1972 differential construction cost is $616,200 in favor of the round towers. It is not expected that the relative ranking of the two systems would be different if the same evaluation were performed today.

10.1.6 Environmental Costs

The round towers are constructed of concrete, while the construction of the rectangular towers would have required wood. Since wood has not been used in the construction of the round cooling towers or as a fill material, chemical preservatives will not be used in the round towers, as would have been the case for rectangular towers. This eliminates the possible discharge of preservatives to the river.

Both systems have similar blowdown, evaporation, makeup requirements; therefore, their relative effects on the Columbia River and its aquatic life would be similar. The greatest difference would result from the difference in the towers' plume rise.

The plume rise from round towers would be greater than from rectangular towers. This is due to the concentrated heat content of the combined six stack exhausts of the round towers, as compared to the less concentrated heat content in the plumes of the multiple cell rectangular towers. The higher plume rise results in reduced local fogging and icing at the plant and on the environment in the Hanford area. This reduction in fogging and icing potential is responsive to the Thermal Power Plant Site Evaluation Councils request that the applicant investigate improvements in this area.

TABLE 10.1-1

CAPITALIZED TOWER ENERGY CONSUMPTION

Capitalized Operating Costs	Four Rectangular Towers	Six Round Towers
a) Capitalized Plant Output due to a fan Outage	232,900	362,300
b) Capitalized Energy Consumption for Tower Fans	1,991,700	1,842,300
c) Capitalized Differential Plant Output due to 0.2°F Cold Water Temperature Difference	147,000	Base
d) Total Capitalized Costs	$2,371,600	$2,204,900
e) Differential Capitalized Costs	$167,000	Base

NOTE: Based on December, 1972 costs (when analysis was performed).

TABLE 10.1-2

COST COMPARISON OF
MECHANICAL DRAFT COOLING TOWERS

Capitalized Construction Costs	Four Rectangular Towers	Six Round Towers
a) Tower Direct Installation Cost,	$ 7,226,000	7,226,000
b) Expanded Engineering Cost on Base Design by Tower Contractor,	$ -	25,000
c) Piping and Electrical Installation Costs,	$ 3,950,800	3,291,600
d) Additional A-E Cost,	$ -	18,000
e) Total Tower Cost,	$ 11,176,800	$10,560,600
f) Differential Tower Cost	$ 616,200	(Base)

Note: Based on December 1972 costs (when analysis was performed)

10.2 INTAKE SYSTEM

The makeup water intake system is made up of three parts: the water inlets, two lead-in pipes approximately 900 feet long, and the pump structure almost fully buried in the river bank. The intake system is designed for a maximum capacity of 25,000 gpm. Although the quantity of makeup water depends on evaporation, drift and blowdown requirements, the average annual makeup water demand is expected to be approximately 15,500 gpm. Three 12,500 gpm pumps are provided with one to serve as a spare.

The infiltration bed intake was the selected intake system at the time of the Construction Permit Stage Environmental Report. However, the Supply System has re-evaluated that decision and the following is a summary of that 1973 evaluation of the environmental, performance, and cost factors of several alternatives. The perforated pipe type of inlet optimizes the previously mentioned factors and therefore was selected as the system to be used for WNP-2. The following discussion shows the procedure and pertinent factors evaluated in selecting this type of intake in 1973. Since no superior designs have become available since 1973, the relative rankings of alternatives would probably still be the same if this analysis were performed today. Consideration of the sunk environmental and monetized costs would result in a decided advantage for retaining the completed system.

10.2.1 Range of Alternatives

Many intake alternatives were considered. The following four schemes were evaluated in detail[1,2]:

a. Perforated pipes mounted above the river bed

b. Conventional intake (modified for fish protection)

c. Infiltration bed

d. Perforated pipes located in an off river channel

10.2.1.1 Perforated Pipes Mounted Above River Bed

This intake (See Figure 3.4-7) utilizing a perforated pipe for water screening is described in Section 3.4 and is the selected intake system for WNP-2.

For fish protection, the design utilizes an external sleeve with 3/8" perforations and an internal sleeve with 3/4" perforations. This design provides a uniform inlet velocity through the external sleeve.

10.2.1.2 Conventional Intake (Modified for fish protection)

A plan and section of the intake are shown in Figure 10.2-1. The essential mechanical features are: trash racks, traveling screens and vertical mixed flow pumps. The structure differs from conventional intakes in that the screens are mounted flush with their supporting walls and fish escape openings are provided in the outer walls. This combination permits a clear fish escape passage directly to right or left from the face of the screen. Traveling screen mesh openings are 1/4 inch clear with possibility that smaller openings may be required seasonally to reduce intake of small fish. The approach water velocity at the screens would not exceed 0.5 fps at minimum river level.

In order to avoid a potential fish trapping slackwater inlet in the shore line, the structure would be located on the low water bank of the river. Access to the structure from the high water bank would be provided by a trestle as shown in Figure 10.2-2.

10.2.1.3 Infiltration Bed

The infiltration bed is shown in Figures 10.2-3 and 10.2-4. It would be located in an off-river channel and water would be drawn into the system through a porous medium composed of sand, gravel, and stone. The water passes through the medium into underlying pipes which lead to the pump structure located several hundred feet inland. A backwash system would be provided to remove materials which collect on the porous bed during operation.

At the infiltration channel entrance a gate structure would be provided to control the water velocity in the channel and across the porous bed.

10.2.1.4 Perforated Pipes Located in an Off River Channel

The perforated pipe intake would be located in a concrete lined channel off the mainstream of the river as shown in Figure 10.2-5. It would utilize the same inlet concept as the perforated pipes located in the river.

This scheme would avoid any obstruction to navigation and the necessity for providing the long lead-in pipe to the pump structure.

With the low channel velocities, sediment will settle at some point along the channel. A two section stilling basin would be provided to divert this sediment into areas where the material can be removed. The individual stilling basin sections can be isolated by gates from the normal flow to the operations would not be carried into the intake area and beyond into the discharge channel.

10.2.2 Normalization of Cost Comparison

All of the alternatives considered were evaluated at a pumping rate of 25,000 gpm. Difference in pumping power required were calculated by estimating the head loss between the inlet and pump suctions. The differential power cost for the alternatives is tabulated in Table 10.2-1, with the perforated pipe intake taken as base.

10.2.3 Effect of Capacity Factor

There would be no effect on plant capacity factor from any of the alternatives.

10.2.4 Monetized Cost

The total differential costs are tabulated in Table 10.2-1 for each alternative. The perforated pipe is the least costly and the infiltration bed is the most costly, based on March, 1973 cost levels. All schemes were evaluated at a pumping rate of 25,000 gpm. If another economic analysis were made today, it is expected that the relative rankings of the systems would be the same.

10.2.5 Alternative Environmental Costs

The following environmental impact factors were considered for this system:

a. Impingement and entrainment of microscopic plankton organisms, fish eggs, larvae and juvenile fish with little or no swimming ability. The volume of water to be pumped in all schemes in relation to the river flow is very small (.15% of minimum river flows).

b. Temporary turbidity increase due to construction dredging and backfilling activities.

c. Permanent damage to river bottom and shoreline.

Table 10.2-2 shows a summary comparison of the four intake schemes with the perforated pipes mounted above the river bed as base.

10.2.5.1 Perforated Pipe Mounted Above River Bed

Very low intake approach velocities and the beneficial effect of the river current sweeping past the exposed inlet pipe surface will keep impingement of organisms to a minimum. The inlet is also located well away from the shore, where out-migrating salmonoid fry concentrations are expected to be less than along the shore.

During construction of the perforated pipe intake, some river turbidity was developed. This was due primarily to the fact that the perforated pipes are located away from the shore. However, temporary turbidity resulting from construction had no noticable effect upon spawning of adult salmon, which takes place upstream of the facility. Construction of the intake system was undertaken during the low water period July, 31 through October, 1975. Adverse effects on migrating juvenile salmonoids were minimal. Adult chinook salmon spawn up river and migrate past the Project primarily along the opposite bank of the river.

The permanent facilities use a minimum of river bank and area compared with other schemes. Only the perforated pipe itself is in the waterway.

10.2.5.2 Conventional Intake (Modified)

The potential for damage to aquatic life would be greater in this type of intake than for the perforated pipe. Entraining of larval fish and other microscopic river organisms drifting or swimming weakly in the water would occur through the 1/4 inch openings of the screens. Decreasing the size of the screen openings would decrease entrainment but increase impingement of these forms.

This structure would extend riverward across the current flow. This would create an eddy below the structure where fish could congregate, which would be an undesirable effect. Construction would have temporarily increased river turbidity. The permanent structure at the shoreline would remove a small area of the benthic habitat and shoreline and interfere with the river's flood flow.

10.2.5.3 Infiltration Bed

This scheme offers the greatest protection from entrainment and impingement of the aquatic life, including fish and non-swimming forms. Intake velocities would be well below the velocities that might affect even the smallest fish.

The major problem for existing facilities of this type has been the clogging of the bed and the need for frequent intermittent backwashing. Backwashing operation would raise river turbidity to some degree, and it is anticipated that during normal operation, turbidity would periodically exceed the acceptable limits.

Turbidity during construction and operation would have had no impact on the spawning of the adult fall chinook salmon.

Construction of the canal and infiltration bed would have caused temporary disturbance to the existing river bed and would have increased river turbidity. A significant portion of the shoreline would have been taken up by the infiltration bed.

Although this system has some merits, the overall environmental impact is found to be greater than the selected system.

10.2.6 Perforated Pipe in a Diversion Channel

This alternative has some advantages over the system used in that it eliminates all obstructions in the river and would cause the least disruption to the river bottom. During construction, there would be some river turbidity. The side channel would tend to collect out-migrating salmonoid fry, and it would be expected that a greater number of fish would pass the perforated pipe in this channel than the one placed in the river. Velocity of the water flow passing the inlet would be far below that for the open river thus reducing fish protection. Hence, the effect on fish greater than for the selected system.

Considering the overall environmental impact, this scheme is less favorable than the selected system.

TABLE 10.2-1
INTAKE SCHEMES
DIFFERENTIAL COST COMPARISON(2)

Costs	Perforated Pipe	Perforated Pipe In Off-River Channel	Infiltration bed	Conventional (Modified)
A. Construction				
Direct Costs	(Base)	$487,000	$1,125,000	$245,000
Escalation	" (2yr.)	53,000 (2yr.)	192,000(2½yr.)	27,000(2yr.)
		540,000	1,317,000	272,000
Modelling				
Laboratory	"	50,000	30,000	10,000
Field	"	-----	150,000	----
Engineering	"	38,000	92,000	19,000
		628,000	1,589,000	301,000
Contingencies	" (15%)	94,000(15%)	377,000(20%)	-40,000(10%)
		722,000	1,966,000	261,000
Financing and Interest (20%)	"	138,000	380,000	66,000
Subtotal A	(Base)	860,000	2,346,000	327,000
B. Operation and Maintenance				
Annual Cost O & M+	(Base)	3,000	8,700	800
Capitalized O & M	"	37,000	110,000	10,000
Incremental Power	"*	---**	3,000*	-2,000
Subtotal B	(Base)	37,000	113,000	8,000
C. Total Cost (A+B)	(Base)	$897,000	$2,459,000	$335,000

\+ Based on total Construction Cost
* Based on 2ft. incremental head loss over conventional scheme
** Based on 1ft. incremental head loss over conventional scheme

Note 1: Costs include all elements of the scheme up to the point of entry into the makeup water pipeline leading to the plant. The electrical substation common to all schemes, is not included. The estimate for the conventional scheme includes the trestle and the pipe section parallel with the trestle.

Note 2: All costs are based on 1973 prices (time of selection. If the same analysis were performed today, the relative rankings of the systems would not change.

TABLE 10.2-2

(SHEET 1 of 2)

COMPARISON OF ALTERNATIVE INTAKE SYSTEMS

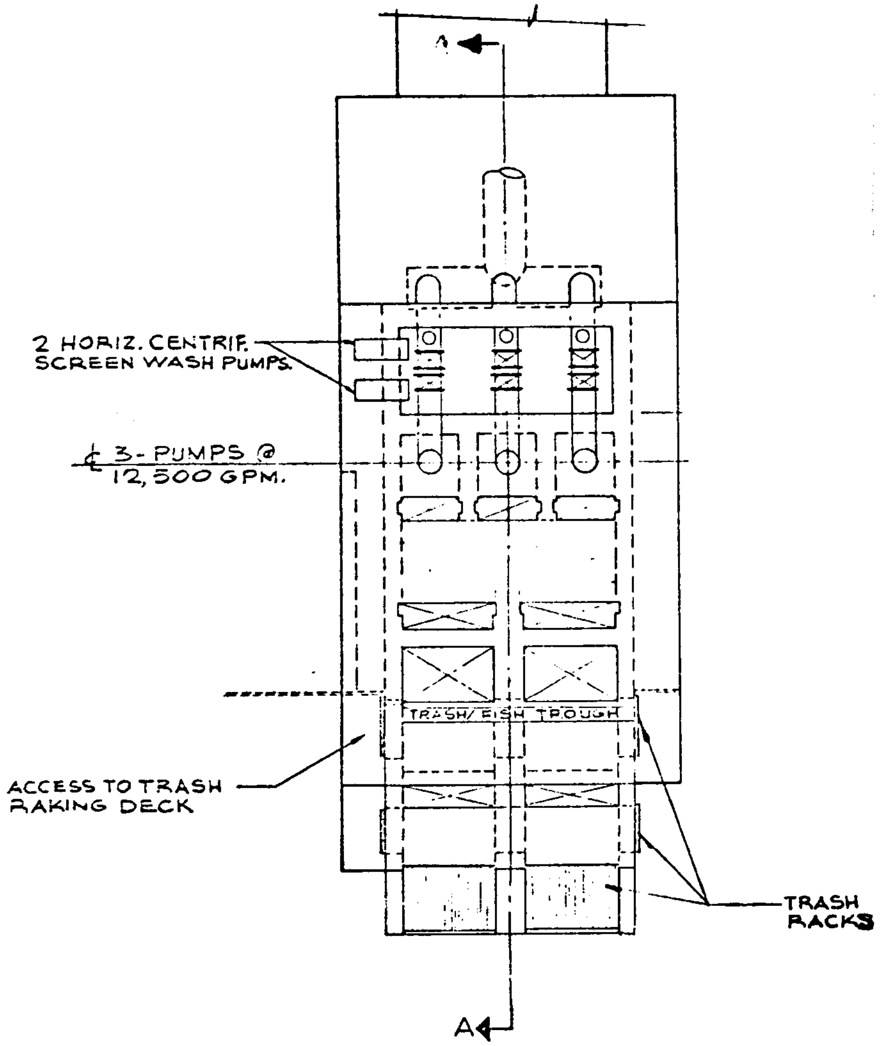
Incremental Capital Cost		Perforated Pipe Intake		Perforated Pipe in Off River Channel		Infiltration Bed		Conventional (Modified) Pumphouse	
		Base		$897,000		$2,459,000		$335,000	
Environmental Costs	Units	Magnitude	Section	Magnitude	Section	Magnitude	Section	Magnitude	Section
1. Natural surface water body									
1.1 Fish Impingement			5.1		10.2		10.2		10.2
Adult salmonids	% Loss	0		0		0		0	
Juvenile salmonids		PS		LP		N		S	
Other adult game fish	% Loss	0		0		0		0	
Other juvenile game fish		ML		ML		N		ML	
1.2 Passage through cooling system			5.1		10.2		10.2		10.2
1.2.1 Phytoplankton	% Change	<0.1		<0.1		<0.1		<0.1	
Zooplankton	% Change	<0.1		<0.1		<0.1		<0.1	
1.2.2 Juvenile salmonids		PS		PS		I		PS	
Other juvenile game fish		I		I		I		I	
1.3 Discharge plume		N		N		ML		N	
1.4 Chemical Effluents		NA		NA		NA		NA	
1.5 Radionuclides discharged to water		NA		NA		NA		NA	
1.6 Consumptive water use	gal/day	NA		NA		NA		NA	
1.7 Plant construction effects			5.1		10.2		10.2		10.2
1.7.1 Physical water quality volume	acres-ft	N		N		N		N	
area	acres	0.25		2.0		2.0		1.0	
1.7.2 Chemical water quality volume	acre-ft	0		0		0		0	
area	acres	0		0		0		0	
1.8 Other impacts		none	5.1	none	10.2	none	10.2	none	10.2
1.9 Combined or interactive effects		N	4.1& 5.1	N	10.2	N	10.2	N	10.2
1.10 Net effects		PI	4.1 & 5.1	PI	10.2	ML	10.2	S	10.2
2. Ground Water		none		none		none		none	
3. Air		NA		NA		NA		NA	

TABLE 10.2-2

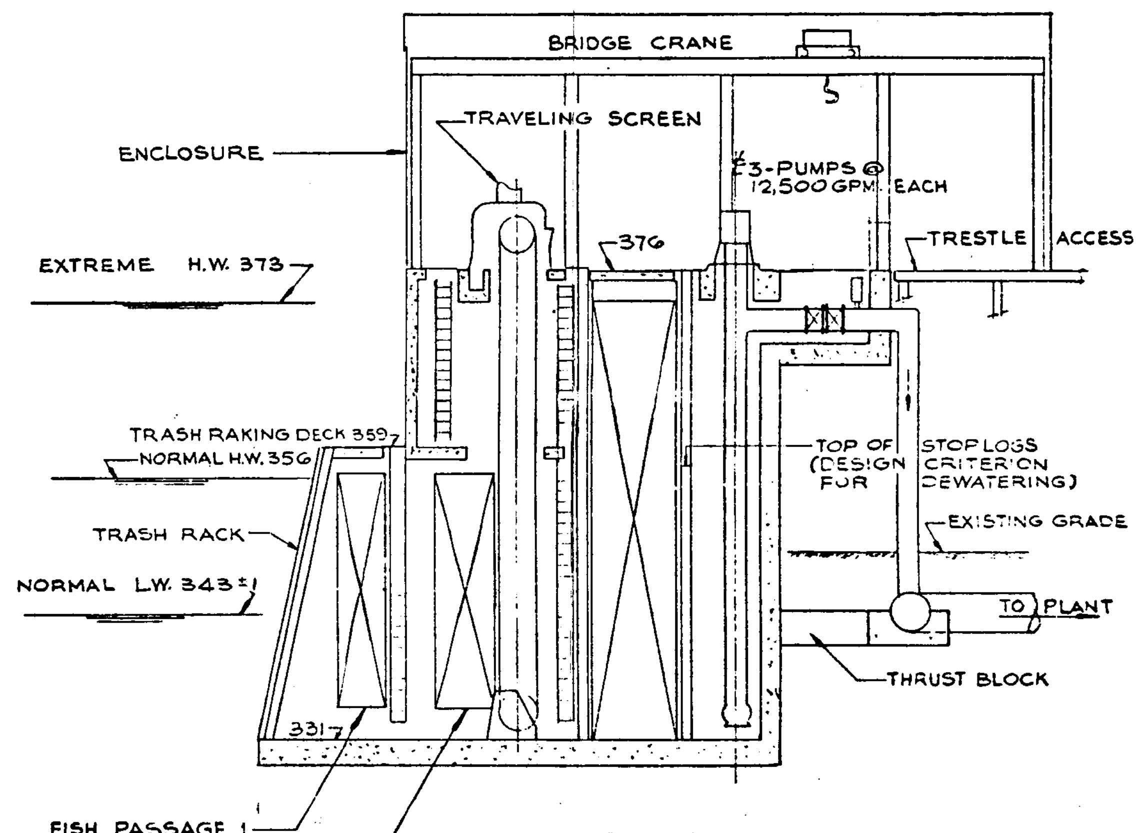
(SHEET 2 of 2)

Environmental Costs	Units	Perforated Pipe Intake Magnitude	Perforated Pipe Intake Section	Perforated Pipe in Off River Channel Magnitude	Perforated Pipe in Off River Channel Section	Infiltration Bed Magnitude	Infiltration Bed Section	Conventional Pumphouse Magnitude	Conventional Pumphouse Section
4. Land									
4.1 Site selected (all additional land required is desert)	acres	1.0	5.1	1.0	10.2	1.0	10.2	1.0	10.2
4.2 Construction activities									
4.2.1 People affected		none	4.1	none		none		none	
4.2.2 Historical places affected		none	2.3	none	2.3	none	2.3	none	2.3
4.2.3 Archeological site disturbed by cooling system		none	2.3	none		none		none	
4.2.4 Wildlife		N	2.7	N		N		N	
4.2.5 Land disturbed	acres	2.0	5.1	2.0	10.2	2.0	10.2	2.0	10.2
4.3 Plant operation									
4.3.1 People affected		none	2.2	none		none		none	
4.3.2 Aesthetics		none	3.1	none		none		S	
4.3.3 Wildlife		N	2.7	N		N		N	
4.3.4 Flood Control		NI		NI		NI		PS	
4.4 Salts from cooling		NA		NA		NA		NA	
4.5 Transmission route		NA		NA		NA		NA	
4.6 Transmission facilities construction		NA		NA		NA		NA	
4.7 Transmission line operations		NA		NA		NA		NA	
4.8 Other land impacts		none	5.1 & 10.2	none	10.2	none	10.2	none	10.2
4.9 Combined effects		none	5.1 & 10.2	none	10.2	none	10.2	none	10.2
4.10 Net effects		N	5.1 & 10.2	N	10.2	N	10.2	N	10.4

LP Larger Potential
PS Potentially Significant
S Significant
ML Minor Locally
NI No Implications
NA Not Applicable
I Insignificant
N Negligible
PI Probably Insignificant

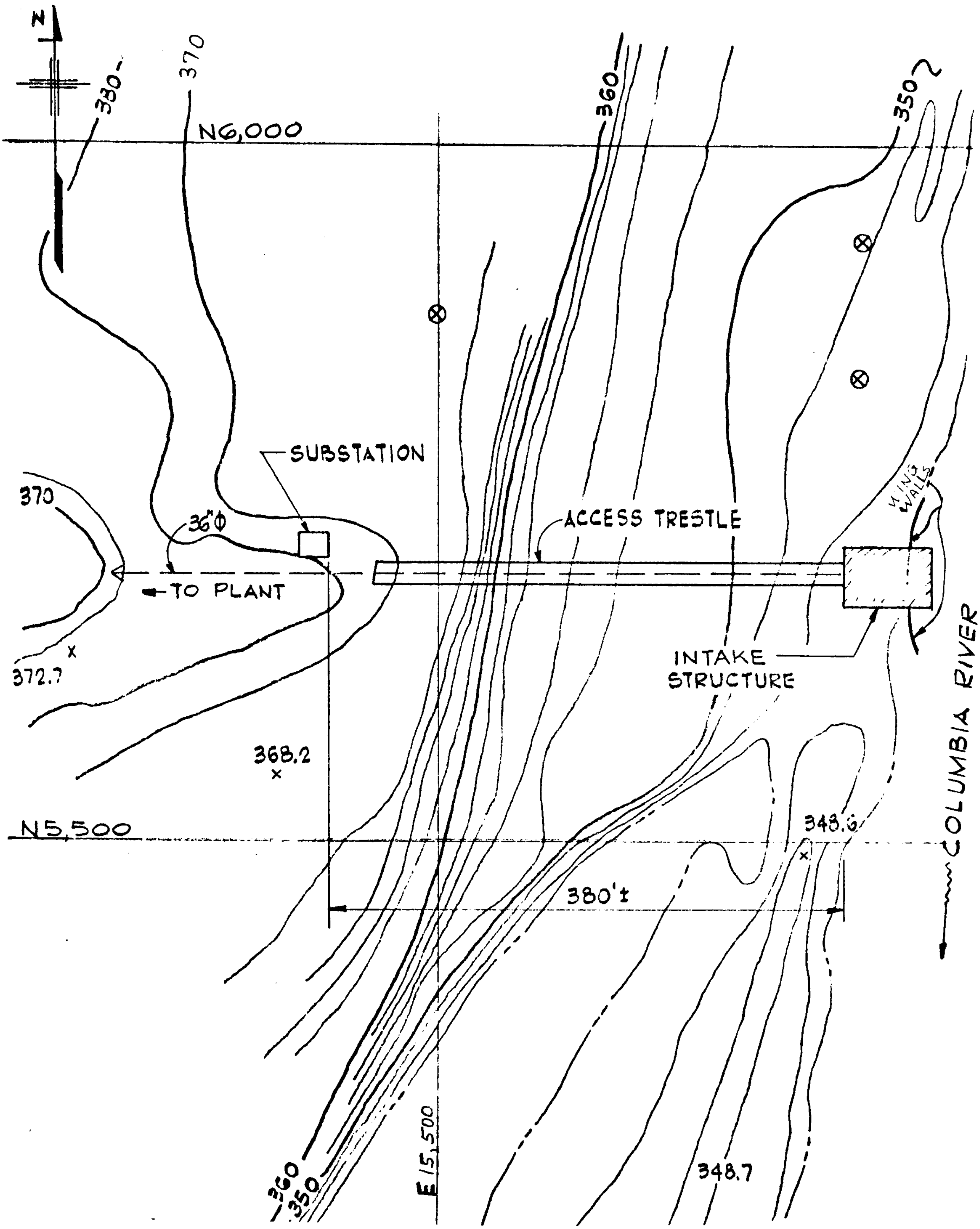


DECK PLAN



SECTION "A–A"

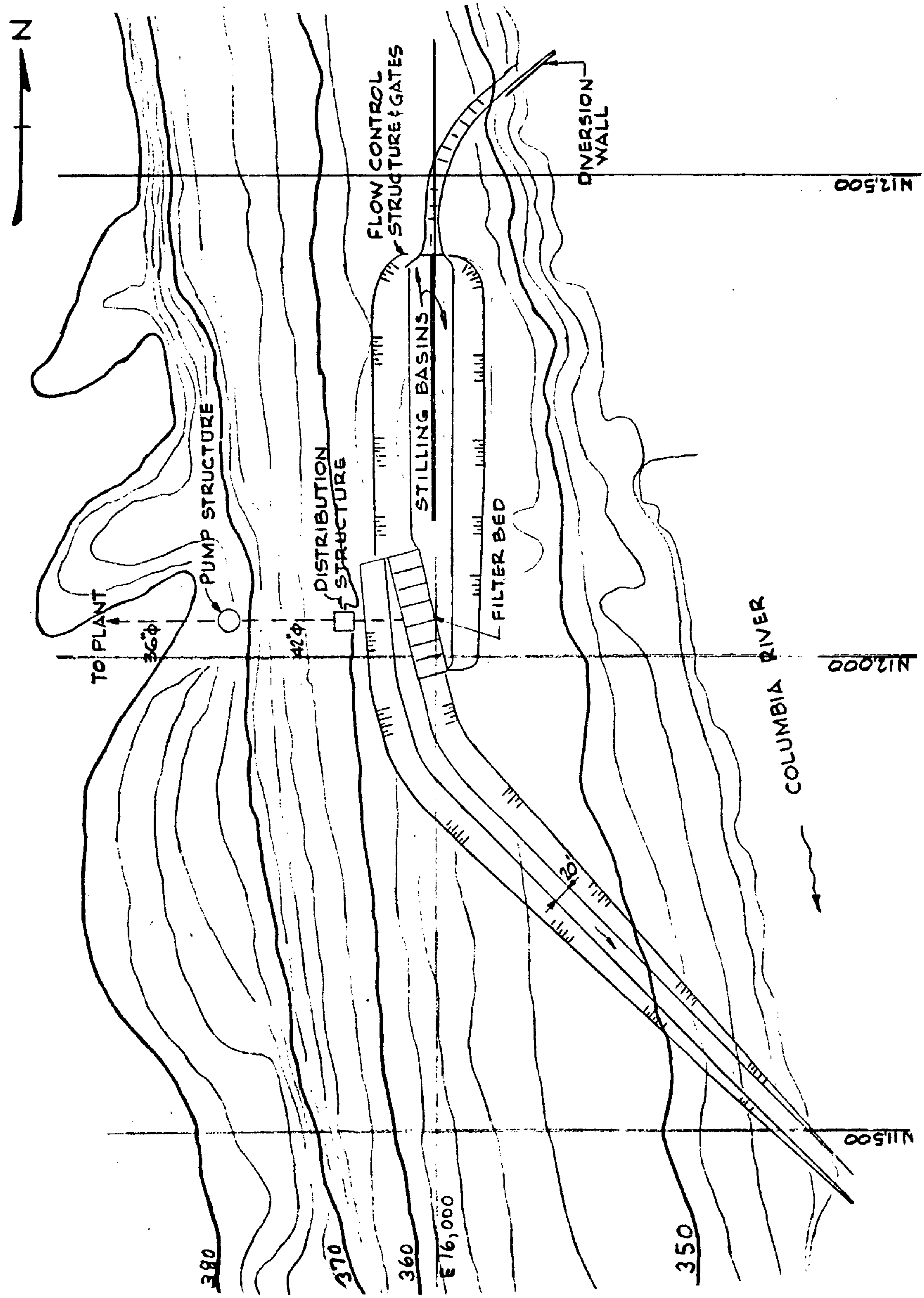
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	MODIFIED CONVENTIONAL INTAKE PLAN AND SECTION FIG. 10.2-1



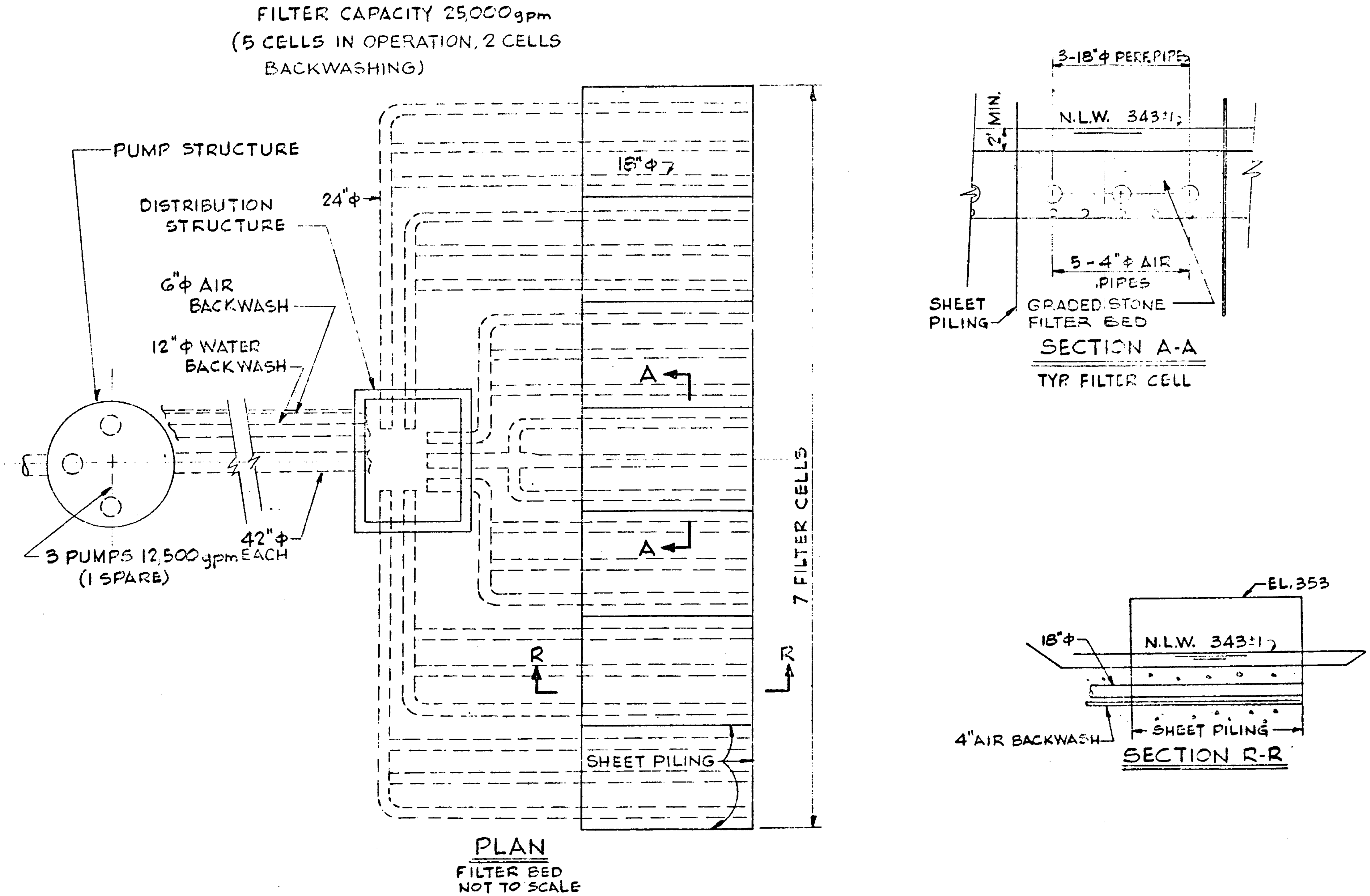
WASHINGTON PUBLIC POWER SUPPLY SYSTEM
WPPSS NUCLEAR PROJECT NO. 2
Environmental Report

MODIFIED CONVENTIONAL INTAKE
GENERAL ARRANGEMENT PLAN

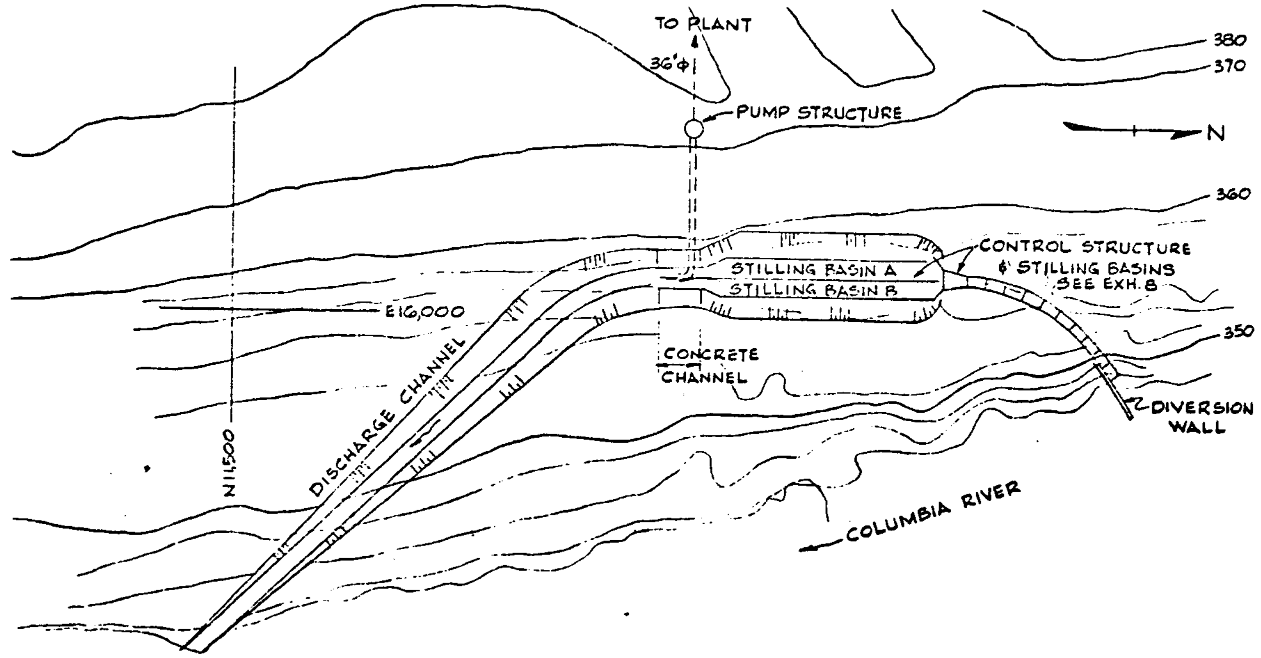
FIG. 10.2-2



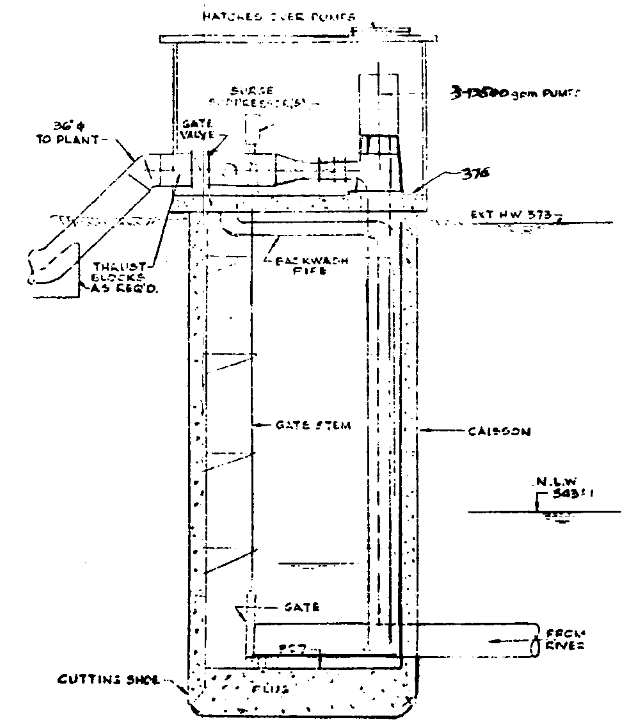
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	INFILTRATION BED INTAKE GENERAL ARRANGEMENT PLAN
	FIG. 10.2-3



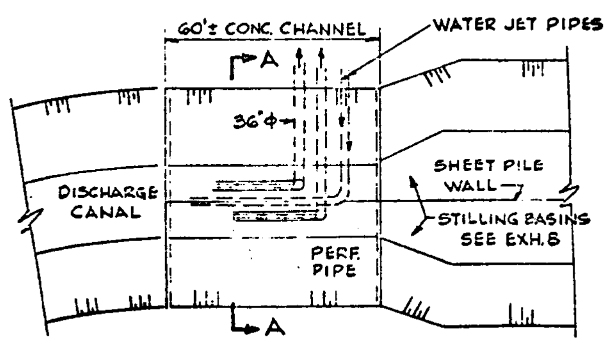
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	INFILTRATION BED INTAKE PLAN AND SECTIONS
	FIG. 10.2-4



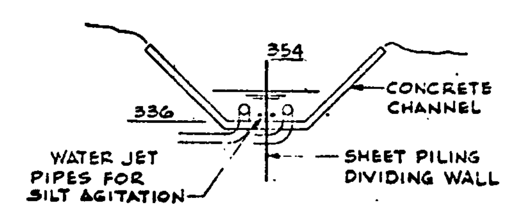
PLAN



PUMP STRUCTURE
SECTION



ENLARGED PLAN



SECTION A-A

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	PERFORATED PIPE INTAKE IN OFF-RIVER CHANNEL FIG. 10.2-5

10.3 DISCHARGE SYSTEM ALTERNATIVES

The single rectangular slot jet was chosen as the preferred discharge type for WNP-2, based on cost and effectiveness of mixing of the effluent with the river. An evaluation of the alternatives that were considered during the selection of the discharge system, including their economical and environmental costs, is given in the WNP-2 Construction Permit Stage Environmental Report and the WNP-2 USAEC Final Environmental Statement. Since those documents, no technological advances have occured which would result in a discharge with a better economical-environmental cost-benefit balance.

10.4 CHEMICAL WASTE TREATMENT

10.4.1 Range of Alternatives

The design for the WNP-2 chemical waste treatment system is described in Section 3.6. In this design, chemicals are neutralized and discharged to the heat dissipation system. Ultimately, these wastes are discharged to the Columbia River with the cooling tower blowdown.

An alternative to this design would be to treat only the small volumes of strong chemical waste produced by the demineralizer. These wastes would be neutralized so as to avoid system corrosion and would be reduced in volume, for eventual off-site disposal, by evaporation. The following techniques were considered:

a. Thermal Evaporation

Thermal evaporation has the advantage of recovering useful water from the chemical wastes. Steam or electrically heated evaporator equipment would produce distilled water and concentrate non-volatile salts for periodic off-site disposal.

b. Atmospheric Evaporation

Atmospheric evaporation of excess water in any evaporation-leaching pond has the advantage of negligible operating attention. A large evaporation-leeching pond is being used for the collection and disposal of storm water, roof drains, area run-off and other miscellaneous drains from the site. The additional load imparted by the chemical waste treatment system would be negligible.

10.4.2 Alternatives Compared Based on Short Term Environmental Effects

The short-term environmental effects due to construction would be negligible. The small incremental load imparted by the chemical waste system would not produce any measurable short term environmental effect.

10.4.3 Alternatives Compared Based on Long Term Environmental Effects

The two alternates suggested would have a minimal long term environmental effect as no chemical wastes would be discharged to the river. The non-volatile salts present in the neutralizer wastes would ultimately be returned to the environment either at an off-site disposal location or through percolation into the ground at the evaporation-leaching pond.

10.4.4 Selected System

Monetized costs for the alternative systems were not determined. The incremental cost associated with disposal by means of the heat dissipation system or the evaporation-leaching pond were too small to be calculated in a meaningful manner. Meaningful costs for the thermal evaporation approach were not calculated because of the low costs involved in alternative methods of disposal. The recommended system described in Section 3.6 was chosen for the following reasons:

a. It provides the simplest and most reliable system.

b. The environmental impact of discharging treated neutralized effluents to the river will be minimal. This is discussed in subsection 10.4.8.

c. While the wastes will be produced infrequently, in small batches, it will be neutralized, monitored, and released to the Columbia River with the cooling tower blowdown, so that it will be subject to continual surveillance.

10.4.5 Power Consumption

Thermal evaporation would require small amounts of energy to vaporize the water present in the neutralized wastes. An average of under 200 pounds per hour of saturated steam would be required. Pumping power requirements for either evaporation method, or the method to be installed, would be negligible.

10.4.6 Effect on Capacity Factor

Neither of the alternatives considered would have any effect on the plant capacity factor.

10.4.7 Monetized Cost

The annual cost of the alternatives was not calculated because of the very small size equipment required for evaporation and the negligible incremental cost of evaporation-leaching pond method.

10.4.8 Environmental Effects

The chemicals returned to the river by the selected method will increase the concentration of dissolved solids in the Columbia River, however, the increase in concentration of dissolved solids would be too small to be measured. The neutralized chemical waste produced by the demineralized plant would contain approximately 2300 pounds of neutral salts per month. The blowdown water from the cooling tower would contain about 360,000 pounds of dissolved salts per month, withdrawn from and returned to the river.

10.5 BIOCIDE TREATMENT

10.5.1 Range of Alternatives

The design for the WNP-2 biological control system is described in Section 3.6. In this design intermittent chlorination of the circulating water will be used for the control of fouling organisms. No other chemical biocides are anticipated at this time.

Experience indicates that the most effective means of controlling biological growths in electric generating utility cooling water systems, compatible with EPA guidelines, is intermittent chlorination. It is anticipated that approximately 240 lbs of chlorine per day will be injected, intermittently, into the circulating water line upstream of the main condenser. Chlorine feed will be at a rate of approximately 2.5 ppm, based on the circulating water flow rate, for a period of 15-20 minutes every 6-8 hours, to control biological growths.

Chlorine dosage will be automatically controlled so that a concentration of about 0.5 ppm will be present after the condenser, in the water going to the cooling tower. It is anticipated that this residual level, after the condenser, will be sufficient to control biological growths. In order to prevent excessive quantities of chlorine passing to the environment, the cooling tower blowdown valve will be closed automatically, during the period when chlorine is being added to the system and until the concentration has dropped to below 0.1 mg/l. This, combined with the natural chlorine demand of the circulating water will prevent the concentrations of chlorine in the cooling tower blowdown from becoming too great.

At the present time there are no demonstrated effective alternates to chlorination for biological control of utility circulating water systems. The following methods were considered:

a. Mechanical Cleaning

Mechanical cleaning, via abrasive materials, of condenser tube surfaces has not been demonstrated to be effective as a means of controlling fouling. Experience indicates that it is necessary to use intermittent chlorination along with mechanical cleaning methods to maintain station availability.

b. Acrolein Treatment

Acrolein is an extremely toxic agent, capable of controlling biological activity and growths in recirculating water systems (on an experimental basis). The effectiveness of acrolein treatment has not been demonstrated in utility cooling water systems. Also, acrolein may not be discharged to the environment and would require neutralization with sodium sulphite which in turn could be considered a pollutant. There are no available automatic analyzers for acrolein so that routine monitoring would not be a possible alternate.

10.5.2 Alternatives Compared Based on Short Term Environmental Effects

The short term environmental effects due to construction would be negligible. The use of mechanical cleaning along with chlorination would make no difference in the quality of the discharge. The environmental effects of acrolein or neutralized acrolein-sodium sulphite solutions have not been fully determined.

10.5.3 Alternatives Compared Based on Long Term Environmental Effects

The long term environmental effects of chemical cleaning combined with chlorination would be the same as the intermittent chlorination method currently proposed. The long term effects of the discharge of acrolein or neutralized acrolein-sodium sulphite solutions is not fully understood.

10.5.4 Selected System

Monitized costs for alternative systems were not determined. Neither of the alternatives considered were operationally nor environmentally superior to the intermittent chlorination proposed. The recommended system described in Section 3.6 was chosen because:

a. Intermittent chlorination has been demonstrated to be effective in similar systems.

b. Chlorine monitoring and feeding equipment has been demonstrated to be reliable in similar systems.

c. The total system can be operated under control using established analytical methods and instrumentation capable of monitoring discharge, and capable of detecting residuals present, if any, in the blowdown water.

10.5.5 Power Consumption

Mechanical cleaning of the condenser using an abrasive ball technique would require small amounts of energy to collect and transport the abrasive materials. The exact energy requirement was not calculated. Energy requirements for the acrolein system would be comparable to the intermittent chlorination system.

10.5.6 Effect on Capacity Factor

None of the alternatives considered would have any effect on the plant capacity factor.

10.5.7 Monetized Cost

The annual cost of the alternatives were not calculated because of the lack of real value of the alternatives.

10.5.8 Environmental Effects

The composition of the cooling tower blowdown water with biological control by means of intermittent chlorination or intermittent chlorination combined with mechanical cleaning would be essentially identical. The environmental effects of small quantities of acrolein or acrolein neutralized with sodium sulphite have not been fully explored.

10.6 SANITARY WASTE SYSTEM

The WNP-2 sanitary waste treatment system has been designed for a maxi-
mum population of 5750 persons, at 30 gallons per capita per day, pro-
5 ducing a total maximum of 170,000 gallons of waste water per day.

10.6.1 Range of Alternatives

The design for the WNP-2 sanitary waste treatment system is described in Section 3.7. Alternative methods for the disposal of sanitary waste include:

a. Municipal Sewage Plant

Disposal of WNP-2 sanitary waste to a municipal waste treat-
ment facility would result in no disposal facilities at the
site. However, the nearest municipal plant is some 15 miles
5 remote and would present extreme problems in the transport of
the sewage, cost of the pipe line and maintenance of the re-
mote pumping stations.

b. Biological Sewage Treatment Facility

A standard package type biological treatment facility of the extended aeration type could be provided. This type of system would include aeration of the incoming waste with recycled activated sludge, gravity separation of the biological floc and excessive sludge. The clarified supernatent would be discharged to the Columbia River.

c. Septic Tank/Drainfield Facility

At Construction Permit stage, a septic tank system was selec-
ted on the basis of least cost and the negligible environ-
mental impact. The system was designed for 100 persons and
was supplemented during the construction phase by holding
tanks and chemical toilets, the contents of which were hauled
5 to off-site sewage lagoons. Continued use of this system
would require rehabilitation and expension of the drainfield
to accommodate greater than anticipated loads.

10.6.2 Aternatives Compared Based on Short Term Environmental Effects

The short term environmental effects of the selected system are slightly greater than those resulting from continued operation of the pre-existing septic tank and waste disposal operation. This is because of the necessary disruption of soil and vegetation caused by construction of the lagoons and sewer lines. The environmental effects of the selected system are not significantly greater than those that would result from the other alternatives.

10.6.3 Alternatives Compared Based on Long Term Environmental Effects

The selected system is expected to have less long term environmental effects than continued operation of the pre-existing septic tanks and holding tanks. The large, but highly variable, loads experienced during the construction and start-up phases requires that a significant fraction of the wastes be hauled off-site to a private lagoon in east Pasco with a round trip distance of 70 miles. This represents a significant expenditure of fuel. Futhermore, the sewage lagoon doesn't comply with the State treatment standards and is subject to closure for possible groundwater contamination. The selected system will provide a greater degree of treatment for wastes discharged to the soil than was provided by the septic tank and drainfield. The long term effects of the other alternatives are no greater than those associated with the selected system.

10.6.4 Selected System

The aerobic lagoon/stabilization pond system described in Section 3.7.1 was chosen for the following reasons:

a. It is the simplest and most reliable system for providing a central waste treatment facility that serves the three Supply System nuclear projects. It is the most flexible system for accommodating the variable waste loads from the three plants from construction through operation. 5

b. Operation of the system would not result in significant environmental impacts.

c. The system provided a least-cost method of treating wastes anticipated for the duration of the plant operating life.

d. The Supply System's construction activities were not vulnerable to closure of an off-site sewage treatment facility or to increases in the disposal charges as they would be with continued operation of the septic tank and chemical toilet operation.

10.6.5 Energy Consumption

Although the selected system requires electrical energy for blowers and pump stations, net energy consumption in the near-term should be less than experienced with the septic tank/holding tank/chemical toilet operation because of the fuel expended in hauling the waste off-site. In the longterm, energy consumption will be reduced because during the

operation phase for the three projects, the total work force and, hence,
5 the waste load will be reduced resulting in corresponding decreases in the requirement for pumping and forced aeration (the latter perhaps being eliminated).

10.6.6 Effect on Capacity

None of the alternatives considered would have any effect on the plant capacity factor.

10.6.7 Monetized Cost

A cost comparison showed that the selected system enjoyed a 10:1 advantage in annual cost over continued operation of the numerous septic tanks and holding tanks at the three Supply System plants. With respect to an upgraded and enlarged septic tank/drain field, ratio was $1\frac{1}{2}$:1 and compared to an activated sludge package plant it was $2\frac{1}{2}$:1.

5

10.6.8 Environmental Effects

The selected system is expected to have the least environmental effect of the alternatives. The most significant effect of the selected system is the disturbance of soil and vegetation caused by its construction and the long-term occupation of approximately 17 acres.

10.7 LIQUID RADWASTE SYSTEMS

The design of the plant limits the quantities of radioactive materials in effluents including liquid wastes to levels which are within the numerical guides for design objectives and limiting conditions of operations set forth in 10CFR50, Appendix I, as indicated in Sections 3.5 and 5.2.

10.8 GASEOUS RADWASTE SYSTEMS

The design of the plant limits the quantities of radioactive materials in effluents including gaseous wastes to levels which are within the numerical guides for design objectives and limiting conditions of operations set forth in 10CFR50, Appendix I, as indicated in Sections 3.5 and 5.2.

10.9 TRANSMISSION FACILITIES

The Bonneville Power Administration, is planning, designing, and constructing the transmission facilities for WNP-2. BPA has submitted an environmental impact statement[1] and the following assessment of the alternative facilities is taken from that document.

10.9.1 H. J. Ashe Substation Evaluation

The requirements for a location in a specified relationship to transmission lines coming from WNP-2 did not allow considerable flexibility for the location of this substation and therefore only one potential site was identified. See section 3.9 for a description of the substation.

10.9.2 General Description of the Proposed and Alternate Routes

Basic considerations in identifying the routing for the 500 KV Ashe-Hanford line were:

1. availability of corridor width to accommodate additional parallel circuits,

2. avoidance of physical barriers,

3. compatibility with testing activities in the explosive test area,

4. environmental impact considerations, and

5. economic costs.

Two alternative routes were identified and considered. Route A, the proposed route, is almost a straight-line corridor between Ashe and Hanford passing through the explosive testing area. Alternative Route B would avoid actual explosives testing areas but is longer and therefore more costly than Route A. No other viable alternate routes which are practical and competitive from either environmental or economic points of view have been identified. Table 10.9-1 gives a comparision of the alternative transmission routes.

The considerations in locating the 230 KV start-up line were based mainly on paralleling the 500 KV Ashe-Hanford line as far as possible for the purpose of joint corridor use. For this reason, only the alternative 500 KV lines are considered in the following sections. For information concering the 230 KV start-up line see Section 3.9. Figure 10.9-1 is an overall map of the alternative routes.

10.9.2.1 Description of Route A and its Impacts

Route A has been separated into three sections. The line location is shown in Figure 10.9-2.

Section I

The 18.3 mile Route A begins at WNP-2, passes through BPA's Ashe Substation (1/2 mile north of WNP-2) and proceeds northwesterly for 4.6 miles, turns west at a slight angle and continues northwest for another 3.1 miles to a crossing of the existing HEW No. 3, 230 KV line.

The first 7.7 miles are located 120 feet east of and parallel to the 230 KV Ashe Tap to ERDA's HEW No. 3 line.

Section II

From the crossing of the 230 KV line, Route A continues for 3.4 miles to an angle point on Gable Mountain, then turns at a slight angle to continue northwest for 4.5 miles to the existing lower Monumental-Hanford 500 KV line right-of-way.

Section III

The last 2.2 miles will be parallel to and 110 feet west of the existing 500 KV steel structured Lower Monumental-Hanford line.

Additional right-of-way width for a future line will be acquired along the east side of the proposed route over its entire length.

New right-of-way width required is as follows:

Section	Right-of-Way Width
I	350 feet, to include WNP-2 230 KV start-up and other future lines.
II	230 feet, except for the last 0.5 miles where the right-of-way width increases from 230 feet to 350 feet.
III	92.5 feet, of additional right-of-way will be needed west of and 87.5 feet east of the Lower Monumental-Hanford line.

10.9.2.1.1 Costs of Route A

Estimated costs for Route A, based on prices current in September, 1973, are:

Transmission Line	$3,705,000
One Hanford Switching Station 500 KV terminal	640,000
Terminal equipment at Ashe Substation and land for the future 500 KV switchyard at Ashe	603,000
Modifications at Hanford Substation	123,000
Power System Control	455,000
TOTAL	$5,526,000

10.9.2.1.2 Land Use

Access road requirements for the proposed route will be approximately as follows:

Section I

New Location on right-of-way - 3 miles

New location off right-of-way - 5 miles

Through the sand dunes area, approximately 3 miles of existing gravelled telephone line access road will be utilized. Short spur roads to the individual tower sites will be needed.

Section II

New location on right-of-way - 6 miles

New location off right-of-way - 0.5 miles

Improvement on and off right-of-way - None

The existing Midway-Eagle Lake line access roads will be used on top of Gable Mountain. Only short spur roads will be required on top of the mountains.

Figure 10.9-3 is an aerial photograph of the proposed route and Figure 10.9-4 is a map of land use. The following table itemizes land cover crossed by Route A:

		Sagebrush and Grass	Comments
Section I	Route in Miles	7.7	Included the proposed 500 KV and 230 KV lines and future lines
	New easement acreage	331	
Section II	Route in Miles	7.9	Includes the proposed 500 KV line and the future line.
	New easement acreage	229	
Section III	Route in Miles	2.2	Includes the proposed 500 KV line and the future line
	New easement acreage	52	

New easements for the 18-mile Route A corridor will require 612 acres of land.

10.9.2.1.3 Impact on Land Use

Since the land crossed by the Route A (See Figure 10.9-3) is mostly open space, impacts will be minimal. If the reservation were opened for public use, existing cover and potential land use would be disrupted to the extent required for easement and access road requirements. Route A, however, is within the Hanford Reservation in which the public use is restricted by ERDA for safety and security reasons. The route will cross the explosives testing area; however, there will be little interference with actual testing. BPA and ERDA have reached an agreement which calls for relocation of certain facilities in the testing area.

Erosion is discussed in Section 4.2.4.

10.9.2.1.4 Impact on Natural and Cultural Resources

Recreation

There are no recreational facilities within the Hanford Reservation.

Historic and Archeological Sites

As shown in Figure 10.9-4, route A does not come near any identified historic or archeological sites. The Washington Archeological Resource Center conducted a survey in March 1974 and concluded that no archeological, historical or paleontological sites will be endangered.

Wildlife and Vegetation

Route A would not adversely affect any wildlife other than sage grouse, except during the construction period, when some animals would be driven away for a short time. This route would not cross any streams.

Due to the clearing of sagebrush from main access roads and tower sites, songbirds, birds of prey, and upland birds within the vicinity may be temporarily disturbed.

Scenic

Except for Gable Mountain, Route A does not cross any scenic resources. Towers constructed on Route A will be visible from quite a distance due to the flat terrain in the Reservation, but are not expected to adversely affect the public.

10.9.2.2 Description of Alternate Route B and Its Impacts

The discussion of this alternative contemplates that the proposed Ashe Tap to AEC HEW No. 3, 230 KV line and a future line would be built parallel to Route B, Thereby retaining all facilities in a single corridor.

Alternate Route B has been separated into three sections in order to discuss the associated impacts and requirements. The line location is shown in Figure 10.9-5.

Section I

The 18.8 mile route would begin at WNP-2 the travel 0.5 miles to the BPA Ashe Substation, then proceed northwest for 5.9 miles to a crossing of the Ashe Tap to the HEW No. 3, 230 KV line. The first 5.9 miles would be parallel to an 120 feet east of the Ashe Tap to the HEW No. 3, 230 KV line.

Section II

Route B would continue for 6.6 Miles to an angle point. It would then turn north for 4.5 miles to a point 110 feet west of the Lower Monumental-Hanford 500 KV line.

Section III

This route would then turn northwest and proceed for 1.8 miles while parallel to the Lower Monumental-Hanford line at a separation of 110 feet from the BPA's Hanford Switching Station.

Additional right-of-way width for a future line would be acquired along the east side of this alternative.

New right-of-way width that would be required is as follows:

Section	Right-of-Way Width
I	355 feet, would include WNP-2 230 KV start-up and other future lines.
II	240 feet, except for the last 0.5 miles where the right-of-way width would increase from 240 feet to 355 feet.
III	107.5 feet, of additional right-of-way would be needed west of the 87.5 feet east of the Lower Monumental Hanford line for a total of 195 feet.

Tower design for Alternate B would be identical to that described for proposed Route A. (See Figure 3.9-2).

10.9.2.2.1 Costs of Route B

Estimated costs for Route B, based on prices current in September 1973, are:

Transmission Line	$3,940,000
One Hanford Switching Station 500 KV terminal	640,000
Terminal equipment at Ashe Substation and land for the 500 KV switchyard at Ashe	603,000
Modifications at Hanford Substation	123,000
Power System Control	455.000
TOTAL	$5,761,000

10.9.2.2.2 Land Use

Access road requirements would be approximately as follows:

Section I

New location on right-of-way - 3 miles

New location off right-of-way - 6 miles

Section II

Existing dirt roads would be used for access to Gable Mountain.

Section III

In Section III there are no new access road locations, improvements, or easements, on or off right-of-way required.

The existing Lower Monumental-Hanford access road system would be used. Short spur roads from the existing access roads to the individual towers of Route B would be required.

Figure 10.9-3 is an aerial photograph of the proposed route and Figure 10.9-4 is a land use map. The following Table describes the miles of line and acres of land use covered by the proposed route.

		Sagebrush and Grass	Comments
Section I	Route in Miles	5.9	Would include the alternate 500 and 230 KV lines and the future line.
	New easement acreage	255	
Section II	Route in Miles	11.1	Would include the alternate 500 KV line and a future line.
	New easement acreage	322	
Section III	Route in Miles	1.8	Would include the alternate 500 KV line and a future line.

New easement acreage	42

New easements for the 18.8 mile Route B would require 619 acres of land.

10.9.2.2.3 Impacts on Land Use

Since the land crossed by Route B is mostly unused (See Figure 10.9-3), open space impacts will negligible. If ERDA opened the reservation for public use, existing cover and potential land use would be disrupted to the extent quantified for easement and access road requirements previously indicated. This route would be with the ERDA Hanford Reservation where the public access is restricted by ERDA for safety and security reasons. Route B would be near the explosive testing area's western fringes. The effects of Route B on erosion would be the same as that caused by Route A.

10.9.2.2.4 Impacts on Natural and Cultural Resources

Recreation

There are no recreational facilities within the study area.

Historic and Archeological Sites

As shown in Figure 10.9-4, route B would not cross any identified historic or archeological sites.

Wildlife and Vegetation

Same effects as Route A.

Scenic

Due to flat terrain, this route's towers could be seen from several miles. Some towers on Gable Mountain would be skylined and therefore would be visible from greater distances than in the case of Route A.

TABLE 10.9-1

ALTERNATIVE TRANSMISSION ROUTES
(Sheet 1 of 2)

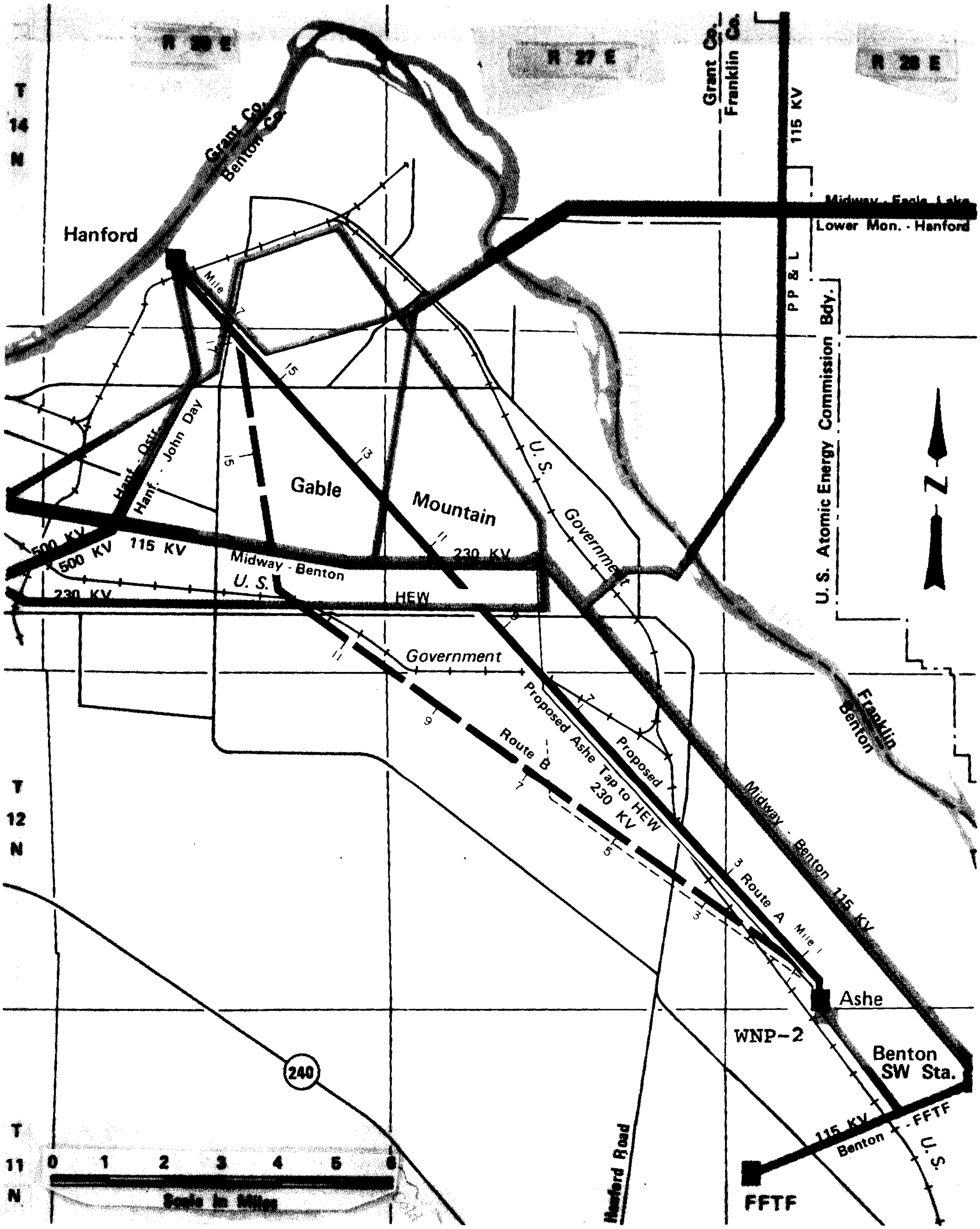
Alternatives		Proposed (A)	(B)
Capital Cost		Base	+ $235,000
Reference Section		10.9.2.1	10.9.2.2
Environmental Costs	Units	Magnitude	Magnitude
1. Land Use (Rank Alternative routes in terms of amount of conflict with present & planned land uses)	from worst to best	2	1
2. Property Values (Rank Alternative routes in terms of total loss in property values)		NTA	NTA
3. Multiple Use (Rank Alternative routes in terms of envisioned multiple use of land preempted by right-of-way)		All rights of way may be used	Same as proposed
4. Length of New Rights-of-Way Required	Miles	18	18.8
5. Number and Length of New Access and Service Roads Required	Miles	14.5	19

TABLE 10.9-1

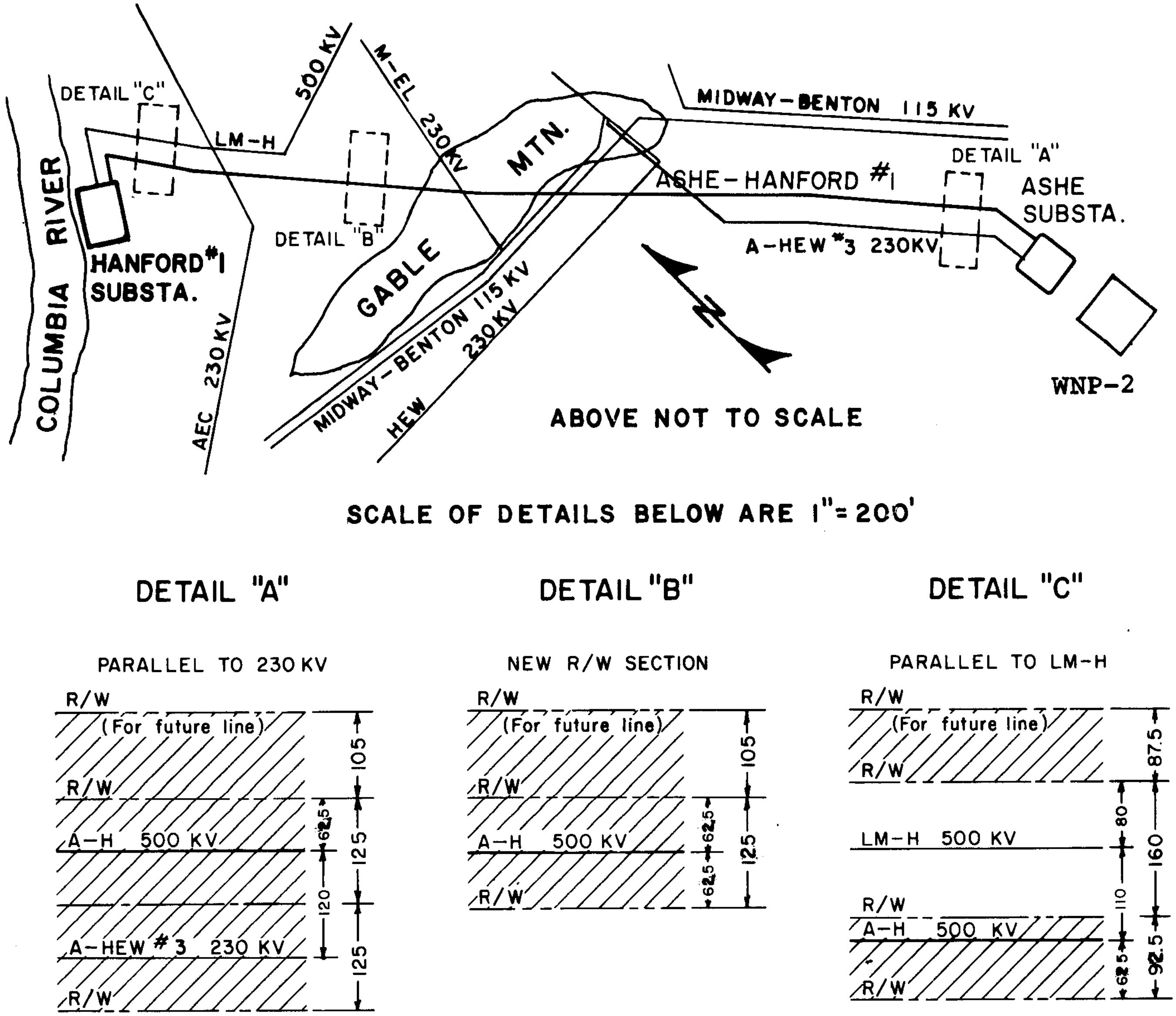
ALTERNATIVE TRANSMISSION ROUTES
(Sheet 2 of 2)

	Alternatives		Proposed (A)	(B)
6.	Number of major road crossings in vicinity of intersection or interchanges		14	12
7.	a) Number of major water ways b) and railroad crossings		0 3	0 3
8.	Number of crest ridge, or other high point crossings		1	1
9.	Number of "Long Views" or transmission lines perpendicular to highways & waterways		0	0
10.	Length of above transmission line in or through visually sensitive area	Miles	0	0

NTA - NOT AVAILABLE



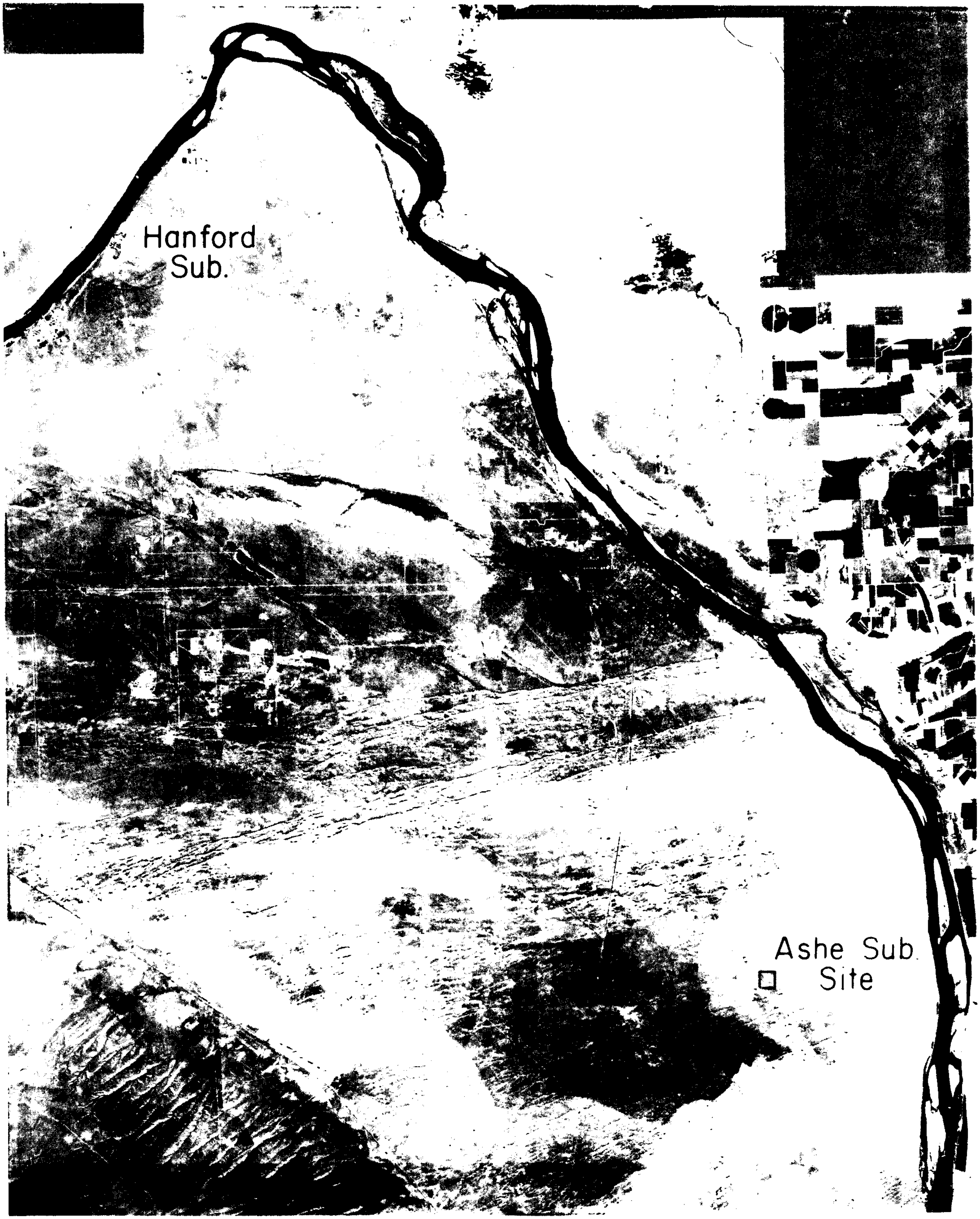
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	OVERALL MAP OF ROUTES (1) "A" AND "B"
	FIG. 10.9-1



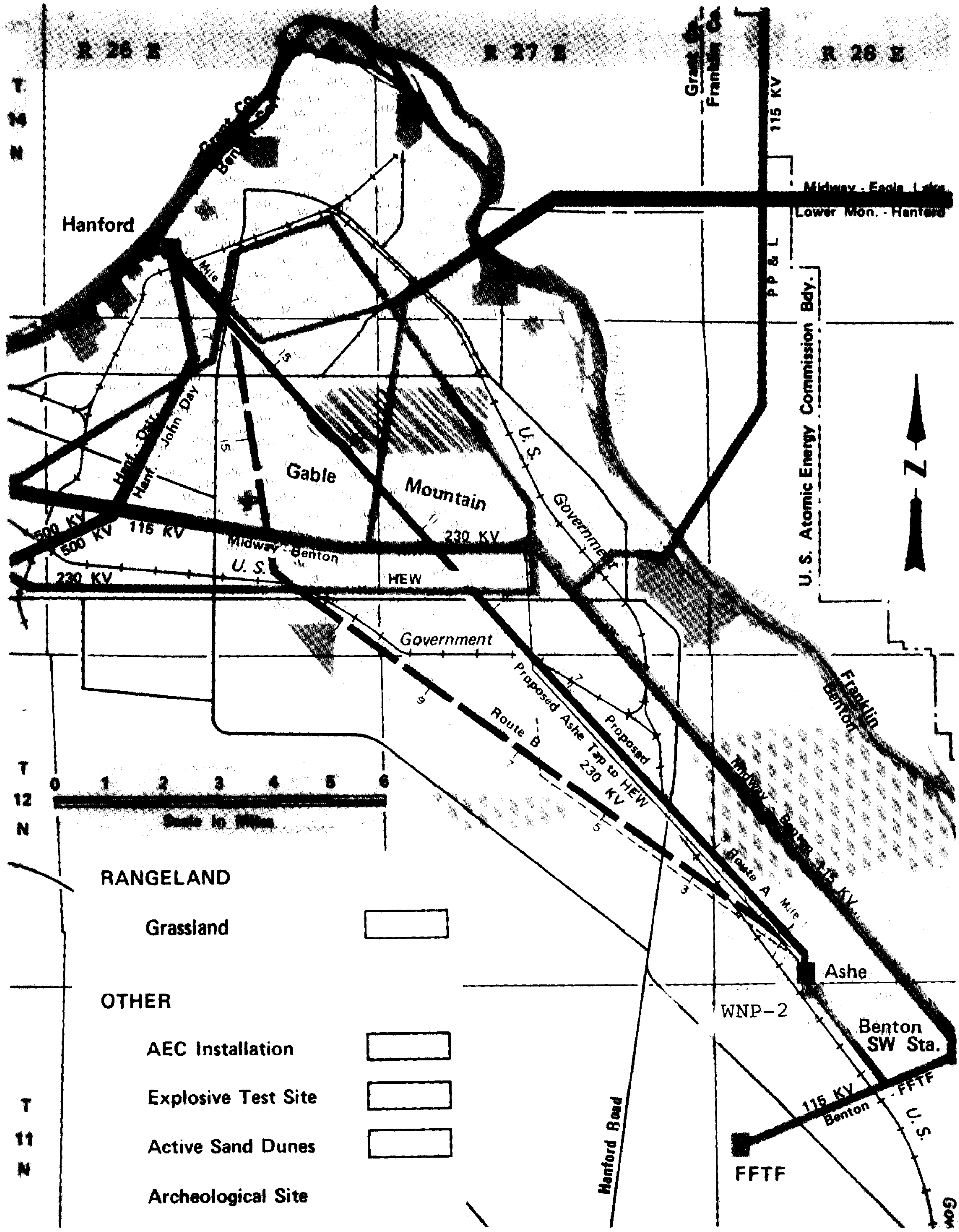
R/W ··· RIGHT OF WAY
A-H ··· ASHE-HANFORD #1
A-HEW #3 ··· ASHE TAP TO HEW #3
LM-H ··· LOWER MONUMENTAL-HANFORD
M-EL ··· MIDWAY-EAGLE LAKE
HEW ··· HANFORD ENERGY WORKS

////// NEW R/W

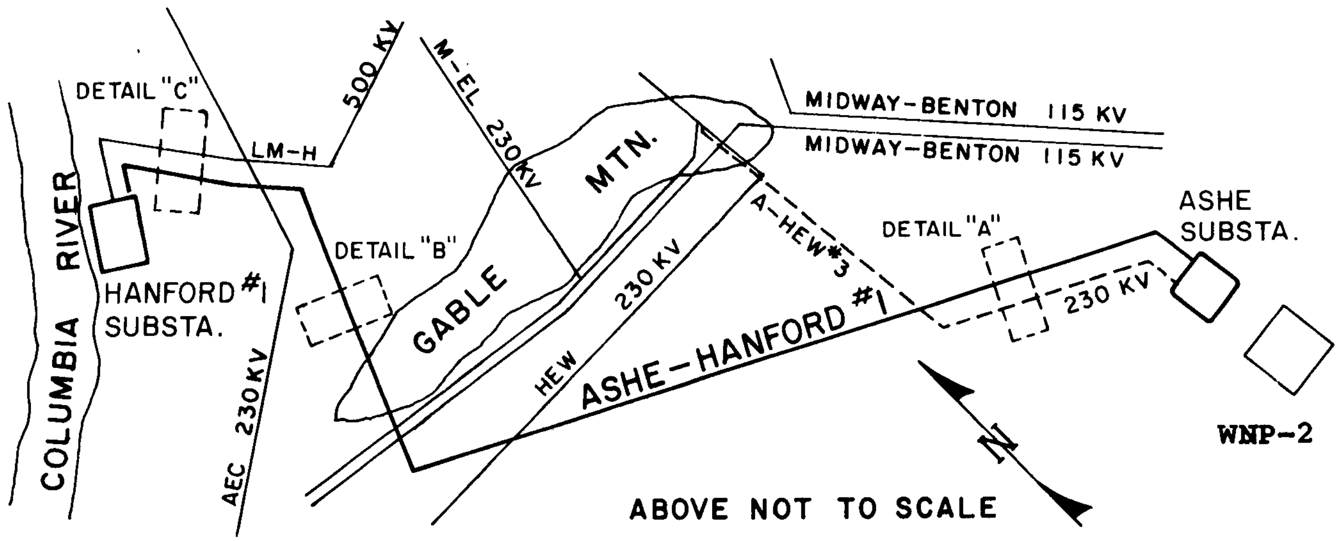
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	RIGHT OF WAY DETAIL MAP (1) ROUTE "A"
	FIG. 10.9-2



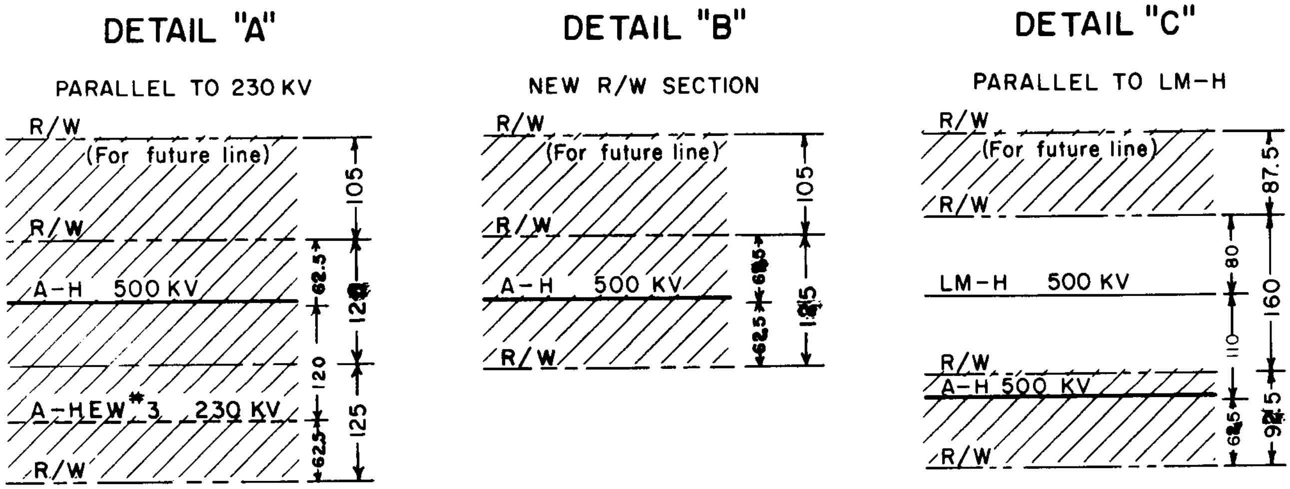
WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	AERIAL PHOTOGRAPH OF LAND (1) CROSSED BY TRANSMISSION LINES
	FIG. 10.9-3



WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	LAND USE-(1) HANFORD RESERVATION
	FIG. 10.9-4



SCALE OF DETAILS BELOW ARE 1" = 200'



R/W · · · RIGHT OF WAY
A-H · · · ASHE-HANFORD #1
A-HEW #3 · · ASHE TAP TO HEW #3 (ALTERNATE)
LM-H · · · LOWER MONUMENTAL-HANFORD
M-EL · · · MIDWAY-EAGLE LAKE
HEW · · · HANFORD ENERGY WORKS

////// NEW R/W

WASHINGTON PUBLIC POWER SUPPLY SYSTEM WPPSS NUCLEAR PROJECT NO. 2 Environmental Report	RIGHT OF WAY DETAIL MAP (1) ROUTE "B"
	FIG. 10.9-5

10.10 OTHER SYSTEMS

There are no other systems that need to be considered for this plant.

CHAPTER 11
SUMMARY BENEFIT-COST ANALYSIS

CHAPTER 11

SUMMARY BENEFIT - COST ANALYSIS

11.1 INTRODUCTION

In the Environmental Report at the construction permit stage, and in earlier sections of this Environmental Report, data have been presented on the need for the facility, environmental and monetary costs and benefits of the facility, and on various project and facility alternatives. The purpose of this section is to summarize and weigh the overall benefits and costs of operating the completed plant. This final balancing must of necessity be qualitative, since it is not possible to quantify all of the costs and benefits in uniform units of measure.

11.2 NEED FOR POWER

The need for the electrical energy to be furnished by WNP-2 has been described in Chapter 1. The project is an essential component of the hydrothermal program in the Pacific Northwest and will be depended upon to help fulfill the future power requirements projected in the West Group Forecast of Power Loads and Resources. Based upon the West Group Forecast of March 1978, which assumed a May 1981 commercial operation date, the probability of not meeting firm energy loads in 1981-1982* is 14.5% with WNP-2 and 18.9% without WNP-2. In 1982-1983 these respective probabilities, with and without WNP-2, are 15.2% and 24.4%. In 1983-1984 the probability of
1 not meeting firm loads is 17.8% with WNP-2 and 30.5% without WNP-2.[(1)]

*July 1, 1981 to June 30, 1982

11.3 Alternatives

Numerous alternatives were considered in the Environmental Report for a construction permit. During plant construction, certain plant alternatives were incorporated into the plant design in an attempt to continuously optimize the benefit-cost balance of the project. Among these later changes were the selection of the cooling tower configuration and make-up water intake system design.

At this stage of the project, any further major changes can not be expected to show a desirable benefit-cost ratio. Since enviromental factors have been considered since early design stages and have continued to receive consideration during the construction phase, the Supply System is confident that the project can be operated as presently designed and constructed with no significant or lasting harm to the environment.

11.4 BENEFIT-COST BALANCE

11.4.1 Benefits

The major benefits of operating WNP-2 are listed in Table 11.4-1. These various benefits have all been discussed in detail in the text of earlier chapters and are only summarized here.

11.4.2 Costs

The capital construction cost of WNP-2 is expected to be
1 $1.077 billion. Annual operating costs are estimated to be about $137 million or 22.5 mills/kwhr at 63 percent plant factor.

The environmental costs of operating WNP-2 are summarized in Table 11.4-2.

11.4.3 Summary Benefit-Cost Analysis

After considering the various monetary, social, and environmental costs of operating WNP-2 and the corresponding benefits to be derived from its operation, the Supply System concludes that operation of WNP-2 represents a positive value to the immediate area where it is located and to the Pacific Northwest. Every effort has been made during design and construction of the facility to minimize environmental, social, and monetary costs of the project so that the plant is currently optimized form a benefit-cost standpoint.

TABLE 11.4-1

SUMMARY BENEFITS OF OPERATING WNP-2*

	Item	Benefit	
1.	Expected Average Generation	6.1 billion kwhr/yr	1
2.	Proportional Distribtuion of Electrical Energy (1990)	30.9% Residential 15.3% Commercial 48.1% Industrial 5.7% Other 100.0% Total	
3.	Generation Taxes	Over $2 million/year 50% to State for schools 22% to Counties 23% to Cities 3% to Fire Districts 2% to Library Districts	1
4.	Use of By-Product Heat	4,000 GPM warm irrigation water for agricultural research	
5.	Direct Employment	104 operation staff 25 support staff 129 total employment	1
6.	Public Facilities	A permanent visitor center will be sponsored.	

*Refer to Section 8.1.1 for details

TABLE 11.4-2

SUMMARY ENVIRONMENTAL COSTS OF OPERATING WNP-2
(Sheet 1 of 4)

Effect	Reference Section	Significance
Land		
Approximately 30 acres of shrub-steppe land diverted to industrial use at the plant site.	2.1	Negligible - represents a very small percentage of the available acreage of similar type (see Fig. 2.2-1).
Approximately 648 acres of right-of-way will be required for transmission.	3.9	Negligible - represents a very small percentage of the available acreage of similar type (see Fig. 10.9-4).
Surface Water		
Consumptive use of water will be about 13,000 gpm.	5.1.2 5.1.4	Negligible - represents only .05% of average steam flow.
Thermal load from blowdown of WNP-2 plus WNP-1/4 is 75,000 Btu/sec.	5.1.2	Negligible - raises bulk river temperature only 0.033°F.
Thermal increases within a limited mixing zone.	5.1.2	Slight - thermal increases will vary according to a sliding scale permitting increases at the mixing zone boundary of a few degrees at cooler river temperatures and a maximum of 0.5°F contributing to a river temperature not exceeding 68°F.

TABLE 11.4-2 (Continued)
(Sheet 2 of 4)

Effect	Reference Section	Significance
Increased total dissolved solids in Columbia River and within a limited mixing zone.	5.3.1	Negligible - will increase bulk river concentrations by a maximum of 0.2%, and concentrations at the limit of the mixing zone by a maximum of 14%.
Ground Water		
Discharge of 2 gpm sanitary waste to tile field.	5.4	Negligible - area has adequate drainage and absorption capacity.
Aquatic Biota		
Loss of drifting biota from impingement & passage.	5.1.3	Slight - less than 0.15% loss at worst flow conditions.
Short time exposure of free floating plankton to heated water and chemical discharges.	5.1.3	Negligible - exposure time is only 5 - 35 seconds and increases are small.
Adverse effect of heated effluent and chemical discharges on salmonids.	5.1.3	Negligible - increases will be small and limited to a very small percentage of the river area. Acclimation and congregation will be discouraged due to intermittancy of discharges and fast stream velocities.
Adverse effect of heated and chemical effluent discharges on benthic flora and fauna.	5.1.3	Negligible - will be small and limited to a very small percentage of the available habitat.

TABLE 11.4-2 (Continued)
(Sheet 3 of 4)

Effect	Reference Section	Significance
Terrestrial Biota		
Accumulation of cooling tower drift salts in soil.	5.1.4	Negligible - a slow cumulative impact predicted to occur over a small area which can be mitigated by irrigation leaching if necessary.
Air		
Some additional fogging and icing from cooling tower plume.	5.1.4	Negligible - less than 1 hour fogging and 0.5 hour icing per year in worst sector. None on public highways.
Radiological		
Increased exposure of biota to radiation.	5.2	Negligible - exposures of terrestrial and aquatic biota will be extremely small compared to those known or expected to cause significant somatic or genetic effects.
Increased individual exposures.	5.2	Negligible - doses are projected to be less than 10CFR50 Appendix I - Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low as Resonably Achievable."

TABLE 11.4-2 (Continued)

(Sheet 4 of 4)

Effect	Reference Section	Significance
Increased population exposures.	5.2	Negligible - the population total body dose from all pathways including radioactive materials transportation is estimated to be less than 0.02% of that received by the same population due to natural sources.
Aesthethic		
Tall structures intrude on a flat plain landscape.	3.1	Negligible - facility is more than 12 miles from centers of population.
Noise level from operation of cooling towers.	5.6	Negligible - facility is far removed from residential or unique wildlife habitats.
Socioeconomic		
Some increases needed in public sector services.	8.2.2.2	Negligible - direct project taxes and personal property taxes offset public sector costs.

CHAPTER 12
ENVIRONMENTAL APPROVALS AND CONSULTATION

CHAPTER 13
REFERENCES

PERMITS AND APPROVALS REQUIRED FOR PLANT CONSTRUCTION AND OPERATION

Agency	Statutory and Other Authority	Permit or Approval	Date Approval Required
U. S. Atomic Energy Commission	42 U.S.C. 2131 et. seq.; 42 U.S.C. 4321	1. Plant Construction Permit	3/73
U. S. Nucl. Regulatory Comm.	42 U.S.C. 2131 et. seq.; 42 U.S.C. 4321 et. seq.; 42 U.S.C. 5841 et. seq.;	1. Plant Operating License 2. Nuclear Instrumentation License 3. Special Nuclear Mat. License	1/79 7/77 7/77
Corps of Engineers, Walla Walla District	Sec. 10 (33 U.S.C. 403) Rivers and Harbors Act of 1899	1. Dredging and Construction Permit for work in navigable waters.	3/75
Federal Aviation Admin. and State Aeronautic Comm.	Federal Aviation Regulations, Part 77; WAC 12-24	Notice of Proposed Construction 1. Meteorological Tower 2. Reactor Building	4/72 7/77
Division of Highways and Transportation		1. Permit for oversize or overweight vehicles.	As required
State Department of Labor and Industries	Washington Industrial Safety and Health Act, 1973	Open for inspection for following items: a. Tunnels b. Occupational Health c. Electric Wiring and Apparatus d. Electric Workers e. Construction Standards f. General Safety Standards	

TABLE 12.1-1

PERMITS AND APPROVALS REQUIRED FOR PLANT CONSTRUCTION AND OPERATION

Agency	Statutory and Other Authority	Permit or Approval	Date Approval Required
Washington State Boiler Inspector	Chapter 70.79 Revised Code of Washington and Chapter 296-104 of Washington Administrative Code	1. ASME Certificate of Authorization	3/74 (expires on completion)
Washington State Thermal Power Plant Site Evaluation Council. Council includes directors or designees from the following agencies: a. Department of Ecology b. Department of Social and Health Services c. Department of Game d. Department of Fisheries e. Department of Natural Resources f. State Parks and Recreation Commission g. Interagency Committee for Outdoor Recreation h. Department of Commerce and Economic Development i. Utilities and Transportation Commission j. Office of Program Planning and Fiscal Management k. Department of Agriculture l. Planning and Community Affairs Agency m. Department of Emergency Services n. Benton County Commissioners	Chapter 80.50, Revised Code of Washington, and Chapter 463 Washington Administrative Code	Approval of site and construction and operation of the plant. (Application filed 1/71) (Includes all state required approvals.) The Certification Agreement to be issued is based upon consideration of, among other things: 1. Plans for public visitation facilities 2. Plans for protection and/or interpretation of archaeological and historical sites encountered during construction 3. Consideration of multipurpose use of cooling water 4. Land use, zoning conformity 5. Plans for borrow pits or other excavations 6. Plans for controlling wind and water erosion 7. Plans for site access 8. Design for intake and outfall facilities 9. Plan for protection of fish and wildlife in plant area 10. Plans for water use 11. Radiation Monitoring Plan 12. Plans for public safety and plant safety	5/72

PERMITS AND APPROVALS REQUIRED FOR PLANT CONSTRUCTION AND OPERATION

Agency	Statutory and Other Authority	Permit or Approval	Date Approval Required
	Federal Water Pollution Control Act Amendments of 1972 (PL 92-500) and Chapter 463 Washington Administrative Code	State Certification of Compliance with Water Quality Regulations (401)	3/72
		National Pollution Discharge Elimination System Permit (402)	9/75
Department of Natural Resources		Lease of river bed occupied by and facilities including discharge diffuser and barge unloading area.	5/75
U.S. Coast Guard, Seattle Office	Code of Federal Regulations Title 33, Section 66	Private Aid to Navigation Permit (For buoy marking intake structure)	4/76

12.2 GENERAL FEDERAL LICENSING

The Application for a Construction Permit was filed with the Atomic Energy Commission on August 19, 1971. The docket number assigned the project was Docket 50-397. The Statutory Authority for this action was 42 N.S.C. 2131 et. seq.; 42 N.S.C. 4321. The hearing before the Atomic Safety and Licensing Board was held January 16, 1973. The Construction Permit was awarded on March 19, 1973.

Application is currently being made for an Operating License with the Nuclear Regulatory Commission. Statutory Authority for this Action is 42 N.S.C. 2131, et. seq.; 42 N.S.C. 4321 et. seq. and 42 N.S.C. 5841 et. seq.

12.3 STATE AND FEDERAL WATER RELATED PERMITS

The authority to grant an NPDES Permit was given to the State of Washington by the Environmental Protection Agency. In the case of new power plants, the authority has been delegated to EFSEC.

A mixing zone for the blowdown discharge was defined in the NPDES permit issued by the Washington State Thermal Power Plant Site Evaluation Council on September 25, 1975. That zone will conform with the qualitative requirements set forth in WAC 173-201-040(4).

Additionally, the FWPCA of 1972 requires that, as a condition of receiving a construction permit or operating license, WPPSS provide the NRC with a certification that Sections 301, 302, 306, and 307 as applicable, of the FWPCA of 1972 will not be violated. A Section 401 Certification was issued by TPPSEC on March 17, 1975.

During construction of WNP-2, in-river and shoreline construction occured for the intake and discharge system. Such construction caused some minor increase in localized temporary turbidity conditions in the area near the construction. This situation was not in violation of water quality standards since the present water quality standards specifically permit a temporary waiver WAC 713-201-040(5). This waiver was obtained in July, 1975, for work conducted in the river between August 1, 1975 and October 15, 1975.

The location of the liquid waste discharge is on the Columbia River (River Mile 352) in Benton County, Washington. The river flows southward from the plant site forming the border between Oregon and Washington (River Mile 309) and then west toward the Pacific Ocean, forming the boundary between Washington and Oregon. Applicable water standards for the Columbia River in the State of Washington are given below.

State of Washington
Department of Ecology
(Abstracted Water Quality Standards)

Water	Zone	Standards	Water Uses to be Projected
Columbia River	Washington-Oregon Border (River Mile 309) to Grand Coulee Dam (River Mile 595)	Class A	Fisheries, wildlife, recreation, water supply, navigation, Hydropower

Water Quality Standards for Class A Water Use

Fecal Coliform Organisms shall not exceed a median value of 100 organisms/100 ml, with not more than 10 percent of samples exceeding 200 organisms/100 ml.

Dissolved oxygen shall exceed 8.0 mg/l.

Temperature (Special condition from Washington - Oregon border to Priest Rapids Dam). Water temperature shall not exceed 20.0° Celsius due to human activities. When natural conditions exceed 20.0° Celsius (freshwater), no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3° Celsius; nor shall such temperature increases, at any time, exceed $t = 34/(T+9)$. 2

pH shall be within the range of 6.5 to 8.5 with a man-caused variation within a range of less than 0.5 units.

Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

Toxic, radioactive, or deleterious material concentrations shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.

Aesthetic values shall not be imparied by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.

12.4 STATE, LOCAL AND REGIONAL PLANNING - ECONOMIC IMPACT

The Benton-Franklin Governmental Conference is the regional A-95 clearinghouse and has been made aware of the potential socio-economic impacts of WPPSS projects in the region. The estimated impacts are discussed in Chapter 8.

12.5 SPECIFIC PERMIT STATUS

The specific details of the status and Statutory Authority of Permits required for WNP-2 are listed in Table 12.1-1.

12.6 OTHER

The Bonneville Power Administration is constructing and will operate the ASHE Substation and transmission lines serving WNP-2 and has responsibility for all permits, approvals, and NEPA requirements associated with those activities.

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APPENDIX I
ENVIRONMENTAL TECHNICAL
SPECIFICATIONS

APPENDIX I

ENVIRONMENTAL TECHNICAL SPECIFICATIONS

APPENDIX II
RADIOLOGICAL DOSE MODELS

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RADIOLOGICAL DOSE MODELS

Biota Dose Model

The equations used for the calculation of internal doses to biota other than man are outlined below. The internal biota dose from a particular radionuclide can be expressed by

$$\text{Dose} = A\,\varepsilon\,b \qquad \text{(mrad/yr)} \qquad \text{(see Reference 1)}$$

where A = conversion factor:

$$= \left(3.7 \times 10^{-2}\ \frac{\text{dis.}}{\text{sec-pCi}}\right)\left(3.1558 \times 10^{7}\ \frac{\text{sec}}{\text{yr}}\right)\left(1.6 \times 10^{-6}\ \frac{\text{erg}}{\text{MeV}}\right)\left(\frac{\text{kg-mrad}}{100\ \text{erg}}\right) = 0.0187\ \frac{\text{dis.-kg-mrad}}{\text{pCi-MeV-yr}}$$

ε = effective absorbed energy in MeV per disintegration (dis.) corresponding to the effective radius of the organism,

b = specific body burden in pCi/kg.

The specific body burden of a primary organism, b_1, (one for which bioaccumulation factors are known) is given by

$$b_1 = W\,C \qquad \text{(pCi/kg)}$$

where C = bioaccumulation factor in pCi/kg of tissue per pCi/ℓ of water, and

W = radionuclide concentration in water in pCi/ℓ.

The concentration W, is obtained from

$$W = \frac{B\ E\ G\ Q}{F}\,(\exp{-\lambda_R T}) \qquad (\text{pCi}/\ell)$$

where B = conversion factor:

$$= \frac{10^{12}\ \text{pCi}}{\text{Ci}}\ \frac{1\ \text{year}}{3.1558 \times 10^{7}\ \text{sec}}\ \frac{1\ \text{ft}^3}{28.317\ell} = 1119\ \frac{\text{pCi-yr-ft}^3}{\text{Ci-sec-}\ell}$$

G = recirculation factor (assumed to be 1 for this plant),

Q = radioisotope release rate in Ci/yr,

F = dilution flow rate in cfs,

E = any additional dilution factor,

T = delay time between release and point of calculation in hours, and

λ_R = radioactive decay constant in hr^{-1}.

Then the internal total-body dose to this organism is

$$Dose_1 = 0.0187\ \varepsilon_1\ b_1 \qquad \text{(mrad/yr)}.$$

The specific body burden for a secondary organism, b_2, (one which consumes primary organisms) can be obtained from

$$b_2 = \frac{1.44\ b_1\ P_2\ f_{w_2}\ \tau_2\ (1-e^{-\lambda_2 t})}{m_2} \quad \text{(pCi/kg) (see Reference 1)}$$

where P_2 = consumption rate of primary organism by secondary organism, in grams per day,

f_{w_2} = fraction of uptake reaching total body of secondary organism,

m_2 = mass of critical organ of secondary organism in grams,

$\lambda 2$ = effective decay constant in secondary organism in day^{-1},

$= \lambda_R + \lambda_{B_2}$

λ_{B_2} = biological removal constant in secondary organisms,

$\tau_2 = \frac{0.693}{\lambda_2}$, and

t = period of exposure in days

Then, the internal total-body dose to the secondary organism can be calculated from

$$Dose_2 = 0.0187\ \varepsilon_2\ b_2$$

External doses to biota from air, water, and shoreline are calculated similar to those to man by means of a model shown below.

Models Used For Dose Estimates to Man, Normal Plant Operation

The fundamental relation for calculation of radiation dose to man from the pathways described in Section 5.2 is given as follows for any radionuclide:

$$R_{ipr} = C_{ip} U_p D_{ipr}$$

where

R_{ipr} = the dose rate to organ r from nuclide i via pathway p

C_{ip} = the concentration of nuclide i in the media of pathway p

U_p = usage: the exposure rate or intake rate associated with pathway p, and

D_{ipr} = a dose factor: a number specific to a given nuclide i, pathway p and organ r which can be used to calculate radiation dose rate from exposure rate to a given concentration of a radionuclide or the intake rate of that radionuclide.

The three terms comprising Equation 1 are discussed in the following subsections.

Concentrations in Environmental Media, C_{ip}

Concentrations in air, water, soil or food are calculated as an integral part of computer programs developed for dose calculations.[(2)] Concentrations in water, aquatic foods and on shoreline sediment are calculated from the radionuclide release rates, the effluent flow rate, the mixing and dilution in the receiving waters, and bioaccumulation factors for aquatic foods. Concentrations in irrigated farm produce and animal products are calculated from concentrations of radionuclides in the irrigation water, irrigation rate, facility lifetime (to determine long-term soil buildup), and decay time between nuclide release and produce consumption.[(3)] Concentrations in air are generated from radionuclide release rates and atmospheric dispersion information from Section 2.3.

Usages, U_p

Hours of exposure to external sources of radiation and intake rates of ingested water and food are supplied for each calculation. Since the principal contributors for external air submersion dose are noble gases, the assumption was made that the air concentrations of radionuclides will be essentially the same indoors as outdoors. For the population dose estimates from water related recreation the usages of the average adult were multiplied by the size of the population involved. For the dose estimates from fish consumption the total fish catch (edible weight) was used.

Dose Factors, D_{ipr}

Equations for calculating internal dose factors were derived from those given by the ICRP for body burden and MPC, and have previously been published.(1,2,4) Effective decay energies for the radionuclides were calculated from the ICRP model, which assumes all of the radionuclide is in the center of a spherical organ with an appropriate effective radius. Where data were lacking, metabolic parameters for the Standard Man were used. These dose factors have units of mrem/yr per pCi/yr taken into the body, either via ingestion or inhalation.

The dose factors for external exposure to air and water were derived on the assumption that the contaminated medium is large enough to be considered an "infinite volume" relative to the range of the emitted radiations. Under that assumption the energy emitted per gram of media is equivalent to the energy absorbed per gram of media. Conversion from MeV per disintegration per gram to rem is made and corrected for the difference in energy absorption between air or water and tissue, the quality factor of the radiation under consideration and for physical geometry of each specific exposure situation.

The dose from submersion in air or immersion in water is an external dose either to the skin, or to both the skin and total body, depending on the penetrating power of the radiation emitted by the airborne radionuclides. Only beta and gamma radiation, which could penetrate 7 mg/cm^2 of tissue, was considered in calculating skin dose. Gamma radiation dose at a 5-cm depth in tissue was used for calculating external dose to the total body (and for internal organs). These dose factors have units of mrem/hr per pCi/m^3 air and mrem/hr per pCi/ℓ water.

Material deposited from the air or from irrigation water onto the ground represents a fairly large, nearly uniform, thin sheet of contamination. The factors for converting surface contamination in pCi/m^2 to gamma dose a 1 m above a uniformly contaminated plane have been described.(2,4,5) Dose factors for exposure to soil (or river sediment) have units of mrem/hr per pCi/m^2 surface.

Pathway Equations

Individual equations tailored to each specific exposure pathway were derived from Equation 1. The principal difference among pathways is the manner in which the radionuclide concentrations are calculated. This section develops the set of equations required for the liquid pathway model and atmospheric pathway model.[2]

Drinking Water

The dose from ingestion of water is calculated from Equation 2:

$$R_{pr} = 1119 \sum_{i=1}^{n} \frac{Q_i\ N_i}{F} M_p \exp\left(-\lambda_i t_p\right) U_P D_{ipr} f_i \qquad (2)$$

where

R_{pr} = total dose rate to organ r from n nuclides i in pathway p (mrem/yr)

N_i = The reconcentration factor as defined in Reference 2 (dimensionless)

Q_i = the release rate of nuclide i (Ci/yr)

F = the flow rate of the liquid effluent (ft^3/sec)

M_p = the mixing ratio at the point of exposure (or the point of withdrawal of drinking water or point of harvest of aquatic food).

λ_i = radiological decay constant of nuclide i (hr^{-1})

t_p = the transit time required for nuclides to reach the point of exposure. For interal dose, t_p is the total time elapsed between release of the nuclides and ingestion of food or water (hr)

1119 = a constant which converts from (Ci/yr)/(ft^3/sec) to pCi/ℓ, and

f_i = the water plant transmission factor (dimensionless) and represents the fraction of radionuclide in water passing through a municipal water treatment plant (see Table 5.2-11)

The summation process adds the dose contribution from each of the nuclides for which dose factors have been derived to yield the total dose for the pathway-organ combination selected.

The first three terms in Equation 2, $\frac{Q_i\ N_i}{F}$, define the concentration of nuclide i in the effluent at the point of discharge.

The expression

$$\frac{Q_i\ N_i}{F}\ M_p\ \exp\ (-\lambda_i t_p)$$

yields the concentration at the time that the water is consumed. The latter concentration is term C_{ip} in Equation 1.

Aquatic Foods

Concentrations of radionuclides in aquatic foods are directly related to the concentrations of the nuclides in water. Equilibrium ratios between the two concentrations (bioaccumulation factors) are those for freshwater organisms. The inclusion of the bioaccumulation factor B_{ip} in Equation 2 converts it to Equation 3 below, which is suitable for calculation of internal dose from consumption of aquatic foods.

$$R_{pr} = 1119\ \frac{U_p\ M_p}{F} \sum_{i=1}^{n} Q_i\ N_i\ B_{ip}\ D_{ipr}\ \exp\ (-\lambda_i t_p) \qquad (3)$$

where

B_{ip} = the bioaccumulation factor for nuclide i in pathway p (pCi/kg per pCi/ℓ; see Table 1.

Farm Products

The model presented for estimating the transfer of radionuclides (except for ^3H and ^{14}C) from irrigation water or from air to plants through both leaves and soil to food products was derived by Soldat(3) for a study of the potential doses to people from a nuclear power complex in the year 2000.

Deposition on Food Products

The source of the radionuclide contamination of the foods may be either deposition with water used for sprinkler irrigation or deposition of airborne radionuclides.

Deposition by Irrigation Water

$$d_i = C_{iw}\ I\ \text{(water deposition)} \qquad (4a)$$

where:

d_i = deposition rate or flux [pCi/(m^2·d)] of radionuclide i

C_{iw} = concentration of radionuclide i in water used for irrigation (pCi/ℓ)

I = irrigation rate $[\ell/(m^2 \cdot d)]$. Amount of water sprinkled on unit area of field in one day.

Deposition Directly from Air

$$d_i = 86{,}400\ \bar{\chi}_i\ V_{di}\ \text{(air deposition)} \tag{4b}$$

where:

86,400 = dimensional conversion factor (sec/d)

V_{di} = deposition "velocity" of radionuclide i (m/sec)

$\bar{\chi}_1$ = annual average air concentration (pCi/m^3) of radionuclide i.

Concentration in Vegetation

The concentration of radioactive material in vegetation resulting from deposition onto the plant foliage and uptake from the soil of prior depositions on the ground is given in Equation 5.

$$C_{iv} = d_i \left[\frac{r\ T_v(1 - e^{-\lambda_{Ei} t_e})}{Y_v\ \lambda_{Ei}} + \frac{B_{iv}(1 - e^{-\lambda_i t_b})}{P\ \lambda_i} \right] e^{-\lambda_i t_h} \tag{5}$$

where:

C_{iv} = concentration of radionuclide i in edible portion of plant v (pCi/kg)

r = fraction of deposition retained on plant (dimensionless), taken to be 0.25

T_v = factor for the translocation of externally deposited radionuclides to edible parts of plants (dimensionless). For simplicity it is taken to be independent of radionuclide and set to 1 for leafy vegetables and fresh forage, and 0.1 for all other produce, including grain. (Reference 3 lists values of this parameter which vary with nuclide.)

λ_i = radiological decay constant for radionuclide i (d^{-1}).

λ_{Ei} = effective removal constant of radionuclide i from plant (d^{-1}) $\lambda_{Ei} = \lambda_i + \lambda_w$, where λ_w = weathering removal constant = $0.693/14\ (d^{-1})$.

t_e = time of above ground exposure of crop to contamination during growing season (d).

Y_v = plant yield [kg(wet weight)/m^2].

B_{iv} = concentration factor for plant uptake of nuclide i from soil [pCi/kg(wet weight) per pCi/kg (dry soil)].

t_b = time for buildup of radionuclide in soil (d), taken to be 30 years if the source of the radionuclide is an operating nuclear facility.

P = soil "surface density" [kg(dry soil)/m^2)]. Assuming a uniform mixing of all radionuclides in a plowlayer of 15 cm depth, P has a value of 224 kg/m^2.

t_h = holdup time (d). The time between harvest and consumption of the food.

The first term inside the brackets relates to the concentration derived from direct foliar deposition during the growing season whereas the second term relates to uptake from soil and reflects the deposition throughout the time from start of deposition until harvest of the plant.

Concentration in Animal Products

The radionuclide concentration in an animal product such as meat, milk or eggs is dependent on the amount of contaminated feed or forage eaten by the animal and its intake of contaminated water. The following equation describes this calculation.[3]

$$C_{ia} = S_{ia} \left[C_{iF} Q_F + C_{iaw} Q_{aw} \right] \tag{6}$$

where:

C_{ia} = concentration in animal product (pCi/ℓ) or (pCi/kg)

S_{ia} = transfer coefficient of radionuclide i from daily intake of animal to edible portion of animal product [pCi/ℓ (milk) per pCi/d] or [pCi/kg (animal product) per pCi/d]

C_{iF} = concentration of nuclide i in feed or forage (pCi/kg) calculated from Equation (5) above

Q_F = consumption rate of contaminated feed or forage by animal (kg/d)

C_{iaw} = concentration of nuclide i in water consumed by animals (pCi/ℓ); assumed usually to be equal to C_{iw}, and

Q_w = consumption rate of contaminated water by animal (ℓ/d).

The second set of terms in the brackets in Equation 6 is omitted if the animal does not drink contaminated water. Animal consumption rates normally assumed are given in Table 2.

Values for various plant concentration factors and animal product transfer coefficients for the elements considered are given in Table 3. Plant concentration factors were taken originally from UCRL-50163, pt. IV[7] and supplemented with radionuclide data as explained in HERMES.[3] Coefficients of transfer from feed to animal products for a limited number of radionuclides were available in the literature. For those for which data were lacking comparisons were made with the behavior of chemically similar elements in man and animals. In some instances, identified with an asterisk in Table 3, the value used was set to 9.9×10^{-4}.

Tritium and Carbon-14 Model

The concentration of tritium or ^{14}C in environmental media (soil, plants and animal products) is assumed to have the same specific activity (pCi of nuclide per kg of soluble element) as the contaminating medium (air or water). The fractional content of hydrogen or carbon in a plant or animal product is then used to compute the concentration of tritium or ^{14}C in the food product under consideration. Hydrogen content in both the water and the nonwater (dry) portion of the food product is used to calculate the tritium concentration. It is assumed that plants obtain all their carbon from airborne carbon dioxide and that animals obtain all their carbon through ingestion of plants.

When ^{14}C is present only in the water used for irrigation it is difficult to model the transfer of this nuclide to vegetation, because plants acquire most of their carbon from the air. At this time we have not yet determined the transfer of carbon from the water to the air or soil. We have therefore conservatively assumed that plants obtain all their carbon from the irrigation water. Such an assumption could lead to plant concentrations which are high by about an order of magnitude or more. To date no operating nuclear facilities have been identified which specify releases of ^{14}C in their liquid effluents. Table 4 lists the parameters used in the computer program for tritium and ^{14}C. These values may be altered based on site-specific data.

The concentration of tritium in vegetation is:

$$C_{iv} = (C_{iw})(9)(F_{hv})^* \tag{7}$$

* The subscript 1 refers to tritium which is the first nuclide in the isotope listing; similarly the subscript 3 in Equation 6 refers to ^{14}C.

where:

C_{1w} = concentration of tritium in the environmental water (pCi/ℓ)

= concentration in irrigation water (for water release)

= pCi $^{3}H/m^{3}$ air: absolute humidity (ℓ/m^3) (for airborne release)

1/9 = fraction of the mass of water which is hydrogen

F_{hv} = fraction of hydrogen in total vegetation (see Table 4).

The concentration of tritium in the animal product is:

$$C_{1a} = \left[\frac{C_{1F}\ Q_F + C_{1aw}\ Q_{aw}}{F_{hF}\ Q_F + Q_{aw}/9}\right] F_{ha} \tag{8}$$

where

C_{1F} = concentration of tritium in feed or forage (pCi/kg) calculated by Equation 7 above, where now $C_{1F} = C_{1v}$

F_{hF} = fraction of hydrogen in animal feed, where now $F_{hf} = F_{hv}$ (grain)

F_{ha} = fraction of hydrogen in animal product (see Table 4)

C_{1aw} = concentration tritium in animal drinking water (set to 0 unless there is a release to water).

Similarly, the concentration of ^{14}C in vegetation is:

$$C_{3v} = C_{3W}\ F_{cv}{}^{(a)} \tag{9}$$

where

C_{3w} = concentration of ^{14}C in the environmental media divided by carbon concentration in that media (pCi C/kg carbon)

= pCi ^{14}C/ℓ divided by carbon concentration in irrigation water (kg/ℓ) for water release

= pCi $^{14}C/m^{3}$ divided by carbon concentration in air (kg/m^3) for air release

(a) The subscript 1 refers to tritium which is the first nuclide in the isotope listing; similarly the subscript 3 in Equation 9 refers to ^{14}C.

F_{cv} = fraction of carbon in total vegetation.

The concentration of ^{14}C in the animal product is:

$$C_{3a} = \left[\frac{C_{3F}\ Q_F + C_{3aw}\ Q_{aw}}{F_{cF}\ Q_F + F_{cw}\ Q_{aw}}\right] F_{ca} \tag{10}$$

For an air release $C_{3aw} = 0$ and since F_{cw} is very small compared to F_{cf}, Equation 10 reduces to:

$$C_{3a} = C_{3F}\left(\frac{F_{ca}}{F_{cf}}\right) \tag{11}$$

Dose Calculations for Man

The dose, R_{vr}, in mrem to a person consuming vegetation is:

$$R_{vr} = \sum_{i=1}^{n} C_{iv}\ U_v\ D_{ir} \tag{12}$$

Similarly the dose from consuming a particular animal product is:

$$R_{ar} = \sum_{i=1}^{n} C_{ia}\ U_a\ D_{ir} \tag{13}$$

where

U_v, U_a = annual consumption of contaminated vegetable or animal products in kg

D_{ir} = a factor which converts intake in pCi of nuclide i to dose in mrem to organ r.

The exposure mode is assumed to be a one year chronic ingestion at a uniform rate. The dose factors employed have been derived from the ingestion and inhalation models given in ICRP Publication 2.(1)

Dose Calculations for Biota

Since the program output lists the radionuclide concentrations in the final product from the consumption by animals of both contaminated feed and drinking water, the internal radiation dose to animals can be estimated in a manner analogous to calculation of internal dose to man. If the assumption were made that the concentration of the radionuclides in meat were similar to the average concentration in the whole animal, then the total body concentration would be similar to that in the meat. The following equations can be used to calculate the dose rate in mrad/yr to an animal containing a constant concentration of a radionuclide.

$$R_c = \sum_{i=1}^{n} 18.7\ \varepsilon_{ia}\ C_{ia} \tag{14}$$

where

ε_{ia} = effective absorbed energy of nuclide i in the animal (MeV/dis)

18.7 = conversion factor calculated as follows:

$$(1.17 \times 10^{6}\ \text{dis}\cdot\text{yr}^{-1}\cdot\text{pCi}^{-1})\ (1.6 \times 10^{-5}\ \text{g}\cdot\text{mrad}\cdot\text{MeV}^{-1})$$

$$= 18.7\ \frac{\text{dis}\cdot\text{g}\cdot\text{mrad}}{\text{pCi}\cdot\text{yr}\cdot\text{MeV}}$$

C_{ia} = concentration of nuclide i in the animal (pCi/g)

Air Submersion

The formulas used to calculate doses from air submersion are given below:

$$R_{pr}(x,\Theta,d) = U_P \sum_{i=1}^{n} \bar{\chi}_i\ D_{ipr} \tag{15}$$

where

$R_{pr}(x,\Theta,d)$ = the external dose rate from n nuclides via pathway p to organ r of a person located a point x meters from the source in a direction d averaged over a sector width of Θ radians (mrem/yr)

U_p = 8766 hr/yr for air submersion, and

D_{ipr} = dose factor for nuclide i (mrem/hr per pCi/m^3) based on a half infinite cloud geometry and corrected for the fractional penetration of beta and gamma radiations to the appropriate tissue depth (7 x 10^{-3} cm for skin 5 cm for total body).

$\bar{\chi}_i$ = annual average concentration (pCi/m^3) of isotope i at point (x,Θ,d).

Equation 15 yields the yearly external dose to a person located at point (x,Θ,d). The population dose in man-rem/yr is determined by multiplying the dose from Equation 15 by the population located within the sector of the annulus of concern. Values of the dose at point (x,Θ,d) are assumed to be applicable to all individuals located in that sector.

Inhalation

The equation used to calculate air inhalation doses is given by

$$R_{ipr}(x,\Theta,d) = \sum_{i=1}^{n} 3.169 \times 10^4 \; D_{ipr} \; \bar{\chi}_i \; U_P \; R_D \qquad (16)$$

where

$R_{ipr}(x,\Theta,d)$ = internal dose rate from n nuclides i via pathway p or organ r of a person located at a point x meters from the source in a direction d, averaged over a sector width of Θ radians (mrem/yr)

3.169×10^4 = dimensional conversion constant (pCi/sec per Ci/yr)

D_{ipr} = dose factor for organ r from inhalation of nuclide i (mrem/yr per pCi/m^2)

U_P = occupancy factor in fraction of a year, and

R_D = cloud depletion factor for iodines. (ref 11, p. c2).

More information on the models used for calculating radiation doses may be found in References 12 and 13.

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TABLE 1

BIOACCUMULATION FACTORS FOR FRESHWATER ORGANISMS AND WATER PLANT TRANSMISSION FACTORS

Element	Bip (pCi/kg organism per pCi/ℓ water)[a] Fish	Crustacea	Molluscs	Algae
H	0.9	0.9	0.9	0.9
Na	100	200	200	500
P	300*	20,000	20,000	50,000
Cr	20	2,000	2,000	4,000
Mn	400	90,000	90,000	10,000
Fe	100	3,200	3,200	1,000
Co	50	200	200	200
Ni	100	100	100	50
Cn	50	400	400	2,000
Zn	65*	10,000	10,000	20,000
Br	420	330	330	50
Rb	2,000	1,000	1,000	1,000
Sr	30	100	100	500
Y	25	1,000	1,000	5,000
Mo	10	10	10	1,000
Tc	15	5	5	40
Ru	10	300	300	2,000
Rh	10	300	300	200
Te	400	75	75	100
I	15	5	5	40
Cs	2,000	100	100	500
Ba	4	200	200	500
La	25	1,000	1,000	5,000
Ce	1	1,000	1,000	4,000
Pr	25	1,000	1,000	5,000
W	1,200	10	10	1,200
Np	10	400	400	300

[a] All values from reference 10, except those marked with asterisk which are derived from Hanford data for ^{32}P and ^{65}Zn.

TABLE 2

CONSUMPTION RATES OF FEED AND WATER BY FARM ANIMALS

	Feed or Forage (kg/day) Q_F		Water (ℓ/day) Q_{aw}
Milk Cow	55	(fresh forage)	60
Beef Cattle	68	(dry feed)	50
Pig	4.2	(dry feed)	10
Poultry (chickens)	0.12	(dry feed)	0.3

TABLE 3

PLANT CONCENTRATION FACTORS AND ANIMAL PRODUCT TRANSFER COEFFICIENTS

Element	Plant/Soil (Dimensionless)	Egg/Feed (day/kg)	Milk/Grass (day/ℓ)	Beef/Feed (day/kg)	Pork/Feed (day/kg)	Poultry/Feed (day/kg)
	------B_{iv}------	-------------------------	-------------------------	S_{ia}	-------------------------	-------------------------
Be	4.7E-04	2.0E-02	2.0E-06	8.0E-04	1.0E-02	4.0E-01
N	7.5E+00	9.9E-04*	1.1E-02	9.9E-04	9.9E-04	9.9E-04
F	2.0E-02	9.9E-04	7.0E-03	2.0E-02	9.0E-02	9.9E-04
Na	5.0E-02	2.0E-01	4.0E-02	5.0E-02	1.0E-01	1.0E-02
P	5.0E+01	1.0E+01	1.2E-02	5.0E-02	5.4E-01	1.9E-01
Ca	4.0E-02	1.0E+00	8.0E-03	3.3E-03	3.3E-03	3.3E-03
Sc	1.1E-03	9.9E-04	2.5E-06	6.0E-03	1.0E-02	4.0E-03
Cr	2.5E-04	9.9E-04	1.1E-03	9.9E-04	9.9E-04	9.9E-04
Mn	3.0E-02	1.0E-01	1.0E-04	5.0E-03	2.0E-02	1.1E-01
Fe	4.0E-04	1.0E-01	6.0E-04	2.0E-02	5.0E-03	1.0E-03
Co	9.4E-03	1.0E-01	5.0E-04	1.0E-03	5.0E-03	1.0E-03
Ni	1.9E-02	1.0E-01	3.4E-03	1.0E-03	5.0E-03	1.0E-03
Cu	1.3E-01	2.0E-01	7.0E-03	1.0E-02	1.5E-02	2.0E-03
Zn	4.0E-01	4.0E-03	6.0E-03	5.0E-02	1.4E-01	2.0E-03
Se	1.3E+00	2.1E+00	2.3E-02	1.0E+00	4.5E-01	3.7E-01
Br	7.6E-01	1.6E+00	2.5E-02	2.0E-02	9.0E-02	4.0E-03
Rb	1.3E-01	3.0E-00	1.0E-02	1.5E-01	2.0E-01	2.0E+00
Sr	2.0E-01	4.0E-01	1.5E-03	3.0E-04	7.3E-03	9.0E-04
Y	2.5E-03	5.0E-04	5.0E-06	5.0E-03	5.0E-03	5.0E-04
Zr	1.7E-04	1.2E-03	2.5E-06	5.0E-04	1.0E-03	1.0E-04
Nb	9.4E-03	1.2E-03	1.2E-03	5.0E-04	1.0E-03	1.0E-04
Mo	1.3E-01	4.0E-01	4.0E-03	1.0E-02	2.0E-02	2.0E-03
Tc	2.5E-01	9.9E-04	1.2E-02	9.9E-04	9.9E-04	9.9E-04
Ru	1.0E-02	4.0E-03	5.0E-02	1.0E-03	5.0E-03	3.0E-04
Rh	1.3E+01	4.0E-03	5.0E-03	1.0E-03	5.0E-03	3.0E-04
Pd	5.0E+00	4.0E-03	5.0E-03	1.0E-03	5.0E-03	3.0E-04
Ag	1.5E-01	9.9E-04	2.5E-02	9.9E-04	9.9E-04	9.9E-04
Cd	3.0E-01	9.9E-04	6.2E-05	1.6E-02	1.6E-02	1.6E-02
Sn	2.5E-03	9.9E-04	1.3E-03	9.9E-04	9.9E-04	9.9E-04
Sb	1.1E-02	7.0E-02	7.5E-04	3.0E-03	7.0E-03	6.0E-03
Te	1.3E+00	4.0E-01	5.0E-04	5.0E-02	1.0E-02	1.0E-02
I	2.0E-02	1.6E+00	1.0E-02	2.0E-02	9.0E-02	4.0E-03
Cs	2.0E-03	6.0E-01	5.0E-03	3.0E-02	2.6E-01	4.5E+00
Ba	5.0E-03	4.0E-01	4.0E-04	5.0E-04	1.0E-02	5.0E-04
La	2.5E-03	2.0E-03	2.5E-06	5.0E-03	5.0E-03	4.0E-03
Ce	5.0E-04	3.0E-03	1.0E-05	1.0E-03	5.0E-03	6.0E-04
Pr	2.5E-03	4.0E-03	2.5E-06	5.0E-03	5.0E-03	1.0E-03
Nd	2.4E-03	2.0E-04	2.5E-06	5.0E-03	5.0E-03	4.0E-03
Pm	2.5E-03	7.0E-03	2.5E-06	5.0E-03	5.0E-03	1.0E-04
Sm	2.5E-03	7.0E-03	2.5E-06	5.0E-03	5.0E-03	4.0E-03
Eu	2.5E-03	7.0E-03	2.5E-06	5.0E-03	5.0E-03	4.0E-03
Tb	2.6E-03	7.0E-03	2.5E-06	5.0E-03	5.0E-03	4.0E-03
Ho	2.6E-03	7.0E-03	2.5E-06	5.0E-03	5.0E-03	4.0E-03
W	1.8E-02	9.9E-04	2.5E-04	9.9E-04	9.9E-04	9.9E-04
Pb	6.8E-02	9.9E-04	1.0E-05	9.9E-04	9.9E-04	9.9E-04
Bi	1.5E-01	9.9E-04	2.5E-04	9.9E-04	9.9E-04	9.9E-04
Po	9.0E-03	9.9E-04	1.2E-04	9.9E-04	9.9E-04	9.9E-04
Ra	1.4E-03	2.0E-05	2.0E-04	9.9E-04	9.9E-04	9.9E-04
Ac	2.5E-03	2.0E-03	2.5E-06	5.0E-03	1.0E-02	4.0E-03
Th	4.2E-03	2.0E-03	2.5E-06	5.0E-03	1.0E-02	4.0E-03
Pa	2.5E-03	2.0E-03	2.5E-06	5.0E-03	1.0E-02	4.0E-03
U	2.5E-03	3.4E-01	6.0E-04	5.0E-03	6.0E-04	1.2E-03
Np	2.5E-03	2.0E-03	2.5E-06	5.0E-03	1.0E-02	4.0E-03
Pu	2.5E-04	2.0E-03	2.5E-08	5.0E-03	1.0E-02	4.0E-03
Am	2.5E-04	2.0E-03	2.5E-06	5.0E-03	1.0E-02	4.0E-03
Cm	2.5E-03	2.0E-03	2.5E-06	5.0E-03	1.0E-02	4.0E-03
Cf	2.5E-03	2.0E-03	7.5E-07	5.0E-03	1.0E-02	4.0E-03

*Where value unknown, a default value of 9.9E-04 was used.

TABLE 4

CALCULATION OF FRACTIONS OF HYDROGEN AND CARBON IN ENVIRONMENTAL MEDIA, VEGETATION, AND ANIMAL PRODUCTS

Food or Fodder	Water	Carbon (dry)	Hydrogen (dry)	Carbon[(a)] (wet)	Hydrogen[(b)] (wet)
	f_w	f_c	f_h	F_{cv}, F_{ca}	F_{hv}, F_{ha}
Fresh Fruits, Vegetables and Grass	0.80	0.45	0.062	0.090	0.10
Grain and Stored Animal Feed	0.12	0.45	0.062	0.40	0.068
Eggs	0.75	0.60	0.092	0.15	0.11
Milk	0.88	0.58	0.083	0.070	0.11
Beef	0.60	0.60	0.094	0.24	0.10
Pork	0.50	0.66	0.10	0.33	0.11
Poultry	0.70	0.67	0.087	0.20	0.10

Absolute Humidity. . . . . 0.008 ℓ/m^3

Concentration of carbon in water . 2.0 x 10^{-5} kg/ℓ[(c)]

Concentration of carbon in air . . 1.6 x 10^{-4} kg/m^3[(d)]

(a) F_{cv} or $F_{ca} = f_c\ (1 - f_w)$

(b) F_{hv} or $F_{ha} = f_w/9 + f_h\ (1\ f_w)$

(c) Assumes a typical bicarbonate concentration of 100 mg/ℓ

(d) Assumes a typical atmospheric CO_2 concentration of 320 ppm_v.

APPENDIX III
STATEMENT BY HISTORIC PRESERVATION OFFICER

APPENDIX III

STATEMENT BY HISTORICAL PRESERVATION OFFICER

RECEIVED
JUL 1 1976

State of Washington

Daniel J. Evans
Governor

June 30, 1976

Arthur M. Skolnik
State Historic
Preservation Officer

In Reply Refer To:

WPPSS Nuclear Project
No. 2, Wooded Island
Archaeological District

40-1900-0220

Mr. R. A. Chitwood
Manager, Licensing and
Environmental Programs
Washington Public Power Supply System
P.O. Box 968
Richland, Washington 99352

Dear Mr. Chitwood:

Mr. Charles H. Odegaard, Director of Washington State Parks & Recreation Commission has referred your letter to me as the State Historic Preservation Officer, responsible for the identification and protection of the cultural resources of the State of Washington, for comment.

Our records indicate that the Wooded Island Archaeological District contains six known archaeological sites (45-BN-107 through 45-BN-112) which relate to the Wanapum Indian people who occupied the area historically. The condition of these sites remains undisturbed and they preserve scientific date pertinent to both the cultural history and the environmental history of the area.

The WNP-2 pumphouse and water intake facility is at a distance from the site and on the west bank of the Columbia River. Primary impact to these significant non-renewable resources does not appear eminent.

Thank you for your concern for these properties listed on the National Register of Historic Places and for the cultural heritage of the State of Washington.

Sincerely,

ARTHUR M. SKOLNIK
State Historic Preservation
Officer

Jeanne M Welch

Jeanne M. Welch,
Archaeologist

kb

Post Office Box 1128 *Olympia, Washington 98504* *(206) 753 - 4011*

APPENDIX IV
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM WASTE DISCHARGE PERMIT

APPENDIX IV

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

WASTE DISCHARGE PERMIT

Issuance Date: September 25, 1975
Expiration Date: September 25, 1980

ATTACHMENT II

NATIONAL POLLUTANT DISCHARGE ELIMINATION
SYSTEM WASTE DISCHARGE PERMIT

State of Washington
Thermal Power Plant Site Evaluation Council
Olympia, Washington 98504

In Compliance With the Provisions of
Chapter 155, Laws of 1973, (RCW 90.48) as amended

and

The Federal Water Pollution Control Act Amendment of 1972,
Public Law 92-500

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
3000 George Washington Way
Richland, Washington 99352

Plant Location:

Section 5, T.11N, R28E W.M.
North of Richland
Benton County, Washington

Receiving Water:

Columbia River

Discharge Location:

Outfall 001
Latitude: 46°28'17"
Longitude: 119°15'45"

Industry Type: Nuclear Steam Electric Generating Plant (Hanford No. 2)

Water Segment No.: 26-03-00

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is authorized to discharge in accordance with the special and general conditions which follow.

Approved: April 28, 1975

Amended: July 14, 1975

Thomas C. Faces

Acting Chairman
Thermal Power Plant Site
Evaluation Council

SPECIAL CONDITIONS

S.1 EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning with the issuance of this permit and lasting until the expiration date of this permit, the permittee is authorized to discharge effluents from Outfall Discharge Serial Number 001 subject to the following limitations and monitoring requirements:

A. LOW VOLUME WASTE SOURCES PORTION OF DISCHARGE SERIAL NUMBER 001

PARAMETER	EFFLUENT LIMITATIONS		MONITORING REQUIREMENTS	
	Daily Maximum	Daily Average	Minimum Frequency	Sample Type
Total Suspended Solids (lb/day)	34	5	3 times per week	Grab
pH	Between 6.5 and 8.5 at all times		3 times per week	Grab
Oil and Grease (lb/day)	7	2.5	Weekly	Grab
Flow (GPD)(1)	40,000	20,000	Each Discharge	Log tank contents prior to discharge.

Compliance with these limitations shall be determined by monitoring all low volume waste sources including liquid radwaste prior to their confluence with the recirculated cooling water.

Note (1) : Permittee is allowed on an intermittent basis to discharge subject to the provisions of G.5 herein to a maximum of 285,000 GPD additional flow originating from the liquid radwaste treatment system.

B. RECIRCULATED COOLING WATER BLOWDOWN PORTION OF OUTFALL DISCHARGE SERIAL NUMBER 001

PARAMETER	EFFLUENT LIMITATIONS		MONITORING REQUIREMENTS	
	Daily Maximum	Daily Average	Minimum Frequency	Sample Type
Temperature	Note (3)		Continuous	Instantaneous
Total Residual Chlorine (mg/l)	0.1 mg/l(1)		Continuous(4)	Grab
pH	Between 6.5 and 8.5 at all times		Continuous(2)	Instantaneous
Flow (GPD)	9.4×10^6	9.4×10^6	Continuous	Instantaneous

Note (1) Upon initiating chlorination, permittee shall terminate all discharges from the recirculating water system to the receiving water until the total residual chlorine concentration has been at or below 0.1 mg/l for 15 minutes. For compliance chlorine will be measured at and will be characteristic of the unit being chlorinated.

Note (2) Permittee shall include an alarm system for the pH control to provide an indication of any variance from established limits.

Note (3) The temperature of the recirculated cooling water blowdown shall not exceed, at any time, the lowest temperature of the recirculated cooling water prior to the addition of the makeup water.

Note (4) Continuous recording of total residual chlorine during periods of active chlorination and for 2 hours after recommencing discharge or until chlorine residual reaches an undetectable level.

GENERAL CONDITIONS

G1. No discharge of polychlorianted biphenyl, such as transformer fluid, is permitted.

G2. All discharges and activities authorized herein shall be consistent with the terms and conditions of this permit. Permittee is authorized to discharge those pollutants which are: (1) contained in the raw water supply, (2) entrained from the atmosphere, or (3) quantitatively and qualitatively identified in the permit application; except as modified or limited by the special or general conditions of this permit. However, the effluent concentrations in permittee's waste water shall be determined on a gross basis and the effluent limitations in this permit mean gross concentrations and not net addition of pollutants. The discharge of any pollutant more frequently than or at a level in excess of that authorized by this permit shall constitute a violation of the terms and conditions of this permit.

G3. The effluent limitation for the total combined flow discharged from outfall No. 001 for any particular pollutant, excluding pH, shall be the sum of the amounts for each contributing inplant stream as authorized by the special or general conditions of this permit.

G4. Permittee shall not discharge any effluent which shall cause a violation of any applicable State of Washington Water Quality Criteria or standards contained in WAC 173-201, as they exist now or hereafter are amended, outside the mixing zone whose boundaries shall be:

a) The boundaries in the vertical plane shall extend from the receiving water surface to the riverbed;

b) The upstream and downstream boundaries shall be 50 feet and 300 feet, respectively, from the center line of the outfall; and

c) The lateral boundaries shall be separated by 100 feet.

G5. Excess process water shall not be discharged to the river unless sampling and analysis has demonstrated that the water complies with the applicable regulations on liquid radioactive discharges. Excess process water not meeting these conditions shall be processed in the liquid radwaste treatment system prior to discharge to the river. The liquid radwaste treatment system shall provide facilities with 24-hour retention capabilities; liquids may be discharged only after sampling and analysis demonstrate that all applicable regulations are complied with at the holding facilities. No other liquid radwaste shall be discharged.

G6. The permittee shall provide an adequate operating staff which is qualified and shall carry out the operation, maintenance, and testing activities required to insure compliance with the conditions of this permit.

G7. Permittee shall handle and dispose of all solid waste material from any waste retention basins or any other source in such a manner as to prevent their pollution of any ground or surface water body. Further, permittee shall not permit leachate from such solid waste material to cause adverse effect on ground or surface water quality.

G8. Whenever a facility expansion, production increase, or process modification is anticipated which will result in a new or increased discharge, or which will cause any of the conditions of this permit to be exceeded, a new NPDES application must be submitted together with the necessary reports and engineering plans for the proposed changes. No change shall be made until plans have been approved and a new permit or permit modification has been issued. If such changes will not violate the effluent limitations specified in this permit, permittee shall notify the Council of such changes prior to such facility expansion, production increase or process modification.

G9. If the toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Federal Act for a toxic pollutant which is present in the permittee's discharge and such standard or prohibition is more stringent than any limitation upon such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee shall be so notified.

G10. If, for any reason, the permittee does not comply with or will not be able to comply with, any daily maximum effluent limitation specified in this permit, the permittee shall provide the Council with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including dates and times; or, if not corrected, the anticipated time the non-compliance is expected to continue and steps being taken to reduce, eliminate and prevent recurrence of the non-complying discharge.

G11. The permittee shall at all times maintain in good working order and efficiently operate all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

G12. The diversion from or bypass of any discharge from facilities utilized by the permittee to maintain compliance with the terms and conditions of this permit is prohibited, except (a) where unavoidable to prevent loss of life or severe property damage, or (b) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the terms and conditions of this permit. The permittee shall promptly notify the Council in writing of each such diversion or bypass in accordance with the procedure specified in condition G-13.

G13. In the event the permittee is unable to comply with any of the conditions of this permit because of a breakdown of waste treatment, equipment or facilities, an accident caused by human error or negligence, electrical power failure, or any other cause, including acts of nature, the permittee shall:

a. Immediately take action to stop, contain, and clean up the unauthorized discharge and correct the problems.

b. As soon as reasonably practicable, notify the Council so that an investigation can be made to evaluate the impact and the corrective actions taken and determine additional action that must be taken.

c. Promptly submit a detailed written report to the Council describing the breakdown, the actual quantity and quality of resulting waste discharges, corrective action taken, steps taken to prevent recurrence, and any other pertinent information.

Compliance with these requirements does not relieve the permittee from responsibility to maintain continuous compliance with the conditions of this permit or the resulting liability for failure to comply.

G14. Permittee shall install an alternative electric power source capable of operating any electrically powered pollution control facilities; or, alternatively, permittee shall certify to the Council that the terms and conditions of this permit will be met in case of a loss of primary power to the pollution control equipment by controlling production.

Monitoring

G15. Permittee shall comply with the Monitoring Program requirements set forth herein.

Monitoring results for the previous quarter shall be summarized on a monthly basis and reported on a Discharge Monitoring Report Form (EPA 3320-1), postmarked no later than the 28th day of the month following the end of the quarter. The first report is due by the 28th day of the first month following the end of the quarter in which the first discharge under this permit occurs. Duplicate signed copies of these, and all other reports required herein, shall be submitted to EPA and the Council at the following addresses:

U.S. EPA Region X
1200 6th Avenue
Seattle, WA 98101
Attention:
Permits Branch M/S 521

TPPSEC
Attention:
Executive Secretary
820 East 5th Avenue
Olympia, WA 98504

G16. The permittee shall retain for a minimum of three years all records of monitoring activities and results, including all reports of recordings from continuous monitoring instrumentations, record of analysis performed and calibration and maintenance of instrumentation. This period of retention shall be extended during the course of any unresolved litigation regarding the discharge of pollutants by the permittee or when requested by the Council. All samples and measurements made under said program shall be representative of the volume and nature of the monitored discharge.

G17. The permittee shall record each measurement or sample taken pursuant to the requirements of this permit for the following information: (1) the date, place, and time of sampling; (2) the dates the analyses were performed; (3) who performed the analyses; (4) the analytical techniques or methods used; and (5) the results of the analyses.

G18. As used in this permit, the following terms are as defined herein:

a. The "daily maximum" discharge means the total discharge by weight during any calendar day.

b. The "daily average" discharge means the total discharge by weight during a calendar month divided by the number of days in the month that the respective discharges occur. Where less than daily samplings is required by the permit, the daily average discharge shall be determined by the summation of the measured daily discharges by weight divided by the number of days during the calendar month when the measurements were made.

c. "Composite sample" is a sample consisting of a minimum of six grab samples collected at regular intervals over a normal operating day and combined proportional to flow, or a sample continuously collected proportional to flow over a normal operating day.

d. "Grab sample" is an individual sample collected in a period of less than 15 minutes.

G19. All sampling and analytical methods used to meet the monitoring requirements specified in this permit shall conform to regulations published pursuant to Section 304g of the Federal Act, or if there is no applicable procedure, shall conform to the latest edition of the following references:

1) American Public Health Association, Standard Methods for the Examination of Water and Wastewaters.

2) American Society for Testing and Materials, A.S.T.M. Standards, part 23, Water, Atmospheric Analysis.

3) Environmental Protection Agency, Water Quality Office Analytical Control Laboratory, Methods for Chemicals Analysis of Water and Wastes.

Alternative methods may be utilized if approval pursuant to 40 CFR 136 or as amended is received by the permittee. The Council shall be notified of each such alternative method approved for use.

G20. Except for data determined confidential under Section 308 of the Act, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Council and the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making a false statement on any such report may result in the imposition of criminal penalties as provided in Section 309 of the Act.

Other Provisions

G21. After notice and opportunity for a hearing this permit may be modified, suspended or revoked in whole or in part during its term for cause including but not limited to the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts;

c A change in any condition that requires either a temporary or permanent reduction or elimination of the permitted discharge.

G22. The permittee shall, at all reasonable times, allow authorized representatives of the Council upon the presentation of credentials:

a. To enter upon the permittee's premises for the purpose of inspecting and investigating conditions relating to the pollution of, or possible pollution of any of the waters of the state, or for the purpose of investigating compliance with any of the terms of this permit;

b. To have access to and copy any records required to be kept under the terms and conditions of this permit;

c. To inspect any monitoring equipment or monitoring method required by this permit; or

d. To sample any discharge of pollutants.

G23. Nothing in this permit shall be construed as excusing the permittee from compliance with any applicable Federal, State or local statutes, ordinances, or regulations.

G24. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject.

G25. Permittee shall study the use of chlorine in cooling tower operation for one year to determine the minimum daily discharge duration of free available and total residual chlorine which will allow the plant to operate efficiently. The results of this study will be evaluated for possible inclusion in this permit.

AMENDMENT NO. 1 TO THE
SITE CERTIFICATION AGREEMENT FOR HANFORD NO. 2
BETWEEN
THE STATE OF WASHINGTON
AND
THE WASHINGTON PUBLIC POWER SUPPLY SYSTEM

This amendment to the Certification Agreement was made and entered into pursuant to Chapter 80.50 of the Revised Code of Washington by and between the State of Washington, acting by and through the Governor of the State of Washington, and the Washington Public Power Supply System, a municipal corporation and a joint operating agency of the State of Washington organized in January 1957 pursuant to Chapter 43.52 of the Revised Code of Washington.

It includes changes to the terms for the construction of the intake system, commencement of the meteorological and environmental surveillance program, scope of the agreement limitations, dimensions of the mixing zone, and specifications for management of waste water discharges. The entire section containing water discharge limitations has been superseded and replaced by the issuance of a National Pollutant Discharge Elimination System Waste Discharge Permit in compliance with the provisions of Chapter 90.48 RCW as amended and the Federal Water Pollution Control Act Amendment of 1972, Public Law 92-500.

This amendment, when duly authenticated, becomes a part of the Certification Agreement and will be filed in front of the Agreement. The following is changed:

A. Section II.C.1. is amended to read as follows:

This Certification Agreement, together with those commitments made by the applicant expressed in its application, as amended, except as to commitments made for the design for the intake and discharge systems, constitute the whole and complete agreement between the parties and supersedes any other negotiations, representations, or agreements, either written or oral.

B. Section III.G.4.(a) is deleted.

C. Section III.G.4.(b) is replaced with the following:

The Supply System shall schedule the construction of the intake structure in the portion of the river bed during the period after July 31 and before October 15. Any work at other times directly in the stream bed of the Columbia River shall require approval of the Council.

D. Section III.H. Add the following as Paragraph 6:

The outfall shall include features as required to achieve dilution within the limits prescribed in General Condition 4 of the attached NPDES Permit.

E. Section IV.B. is deleted and replaced with the Hanford No. 2 National Pollutant Discharge Elimination System Waste Discharge Permit hereby appended as Attachment II to the Certification Agreement.

F. Section V.B.1. The last sentence of this paragraph is deleted and replaced with the following:

"The Supply System agrees to begin the meteorological and environmental surveillance program no later than two years prior to fuel loading; provided that fish impingement monitoring shall begin no later than intake pump startup."

Dated at Olympia, Washington, this 25th day of September 1975.

FOR THE STATE OF WASHINGTON

Daniel J. Evans, Governor

FOR THE WASHINGTON PUBLIC POWER SUPPLY SYSTEM

J. J. Stein, Managing Director

Approved as to form this 25th day of September 1975

Darrel L. Peeples
Assistant Attorney General