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INTRODUCTION AND GENERAL DESCRIPTION OF PLANT

1.1 INTRODUCTION

This Final Safety Analysis Report (FSAR) was submitted in support of an application by Energy Northwest for a Class 103 operating license for a single unit nuclear power plant. The facility is known as the Columbia Generating Station (CGS) and was formerly known as WNP-2.

Energy Northwest was the applicant for the operating license for CGS. The plant was designed, constructed, and is being operated under the responsibility of Energy Northwest.

CGS is located within the Hanford Site of the Department of Energy (DOE), Benton County, Washington, approximately 12 miles north of the City of Richland. The site is approximately 3 miles west of the Columbia River at River Mile 352.

This plant has a boiling water reactor (BWR) nuclear steam supply system (NSSS) designed and supplied by the General Electric Company (GE). The plant utilizes a single-cycle, forced-circulation system and is designated as a BWR/5.

The containment was designed by Burns and Roe, Inc., and consists of primary and secondary containment systems. The primary containment structure is a free-standing steel pressure vessel of a specific design by Pittsburgh Des Moines Steel Co. The vessel contains both a drywell and a suppression chamber, which is consistent with the features of a BWR/Mark II containment.

The secondary containment structure is composed of the reactor building, which completely encloses primary containment.

The authorized maximum rated power level limit of the reactor is 3544 MWt. The design power level limit is 3629 MWt. The net electrical power output is approximately 1190 MWe and the gross electrical output is 1230 MWe.

Energy Northwest was granted an operating license for CGS on December 20, 1983, and the plant began commercial operation on December 13, 1984.

1.2 GENERAL PLANT DESCRIPTION

1.2.1 PRINCIPAL DESIGN CRITERIA

The principal design criteria are presented in two ways. First, they are classified as either a power generation function or a safety function. Second, they are grouped according to system. Although the distinctions between power generation or safety functions are not always clear-cut and are sometimes overlapping, the functional classification facilitates safety analyses, while the grouping by system facilitates the understanding of both the system function and design.

1.2.1.1 General Design Criteria

1.2.1.1.1 Power Generation Design Criteria

a. The plant was designed so that it can be fabricated, erected, and operated to produce electric power in a safe and reliable manner. Plant design conforms to applicable codes and regulations as stipulated in Table 1.2-1;

b. The plant is designed to produce steam for direct use in a turbine-generator unit;

c. Heat removal systems are provided with sufficient capacity and operational adequacy to remove heat generated in the reactor core for the full range of normal operational conditions and abnormal operational transients;

d. Backup heat removal systems are provided to remove decay heat generated in the core under circumstances wherein the normal operational heat removal systems become inoperative. The capacity of such systems is adequate to prevent fuel cladding damage;

e. The fuel cladding, in conjunction with other plant systems is designed to retain integrity throughout the range of normal operational conditions and abnormal operational transients;

f. The fuel cladding can accommodate, without loss of integrity, the pressures generated by fission gases released from fuel material throughout the design life of fuel;

g. Control equipment has been provided to allow the reactor to respond automatically to minor load changes, major load changes, and abnormal operational transients;

h. Reactor power level can be manually controlled;

i. Control of the reactor is possible from a single location;

j. Reactor controls, including alarms, are arranged to allow the operator to rapidly assess the condition of the reactor system and locate system malfunctions; and

k. Interlocks or other automatic equipment are provided as backup to procedural controls to avoid conditions requiring the functioning of nuclear safety systems or engineered safety features (ESF).

1.2.1.1.2 Safety Design Criteria

a. The plant design conforms to applicable codes and regulations;

b. The plant is designed, fabricated, erected, and will be operated in such a way that the release of radioactive materials to the environment is limited to the limits and guideline values of applicable federal regulations pertaining to the release of radioactive materials for normal operations and abnormal transients and accidents;

c. The reactor core is designed so its nuclear characteristics do not contribute to a divergent power transient;

d. The reactor is designed so there is no tendency for divergent oscillation of any operating characteristic, considering the interaction of the reactor with other appropriate plant systems;

e. Gaseous, liquid, and solid waste disposal facilities are designed so the discharge and offsite shipment of radioactive effluents can be made in accordance with applicable regulations;

f. The design provides means by which plant operators can be informed when limits on the release of radioactive material are approached;

g. Sufficient indications are provided to allow determination that the reactor is operating within the envelope of conditions considered by plant safety analysis;

h. Radiation shielding is provided and access control patterns have been established to allow a properly trained operating staff to control radiation doses within the limits of applicable regulations in any mode of normal plant operations;

i. Those portions of the nuclear system that form part of the reactor coolant pressure boundary (RCPB) are designed to retain integrity as a radioactive material barrier following abnormal operational transients and accidents;

j. Nuclear safety systems and ESF act to ensure that no damage to the RCPB results from internal pressures caused by abnormal operational transients and accidents;

k. Where positive, precise action is immediately required in response to abnormal operational transients and accidents, such action is automatic and requires no decision or manipulation of controls by plant operations personnel;

l. Essential safety actions can be carried out by equipment of sufficient redundance and independence such that no single failure of active components can prevent the required actions. For systems or components to which IEEE-279 (Criteria for Protection Systems for Nuclear Power Generating Stations) and/or IEEE-308 (Criteria for Class 1E Electrical systems for Nuclear Power Generating Stations) applies, single failures of both active and passive electrical components were considered in recognition of the higher anticipated failure rates of passive electrical components relative to passive mechanical components;

m. Provisions have been made for control of active components of nuclear safety systems and ESF from the control room;

n. Nuclear safety systems and ESF are designed to permit demonstration of their functional performance requirements;

o. The design of nuclear safety systems and ESF includes allowances for natural environmental disturbances such as earthquakes, tornadoes, floods, and storms at the site;

p. Standby electrical power sources have sufficient capacity to power all nuclear safety systems and ESF requiring electrical power;

q. Standby electrical power sources are provided to allow prompt reactor shutdown and removal of decay heat under circumstances where offsite power sources are not available;

r. Features of the plant that are essential to the mitigation of accident consequences are designed, fabricated, and erected to quality standards that reflect the importance of the safety action to be performed;

s. A primary containment has been provided that completely encloses the reactor system, drywell, and suppression pool. The primary containment employs the pressure suppression concept;

t. The primary containment is designed to retain integrity as a radioactive material barrier during and following accidents that release radioactive material into the primary containment volume;

u. It is possible to test primary containment integrity and leaktightness at periodic intervals;

v. A secondary containment has been provided that completely encloses both the primary containment and fuel storage areas. The secondary containment includes the standby gas treatment (SGT) system for controlling release of radioactive materials leaking from the primary containment in the event of an accident and also has the capability for filtering radioactive materials directly from the primary containment atmosphere during shutdown conditions;

w. The secondary containment has been designed to act as a radioactive material barrier, if required, when the primary containment is open for expected operational purposes;

x. The primary containment and secondary containment, in conjunction with other ESF, limit radiological effects of accidents resulting in the release of radioactive material to the containment vessel to significantly less than 10 CFR 50.67 limits;

y. Provisions have been made for removing energy from within the containment vessel as necessary to maintain the integrity of the containment system following accidents that release energy to the primary containment;

z. Piping that penetrates the primary containment structure and could serve as a path for the uncontrolled release of radioactive material to the environs is automatically isolated whenever such uncontrolled radioactive material release is threatened. Such isolation shall be effected in time to limit radiological effects to less than specified acceptable limits;

aa. Emergency core cooling systems (ECCS) are provided to limit fuel cladding temperature to temperatures below the onset of fragmentation in the event of a loss-of-coolant accident (LOCA);

bb. The ECCS provide for continuity of core cooling over the complete range of postulated break sizes in the RCPB and are redundant;

cc. Operation of the ECCS is initiated automatically when required, regardless of the availability of offsite power supplies and the normal generating system of the plant;

dd. The control room has been shielded against radiation and provided with a high efficiency filtration system so that continued occupancy under accident conditions is possible;

ee. In the event that the control room becomes inaccessible, it is possible to bring the reactor from power range operation to cold shutdown conditions by utilizing the local controls and equipment that are available outside the control room on the remote shutdown control panels;

ff. Backup reactor shutdown capability has been provided independent of normal reactivity control provisions. This backup system has the capability to shut down the reactor from any normal operating condition and subsequently to maintain the shutdown condition; and

gg. Fuel handling and storage facilities are designed to prevent inadvertent criticality and to maintain adequate shielding and cooling of spent fuel. Provision is made for maintaining the cleanliness of spent fuel cooling and shielding water.

1.2.1.2 System Criteria

The principal design criteria for particular systems are listed in the following subsections.

1.2.1.2.1 Nuclear System Criteria

a. The fuel cladding is designed to retain integrity as a radioactive material barrier throughout the design power range. The fuel cladding is designed to accommodate, without loss of integrity, the pressures generated by the fission gases released from the fuel material throughout the design life of the fuel;

b. The fuel cladding, in conjunction with other plant systems, is designed to retain integrity throughout any abnormal operational transient;

c. Those portions of the nuclear system that form part of the RCPB are designed to retain integrity as a radioactive material barrier following abnormal operational transients and accidents;

d. Heat removal systems are provided in sufficient capacity and operational adequacy to remove heat generated in the reactor for the full range of normal operational conditions from plant shutdown to design power and for any abnormal operational transient. The capacity of such systems is adequate to prevent fuel cladding damage;

e. Heat removal systems are provided to remove decay heat generated in the core under circumstances wherein the normal operational heat removal systems become inoperative. The capacity of such systems is adequate to prevent fuel cladding damage. The reactor is capable of being automatically shut down in sufficient time to permit decay heat removal systems to become effective following loss of operation of normal heat removal systems;

f. The reactor core and reactivity control system is designed so that control rod action is capable of bringing the core subcritical and maintaining it so, even with the rod of highest reactivity worth fully withdrawn and unavailable for insertion;

g. The reactor core is designed so that its nuclear characteristics do not contribute to a divergent power transient; and

h. The nuclear system is designed so there is no tendency for divergent oscillation of any operating characteristic, considering the interaction of the nuclear system with other appropriate plant systems.

1.2.1.2.2 Power Conversion System Criteria

Components of the power conversion system have been designed to perform the following basic objectives.

a. Produce electrical power from the steam exiting from the reactor, condense the steam into water, and return the water to the reactor as heated feedwater, with a major portion of its gaseous and particulate impurities removed; and

b. Ensure that any fission products or radioactivity associated with the steam and condensate during normal operation are safely contained inside the system or are released under controlled conditions in accordance with waste disposal procedures.

1.2.1.2.3 Electrical Power Systems Criteria

Sufficient offsite and onsite standby sources of electrical power are provided to attain prompt shutdown and continued maintenance of the plant in a safe condition under all credible

circumstances. The power sources are adequate to accomplish all required engineered safety feature functions under postulated design basis accident conditions.

1.2.1.2.4 Radwaste System Criteria

a. The gaseous and liquid radwaste systems are designed to limit the release of radioactive effluents from the plant during normal operation within those limits specified in 10 CFR 20 and 10 CFR 50, Appendix I;

b. The solid radwaste disposal system is designed so that during normal operation offsite shipments will be in accordance with applicable regulations, including 10 CFR 20, 10 CFR 71, and 49 CFR 171 through 10 CFR 179, as appropriate; and

c. The design of the systems provide means by which plant operations personnel are alerted whenever operational limits on the release of radioactive material are approached.

1.2.1.2.5 Auxiliary Systems Criteria

a. Fuel handling and storage facilities are designed to prevent criticality and to maintain adequate shielding and cooling for spent fuel. Provision is made for maintaining the cleanliness of spent fuel cooling and shielding water;

b. Other auxiliary systems, such as standby service water (SW), high pressure core spray (HPCS) SW, fire protection (FP), heating and ventilating, communications, and lighting systems, are designed to function during normal, abnormal, and/or accident conditions; and

c. Auxiliary systems that are not required to effect safe shutdown of the reactor or maintain it in a safe shutdown condition are designed such that failure of these systems shall not prevent the essential auxiliary systems from performing their design functions.

1.2.1.2.6 Shielding and Access Control Criteria

a. Radiation shielding is provided and access control patterns are established to allow a properly trained operating staff to control radiation doses within the limits of published regulations in any normal mode of plant operation; and

b. The control room is shielded against radiation and has a high efficiency filtration system, so that occupancy is possible under accident conditions and

TEDE doses are less than those set by Criterion 19 of 10 CFR Part 50, Appendix A and 10 CFR 50.67.

1.2.1.2.7 Nuclear Safety Systems and ESF Criteria

Principal design criteria for nuclear safety systems and ESF correspond to criteria j through q, aa through cc, and ee through ff in Section 1.2.1.1.2.

1.2.1.2.8 Process Control Systems Criteria

The principal design criteria for the process control systems are listed for the nuclear system, the power conversion system, and the electrical power system:

a. Nuclear System Process Control Criteria

   1. Control equipment is provided to allow the reactor to respond automatically to load changes within design limits.

   2. It is possible to manually control the reactor power level.

   3. Control of the reactor is possible from a central location.

   4. Nuclear systems process controls and alarms are arranged to allow the operator to rapidly assess the condition of the nuclear system and to locate process system malfunctions.

   5. Interlocks or other automatic equipment are provided as a backup to procedural controls to avoid conditions requiring the actuation of nuclear safety systems or ESF.

b. Power Conversion System Process Control Criteria

   1. Control equipment is provided to control the reactor pressure throughout its operating range.

   2. The turbine is able to respond automatically to minor changes in load.

   3. Control equipment in the feedwater system maintains the water level in the reactor vessel at the optimum level required by steam separators.

   4. Control of the power conversion equipment is possible from a central location.

5. Interlocks or other automatic equipment are provided in addition to procedural controls to avoid conditions requiring the actuation of ESF.

c. Electrical Power System Process Control Criteria

1. The redundant portions of the Class 1E power systems are designed with either division of the system being adequate to safely shut down the unit.

2. Protective relaying is used to detect and isolate faulted equipment from the system with a minimum of disturbance in the event of equipment failure.

3. Primary and secondary undervoltage relays are located on the 4.16-kV Class 1E equipment buses to isolate these buses from the normal auxiliary power system in the event of Class 1E bus under voltage and to initiate starting of the standby power system diesel generators.

4. Standby power diesel generators' start is initiated by control relays. The generators are also loaded by a sequenced control system to meet the existing emergency condition.

5. All electrically operated breakers can be operated from the main control room.

6. Metering for essential generators, transformers, and circuits is monitored in the main control room.

1.2.1.3 Plant Design Criteria

The plant design criteria are based on general design criteria given in Appendix A of 10 CFR Part 50. Conformance to these criteria is discussed in Section 3.1. The classification of structures, components, and systems is discussed in Section 3.2.

The principal regulations are codes that are used extensively in plant design are highlighted in Table 1.2-1. Note that the codes listed may not be applicable in their entirety. The many codes and regulations applicable to individual systems or structures are discussed throughout the FSAR.

The plant shielding and radiation zone classification can be found in Table 1.2-2. Chapter 12 provides further details.

1.2.2 PLANT DESCRIPTION

1.2.2.1 Site Characteristics

1.2.2.1.1 Site Location and Size

Columbia Generating Station (CGS) is located in the southeast area of the Department of Energy (DOE) Hanford Reservation in Benton County, Washington. The site is approximately 3 miles west of the Columbia River at River Mile 352, approximately 12 miles north of the City of Richland, 18 miles northwest of Pasco, and 21 miles northwest of Kennewick. The site is approximately square shaped with a corridor extending to the makeup water pump house located on the Columbia River as shown in Figure 1.2-1. The CGS site encompasses an area of approximately 1089 acres.

1.2.2.1.2 Description of Site Environs

1.2.2.1.2.1 Site Land. See Section 2.1 for site land description.

1.2.2.1.2.2 Population. See Section 2.1 for population description.

1.2.2.1.2.3 Land Use. Natural physical characteristics of the site which make it well-suited for operation of the plant include: favorable geographical, geological, and seismological characteristics; adequate water supply; ideal climatological characteristics; and remoteness from population centers or areas of special ecological concern. The site area had served as a nuclear industrial center since 1943 when it was selected by the federal government as the location for construction of one of the world's first nuclear production reactors. Since 1943, nine plutonium production reactors and a number of test reactors have been constructed and operated at the Hanford Site.

1.2.2.1.2.4 Meteorology. The climate around CGS is basically continental with a wide range of annual temperatures. See Section 2.3 for additional information.

1.2.2.1.2.5 Hydrology. The Columbia River is the major surface water resource of the region. The river also forms a potential discharge boundary for the aquifer. The surface soils at Hanford are sufficiently permeable to take in water from precipitation and industrial discharges. See Section 2.4 for additional information.

1.2.2.1.2.6 Geology. The Hanford site lies in the east central part of the Pasco Basin, a structural and topographic depression in the Columbia Plateau. The region is underlain by three major geologic units: (a) Tertiary basaltic lavas and intercalated sediments of the Columbia River Group at the base, (b) Plio-Pleistocene sediments of the Ringold Formation, and (c) the Pasco (glaciofluvial) gravels and associated sediments of late Pleistocene age at the surface. See Section 2.5 for additional information.

1.2.2.1.2.7 Seismology. The CGS site is situated in an area characterized by low seismicity and widely scattered epicenters. See Section 2.5 for additional information.

1.2.2.1.3 Design Basis Depending on Site Environs

a. Offgas System

An offgas (OG) system consisting of hold-up piping, charcoal adsorbers, and an elevated release is provided for the controlled release of gaseous effluent to the atmosphere. Gaseous releases will be as low as reasonably achievable (ALARA) in accordance with 10 CFR Part 50, Appendix I, and less than 10 CFR Part 20 limits;

b. Liquid Waste Effluents

Liquid waste will be processed and recycled, and releases of excess inventory will be such that concentrations at the point of discharge will be as low as reasonably achievable in accordance with 10 CFR Part 50, Appendix I, and less than 10 CFR Part 20 limits;

c. Wind Loading and Seismic Design

The structures and components whose failure might cause a design basis accident or result in an uncontrolled release of radioactive fission products will be designed to resist wind loads of tornado velocity and earthquake ground motions which are significantly higher than those expected to occur at the site during the service life of the plant; and

d. Flooding

The maximum assumed flood elevation for design purposes is the sum total of the elevations of water due to the following effects:

1. Breach of any of the upstream dams due to seismic forces,
2. High flow in the Columbia River, and
3. Wind and wave action.

1.2.2.2 General Arrangement of Structures and Equipment

The principal structures located on the plant site are the following:

a. Reactor building - the building that houses the major portion of the nuclear steam supply system (NSSS), the drywell, suppression pool, primary containment, new and spent fuel pools, refueling equipment, and ECCS;

b. Radwaste and control building - the building that houses the liquid and solids radwaste systems, components of the OG system, and the main control room;

c. Turbine building - the building that houses the power conversion equipment;

d. Diesel generator building - the building that houses the standby diesel generators, diesel fuel oil (DO) storage tanks, and associated controls and instrumentation;

e. Circulating water pump house (Wind River Building) - a structure housing the main circulating water (CW) pumps, plant service water (TSW) pumps, and FP pumps;

f. Standby service water pump houses - structures that house the redundant standby SW pumps and the HPCS SW pump;

g. Spray ponds - cooling ponds provided as the ultimate heat sink (UHS);

h. Makeup water pump house - a structure that houses the cooling tower makeup (TMU) water pumps;

i. General service building (Yakima Building) - a structure that houses the potable water (PWC) storage tank, demineralized water (DW) storage tank, offices for plant administration, lunch room, and machine shop;

j. Transformer yard;

k. Condensate storage tanks (CSTs);

l. Cooling towers; and

m. Plant Engineering Center (Deschutes Building).

The arrangement of these structures on the plant site is shown in Figure 1.2-1. The arrangement of the equipment inside the main buildings is shown in Figures 1.2-2 through 1.2-24.

1.2.2.3 Symbols Used on Engineering Drawings

Figure 1.2-25 defines General Electric's (GE) piping and instrumentation symbols, and Figure 1.2-26 through 1.2-28 shows Burns and Roe piping and instrumentation symbols. Figure 1.2-29 defines the logic symbols used on NSSS functional control diagrams.

1.2.2.4 Nuclear System

The nuclear system includes a direct-cycle, forced-circulation, GE boiling water reactor (BWR) that produces steam for direct use in the steam turbine. A heat balance showing the major parameters of the nuclear system for the rated power conditions is shown in Figure 10.1-1.

1.2.2.4.1 Reactor Core and Control Rods

Fuel for the reactor core consists of slightly enriched uranium dioxide pellets sealed in Zircaloy-2 tubes. These tubes (or fuel rods) are assembled into individual fuel assemblies. Gross control of the core is achieved by movable, bottom-entry control rods. The control rods are cruciform in shape and are dispersed throughout the lattice of fuel assemblies. The control rods are positioned by individual control rod drives (CRDs).

Each fuel assembly has several fuel rods with gadolinia (Gd_2O_3) mixed in solid solution with UO_2. The Gd_2O_3 is a burnable poison which diminishes the reactivity of the fresh fuel. It is depleted as the fuel reaches the end of its first cycle.

A conservative limit of plastic strain is the design criterion used for fuel rod cladding failure. The peak linear heat generation for steady-state operation is well below the fuel damage limit even late in life. Experience has shown that the control rods are not susceptible to distortion and have an average life expectancy many times the residence time of the fuel loading.

1.2.2.4.2 Reactor Vessel and Internals

The reactor vessel contains the core and supporting structures; the steam separators and dryers; the jet pumps; the control rod guide tubes; the distribution lines for reactor feedwater (RFW), HPCS, low-pressure core spray (LPCS), and standby liquid control (SLC); the in-core instrumentation; and other components. The main connections to the vessel include main steam (MS) lines, reactor recirculation (RRC) lines, RFW lines, CRD and in-core nuclear instrument housings, HPCS and LPCS lines, residual heat removal (RHR) lines, SLC line,

core differential pressure line, jet pump pressure-sensing lines, and water level instrumentation.

The reactor vessel is designed and fabricated in accordance with applicable codes for a pressure of 1250 psig. The nominal operating pressure in the steam space above the separators is 1035 psia. The vessel is fabricated of low-alloy steel and is clad internally with stainless steel (except for the top head, and certain nozzles and nozzle weld zones which are unclad).

The reactor core is cooled by demineralized water that enters the lower portion of the core and boils as it flows upward around the fuel rods. The steam leaving the core is dried by steam separators and dryers located in the upper portion of the reactor vessel. The steam is then directed to the turbine through the MS lines. Each MS line is provided with two MS isolation valves (MSIVs) in series, one on each side of the primary containment barrier.

1.2.2.4.3 Reactor Recirculation System

The RRC system pumps reactor coolant through the core. This is accomplished by two recirculation loops external to the reactor vessel but inside the primary containment. Each external loop contains a mechanical pump, two motor-operated maintenance valves, and one flow control valve which is mechanically blocked full open. The two motor-operated valves are used as pump suction and pump discharge shutoff valves. The flow control valves are no longer used to control reactor power level and therefore are kept in a mechanically blocked full open position.

The internal portion of the loop consists of the jet pumps, which contain no moving parts. The jet pumps provide a continuous internal circulation path for the major portion of the core coolant flow. The jet pumps are located in the annular region between the core shroud and the vessel's inner wall. Any recirculation line break would still allow core flooding to approximately two-thirds of the core height, the level of the inlet of the jet pumps.

1.2.2.4.4 Residual Heat Removal System

The RHR system is a system of pumps, heat exchangers, and piping that fulfills the following functions:

a. Removes decay and sensible heat during and after plant shutdown;

b. Injects water into the reactor vessel, following a LOCA, rapidly enough to reflood the core and maintain fuel cladding below the fragmentation temperature independent of other core cooling systems. This is further discussed in Section 1.2.2.5.8;

c. Removes heat from the primary containment, following a LOCA, to limit the increase in primary containment pressure. This is accomplished by cooling and recirculating the suppression pool water (containment cooling) and by spraying the drywell and suppression pool air spaces (containment spray) with suppression pool water; and

d. Removes some of the airborne radioactivity from the primary containment atmosphere following a LOCA by spraying the drywell.

1.2.2.4.5 Reactor Water Cleanup System

The reactor water cleanup (RWCU) system recirculates a portion of reactor coolant through a filter-demineralizer to remove particulate and dissolved impurities from the reactor system under controlled conditions. It also removes excess coolant from the reactor system under controlled conditions.

1.2.2.4.6 Nuclear Leak Detection System

The nuclear leak detection (LD) system consists of temperature, pressure, flow, and fission-product sensors with associated instrumentation and alarms. This system detects and annunciates leakage in the following systems:

a. Main steam system,
b. Reactor water cleanup system,
c. Residual heat removal system,
d. Reactor core isolation cooling (RCIC) system,
e. Reactor feedwater system,
f. High-pressure core spray system,
g. Low-pressure core spray system,
h. Reactor recirculation system, and
i. Reactor pressure vessel (RPV) flange.

Small leaks generally are detected by temperature and pressure changes, fill-up rate of drain sumps, and fission-product concentration inside the primary containment. Large leaks are also detected by changes in reactor water level and changes in flow rates in process lines.

1.2.2.5 Nuclear Safety Systems and Engineered Safety Features

1.2.2.5.1 Reactor Protection System

The reactor protection system (RPS) initiates a rapid, automatic shutdown (scram) of the reactor, if required, to prevent fuel cladding damage or nuclear system process barrier damage following abnormal operational transients. The RPS overrides all operator actions and process

controls and is based on a fail-safe design philosophy that allows appropriate protective action even if a single component failure occurs.

1.2.2.5.2 Neutron Monitoring System

Although not all portions of the neutron monitoring system qualify as a nuclear safety system, those that provide high neutron flux signals to the RPS do. The intermediate range monitors (IRMs) and average power range monitors (APRMs), which monitor neutron flux via in-core detectors, signal the RPS to scram in time to prevent excessive fuel cladding damage as a result of overpower transients. The APRM modules also provide inputs to the thermal power monitors (TPMs) which approximate fuel thermal conditions and also provide scram signals to the RPS.

1.2.2.5.3 Control Rod Drive System

When a scram is initiated by the RPS, the CRD system inserts the negative reactivity necessary to shut down the reactor. Each control rod is controlled individually by a hydraulic control unit. When a scram signal is received, high-pressure water stored in an accumulator in the hydraulic control unit forces its control rod into the core.

1.2.2.5.4 Control Rod Drive Housing Supports

Control rod drive housing supports are located underneath the reactor vessel near the control rod housings. The supports limit the travel of a control rod in the event that a control rod housing is ruptured. The supports prevent a nuclear excursion as a result of a housing failure and thus protect the fuel barrier.

1.2.2.5.5 Control Rod Velocity Limiter

A control rod velocity limiter is attached to each control rod to limit the velocity at which a control rod can fall out of the core should it become detached from its CRD. This action limits the rate of reactivity insertion resulting from a rod drop accident. The limiters contain no moving parts.

1.2.2.5.6 Pressure Relief System (Nuclear System)

A pressure relief system consisting of safety/relief valves (SRVs) mounted on the MS lines is provided to prevent excessive pressure inside the nuclear system following either abnormal operational transients or accidents.

1.2.2.5.7 Reactor Core Isolation Cooling System

The RCIC system provides makeup water to the reactor vessel when the vessel is isolated. The RCIC system uses a steam-driven turbine-pump unit and operates automatically in time and with sufficient coolant flow to maintain adequate water level in the reactor vessel. RCIC is not an engineered safety feature. It is included here, however, because of its similar functions.

1.2.2.5.8 Emergency Core Cooling System

Four ECCS are provided to maintain fuel cladding below fragmentation temperature in the event of a breach in the RCPB that results in a loss of reactor coolant. The systems are

a. High-pressure core spray system,
b. Automatic depressurization system (ADS),
c. Low-pressure core spray system, and
d. Low-pressure coolant injection (LPCI), an operating mode of the RHR system.

1.2.2.5.8.1 High-Pressure Core Spray System. The HPCS system provides and maintains an adequate coolant inventory inside the reactor vessel to maintain fuel cladding temperatures below the fragmentation temperature in the event of breaks in the RCPB. The system is initiated by either high pressure in the drywell or low water level in the vessel. It operates independently of all other systems over the entire range of pressure differences from greater than normal operating pressure to zero. The HPCS cooling decreases vessel pressure to enable the low pressure cooling systems to function. The HPCS system is powered by its own diesel generator if auxiliary power is not available, and the system may also be used as a backup for the RCIC system.

1.2.2.5.8.2 Automatic Depressurization System. The ADS rapidly reduces reactor vessel pressure during a LOCA situation in which the HPCS system fails to maintain the reactor vessel water level. The depressurization provided by the system enables the low pressure ECCS to deliver cooling water to the reactor vessel. The ADS uses some of the relief valves that are part of the nuclear system pressure relief system. The automatic relief valves are arranged to open when conditions indicate that the HPCS system is not delivering sufficient cooling water to the reactor vessel to maintain the water level above a preselected value. The ADS will not be activated unless either the LPCS or LPCI pumps are operating. This is to ensure that adequate coolant will be available to maintain reactor water level after the depressurization.

1.2.2.5.8.3 Low-Pressure Core Spray System. The LPCS system consists of one independent pump and the valves and piping to deliver cooling water to a spray sparger over the core. The system is actuated by conditions indicating that a breach exists in the RCPB but water is delivered to the core only after reactor vessel pressure is reduced. This system provides the capability to cool the fuel by spraying water into each fuel channel. The LPCS loop

functioning in conjunction with either the ADS or HPCS can maintain the fuel cladding below the prescribed temperature following a LOCA.

1.2.2.5.8.4 Low-Pressure Coolant Injection. The LPCI is an operating mode of the RHR system, but is discussed here because the LPCI mode acts as an engineered safety feature in conjunction with other ECCS. The LPCI uses the pump loops of the RHR to inject cooling water directly into the pressure vessel. The LPCI is actuated by conditions indicating a breach in the RCPB, but water is delivered to the core only after reactor vessel pressure is reduced. The LPCI operation provides the capability of core reflooding, following a LOCA, in time to maintain the fuel cladding below the prescribed temperature limit.

1.2.2.5.9 Primary Containment

1.2.2.5.9.1 Functional Design. The primary containment is part of the overall containment system which provides the capability to reliably limit the release of radioactive materials to the environs subsequent to the occurrence of the postulated LOCA so that offsite doses will be below the limits stated in 10 CFR Part 50.67. Its design employs an over-and-under, steel pressure vessel which houses the reactor vessel, the RRC loops, and other branch connections of the reactor primary system. The pressure suppression system consists of a drywell, a pressure suppression chamber which stores a large volume of water, a connecting submerged vent system between the drywell and water pool, isolation valves, containment cooling system, and other service equipment. In the event of a RCPB piping failure within the drywell, reactor water and steam would be released into the drywell air space. The resulting increase of drywell pressure would then force a mixture of air, steam, and water through the vents into the pool of water which is stored in the suppression pool, resulting in a rapid pressure reduction in the drywell. Air which is transferred to the suppression chamber, pressurizes the suppression chamber, and is subsequently vented back to the drywell.

1.2.2.5.9.2 Drywell Cooling System. The drywell cooling system is based on recirculating cooling water through the drywell air-handling units to maintain the required ambient temperature. Air is distributed through ductwork and/or up through the annular space between the reactor vessel insulation and the sacrificial shield wall. Air is distributed to areas requiring cooling, such as the RRC motors, the CRD area, and the bellows area. Return air is ducted back to the operating units. The arrangement simplifies the design, operation, and air distribution balance of the system.

Reactor building closed cooling water (RCC) is supplied to the air handling units to dissipate absorbed heat only under normal and loss of power conditions.

The drywell cooling system is not required for safe shutdown, but it is designed with redundant equipment and powered from essential buses to ensure continuous operation to satisfy the power-generation design objective.

The drywell cooling system is designed to operate during offsite power loss. Control switches for operating the equipment are located in the main control room.

1.2.2.5.9.3 Suppression Pool Cooling. The containment cooling subsystem of the RHR system is placed in operation to limit the temperature of the water in the suppression pool following a design basis LOCA, to control the pool temperature during normal operation of the SRVs and the RCIC system, and to reduce the pool temperature following an isolation transient. In the containment cooling mode of operation, the RHR main system pumps take suction from the suppression pool and pump the water through the RHR heat exchangers where cooling takes place by transferring heat to SW. The fluid is then discharged back to the suppression pool or the RPV.

1.2.2.5.9.4 Containment Spray. The redundant containment spray cooling subsystems of the RHR system provide containment cooling for postaccident conditions. Water pumped through the RHR heat exchangers can be diverted to spray headers in the drywell and above the suppression pool. The spray removes energy from the drywell atmosphere by condensing the water vapor. The drywell spray also removes particulate fission product from the drywell atmosphere. Approximately 5% of this flow can be directed to the suppression chamber to cool the gas above the water surface.

1.2.2.5.9.5 Containment Atmosphere Control. In the event of a LOCA, hydrogen and oxygen will be generated in the reactor. Containment atmosphere control is provided by inerted containment, containment atmosphere mixing, and hydrogen and oxygen monitoring in a post-LOCA event.

1.2.2.5.10 Primary Containment and Reactor Vessel Isolation System

The primary containment and reactor vessel isolation system includes sensors, trip channels, control switches and remotely activated valve closing mechanisms associated with the valves, which, when closed, effect isolation of the primary containment or reactor vessel or both.

The purpose of the system is to provide timely protection against the onset and consequences of accidents involving the gross release of radioactive materials from the fuel and the nuclear system process barrier. The primary containment and reactor vessel isolation control system initiates automatic isolation of the RCPB and the primary containment vessel whenever monitored variables exceed preselected operation limits.

All pipelines that both penetrate the primary containment and offer a potential release path for radioactive material are provided with redundant isolation capabilities.

1.2.2.5.11 Main Steam Line Isolation Valves

Although all pipelines that both penetrate the containment and offer a potential release path for radioactive material are provided with redundant isolation capabilities, the main steam lines, because of their large size and large mass flow rates, are given special isolation consideration. Automatic MSIVs are provided in each MS line. Each is powered by both air pressure and spring force. These valves fulfill the following objectives:

a. Prevent excessive damage to the fuel barrier by limiting the loss of reactor coolant from the reactor vessel resulting from either a major leak from the steam piping outside the primary containment or from a malfunction of the pressure control system resulting in excessive steam flow from the reactor vessel,

b. Limit the release of radioactive materials (i.e., iodine spiking) by isolating the RCPB in case of a rapid depressurization of RPV and resulting release of radioactive materials from the fuel to the reactor cooling water and steam, and

c. Limit the release of radioactive materials by closing the primary containment barrier in case of a major leak from the nuclear system inside the primary containment.

1.2.2.5.12 Main Steam Line Flow Restrictors

A venturi-type flow restrictor is installed in each MS line. These devices limit the loss-of-coolant from the reactor vessel before the MSIVs are closed in case of an MS line break outside the primary containment.

1.2.2.5.13 Main Steam Line Radiation Monitoring System

The main steam line radiation monitoring system consists of four gamma radiation monitors located externally to the main steam lines just outside the containment. The monitors are designed to detect a gross release of fission products from the fuel. On detection of high radiation, the trip signals generated by the monitors are used to initiate a closure to the reactor water sample valves, mechanical vacuum pump trip, the mechanical vacuum pump lines isolation, and alarms.

1.2.2.5.14 Standby Service Water and High-Pressure Core Spray Service Water Systems

The SW system consists of two completely redundant systems. Each system consists of a pump and piping supplying the associated RHR system heat exchanger, standby diesel generator, essential heating, ventilating, and air conditioning (HVAC) coolers, RHR pump seal coolers, SW motor bearing coolers, and sample coolers with safety grade cooling water from

the UHS spray ponds. The Division I SW system also provides cooling water to the LPCS motor bearing cooler.

Cooling water is supplied during a postulated LOCA to the RHR heat exchangers to remove heat when the containment cooling mode of the RHR system is placed in operation. During normal operation, SW is also supplied to the RHR heat exchangers for the shutdown function of the RHR system.

The SW is available to the shell side of the fuel pool cooling and clean up (FPC) system heat exchangers in the event that the normal cooling water supply from the RCC system becomes unavailable.

The HPCS SW system shares spray pond A with the SW system. The pump supplies cooling water to the HPCS diesel generator and the essential HVAC coolers for the HPCS diesel generator and HPCS pump areas.

Cooling water is supplied to all diesel generator cooling systems whenever the diesel generators are started.

1.2.2.5.15 Reactor Building - Secondary Containment

The reactor building completely surrounds the primary containment. The building provides secondary containment when the primary containment is closed and in service, and serves as the primary barrier during operations with the potential to drain the reactor vessel (OPDRV). The reactor building also houses refueling and reactor servicing equipment, new and spent fuel storage facilities, and other reactor safety and auxiliary systems. Secondary containment is not required during movement of irradiated fuel assemblies or core alterations.

The design of the reactor building includes provisions for seismic load resistance and low infiltration and exfiltration rates. The building consists of poured-in-place, reinforced-concrete exterior walls up to the refueling floor. Above this level, the building structure is steel frame with insulated metal siding with sealed joints. Access to the building is through interlocked double doors.

1.2.2.5.16 Reactor Building Ventilation Exhaust Radiation Monitoring System

The reactor building ventilation exhaust radiation monitoring system consists of a number of radiation monitors arranged to monitor the activity level of the ventilation exhaust from the reactor building and primary containment. Upon detection of high radiation, the reactor building is automatically isolated and the SGT system is started.

1.2.2.5.17 Standby Gas Treatment System

The SGT system consists of two identical filter trains. Each filter train consists of a filter unit, two fans, ductwork, and associated valves.

Either filter train may be considered as an installed spare with the other train capable of passing the required amount of air. Either train alone is capable of exchanging the total reactor building volume once in a 24 hr period.

Each filter unit contains electric heaters, a prefilter, high-efficiency particulate filters (water and fire resistant), an iodine filter (high ignition temperature), and instrumentation to measure temperature and flow.

The system maintains a slightly negative internal building pressure and can process all gaseous effluent prior to its discharge from the reactor building.

All equipment is connected to the essential buses and is started either automatically or manually from the main control room.

1.2.2.5.18 Standby Alternating Current Power Supply System

The standby ac power supply system consists of two diesel generator sets, switchgear, and associated distribution system equipment and auxiliaries.

These diesel generator sets are associated with redundant (Divisions 1 and 2) separation divisions; each diesel generator set serves a particular division. The capacity of each diesel generator set is sufficient to attain shutdown under both normal and LOCA conditions, in the event that both the offsite and the normal auxiliary power sources are unavailable to supply plant loads. Since load distribution is such that redundant auxiliary systems are separated by division, safe shutdown can be achieved with only one of the two diesel generators operating.

The standby ac power supply system diesel generators and associated equipment are designed to Class 1E standards and are located within Seismic Category I structures. Equipment of each division is separated so that failure of any component of one division will not jeopardize proper functioning of the other division.

Although it is not a part of the standby ac power supply system, another independent diesel generator unit supplies ac power exclusively to the HPCS system (see Section 1.2.2.5.8.1) in the event that both the offsite and the normal auxiliary power sources are unavailable to supply plant loads.

The HPCS diesel generator may also be cross connected to either Division 1 or to Division 2 as described in Section 8.3.1.1.7.2.1.

1.2.2.5.19 Direct Current Power Supply System

The dc power supply system consists of station batteries, battery chargers, distribution equipment, and related auxiliaries.

The dc system furnishes power at three voltage levels: 250 V, 125 V, and +24 V. The 250-V and 125-V subsystems supply power to both Class 1E and non-Class 1E loads; the 24-V subsystem supplies power for the startup range and power range neutron monitoring systems.

The primary power sources for the system are the dc output station battery chargers. Station batteries associated with each charger operate in a "float-charge" configuration to ensure maintaining the batteries in a fully charged condition. In the event of loss of charger dc output, the station batteries furnish a secondary source of dc supply.

The 125-V and +24-V dc power supply subsystems are each divided into electrically and physically independent divisions. Each battery, together with its independent battery charger, is associated with one of the segregated divisions. The batteries and their associated chargers are located in separate rooms.

The ampere-hour capacity of each battery is capable of supplying all essential loads for a minimum of 2 hr in the event that dc output from the battery chargers is lost.

1.2.2.5.20 Standby Liquid Control System

Although not intended to provide prompt reactor shutdown, as the control rods are, the Standby Liquid Control (SLC) system provides a redundant, independent, and alternate method to bring the nuclear fission reaction to subcriticality and to maintain a subcritical condition as the reactor cools. The system makes possible an orderly and safe shutdown in the event that not enough control rods can be inserted into the reactor core to accomplish shutdown in the normal manner. The system is sized to counteract the positive reactivity effect from rated power to the cold, clean shutdown condition.

The SLC system is also used to maintain the suppression pool pH greater than 7.0 following a LOCA to minimize re-evolving gaseous iodine fission products to the containment atmosphere.

1.2.2.5.21 Safe Shutdown from Outside the Main Control Room

In the event that the control room becomes inaccessible, the reactor can be brought from power range operation to cold shutdown conditions by the use of local controls and equipment that are available outside the control room.

1.2.2.5.22 Main Steam Line Isolation Valve Leakage Control System (Deactivated)

The main steam line isolation valve leakage control (MSLC) system was designed to minimize the fission products which could bypass the SGT system after a LOCA. The MSLC system is not credited for accident mitigation and is no longer needed; MSLC is administratively de-activated. Connections between MSLC and other systems are physically isolated, MSLC components are de-energized, closed, or otherwise taken out of service.

1.2.2.5.23 Fuel Pool Cooling and Cleanup System

The FPC system provides for the removal of decay heat from stored spent fuel and maintains specified water temperature, purity, clarity, and level. This prevents boiling of the pool water and controls the buildup of excessive radioactive materials in the cooling water, thereby minimizing potential radiation exposure to plant personnel. The cooling portion of the system is designed to Seismic Category I requirements and may be isolated from the Seismic Category II cleanup portion of the system by automatic Seismic Category I isolation valves which actuate on low-fuel pool water level. Normally the RCC system furnishes non-safety grade cooling water to the FPC system. If required, safety grade cooling and makeup water is available to the FPC system from the SW system.

1.2.2.5.24 Hardened Containment Vent (HCV) System

The HCV system is designed to meet the requirements of NRC Order EA-13-109. The primary design objective of the HCV system is to provide sufficient venting capacity from the wetwell to prevent an overpressure failure of the containment by maintaining containment pressure below the primary containment design pressure and the primary containment pressure limit (PCPL). The HCV system is designed to operate during severe accident conditions which include the elevated temperatures, pressures, radiation levels, and concentrations of combustible gases such as hydrogen and carbon monoxide associated with accidents involving extensive core damage, including accidents involving a breach of the reactor vessel by molten core debris.

The HCV system is designed as a stand-alone system that can function without the support of other plant systems. Other than the two containment isolation valves, the remaining components such as the dedicated nitrogen and battery systems and control room and remote operating stations or instrumentation are not discussed or assumed in mitigating any Chapter 15 accidents.

1.2.2.6 <u>Power Conversion System</u>

1.2.2.6.1 Turbine Generator

The turbine is an 1800 rpm, tandem-compound (one double-flow high-pressure turbine and three double-flow low-pressure turbines), reheat unit with an electrohydraulic governor for

normal operation. The turbine generator is provided with an emergency trip system for turbine overspeed. The rating of the turbine generator is 1,173,046 kW.

The generator is a direct-driven, three-phase, 60 Hz, 25,000 V, 1800 rpm, hydrogen inner-cooled, synchronous generator rated at 1,230 MVA at 0.975 power factor, 0.58 short circuit ratio at a maximum hydrogen pressure of 78 psig.

1.2.2.6.2 Main Steam System

The MS system consists of four 26-in. diameter lines (which expand to 30-in. diameter lines inside the turbine building) extending from the outermost MSIVs to the main turbine stop valves. The use of four main steam lines permits testing of the turbine stop valves and MSIVs during station operation with only a minimum of load reduction. The design pressure and temperature of the MS system from the outermost MSIV to the turbine stop valve is 1250 psig at 575°F. Other features include drains and parts of the turbine bypass system.

1.2.2.6.3 Main Condenser

The main condenser is a triple-pressure, single-pass, deaerating-type condenser with a divided water box. The condenser includes provisions for accepting up to 25% of the MS flow at design conditions from the turbine bypass system and serves as a heat sink for several other flows, such as exhaust steam from the RFW pump turbines, cascading heater drains, feedwater heater shell operating vents, and condensate pump suction vents.

1.2.2.6.4 Main Condenser Evacuation System

The main condenser evacuation system is designed to remove noncondensable gases from the condenser, including air inleakage and dissociation products originating in the reactor, and to continuously exhaust them to the gaseous radwaste system during operation. The system consists of two 100%-capacity, twin-element first stage and single-element second stage steam jet air ejector units complete with intercondensers for normal plant operation and a mechanical vacuum pump for use during startup. Discharge from the vacuum pumps during startup is routed to the elevated release point.

1.2.2.6.5 Turbine Gland Seal System

The turbine gland seal system is designed to provide a means of preventing air leakage into or radioactive steam leakage out of the turbine. The system consists of two 100% steam evaporators, steam seal pressure regulators, steam seal header, gland seal steam condenser and blowers, and the associated piping, valves, and instrumentation.

1.2.2.6.6 Steam Bypass System and Pressure Control System

A turbine bypass system is provided which passes steam directly to the main condenser under the control of the pressure regulator. Steam is bypassed to the condenser whenever the reactor steaming rate exceeds the load permitted to pass to the turbine generator. The capacity of the turbine bypass system is 25% of the turbine design steam flow. The Digital Electro-Hydraulic (DEH) control system provides main turbine control (governor) valve and bypass valve position demands so as to maintain a nearly constant reactor pressure during normal plant operation.

1.2.2.6.7 Circulating Water System

The CW system provides the condenser with a continuous supply of cooling water. It is a closed system utilizing forced draft cooling towers. Makeup water to the system is provided from TMU pumps located in an intake structure on the Columbia River. The makeup water replaces the water lost by evaporation, drift, and blowdown.

1.2.2.6.8 Condensate and Feedwater System

The condensate and feedwater system pumps condensate from the condenser hotwell to the RPV. Condensate is pumped by three main condensate (COND) pumps through the gland seal steam condenser, the steam jet air ejector condensers, and the offgas condenser. After leaving the offgas condenser, the condensate is pumped through a full-flow condensate filter-demineralizer system. The filter-demineralizer effluent is then pumped by three condensate booster pumps through the five low-pressure heaters. The last low-pressure heater discharges to the suction of the RFW pumps. The discharge from the two turbine-driven RFW pumps passes through the sixth stage of feedwater heating and then flows to the RPV. Feedwater flow is controlled by varying the speed of the steam-driven turbine.

1.2.2.6.9 Condensate Filter-Demineralizer System

The full-flow condensate filter-demineralizer system with instrumentation and semiautomatic controls is designed to ensure a constant supply of high-quality water to the reactor.

1.2.2.7 Electrical Systems, Instrumentation, and Control

1.2.2.7.1 Electrical Power Systems

The plant consists of a single main generator directly connected to a main power transformer through an isolated phase electrical bus duct. The main power transformer steps up the output of the 25-kV generator to a nominal 500-kV transmission system voltage.

The output of the main power transformer is connected to a 500-kV switchyard consisting of circuit breakers, disconnect switches, buses, and associated equipment arranged in a ring bus configuration.

A 230-kV offsite supply is provided to a separate startup auxiliary transformer to supply maximum startup, operating and shutdown load requirements for a normal plant auxiliary loads and for safety loads. In addition, a separate 115-kV offsite supply serves a backup auxiliary transformer with sufficient capacity to provide the power requirements of plant safe shutdown loads.

1.2.2.7.2 Electrical Power Systems Process Control and Instrumentation

Main generator electrical controls are located in the main control room. These include main generator circuit breaker controls, synchronizing equipment, and generator excitation and voltage control equipment. Instrumentation is also provided in the main control room for the main generator connections and equipment. This includes indicating instruments for voltage, current, kW, MVAR, and frequency. Recording instruments are provided for generator MW output and main bus voltage. Kilowatt-hour meters are provided for main generator outputs and for auxiliary power system loads. Instrumentation is provided for monitoring generator and transformer temperatures. Other types of monitoring instrumentation are provided as required to ensure proper operation of equipment. Circuit breaker controls, metering, and indication for the auxiliary power system are also located in the main control room.

High-speed protective relaying equipment is provided for the main generator, main and auxiliary transformers, main buses, transmission lines, and interconnecting cables and bus ducts to provide proper isolation of this equipment in the event of electrical faults. The protective relay system includes breaker failure protection and backup relaying to ensure proper isolation of electrical faults in the event of a failure of the primary protective relaying.

1.2.2.7.3 Nuclear System Process Control and Instrumentation

1.2.2.7.3.1 Reactor Manual Control System. The reactor manual control system (RMCS) provides the means by which control rods are positioned from the control room for power control. The system operates valves in each CRD hydraulic control unit to change control rod position. Only one control rod can be manipulated at a time. The RMCS includes the logic that restricts control rod movement (rod block) under certain conditions as a backup to procedural controls.

1.2.2.7.3.2 Recirculation Flow Control System. During normal power operation, a variable frequency power supply is used to control flow by varying the RRC pump motor speed. Adjusting the frequency changes motor speed and the coolant flow-rate through the core, thereby changing the core power level.

1.2.2.7.3.3 Neutron Monitoring System. The neutron monitoring system is a system of in-core neutron detectors and out-of-core electronic monitoring equipment. The system provides indication of neutron flux, which can be correlated to thermal power level for the entire range of flux conditions that can exist in the core. The source range monitors (SRM) and the intermediate range monitors (IRM) provide flux level indications during reactor startup and low power operation. The local power range monitors (LPRM) and average power range monitors (APRM) allow assessment of local and overall flux conditions during power range operation. The traversing in-core probe system (TIP) provides a means to calibrate the individual LPRM sensors. The neutron monitoring system provides inputs to the reactor manual control system to initiate rod blocks if preset flux limits are exceeded, and inputs to the RPS to initiate a scram if other limits are exceeded.

1.2.2.7.3.4 Refueling Interlocks. A system of interlocks that restricts movement of refueling equipment and control rods when the reactor is in the refueling and start-up modes is provided to prevent an inadvertent criticality during refueling operations. The interlocks back up procedural controls that have the same objective. The interlocks affect the refueling platform, refueling platform hoists, fuel grapple, and control rods.

1.2.2.7.3.5 Reactor Vessel Instrumentation. In addition to instrumentation for the nuclear safety systems and ESF, instrumentation is provided to monitor and transmit information that can be used to assess conditions existing inside the reactor vessel and the physical condition of the vessel itself. This instrumentation monitors reactor vessel pressure, water level, coolant temperature, reactor core differential pressure, coolant flow rates, and RPV head inner seal ring leakage.

1.2.2.7.3.6 Process Computer System. An on-line process computer is provided to monitor and log process variables and to make certain analytical computations. The rod worth minimizer function of the computer prevents rod withdrawal under low power conditions if the rod to be withdrawn is not in accordance with a preplanned pattern. The effect of the rod block is to limit the reactivity worth of the control rods by enforcing adherence to the preplanned rod pattern.

1.2.2.7.4 Power Conversion Systems Process Control and Instrumentation

1.2.2.7.4.1 Digital Electro-Hydraulic Control System. The DEH control system maintains control of the turbine governor valves and turbine bypass valves to allow proper generator and reactor response to system load demand changes while maintaining the nuclear system pressure essentially constant. When the generator is not connected to the grid, the DEH control system maintains turbine-generator speed (frequency) in response to reactor pressure changes by adjusting steam flow to the turbine valves and bypass valves.

The turbine generator speed/load controls can initiate rapid closure of the turbine control (governor) valves and rapid opening of the turbine bypass valves to prevent turbine overspeed on a generator electric load loss.

1.2.2.7.4.2 Feedwater System Control. A three-element controller is used to regulate the feedwater system so that proper water level is maintained in the reactor vessel. The controller uses main steam flow rate, reactor vessel water level, and feedwater flow rate signals. The feedwater control signal is used to control the speed of the steam turbine-driven feedwater pumps. During startup, shutdown, and low plant load conditions, the steam turbine-driven feedwater pumps are run at constant speed, and the feedwater control signal is used to modulate a startup feedwater control valve to maintain proper reactor water level.

1.2.2.8 Radioactive Waste Systems

1.2.2.8.1 Liquid Radwaste System

This system collects, treats, stores, and disposes of all radioactive liquid wastes. These wastes are accumulated directly in radwaste tanks or in sumps at various locations throughout the plant for subsequent transfer to collection tanks in the radwaste facility. Wastes are processed on a batch basis with each batch being processed by such method or methods appropriate for the quality and quantity of materials determined to be present. Processed liquid wastes may be returned to the condensate system or discharged to the circulating water blowdown line to the river. The liquid wastes in the discharge piping are diluted with circulating water blowdown to achieve a concentration at the site boundary which is below the limits of 10 CFR Part 20.

Equipment is selected, arranged, and shielded to permit operation, inspection, and maintenance with minimum personnel exposure. For example, tanks and processing equipment which contain significant radiation sources are located behind shielding, and sumps, pumps, instruments, and valves are located in controlled access rooms or spaces. Processing equipment is selected and designed to require a minimum of maintenance.

Protection against accidental discharge of liquid radioactive waste is provided by design redundancy, instrumentation for detection and alarm of abnormal conditions, and procedural controls.

1.2.2.8.2 Solid Radwaste System

Solid radioactive wastes are collected, processed, and packaged for storage and ultimate burial. These wastes are generally stored on the site until the short half-lived isotopes have decayed. Wet solid wastes are collected, dewatered, and solidified in steel containers. Examples of these wastes are filter residue, concentrated wastes, and spent resins. Dry solid wastes such as paper, air filters, rags, and used clothing are compressed and packaged in steel containers.

1.2.2.8.3 Gaseous Radwaste System

The purpose of the gaseous radwaste system is to process and control the release of gaseous radioactive wastes to the site environs so that the total radiation exposure to persons outside the controlled area does not exceed the limits of the applicable regulations, 10 CFR 20 and 10 CFR 50, Appendix I, even with some defective fuel rods.

The offgases from the main condenser are the major source of gaseous radioactive waste. The treatment of these gases includes volume reduction through a catalytic hydrogen-oxygen recombiner, water vapor removal through a condenser, decay of short-lived radioisotopes through a holdup line, further condensation, filtration, adsorption of isotopes on activated charcoal beds, further filtration through high efficiency filters, and final release.

Continuous radiation monitors are provided which indicate radioactive release from the reactor and from the charcoal absorbers. The radiation monitors are used to isolate the OG system on high radioactivity to prevent gas of unacceptably high activity from release.

Since clean gland seal steam is used, the offgases from the gland seal steam condenser are not treated prior to release.

The design of the OG system is such that the annual exposure to any offsite person during normal operation from gaseous sources will be ALARA and less than 10 CFR 20.

1.2.2.9 Radiation Monitoring and Control

1.2.2.9.1 Process Radiation Monitoring

Radiation monitors are provided on various lines to monitor either for radioactive materials released to the environs via process liquids and gases or for process system malfunctions. All effluents from the plant which are potentially radioactive are monitored. Several of the effluent monitoring systems record the results prior to discharge as noted on the following list of the major monitoring systems provided.

a. Main steam line radiation monitoring system,

b. Air ejector and offgas radiation monitoring systems (results recorded except for the charcoal bed vault),

c. Liquid radwaste effluent radiation monitoring system,

d. Plant service water and circulating water blowdown radiation monitoring systems,

e. Standby service water radiation monitoring system,

f. Reactor building ventilation exhaust plenum radiation monitoring system (results recorded),

g. Reactor building elevated release point radiation monitoring system (results recorded except for particulate/iodine sample),

h. Turbine building ventilation exhaust radiation monitoring system, (results recorded),

i. Radwaste building ventilation exhaust radiation monitoring system (results recorded), and

j. Reactor building closed cooling water monitoring system.

1.2.2.9.2 Area Radiation Monitors

Radiation monitoring devices are provided in key areas throughout the plant buildings to ensure that plant personnel will not be inadvertently exposed to high radiation doses.

1.2.2.9.3 Site Radiological Environmental Monitoring

A comprehensive radiation surveillance program was initiated in the spring of 1978 to measure radiation levels in the environs surrounding the plant. The program is designed to measure radiation exposure or radioisotope levels in the environment.

The details of this monitoring program are given in the Offsite Dose Calculation Manual (ODCM).

1.2.2.9.4 Liquid Radwaste System Control

Liquid wastes to be discharged are handled on a batch basis with protection against accidental discharge provided by procedural controls. Instrumentation with alarms to detect abnormal concentration of the radwaste is provided, including automatic closure of discharge valves isolating the system from the environment.

1.2.2.9.5 Solid Radwaste System Control

The solid radwaste system collects, treats, and stores solid radioactive wastes for offsite shipment. Wastes are handled on a batch basis. Radiation levels of the various batches are monitored by the operator.

1.2.2.9.6 Gaseous Radwaste System Control

Gaseous radwastes are discharged through a reactor building elevated release point. Radiation levels of the release are continuously monitored and recorded. Isolation of the main condenser

offgas is automatically initiated prior to release should the activity of the offgas exceed discharge limits.

1.2.2.10 Shielding

The shielding in the plant is designed to minimize exposure of plant personnel to radiation. The radiation levels during operation or shutdown conditions have been considered in determining the shielding requirements.

1.2.2.11 Fuel Handling and Storage Systems

1.2.2.11.1 New and Spent Fuel Storage

New and spent fuel storage racks are designed to prevent inadvertent criticality and load buckling. Sufficient coolant and shielding are maintained to prevent overheating and excessive personnel exposure, respectively. The design of the fuel pool provides for corrosion resistance, adherence to Seismic Category I requirements, and prevention of K_{eff} from exceeding 0.95 under dry or flooded conditions.

1.2.2.11.2 Fuel Handling System

The fuel handling equipment includes a fuel inspection stand, fuel preparation machine, a 125-ton crane, a refueling platform, a new fuel transfer basket, jib cranes, and other related tools for fuel and reactor servicing.

1.2.2.11.3 Fuel Pool Cooling and Cleanup System

The FPC system removes decay heat from stored spent fuel and maintains specified water temperature, purity, clarity, and level. This prevents fuel pool boiling and buildup of excessive radioactive materials in the cooling water, thereby minimizing possible exposures to plant personnel.

Cooling of spent fuel is accomplished by the Seismic Category I cooling system as described in Section 9.1.3. It can be isolated from the Seismic Category II cleanup portion of the system by automatic, redundant, Seismic Category I isolation valves which actuate on low fuel pool water level. If required, safety grade cooling and makeup water from the SW system is available to the system by remote-manual operation of redundant Seismic Category I valves to provide long-term cooling and prevent fuel pool boiloff which might result in unacceptable building environmental conditions.

1.2.2.12 Cooling Water and Auxiliary Systems

1.2.2.12.1 Reactor Building Closed Cooling Water System

The RCC system consists of pumps, heat exchangers, controls, and instrumentation to provide adequate cooling for the reactor auxiliary systems. The system is designed to provide a closed cooling water loop between nonessential systems which are potentially radioactive and the TSW system.

1.2.2.12.2 Plant Service Water System

Normal TSW is supplied from service water pumps located in the circulating water pump house. Two service water pumps are provided. The TSW system is designed to remove heat from various auxiliary equipment located within the plant.

1.2.2.12.3 Ultimate Heat Sink

Two spray ponds that serve as the UHS conservatively have a combined equivalent storage of 30 days, assuming no makeup and maximum evaporation and drift losses. Provisions are made to replenish the sink to allow continued cooling capability beyond the initial 30-day period.

1.2.2.12.4 Demineralized Water Makeup System

The DW makeup system is comprised of the trailer-mounted demineralizers and the DW system.

The DW system is designed to provide demineralized water to the CSTs for plant makeup and demineralized water for other plant operating requirements.

1.2.2.12.5 Potable Water and Sanitary Drain Systems

The plant potable water (PW) system provides water for drinking and sanitary purposes. Potable water is normally supplied from the tower makeup system (see Section 9.2.3).

The sanitary drain system effluent is directed to a central sanitary waste treatment facility which uses aerated lagoons in series with lined facultative stabilization ponds. The treatment plant, about 2500 ft SE of the CGS reactor, also receives waste from the WNP-1/4, the Plant Support Facility, and the DOE's 400 Area.

1.2.2.12.6 Process Sampling Systems

The process sampling system provides process information that is required to monitor plant and equipment performance and changes to operating parameters. Representative liquid and

gas samples are taken automatically and/or manually during normal plant operation for laboratory or on-line analyses.

1.2.2.12.7 Condensate Supply System

The condensate storage facility provides a source of water for testing and makeup during operation. Two 400,000 gal CSTs are interconnected to simultaneously supply condensate to the main condenser via one header, to the CRD pumps via a second header, and to the RHR, RCIC, and HPCS systems and condensate supply and condensate filter/demineralizer backwash pumps via a third header. The condensate supply pumps deliver condensate to miscellaneous services in the reactor and radwaste buildings.

Condensate is returned to the CSTs from the HPCS, RCIC, and radwaste systems, from CRD, condensate supply, and condensate filter/demineralizer backwash pump mini-flows, and from the main condensate system (equivalent to excess CRD injection water). Initial fill and makeup is from the DW system.

1.2.2.12.8 Equipment and Floor Drainage Systems

Plant equipment and floor drainage systems handle both radioactive and nonradioactive drains. Drainage systems which carry radioactive waste are isolated from drainage systems which do not carry radioactive waste.

All drains in the reactor building and radwaste building are considered radioactive. Turbine building drains are divided into radioactive and nonradioactive but all are directed to the radwaste system for processing. Floor and equipment drains in the diesel generator building and service building are routed to the storm water drainage system. The storm water drainage system is normally nonradioactive, however some accumulation of radioactive material (notably tritium) can occur.

1.2.2.12.9 Compressed Air Systems

The compressed air system consists of the control and service air system and the containment instrument air (CIA) system.

The control air system (CAS) is designed to supply clean, dry, oil-free air to station instrumentation and controls and to the accumulators of the MSIVs located outside the primary containment.

The service air (SA) system is designed to supply clean, oil-free air for station services, such as backwashing demineralizers and filters, hose connections for maintenance throughout the station and breathing air at selected locations.

The CIA system is designed to deliver nitrogen or clean, dry, oil-free air for MSIVs, SRV accumulators, and pneumatic operators located inside the primary containment.

1.2.2.12.10 Heating, Ventilating, and Air Conditioning Systems

The HVAC systems are designed to maintain proper air quality for personnel comfort and safety. In addition, the main control room, the critical switchgear area, the cable spreading room HVAC systems, the SW pump room heat removal systems, the reactor building emergency pump and critical electric equipment area cooling systems, and the ventilation system for the standby diesel generators are designed to operate under all station conditions. The primary containment drywell cooling and ventilation system is designed to operate during normal operation and under most upset conditions except a LOCA. All air distribution systems are designed so that airflow is directed from areas of lesser potential contamination to areas of progressively greater potential contamination.

Three separate and redundant HVAC systems service the main control room, cable spreading room, and critical switchgear areas. SW is used as the cooling medium for each system when the normal cooling water supply is unavailable.

Heating and ventilation for the standby diesel generator rooms is provided continuously for each diesel generator unit. Water cooled air handling units provide additional cooling when the diesel generators operate.

The turbine building is provided with a once-through ventilation system based on the use of evaporative coolers.

Ventilation for the radwaste building is provided by means of a once-through ventilation system with particulates filtered before release to the atmosphere.

The SW pump room heat removal systems consist of two independent and separate fan coil units.

The reactor building emergency pump and critical electric equipment area cooling system consists of 13 air handling units which operate to supply cool air to each of the critical equipment rooms when pumps are started and during abnormal conditions.

The primary containment drywell cooling and ventilation system consists of five fan coil units and nine recirculation fans. During normal operation, a minimum three out of five fan coil units are operating.

Ventilation for the reactor building is provided by a once-through ventilation system based on the use of evaporative coolers. The system incorporates the necessary isolation valves to

ensure the necessary secondary containment integrity. A drywell and suppression chamber purge capability is provided as part of this system.

Other HVAC systems provide ventilation to the service building and other miscellaneous areas.

1.2.2.12.11 Fire Protection System

The FP system is designed to provide for the detection and extinguishing of fires.

Manual pull stations and automatic fire detectors are located appropriately throughout the plant and fire alarms are annunciated in the main control room.

The FP system provides a reliable water distribution system for extinguishing fires. Two motor-driven fire pumps are used for normal service, with a diesel-engine-driven fire pump as a backup. A second diesel-driven fire pump with a separate water supply provides an additional backup. Motor-driven jockey pump is provided to maintain system pressure and to prevent cycling of the main fire pumps.

Automatic suppression systems provide protection to higher hazard areas of the plant including:

- Deluge systems protect the transformers and most other areas containing oil piping and oil storage equipment.
- A low-pressure carbon dioxide (CO_2) system is provided for the generator exciter housing.
- A total flooding Halon system is provided for the main control room power generation control complex (PGCC) subfloor.
- Wet pipe sprinklers protect the turbine/generator bearings and other miscellaneous areas.
- Preaction sprinkler systems protect diesel generators, day tank/transfer pump rooms, and areas with high concentrations of electrical cables.

Manual suppression includes:

- Fire hydrants spaced around the yard fire main loop.
- Fire hose stations located throughout the plant.

- Portable fire extinguishers of appropriate types are strategically and conspicuously placed throughout the plant.

1.2.2.12.12 Communications Systems

The plant communication systems are designed to provide reliable communication inside and outside the plant and from the plant to local fire protection and law enforcement authorities. The system utilizes a public address and building wide alarm system, a public telephone system, a private digital telephone system, a sound powered telephone system, a radio communication system, and an automatic transmission telephone link to the Dittmer Control Center of the Bonneville Power Administration (BPA).

1.2.2.12.13 Lighting Systems

The plant lighting systems are normal ac lighting, normal-emergency ac lighting, dc lighting, and battery-pack emergency lighting. Lighting intensities are designed to provide indoor and outdoor illumination consistent with the July 1974 Illumination Engineering Society recommendations, and meet or exceed Occupational Safety and Health Act (OSHA) requirements.

1.2.2.12.14 Normal Auxiliary Alternating Current Power System

The plant normal auxiliary ac power system consists of two normal auxiliary transformers, the 4.16-kV and 6.9-kV normal auxiliary (non-Class 1E) distribution system, the 480-V auxiliary power distribution system and the 120/208-V non-Class 1E distribution system.

The normal ac auxiliary transformers provide power to all plant auxiliaries and comprise the normal plant ac power source when the main generator is operating. One of the normal auxiliary transformers is a dual secondary type with both secondary windings stepping down the generator voltage to 4.16 kV for supply to 4.16-kV non-Class 1E switchgear buses. The other normal auxiliary transformer steps down the generator voltage to 6.9 kV for supply of 6.9-kV non-Class 1E switchgear buses.

The plant 480-V ac auxiliary power system distributes ac power necessary for normal auxiliary and ESF 480-V plant loads. All non-ESF elements of this distribution system are capable of being supplied from the normal auxiliary power source or from the startup power source via the 4.16 kV-non-Class 1E switchgear. The ESF portions of the 480-V distribution system are supplied via the 4.16-kV Class 1E switchgear, and therefore are capable of being supplied by either the normal, startup, backup, or standby sources.

The 120/208-V non-Class 1E ac power system provides power for non-ESF loads.

1.2.2.12.15 Diesel Generator Fuel-Oil Storage and Transfer System

The diesel fuel oil storage and transfer system consists of separate, independent diesel oil supply subsystems serving each of two emergency diesel generators and the HPCS diesel generator. Each full capacity subsystem consists of a fuel oil storage tank, a transfer pump, a day tank, interconnecting piping, strainers and valves, and associated instrumentation and controls.

1.2.2.12.16 Auxiliary Steam System

The auxiliary steam (AS) system normally operates only when the heating steam evaporators are inoperative during plant shutdown. The system then supplies steam to HVAC systems for air and water space heating and for humidification and also to the radwaste system. The system consists of fuel oil storage tank and transfer pumps, auxiliary boiler, blowdown tank, chemical feed tank and metering pump, deaerator and boiler feed pumps, condensate return tank pumps, steam supply and condensate return piping and valves, and associated instruments and controls.

1.2.3 COMPLIANCE WITH NRC REGULATORY GUIDES

The CGS conformance to the NRC regulatory guides is documented in Section 1.8 and in appropriate sections of this FSAR.

Table 1.2-1

Principal Regulations and Codes Followed in Plant Design

Number	Title
10 CFR series	Code of Federal Regulations, principally:
10 CFR 20	Standards for Protection Against Radiation
10 CFR 50	Licensing of Production and Utilization Facilities
10 CFR 50, Appendix A	General Design Criteria for Nuclear Power Plant Construction Permits
10 CFR 50, Appendix B	Quality Assurance Criteria
10 CFR 50, Appendix I	Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion "As Low As Is Reasonably Achievable"
10 CFR 100	Reactor Site Criteria
IEEE-279	IEEE Criteria for Nuclear Power Generating Station Protection Systems
IEEE-308	IEEE Criteria for Class IE Electrical Systems for Nuclear Power Generating Stations
ASME B&PV	ASME Boiler and Pressure Vessel Code:
Section III	Nuclear Components
Section VIII	Pressure Vessels
Section XI	Inservice Inspection
AEC Press Release IN-817	Tentative Regulatory Supplementary Criteria for ASME Code-Constructed Pressure Vessels
ANSI-B31.1.0	ANSI Standard Code for Pressure Piping, Power Piping

NOTE: Additional codes and regulations applying to specific areas of system design are referenced in discussions of individual systems.

Table 1.2-2

Plant Shielding and Zone Classification

Zone	Description	Design Dose Rate (mrem/hr)
I	Uncontrolled, unlimited access	$\leq$1.0
II	Controlled, limited access	$\leq$2.5
III	Controlled, occupancy for short periods, normally inaccessible	$\leq$100
IV	For very short periods. Secured and controlled entrance.	$>$100

NOTES:

1. Radiation Zone I areas can be occupied by plant personnel or visitors for unlimited periods.

2. Radiation Zone II areas are areas where whole body dose is not expected to exceed 1.25 rem per calendar quarter.

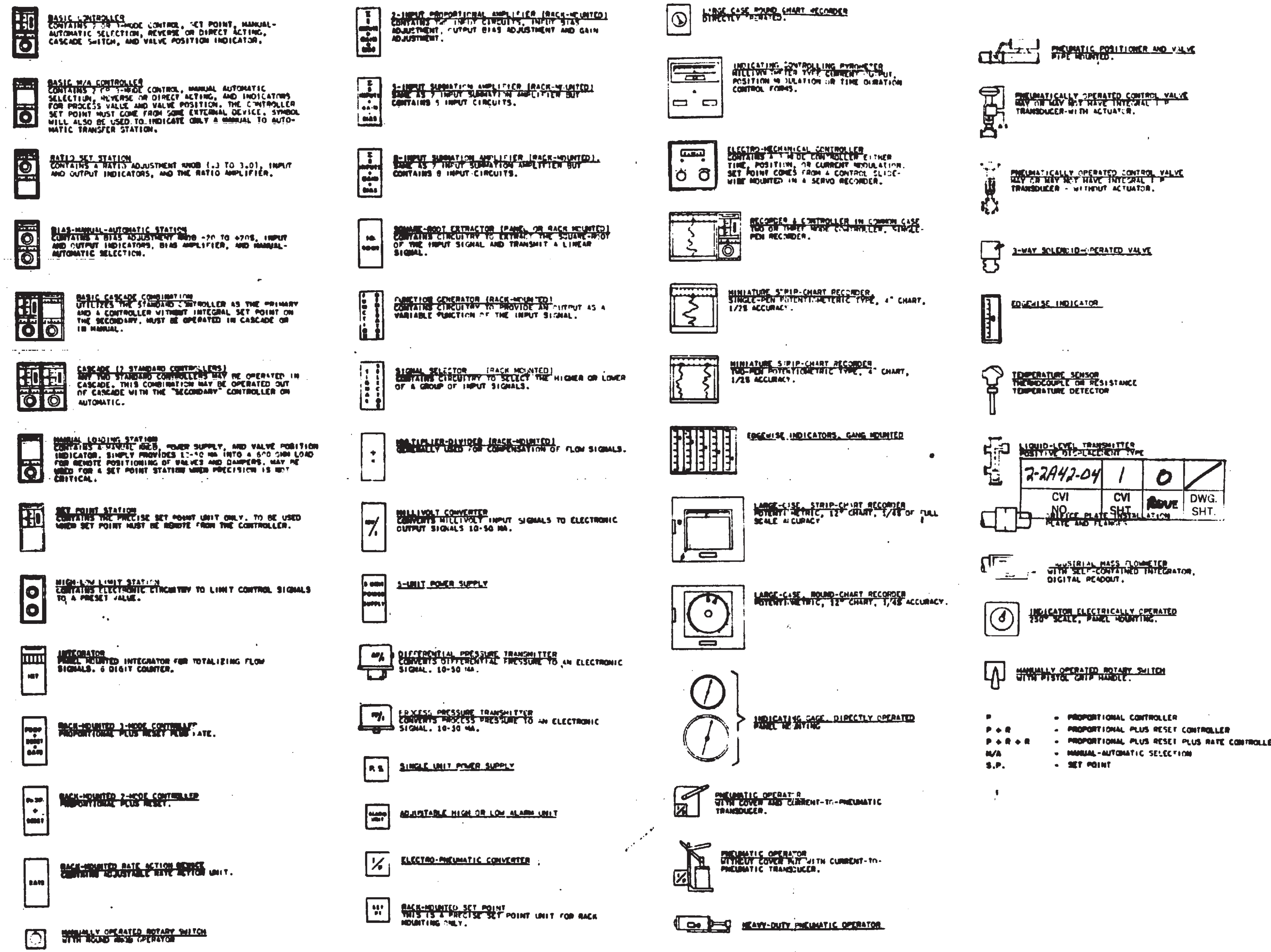
3. Areas having dose rates in excess of 100 mrem/hr are posted as high radiation areas and access is secured and controlled.

4. Radiation Zone III and IV areas can be entered only after the radiation level is determined and the working time limit is established.

5. Accessible areas have dose rates of less than 100 mrem/hr.

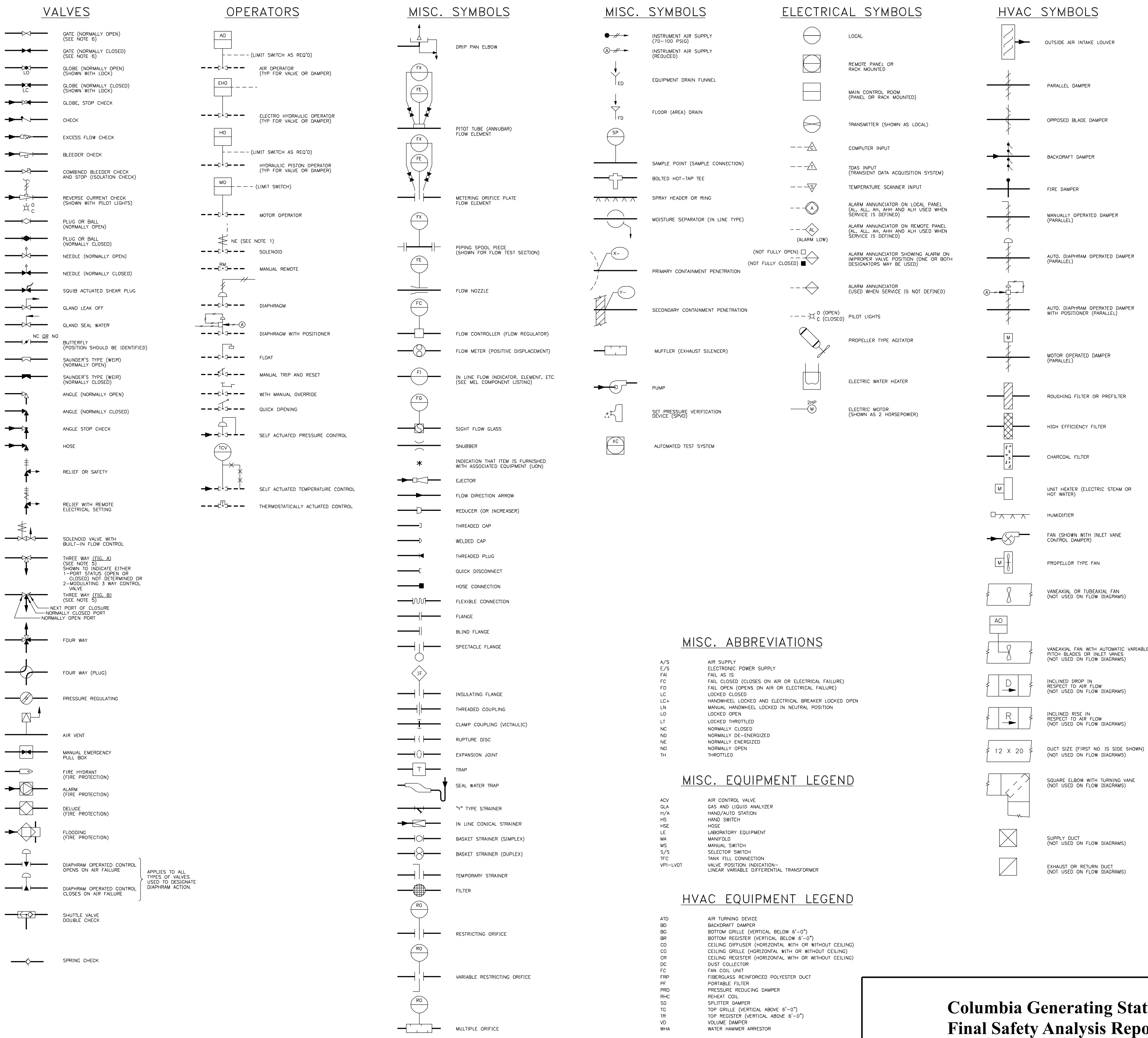
6. Access to all controlled areas is through controlled check points.

7. Controlled and limited access areas are identified by warning signs.



Columbia Generating Station Final Safety Analysis Report	General Electric Piping and Instrumentation Drawing Symbols
	Draw. No. 02A42-04,1 | Rev. 0 | Figure 1.2-25

Form No. 960690



MISC. ABBREVIATIONS

A/S	AIR SUPPLY
E/S	ELECTRONIC POWER SUPPLY
FAI	FAIL AS IS
FC	FAIL CLOSED (CLOSES ON AIR OR ELECTRICAL FAILURE)
FO	FAIL OPEN (OPENS ON AIR OR ELECTRICAL FAILURE)
LC	LOCKED CLOSED
LC+	HANDWHEEL LOCKED AND ELECTRICAL BREAKER LOCKED OPEN
LN	MANUAL HANDWHEEL LOCKED IN NEUTRAL POSITION
LO	LOCKED OPEN
LT	LOCKED THROTTLED
NC	NORMALLY CLOSED
ND	NORMALLY DE-ENERGIZED
NE	NORMALLY ENERGIZED
NO	NORMALLY OPEN
TH	THROTTLED

MISC. EQUIPMENT LEGEND

ACV	AIR CONTROL VALVE
GLA	GAS AND LIQUID ANALYZER
H/A	HAND/AUTO STATION
HS	HAND SWITCH
HSE	HOSE
LE	LABORATORY EQUIPMENT
MA	MANIFOLD
MS	MANUAL SWITCH
S/S	SELECTOR SWITCH
TFC	TANK FILL CONNECTION
VPI-LVDT	VALVE POSITION INDICATION- LINEAR VARIABLE DIFFERENTIAL TRANSFORMER

HVAC EQUIPMENT LEGEND

ATD	AIR TURNING DEVICE
BD	BACKDRAFT DAMPER
BG	BOTTOM GRILLE (VERTICAL BELOW 6'-0")
BR	BOTTOM REGISTER (VERTICAL BELOW 6'-0")
CD	CEILING DIFFUSER (HORIZONTAL WITH OR WITHOUT CEILING)
CG	CEILING GRILLE (HORIZONTAL WITH OR WITHOUT CEILING)
CR	CEILING REGISTER (HORIZONTAL WITH OR WITHOUT CEILING)
DC	DUST COLLECTOR
FC	FAN COIL UNIT
FRP	FIBERGLASS REINFORCED POLYESTER DUCT
PF	PORTABLE FILTER
PRD	PRESSURE REDUCING DAMPER
RHC	REHEAT COIL
SD	SPLITTER DAMPER
TG	TOP GRILLE (VERTICAL ABOVE 6'-0")
TR	TOP REGISTER (VERTICAL ABOVE 6'-0")
VD	VOLUME DAMPER
WHA	WATER HAMMER ARRESTOR

NOTES

1. ALL SOLENOID VALVES SHOWN IN DE-ENERGIZED POSITION. "NE" DENOTES SOLENOID NORMALLY ENERGIZED DURING PLANT OPERATION. "ND" DENOTES NORMALLY DE-ENERGIZED.
2. TYPICAL INSTRUMENT DESIGNATION (EPN):
   INSTRUMENT (SEE NOTE 9) — PS; INSTRUMENT NUMBER — 18A; SYSTEM (SEE NOTE 9) — RRC
   (EPN = RRC-PS-18A)
3. TYPICAL EQUIPMENT DESIGNATION (EPN):
   TOA-HV-1 — SYSTEM (SEE NOTE 9); EQUIPMENT (SEE NOTE 9); EQUIPMENT NUMBER
4. TYPICAL PIPING DESIGNATION:
   4" MS(1)-1-4 — PIPE SIZE; SYSTEM AND (SUBSYSTEM) (SEE NOTE 9) (SEE NOTE 10); SERVICE RATING: 1 = 150# CLASS, 2 = 300# CLASS, 3 = 600# CLASS, 4 = 900# CLASS, 5 = 1500# CLASS, 6 = 2500# CLASS; UNIQUE LINE NUMBER IDENTIFIER (AS REQ'D) FOR ASME SECTION III LINES
5. WHERE THREE WAY VALVE OPERATIONS ARE NOT FINAL, "FIG. A" IS USED (SEE VALVE SYMBOLS). WHERE VALVE OPERATION IS FINAL, "FIG. B" IS USED.
6. "NORMALLY OPEN" SYMBOL (UNSHADED) AND "NORMALLY CLOSED" SYMBOL (SHADED) VALVE POSITIONS OR ORIENTATIONS ARE DRAWN TO DEPICT THE SYSTEMS IN NORMAL POWER OPERATION OF THE PLANT, WITH STANDBY, SUPPORTING, OR EMERGENCY SYSTEMS SHOWN IN STANDBY CONDITION. TO DETERMINE ACTUAL VALVE POSITIONS THE USER MUST CONSULT THE SYSTEM OPERATION PROCEDURES AND THE OPERATIONS CREW.
7. FOR OPERATING CONDITIONS, DESIGN CONDITIONS AND COMPLETE PIPING DESIGNATION SEE THE WNP-2 SPECIFICATION TABLES 1 & 2; SECTION 15B.1 FOR B31.1 PIPING; SECTION 1 FOR ASME SECTION III PIPING AND SECTION 2 FOR ASME SECTION III TUBING.
8. CODE GROUP DESIGNATION APPLIES ONLY THROUGH PRIMARY ROOT VALVES UNLESS SPECIFICALLY NOTED OTHERWISE. M619 DRAWING SERIES GIVES CODE GROUP FOR INSTRUMENTATION.
9. SYSTEM AND COMPONENT ABBREVIATIONS CAN BE FOUND IN THE MASTER EQUIPMENT LIST (MEL) OR IN SECTION 1.2 OF THE FSAR WHICH IS UPDATED ANNUALLY.
10. THE SUBSYSTEM (NOTE 4) DESIGNATES A PROCESS FUNCTION.
11. FOR "ISOLATION SIGNAL CODES" FOR PRIMARY CONTAINMENT ISOLATION VALVES SEE FSAR TABLE 6.2-16.

PIPING AND SYSTEM CODE GROUPS

CODE GROUP	APPLICABLE CODE
A	ASME BOILER AND PRESSURE VESSEL CODE SECTION III CLASS 1.
B	ASME BOILER AND PRESSURE VESSEL CODE SECTION III CLASS 2.
C	ASME BOILER AND PRESSURE VESSEL CODE SECTION III CLASS 3.
D	ANSI B31.1 CODE FOR PRESSURE PIPING.
E	NSSS ENGINEERED INSTRUMENTS.

QUALITY ASSURANCE CLASSES

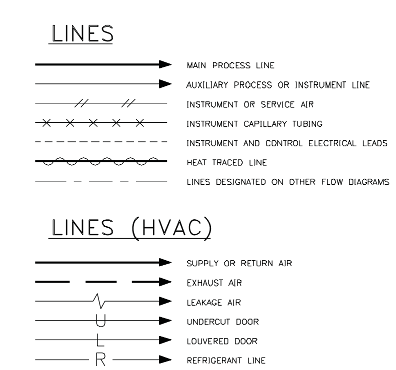
REQUIREMENTS FOR QUALITY ASSURANCE CLASSES ARE SPECIFIED IN THE WNP-2 SPECIFICATIONS.

SEISMIC REQUIRMENTS

REQUIREMENTS FOR SEISMIC CLASSES ARE SPECIFIED IN THE WNP-2 SPECIFICATIONS.

BUILDING LOCATION LEGEND

A	AUXILIARY BUILDINGS
C	PART OF OR WITHIN PRIMARY CONTAINMENT
D	DIESEL GENERATOR BUILDING
L	OFFSITE LOCALE
M	MAKEUP WATER PUMP HOUSE
O	OUTDOORS ON SITE
P	PUMP HOUSE
R	REACTOR BUILDING
S	SERVICE BUILDING
T	TURBINE GENERATOR BUILDING
W	RADWASTE/CONTROL BUILDING



Columbia Generating Station
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Flow Diagram Legend, Symbols and Abbreviations

Draw. No. M501 | Rev. 52 | Figure 1.2–26

System Acronyms

AAP	Alternate Access Point Bldg. and Appurtenances
AEA	Tech. Support Cntr. Exhaust Air
AMA	Tech. Support Cntr. Mixed Air
ANN	Annunciators
AOA	Tech. Support Cntr. Outside Air
APRM	Average Power Range Monitors
APWH	Tech. Support Cntr. Potable Hot Water
AR	Air Removal
ARA	Tech. Support Cntr. Return Air
ARE	Tech. Support Cntr. Refrig. Equipment
ARI	Alternate Rod Insertion
ARM	Area Radiation Monitoring
AS	Auxiliary Steam
BA	Backwash Air
BAS	Breathing Air Supply
BCF	Boiler Chemical Feed
BD	Cond. Blowdown or Rad. Boards
BS	Bleed (Extraction) Steam
CAC	Containment Atmosphere Control (Deactivated)
CAS	Control Air System
CBD	Circ. Water Blowdown
CCH	Control Room Chilled Water
CEP	Containment Exhaust Purge
CF	Chemical Feed
CHEM	Chemistry Equipment
CIA	Containment Instrument Air
CJW	Cooling Jacket Water
CL	Chlorine
CMS	Containment Monitoring System
CN	Containment Nitrogen
CND	Condenser Drains & Vents
CO	Condensate (Auxiliary)
CO_2	Carbon Dioxide
COMM	Communications
COND	Condensate (Nuclear)
CP	Cathodic Protection
CPR	Condensate Demineralizer
CRA	Containment Recirculating Air
CRD	Control Rod Drive
CSP	Containment Supply Purge
CTMA	Cooling Tower Electrical Bldg. Mixed Air
CVB	Containment Vacuum Breakers
CW	Circulating Water
DCN	CRD Decontamination
DCW	Diesel Cooling Water
DE	Diesel Exhaust (Engine)
DEA	Diesel Building Exhaust Air
DEH	Digital Electro-hydraulic Control
DG	Diesel Generator
DLO	Diesel Lube Oil
DMA	Diesel Building Mixed Air
DO	Diesel Oil
DOA	Diesel Building Outside Air
DRA	Diesel Building Return Air
DSA	Diesel (Engine) Starting Air
DW	Demineralized Water
EDR	Equipment Drains Radioactive
ELEC	Electrical Maintenance Equipment
EOF	Emergency Offsite Facility
ERM	Environmental Rad. Monitoring
ES	Exhaust Steam (Turbine)
FAC	Facilities Generic Equipment
FD	Floor Drain
FDR	Floor Drain Radioactive
FO	Fuel Oil
FP	Fire Protection
FPC	Fuel Pool Cooling
FW	Filtered Water
GEA	Guard House Exhaust Air
GFP	Guard House Fire Protection
GH	Main Guard House
GMA	Guard House Mixed Air
GOA	Guard House Outside Air
GPWH	Guard House Water Hot Potable
GRA	Guard House Return Air
GY	Glycol
H_2	Hydrogen (Turbine Generator)
HCO	Heating Steam Condensate
HD	Heater Drain
HHW	Heating Hot Water
HP	Health Physics
HPCS	High Pressure Core Spray
HS	Heating Steam
HSSF	Hydrogen Storage and Supply Facility
HSV	Heating Steam Vent
HT	Heat Tracing
HV	Heater Vent
HWC	Hydrogen Water Chemistry
HY	RRC Hydraulic Control
IBD	ISO Phase Bus Duct Cooling
IR	Instrument Rack
IRM	Intermediate Range Monitor
IRON	Chemical Feed
LD	Leak Detection
LE	Laboratory Equipment (Permanent Plant)
LF	Laundry Facility
LPCS	Low Pressure Core Spray
LPDS	Loose Parts Detection System
LPRM	Local Power Range Monitor
MD	Miscellaneous Drain
MECH	Mechanical Maintenance Equipment
MEL	Master Equipment List
MET	Meteorological
MLF	Mobile Laundry Facility
MS	Main Steam (Nuclear)
MSH	Machine Shop Equipment
MSLC	Main Steam Leakage Control (Deactivated)
MT	Material Transport
MW	Miscellaneous Waste
MWR	Miscellaneous Waste Radioactive
NSSE	Nuclear System Servicing Equipment
NSSS	Nuclear Steam Supply System
OFEA	Offsite Facility Exhaust Air
OFMA	Offsite Facility Mixed Air
OFOA	Offsite Facility Outside Air
OFRA	Offsite Facility Recirculation Air
OG	Off Gas
OL	Obstruction Lighting
PDIS	Plant Data Information System
PEA	Pumphouse Exhaust Air
PI	Process Instrumentation
PL	Plant Equipment
PMA	Pumphouse Mixed Air
POA	Pumphouse Outside Air
PPC	Plant Process Computer
PRA	Pumphouse Return Air
PRM	Process Radiation Monitoring
PS	Process Sampling
PSD	Plant Sanitary Drain
PSR	Process Sampling Radioactive
PVMS	Plant Vibration Monitoring System
PVR	Process Vents Radioactive
PWC	Potable Cold Water
PWH	Potable Hot Water
PWR	Process Waste Radioactive
RBM	Rod Block Monitor
RCC	Reactor Closed Cooling Water
RCIC	Reactor Core Isolation Cooling
RD	Roof Drain
REA	Reactor Building Exhaust Air
RFT	Reactor Feedwater Turbine
RFW	Reactor Feedwater
RHR	Residual Heat Removal
ROA	Reactor Building Outside Air
RPIS	Rod Position Indicator System
RPS	Reactor Protection System
RPWH	Reactor Building Potable Hot Water
RRA	Reactor Building Return Air
RRC	Reactor Recirculation
RSE	Reactor Service Equipment
RWCU	Reactor Water Cleanup
RWM	Rod Worth Minimizer
S	Sampling
SA	Service Air
SAT	Sulfuric Acid Treatment
SCH	Service Building Chilled Water
SCI	Supervisory Control
SCW	Stator Cooling Water
SEA	Service Building Exhaust Air
SEC	Plant Security
SEIS	Seismic Monitoring System
SFS	Spent Fuel Storage
SGT	Standby Gas Treatment
SHCO	Service Building Heating Condensate
SHHW	Service Building Heating Hot Water
SLC	Standby Liquid Control
SM	Salinity Monitoring
SMA	Service Building Mixed Air
SO	Seal Oil
SPTM	Suppression Pool Temp Monitoring
SPWH	Service Building Potable Hot Water
SRA	Service Building Return Air
SRM	Source Range Monitoring
SS	Sealing Steam
SW	Standby Service Water
SWA	Solid Waste
SWCF	Service Water Chemical Feed
TDAS	Transient Data Acquisition System
TEA	Turbine Building Exhaust Air
TG	Turbine Generator
TIP	Traversing Incore Probe
TMU	Tower Makeup Water
TO	Turbine (Lube) Oil
TOA	Turbine Building Outside Air
TPWH	Turbine Bldg. Potable Hot Water
TRA	Turbine Building Return Air
TSC	Technical Support Center
TSW	Plant Service Water
VES	Vessel (Sect. 8, Non Power Block)
VRMA	Variable Speed Drive Bldg. Mixed Air
WCH	Radwaste Building Chilled Water
WEA	Radwaste Building Exhaust Air
WHCO	Radwaste Heating Condensate
WMA	Radwaste Building Mixed Air
WNP2	Washington Nuclear Plant 2 (Columbia Generating Station)
WOA	Radwaste Building Outside Air
WPWH	Radwaste Bldg. Potable Hot Water
WRA	Radwaste Building Return Air
WRE	Radwaste Building Refrigeration
WRM	Wide Range Monitoring
ZINC	Chemical Feed System

Equipment Acronyms

AA	Audio Alarm
AC	Air Conditioning Unit
ACC	Accumulator
ACM	Acoustic Monitor/Sensor
AD	Air Damper
AH	Air Handling Unit
AI	Air Indicator
ALM	Alarm Annunciator-Do Not Use
ALT	Alternating Relay
AM	Ammeter
AMP	Amplifier
ANN	Annunciator
AO	Air Operator
AR	Air Receiver
AR/FR	Analyzer and Flow Recorder
ASM	Assembly
ASW	Air Switch (4-way Valve)
AT	Air Transmitter
ATD	Amp Transducer
ATS	Automatic Transfer Switch
AUD	Audio Monitor
AUX	Auxiliary Unit
AV	Air Valve
AW	Air Washer
AY	Analyzer
B0	24 Volt Battery
B1	125 Volt Battery
B2	250 Volt Battery
B3	12 Volt Battery
B4	48 Volt Battery
BDET	Badge (Keycard) Detector
BELL	Bell (Fire Protection)
BFI	Blown Fuse Indicator
BL	Baler
BLDG	Bldg (For PSD System Only)
BLR	Boiler
BT	Bolted Tee (For SA System)
BU	Emerg Lighting Battery Unit
BUOY	Buoy
C	Compressor
C0	24 Volt Battery Charger
C1	125 Volt Battery Charger
C2	250 Volt Battery Charger
C3	12 Volt Battery Charger
CAB	Cabinet
CAP	Capacitor
CB	Circuit Breaker
CC	Cooling Coil
CCTV	Closed Circuit Television
CCU	Central Control Unit
CE	Conductivity Element
CERA	Cond Element Retractor Assembly
CF	Charcoal Filter
CFG	Centrifuge
CH	Channel
CHL	Chlorinators
CHM	Chamber
CHR	Chiller
CHS	Chassis
CI	Conductivity Indicator
CIC	Conductivity Ind Controller
CIS	Conductivity Ind Switch
CIT	Conductivity Ind Transmitter
CITS	Conductivity Ind Transmitter Switch
CJW	Cooling Jacket Water
CM	Communications Monitor
CNTR	Contractor
COE	Corrosivity Element
COIC	Corrosivity Indic Cont
COMP	Computer
CONN	Connector
COR	Corrosivity Recorder
COS	Carbon Monoxide Sensor
COT	Corrosivity Transmitter
CP	Control Panel
CPL	Data Coupler
CPTR	Compactor
CPU	Central Processing Unit
CR	Conductivity Recorder; Control Room Chiller
CRA	Crane
CRB	Control Rod Blade
CRM	Control Module
CRS	Conductivity Recorder Switch
CRT	Terminal Display Screen
CS	Conductivity Switch
CSK	Shield Transfer Cask
CT	Current Transformer/Cooling Tower
CU	Condensing Unit
D	Damper (Backdraft Or Motor)
DC	Decoder
DCM	Dry Cleaning Machine
DCN	CRD Decontamination System
DDR	Disk Drive Recorder
DE	Density Element
DET	Detector
DFS	Differential Flow Switch
DG	Digital Display Generator
DH	Drywell Head
DIF	Diffuser
DIO	Diode, Control Rectifier
DISC	Disconnect Switch
DLR	Differential Level Recorder
DLS	Differential Level Switch
DLT	Differential Level Transmitter
DM	Demineralizer
DMM	Display Memory Module
DMS	Demister
DMTR	Demand Meter
DOE	Dissolved Oxygen Element
DOIT	Dissolved Oxygen Indic Trans
DOOR	Door
DOR	Dissolved Oxygen Recorder
DP	Distribution Panel
DPC	Diff Press Controller
DPE	Drip Pan Elbow
DPI	Diff Press Ind
DPIC	Diff Press Ind Controller
DPIR	Diff Press Ind Recorder
DPIS	Diff Press Ind Switch
DPIT	Diff Press Ind Transmitter
DPR	Diff Press Recorder
DPS	Diff Press Switch
DPT	Diff Press Transmitter
DR	Demand Recorder
DRVE	Drive Mechanism For CRD
DS	Density Switch
DT	Dens Trans Or Drive Turbine
DTIS	Diff Temp Indicating Switch
DTRS	Diff Temp Recording Switch
DTS	Diff Temp Switch
DTT	Diff Temp Transmitter
DU	Deaerator
DV	Deluge Valve
DVSP	Dump Valve Solenoid Pilot
DVSPV	Dump Valve Solenoid Pilot Valve
DWS	Demineralized Water Shower
DY	Dryer
E/I	Volt To Current Converter
E/P	Electro Pneumatic Converter
E/S	Electronic Power Supply
EAMP	Preamplifier
EC	Electronic Controller
ECG	Electrochemical Generator
ED	Eductor
EF	Electronic Filter
EFC	Excess Flow Check Valve
EHC	Electric Heating Coil
EHO	Electrohydraulic Operator
EI	Power Supply Monitor
EIS	Power Supply Monitor Switch
EJ	Expansion Joint
EJC	Ejector
ELEV	Elevator
ELP	Emergency Lighting Panel
EMSQ	Mean Square Voltage Device
ENG	Engine
EPA	Electrical Protection Assem
EPP	Emergency Power Panel
EQ	Speciality Equip and Tools
ERB	Emerg Rmt Ballast (Lighting)
ES	Exhaust Silencer
ESH	Electric Strip Heater
EUH	Electric Unit Heater
EV	Evaporator
EX	Exhauster
EXC	Exciter
F	Filter
F/U	Flow Unit
FA	Flame Arrestor
FC	Flow Controller
FCN	Fuel Oil Tk Fill Connector
FCV	Flow Control Valve
FD	Fire Damper
FDg	Freon Degreaser
FE	Flow Element
FG	Flow Glass
FGEN	Function Generator
FH	Fume Hood
FHB	Fuel Handling Box
FI	Flow Indicator
FIC	Flow Indicating Controller
FICS	Flow Indicating Controller Switch
FIS	Flow Indicating Switch
FIT	Flow Indicating Transmitter
FL	Filter
FLP	Fillport Assem
FLT	Filter
FLX	Flexible Connection
FN	Fan
FO	Freon Actuated Operator
FP	Filter Polisher
FQ	Flow Integrator
FQI	Flow Integrating Indicator
FQS	Flow Integrating Switch
FR	Flow Recorder
FR/DL	Flow and Diff. Level Recorder
FRC	Flow Recording Controller
FRDLR	Flow and Diff Level Recorder
FRS	Flow Recording Switch
FS	Flow Switch
FSPV	Flow Solenoid Pilot Valve
FT	Flow Transmitter
FTD	Frequency Transducer
FU	Filter Unit
FUSE	Fuse
FX	Flow Test Connection
FY	Flow Sig. Cond.
GATE	Gate
GCAL	AGS Calibrator
GEN	Generator
GOV	Governor
GVT	Gravity Ventilator
H	Heater
H_2E	Hydrogen Element
H_2I	Hydrogen Indicator
H_2IS	H_2 Indicating Switch/Monitor
H_2IT	Hydrogen Ind Transmitter
H_2R	Hydrogen Recorder
H_2T	Hydrogen Transmitter
HAS	High Amplitude Selector
HC	Heating Coil
HCU	Hydraulic Control Unit
HF	HEPA Filter
HM	Hour Meter
HMI	Human Machine Interface
HO	Hydraulic Operator
HOI	Hoist
HP	Valve Act. Hyd. Power Unit
HPU	Hydraulic Power Unit
HR	Hydrogen Recombiner
HS	Hose Station
HSS	High Selector Switch
HT	Hydrant
HTC	Heat Trace Cable
HTP	Heat Trace Panel
HU	Humidifier
HUM	Humidifier (Obsolete. Use HU)
HV	Heating and Ventilation Unit
HVRB	High Voltage Rubber Blanket
HX	Heat Exchanger
HZM	Hertz Meter
I/P	Current Pneumatic Converter
ID	Ionization Detector
IL	Indicating Light
IMD	Inductive Motor Drive
IN	Inverter
IND	Inductor
INDX	Indexer
IOS	Current Operated Switch
IR	Instrument Rack
IS	Intake Silencer
ISOL	Isolator, Isolation Device
ITD	Current Transducer
IX	Ion Exchanger
JB	Junction Box
JP	Jet Pump
KBD	Computer Keyboard (Security)
L	Lubricator
LA	Lightning Arrestor
LAG	Dynamic Compensator
LAS	Low Amplitude Selector
LC	Level Controller
LCRM	Log Count Rate Meter
LCV	Level Control Valve
LE	Level Element
LF	Lighting Fixture
LG	Level Glass
LI	Level Indicator
LIC	Level Indicating Controller
LIS	Level Indicating Switch
LITS	Level Indic Trans Switch
LMS	Limit Switch
LMTR	V/I Signal Limiter
LNR	Linear Reactor
LOC	Lube Oil Conditioner
LP	Lighting Panel
LPW	24 Volt Lambda Power Supply
LR	Level Recorder
LR/PR	Level/Pressure Recorder
LRS	Level Recording Switch
LS	Level Switch
LSC	Lightning Strike Counter
LSPV	Sol. Pilot Valve TMU-level
LSS	Low Selector Switch
LT	Level Transmitter
LTD	Level Transmitter Detector
LVDT	Linear Var. Dif. Transformer
LVS	Low Volume Selector
LWS	Low Differential Pressure
M	Motor
M/A	Manual/Auto Station
MA	Manifold
MACH	Machine
MBS	Maint. Bypass Switchgear
MC	Moisture Controller
MDET	Metal Detector
MDS	Manual Discharge Station
MDU	Motion Detection Unit
ME	Moisture Element
MG	Motor-Generator Set
MHDD	Moving Head Disc Drive
MI	Moisture Indicator
MIC	Moisture Indicating Controller
MIS	Moisture Indicating Switch
MM	Motor Module (TIP System)
MO	Motor Operator
MODEM	Modem
MON	Monitor
MPDS	Microprocessor Data System
MPS	Manual Pull Station
MR	Moisture Recorder
MS	Moisture Separator
MT	Mositure Transmitter
MTA	Dew Point Transmitter Amplif
MTS	Manual Transfer Switch
MUX	Multiplexer
MV	Manifold Valve
MV/I	M/Volt To Current Converter
MW	Microwave Receiver
MX	Mixer

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Equipment Acronyms

Draw. No. 950021.42 | Rev. 2 | Figure 1.2-28.1

Amendment 54
April 2000

Equipment Acronyms (con't)

MZ	Multizone Air Conditioner
NR	Neutral Grounding Resistor
O/M	Input/Out Module
O_2/H_2	Oxygen /Hydrogen$_2$
O_2E	Oxygen Element$_2$
O_2H_2R	Oxygen/Hydrogen Recorder$_2$
O_2I	Oxygen Indicator$_2$
O_2R	Oxygen Recorder$_2$
OS	Oil Separator
OSC	Oscillograph
OZG	Ozone Generator
P	Pump
P/B	Push Button
P/E	Pneumatic/Electric Converter
P/I	Pressure/Current Converter
P/P	Pressure Inverter
PA	Pre-Amps
PBU	Seismic Playback Unit
PC	Pressure Controller
PCV	Pressure Control Valve
PDM	Power Distribution Module
PDP	Power Distribution Panel
PE	Pressure Element
PH	Ph Ind Transmitter Recorder
PHB	Pneumatic Hydraulic Booster
PHC	Ph Controller
PHE	Ph Element
PHEC	Photoelectric Controller
PHED	Photoelectric Detector
PHIC	Ph Indicating Controller
PHIT	Ph Indicating Transmitter
PHITS	Ph Indicating Transmitter Switch
PHR	Ph Recorder
PHT	Ph Transmitter
PI	Pressure Indicator
PIC	Press Indicating Controller
PICS	Press Indicating Controller and Switch
PIS	Pressure Indicating Switch
PL	Programmable Logic Card
PLC	Programmable Logic Controller
PNL	Panel
POC	Disc Position Signal Conv
POE	Position Indication Element
POI	Position Indicator
POIC	Position Indicating Controller
POS	Position Switch
POT	Position Transmitter
POTR	Potentiometer "CL.1E Only"
POV	Pilot Operated Pop Off Valve
PP	Power Panel
PR	Pressure Recorder
PRN	Line Printer
PROG	Programmer
PRTM	Programmable Timer
PRV	Pressure Reg. Valve
PS	Pressure Switch
PT	Poten. Xmfer Or Press. Transm.
PTA	Barometric Pressure Amplifier
PTD	Pressure Transducer
PTZM	Pan Tilt Zoom Monitor
PUI	Purity Indicator
PUIT	Purity Indicator Transmitter
PUS	Purity Switch
QCC	Quick Couple Connection
QDC	Quick Disconnect
QHM	Run Time Meter
QSV	Quick Acting Solenoid Valve
R	Reservoir
R/I	Resistance/Current Converter
RA	Radiation Amplifier
RAD	Radiation Mon. Control Board
RC	Radiation Controller
RCM	Respirator Cleaning Module
RD	Rupture Disc
RDCC	Rod Drive Control Cabinet
RDD	Rod Detector Display
RE	Radiation Element
RECT	Rectifier
REL	Relay
RES	Resistor
RF	Refrigeration Machine(OG)
RFM	Radio Frequency Monitor
RG	Regulator
RI	Radiation Indicator
RIS	Radiation Indicating Switch
RLY	Relay
RM	Radiation Monitor
RMC	Remote Manual Controller
RMS	Remote Manual Switch
RO	Restricting Orifice
ROD	Control Rod
RPIS	Rod Position and Info Sys.
RPV	Reactor Pressure Vessel
RR	Radiation Recorder
RRM	Refrigerant Recovery Machine
RSA	Response Spectrum Annunciator
RSCC	Rod Sequence and Control Cab
RSDP	Rod Sequence Display Panel
RSM	Radiation Sampler
RSMD	Rod Select Module
RSR	Response Spectrum Recorder
RSRT	RSR Transducer for RSA
RST	Resin Trap
RT	Radiation Transmitter
RTM	Run Time Meter
RV	Relief Value
RVT	Roof Ventilator
S	Electronic Trip Unit
SC	Speed or Seismic Controller
SCAN	Scanner
SCL	Scaler
SCR	Screen
SE	Speed Element
SEW	Safety Eye Wash/Shower
SF	Spectacle Flange
SH	6.9 Kv Switch Gear
SHRED	Shredder
SI	Speed Indicator
SIOA	Silicon and Oxygen Analyzer
SL	480 Volt Switch Gear
SM	4.16 Kv Switch Gear
SMA	Smoke Alarm, Surface Mt. Acceler.
SMD	Smoke Detector
SNB	Snubber
SOL	Solenoid (Mech. Linkage)
SP	Sample Probe
SPC	Spacer
SPS	Speed Switch (Temp. Entry)
SPV	Solenoid Pilot Valve
SPVD	Set Press Verification Device
SQRT	Square Root Extractor
SR	Sample Rack
SRU	Signal Resistor Unit
SS	Speed or Seismic Switch
SSW	Step Switch
ST	Strainer
SUH	Steam Unit Heater
SUM	Summer
SUMP	Sump
SV	Solenoid Valve
SYNC	Synchroscope Meter
T	Trap
T/SS	Temp Selector Switch
TA	Trip Auxiliary Unit
TAPE	Magnetic Tape Unit
TAS	Tamper Alarm Switch
TB	Terminal Box
TBE	Turbidity Element
TBIT	Turbidity Indicating Trans
TBR	Turbidity Recorder
TBS	Turbidity Switch
TBT	Turbidity Transmitter
TC	Temperature Controller
TCV	Temperature Control Valve
TD	Time Delay
TDS	Time Delay Relays
TE	Temperature Element
TE/ME	Temperature/Moisture Element
TEST	Test (MEL Diagnostics)
THD	Thermal Detector
TI	Temperature Indicator
TIC	Temperature Indicating Controller
TIS	Temperature Indicating Switch
TJR	Temperature Scanning Recorder
TK	Tank
TM	Timer
TN	Turn Style
TNG	Turning Gear
TPA	Triaxial Peak Accelerograph
TPSA	Testable Pipe Spool Assembly
TQ	Time Totalizer
TQR	Torque Recorder
TQS	Torque Switch
TQT	Torque Transmitter
TR	Temp./ Triax. Record./Transform.
TRB	Terminal Block
TRC	Temperature Recorder Controller
TRL	Translator
TRS	Temperature Recording Switch
TS	Temperature Switch
TSC	Temperature Scanner
TT	Temperature Transmitter
TT/MT	Temperature/Moisture Transmitter
TUBE	LPRM Guide Tube Assembly
TV	Test Valve
TW	Thermal Well
TY	SMA HVAC, Special Func. Relay
UFM	Uniplex Field Module
USG	Ultra-Sonic Generator
UTD	Ultra-Sonic Transducer
UV/OR	UV Oxidation Reactor
UVD	Ultra-Violet Detector
V	Valve
V/F	Voltage/Freq. Converter
VARM	Var. Meter
VATD	Var. Transducer
VBAM	Vibration Differential Amp
VBE	Vibration Element
VBEC	Vibration/Eccentricity Indicator
VBI	Vibration Indicator
VBIS	Vibration Indicating Switch
VBR	Vibration Recorder
VBS	Vibration Switch
VCR	Video Cassette Recorder
VD	Viewing Device
VE	Vibration Element
VIR	Vibration Instrument Rack
VM	Voltmeter
VMP	Vibration Monitoring Panel
VPI	Valve Pos. Indication System
VSC	Variable Speed Controller
VT	Velocity Transmitter
VTD	Voltage Transducer
VX	Process Instrument Valve
VZ	Vaporizer
W	Watt
WDA	Wind Direction Amplifier
WDR	Wind Direction Recorder
WDT	Wind Direction Transmitter
WELL	Well (For PSD System Only)
WHM	Watt Hour Meter
WM	Watt Meter
WR	Water Reprocessing Unit
WSA	Wind Speed Amplifier
WSR	Wind Speed Recorder
WST	Wind Speed Transmitter
WTD	Watt Transducer
WUH	Water Unit Heater
X	Primary Containment Penetration
XAR	Resid. Chlorine Analyzer Recorder
XAY	Analyzer, Special Types
XD	Explosives Detector
XE	Element, Special Types
XI	Indicator, Special Types
XR	Recorder, Special Types
XS	Sensor, Special Types
XT	Transmitter, Special Types
ZONE	Fire Protection Zone Desig.
ZS	Tamper Switch

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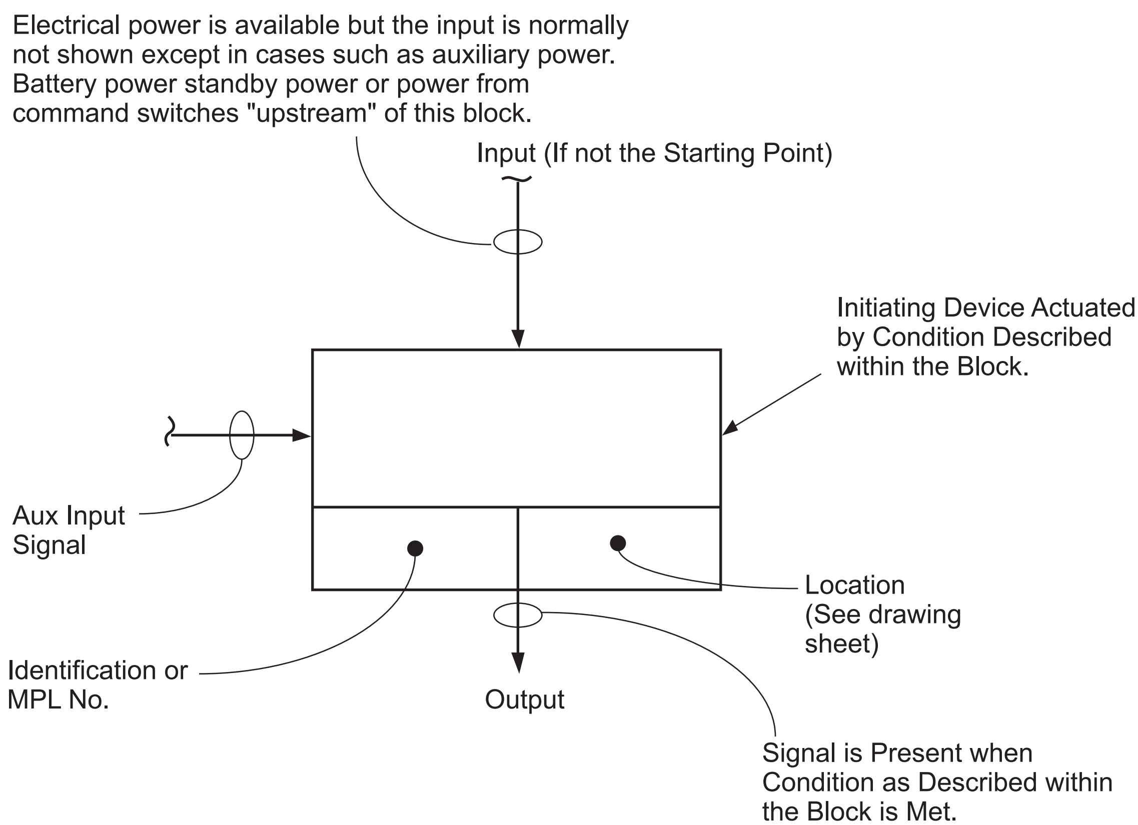
Equipment Acronyms (Con't)

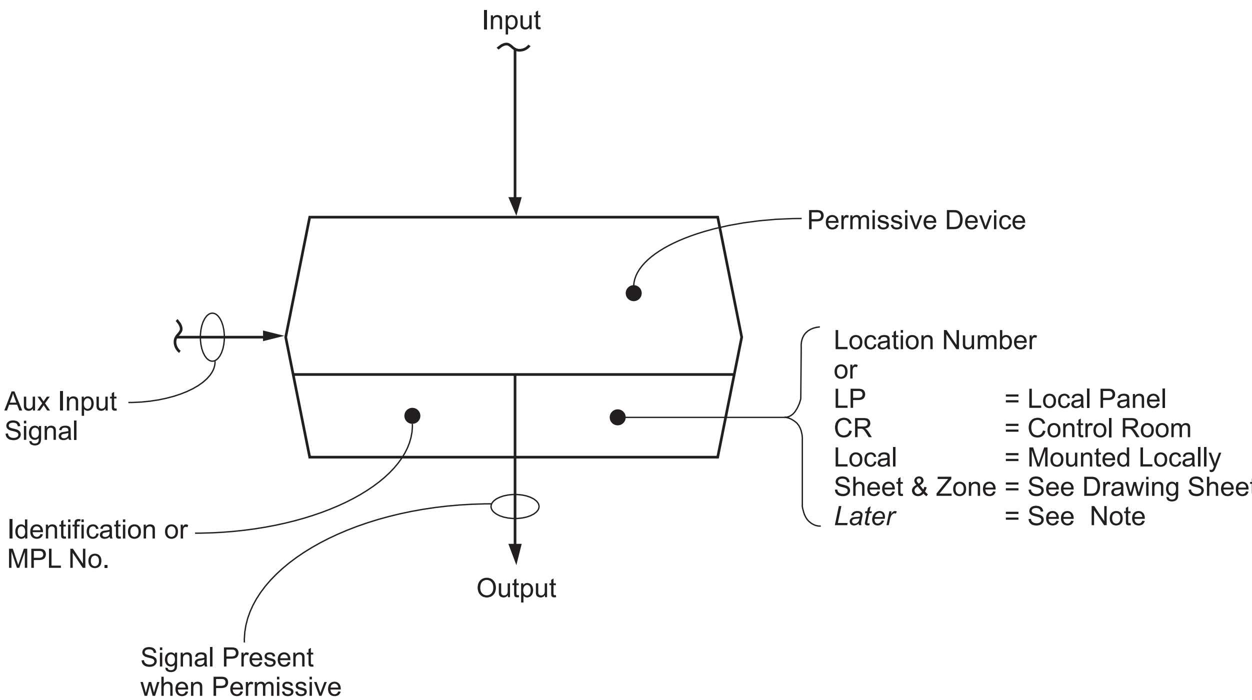
Draw. No. 950021.44 | Rev. | Figure 1.2-28.2

Form No. 960690

This block is the command switching or primary actuating function. This block can represent a switch, valve probe timer, or trip circuit. This block is normally the starting point of a functional sequence with an output only, but can have input and aux. input depending on the type of device. The same device may have a number of outputs, but each functional sequence initiated shall be shown by an individual block showing the same identification number and cross-reference. (See drawing sheet.)



Logic Symbols for NSSS
Functional Control Diagrams

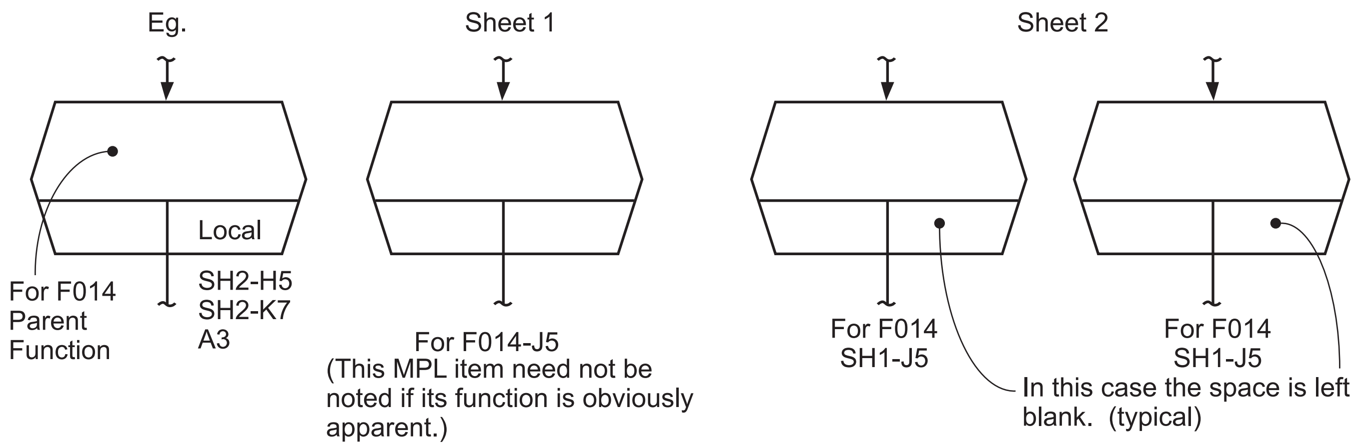


This block defines a permissive function which must be satisfied to permit the signal flow to pass to the next block. This block has incoming, outgoing, and may have auxiliary signals. The output from this permissive may be sealed in.

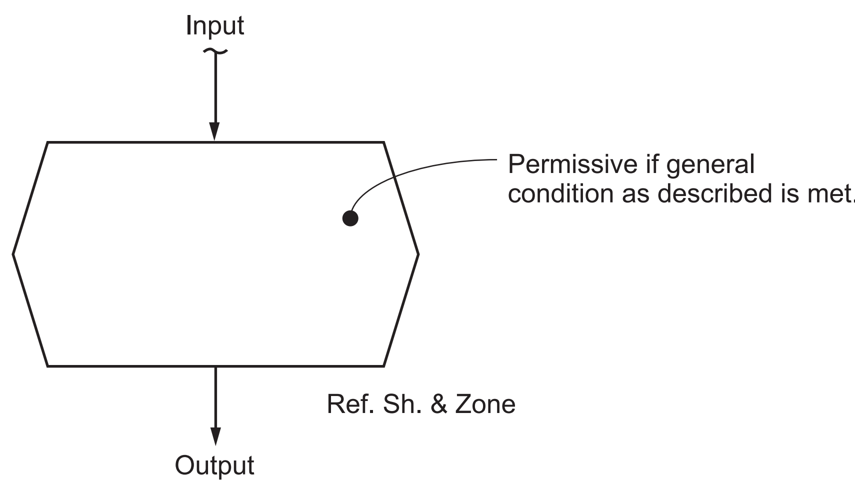
Note:

The word *later* may be used if the location is unknown but the correct location shall be noted on a future revision.

If a permissive or a primary function is shown in more than one place on drawings, provide a cross-reference to the parent function. (Formally an "X" was shown in the location of other switch handle positions, indicating that their blocks were an intricate part of the numbered switch assembly, but a different position of the switch handle. The "X" in location is inactive for new design.)

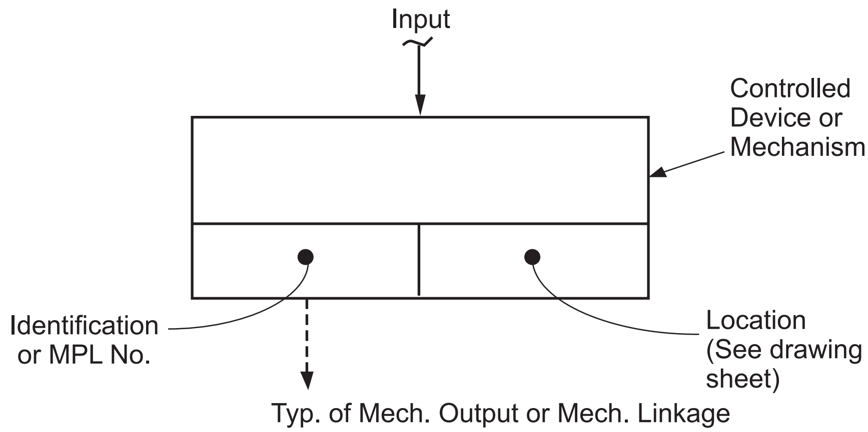


Show MPL item number of the valve or equipment served adjacent to the permissive or primary function. (See example)

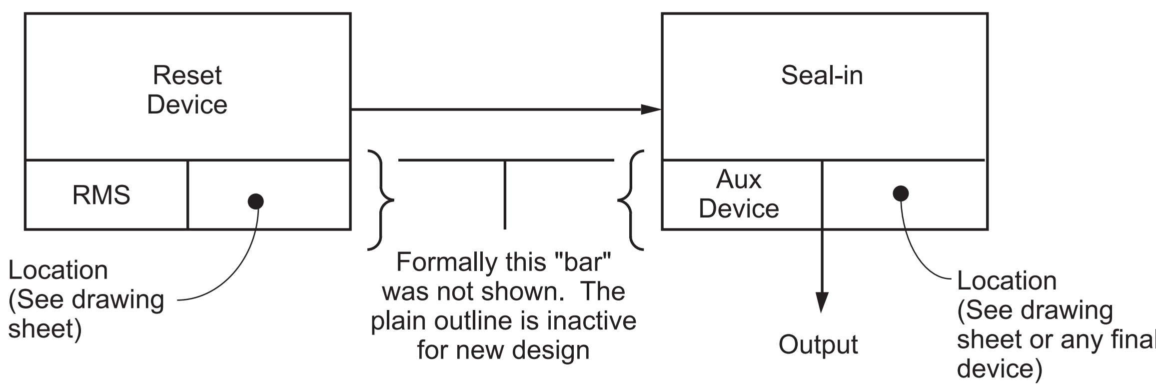


This block is a permissive <u>condition</u>.

Where the permissive is a general condition and not identified with a single device, the outer enclosure only is shown. It only has an input and output.

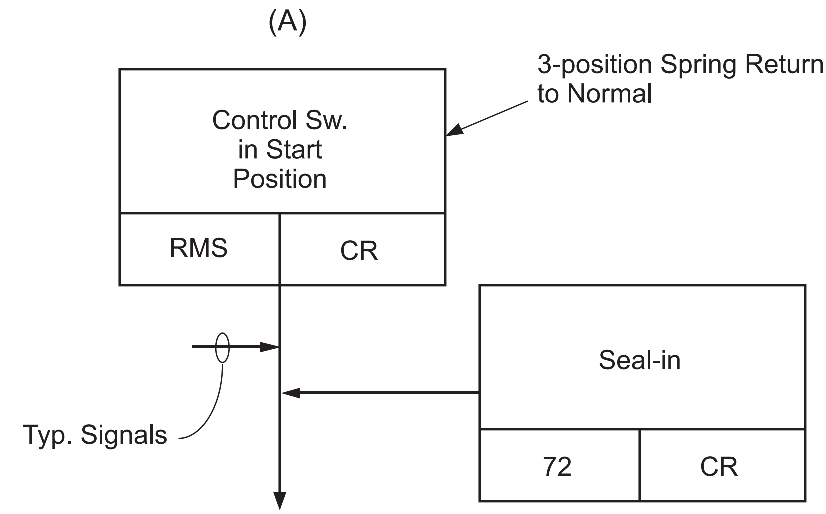


This block is a final device. It can be a relay, valve, electro-mech. sw., etc. Normally it has only inputs, but can have mech. outputs or position switch outputs.

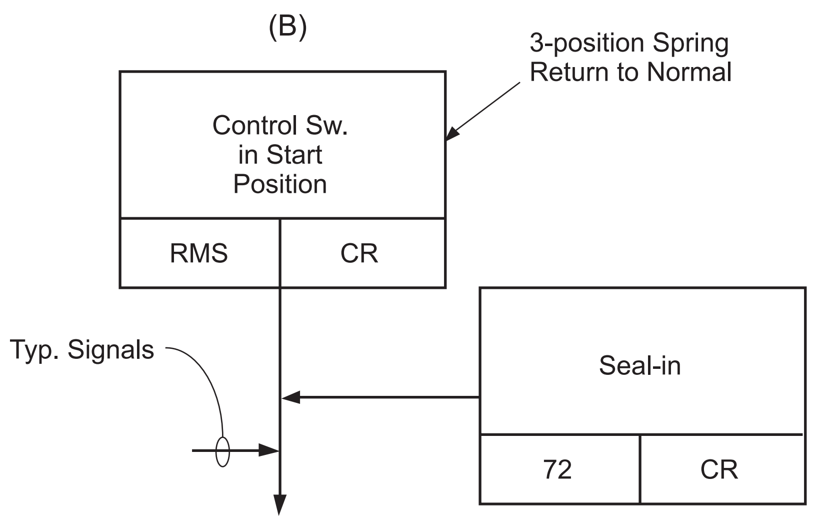


This is a seal-in with a manual reset device. The function of the seal-in is to latch in a signal and to continue that signal until manually reset. A seal-in shown without a reset device implies that the reset device is part of, and located on the nearest valve or contactor and is automatically reset by breaking the signal downstream of the seal-in signal. In all other cases the reset device shall be shown in conjunction with the seal-in.

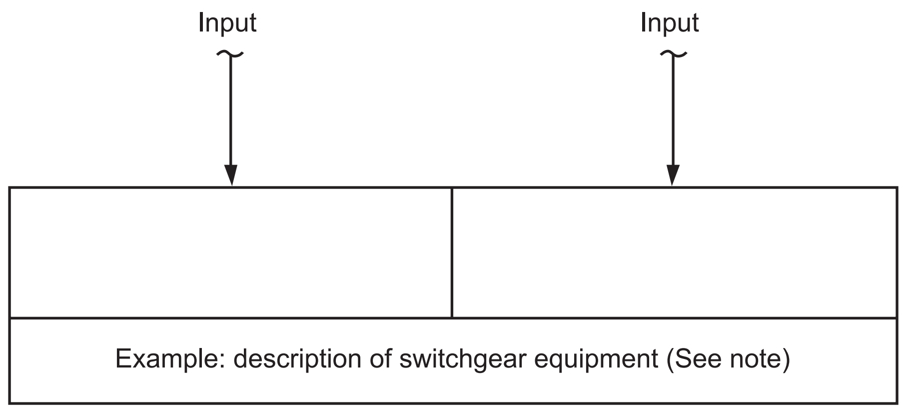
Examples of Typical Seal-in Blocks.



In this case, all signals at this point would be sealed-in.



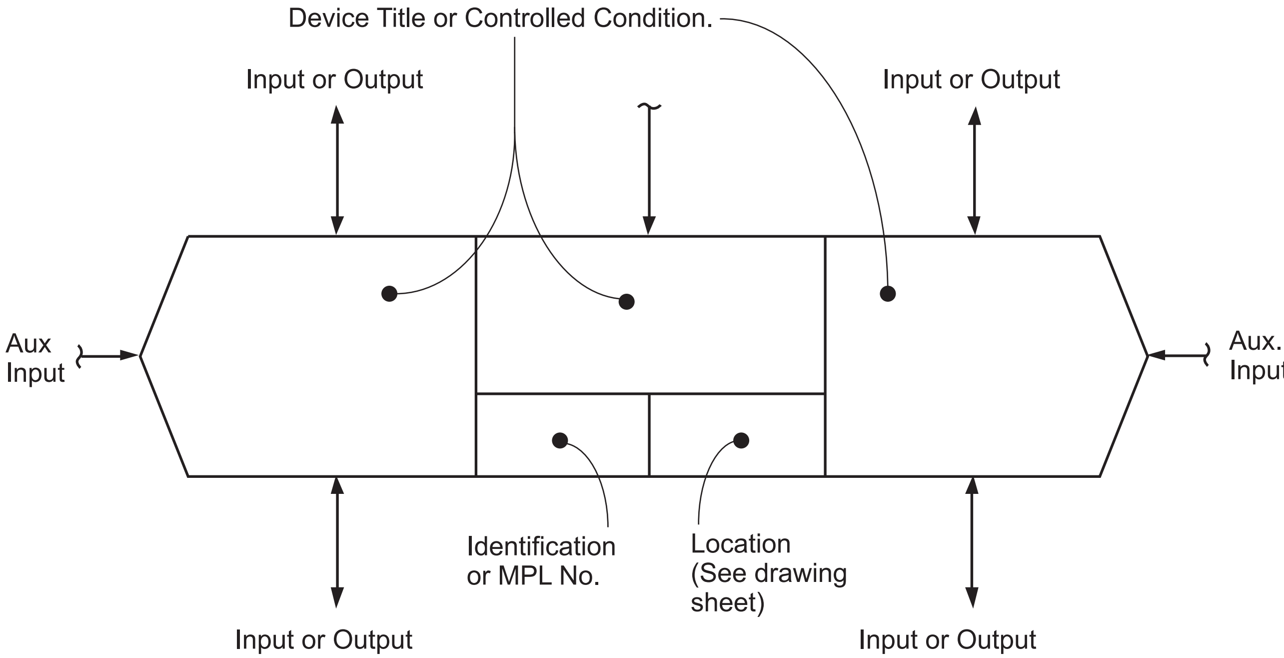
In this case, only the control sw. signal would be sealed-in.



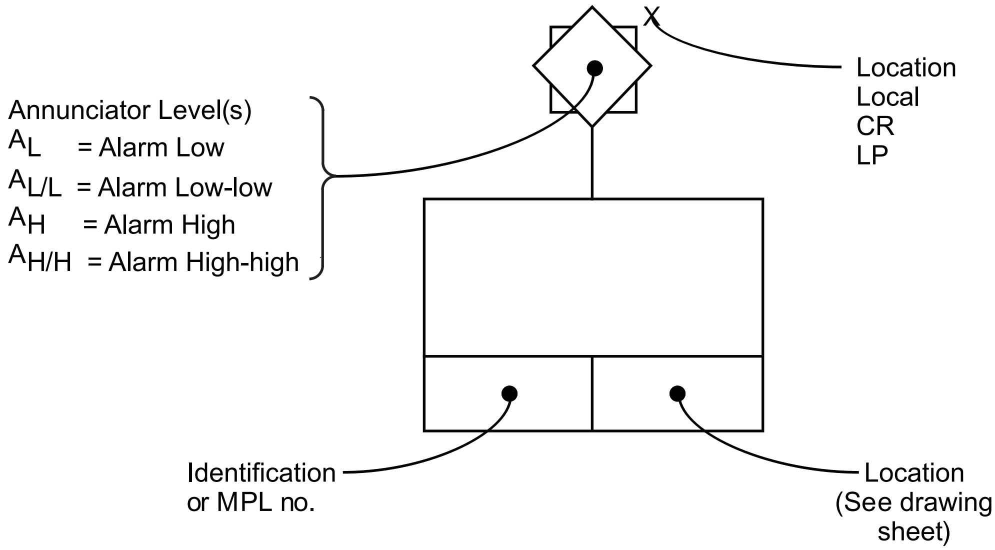
This block is a final device used to represent motor starters, circuit breakers, etc. It has only input signals. The input to the right causes an opposed action to the input on the left, such as left-open: right-close.

Note:

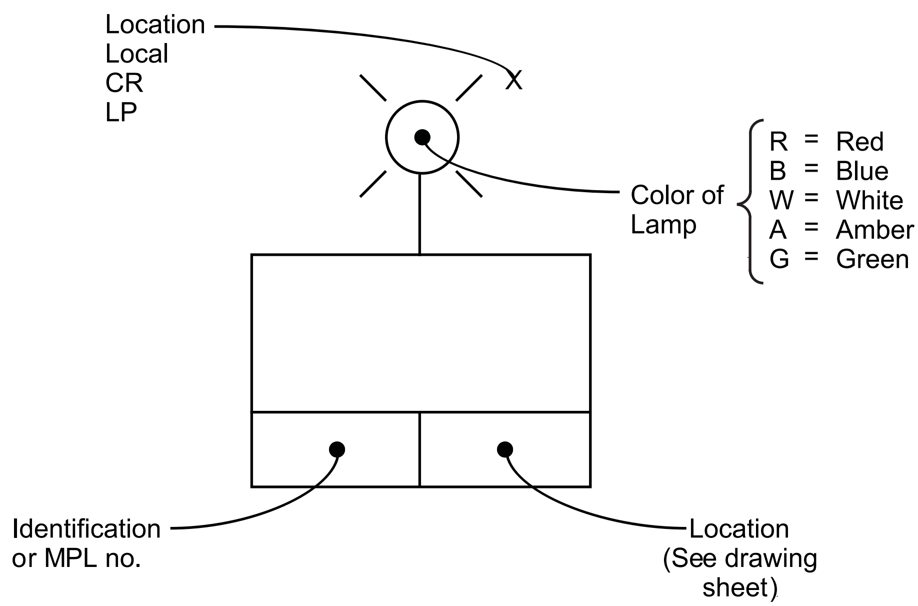
A final device may have more than one input. Each of these inputs can initiate the block. The block can have electrical inputs to indicating devices. Switchgear descriptions are found in ANSI spec. C37.2.



This block is a permissive operated by devices such as valve or pump switchgear designated in the inner block. This condition or device effects the operation of the final device. It has elect. inputs, mech. inputs, aux. inputs (mech. or elec.), and mech. or elect. outputs. This device is normally a valve. This is also used for other input/output power sources such as air or hydraulic. A solenoid pilot valve for an air operated valve is an example of this type of device (see Figure 1.2-26). When the two side blocks are the controlling blocks they have aux. input signals.



This block is a primary function for annunciators.



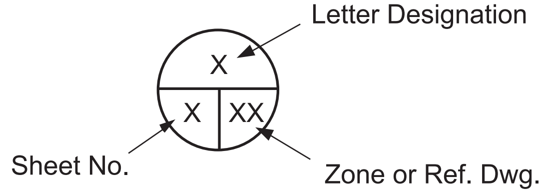
This block is a primary function for ind. lights.

This line represents an elec. flow signal. This line may actuate a final device and may be used to represent actuation of a permissive block.

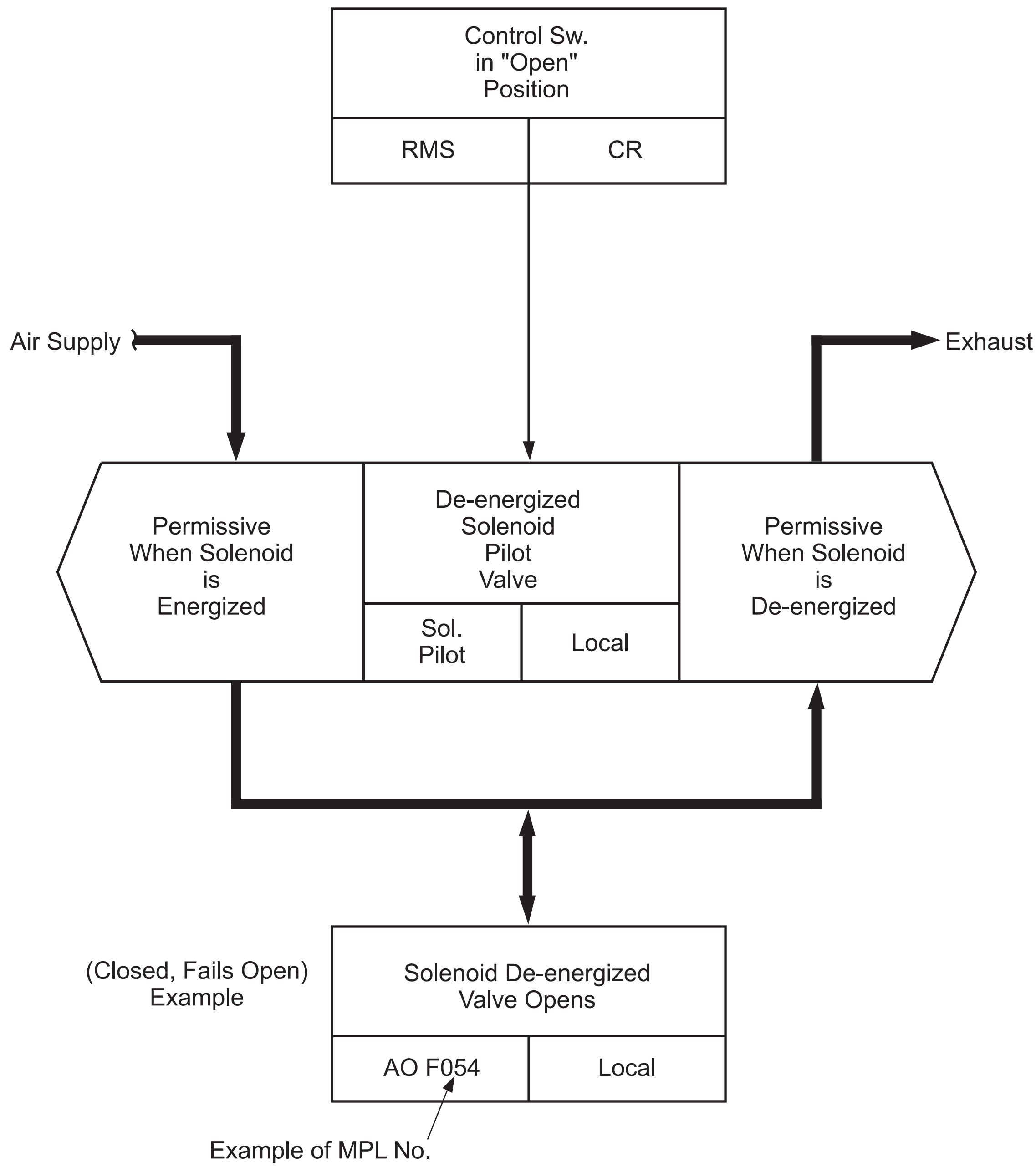
This line represents an auxiliary signal source such as air or hydraulic, and is not electrical.

This line represents mechanical outputs and /or mechanical linkage.

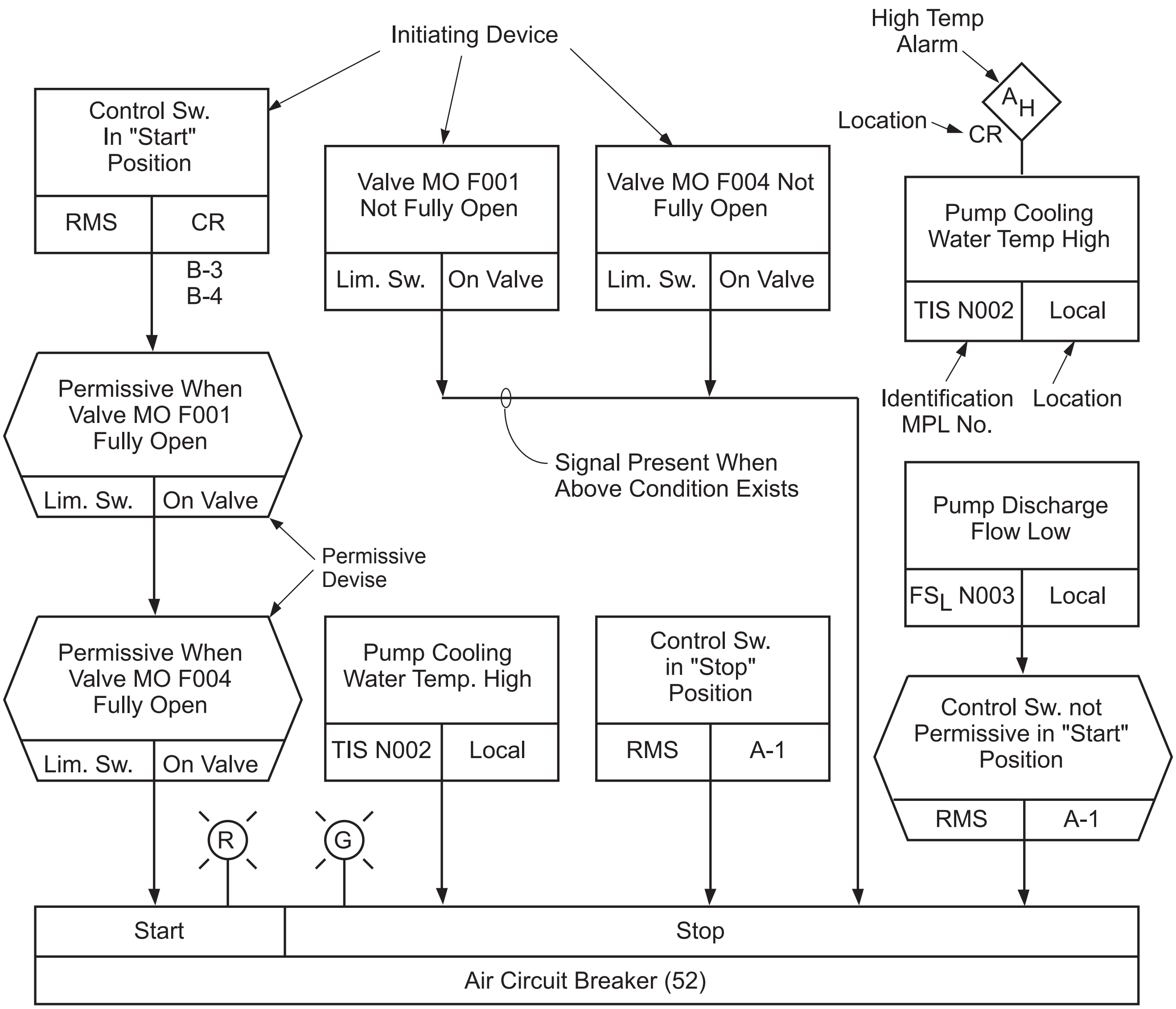
This symbol represents the start of the primary initiating signal.



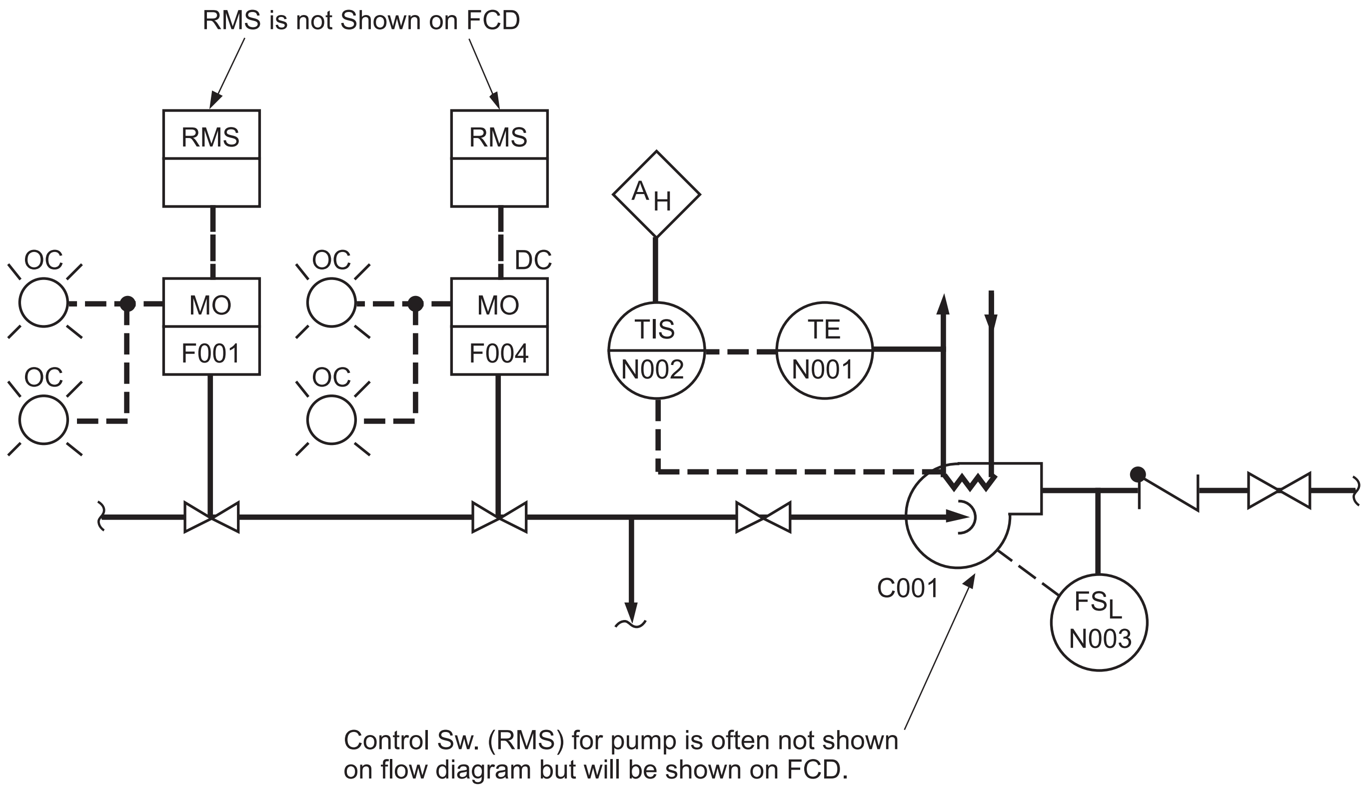
This symbol represents a match circle. The letter designation on one dwg. must match the letter on the interfacing dwg.

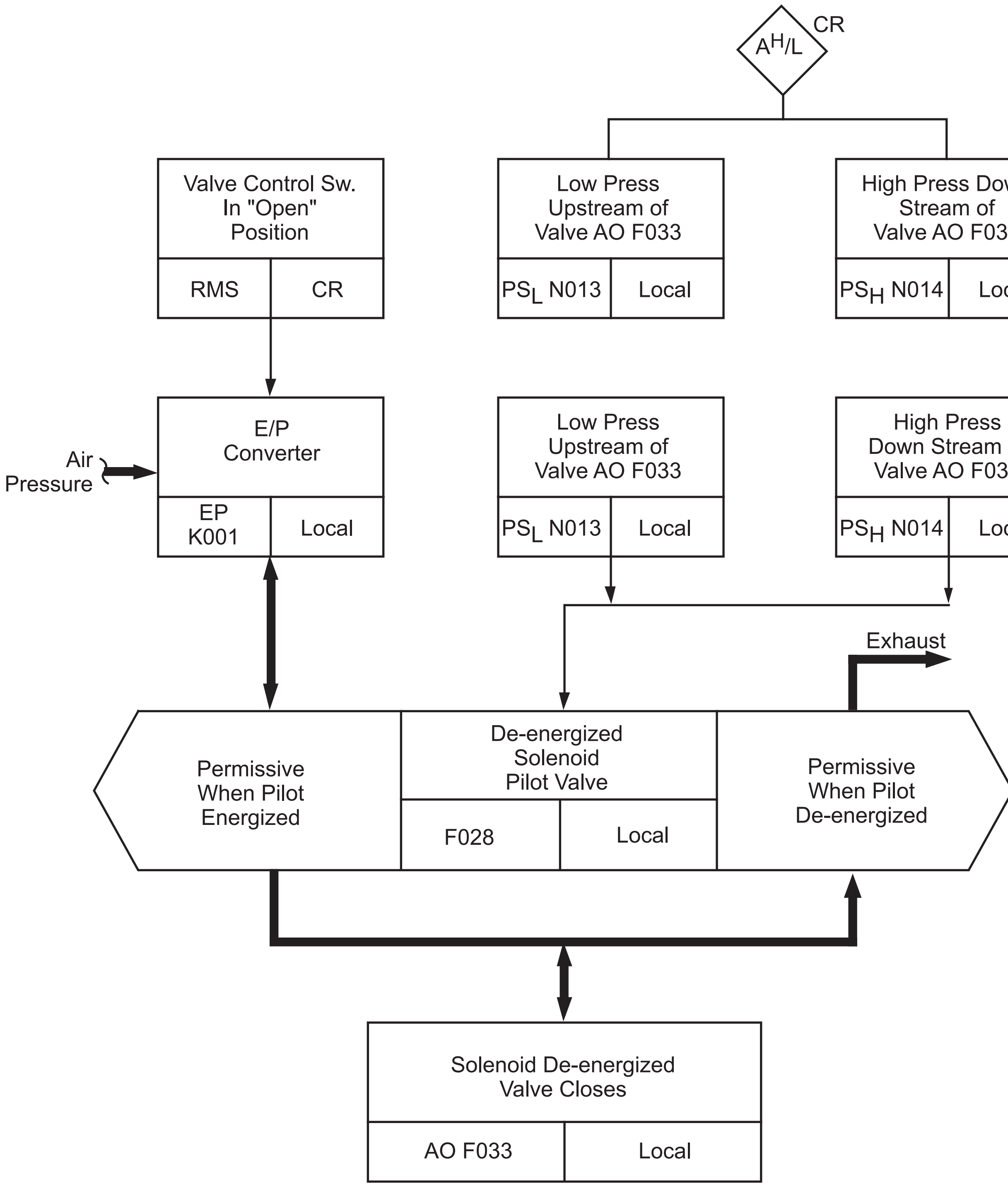


Typical A.O. Valve Example


Initiating Device
High Temp
Alarm
Location
CR
Control Sw.
In "Start"
Position
RMS
CR
B-3
B-4
Valve MO F001
Not Fully Open
Lim. Sw.
On Valve
Valve MO F004 Not
Fully Open
Lim. Sw.
On Valve
Pump Cooling
Water Temp High
TIS N002
Local
Identification
MPL No.
Location
Permissive When
Valve MO F001
Fully Open
Lim. Sw.
On Valve
Signal Present When
Above Condition Exists
Pump Discharge
Flow Low
FSL N003
Local
Permissive
Devise
Permissive When
Valve MO F004
Fully Open
Lim. Sw.
On Valve
Pump Cooling
Water Temp. High
TIS N002
Local
Control Sw.
in "Stop"
Position
RMS
A-1
Control Sw. not
Permissive in "Start"
Position
RMS
A-1
R
G
Start
Stop
Air Circuit Breaker (52)

Typical Flow Diagram Example

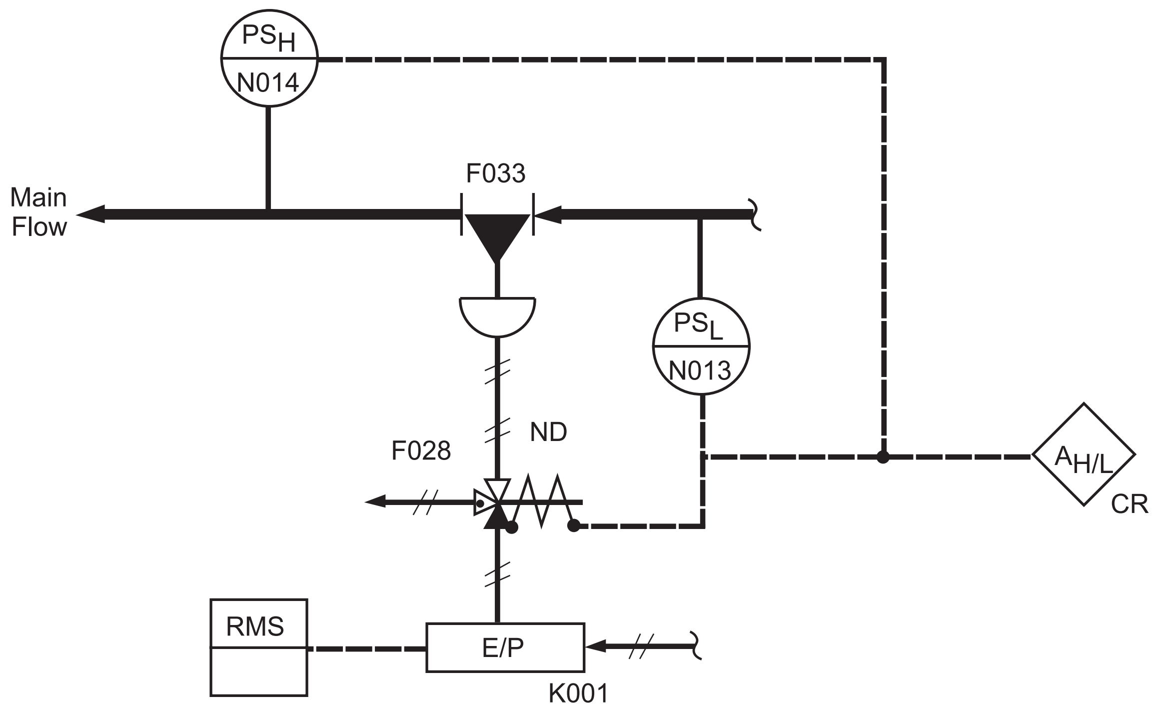




Bleed-off Flow Control Valve AO F033
Functional Control Diagram

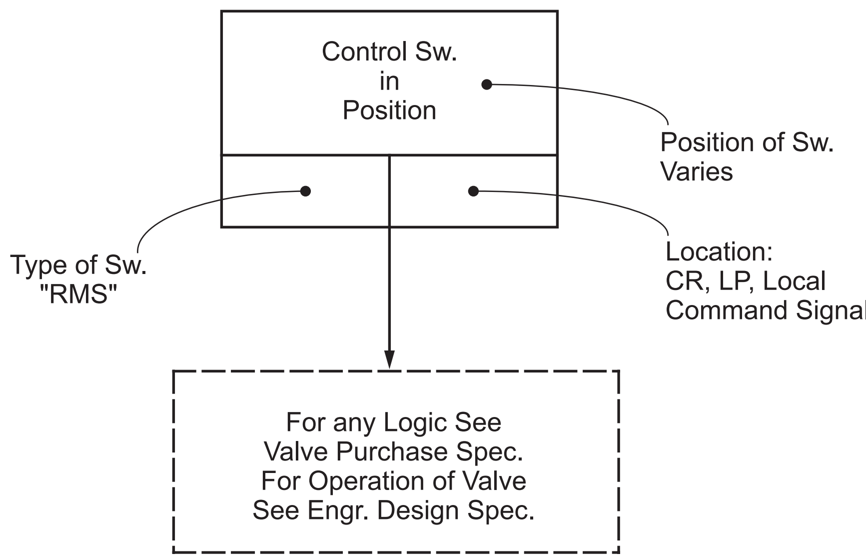
Columbia Generating Station Final Safety Analysis Report	Logic Symbols for NSSS Functional Control Diagrams
	Draw. No. 950021.57 / Rev. / Figure 1.2-29.13

Typical Flow Diagram Example



Notes: 1. Aux relays and devices are not shown on FCD.

This Figure is for a Typical Check Valve.



Testable Check Valve AO _ _ _ _

Reason for the above change is to have one standard logic for all testable check valve AO regardless of manufacturer.

Columbia Generating Station Final Safety Analysis Report	Logic Symbols for NSSS Functional Control Diagrams		
	Draw. No. 950021.59	Rev.	Figure 1.2-29.15

1.3 COMPARISON TABLES

The italicized information is historical and was provided to support the application for an operating license.

1.3.1 COMPARISONS WITH SIMILAR FACILITY DESIGNS

This section highlights the principal design features of CGS and compares its major features with other boiling water reactor (BWR) facilities. The design of this facility is based on proven technology obtained during the development, design, construction, and operation of BWRs of similar types. The data, performance, characteristics, and other information presented here represent the design of the facilities at the time of the CGS operating license review.

1.3.1.1 Nuclear Steam Supply System Design Characteristics

Table 1.3-1 summarizes the design and operating characteristics for the nuclear steam supply systems. Parameters are related to rated power output for a single plant unless otherwise noted. The fuel thermal, hydraulic, and nuclear design data are that for the initial core load. Cycle specific data are provided in Chapter 4, Section 5.2, and Appendix 15F.

1.3.1.2 Power Conversion System Design Characteristics

Table 1.3-2 compares the power conversion system design characteristics.

1.3.1.3 Engineered Safety Features Design Characteristics

Table 1.3-3 compares the engineered safety features design characteristics.

1.3.1.4 Containment Design Characteristics

Table 1.3-4 compares the containment design characteristics.

1.3.1.5 Radioactive Waste Management Systems Design Characteristics

Table 1.3-5 compares the radioactive waste management design characteristics.

1.3.1.6 Structural Design Characteristics

Table 1.3-6 compares the structural design characteristics.

1.3.1.7 Electrical Power Systems Design Characteristics

Table 1.3-7 compares the electrical power systems design characteristics.

1.3.2 COMPARISON OF FINAL AND PRELIMINARY INFORMATION

Significant changes that have been made in the facility design since submission of the PSAR are listed in Table 1.3-8. Items in Table 1.3-8 are cross referenced to the appropriate portion of the FSAR that describes the changes and the bases for them.

Table 1.3-1

Comparison of Nuclear Steam Supply System Design Characteristics[a]

	CGS[b] BWR 5 251-764	HATCH 1[c] BWR 4 218-560	ZIMMER[c] BWR 5 218-560
<u>Thermal and Hydraulic Design</u> (see Section 4.4)			
Rated power (MWt)	3323	2436	2436
Design power (MWt) (ECCS design basis)	3468	2550	2550
Steam flow rate (1b/hr)	14.295×10^6	10.03×10^6	10.477×10^6
Core coolant flow rate (1b/hr)	108.5×10^6	78.5×10^6	78.5×10^6
Feedwater flow rate (1b/hr)	14.256×10^6	10.445×10^6	10.477×10^6
System pressure, nominal in steam dome (psia)	1020	1020	1020
Average power density (KW/liter)	49.15	51.2	50.51
Maximum thermal output (KW/ft)	13.4	13.4	13.4
Average thermal output (KW/ft)	5.38	7.11	5.45
Maximum heat flux (Btu/hr-ft^2)	428,360	428,300	354,000
Average heat flux (Btu/hr-ft^2)	145,060	164,700	143,900
Maximum UO_2 temperature (°F)	4380	4380	3325
Average volumetric fuel temperature (°F)	1100	1100	1100
Average cladding surface temperature (°F)	558	558	558
Minimum critical power ratio (MCPR)	1.24	1.9[d]	1.21
Coolant enthalpy at core inlet (Btu/1b)	527.6	526.2	527.4
Core maximum exit voids within assemblies	79	79	75
Core average exit quality (% steam)	13.5	12.9	13.6
Feedwater temperature (°F)	420	387.4	420
Design power peaking factor			
Maximum relative assembly power	1.40	1.40	1.40
Local peaking factor	1.15	1.24	1.24
Axial peaking factor	1.40	1.5	1.4
Total peaking factor	2.51	2.6	2.43

Table 1.3-1

Comparison of Nuclear Steam Supply System Design Characteristics[a] (Continued)

	CGS[b] BWR 5 251-764	HATCH 1[c] BWR 4 218-560	ZIMMER[c] BWR 5 218-560
<u>Nuclear Design (First Core)</u> (see Section 4.3)			
Water/UO_2 volume ratio (cold)	2.55	2.53	2.41
Reactivity with strongest control rod out (k_{eff})	< 0.99	< 0.99	< 0.99
Moderator void coefficient			
Hot, no voids ($\Delta k/k$ - %void)	-1.0×10^{-3}	-1.0×10^{-3}	-1.0×10^{-3}
At rated output ($\Delta k/k$ - %void)	-1.6×10^{-3}	-1.6×10^{-3}	1.6×10^{-3}
Fuel temperature doppler coefficient			
At 68°F ($\Delta k/k$ - °F fuel)	-1.3×10^{-5}	-1.3×10^{-5}	-1.3×10^{-5}
Hot, no voids ($\Delta k/k$ - °F fuel)	-1.2×10^{-5}	-1.2×10^{-5}	-1.2×10^{-5}
At rated output ($\Delta k/k$ - °F fuel)	-1.3×10^{-5}	-1.3×10^{-5}	-1.3×10^{-5}
Initial average ^{235}U enrichment wt (%)	1.91	2.23	1.90
Fuel average discharge exposure (MWd/short ton)	10,300	19,000	15,053
<u>Core Mechanical Design</u> (see Sections 4.2 and 7.6)			
Fuel assembly			
Number of fuel assemblies	764	560	560
Fuel rod array	8 x 8	7 x 7	8 x 8
Overall dimensions (in.)	176	176	176
Weight of UO_2 per assembly (1b) (pellet type)	458 (chamfered)	490.4 (undished) 483.4 (dished)	465.15
Weight of fuel assembly (1b)	600	681 (undished) 675 (dished)	698

Table 1.3-1

Comparison Of Nuclear Steam Supply System Design Characteristics[a] (Continued)

	CGS[b] BWR 5 251-764	HATCH 1[c] BWR 4 218-560	ZIMMER[c] BWR 5 218-560
Core Mechanical Design (see Sections 4.2 and 7.6) (Continued)			
Fuel rods (NEDE-20944P)			
Number per fuel assembly	62	49	63
Outside diameter (in.)	0.483	0.563	0.493
Cladding thickness (in.)	0.032	0.032	0.034
Cap. pellet to cladding (in.)	0.0045	0.006	0.0045
Length of gas plenum (in.)	10	16	14
Cladding material[e]	Zircaloy-2	Zircaloy-2	Zircaloy-2
Fuel pellets			
Material	UO_2	UO_2	UO_2
Density (% of theoretical)	95	95	95
Diameter (in.)	0.410	0.487	0.416
Length (in.)	0.410	0.5	0.420
Fuel channel			
Overall dimension, length (in.)	166.9	166.9	166.9
Thickness (in.)	0.100	0.080	0.100
Cross section dimensions (in.)	5.494 x 5.494	5.44 x 5.44	5.48 x 5.48
Material	Zircaloy-4	Zircaloy-4	Zircaloy-4
Core assembly			
Fuel weight as UO_2 (1b)	349,900	272,850	260,538
Core diameter (equivalent) (in.)	187.1	160.2	160.2
Core height (active fuel) (in.)	150	144	146

Table 1.3-1

Comparison of Nuclear Steam Supply System Design Characteristics[a] (Continued)

	CGS[b] BWR 5 251-764	HATCH 1[c] BWR 4 218-560	ZIMMER[c] BWR 5 218-560
Core Mechanical Design (see Sections 4.2 and 7.6) (Continued)			
Reactor control system			
Method of variation of reactor power	Movable control rods and variable forced coolant flow	Movable control rods and variable forced coolant flow	Movable control rods and variable forced coolant flow
Number of movable control rods	185	137	137
Shape of movable control rods	Cruciform	Cruciform	Crucifom
Pitch of movable control rods	12.0	12.0	12.0
Control material in movable rods	B_4C granules compacted in SS tubes	B_4C granules compacted in SS tubes	B_4C granules compacted in SS tubes
Type of control rod drives	Bottom entry locking piston	Bottom entry locking piston	Bottom entry locking piston
Type of temporary reactivity control for initial core	Burnable poison; gadoliniaurania fuel rods	Burnable poison; gadoliniaurania fuel rods	Burnable poison; gadoliniaurania fuel rods
In-core neutron instrumentation			
Number of in-core neutron detectors (fixed)	172	124	124
Number of in-core detector assemblies	43	31	31
Number of detectors per assembly	4	4	4
Number of flux mapping neutron detectors	5	4	4

Table 1.3-1

Comparison of Nuclear Steam Supply System Design Characteristics[a] (Continued)

	CGS[b] BWR 5 251-764	HATCH 1[c] BWR 4 218-560	ZIMMER[c] BWR 5 218-560
Core Mechanical Design (see Sections 4.2 and 7.6) (Continued)			
In-core neutron instrumentation (Continued)			
Range (and number) of detectors			
Source range monitor	Source to 0.001% power (4)[f]	Source to 0.001% power (4)[f]	Source to 0.001% power (4)[f]
Intermediate range monitor	0.001% to 10% power (8)[f]	0.001% to 10% power (8)[f]	0.001% to 10% power (8)[f]
Local power range monitor	5% to 125% power (172)[f]	5% to 125% power (124)[f]	5% to 125% power (124)[f]
Average power range monitor	2.5% to 125% power (6)[f]	2.5% to 125% power (6)[f]	2.5% to 125% power (6)[f]
Number and type of in-core neutron sources	7 Sb-Be	5 Sb-Be	5 Sb-Be
Reactor Vessel Design (see Section 5.3)			
Material	Carbon steel stainless clad	Carbon steel stainless clad	Carbon steel stainless clad
Design pressure (psig)	1250	1265	1250
Design temperature (°F)	575	575	575
Inside diameter (ft-in.)	20-11	18-2	18-2
Inside height (ft-in.)	72-11	69-4	69-4
Minimum base metal thickness (cylindrical section) (in.)	6.75	5.53	5.375
Minimum cladding thickness (in.)	1/8	1/8	1/8

Table 1.3-1

Comparison Of Nuclear Steam Supply System Design Characteristics[a] (Continued)

	CGS[b] BWR 5 251-764	HATCH 1[c] BWR 4 218-560	ZIMMER[c] BWR 5 218-560
Reactor Coolant Recirculation Design (see Sections 5.1, 5.2, and 5.4)			
Number of recirculation loops	2	2	2
Design pressure:			
Inlet leg (psig)	1250	1148	1250
Outlet leg (psig)	1650;[g] 1550[h]	1274	1675;[g] 1575[h]
Design temperature (°F)	575	562	575
Pipe diameter (in.)	24	28	20
Pipe material (ANSI)	304/316	304/316	304/316
Recirculation pump flow rate (gpm)	47,200	42,200	33,880
Number of jet pumps in reactor	20	20	20
Main Steam lines (see Section 5.4)			
Number of steam lines	4	4	4
Design pressure (psig)	1250	1146	1250
Design temperature (°F)	575	563	575
Pipe diameter (in.)	26	24	24
Pipe material	Carbon steel	Carbon steel	Carbon steel

[a] Parameters are related to rated power output for a single plant unless otherwise noted.
[b] See Section 1.3.1 regarding the status of the data presented here.
[c] Values correspond to original licensing.
[d] For Hatch, minimum critical heat flux ratio (MCHFR) was used.
[e] Free-standing loaded tubes.
[f] Channels of monitors from LPRM detectors.
[g] Pump and discharge piping to and including discharge block valve.
[h] Discharge piping from discharge block valve to vessel.

Table 1.3-2

Comparison of Power Conversion System Design Characteristics

	CGS BWR 5 251-764	HATCH I[a] BWR 4 218-560	ZIMMER[a] BWR 5 218-560
Turbine Generator (see Sections 10.2 and 10.4)			
Rated power (MWt)	3468[b]	2550	2550
Rated power (MWe) (gross)	1205[b]	813	883
Generator Speed (rpm)	1800	1800	1800
Rated steam flow (1b/hr)	15.018×10^{6}[b]	10.48×10^{6}	11.0×10^{6}
Inlet pressure (psia)	955	950	950
Steam Bypass System (see Section 10.4.4)			
Capacity (% design steam flow)	25	25	25
Main Condenser (see Section 10.4.1)			
Heat removal capacity (Btu/hr)	7702×10^{6}	5720×10^{6}	7053×10^{6}
Circulating Water System (see Section 10.4.5)			
Number of pumps	3	2	3
Flow rate (gpm/pump)	186,000	185,000	150,000
Condensate and Feedwater System (see Section 10.4.7)			
Design flow rate (1b/hr)	14.26×10^{6}	10.096×10^{6}	10.971×10^{6}
Number of condensate pumps	3	3	3
Number of condensate booster pumps	3	3	3
Number of feedwater pumps	2	2	2
Number of feedwater booster pumps	None	None	None
Condensate pump drive	ac power	ac power	ac power
Booster pump drive	ac power	ac power	ac power
Feedwater pump drive	Turbine	Turbine	Turbine

[a] Values correspond to original licensing.
[b] Maximum calculated value.

Table 1.3-3

Comparison of Engineered Safety Features
Design Characteristics

	CGS BWR 5 251-764	HATCH I BWR 4 218-560	ZIMMER BWR 5 218-560
Emergency Core Cooling Systems (systems sized on design power) (see Section 6.3)			
Low pressure core spray systems			
Number of loops	1	2	1
Flow rate (gpm)	6350 at 128 psid	4625 at 120 psid	4725 at 119 psid
High pressure core spray system			
Number of loops	1	1[a]	1
Flow rate (gpm)	1550 at 1130 psid	4250	1330 at 1110 psid
	6350 at 200 psid		4725 at 200 psid
Automatic depressurization system			
Number of relief valves	7	7	7
Low pressure coolant injection[b]			
Number of loops	3	2	3
Number of pumps	3	4	3
Flow rate (gpm/pump)	7450 at 26 psid	7700 at 20 psid	5050 at 20 psid
Residual Heat Removal System (see Section 5.4.7)			
Reactor shutdown cooling mode:			
Number of loops	2	2	2
Number of pumps	2	4	2
Flow rate (gpm/pump)[c]	7450	7700	5050
Duty (Btu/hr/heat exchanger)[d]	41.6×10^6	32×10^6	30.8×10^6
Number of heat exchangers	2	2	2
Primary containment cooling mode:			
Flow rate (gpm)	7450[e]	30,800	5050[e]

Table 1.3-3

Comparison of Engineered Safety Features Design Characteristics (Continued)

	CGS BWR 5 251-764	HATCH I BWR 4 218-560	ZIMMER BWR 5 218-560
Standby Service Water System (see Section 9.2.7)			
Flow rate (gpm/heat exchanger)	7400	8000	5000
Number of pumps	3[f]	4	4
Reactor Core Isolation Cooling System (see Section 5.4.6)			
Flow rate (gpm)	600 at 1150 psid	400 at 1120 psid	400 at 1120 psid
Fuel Pool Cooling and Cleanup System (see Section 9.1.3)			
Capacity (Btu/hr)	8.0×10^6	5.7×10^6	6.6×10^6

[a] *High-pressure coolant injection system utilized.*
[b] *A mode of RHR system.*
[c] *Capacity during reactor flooding mode with more than one pump running.*
[d] *Heat exchanger duty at 20 hr following reactor shutdown.*
[e] *Flow per heat exchanger.*
[f] *Includes HPCS service water pumps.*

Table 1.3-4

Comparison of Containment Design Characteristics

	CGS BWR 5 251-764	HATCH 1 BWR 4 218-560	ZIMMER BWR 5 218-560
Primary Containment[a] (see Sections 3.8.2 and 6.2.2)			
Type	Over and under pressure suppression	Pressure suppression	Over and under pressure suppression
Construction	Steel-free standing	Steel-free standing	Concrete pre-stressed with steel liner
Drywell	Frustum of cone upper portion	Light bulb/steel vessel	Frustum of cone upper portion
Pressure-suppression chamber	Cylindrical lower portion with eliptical bottom	Torus/steel vessel	Cylindrical lower portion
Pressure-suppression chamber internal design pressure (psig)	45	56	45
Pressure-suppression chamber external design pressure (psi)	2	2	2
Drywell internal design pressure (psig)	45	56	45
Drywell external design pressure (psi)	2	2	2
Drywell free volume (ft^3)	200,540[b]	146,240	180,000
Pressure-suppression chamber free volume (ft^3)	144,184 max	110,950	93,000
Pressure-suppression pool water volume (ft^3)	112,197 min[c]	87,300	102,000
Submergence of downcomer vent pipe below pressure pool surface (ft)	12 max. 11.67 min.	3.67	10
Design temperature of drywell (°F)	340	281	340
Design temperature of pressure-suppression chamber (°F)	275	281	275
Downcomer vent pipe pressure loss factor	1.9	6.21	2.17
Break area/total vent area	0.105	0.0194	0.008

Table 1.3-4

Comparison of Containment Design Characteristics (Continued)

	CGS BWR 5 251-764	HATCH 1 BWR 4 218-560	ZIMMER BWR 5 218-560
Primary Containment[a] (see Sections 3.8.2 and 6.2.2) (Continued)			
Calculated maximum pressure after blowdown to dwell (no pre-surge) (psig)	34.7	46.5	40.4
Pressure-suppression chamber (psig)	27.6	28	35.6
Initial pressure-suppression pool temperature rise (°F)	35	50	35
Leakage rate (% free volume/day at 45 psig and 200°F)	0.5	1.2 at 59 psig	0.635
Secondary Containment (see Sections 3.8.4 and 6.2.3)			
Type	Controlled leakage, elevated release	Controlled leakage, elevated release	Controlled leakage, elevated release
Construction			
Lower levels	Reinforced concrete	Reinforced concrete	Reinforced concrete
Upper levels	Steel super-structure and siding	Steel super-structure and siding	Steel super-structure and siding
Roof	Steel decking	Steel decking	Steel decking
Internal negative design pressure (in. H_2O)	0.25	0.25	0.25
Design inleakage rate (% free volume/day at 0.25 in. H_2O)	100	100	100

[a] Where applicable, containment parameters are based on design power.
[b] Maximum water level in suppression pool.
[c] Does not include the water within the reactor pedestal (10,065 ft^3) or the 12 ft of water below the downcomer vent pipe exits (15,000 ft^3).

Table 1.3-5

Radioactive Waste Management Systems
Design Characteristics

	CGS BWR 5 251-764	HATCH 1 BWR 4 218-560	ZIMMER BWR 5 218-560
Gaseous Radwaste (see Section 11.3)			
Design Bases (noble gases μCi/sec)	*100,000 at 30 minutes*	*100,000 at 30 minutes*	*100,000 at 30 minutes*
Process treatment	*Low temperature charcoal*	*Recombiner ambient charcoal*	*Chilled charcoal*
Number of beds	*8*	*12*	*5*
Design condenser in-leakage (cfm)	*30*	*40*	*12.5*
Release point - height above ground (ft)	*230*	*394*	*172*
Liquid Radwaste (see Section 11.2)			
Treatment of			
1. Floor drains[a]	*F, D, and R*	*F, D, and R*	*F, E, and R*
2. Equipment drains[a]	*F, D, and R*	*F, D, and R*	*F, D, and R*
3. Chemical drains[a]	*Neutralized, E, D, and R*	*F, discharged E, solid to radwaste*	*E, D, concentrates to solid radwaste distillate R*
4. Detergent drains[a]	*Chemical addition, F, E, and sent to circulating water discharge[b]*	*Diluted and sent to circulating water discharge*	*Reverse osmosis discharge*
5. Expected annual average release (μCi) (excluding tritium)	*170*	*2000*	*1.09*

[a] *Legend:*
D = demineralized.
F = filtered.
E = evaporator/concentrator.
R = recycled, i.e., returned to condensate storage.

[b] *Laundry will be processed offsite by authorized contractor.*

Table 1.3-6

Comparison of Structural Design Characteristics

	CGS BWR 5 251-764	HATCH 1 BWR 4 218-560	ZIMMER BWR 5 218-560
Seismic Design (see Section 3.7)			
Operating basis earthquake (horizontal g)	*0.125*	*0.08*	*0.10*
Safe shutdown earthquake (horizontal g)	*0.250*	*0.15*	*0.20*
Wind Design (see Section 3.3)			
Maximum sustained (mph)	*100*	*105*	*90*
Tornados			
Translational (mph)	*60*	*60*	*60*
Tangential (mph)	*300*	*300*	*300*

Table 1.3-7

Comparison of Electrical Systems Design Characteristics

	CGS[a] BWR 5 251-764	HATCH 1 BWR 4 218-560	ZIMMER BWR 5 218-560
Transmission System (see Section 8.2)			
Outgoing lines (number - rating)	1 - 500 kV	4 - 230 kV	3 - 345 kV
Normal auxillary ac power			
Incoming lines (number - rating)	1 - 230 kV 1 - 115 kV	4 - 230 kV	1 - 69 kV 1 - 345 kV
Normal auxiliary transformers	2	2	1 (unit auxiliary)
Startup/backup auxiliary transformers	2	2	2
Standby ac power supply			
Number of diesel generators	3[b]	3[c]	3
Number of 4160-V shutdown (Class 1E) buses	3[b]	3	3
Number of 480-V shutdown (Class 1E) buses	5[b]	2 (600 V)	5
Power Supply (dc) (see Section 8.3.2)			
Number of 24-V batteries	4	2 (48 V)	
Number of 125-V batteries	6[d]	3	3
Number of 250-V batteries	1	2	1
Number of 24-V buses	2	2 (24/48 V)	
Number of 125-V buses	6[d]	3	3
Number of 250-V buses	1	2	1

[a] Does not include 450-V dc security system.
[b] HPCS system included.
[c] Total of five for two units.
[d] HPCS battery and bus included.

Table 1.3-8

Significant Design Changes from PSAR to FSAR

Item	*Change*	*Reason for Change*	*FSAR Portion in Which Change is Discussed*
Offgas system class change	*The offgas system components are Quality Group C, whereas the system components were described in the PSAR as being Quality Group D.*	*Improve assurance of system integrity.*	*11.3.1*
Control rod drive position indication	*Changed to 11 wire probe and solid state.*	*Improved reliability and increased frequency of checking actual rod position.*	*7.7.1*
Control rod drive system	*Deleted CRD return line and pump test bypass, revised cooling and exhaust water headers, added relief valves interconnecting cooling water and exhaust headers, redirected system exhaust flow through the multiple solenoid valves in each HCU.*	*GE recommendation.*	*4.6.1.1.2.4*
Recirculation pump and motor	*The flow rate and horsepower required has been reduced; voltage has changed from 4160 V to 6600 V. A low-frequency motor generator set was added to provide 25% speed.*	*Detailed system.*	*5.4.1*
Jet pumps	*The jet pump design was changed to improve five-hole type.*	*Design improvement, increased efficiency.*	-
Recirculation flow measurement	*The recirculation flow measurement design was changed from a flow element to an elbow-tap type.*	*To improve flow measurement accuracy.*	*7.3.1*
Recirculation system	*The pressure interlock for RHR injection was changed.*	*IEEE-279 requirements.*	*7.3.1, 7.6.1*
Recirculation system	*Bypass line around reactor recirculation system flow control valve was eliminated.*	*Reduce the possibility of cavitation and cracking of piping in the recirculation system. Need eliminated by addition of low frequency motor generator set.*	

Table 1.3-8

Significant Design Changes from PSAR to FSAR (Continued)

Item	*Change*	*Reason for Change*	*FSAR Portion in Which Change is Discussed*
Nuclear fuel	*The number of fuel pins in each fuel bundle has been changed from 7 x 7 to 8 x 8 (including two water rods).*	*Improved fuel performance by increasing safety margins.*	*4.2*
Nuclear boiler	*A turbine building high temperature trip for MSIVs was added.*	*Improve leak detection capability.*	*7.3.1*
Nuclear boiler	*An additional test mode was added for closing MSIVs one at a time to 90% of full open in the fast mode (close in slow mode already existed).*	*Verifies that the spring force on the valves will cause them to close under loss-of-air conditions.*	*5.4.5*
Main steam line isolation	*A main condenser low vacuum initiation of the main steam line isolation was added.*	*NRC requirement.*	*7.3.1*
Main steam line isolation	*Reactor isolation was deleted for reactor high water level.*	*To provide improved plant availability.*	*5.4.5*
Main steam line drain system	*A main steam line drain system was improved.*	*Prevent accumulation of condensate in an idle line outboard of MSIV.*	*5.1.1*
RPV code	*The RPV code was updated to ASME 1971 and Summer 1971 addenda.*	*Update to applicable code as much as possible.*	*5.2.1*
Level instrumentation	*The RPV level instrumentation was revised to eliminate Yarway columns and replace them with a conventional condensing chamber type; also, separation and redundancy features were added.*	*Improve ECCS separation per IEEE-279 and improve reliability.*	*7.3.1*
Turbine seal setpoint pressure	*The turbine seal setpoint pressure was changed from 50 psia to 125 psia.*	*Ensures that main turbine condenser can extract reactor steam at temperature above cooling capability of RWCU system.*	-
Leak detection system	*The leak detection system was revised to upgrade the capability and incorporate the requirements of IEEE-279.*	*To meet IEEE-279 requirements.*	*7.6.1*

Table 1.3-8

Significant Design Changes from PSAR to FSAR (Continued)

Item	*Change*	*Reason for Change*	*FSAR Portion in Which Change is Discussed*
Reactor vibration monitoring	*A confirmatory vibration monitoring test was added.*	*NRC requirement.*	*14.2.12.3.34*
RWCU system sample station	*The P&IDs were changed to provide continuous monitoring.*	*Technical Specifications requirements.*	-
LPCS system	*Valve F011 was changed from air-operated to motor-operated control.*	*To provide Seismic Category I rated control power to this essential active component.*	*7.3.1.1.1.3*
LPCS system	*Direct connection to condensate storage replaced by removable spool piece connection to RHR.*	*Condensate used only for system commissioning tests.*	*Figure 6.3-5*
PRT replaced by RPT	*Prompt relief trip (PRT) was replaced by recirculation pump trip (RPT) for quick insertion of negative reactivity.*	*Increased reliability.*[a]	*7.6.1.5*
Main steam system	*Relief valve augmented bypass (REVAB) was deleted.*	*Licensing requirement.*[a]	-
Feedwater sparger	*The thermal sleeve was changed to provide welded design of sparger to nozzle.*	*To eliminate vibration, failure, and leakage.*	*5.3*
Standby liquid control (SLC) system	*Interlocks on the SLC system were revised.*	*To prevent inadvertent boron injection during system testing.*	*7.4.1, 9.3.5*
Standby liquid control (SLC) system	*RCPB extended to explosive valves*	*To meet isolation criteria.*	-
RCIC steam supply	*A warmup bypass line and valve was added.*	*Permits pressurizing and prewarming of the steam supply line downstream to the turbine during reactor vessel heatup.*	*5.4.6*
RCIC vacuum breaker system	*A vacuum breaker system was added to the RCIC turbine exhaust line into the suppression pool.*	*To prevent backup of water in the pipe and consequential high dynamic pipe loads and reactions.*	*5.4.6*

Table 1.3-8

Significant Design Changes from PSAR to FSAR (Continued)

Item	*Change*	*Reason for Change*	*FSAR Portion in Which Change is Discussed*
RCIC system	*Each component has been made capable of functional testing during normal plant operation.*	*Improved testability.*	*5.4.6*
Automatic depressurization system (ADS)	*The interlocks on the automatic depressurization system were revised.*	*To meet IEEE-279 requirements.*	*7.3.1*
RPV support	*The support for the RPV was changed from a ring girder to a bearing plate.*	*Provides a better seismic and alignment capability.*	*5.3.3.1.4.1*
Plant service water pumps	*Upon loss of offsite power without a LOCA, the normal 4160 V service buses (SM-75, SM-85), are connected to SM-7 and SM-8 to provide automatic starting of a plant service water pump for drywell cooling.*	*Provides service water for drywell cooling automatically after loss of offsite power without a LOCA.*	*Figure 8.1-2, Tables 8.3-1 and 8.3-2*
Reactor building cooling system	*ESF cooling units have been added to critical electric equipment areas in the reactor building.*	*To provide suitable ambient temperature conditions for essential electrical and control equipment located in the reactor building in the event of a LOCA.*	*9.4.9*
Standby gas treatment system	*Added second fan (powered from alternate power bus) to each standby gas treatment system.*	*To remove need for crosstie between the two systems.*	*6.5.1.2*
Standby gas treatment system	*Added facility to recirculate air from SGTS back into reactor building.*	*So that potential decay heat in filter can be removed without discharge to atmosphere in event of divisional power failure.*	*6.5.1.2*
Standby gas treatment system	*Added second electric preheater (powered from alternate power bus) to each SGTS unit.*	*To provide means of controlling relative humidity of air entering charcoal filter in event of primary heater or divisional power failure.*	*6.5.1.2*

Table 1.3-8

Significant Design Changes from PSAR to FSAR (Continued)

Item	Change	Reason for Change	FSAR Portion in Which Change is Discussed
Control room HVAC system	*Added two remote air intakes for pressurizing control room in event of a LOCA.*	*To limit doses to operating personnel to limits of 10 CFR 50.*	*9.4.1.2*
Ventilation system for areas in which essential cable is routed	*Added to ESF ventilation system to ventilate corridors and cable chases through which essential cable is routed (diesel generators to control room).*	*To provide suitable ambient temperatures for essential cable in the event of a LOCA*	*9.4.8*
Offgas system charcoal vault	*Added a refrigeration system to the vault in which the offgas system charcoal adsorber filters are housed.*	*To maintain charcoal adsorbers at a temperature of 0°F.*	*9.4.5, 11.3.2.1*
Makeup water pumps transformer vault ventilation	*Added a ventilation system to makeup water pump transformer rooms powered from the emergency buses.*	*To ensure suitable ambient temperatures for transformers in the event of a loss of offsite power caused by a tornado.*	*9.4.6*
Radioactive waste solidification process	*Cement-sodium silicate solidification process to be used in lieu of urea-formaldehyde process.*	*To eliminate the generation of free water in solidified containers, a problem inherent to the urea-formaldehyde process.*	*11.4*
Air ejector	*Three-stage air ejector to two-stage air ejector.*	*Manufacturer offered a two-stage unit that meets the same operating conditions.*	*10.4.2*
Sealing steam supply	*The gland steam evaporator will produce sealing steam using main steam on its tube side during startup and shutdown modes. PSAR stated auxiliary boiler would be used.*	*Adequate sealing steam can be produced with main steam pressure down to 125 psig.*	*10.4.3*
Containment instrument air	*The CIA air compressors were removed and the system is now supplied with nitrogen during reactor operation. Redundant bottled gas supply utilized for supplying ADS valve accumulators for accident conditions.*	*The purpose of the safety related bottled gas supplies is to back up the non-safety-related cryogenic nitrogen supply.*	*9.3.1.1.2*

Table 1.3-8

Significant Design Changes from PSAR to FSAR (Continued)

Item	*Change*	*Reason for Change*	*FSAR Portion in Which Change is Discussed*
Offgas holdup line	*Radiography of circumferential welds was not done.*	*A partial section of the line was buried before radiography was done. Welds were magnetic particle tested and line was hydro-tested at 1200 psig and then helium pressure decay leak tested with a sensitivity of 10^{-2} cm^3/sec.*	-
Wet solid radwastes	*Packaged in 50 ft^3 containers rather than 50-gal drums.*	*Reduce handling time and operator exposure.*	*11.4.2.10*
Turbine bypass valve system	*Four bypass valves are used rather than three.*	*Solution to operating problems with bypass valves on Cooper Nuclear station.*	*10.4.4*
Main steam isolation valve leakage control system	*Added to plant.*	*NRC requirement.*	*6.7*
Main steam line from outermost isolation valve to turbine stop valve	*Piping has been upgraded from Code Group D to Code Group B.*	*NRC requirement.*	*10.3.2*
Radwaste tank sizes			
1. Waste sludge phase separator	*From 12,500 to 13,000 gal.*	*To increase capacity.*	*Table 11.4-4*
2. Chemical waste tank	*From 13,000 to 15,000 gal.*	*To increase capacity.*	*Table 11.2-13*
3. Decontamination solution concentrated waste tank	*From single 700-gal to two 700-gal tanks.*	*To provide spare tank.*	*Table 11.4-4*

Table 1.3-8

Significant Design Changes from PSAR to FSAR (Continued)

Item	*Change*	*Reason for Change*	*FSAR Portion in Which Change is Discussed*
4. Concentrated waste measuring tank	*From 100 to 400 gal.*	*Due to increase in shipment container size from 50 gal to 50 ft^3.*	*Table 11.4-4*
5. Condensate phase separators	*From 12,500 to 23,500 gal.*	*To increase capacity in event of higher than normal backwash requirements.*	*Table 11.4-4*
6. Chemical addition tank	*From single 1000-gal tank to two 200-gal tanks.*	*To provide capability for both acid and caustic addition from separate tanks. Original tank oversized.*	*Table 11.2-13*
Floor drain system	*Influent waste radionuclide concentration changed from range of10^{-4} to 10^{-2} µCi/ml to on order of 10^{-1} µCi/ml.*	*Reevaluation of source terms.*	*11.2.2.2.2*
Liquid radwaste system	*GALE code was used to calculate radioactive discharges with 2500-gpm blowdown. Blowdown of 4000 gpm was used in the PSAR.*	*NRC requirement to use GALE Code. Change in blowdown results in more conservative (higher) radionuclide concentrations.*	*11.2.3.2*
Cleaning of filters	*Changed from steam cleaning connections to chemical cleaning system.*	*Design improvement.*	*Figure 10.4-5*
Missiles from tornadoes	*Selection of credible missiles.*	*For FSAR, followed specific missiles identified in NRC Standard Review Plan.*	*3.5.1.4*
Cleaning of filters	*Changed from steam cleaning connections to chemical cleaning system.*	*Design improvement.*	*Figure 10.4-5*
Missiles from tornadoes	*Selection of credible missiles.*	*For FSAR, followed specific missiles identified in NRC Standard Review Plan.*	*3.5.1.4*
Primary containment vessel	*New loads due to hydro-dynamic effects of safety/relief valve actuation and LOCA (neither in PSAR or FSAR; see Dynamic Analysis Report).*	*To accommodate new GE load requirements.*	*3.8.2*

Table 1.3-8

Significant Design Changes from PSAR to FSAR (Continued)

Item	*Change*	*Reason for Change*	*FSAR Portion in Which Change is Discussed*
Diesel generator building fire protection system	*Changed from CO_2 system to dry pipe preaction system. after a fire.*	*To provide accessibility to the diesel immediately. Also availability of unlimited water supply*	*Appendix F*
Cable chase fire protection system	*Added dry pipe preaction system for cable chase and diesel generator building corridor.*	*To protect divisional cable concentrations in these areas.*	*Appendix F*
500-kV line	*Hookstick changed to motor-operated switch.*	*Available standard switches are supplied with motor operators.*	*Fig. 8.1-2*
500-kV line	*Line terminates at H. J. Ashe Swtichyard rather than Hanford Switching Station.*	*BPA revisions to 500 kV grid.*	*8.1.2*
230-kV line	*Deleted hookstick and 230-kV OCB at plant switchyard.*	*OCB relocated to H. J. Ashe Switchyard.*	*Fig. 8.1-2*
115-kV line	*Replace circuit interrupter with 115-kV OCB at plant switchyard.*	*Equipment availability.*	*Fig. 8.1-2*
Backup source	*Utilized to supply essential loads during diesel generator testing.*	*PSAR did not consider particulars of diesel generator testing.*	*8.3.1.1.7.1.7*
Diesel generator starting	*Deleted automatic starting due to startup or backup transformer undervoltage.*	*Class 1E bus undervoltage is the only undervoltage condition requiring diesel generator start*	*8.3.1.1.7.1.7* *8.3.1.1.7.2.7*
Diesel generator trips during emergency operation	*Added incomplete sequence trip to Division 1 and 2 diesel generators.*	*Incomplete sequence indicates a diesel generator malfunction having an imminent possibility of unit damage.*	*8.3.1.1.7.1.8*
125-V, 250-V-dc battery capability	*Revised supply capability from 4 hr to 2 hr.*	*Increased dc load*	*8.3.2*
125-V, 250-V-dc charger capability	*Revised recharge capability from 8 hr to 24 hr.*	*Increased dc load*	*8.3.2*

Table 1.3-8

Significant Design Changes from PSAR to FSAR (Continued)

Item	*Change*	*Reason for Change*	*FSAR Portion in Which Change is Discussed*
Spare 125-V-dc charger	*Spare charger serves as a backup for Divisions 1 and 2 only.*	*Spare charger is too large to provide backup to Division 3.*	*8.3.2*
Communication systems	*The commercial telephone exchange system is not redundant.*	*Redundancy not required.*	*8.2.1.5*
Fuel pool cooling and cleanup system	*Upgraded cooling portion of system to Seismic Category I to provide long-term cooling and safety grade makeup water capability for coolant of spent fuel following refueling.*	*To prevent fuel pool boiling and resultant adverse environmental conditions which could affect safety-related electrical equipment in the reactor building.*	*9.1.3*

[a] *PRT and REVAB were proposed at the CP stage as non-safety-related power generation type systems to reduce the thermal-hydraulic effects of transient events in the core. However, during experiments in the MK-11 suppression pool dynamics test program, it was decided that less frequent relief valve cycling during plant operation was desirable. Consequently, the recirculation pump trip (RPT) system was developed to perform functions previously assigned to PRT and REVAB.*

1.4 IDENTIFICATION OF AGENTS AND CONTRACTORS

The italicized information is historical and was provided to support the application for an operating license.

1.4.1 APPLICANT/OPERATOR

Energy Northwest is 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, as amended. Energy Northwest assumes the responsibility for safe operation and maintenance of the plant and for providing related services as described in Chapter 13.

1.4.2 ENGINEER AND CONSTRUCTION MANAGEMENT - BURNS & ROE, INC.

Burns and Roe, Inc. (B&R) provides engineering and initial construction management and quality assurance services for the design and construction of the plant, integrating the major plant items furnished by the General Electric Company (GE) and Westinghouse Electric Corporation.

Burns & Roe was founded in 1932 and incorporated in 1935 as Burns and Roe, Inc. Burns & Roe has been active in the fields of power generation and distribution, sea water and brackish water desalination, waste water renovation, and engineering, design, and/or construction management services for over 50 thermal power generating units representing more than 11,400,000 kW of new generating capacity, of which more than 4,800,000 kW is nuclear. Burns & Roe, Inc., has been continuously engaged in construction of engineering activities since 1935.

1.4.3 NUCLEAR STEAM SYSTEM SUPPLIER - GENERAL ELECTRIC COMPANY

General Electric designed, fabricated, and delivered the direct-cycle boiling water nuclear steam supply system (NSSS) for Columbia Generating Station (CGS). General Electric also fabricated the first core of nuclear fuel and provided technical direction of installation and startup of this equipment.

General Electric has engaged in the development, design, construction, and operation of boiling water reactors (BWRs) since 1955. Table 1.4-1 lists GE reactors completed, under construction, or ordered (several later canceled). Thus, GE has substantial experience, knowledge, and capability to design, manufacture, and furnish technical assistance for the installation and startup of reactors.

General Electric continues to provide technical support for the operation of CGS as requested by Energy Northwest. This includes providing support for the CGS Megawatt Improvement Program (see Section 1.1).

1.4.4 TURBINE GENERATOR SUPPLIER - WESTINGHOUSE ELECTRIC CORP.

Westinghouse Electric Corporation designed, fabricated, delivered, and installed the turbine generator for CGS. They also provided technical assistance for the startup of this equipment.

Westinghouse Electric Corporation has a long history in the application of turbine generators in nuclear power stations going back to the inception of commercial electrical power production using nuclear facilities. Westinghouse furnished the turbine generator unit for Shippingport No. 1. This unit was shipped in 1956. Westinghouse also furnished the turbine generator unit for Yankee Atomic Power Company Rowe No. 1. This unit was shipped in 1959. San Onofre No. 1 and Connecticut Yankee, Haddam Neck No. 1 unit went into commercial operation in 1968. Westinghouse nuclear turbine generators produced over 300 billion kW hr of electricity through May 1976, when 25 nuclear turbine generators totaling over 16,500 MW were in service. By 1984, 75 Westinghouse nuclear turbine generators should be in service producing over 61,319 MW. Inlet steam pressures of these units vary between 750 psig and 1000 psig and electrical outputs vary from 500,000 kW to 1,090,000 kW.

Westinghouse continues to provide technical and maintenance support for the turbine generator on an as-requested basis. They also provided replacement for the three low-pressure turbine rotors installed in the Spring 1992 refueling outage.

1.4.5 SYSTEM COMPLETION CONTRACTOR - BECHTEL

As System Completion Contractor, Bechtel provides field and home office services in project planning and control, engineering, construction completion, startup support, and quality verification for CGS. The Bechtel organization was founded in 1898, in the midwest, by Warren A. Bechtel. In 1940, Bechtel went international, working on a pipeline system in Venezuela; and then vastly diversified its activities during World War II, becoming involved in naval bases, shipyards, pipelines, refineries, and aircraft modification. Next, Bechtel pioneered in the nuclear power field, constructing the first reactor to produce useful electricity in 1949, and building Dresden I, the first commercial nuclear power station. Today, Bechtel is recognized as one of the world's leading engineering and construction firms.

1.4.6 MAJOR CONTRACTORS

1.4.6.1 Fischbach/Lord

Fischbach/Lord is responsible for the major electrical installation at CGS, consisting of raceways, conduit, cable, terminators, and electrical equipment. They were formed as a joint venture, solely for this project, in 1974.

1.4.6.2 Pittsburgh-Des Moines Steel Company

Pittsburgh-Des Moines Steel Company is responsible for engineering, fabrication, and installation of materials in the Primary Containment Vessel.

1.4.6.3 Wright-Schuchart- Harbor/Boecon (Boeing Construction)/General Energy Resources, Inc.

Wright-Schuchart-Harbor/Boecon/General Energy Resources, Inc. (WBG) was formed as a joint venture October 1, 1977, to be responsible for installation of major mechanical equipment, power, and process piping for CGS.

1.4.6.4 Bechtel

During plant construction, Bechtel served as the Construction Manager. During the operating phase Bechtel, as the Site Support Services contractor, is providing field engineering and installation support for plant modifications. Also, as Technical Services contractor, they are providing engineering support under Energy Northwest direction and under the Energy Northwest quality assurance program as requested by Energy Northwest. Under these contracts Bechtel is providing support to the Megawatt Improvement Program (see Section 1.1).

1.4.6.5 Deleted

1.4.6.6 Westinghouse Electric

Westinghouse provided the turbine generator. They provided replacement of the three low-pressure rotors which were installed in 1992. Westinghouse also provided a new plant simulator which was installed in 1995.

1.4.7 CONSULTING ENGINEER - R. W. BECK AND ASSOCIATES

The independent consulting firm of R. W. Beck and Associates is the consulting engineer for Energy Northwest's Columbia Generating Station. This firm was also a consulting engineer for WNP-1. Having extensive experience in preparing engineering feasibility and financing studies and reports necessary for the success of utility and civic improvement projects, the firm is well qualified for employment as a consulting engineer and was chosen as a result of its experience.

The duties of the consulting engineer are briefly summarized as follows: prepare estimates of plant capability, energy potential, usability within area loads and resources, the cost of power and energy output of the project, and generally determine the feasibility of the project. These duties will include assisting in preparation of a Bond Resolution, preparation of an engineering report, schedules for investment of funds, schedules for debt service payments, and other engineering services necessary to facilitate the financing of the project.

Table 1.4-1

Commercial Nuclear Reactors Completed, Under Construction, or in Design by General Electric

Station	Utility	Rating (MWe)	Year of Order	Year of Startup
Dresden 1 [a]	Commonwealth Edison	207	1955	1960
Humboldt Bay [a]	Pacific G&E	63	1958	1963
Kah1 [a]	Germany	15	1958	1961
Garigliano [a]	Italy	150	1959	1964
Big Rock Point	Consumers Power	71	1959	1965
JPDR	Japan	11	1960	1963
KRB [a]	Germany	237	1962	1967
Tarapur 1	India	190	1962	1969
Tarapur 2	India	190	1962	1969
GKN	Holland	52	1963	1968
Oyster Creek	JCP&L	620	1963	1969
Nine Mile Point 1	Niagara Mohawk	610	1963	1969
Dresden 2	Commonwealth Edison	794	1965	1970
Pilgrim 1	Boston Edison	655	1965	1972
Millstone 1	NUSCo	660	1965	1970
Tsuruga	Japan	340	1965	1970
Nuclenor	Spain	440	1965	1971
Fukushima 1	Japan	439	1966	1971
BKW KKM	Switzerland	306	1966	1972
Dresden 3	Commonwealth Edison	794	1966	1971
Monticello	Northern States	536	1966	1971
Quad Cities 1	Commonwealth Edison	789	1966	1972
Browns Ferry 1	TVA	1065	1966	1974
Browns Ferry 2	TVA	1065	1966	1975
Quad Cities 2	Commonwealth Edison	789	1966	1972
Vermont Yankee	Vermont Yankee	514	1966	1972
Peach Bottom 2	Philadelphia Electric	1065	1966	1974
Peach Bottom 3	Philadelphia Electric	1065	1966	1974
James A. FitzPatrick	New York Power Authority	821	1966	1975
Bailly [b]	NIPSCo	660	1966	----
Shoreham [b]	LILCo	819	1967	1985
Cooper	Nebraska PPD	778	1967	1974
Brown Ferry 3	TVA	1065	1967	1977
Limerick 1	Philadelphia Electric	1055	1969	1985
Hatch 1	Georgia	786	1967	1975
Fukashima 2	Japan	762	1967	1974
Brunswick 1	Carolina P&L	790	1968	1977
Brunswick 2	Carolina P&L	790	1968	1975
Arnold	Iowa ELP	545	1968	1975
Fermi 2	Detroit Edison	1056	1968	1984
Limerick 2	Philadelphia Electric	1055	1969	----

Table 1.4-1

Commercial Nuclear Reactors Completed, Under Construction, or in Design by General Electric (Continued)

Station	Utility	Rating (MWe)	Year of Order	Year of Startup
Hope Creek 1	PSE&G	1067	1969	1986
Hope Creek 2[b]	PSE&G	1067	1969	----
Zimmer[b]	CCDPP	810	1969	----
Chinshan	Taiwan	610	1969	1977
Caorso 1	Italy	827	1969	1975
Hatch 2	Georgia	795	1970	1979
LaSalle County 1	Commonwealth Edison	1078	1970	1983
LaSalle County 2	Commonwealth Edison	1078	1970	1984
Susquehanna 1	Pennsylvania P&L	1050	1968	1983
Susquehanna 2	Pennsylvania P&L	1050	1968	1984
Chinshan 2	Taiwan	610	1970	1978
Columbia Generating Station	Energy Northwest	1103	1971	1984
Nine Mile Point 2	Niagara Mohawk	1090	1971	1986
Grand Gulf 1	Midsouth	1250	1972	1985
Kaiseraugst[b]	Switzerland	915	1971	----
Fukushima	Japan	1135	1971	1976
Takai 2	Japan	1135	1971	1976
River Bend 1	Gulf States	940	1971	1985
River Bend 2[b]	Gulf States	940	1971	----
Perry 1	Cleveland Electric	1205	1971	1985
Perry 2[b]	Cleveland Electric	1205	1971	----
Hartsville A-1[b]	TVA	1233	1972	----
Hartsville B-1[b]	TVA	1233	1972	----
Hartsville A-2[b]	TVA	1233	1972	----
Hartsville B-2[b]	TVA	1233	1972	----
Laguna Verde 1	Mexico	660	1972	1977
Leibstadt	Switzerland	940	1972	1978
Kuosheng 1	Taiwan	992	1972	1978
Kuosheng 2	Taiwan	992	1972	1979
Clinton 1	Illinois Power	950	1973	1986
Clinton 2[b]	Illinois Power	950	1973	----
Montague 1[b]	NUSCO	1150	1973	----
Allens Creek 1[b]	Houston L&P	1200	1973	----
Skagit 1[b]	Puget SD	1288	1973	----
Skagit 2[b]	Puget SD	1288	1973	----
Barton 3[b]	Alabama	1220	1973	----
Blackfox 1[b]	Oklahoma	1150	1973	----
Blackfox 2[b]	Oklahoma	1150	1973	----
Cofrentes	Spain	975	1973	1977
Laguna Verde 2	Mexico	660	1973	1978
Enel 6[b]	Italy	982	1974	----
Enel 8[b]	Italy	982	1974	----

[a] Retired
[b] Discontinued

1.5 REQUIREMENTS FOR FURTHER TECHNICAL INFORMATION

The italicized information is historical and was provided to support the application for an operating license.

1.5.1 GENERIC ISSUES

NUREG-0933, "A Prioritization of Generic Safety Issues" presents the generic issues as follows:

a. *TMI action plan items*

In NUREG-0933, these follow the content and format of NUREG-0660 and NUREG-0737.

b. *Task action plans*

These include both the unresolved safety issues (USIs) previously included in NUREG-0606 and the Category A Generic Activities previously included in NUREG-0371 and the Category B, C and D Generic Activities previously included in NUREG-0471.

c. *Human factors*

These are the human factors considerations of NUREG-0660 and NUREG-0737.

d. *Chernobyl Issues*

This part addresses the recommendations of NUREG-1251.

In the sections below, these issues are addressed as unresolved safety issues (USIs), generic safety issues (GSIs), and TMI Task Action Plans. Human Factors considerations are included as part of the TMI Task Action Plans. Chernobyl is not addressed below or on the CGS docket as NUREG-1251 lead to the conclusion that no immediate changes in NRC regulations regarding the design or operation of U.S. commercial reactors were required. However, NUREG-1251 and INPO SER 34-86, "Chernobyl Unit 4 Accident," and INPO SOER 87-1, "Core Damaging Accident Following an Improperly Conducted Test," were reviewed by Energy Northwest to identify the need for any changes to hardware, procedures, or training at CGS.

1.5.1.1 Unresolved Safety Issues

1.5.1.1.1 Unresolved Safety Issues Introduction

Unresolved safety issues are issues identified by the NRC that affect a number of plants, question the adequacy of existing requirements, have no current resolution and are judged to be unacceptable if left unresolved for the life of the plant.

A December 20, 1977, amendment to the Energy Reorganization Act required that the NRC develop a plan providing for specification and analysis of USIs and take action as necessary to implement corrective measures with respect to such issues. In a joint Explanatory Statement of the House - Senate Conference Committee for the FY 1978 Appropriations Bill this was explained to mean that a plan was to be developed to resolve the USIs. In September 1989, the NRC achieved resolutions of all of the identified USIs.

On October 19, 1989, the NRC issued Generic Letter 89-21, "Request for Information Concerning Status of Implementation of Unresolved Safety Issue (USI) Requirements." This generic letter requested that licensees and construction permit holders review and report on the status of the implementation of USIs for which final technical resolution had been achieved.

Energy Northwest responded to this request in Reference 1.5-1. The NRC responded to this submittal by Reference 1.5-2 and identified anticipated transient without scram (ATWS), Station Blackout and Safety Implications of Control Systems (A-9, A-44, and A-47, respectively) as not being implemented. (Subsequently, these have been resolved as discussed below.)

1.5.1.1.2 Implementation of Specific Unresolved Safety Issues

A-8 Mark II Containment Pool Dynamic Loads

Resolution of A-8 for CGS is documented in NUREG-0892 (the SER for CGS) and Supplements 4 and 5 in Sections 6.2.1.8 and 3.9.3.1, respectively.

A-9 Anticipated Transients Without Scram

In the safety evaluation transmitted with Reference 1.5-7, the NRC stated that the standby liquid control (SLC) flow and sodium pentaborate decahydrate concentration for CGS were in compliance with the ATWS rule.

The design requirements for resolution of ATWS for CGS were to install an alternate rod injection (ARI) system (see Section 7.4.1.6), a standby liquid control (SLC) system (see Sections 7.4.1.2 and 9.3.5), and to trip the reactor recirculation pumps automatically by a recirculation pump trip (RPT) system under conditions indicative of an ATWS (Section

7.4.1.5). In addition, ATWS equipment needed to be qualified for the environmental conditions associated with anticipated operational occurrences and to ATWS conditions up to the time the required function is completed (Reference 1.5-10). The FSAR Section 15.8 ATWS analysis also needed to be revised.

In Reference 1.5-3, the NRC stated that the CGS alternate rod injection system was in compliance with the ATWS rule. The reference also stated that the RPT system required two modifications to be in compliance with the rule. Reference 1.5-4 documents the implementation of the changes required to resolve these two issues.

In Reference 1.5-5, Energy Northwest informed the NRC that confirmation of the environmental qualifications of ATWS equipment remained to be confirmed. Reference 1.5-6 documented that the confirmation had been completed.

In FSAR Amendment 42, Section 15.8 was revised to include new ATWS analyses. Technical Specification Amendment 93 was issued on August 9, 1991 which addressed modifications to the ATWS-RPT system. With this amendment, all activities required for ATWS resolution for CGS were completed.

A-10 BWR Feedwater Nozzle Cracking

NRC review of CGS relative to A-10 and NUREG-0619, which Generic Letter 89-21 states resolves this USI, is documented in NUREG-0892, Sections 3.9.3.1, 5.2.3.1, and 5.2.4. While these sections address A-10, they do not specifically state that the total issue is resolved for CGS. However, as no concerns were raised in the subsequent five supplements to NUREG-0892 and as Energy Northwest was not aware of a concern of the NRC's regarding A-10 subsequent to the issuance of the operating license, in Reference 1.5-1 Energy Northwest stated that it believed A-10 to be resolved for CGS. This position was apparently accepted by the NRC by the issuance of Reference 1.5-2.

A-11 Reactor Vessel Material Toughness

NRC acceptance of the CGS commitment to 10 CFR 50, Appendix G, is discussed in NUREG-0892, Section 5.3.2. In NUREG-0744 and Generic Letter 82-26 issued subsequent to the publication of the original issue of NUREG-0892, a response by licensees was not required; they only provided guidance to licensees who may have been required to submit a fracture analysis to justify continued operation. This was not the case for CGS.

A-17 Systems Interactions

Generic Letter 89-18 issued September 6, 1989 transmitted NRC final resolution of this USI. No formal reply was required. Energy Northwest incorporated information contained and referenced in this Generic Letter into the CGS IPE program, the results of which were

submitted to the NRC by Reference 1.5-22. However, as no formal action to Generic Letter 89-18 was required, Energy Northwest considered this USI closed for CGS prior to the completion of the IPE. This was so stated in Reference 1.5-1.

A-24 Qualification of Class 1E Safety Related Equipment

In NUREG-0892 Supplement 4, Section 3.11.5, the NRC states that CGS has demonstrated conformance to NUREG-0588. Generic Letter 89-21 states that Revision 1 to NUREG-0588 resolved A-24. By NRC memorandum, J. Knight to T. Novak, dated November 1983 (8312120370), Mr. Knight states that the CGS review was to Revision 1 of the NUREG.

A-31 Residual Heat Removal Shutdown Requirements

NUREG-0892 states in Section 5.4.2.1 that the CGS RHR system conforms to the Commission's regulations and applicable Regulatory Guides. Generic Letter 89-21 states that A-31 was resolved in May 1978 by publication of SRP 5.4.7. As NUREG-0892 was written in May 1982, Energy Northwest stated in Reference 1.5-1 that this established closure of A-31 for CGS.

A-36 Control of Heavy Loads

NUREG-0892 Supplement 4, Section 9.1.5, states that the guidelines of NUREG-0612 have been satisfied for CGS. Generic Letter 89-21 states that NUREG-0612 resolves A-36.

A-39 Determination of Safety Relief Valve Pool Dynamic Load and Temperature Limits

Section 6.2.1.8 of NUREG-0892 Supplements 1 and 4, provides NRC acceptance of the resolution of this issue for CGS.

A-40 Seismic Design Criteria

NUREG-1233 issued September 1989 states that the proposed changes that constitute the resolution of USI-40 are to apply to new applicants only. CGS is not one of the plants identified in Generic Letter 89-21 that needed to be reviewed to the new criteria.

A-42 Pipe Cracks in Boiling Water Reactors

NUREG-0892 states in Section 5.2.3.1 that CGS conforms to the requirements of NUREG-0313, Revision 1, which Generic Letter 89-21 states resolves A-42. NUREG-0892 Supplement 5, Section 5.2.3.2, provides additional information on this issue. Also see Section 5.2.3.2.3. Additional consideration for BWR pipe cracks beyond the scope of A-42 were raised by the NRC in Generic Letter 88-01. The resolution of Generic Letter 88-01 for CGS

is provided in References 1.5-21, 1.5-35, and 1.5-36, and in the Bases for CGS Technical Specifications.

A-43 Containment Emergency Sump Performance

Generic Letter 89-21 states that resolution of A-43 only applies to new plants (i.e., those reviewed after October 1985) and, as such, does not apply to CGS.

A-44 Station Blackout

See Appendix 8A.

A-45 Shutdown Decay Heat Removal

According to guidance provided in Generic Letter 89-21 and Supplement 9 to NUREG-0933, Energy Northwest incorporated closure of A-45 into the CGS IPE program the results of which were submitted to the NRC by Reference 1.5-22.

A-46 Seismic Qualification of Equipment in Operating Plants

Generic Letter 87-03 issued February 27, 1987 which addresses A-46 resolution for CGS did not require any action or plant review. NUREG-1211, Enclosure 1, established Generic Letter 87-03 as applicable to CGS rather than Generic Letter 87-02. As such, Energy Northwest considers this USI closed for CGS. Also, NUREG-0892, Supplement 5 in Appendix C states that A-46 only applies to plants that were operating at the time.

A-47 Safety Implication of Control System

Generic Letter 89-19 provides requirements to close A-47. The overfill protection system required of BWRs is provided for in CGS. Closure of this issue was provided by Reference 1.5-9.

A-48 Hydrogen Control Measures and Effects of Hydrogen Burn on Safety Equipment

As stated in Generic Letter 89-21, A-48 is closed and implemented for Mark II BWRs such as CGS.

1.5.1.1.3 Unresolved Safety Issues Implementation Summary

The resolution of all USIs for CGS has been achieved with the NRC. Regarding Station Blackout (A-44), 10 CFR 50.63(c)(4) provides for a 2 year implementation schedule for closure of identified modifications.

1.5.1.2 Generic Safety Issues

1.5.1.2.1 Generic Safety Issues Introduction

In Generic Letter 90-04, Reference 1.5-12, the NRC requested that licensees and construction permit holders address a list of specific generic safety issues (GSIs) listed in the generic letter. Energy Northwest's response to this request for CGS was provided in Reference 1.5-13.

1.5.1.2.2 Implementation of Specific Generic Safety Issues

The following summarizes the CGS implementation of applicable GSIs listed in Generic Letter 90-04 and other GSIs that have been resolved for CGS subsequent to the issuance of the Generic Letter. The following is a summary of information provided in Reference 1.5-13 with updated information provided as appropriate.

GSI/Subject	*Status*
40/BWR Scram System Pipe Breaks	*Closed as documented in NUREG-0892 (p. 4-4) and documents listed in Reference 1.5-13*
41/BWR Scram Discharge Volume	*Closed as documented in NUREG-0892 (p. 7-6)*
43/Reliability of Air Systems	*Closed as discussed in References 1.5-13 and 1.5-15*
48/LCOs for Class 1E vital Instrumentation Buses - Generic Letter 91-11 (added subsequent to Generic Letter 90-04 response)	*Closed as documented in Reference 1.5-19*
49/Interlocks and LCOs for Class 1E Tie Breakers - Generic Letter 91-11 (added subsequent to Generic Letter 90-04 response).	*Closed as documented in Reference 1.5-19*
51/Improved Reliability of Open-Cycle Service Water Systems	*Closed subsequent to Generic Letter 90-04 as addressed by References 1.5-11, 1.5-37, and 1.5-38*

67/Improved Accident Safety Report Monitoring	*Closed as summarized in NRC Evaluation for CGS Regulatory Guide 1.97 implementation (Reference 1.5-14)*
75/Salem ATWS Events	*Closed subsequent to the Generic Letter 90-04 response by letters listed in Reference 1.5-13, Reference 1.5-17, and issuance of Technical Specification Amendment 90. Generic Letter 83-28, Supplement 1, issued October 7, 1992, did not change this status as CGS does not use reactor trip breakers.*
79/RPV Thermal Stress During Natural Convection Cooldown	*Closed subsequent to Generic Letter 90-04 by Generic Letter 92-02 as not impacting BWRs*
86/Long Range Plan for Stress Corrosion Cracking in BWR Piping	*Closed based upon documents listed in Reference 1.5-13.*
A-13/Snubber Operability Assurance	*NUREG-0933 states that this issue was resolved in 1980 by revision to the Standard Technical Specifications (STS). As the original CGS Technical Specifications were based upon Revision 3 to the BWR STS issued in 1980, this concern is resolved for CGS. In particular, for the five issues mentioned for GSI A-13 resolution in Generic Letter 90-04:* *1. The arbitrary capacity limit of 50,000 lbs that previously existed in Technical Specifications does not appear in the CGS Technical Specifications.* *2. The requirement for NRC approval of seal material does not appear in the CGS Technical Specifications.* *3, 4. Monitoring and IST programs to ensure snubber reliability do exist in the CGS Licensee Controlled Specifications. They are significantly expanded from that included in earlier programs.*

	5. The CGS Licensee Controlled Specifications allow for an in-place snubber IST program. *Thus, the five requirements of A-13 resolution as discussed in Generic Letter 90-04 have been implemented for CGS*
A/30 Adequacy of Safety Related DC Power Supplies - Generic Letter 91-06 (added subsequent to Generic Letter 90-04 response)	*Closed as documented in Reference 1.5-18*
A-35/Adequacy of Offsite NUREG-0892 Power Systems	*Closed as documented in NUREG-0892 (p. 8-16) and discussed in Reference 1.5-13)*
B-63/Installation of Low Pressure Systems Connected to the RCPB	*Closed as discussed in Question 040.079 (FSAR Volume 22) and Reference 1.5-13*

1.5.1.2.3 Generic Safety Issues Implementation Summary

Implementation of the applicable GSIs of Generic Letter 90-04 is complete.

1.5.1.3 TMI Task Action Plans

The CGS responses to the TMI-2 action plans as they were included in NUREG-0737 are provided in Appendix B. This Appendix agrees with Reference 1.5-16 in documenting that all TMI Task Action Plans have been implemented for CGS.

1.5.2 REFERENCES

1.5-1 Letter, GO2-89-215, G. C. Sorensen to NRC, "Response to Generic Letter 89-21 Requesting Plant Status on Implementation of Unresolved Safety Issues," dated November 30, 1989.

1.5-2 Letter, R. B. Samsworth (NRC) to G. C. Sorensen (SS), "Unimplemented Unresolved Safety Issues at WNP-2 (TAC No. 74538)," dated March 20, 1990.

1.5-3 Letter, R. B. Samworth (NRC) to G. C. Sorensen (SS), "ATWS Rule 10 CFR 50.62 relating to ARI and RPT Systems," dated November 6, 1988.

1.5-4 Letter, GO2-90-110, G. C. Sorensen to NRC, "Anticipated Transients Without Scram (ATWS) Design Modifications," dated June 22, 1990.

1.5-5 *Letter, GO2-89-110, G. C. Sorensen (SS) to NRC, "Anticipated Transients Without Scram Implementation Schedule," dated June 16, 1989.*

1.5-6 *Letter, GO2-90-116, G. C. Sorensen (SS) to NRC, "Resolution of ATWS for WNP-2," dated June 29, 1990.*

1.5-7 *Letter, R. B. Samworth (NRC) to G. C. Sorensen (SS), "Issuance of Amendment No. 43," dated May 29, 1987.*

1.5-8 *Letter, GO2-89-062, G. C. Sorensen (SS) to NRC, "Response to Station Blackout Rule using HPCS Diversion III as Alternate AC Power," dated April 17, 1989.*

1.5-9 *PL Eng (NRC) to G. C. Sorensen (SS), Response to "Request for Action Related to Resolution of Unresolved Safety Issue A-47 - Safety Implications of Control System in LWR Nuclear Power Plants, pursuant to 10 CFR 50.54(f) - Generic Letter 89-19 (TAC NO. 75019)," dated November 13, 1991.*

1.5-10 *BWROG Topical Report NEDE-31096-P, "Anticipated Transients Without Scram; Response to NRC ATWS Rule 10 CFR 50.62," dated December 1985.*

1.5-11 *Letter, PL Eng (NRC) to G. C. Sorensen (SS), Evaluation of Response to NRC Generic Letter 89-13, "Service Water System Problems Affecting Safety-Related Equipment (TAC No. 74086)," dated April 26, 1992.*

1.5-12 *Generic Letter 90-04, "Request for Information on the Status of Licensee Implementation of Generic Safety Issues Resolved With Imposition of Requirements or Corrective Actions," dated April 25, 1990.*

1.5-13 *Letter, GO2-90-113, G. C. Sorensen to NRC, "Response to Generic Letter 90-04 Regarding Status of Implementation of Generic Safety Issues, (TAC No. 75993)," dated June 28, 1990.*

1.5-14 *Letter, G. W. Knighton (NRC) to G. C. Sorensen (SS), "Emergency Response Capability - Conformance to Regulatory Guide 1.97, Revision 2, (TAC No. 59516)," dated March 23, 1988.*

1.5-15 *Letter, GO2-89-128, G. C. Sorensen to NRC, "Final Response to Generic Letter 88-14, 'Instrument Air Supply Problems Affecting Safety-Related Equipment," dated July 28, 1989.*

1.5-16 NUREG-1435 Supplement 2, "Status of Safety Issues at Licensed Power Plants," dated December 1992.

1.5-17 Letter, P. L. Eng (NRC) to G. C. Sorensen (SS), "Response to Generic Letter 90-03 for Washington Nuclear Plant 2 (TAC No. 76314)," dated November 8, 1990.

1.5-18 Letter, W. M. Dean (NRC) to G. C. Sorensen (SS), "Response to Generic Letter 91-06, MPA L106, Resolution of Generic Issue A-30, Adequacy of Safety Related DC Power Supplies, Pursuant to 10 CFR 50.54(f) for Washington Public Power Supply System Unit 2 (TAC NO. M81515)," dated March 27, 1992.

1.5-19 Letter, P. L. Eng (NRC) to G. C. Sorensen (SS), "Response to Generic Letter 91-11, 'Resolution of Generic Issues 48-LCOs for Class 1E Vital Instruments Buses and 49 - Interlocks and LCOs for Class 1E Tie Breakers' pursuant to 10 CFR 50.54(f) for Washington Public Power Supply System Nuclear Plant No. 2 (TAC No. M82484)," dated March 2, 1992.

1.5-20 Letter, P. L. Eng (NRC) to G. C. Sorensen (SS), "Status of TMI Item I.D.1.2, 'Detailed Control Room Design Review (DCRDR) at Washington Public Power Supply System Nuclear Project No. 2 (WNP-2) (TAC No. 56181)," dated November 13, 1991.

1.5-21 Letter, P. L. Eng (NRC) to G. C. Sorensen (SS), "Response to GL 88-01, Intergranular Stress Corrosion in Piping (TAC No. 69161)," dated December 28, 1990.

1.5-22 Letter, GO2-92-206, G. C. Sorensen (SS), "Response to Generic Letter 88-20," Individual Plant Examinations for Severe Accident Vulnerabilities 10 CFR 50.54(f)," dated August 28, 1992.

1.5-23 through 1.5-34 Deleted

1.5-35 Letter, GO2-92-004, G. C. Sorensen to NRC, "Response to NRC SER on Generic Letter 88-01 (TAC No. 69161)," dated January 8, 1992.

1.5-36 Letter, GO2-92-086, G. C. Sorensen to NRC, "Additional Response to Generic Letter 88-01 Safety Evaluation Report (TAC Nos. M80358 and M69161)," dated April 10, 1992.

1.5-37 Letter, GO2-90-017, G. C. Sorensen to NRC, "Response to Generic Letter 89-13, Service Water System Problem Affecting Safety-Related Equipment," dated February 5, 1990.

1.5-38 Letter, GO2-91-041, G. C. Sorensen to NRC, "Response to Generic Letter 89-13, Service Water System Problems Affecting Safety-Related Equipment," dated February 28, 1991.

1.6 MATERIAL INCORPORATED BY REFERENCE

Table 1.6-1 is a list of General Electric topical reports and other reports and documents which are incorporated in whole or in part by reference. These documents were filed with the NRC.

Table 1.6-1

Topical Reports

Report	Title	FSAR Section
General Electric Company		
APED-4824	Maximum Two-Phase Vessel Blowdown from Pipes (April 1965)	6.2
APED-5458	Effectiveness of Core Standby Cooling Systems for General Electric Boiling Water Reactors (March 1968)	5.4
APED-5460	Design and Performance of General Electric BWR Jet Pumps (July 1968)	3.9
APED-5555	Impact Testing on Collet Assembly for Control Rod Drive Mechanism 7RDB144A (November 1967)	4.6
APED-5640	Xenon Considerations in Design of Large Boiling Water Reactors (June 1968)	4.1
APED-5652	Stability and Dynamic Performance of the General Electric Boiling Water Reactor (April 1969)	4.1
APED-5696	Tornado Protection for the Spent Fuel Storage Pool (November 1968)	3.3, 3.5, 9.1
APED-5706	Incore Neutron Monitoring System for General Electric Boiling Water Reactors (November 1968; revised April 1969)	7.6
APED-5750	Design and Performance of General Electric Boiling Water Reactor Main Steam Line Isolation Valves (March 1969)	3.9, 5.4
GEAP-5620	Failure Behavior in ASTM A106B Pipes Containing Axial Through-Wall Flaws (April 1968)	5.2

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
GEAP-10546	Theory Report for Creep-Plast Computer Program (January 1972)	4.1
GEAP-13197	Emergency Cooling in BWRs Under Simulated Loss-of-Coolant (BWR PLECMP) Final Report (June 1971)	6.2
GE-NE-778-028-0790	GE Duralife 215 Control Rod Safety Evaluation, Revision 2 (July 1992)	4.2
GE-NE-187-24-0992	Washington Public Power Supply System Nuclear Project 2, SRV Setpoint Tolerance and Out-of-Service Analysis, Revision 2 (July 1993)	6.3
NEDC-31984-P	Generic Evaluations of General Electric Boiling Water Reactor Power Uprate - (July 1991)	5.4, 15.8
NEDC-32115-P	Washington Public Power Supply System Nuclear Project 2, SAFER/GESTR-LOCA Loss-of-Coolant Accident Analysis (September 1992)	6.3
NEDC-32141-P	Power Uprate With Extended Load Line Limit Safety Analysis for WNP-2 (June 1993)	5.4, 15.8
NEDC-32232-P	WNP-2 Reactor Recirculation Adjustable Speed Drive (ASD) System Reliability Analysis (August 1993)	7.7
NEDC-32983-P-A	General Electric Methodology for Reactor Pressure Vessel Fast Neutron Flux Evaluations (January 2006)	4.3.2.8, 4.3.4
NEDC-33507-P	Energy Northwest Columbia Generating Station APRM/RBM/Technical Specifications/Maximum Extended Load Line Limit Analysis (ARTS/MELLLA), Revision 1 (January 2012)	15.4

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
NEDE-10169	Safe-System Analysis for Standby Core Cooling Equipment (September 1970)	3A
NEDE-10313-P	PDA - Pipe Dynamic Analysis Program for Pipe Rupture Movement	3.6
NEDE-11146-P	Design Basis for New Gas System (July 1971)	11.3
NEDE-13442-P-01	Mark II - Pressure Suppression Test Program (May 1976)	3A
NEDE-20944-P	BWR/4 and BWR/5 Fuel Design (October 1976)	Table 1.3-1
NEDE-21175-3-P	Fuel Assembly Evaluation of Combined Safe Shutdown Earthquake (SSE) and Loss-of-Coolant Accident (LOCA) Loadings (July 1982)	3.9
NEDE-21354-P	BWR Fuel Channel Mechanical Design and Deflection (September 1976)	3.9
NEDE-21471-P	Analytical Model for Estimating Drag Forces on Rigid Submerged Structures Caused by LOCA and Safety/Relief Valve Ramshead Air Discharges (September 1977)	3A
NEDE-21544-P	Mark II Pressure Suppression Containment System, an Analytical Model of the Pool Swell Phenomenon (December 1976)	3A, 6.2
NEDE-21821	BWR Feedwater Nozzle/Sparger Final Report (March 1978)	5.2, 5.3
NEDE-23604	Brunswick Unit 1 Reactor Internals Vibration and Temperature Measurements (June 1977)	5.3

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
NEDE-23749-P	Analytical Model for Computing Transient Pressure and Forces in the S/RVDL (February 1978)	3.9
NEDE-23806-P	MK II Main Vent Lateral Loads Summary Report (October 1978)	3A
NEDE-24010-P	Technical Bases for the Use of the SRSS Method for Combining Dynamic Loads for Mark II Plants (July 1977) with Supplement 1 (October 1978), Supplement 2 (December 1978), and Supplement 3 (August 1979)	3.9
NEDE-24011-P-A	General Electric Standard Application for Reactor Fuel (most recent approved version referenced in COLR)	1.8, 3.9, 4.1, 4.2, 4.3, 4.4, 15.1, 15.4
NEDE-24057-P	Assessment of Reactor Internals Vibration in BWR/4 and BWR/5 Plants (November 1977)	3.9
NEDE-24106-P	Dynamic Lateral Loads on a Main Vent Downcomer - Mark II Containment (March 1978)	3A
NEDE-24222	Assessment of Boiling Water Reactor Mitigation of Anticipated Transient Without Scram, Volume II (December 1979)	15.8
NEDE-24285-P	Chugging Loads - Revised. Definition and Application Methodology for Mark II Containments (July 1981)	3A
NEDE-24288-P	Generic Condensation Oscillation Load Definition Report (November 1980)	3A
NEDE-24302-P	Generic Chugging Load Definition Report (April 1981)	3A

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
NEDE-24695	RVF0R04 User's Manual, S/RVDL Clearing Transient Pressures and Forces in the S/RDL (December 1979)	3.9
NEDE-24794-P	Dynamic Lateral Loads on Mark II Main Vent Downcomer - Correlation of Independent Reference Data (March 1980)	3A
NEDE-24811-P	4T Condensation Oscillation Test Program Final Test Report (May 1980)	3A
NEDE-24822-P	Mark II Improved Chugging Methodology (May 1980)	3A
NEDE-24834	Hanford 2 Crimped Control Rod Drive Line (June 1980)	3.6
NEDE-24988-P	Analysis of Generic BWR Safety/Relief Valve Operability Test Results (October 1981)	5.2, 5.4, Table F.4-1
NEDE-25100-P	CAORSO SRV Discharge Tests Phase I Test Report (May 1979)	3A
NEDE-25118	CAORSO SRV Discharge Tests Phase II ATR Report (August 1979)	3A
NEDE-31096-P	Licensing Topical Report, Anticipated Transient Without Scram (February 1987)	4.6, 7.4, 9.3
NEDM-10320	The General Electric Pressure Suppression Containment Analytical Model (March 1971)	3A, 6.2
NEDO-10029	An Analytical Study on Brittle Fracture of GE BWR Vessel Subject to the Design Basis Accident (July 1969)	1.8
NEDO-10320	The General Electric Pressure Suppression Containment Analytical Model (April 1971)	3A 6.2

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
NEDO-10329	Loss-of-Coolant Accident and Emergency Core Cooling Models for General Electric Boiling Water Reactors (April 1971); Supplement 1, (April 1971); Addenda, (May 1971)	6.2
NEDO-10349	Analysis of Anticipated Transients Without Scram (March 1971)	15.8
NEDO-10466-A	Power Generation Control Complex Design Criteria and Safety Evaluation (September 1977)	8.3, 9.5, F.2, F.3, F.7
NEDO-10527	Rod Drop Accident Analysis for Large Boiling Water Reactors (March 1972); Supplement 1, (July 1972); Supplement 2, (January 1973)	4.2, 15.4
NEDO-10602	Testing of Improved Jet Pump for the BWR/6 Nuclear System (June 1972)	3.9
NEDO-10734	A General Justification for Classification of Effluent Treatment System Equipment as Group D (February 1973)	11.3
NEDO-10751	Experimental and Operational Confirmation of Off-Gas System Design Parameters (January 1973) (Proprietary)	11.3
NEDO-10802	Analytical Methods of Plant Transient Evaluations for General Electric Boiling Water Reactor (February 1973)	15.2
NEDO-10899	Chloride Control in BWR Coolants (June 1973)	1.8, 5.2
NEDO-10905	HPCS Power Supply	1.8, 8.3

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
NEDO-10951	Releases from BWR Radwaste Management Systems (July 1973)	11.2
NEDO-10958-A	General Electric BWR Thermal Analysis Basis (GETAB): Data, Correlation, and Design Application (January 1977)	15.0
NEDO-20533	The General Electric Mark III Pressure Suppression Containment System Analytical Model (June 1974)	3A, 6.2
NEDO-20566-A	Analytical Model for Loss-of-Coolant Analysis in Accordance with 10 CFR 50, Appendix K (Proprietary) (September 1986)	3.9, 4.2, 6.3
NEDO-20626	Studies of BWR Designs for Mitigation of Anticipated Transients without Scrams (October 1974)	6.2, 9.3
NEDO-20761	Millstone Nuclear Power Station, Refueling/Maintenance Outage (Fall 1974)	12.2
NEDO-21061	Mark II Containment Dynamics Forcing Functions Information Report (September 1976, June 1978, November 1981)	3A, 6.2
NEDO-21142	Realistic Accident Analysis for General Electric Boiling Water Reactor - The RELAC Code and User's Guide (December 1977)	15.2, 15.6
NEDO-21231	Banked Position Withdrawal Sequence (September 1976)	15.4
NEDO-21471	Analytical Model for Estimating Drag Forces on Rigid Submerged Structures Caused by LOCA and Safety/Relief Valve Ramshead Air Discharges (September 1977)	3A

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
NEDO 21667	Comparison of the 1/13 Scale Mark II Containment Multivent Pool Swell Data with Analytical Methods (August 1977)	3A
NEDO-21708	Radiation Effects in Boiling Water Reactor Vessel Steels (October 1977)	5.3
NEDO-21778-A	Transient Pressure Rises Affecting Fracture Toughness Requirements for Boiling Water Reactors January 24, 1978 (January 17, 1979)	5.3
NEDO-21985	Functional Capability Criteria for Essential Mark II Piping (September 1978)	3.9
NEDO-23678-P	Mark II Pressure Suppression Test Program Phases I, II, and III of the 4T Tests (June 1978)	3A
NEDO-24057-P	Assessment of Reactor Internals Vibration in BWR/4 and BWR/5 Plants (November 1977)	3.9
NEDO-24154-A	Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors, Volumes 1 and 2 (August 1986)	5.2
NEDO-24210	PISYS Analysis of NRC Problem (August 1979)	3.9
NEDO-24226	General Electric Company, Control Blade Lifetime With Potential B_4C Loss, with Supplement 1 (December 1979)	4.2
NEDO-24288	Mark II Containment Program - Generic Condensation Oscillation Load Definition Report (February 1981)	3A
NEDO-24548	Technical Description Annulus Pressurization Load Adequacy Evaluation (January 1979)	6.2

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
NEDO-24708-A	Additional Information Required for NRC Staff Generic Report on Boiling Water Reactors (June 1980)	7.4, B, I, Table F.4-1
NEDC-24154-P-A	Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors, Volumes 1, 2, 3 and 4 (February 2000)	15.0, 15.1, 15.2, 15.3, 15.5
NEDC-32084P-A	TASC-03A A Computer Program for Transient Analysis of a Single Channel (July 2002)	6.3
NEDC-32601P-A	Methodology and Uncertainties for Safety Limit MCPR Evaluations (August 1999)	4.4
NEDC-32694P-A	Power Distribution Uncertainties for Safety Limit MCPR Evaluations (August 1999)	4.4
NEDC-32868P	GE14 Compliance With Amendment 22 of NEDE-24011-P-A (GESTAR II) (May 2013)	4.1, 4.2, 4.3, 4.4, 15.4
NEDE-32906P	Supplement 3-A Migration to TRACG04/PANAC11 from TRACG02/PANAC10 for TRACG AOO and ATWS Overpressure Transients (April 2010)	5.2
NEDC-32950P	Compilation of Improvements to GENE's SAFER ECCSLOCA Evaluation Model (July 2007)	6.3
NEDC-33270P	GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR 11) (May 2013)	4.1, 4.2, 4.3, 4.4, 9.1, 15.4
NEDE-23785-1-PA	The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident. Volumes 1, 2, and 3 (October 1984)	6.3

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
NEDE-23785P-A	The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-of-Coolant Accident. Volume 3 Supplement 1, Additional Information for Upper Bound PCT Calculation. (March 2002)	6.3
NEDE-24011-P-A-US	General Electric Standard Application for Reactor Fuel (GESTAR II) (Supplement for United States) (most recent approved version referenced in COLR)	3.9, 4.1, 4.2, 4.3, 4.4, 15.4
NEDE-30130-P-A	Steady State Nuclear Methods (April 1985)	15.1, 15.4

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
Other References		
WPPSS-74-2-R2 and Supplements WPPSS-74-2-R2A and WPPSS-74-2-R2B	Washington Public Power Supply System Sacrificial Shield Wall (March 1974) Sacrificial Shield Wall Design Supplemental Information (February 1975, August 1975)	3.8, 6.2
Report Submitted with letter GO2-80-172, August 8, 1980	Engineering Evaluation of the WNP-2 Sacrificial Shield Wall (March 1974)	3.8, 6.2
Report submitted with letter GO2-80-182, August 19, 1980	Engineering Evaluation of the WNP-2 Sacrificial Shield Wall, Supplement No. 1	3.8, 6.2
--	Plant Design Assessment Report for SRV and LOCA Loads	3A
WPPSS-74-2-R3	Burns & Roe, Inc., Protection Against Pipe Breaks Outside Containment (April 1974)	3.5
WPPSS-74-2-R5	Drywell to Wetwell Leakage Study (July 1974, February 1974) (GO2-74-17, dated May 9, 1974)	6.2, 3.8
Inservice Inspection Program Plan	Inservice Inspection Program Plan Interval - 4	5.2.4, 6.6
Preservice Inspection Program Plan	Preservice Inspection Program Plan	5.2.4, 6.6

Table 1.6-1

Topical Reports (Continued)

Report	Title	FSAR Section
CGS-FTS-0168	Columbia Generating Station Alternative Source Term (report consolidated from letters GO2-04-170 dated September 30, 2004, GO2-06-116 dated September 11, 2006, GO2-05-054 dated March 16, 2005, GO2-05-160 dated September 29, 2005, GO2-06-043 dated March 21, 2006, GO2-06-105 dated August 7, 2006 and GO2-06-108 dated August 24, 2006)	1.8, 15.4, 15.6, 15.7

1.7 ACRONYMS

The acronyms used in this FSAR follow

ACI	American Concrete Institute
ACRS	Advisory Committee on Reactor Safeguards
ADS	automatic depressurization system
AEC	Atomic Energy Commission
AISC	American Institute of Steel Construction
ALARA	as low as is reasonably achievable
ALI	annual limit on intake
AMP	Aging Management Programs
ANSI	American National Standards Institute
APRM	average power range monitor
ARM	area radiation monitor
ART	adjusted reference temperature
AS	auxiliary steam
ASCE	American Society of Civil Engineers
ASD	adjustable speed drive
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATWS	anticipated transient without scram
AWS	American Welding Society
B&R	Burns and Roe, Inc.

BISI	bypass & inoperable status indication
BOC	beginning of cycle
BPA	Bonneville Power Administration
BPC	Bechtel Power Corporation
BWR	boiling water reactor
BWROG	Boiling Water Reactor Owners Group
BWRVIP	BWR Vessel and Internals Project
CAS	central alarm station, control air system
CASS	Cast Austenitic Stainless Steel
CEP	containment exhaust purge
CGS	Columbia Generating Station
CHF	critical heat flux
CIA	containment instrument air
CLB	current licensing basis
CMFA	common mode failure analysis
COLR	Core Operating Limits Report
COND	main condensate system
CPR	critical power ratio
CRA	primary containment cooling system
CRD	control rod drive
CRDA	control rod drop accident
CRDRL	control rod drive return line

CREF	control room emergency filtration
CRPI	control rod position indication
CSP	containment purge supply
CST	condensate storage and transfer, condensate storage tank
CUF	Cumulative Usage Factor
CW	circulating water
DAC	derived air concentrations
DAW	dry active radioactive waste
DB	design basis
DBA	design basis accident
DBE	design basis earthquake
DG	diesel generator
DEH	digital electrohydraulic
DLR	dosimeter of legal record
DOE	Department of Energy
DOP	dioctylphthalate
DSA	Diesel Starting Air
DZO	depleted zinc oxide
ECA	engineering change authorization
ECCS	emergency core cooling system
ECN	engineering change notice
EDR	equipment drain (radioactive) processing

EFCV	excess flow check valve
EFPY	Effective Full Power Years
EHC	electrohydraulic control
EMA	Equivalent Margin Analysis
EOC	end of cycle
EOF	emergency operations facility
EPA	electrical protection assembly
EPN	equipment piece number
EPRI	Electric Power Research Institute
EPZ	emergency planning zone
EQ	Environmental Qualification, Environmentally Qualified
ESF	engineered safety feature
EWD	electrical wiring diagram
FA	full arc (mode of TGV operation)
FAC	Flow Accelerated Corrosion
FANP	Framatome ANP
F-B/V	front to back/vertical
FCD	functional control diagram
FCV	flow control valve
FDDR	Field Deviation Disposition Request
FDR	floor drain (radioactive) processing system
FLECHT	full-length emergency cooling heat transfer

FMEA	failure modes effects analysis
FPC	fuel pool cooling and cleanup
FSAR	Final Safety Analysis Report
GE	General Electric Company
HAD	heat actuated device
HCA	horizontal control accelerometer
HCU	hydraulic control unit
HCV	Hardened Containment Vent
HELB	high energy line break
HEPA	high-efficiency particulate air/absolute
HID	high-intensity discharge (lighting--vapor lamp)
HPCS	high-pressure core spray
H&V	heating and ventilating
HVAC	heating, ventilating, and air conditioning
HX	heat exchanger
IASCC	Irradiation Assisted Stress Corrosion Cracking
IBA	intermediate break accident
IDC	incident detection circuitry
IDS	instrument data sheet
IED	instrument engineering diagram
IEEE	Institute of Electrical and Electronics Engineers
IGA	Intergranular Attack

IGSCC	intergranular stress corrosion cracking
IHSI	Induction Heat Stress Improvement
IRM	intermediate range monitor
ISA	Instrument Society of America
ISI	In-Service Inspection
ISP	Integrated Surveillance Program
LCO	Limiting Condition of Operation
LCS	leak control system
LDS	leak detection system
LHGR	linear heat generation rate
LLRT	local leak rate test
LOCA	loss-of-coolant accident
LPCI	low-pressure coolant injection
LPCS	low-pressure core spray
LPRM	local power range monitor
LPZ	low population zone
LRA	License Renewal Application
LSSS	limiting safety system setting
MAPLHGR	maximum average planar linear heat generation rate
MCC	motor control center
MCPR	minimum critical power ratio
MEL	Master Equipment List

MG	motor-generator
MLD	mean low water datum
MLHGR	maximum linear heat generation rate
MOV	motor-operated valve
MS	main steam
MSIV	main steam isolation valve
MSIV-LCS	main steam isolation valve leakage control system
msl	mean sea level
MSL	main steam line
MSLC	main steam isolation valve leakage control
MWR	mixed waste (radioactive)
MWt	Megawatt thermal
NB	nuclear boiler
NBR	nuclear boiler rated (power)
NDE	nondestructive examination
NDT	nil-ductility transition
NDTT	nil-ductility transition temperature
NEC	National Electrical Code
NED	Nuclear Energy Division (GE)
NFPA	National Fire Protection Association
NEPIA	Nuclear Energy Property Insurance Association
NMS	neutron monitoring system

NPDES	National Pollutant Discharge Elimination System
NPHS	net positive suction head
NRC	Nuclear Regulatory Commission
NSAS	non-safety affecting safety
NSOA	nuclear safety operational analysis
NSSS	nuclear steam supply system
NSSSS	nuclear steam supply shutoff system
OBE	operating basis earthquake
OQAPD	Operational Quality Assurance Program Description
ODCM	Offsite Dose Calculation Manual
OPRM	Oscillation Power Range Monitor
OSHA	Occupational Safety and Health Act
OT	operating transient
OS&Y	outside screw and yoke
OT	operating transient
PA	Public Address (System)
PABX	Private Automatic Branch Exchange
PATP	Power Ascension Test Program
PCIOMR	preconditioning cladding interim operating management recommendation
PCRVICS	primary containment and reactor vessel isolation control system
PCS	process computer system

PCT	peak cladding temperature
PDIS	plant display information system
PEC	Plant Engineering Center
PGCC	power generation control complex
P&ID	piping and instrumentation diagram
PMF	probable maximum flood
PPM	Plant Procedure Manual
PRM	power range monitor
PSAR	Preliminary Safety Analysis Report
PSF	Plant Support Facility
PVS	plant vent stack
RBM	rod block monitor
RCC	reactor building closed cooling water
RCIC	reactor core isolation cooling
RCPB	reactor coolant pressure boundary
REA	reactor building exhaust air
RFW	reactor feedwater
RHR	residual heat removal
RMC	reactor manual control
RMS	remote manual switches
ROA	reactor building outside air

RPIS	rod position information system
RPS	reactor protection system
RPT	recirculation pump trip
RPV	reactor pressure vessel
RRC	reactor recirculation system
RRS	required response spectra
RSO	reactor system outline
RT_{NDT}	Reference Temperature for Nil-Ductility Transition
RWCU	reactor water cleanup
RWM	rod worth minimizer
RWP	Radiation Work Permit
SA	service air
SACF	single active component failure
SAF	single active failure
SAR	Safety Analysis Report
SAS	Secondary Alarm Station
SBA	small break accident
SBO	station blackout
SCC	Stress Corrosion Cracking
SCF	single component failure
SCC/IGA	SCC/intergranular attack

SCC/IASCC	SCC/irradiation assisted stress corrosion cracking
SDC	shutdown cooling
SEF	single equipment failure
SER	Safety Evaluation Report
SF	single failure (NSOA)
SGT	standby gas treatment
SGTS	standby gas treatment system
SJAE	steam jet air ejector
SLC	standby liquid control
SLMCPR	minimum critical power ratio safety limit
SLO	single loop operation
SMS	Scheduled Maintenance System
SOE	single operator error
SPC	Siemens Power Corporation
SPV	solenoid pilot valve
SRM	source range monitor
SRO	Senior Reactor Operator
SRP	Standard Review Plan
SRV	safety/relief valve
SS	safe shutdown
SS	stainless steel

SSC	structures, systems, and components
SSE	safe shutdown earthquake
S-S/V	side-to-side/vertical
SSW	sacrificial shield wall
SW	standby service water
SWP	Site Wide Procedure
TCV	turbine control valve
TDAS	transient data acquisition system
TEDE	total effective dose equivalent
TG	turbine generator
TGV	turbine governor valve
TIP	traversing in-core probe
TLAA	Time Limited Aging Analysis
TLD	thermoluminescent dosimeter
TMU	tower makeup
TPM	thermal power monitor
TRS	test response spectra
TSC	Technical Support Center
TSPM	Test and Startup Program Manual
TSW	plant service water (turbine building service water)
TWG	Test Working Group
UBC	Uniform Building Code

UHS	ultimate heat sink
UPS	uninterruptable power supply
USE	Upper Shelf Energy
WNP-2	Washington Nuclear Project No. 2
WPPSS	Washington Public Power Supply System
ZPA	zero period acceleration

1.8 CONFORMANCE TO NRC REGULATORY GUIDES

1.8.1 INTRODUCTION

This section of the FSAR contains information on Energy Northwest's conformance assessment of CGS to Regulatory Guides, Division 1, Power Reactor Guides and revisions thereof as noted.

Since the scope of equipment responsibility is project unique and the time of equipment design, procurement, manufacture, installation, and operation varies with the supplier, a unique assessment for the nuclear steam supply system (NSSS) scope of supply and balance of plant (BOP) scope of supply is necessary and is presented.

1.8.2 NUCLEAR STEAM SUPPLY SYSTEM SCOPE OF SUPPLY EVALUATION

The following paragraphs define the nomenclature and the manner in which the NSSS scope of supply assessment is to be interpreted.

Regulatory Guides - Incorporated in the Design

This section serves to identify specific safety or regulatory guides which were included in the plant as a design commitment during the construction permit review. It also identifies those incorporated by commitment after the construction permit issuance. All of these are specifically noted as "Incorporated in the Design."

Regulatory Guides - Assessed Capability in the Design

For those other regulatory guides which have been issued before, during, or after the construction permit issuance, Energy Northwest (through his agents and/or suppliers) has performed an assessment evaluation to determine the capability of the previously approved design to accommodate and meet these new requirements. These are noted as "Assessed Capability in the Design."

Conformance to the regulatory guide falls under either one of two categories - "Full Compliance" or "Meeting Intent Through an Alternate Approach."

Regulatory Guide - Full Compliance

Any regulatory guide so noted, whether by direct conformance or by assessed capability, complies with subject requirements as described in the FSAR.

Regulatory Guide - Meeting Intent by Alternate Approach

This designation is based on NRC rules which state that "Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission." The description and justification of an alternate approach is provided where this method is employed.

The following evaluation represents the NSSS scope of supply regulatory guide assessment.

Regulatory Guide 1.1, Revision 0, November 1970

Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps.

Regulatory Guide Intent:

This guide prohibits design reliance on pressure and/or temperature transients expected during a loss-of-coolant accident (LOCA) for ensuring adequate net positive suction head (NPSH). The requirements of this regulatory guide are applicable to the high-pressure core spray (HPCS), low-pressure core spray (LPCS), and residual heat removal (RHR) pumps.

Applicable Assessment:

Incorporated in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in CGS is in full compliance with this regulatory guide.

General Compliance or Alternate Approach Assessment:

The boiling water reactor (BWR) design conservatively assumes 0 psig containment pressure and maximum expected temperature of the pumped fluids; thus no reliance is placed on pressure and/or temperature transients to assure adequate NPSH.

Requirements for NPSH are available at the centerline of the pump suction nozzles for each pump.

Specific Evaluation Reference:

See Sections 6.2 and 6.3.

Similar Application Reference:

Similar application was used for LaSalle and GESSAR.

Regulatory Guide 1.2, Revision 0, November 1970

Thermal Shock to Reactor Pressure Vessels

Regulatory Guide Intent:

This regulatory guide states that potential reactor pressure vessel brittle fracture which may result from emergency core cooling systems (ECCS) operation need not be reviewed in individual cases if no significant changes in presently approved core and pressure vessel designs are proposed. Should it be concluded that the margin of safety against reactor pressure vessel brittle failure due to ECCS operation is unacceptable, and engineering solution, such as annealing, could be applied to ensure adequate recovery of the fracture toughness properties of the vessel material. This regulatory guide requires that available engineering solutions be outlined and requires that it be demonstrated that the design does not preclude their use.

Application Assessment:

Incorporated in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in CGS is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The reactor pressure vessel used for CGS employs no significant core or vessel design changes from previously approved BWR pressure vessels such as Browns Ferry, all units.

An investigation of the structural integrity of BWR pressure vessels during a design-basis accident (DBA) has been conducted (see NEDO-10029, "An Analytical Study on Brittle Fracture of GE-BWR Vessel Subject to the Design Basis Accident"). It has been determined, based on methods of fracture mechanics, that no failure of the vessel by brittle fracture as a result of a DBA will occur.

The investigation included

a. A comprehensive thermal analysis considering the effect of blowdown and the LPCI system reflooding,

b. A stress analysis considering the effects of pressure, temperature, seismic load, jet load, dead weight, and residual stresses,

c. The radiation effect on material toughness [nil ductility transition temperature (NDTT) shift and critical stress intensity], and

d. Methods for calculating crack tip stress intensity associated with a nonuniform stress field following DBA.

This analysis incorporated very conservative assumptions in all areas (particularly in the areas of heat transfer, stress analysis effects of radiation on material toughness, and crack tip stress intensity). Therefore, the results reported in NEDO-10029 provide an upper bound limit on brittle fracture failure mode studies. Because of the upper bound approach, it is concluded that catastrophic failure of the pressure vessel due to the DBA is shown to be impossible from a fracture mechanics point of view. In the case studies, even if an acute flaw does form on the vessel inner wall, it will not propagate as the result of the DBA.

The criteria of 10 CFR 50, Appendix G, are interpreted as establishing the requirement for annealing. Paragraph IV C of Appendix G requires vessels to be designed for annealing of the beltline only where the predicted value of adjusted RT_{NDT} exceeds 200°F as defined in paragraph NB2331 of the ASME Section III Code. This predicted value is not exceeded; therefore design for annealing is not required.

Specific Evaluation Reference:

See Section 5.3.1.5.

Similar Application Reference:

Similar application was used for Browns Ferry 1, 2, and 3.

Regulatory Guide 1.6, Revision 0, March 1971

Independence Between Redundant Standby (Onsite) Power Source and Between Their Distribution Systems

Regulatory Guide Intent:

The guide states the extent and nature of independence of the two onsite power divisions required by General Design Criterion (GDC) 17. Key features that ensure operation and prevent cascading single failures from disrupting both power systems are delineated.

Application Assessment:

Incorporated in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

This regulatory guide is applicable to redundant standby (onsite) power sources and their distribution systems.

HPCS Onsite Power System (NSSS Scope of Supply)

Division 3 (HPCS) is provided with one offsite power source. Only one offsite supply is connected because no credit is given to offsite power sources in accident analysis. The diesel generator breaker can be closed automatically only if the other source breakers to the (HPCS) load group are open.

When the HPCS diesel generator breaker is closed, no other source breaker can be closed automatically. No other means exist for automatically connecting redundant load groups with each other. The HPCS diesel generator may be manually connected to either Division 1 or to Division 2 in the extended station blackout (SBO) or non-DBA loss of offsite power (LOOP) scenario described in Section 8.3.1.1.7.2.1. The source breakers are administratively controlled in the open position to prevent paralleling of standby sources.

Sufficient interlocks are provided to prevent paralleling the diesel generators manually by operator error during loss of offsite power. Division 3 diesel generator is provided with only one prime mover.

The HPCS division dc load group is fed from one battery charger and one battery.

The HPCS standby power source and distribution system is independent from the other two standby power sources and associated distribution system in the plant.

Specific Evaluation Reference:

See Section 8.3.1.2.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.9, Revision 0, March 1971

Selection of Diesel Generator Set Capacity for Standby Power Supplies

Regulatory Guide Intent:

This guide provides an approach for ensuring sufficient onsite power capability and for determining load requirements of diesel generator set power sources.

Application Assessment:

Incorporated in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

This regulatory guide is applicable to the standby ac power supply for the HPCS diesel. The specific guidelines are unduly restrictive when applied to the selection of the diesel generator set dedicated to the HPCS system. This is mainly due to the unique application of the special HPCS equipment relative to normal diesel generator units.

Specific conformance and alternate positions to and with Regulatory Guide 1.9 are described in the following statements:

Regulatory Guide 1.9, Position 2 Conformance

Chapter 8 illustrates that the 2000-hr rating of the HPCS diesel generator, the 90% of 30-minute rating, and the maximum coincidental load, are in conformance with this position. Intermittent loads such as motor-operated valves are considered for long-term loads.

Regulatory Guide 1.9, Position 3 Conformance

CGS load requirements were verified as test data was completed and analyzed, following the preoperational tests.

Regulatory Guide 1.9, Position 4 Conformance

The HPCS diesel generator unit is considered as a unique application with justifiable departure from the strict conformance to Regulatory Guide 1.9, Revision 0, regarding voltage and frequency limits during the initial loading transient. The HPCS system consists of one large pump and motor combination which represents more than 90% of the total load; consequently, limiting the momentary voltage drop to 25% and the momentary frequency drop to 5% would not significantly enhance the reliability of HPCS operation. To meet the specific regulatory guide requirements, a diesel generator unit approximately two to three times as large as that required to carry the continuous rated load would be necessary. The specific diesel engine-electric generator-pump assembly was designed specifically for this integral operation. The frequency and voltage over-shoot requirements of Regulatory Guide 1.9, Revision 0, are met. A factory testing program on a prototype unit has verified the following functions:

a. System fast-start capabilities,

b. Load-carrying capability,

c. Load shedding capability,

d. Ability of the system to accept and carry the required loads, and

e. The mechanical integrity of the diesel-engine generator unit and all of the major system auxiliaries.

GE Licensing Topical Report, HPCS Power Supply, NEDO-10905, describes the theoretical analytical aspects of the unique application including prototype and reliability test considerations.

The design of the HPCS diesel generator conforms with the applicable sections of IEEE criteria for Class 1E "Electrical Systems for Nuclear Power Generation Stations," IEEE 308-1971.

The generator has the capability of providing power for starting the required loads with operationally acceptable voltage and frequency recovery characteristics. A partial or complete load rejection will not cause the diesel engine to trip on overspeed.

A special prototypic test conducted at the LaSalle facility verified the hardware and load aspects of the HPCS power supply concept. This test is described in topical report NEDO-10905, Revision 3.

The scope of Regulatory Guide 1.9, Revision 0 does not include recommendations for surveillance testing. The surveillance requirements for demonstrating the operability of the diesel generators are consistent with the recommendations of Regulatory Guide 1.9 Revision 3 as described in the Bases for Technical Specification B 3.8.1. Compliance with Regulatory Guide 1.9 Rev. 0, as an acceptable basis for the selection of diesel generator sets of sufficient margin to implement General Design Criterion 17, remains as described herein.

Specific Evaluation Reference:

See Section 8.3.1.2.1.4.

Similar Application Reference:

Similar application was used for LaSalle; for comparison see Table 8.3-6.

Regulatory Guide 1.13, Revision 0, March 1971

Fuel Storage Facility Design Basis

Regulatory Guide Intent:

This guide delineates design criteria that are appropriately applied to the fuel storage facility of the CGS plant.

Application Assessment:

Incorporated in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General compliance or Alternate Approach Assessment:

This regulatory guide is applicable to the refueling platform within NSSS scope of supply.

The refueling platform is designed to prevent it from toppling into the pools during a safe shutdown earthquake (SSE). Redundant safety interlocks are provided as well as limit switches to prevent accidentally running the grapple into the pool walls.

Specific Evaluation Reference:

See Section 9.1.4.3.

Similar Application References:

Similar application was used for Nine Mile Point 2.

Regulatory Guide 1.20, Revision 2, May 1976

Comprehensive Vibration Assessment Program for Reactor Internals During Preoperational and Initial Startup Testing

Regulatory Guide Intent:

Regulatory Guide 1.20 describes a comprehensive vibration assessment program for reactor internals during preoperational and initial startup testing. The vibration assessment program meets the requirements of Criterion 1, "Quality Standards and Records," of Appendix A to 10 CFR Part 50 and Section 50.34, "Contents of Applications; Technical Information," of 10 CFR Part 50.

Application Assessment:

Incorporated in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General or Alternate Approach Statement:

This regulatory guide is applicable to the core support structures and other reactor internals.

A vibration measurement program has been defined for the confirmatory testing of this plant during initial startup tests.

CGS *reactor internals were tested in accordance with provisions of Regulatory Guide 1.20, Revision 2, Category IV, using Tokai-2 as the limited valid prototype.*

Specific Evaluation Reference:

See Sections 3.9.2.1, 3.9.2.3, and 3.9.2.4.

Similar Application Reference:

Similar application was used for Browns Ferry 1.

Regulatory Guide 1.21, Revision 1, June 1974

Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants

Regulatory Guide Intent:

Regulatory Guide 1.21 describes programs for measuring, reporting, and evaluating releases of radioactive materials in liquid and gaseous effluents and guidelines for classifying and reporting the categories and curie content of solid wastes.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The process and effluent radiological monitoring and sampling system is designed to provide the monitoring and sampling capability required to make the measurements, evaluations, and reports recommended by this guide.

The radiation monitoring systems (RMS) provided to meet these objectives are

a. For gaseous effluent streams

   Reactor building ventilation exhaust plenum RMS

b. For liquid effluent streams

   1. Radwaste effluent RMS, and
   2. Service water RMS

c. For gaseous process streams

   1. Offgas pretreatment RMS,
   2. Offgas posttreatment RMS, and
   3. Carbon bed vault RMS

d. For liquid process streams

   1. RHR service water RMS, and
   2. Reactor building closed cooling water RMS

These systems have the capability for alarm and initiation of automatic closure of waste treatment discharge valves in the affected systems prior to exceeding the normal operation limits specified in Technical Specifications thereby satisfying the intent of the regulatory guide.

Specific Evaluation Reference:

See Sections 7.6.1.1 and 11.5.1.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.22, Revision 0, February 1972

Periodic Testing of Protection System Actuation Function

Regulatory Guide Intent:

This guide describes acceptable design approaches that facilitate the periodic testing, during reactor operation, of actuation devices/equipment incorporated into the reactor protection system design. This regulatory guide is applicable to the systems within NSSS scope of supply listed in this regulatory guide.

Application Assessment:

Incorporated in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used for this facility is in full compliance with this regulatory guide.

General Compliance or Alternate Approach Assessment:

Compliance for each system is discussed for this plant in the listed references.

	Section
Reactor protection system	7.2.2.3
Emergency core cooling system	
HPCS	7.3.2.1.3
Automatic depressurization system (ADS)	7.3.2.1.3
LPCS	7.3.2.1.3
LPCI (RHR)	7.3.2.1.3
Primary containment and reactor vessel isolation control system (PCRVICS)	7.3.2.1.3
Reactor core isolation cooling (RCIC)	7.4.2.3
Leak detection system	7.6.2.4
HPCS standby power supply	8.1.3
RHR system containment spray cooling system	7.3.2.1.3
Suppression pool cooling system	7.3.2.1.3
Reactor shutdown cooling system	7.4.2.3
Standby liquid control system	7.4.2.3
Process radiation monitoring system	7.6.2.4

Specific Evaluation Reference:

See above.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.26, Revision 3, February 1976

Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants

Regulatory Guide Intent:

Regulatory Guide 1.26 describes a quality classification system for determining acceptable quality standards for important to safety components containing water, steam, or radioactive material other than those components addressed in 10 CFR 50.55a.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The definition of quality group classifications for this plant was made initially and recorded in the Preliminary Safety Analysis Report (PSAR) in accordance with ASME Boiler and Pressure Vessel Code (B&PV), Sections III and VIII. Quality group classifications were maintained during design and construction and are actively maintained during plant operations and modifications commensurate with the safety functions performed by the safety-related components.

This regulatory guide is applicable to Quality Groups B through D pressure parts including piping, pumps, valves, and vessels. Section 3.2 shows the quality groups classifications of these parts.

Specific Evaluation Reference:

See Section 3.2.

Similar Application Reference:

Similar application was used for LaSalle.

The italicized information is historical and was provided to support the application for an operating license.

Regulatory Guide 1.28, Revision 0, June 1972

Quality Assurance Program Requirements (Design and Construction).

Regulatory Guide Intent:

This guide describes an acceptable method of complying with the NRC's regulations with regard to overall quality assurance program requirements.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with provisions of NRC regulations and regulatory guides or NRC-approved alternate positions.

General Compliance or Alternate Approach Assessment:

The General Electric BWR Quality Assurance Program has been developed over the years such that at any point in time it has been in compliance with mandatory regulatory requirements such as 10 CFR 50, Appendix B, and the ASME Code. Implementation of the applicable ANSI-N45.2 series standards and the associated NRC regulatory guides (or NRC-approved GE alternate positions) has been an evolutionary process and although partial implementation has always been effected before the date of issue of the regulatory guide or "AEC Guidance on Quality Assurance," which recognized applicable ANSI standards, full implementation was not necessarily in place until the GE commitment date (see Attachment A for complete listing of GE commitment dates and extent of commitment).

Since GE operates under a single quality assurance (QA) program, quality system improvements, such as more formalized audits or certification programs, are generally implemented across the board on all active projects with no opportunity for retrofit of completed work; therefore, work performed later in a project is typically subject to more quality assurance effort as a result of additional requirements. Attachment B gives a graphic representation of the time relation of some of the major project activities with the date of issue of regulatory guides and the GE commitment dates. Because of the long generation cycle of the related ANSI Standard, GE had already

upgraded its QA program to at least partially implement each of the related ANSI Standards, where applicable, prior to the date of issue of the regulatory guide.

Attachment B also shows approximate dates of NRC and utility customer/architect-engineer QA audits. These audits have been performed frequently enough and over a long enough time period to establish confidence that GE has been following a QA program which has kept current with customer and regulatory requirements. Obviously, where most equipment is ordered years in advance of shipment, the QA program at the time of shipment will necessarily be somewhat different from that which was in effect at the time of ordering; however, at any point in time the GE QA program has been equal or better than the requirements in effect at that time.

Specific Evaluation Reference:

Information was provided at the PSAR stage.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.29, Revision 3, September 1978

Seismic Design Classification

Regulatory Guide Intent:

Regulatory Guide 1.29 describes an acceptable method of identifying and classifying those features of light-water-cooled nuclear power plants that should be designed to withstand the effects of the SSE.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

This regulatory guide is used as a basis for defining the systems and components which must meet Seismic Category I requirements.

For the purpose of defining equipment that should be described to withstand the SSE, NSSS equipment conforms to the guide. The regulatory guide needs to be more specifically integrated in the following areas:

C.1(b)

Application of this guide is limited to those reactor vessel internals which use engineered safety features, such as core spray piping, core spargers, and hardware, etc.

C.1(h)

The component cooling water portions of the reactor recirculation pumps are not required to be Seismic Category I since the pumps do not perform a safety function.

Specific Evaluation Reference:

See Section 3.2, Table 3.2-1, and the OQAPD.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.30, Revision 0, August 1972

Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment.

Regulatory Guide Intent:

This guide describes an acceptable method of complying with the NRC's regulations with regard to overall QA program requirements.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with the provisions of NRC regulatory guide or NRC regulations and NRC-approved alternate positions.

General Compliance or Alternate Approach Assessment:

Reference compliance assessment for Regulatory Guide 1.28.

Specific Evaluation Reference:

Information was provided at the PSAR stage. Compliance is discussed in the OQAPD.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.31, Revision 1, June 1973

Control of Stainless Steel Welding

Regulatory Guide Intent:

Regulatory Guide 1.31 describes an acceptable method of implementing requirements with regard to the control of welding when fabricating and joining austenitic stainless steel components and systems.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

All austenitic stainless steel weld filler materials were supplied with a minimum of 5% delta ferrite. This amount of ferrite is considered adequate to prevent microfissuring in austenitic stainless steel welds.

An extensive test program performed by GE, with the concurrence of the NRC, has demonstrated that controlling weld filler metal ferrite at 5% minimum produces production welds which meet the requirements of this regulatory guide.

A total of approximately 400 production welds in five BWR plants were measured and all welds met the requirements of the Interim Regulatory Position.

Specific Evaluation Reference:

See Section 5.2.3.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.32, Revision 1, March 1976

Use of IEEE 308-1974, "Criteria for Class 1E Electric Systems for Nuclear Power Generating Stations"

Regulatory Guide Intent:

This guide describes a method for implementation of electrical safety related equipment design relative to GDC 17 and 18. This guide does contain some conflicts between GDC 17 and IEEE 308-1974 that of course will require resolution by plant design implementation. This regulatory guide is applicable to the battery and battery charger of the HPCS standby power system.

Applicable Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The HPCS battery charger has sufficient capacity to restore its battery to full charge under the maximum steady-state load within a 24-hr period. A period of 24 hr is considered to be adequate to restore the battery from the design minimum charge state to the fully charged state irrespective of the status of the plant.

Specific Evaluation Reference:

See Section 8.3.1.2.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.34, Revision 0, December 1972

Control of Electroslag Weld Properties.

Regulatory Guide Intent:

Regulatory Guide 1.34 describes an acceptable method of implementing requirements regarding control of weld properties when fabricating electroslag welds for nuclear components made of ferritic or austenitic materials.

Application Assessment:

Not applicable.

Compliance or Alternative Approach Statement:

Not applicable.

General Compliance or Alternate Approach Assessment:

The electroslag welding process is not used on components within the NSSS scope of supply. Therefore this regulatory guide is not applicable.

Specific Evaluation Reference:

Not applicable.

Similar Application Reference:

Not applicable.

Regulatory Guide 1.37, Revision 0, March 1973

Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants.

Regulatory Guide Intent:

This guide describes an acceptable method of complying with the NRC's regulations with regard to overall QA program requirements.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with the provisions of NRC regulations and NRC regulatory guide or NRC-approved alternate position.

General Compliance or Alternate Approach Assessment:

Reference compliance assessment for Regulatory Guide 1.28.

Specific Evaluation Reference:

Information was provided at the PSAR stage. Compliance is discussed in the OQAPD.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.38, Revision 2, May 1977

Quality Assurance Requirements for Packaging, Shipping, Receiving, Storage and Handling of Items for Water-Cooled Nuclear Power Plants.

Regulatory Guide Intent:

This guide describes an acceptable method of complying with the NRC's requirements for handling of nuclear materials.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with the provisions of NRC regulations and the NRC regulatory guide or NRC-approved alternate position.

General Compliance or Alternate Approach Assessment:

Reference compliance assessment for Regulatory Guide 1.28.

Specific Evaluation Reference:

Information was provided at the PSAR stage.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.41, Revision 0, March 1973

Preoperational Testing of Redundant On-Site Electric Power Systems to Verify Proper Load Group Assignments.

Regulatory Guide Intent:

The requirements of this regulatory guide are applicable to the total onsite electric power systems within Energy Northwest's responsibility.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in full compliance with this regulatory guide.

General Compliance or Alternate Approach Assessment:

The HPCS power system is designed to be tested independently of any other redundant load group.

Specific Evaluation Reference:

See Sections 8.3 and 14.2.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.43, Revision 0, May 1973

Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable since stainless steel cladding on coarse grain low-alloy steel for safety class components is not used.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.44, Revision 0, May 1973

Control of the Use of Sensitized Steel

Regulatory Guide Intent:

The purpose of Regulatory Guide 1.44 is to address GDC 1 and 4 and 10 CFR 50 Appendix B requirements to control "the application and processing of stainless steel to avoid severe sensitization could lead to stress corrosion cracking." The guide proposes that this should be done by limiting sensitization due to welding as measured by ASTM A 262 Practice A or E, or another method that can be demonstrated to show nonsensitization in austenitic stainless steels.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

Tests by GE indicate that the test specified by A262 A or E (Detecting Susceptibility to Intergranular Attack in Stainless Steel) detects sensitization in a gross way, and the tests do not provide a precise method of predicting susceptibility to stress corrosion cracking in the BWR environment.

All austenitic stainless steel for CGS was purchased in the solution heat treated condition in accordance with applicable ASME and ASTM specifications. Carbon content was limited to 0.08% maximum, and cooling rates from solution heat treating temperatures were required to be rapid enough to prevent sensitization.

Welding heat input was restricted to 110,000 joules per inch maximum, and interpass temperature was restricted to 305°F. High heat welding processes such as block welding and electroslag welding were not permitted. All weld filler metal and castings were required by specification to have a minimum of 5% ferrite.

Whenever any wrought austenitic stainless steel was heated to temperatures over 800°F, by means other than welding or thermal cutting, the material was re-solution heat treated.

These controls were used to avoid severe sensitization and to comply with the intent of Regulatory Guide 1.44.

Specific Evaluation Reference:

See Section 5.2.3.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.45, Revision 0, May 1973

Reactor Coolant Pressure Boundary Leak Detection System.

Regulatory Guide Intent:

The guidelines are prescribed to ensure that leakage detection and collection systems provide maximum practical identification of leaks from within the reactor coolant pressure boundary (RCPB).

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The leak detection system consists of temperature, pressure, fission product monitoring and flow sensors with associated instrumentation and alarms. This system detects, annunciates, and isolates (in certain cases) leakages in the following systems:

a. Main steam lines,
b. Coolant systems within the drywell,
c. Reactor water cleanup (RWCU) system,
d. RHR system,
e. RCIC system,
f. Feedwater system, and
g. HPCS system.

Leakage is separated into identified and unidentified categories thus meeting position C.1 of Regulatory Guide 1.45. The affected systems and the leakage detection methods are discussed in Section 5.2.5.1.

Small unidentified leaks (5 gpm and less) inside the drywell are detected by temperature changes, pressure changes, drain sump pump activities, fission product monitoring, and floor drain flow monitoring; floor drain flow includes drywell cooler condensate flow.

Large leaks are also detected by changes in reactor water level and changes in flow rates in process lines.

The 5 gpm leakage rate is the limit on unidentified leakage inside the drywell. The leak detection system is capable of monitoring the flow rates with an accuracy of 1 gpm and is thus in compliance with paragraph C.2 of Regulatory Guide 1.45.

By monitoring drywell equipment and floor drain sump flow rates, which includes drywell coolers' condensate flow rates and fission products (airborne particulate and gaseous radioactivity), position C.3 is satisfied.

Isolation and/or alarm of affected systems and the detection methods used are summarized in Table 5.2-12.

Monitoring of coolant for radiation in the Residual Heat Removal (RHR) and Reactor Water Cleanup (RWCU) heat exchangers satisfies position C.4 of the Regulatory Guide. (For system details see Sections 7.6.1.2 and 11.5.)

The three methods differ in sensitivity and response time. Position C.5 requires the leak detection system be able to detect a leakage rate of 1 gpm in less than 1 hour. See Section 7.6.2.4 for further discussion.

The leakage detection system instruments listed in Table 7.6-2 have been evaluated and are capable of performing their functions following an operating basis seismic event. The drywell airborne particulate monitoring channel will remain functional following a safe shutdown earthquake. This satisfies position C.6 of Regulatory Guide 1.45.

Leakage detection indicators and alarms are provided in the main control room. This satisfies C.7 for the NSSS scope of supply. Procedures are developed for converting the various indications to a common leakage equivalent for the operators to satisfy remainder of C.7.

The leakage detection systems are equipped with provisions to permit testing for operability and calibration during operation by the following methods:

a. Continuous monitoring of sump level compared to flow rates into sump,
b. Operability checked by comparing one method to another,
c. Simulation of signals into trip monitors, and
d. Channel "A" against Channel "B" of the same method.

Thus position C.8 is satisfied.

Limiting conditions for identified and unidentified leakage are established as 20 gpm and 5 gpm respectively, thus satisfying position C.9.

Specific Evaluation Reference:

See Sections 5.2.5 and 7.6.2.4.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.46, Revision 0, May 1973

Protection Against Pipe Whip Inside Containment

Regulatory Guide Intent:

Regulatory Guide 1.46 describes an acceptable basis for selecting the design locations and orientations of postulated breaks in fluid system piping within the reactor containment and for determining the measures that should be taken for restraint against pipe whipping that may result from such breaks.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

This regulatory guide is applicable to the recirculation pipe lines.

The design of the containment structure, component arrangement, Class 1 pipe runs, pipe whip restraints and compartmentalization was done in consonance with the acknowledgment of protection against dynamic effects associated with postulated rupture of piping. Analytically sized and positioned pipe whip restraints were engineered to preclude damage based on the pipe break evaluation.

Pipe whip requirements for fluid system piping within the primary containment that, under normal operation, has service temperature greater than 200°F or pressures greater than 275 psig, complied with ANS N176, "Design Basis for Protection Against Pipe Whip," and Regulatory Guide 1.46 except as delineated in the following criteria for no breaks in Class 1 piping:

a. If Equation 10 of NB-365301, ASME Code Section III results in $S < 2.4\ S_m$ for ferritic or austenitic steels, no other requirements need be met. Stress range should be calculated between any two load sets (including zero load set) according to NB-3600 for upset and on operating basis earthquake (OBE) event transient;

b. If Equation 10 results in $2.4 < S < 3.0\ S_m$ for ferritic or austenitic steels, the cumulative usage factor, U, calculated on the bases of Equation 14 of NB-3653.6, must be less than 0.1; and

c. If Equation 10 results in $S > 3.0\ S_m$ for ferritic or austenitic steels, then the stress value in Equations 12 and 13 of NB-3653.6 must not be greater than $2.4\ S_m$.

Specific Evaluation Reference:

See Section 3.6.

Similar Application Reference:

Similar application was used in GESSAR.

Regulatory Guide 1.47, Revision 0, May 1973

Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems.

Regulatory Guide Intent:

This guide describes an acceptable method of complying with the requirements of IEEE 279-1971 and Appendix B to 10 CFR 50.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of the regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The alternate approach is provided in Section 7.1.2.4.

Specific Evaluation Reference:

See Section 7.1.2.4.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.48, Revision 0, May 1973

Design Limits and Loading Combinations for Seismic Category I Fluid System Components.

Regulatory Guide Intent:

Regulatory Guide 1.48 provides acceptable design limits and appropriate combinations of loadings associated with normal operation, postulated accidents, and specified seismic events for the design of the Seismic Category I fluid system components.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

For a comparison of NSSS with Regulatory Guide 1.48, see the attached tabulation.

The design basis was representative of good industry practices at the time of design, procurement, and manufacture and is shown to be in general agreement with requirements of Regulatory Guide 1.48, with the following clarifications:

a. The probability of an OBE of the magnitude postulated for CGS is consistent with its classification as an emergency event. However, for design conservatism, loads due to the OBE vibration motion have been included under upset conditions; loads due to the OBE vibratory motion plus associated transients, such as a turbine trip, have been considered in the equipment design under emergency conditions consistent with the probability of the OBE occurrence; and

b. The use of increased stress levels for Class 2 components is consistent with industry practice as specified in ASME Code Section III.

Specific Evaluation Reference:

See Section 3.9.3.

Similar Application Reference:

Similar application was used for LaSalle.

COMPARISON WITH REGULATORY GUIDE 1.48

		NRC Regulatory Guide 1.48			Columbia Generating Station			
Component	Plant Condition	Loading Combination[1/]	Design Limit	Regulatory Guide Paragraph	Loading Combination[(f)]	Code allowable Stresses	ASME Section III Reference	How CGS Compares With NRC Regulatory Guide 1.48
Class 1 vessels	Upset (U)	(NPC or UPC) + 0.5 SSE	NB-3223	1.a	(NPC or UPC), 0.5 SSE	3.0Sm (includes secondary stresses)	NB-3223	Reflects industry position
	Emergency (E)	EPC	NB-3224 2/	1.b	EPC, 0.5 SSE + transient	1.8Sm	NB-3224	
	Faulted (F)	NPC + SSE + DSL	NB-3225	1.c	NPC + SEE + DSL	App.F-Sec. III	NB-3225	
Class 1 piping	U	(NPC or UPC) + 0.5 SSE	NB-3654	1.a	(NPC or UPC), 0.5 SSE	3.0Sm (includes secondary stresses)	NB-3654	Reflects industry position
	E	EPC	NB-3655 2/	1.b	EPC, 0.5 SSE + transient	2.25Sm	NB-3655	
	F	NPC + SSE + DSL	NB-3656	1.c	NPC + SSE + DSL	3.0Sm	NB-3656	
Class 1 pumps (inactive)	U	(NPC or UPC) + 0.5 SSE	NB-3223[5/]	2.a	(NPC or UPC), 0.5 SSE	1.65Sm	NB-3223	Reflects industry position
	E	EPC	NB-3224 1/	2.b	EPC, 0.5 SSE + transient	1.8Sm	NB-3224	
	F	NPC + SSE + DSL	NB-3225	2.c	NPC + SSE + DSL	App. F-Sect. III	NB-3225	
Class 1 pumps (active)	U	(NPC or UPC) + 0.5 SSE	NB-3222 5/	4.a.1	(NPC or UPC), 0.5 SSE	Not applicable	Not applicable	Not applicable
	E	EPC	NB-3222 6/	4.a.2	EPC			
	F	NPC + SSE + DSL	NB-3222 7/ 8/	4.a.3	NPC + SSE + DSL			
Class 1 valves (inactive) by analysis	U	(NPC or UPC) + 0.5 SSE	NB-3223[5/]	2a	(NPC or UPC), 0.5 SSE	Not applicable	Not applicable	Not applicable
	E	EPC	NB-3224 4/	2.b	EPC			
	F	NPC + SSE + DSL	NB-3225[2/]	2.c	NPC + SSE + DSL			
Class 1 valves (inactive) designed by either std. or alternative design rules	U	(NPC or UPC) + 0.5 SSE	1.1 Pr	3.a	(NPC or UPC), 0.5 SSE	1.1 Pr	NB-3525	Reflects industry position
	E	EPC	1.2 Pr	3.b	EPC, 0.5 SSE + transient	1.2 Pr	NB-3526	
	F	NPC + SSE + DSL	1.5 Pr	3.c	NPC + SSE + DSL	1.5 Pr	NB-3527	
Class 1 valves (active) by analysis	U	(NPC or UPC) + 0.5 SSE	NB-3222 5/	4.a.1	(NPC or UPC, 0.5 SSE	Not applicable	Not applicable	Not applicable
	E	EPC	NB-3222 6/	4.a.2	EPC			
	F	NPC + SSE + DSL	NB-3222 7/ 8/	4.a.3	NPC + SSE + DSL			
Class 1 valves (active) designed by std. or alternative design rules	U	(NPC or UPC) + 0.5 SSE	1.0 Pr	5.a.1	(NPC or UPC), 0.5 SSE	1.0 Pr	NB-3525	Reflects industry position
	E	EPC	1.0 Pr 6/	5.a.2	EPC	1.0 Pr (a)	NB-3526	
	F	NPC + SSE + DSL	1.0 Pr	5.a.3	NPC + SSE + DSL	1.0 Pr	NB-3527	

COMPARISON WITH REGULATORY GUIDE 1.48 (Continued)

Component	Plant Condition	NRC Regulatory Guide 1.48: Loading Combination[1/]	NRC Regulatory Guide 1.48: Design Limit	NRC Regulatory Guide 1.48: Regulatory Guide Paragraph	Columbia Generating Station: Loading Combination[(f)]	Columbia Generating Station: Code Allowable Stresses	Columbia Generating Station: ASME Section III Reference	How CGS Compares With NRC Regulatory Guide 1.48
Class 2 & 3 vessels	U	(NPC or UPC) + 0.5 SSE	1.1S } 9/	6.a	(NPC or UPC), 0.5 SSE	σm = 1.1S } (c)	code case 1607	Faulted condition,
(Division 1) of section	E	EPC	1.1S } 9/	6.b	EPC,0.5 SSE + transient	} (c)	NC/NB	NRC more conservative,
VIII of the ASME Code	F	NPC + SSE + DSL	1.5S } 9/	6.c	NPC + SSE + DSL	σm = 2.0S } (c)	3321.1(b)	reflects industry position
Class 2 vessels	U	(NPC or UPC) + 0.5 SSE	NB-3223 } 2/	7.a	(NPC or UPC), 0.5 SSE	Not applicable	Not applicable	Not applicable
(Division 2) of section	E	EPC	NB-3224 } 2/	7.b	EPC			
VIII of the ASME Code	F	NPC + SEE + DSL	NB-3225 } 2/	7.c	NPC + SSE + DSL			
Class 2 & 3	U	(NPC or UPC) + 0.5 SSE	NC3611.1(b)(4)(c)(b)(1) } 10/	8.a	(NPC or UPC), 0.5 SSE	1.2 Sh	NC/ND 3611.3(b)	NRC more conservative,
piping	E	EPC	NC3611.1(b)(4)(c)(b)(1) } 10/	8.a	EPC,0.5 SSE + transient	1.8 Sh	NC/ND 3611.3(c)	Reflects industry
	F	NPC + SSE + DSL	NC3611.1(b)(4)(c)(b)(2) } 10/	8.b	NPC + SSE + DSL	2.4 Sh	(4)(b) (b) code case1606, NC/ND 3611.3(d) [see note (b)]	position
Class 2 & 3 pumps (inactive)	U	(NPC or UPC) + 0.5 SSE	$\sigma m \leq 1.1S \geq \frac{\sigma m + \sigma b}{1.5}$	9.a	(NPC or UPC), 0.5 SSE	Not applicable	Not applicable	Not applicable
	E	EPC	$\sigma m \leq 1.1S \geq \frac{\sigma m + \sigma b}{1.5}$	9.a	EPC			
	F	NPC + SEE + DSL	$\sigma m \leq 1.2S \geq \frac{\sigma m + \sigma b}{1.5}$	9.b	NPC + SEE + DSL			
Class 2 & 3 pumps (inactive)	U	(NPC or UPC) + 0.5 SSE	$\sigma m \leq 1.1S \geq \frac{\sigma m + \sigma b}{1.5}$ } 11/	10.a	(NPC or UPC), 0.5 SSE	σm = 1.1S } (a) (c)	Code case 1636, NC/ND3423	Reflects industry position
	E	EPC	$\sigma m \leq 1.1S \geq \frac{\sigma m + \sigma b}{1.5}$ } 11/	10.a	EPC,0.5 SSE + transient	} (a) (c)	[see note (b)]	
	F	NPC + SSE + DSL	$\sigma m \leq 1.1S \geq \frac{\sigma m + \sigma b}{1.5}$ } 11/	10.a	NPC + SSE + DSL	σm = 1.2S } (a) (c)		
Class 2 & 3 valves (inactive)	U	(NPC or UPC) + 0.5 SSE	1.1 Pr	11.a	(NPC or UPC), 0.5 SSE	σm = 1.1S } (c)	Code case1636,	Equally conservative
	E	EPC	1.1 Pr	11.a	EPC,0.5 SSE + transient	} (c)	NC/ND3621	
	F	NPC + SSE + DSL	1.2 Pr	11.b	NPC + SSE + DSL	σm = 2.0S } (c)	[see note (b)]	
Class 2 & 3 valves (active)	U	(NPC or UPC) + 0.5 SSE	1.0 Pr } 11/	12.a	(NPC or UPC), 0.5 SSE	σm = 1.1S } (a) (c)	Code case1636,	Equally conservative
	E	EPC	1.0 Pr } 11/	12.a	EPC,0.5 SEE + transient	} (a) (c)	NC/ND3621	(e)
	F	NPC + SSE + DSL	1.0 Pr } 11/	12.a	NPC + SSE + DSL	σm = 1.2S } (a) (c)	[see note (b)]	

COMPARISON WITH REGULATORY GUIDE 1.48 (Continued)

NOTES

Numerical indicators (e.g., 1/) in the regulatory guide portion of the table correspond to the footnotes of Regulatory Guide 1.48. Alphabetical indicators in CGS portion of table (or comparative column) correspond to the following:

[a]In addition to compliance with the design limits specified, assurance of operability under all design loading combinations shall be in accordance with Section 3.9.3.2.

[b]Referenced paragraphs of code currently in course of preparation.

[c]The design limit for local membrane stress intensity or primary membrane plus primary bending stress intensity is 150% of that allowed for general membrane (except as limited to 2.4S for inactive components under faulted condition). See Section 3.9.5.2.

[d]Not used.

[e]Inactive limits may be used since operability will be demonstrated in accordance with Section 3.9.3.2.

[f]When selecting plant events for evaluation, the choice of the events to be included in each plant condition is selected based on the probability of occurrence of the particular load combination. The combination of loads are those identified in Table 3.9-2.

LEGEND:

UPC = upset plant conditions
NPC = normal plant conditions
EPC = emergency plant conditions
DSL = dynamic system loading
SSE = safe shutdown earthquake

DELETED Contents of
Regulatory Guide 1.49, Revision 1, December 1973

Regulatory Guide 1.50, Revision 0, May 1973

Control of Preheat Temperature for Welding of Low-Alloy Steel

Regulatory Guide Intent:

This guide delineates preheat temperature control requirements and welding procedure qualifications supplementing those in ASME Sections III and IX.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The use of low-alloy steel is restricted to the reactor pressure vessel. Other ferritic components in the RCPB are fabricated from carbon steel materials.

Preheat temperatures employed for welding of low-alloy steel meet or exceed the requirements of ASME Section III. Components were either held for an extended time at preheat temperature to ensure removal of hydrogen, or preheat was maintained until postweld heat treatment. The minimum preheat and maximum interpass temperature were specified and monitored.

All welds were nondestructively examined by radiographic methods. In addition, a supplemental ultrasonic examination was performed.

By meeting and/or exceeding the recommendation of the ASME Code, the intent of the regulatory guide is satisfied even though the design was significantly developed prior to issuance of the specific guide wording.

Specific Evaluation Reference:

See Section 5.2.3.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.53, Revision 0, June 1973

Application of the Single-Failure Criterion to Nuclear Power Plant Protection Systems

Regulatory Guide Intent:

Regulatory Guide 1.53 requires that protection systems meet the requirements of Section 4.2 of IEEE 279-1971, which is also required by ANSI-N 42.7-1972 in that any single failure within the protection systems shall not prevent proper protective action at the system level when required. This guide provides guidance on an acceptable method of complying with this requirement.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in full compliance with this regulatory guide.

General Compliance or Alternate Approach Assessment:

Compliance is achieved by specifying, designing, and constructing the engineered safeguards systems to meet the single failure criterion, Section 4.2 of IEEE 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," and IEEE 379-1972, "IEEE Trial-Use Guide for the Application of the Single-Failure Criterion to Nuclear Power Generating Station Protection Systems."

This regulatory guide applies to the following NSSS supplied protection systems: reactor protection system (RPS), ECCS, and PCRVICS.

The reactor protection system has separate and redundant instrument channels, logic, and actuation circuits to ensure that the single failure criterion is met. The PCRVICS is similarly designed.

The ECCS is divided into the ADS, HPCS, LPCS and RHR (LPCI) which meets the single failure criterion on a network basis.

Specific Evaluation Reference:

See Sections 7.2.2.2 and 7.3.2.1.2.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.54, Revision 0, June 1973

Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants.

Regulatory Guide Intent:

This guide describes an acceptable method of complying with QA requirements for protective coatings.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with the provisions of NRC regulations and the NRC regulatory guide or NRC-approved alternate position.

General Compliance or Alternate Approach Assessment:

Reference compliance assessment for Regulatory Guide 1.28.

Specific Evaluation Reference:

Information was provided at the PSAR stage.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.56, Revision 0, June 1973

Maintenance of Water Purity in Boiling Water Reactors

Regulatory Guide Intent:

This guide describes an acceptable method of implementing GDC 13, 14, 15, and 31 with regard to minimizing the probability of corrosion-induced failure of the RCPB in BWRs by maintaining acceptable purity levels in the reactor coolant and acceptable instrumentation to determine the condition of the reactor coolant.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

Materials in the primary system are primarily Type 304 stainless steel and Zircaloy cladding. The reactor water chemistry limits have been established to provide an environment favorable to these materials. Design and Licensee Controlled Specifications (LCS) limits are placed on conductivity and chloride concentrations. Operationally, the conductivity is limited because it can be continuously and reliably measured and gives an indication of abnormal conditions and the presence of unusual materials in the coolant. Chloride limits are specified to prevent stress corrosion cracking of stainless steel.

The water quality requirements are further supported by GE topical report NEDO-10899.

Specific Evaluation Reference:

See Section 5.2.3.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.58, Revision 0, August 1973

Qualification of Nuclear Power Plant Inspection, Examination, and Testing Personnel

Regulatory Guide Intent:

This guide describes an acceptable method of complying with the NRC's regulations on qualification of nuclear power plant inspection, examination and testing personnel.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with the provisions of NRC regulations and the NRC regulatory guide or NRC-approved alternate position.

General Compliance or Alternate Approach Assessment:

Reference compliance assessment for Regulatory Guide 1.28.

Specific Evaluation Reference:

Information was provided at the PSAR stage. Compliance is discussed in the OQAPD.

Similar Application Reference:

Similar application has not been used in other plants.

Regulatory Guide 1.60, Revision 1, December 1973

Design Response Spectra for Seismic Design of Nuclear Power Plants.

Regulatory Guide Intents:

This guide delineates procedures for defining response spectra for designing Seismic Category I structures, systems, and components.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The input loadings for the seismic analysis of the CGS plant structures were given in terms of response spectra based on data available on earthquake acceleration time history records which was accepted industry practice at the time of the CGS design. This method was acceptable to the NRC prior to the issuance of this regulatory guide because no other guidance was available.

Specific Evaluation Reference:

See Section 3.7.1.1.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.61, Revision 0, October 1973

Damping Values for Seismic Design of Nuclear Power Plants

Regulatory Guide Intent:

This guide delineates damping values that should be applied to modal dynamic analysis of Seismic Category I elements.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The damping values used in the seismic analysis conform to the data available on this at the time the analysis was performed which was the practice accepted by industry and the NRC at the time of the CGS design.

The values used in Table 3.7-1 are less than those given by the regulatory guide. The calculated responses are therefore conservative.

Specific Evaluation Reference:

See Section 3.7.1.3.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.62, Revision 0, October 1973

Manual Initiation of Protective Actions.

Regulatory Guide Intent:

Regulatory Guide 1.62 requires that manual initiation of each protective action at the system level be provided, that such initiation accomplishes all actions performed by automatic initiation, and that protective action at the system level go to completion once manually initiated. In addition, manual initiation should be by switches readily accessible in the control room, and a minimum of equipment should be used in common with automatically initiated protective action.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in full compliance with this regulatory guide.

General Compliance or Alternate Approach Assessment:

Means are provided for manual initiation of primary containment and reactor vessel isolation control system (NSSS only), ECCS, and reactor protection system scram at the system level through the use of armed push buttons, as described below:

Action Initiated	Number of Switches
Primary containment and reactor vessel isolation (NSSS Only)	Four, two in Division 1 and two in Division 2
ADS	Four, two in Division 1 and two in Division 2
HPCS	One switch in Division 3
RHR (loop A)/LPCS	One switch in Division 1
RHR (loop B)/RHR (loop C)	One switch in Division 2
Reactor protection system (SCRAM)	Four, two in Division 1 and two in Division 2

Operation of these switches accomplishes the initiation of all actions performed by the automatic initiation circuitry.

The amount of equipment common to both manual and automatic initiation of the above function is kept to a minimum through implementation of manual activation as close as possible to the final devices actuators (relays, scram contractor) of the protection system. No failure in the manual, automatic or common portions of the protection system will prevent initiation of a given function by manual or automatic means.

Manual initiation of any of the above functions, once initiated, goes to completion as required by IEEE 279-1971, Section 4.16.

Specific Evaluation Reference:

See Sections 7.2.2.3 and 7.3.2.1.3.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.64, Revision 2, June 1976

Quality Assurance Requirements for the Design of Nuclear Power Plants

Regulatory Guide Intent:

This guide describes an acceptable method of complying with the NRC's QA requirements for the design of the nuclear power plants.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with the provisions of NRC regulations and the NRC regulatory guide or NRC-approved alternate position.

General Compliance or Alternate Approach Assessment:

Reference compliance assessment for Regulatory Guide 1.28.

Specific Evaluation Reference:

Information was provided at the PSAR stage. Compliance is discussed in the OQAPD.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.65, Revision 0, October 1973

Materials and Inspection for Reactor Vessel Closure Studs.

Regulatory Guide Intent:

Regulatory Guide 1.65 defines acceptable materials and testing procedures with regard to reactor vessel closure stud bolting for light-water-cooled reactors.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The reactor pressure vessel closure studs are SA-540 Grade B23 or 24 (AISI4340) and have a maximum ultimate tensile strength of 170 ksi. Additionally, specified bolting material must have Charpy V notch impact properties of 45 ft-lb minimum with 25 mils lateral expansion. Nondestructive examination before and after threading is specified to be in accordance with subarticle NB-2580 ASME Section III, which complies with regulatory position C.2. Subsequent to fabrication, the studs are manganese phosphate coated and are lubricated with a graphite/alcohol or a nickel powder base lubricant.

In relationship to regulatory position C.2.b, the bolting materials were ultrasonically examined after final heat treatment and prior to threading, as specified. The specified requirement for examination according to ASME Section II Recommended Practice SA-388 was complied with. The specific procedures approved for use in practice are judged to ensure comparable material quality and, moreover, are considered adequate on the basis of compliance with the applicable requirements of ASME Section III paragraph NB-2585.

Additionally, straight beam examination was performed on 100% of cylindrical surfaces, and from both ends of each stud using a 3/4 maximum diameter transducer. In addition to the code required notch, the reference standard for the radial scan contained a 0.5-in. diameter flat bottom hole with a depth of 10% of the thickness, and the end scan standard contained a 0.25-in. diameter flat bottom hole 0.5-in. deep. Also, angle beam examination was performed on the outer cylindrical surface of nuts

and washers per ASME SA-388 in both an axial and circumferential direction. Any indication greater than the indication from the applicable calibration feature is unacceptable. A distance-amplitude correction curve per NB-2585 is used for the longitudinal wave examination. Surface examinations were performed on the studs and nuts after final heat treatment and threading, as specified in the Regulatory Guide, in accordance with NB-2583 of ASME Code Section III, 1971 Edition through November 1971 Addenda.

In relationship to regulatory position C.3, GE practice allows exposure of stud bolting surfaces to high purity fill water; nuts and washers are stored dry during refueling.

In relationship to regulatory position C.4, ASME Section XI and Appendix VIII guidance is followed, as implemented in the In-Service Inspection Program, to monitor the structural integrity of the stud bolting and ability to perform their function.

Specific Evaluation Reference:

See Section 5.3.1.7.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.66, Revision 0, October 1973

Nondestructive Examination of Tubular Products.

Regulatory Guide Intent:

This guide describes a method of implementing requirements acceptable to NRC regarding nondestructive examination requirements of tubular products used in the RCPB.

Applicable Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

Wrought tubular products were supplied in accordance with applicable ASTM/ASME material specifications. These specifications require a hydrostatic test on each length of tubing. Additionally, the specification for the tubular product used for CRD housings specified ultrasonic examination to paragraph NB-2550 of ASME Code Section III.

These RCPB components met the requirements of ASME Codes existing at time of placement of order which predated Regulatory Guide 1.66. At the time of the placement of the orders, 10 CFR 50, Appendix B requirements and ASME code requirements assured adequate control of quality for the products.

This regulatory guide was withdrawn on September 28, 1977, by the NRC because the additional requirements imposed by the guide were satisfied by the ASME Code Section III.

Specific Evaluation Reference:

See Sections 4.5.2.3 and 5.2.3.3.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.67, Revision 0, October 1973

Installation of Overpressure Protection Devices

Regulatory Guide Intent:

This regulatory guide describes a method acceptable to the NRC staff for implementing GDC 1 with regard to the design of piping for safety valve and relief valve stations which have open discharge systems with limited discharge pipes and which have inlet piping that neither contains a water seal nor is subject to slug flow of water on discharge of the valves.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified RHR shutdown suction line thermal relief piping is located between the containment isolation valves. However, the intent of the regulatory guide does not apply due to the very short duration and small discharge of the thermal relief function.

General Compliance or Alternate Approach Assessment:

This regulatory guide is not considered to be applicable to this piping due to the small size and very short operation time of the valve (0.75 in. x 1 in.). The only purpose of the valve is to relieve the excess pressure caused by the difference of thermal expansion between the pipe and the water contained between the containment isolation valves.

Specific Evaluation Reference:

See Section 3.9.3.1.14.

Similar Application Reference:

Not applicable.

Regulatory Guide 1.68, Revision 0, November 1973

Preoperational and Initial Startup Test Programs for Water-Cooled Power Reactors

Regulatory Guide Intent:

Regulatory Guide 1.68 describes the requirements for the initial startup test programs. This regulatory guide is applicable to such activities as precritical tests and low-power tests.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The following discussion describes the alternate acceptable approaches for specific conformance to this regulatory guide.

The format of the CGS test procedures is different from that of the guide, but since the content specifies the required elements, the procedures are in compliance.

The reference sections refer to those of the regulatory guide. Those sections not listed are in compliance.

Section C.2.b: Operational limitations for the protection of public health and safety are included in the Technical Specifications for the plant. The General Electric startup instructions contain notes of caution which supplement the Technical Specifications. The Technical Specifications should be the instrument for describing operational (including testing) limitations. Therefore, the identification of "safety precautions" in test procedures should be limited to those items which, if not observed, could lead to reduction of system safety performance below expected levels and not the minor procedural and test details which would not cause such a reduction.

Section C.2.c: The generic simulation test appearing in Chapter 14 should appear by reference in preoperational and initial startup test programs where onsite full

simulation tests are not possible. The guide wording would change to ”… less than full simulation should be provided or referenced for test where full…”

Appendix A, Section C.2.h: The comparison of critical control rod pattern with predicted patterns (Appendix A, Section C.2.d) provides required knowledge of effective overall rod worth. Individual control rod calibrations cannot be performed in a meaningful manner in a large multirodded BWR. Therefore, this part of the guide is not applicable to BWRs.

Appendix A, Section C.2.i: The functional requirement of the reactor head cooling system design is required at operating pressures less than or equal to 135 psig. Therefore, for this paragraph to be applicable “(135 psig)” should be part of last sentence.

Appendix A, Section D.2.a: The high-pressure coolant injection (HPCI) has been replaced by an HPCS system. Due to the configuration of the sprays directly on the core, this system cannot be operated at power. The HPCS injection/core spray is demonstrated during the preoperational test program.

Appendix A, Section D.2.b: Friction tests are performed on four drives at rates pressure.

Appendix A, Section D.2.f: It is necessary to make more than two calibrations and, therefore, it is not appropriate to limit the test to 50% and 100% power levels.

Appendix A, Section D.2.g: At least six chemical analyses of fluid system are necessary; therefore, the limitations of 25%, 50%, 75%, and 100% are not appropriate.

Appendix A, Section D.2.1: Since this plant design does not include an emergency condenser, this section is not appropriate.

Appendix A, Section D.2.n: Control rod calibration in a large multirodded BWR has not been found to provide meaningful data. Any safety-related problems associated with control rods would be discovered during safety related testing, and therefore, this section is not appropriate.

Appendix A, Section D.2.p: Since the main steam valve function tests are conducted at a minimum of six power and flow conditions, the limitations of 25%, 50%, and 75% are not appropriate.

Appendix A, Section D.2.s and t: Turbine trip and generator trip have essentially the same effect on the reactor and safety related system actuation. Sections D.2.s and D.2.t should be combined into one test.

Appendix A, Section D.2.y: Minimum critical heat flux ratio (MCHFR) is an obsolete limit that has been replaced with minimum critical power ratio (MCPR). Core performance evaluation tests must be performed at every test condition.

Appendix A, Section D.2.aa: Comparison tests are made throughout the test program, and therefore, limitations of 25%, 50% and 100% are not appropriate.

Appendix C, Section B.2.d: Functionally testing the associated control rod immediately following installation of each fuel cell is not appropriate. Functional testing of all control rods after fuel loading and prior to startup to critical procedures is applicable.

Appendix A, Section A.5.a: The "demonstration of water injection for a LOCA" is an ECCS test. Therefore, "demonstration of water injection for a loss-of-coolant accident" is not within the scope of the reactor coolant makeup system test.

Appendix A, Section C.2.c: The "calibration of intermediate range monitor with power" is not meaningful due to local control rod effects.

Appendix A, Section D.2.w: Feedwater pump trip should be performed to check recirculation pump runback.

Appendix C, Section B.1.b: Poison curtains are not applicable since they are not used in this plant.

Appendix C, Section B.2.a: Poison curtains are not applicable.

Appendix C, Section B.3.c: The insertion of locked control rods is excluded in any withdrawal sequence.

Appendix D, Section D.2.0: The rod pattern exchange is not a part of the Startup Power Ascension Program since it does not involve the approach of any safety margin or operating limit. The rod pattern exchange procedure at power is part of the Nuclear Performance Evaluation Procedure and will be performed during the fuel cycle as necessary. The simultaneous trip of both recirculation pumps is not performed at 100% of rated power. The analysis of this event (see Section 15.3.1) indicates there is no decrease in the MCPR and therefore, it does not involve the approach of any safety margin or operating limit.

<u>Specific Evaluation Reference</u>:

See Section 14.2.

<u>Similar Application Reference</u>:

Similar application was used for Brunswick 1 and Browns Ferry 3.

Regulatory Guide 1.70, Revision 2, September 1975

Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants

Regulatory Guide Intent:

This guide describes the minimum acceptable requirements for format and content of Safety Analysis Reports.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in full compliance with this regulatory guide or through the incorporation of the NRC approved alternate approach cited.

General Compliance or Alternate Approach Assessment:

The NSSS scope of supply inputs include all the appropriate scope responsibilities and information required in Regulatory Guide 1.70, Revision 2, in both format and content, except as described below. Appendix A of NEDE-24011-P-A, General Electric Standard Application for Reactor Fuel (GESTAR II) (most recent approved revision referenced in the COLR), provides a road map for incorporating nuclear fuel design and analysis characteristics described in GESTAR II into the FSAR. GESTAR II is consistent with Regulatory Guide 1.70, Revision 3.

Specific Evaluation Reference:

For Regulatory Guide 1.70, Revision 2, see NSSS scope of supply portions of this FSAR.

For Regulatory Guide 1.70, Revision 3, see Sections 4.1, 4.2, 4.3 and 4.4.

Similar Application Reference:

Similar application was used for Grand Gulf 1 and 2 and Susquehanna 1 and 2.

Regulatory Guide 1.71, Revision 0, December 1973

Welder Qualification for Areas of Limited Accessibility

Regulatory Guide Intent:

Regulatory Guide 1.71 requires that weld fabrication and repair for wrought low-alloy and high-alloy steels or other materials such as static and centrifugal castings and bimetallic joints should comply with fabrication requirements of Section III and Section IX of the ASME B&PV Code. It also requires additional performance qualifications for welding in areas of limited access.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

All ASME Section III welds were fabricated in accordance with the requirements of Section III and IX of the ASME B&PV Code. There are few restrictive welds involved in the fabrication of BWR components. Welder qualification for welds with the most restrictive access was accomplished by mock-up welding. Mock-ups were examined with radiography or sectioning.

All reactor pressure boundary welding was performed in accordance with ASME Section IX. Reactor internal component welding was performed in accordance with ASME Section IX or appropriate AWS requirements.

Specific Evaluation Reference:

See Section 5.2.3.

Similar Application Reference:

Similar application was used for Zimmer and LaSalle.

Regulatory Guide 1.73, Revision 0, January 1974

Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants.

Regulatory Guide Intent:

Regulatory Guide 1.73 endorses the requirements of IEEE 382-1972, "Trial-Use Guide for Type Test of Class 1 Electric Valve Operators for Nuclear Power Generating Station." Regulatory position stipulations are also included.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in full compliance with this regulatory guide.

General Compliance or Alternate Approach Assessment:

This regulatory guide is applicable to the recirculation system gate valve and the HPCS injection valve motor operators.

These valve operators have been tested in accordance with the test sequence outlined in Section 4.5.2 of the IEEE 382-1972. The qualifying tests have been made under environmental conditions (temperature, pressure, humidity, radiation) that are at least as severe as those that the valve operator will be exposed to during and following a DBA (LOCA).

Specific Evaluation Reference:

See Section 3.11.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.74, Revision 0, February 1974

Quality Assurance Terms and Definitions

Regulatory Guide Intent:

This guide identifies quality assurance terms and acceptable definitions.

Application Assessment;

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with the provisions of NRC regulations and the NRC regulatory guide or NRC-approved alternate position.

General Compliance or Alternate Approach Assessment:

Reference compliance assessment for Regulatory Guide 1.28.

Specific Evaluation Reference:

Information was provided at the PSAR stage. Compliance is discussed in the OQAPD.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.75, Revision 0, February 1974

Physical Independence of Electrical Systems

Regulatory Guide Intent:

This guide presents a detailed method of ensuring physical independence of electric systems, including requirements of preparation, identification, and isolation.

Application Assessment:

Assessed capability in design

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

When evaluating the applicability of Regulatory Guide 1.75 and its attendant IEEE Standard (IEEE-384-1971), consideration should be given to the fact that design was significantly developed prior to their issuance.

The following is a point-by-point definition of the implementation of IEEE-384 as modified by Regulatory Guide 1.75 for the CGS plant. The numbers and titles in the following see those of IEEE-384.

1. Scope

   Compliance with scope.

2. Purpose

   Compliance with purpose.

3. Definitions

   All definitions apply including Regulatory Guide 1.75 except for small nomenclature aspects in C.1 and C.2 associated within floor sections.

4. General Separation Criteria

4.1 Required Separation

4.2 Equipment and Circuits Requiring Separation

The equipment and circuits requiring separation are determined and delineated early in the plant design. Distinctive identification of those equipment and circuits were not provided on specifically noted documents and drawings but the documents and drawings are identified as applying to the "protection systems."

4.3 Methods of Separation

Barriers are used to separate divisional devices and wiring. Safety system logic is implemented with relay coil to relay contact separation of multidivisional and nondivisional signals. Distance separation was provided to the extent feasible at manufacturing time. These served the purpose or intent of requirements at that time.

4.4 Compatibility with Mechanical Systems

The Class 1E equipment and circuits are specified to be located so that a failure in the mechanical systems served by the Class 1E systems does not disable redundant portions of the Class 1E systems.*

4.5 Associated Circuits

Associated circuits are treated as non-Class 1E circuits and are separated to the extent that good electrical isolation is assured. This assurance was provided without Class 1E isolators. Some physical separation is provided.

4.6 Non-Class 1E Circuits

4.6.1 Separation from Class 1E Circuits

Same as 4.5 response above.

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* Information on compliance of actual installation is provided in Section 1.8.3.

4.6.2 Separation from Associated Circuits

Same as 4.5 response above.

5. Specific Separation Criteria

5.1 Cables and Raceways

To the extent that the 5.1 series of subparagraphs might be used to critique the power generation control complex (PGCC) equipment, the physical reality of the floor sections is obviously not recognized in the IEEE-384 test. However, the floor sections are inherently in accordance with the design concepts stated in these subparagraphs and therefore comply on that basis.

5.2 Standby Power Supply

Comply as applied to the Division 3 HPCS Diesel Generator.*

5.3 DC System

Comply as applied to the Division 3 HPCS Diesel Generator.*

5.4 Distribution System

Comply as applied to the Division 3 HPCS Diesel Generator.*

5.5 Containment Electrical Penetrations

Not in NSSS scope of supply.

5.6 Control Switch Boards

5.6.1 Location and Arrangement†

Class 1E equipment and circuits are located on separate control switchboards or where operationally necessary on a single control switchboard.

* Division 1 and 2 power compliance is provided in Section 1.8.3.

† The control room structure and location as well as local control switchboard location is discussed in Section 1.8.3.

5.6.2 Internal Separation

Most of the devices requiring separation are separated by barriers. With several divisions in one panel, and for relays which must accept multidivisional signals, 6-inch separation is impossible. Therefore, separation is done on a best effort approach. Design has used the relay coil to relay contact separation to comply with the regulatory guide.

5.6.3 Internal Wiring Identification

Panel internals wiring is not color-coded, but wires are marked with their respective Connection Diagram identify at each point of termination.

5.6.4 Common Terminations

Relay coil to relay contact separation has been used.

5.6.5 Non-Class 1E Wiring

Electrical isolation is provided, though not necessarily with Class 1E isolators. Some physical separation is provided.

5.6.6 Cable Entrance

Not in NSSS scope of supply.

5.7 Instrumentation Cabinets

Compliance

5.8 Sensors and Sensor to Process Connections

Compliance

5.9 Actuated Equipment

Not in NSSS scope of supply.

Specific Evaluation Reference:

See Section 8.3.1.4.2.7

Similar Application Reference:

Application of this regulatory guide is plant unique due to NRC agreements during the various stages of licensing and scope of responsibility of design and engineering necessary to comply with the NRC interpretation. Therefore reference plants cannot be cited.

Regulatory Guide 1.84

Design, Fabrication, and Materials Code Case Acceptability, ASME Section III

Regulatory Guide Intent:

This guide lists all Section III Code Cases that the NRC has approved for use. It is updated on a regular basis to reflect the changes to the ASME Code Cases and the current position of the NRC on acceptability for use. The guide contains tables that detail the NRC acceptance requirements for current, annulled, and superseded Code Cases. Code Cases that the NRC determined to be unacceptable are listed in Regulatory Guide 1.193, "ASME Code Cases Not Approved for Use".

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The current version of the Regulatory Guide is utilized to determine acceptable Code Cases for all new and existing plant applications. The FSAR does not track individual Code Cases and revision numbers. Not all acceptable Code Cases listed in the regulatory guide are used. The Code Cases that are utilized for Columbia are referred to in the plant design/installation documentation.

General Compliance or Alternate Approach Assessment:

Code Cases are utilized in accordance with the requirements of the regulatory guide provisions for acceptance. Section III Code Cases that are not yet endorsed may be utilized via submittal to the NRC for approval in accordance with the regulatory guide. The plant scope of supply is in full compliance with this regulatory guide.

Specific Evaluation Reference:

See Section 3.2.

Similar Application Reference:

None.

Regulatory Guide 1.85, Revision 31, 1998*

Code Case Acceptability ASME Section III Materials

Regulatory Guide Intent:

This guide provides a list of ASME materials code cases that have been generically approved by the NRC.

Code cases on this list may be used until annulled. Annulled cases are considered "active" for equipment that has been contractually committed to fabrication prior to the annulment.

This guide and later revisions require NRC approval of code cases for Class 1, 2, and 3 components.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

The GE procedure is to obtain NRC approval of code cases on Class 1 components only. NRC approval of Class 2 and 3 code cases was not required by 10 CFR 50.55(a).

All Class 2 and 3 equipment has been designed to ASME Code or ASME approved Code Cases. This provision together with quality control requirements provide adequate safety equipment functional assurances.

Specific Evaluation Reference:

See Section 5.2.1.

* Regulatory Guide 1.85 was withdrawn in 2004. See Regulatory Guide 1.84 for NRC acceptance of current Materials Code Cases.

Similar Application Reference;

Similar application was used for LaSalle.

Regulatory Guide 1.88, Revision 2, October 1976

Collection, Storage, and Maintenance of Nuclear Power Plant Quality Assurance Records.

Regulatory Guide Intent:

This guide describes an acceptable method of complying with the NRC's regulations for collection, storage, and maintenance of quality assurance records.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The identified BWR Quality Assurance Program used in this facility reflects compliance with the provisions of NRC regulations and the regulatory guide or NRC-approved alternate position.

General Compliance or Alternate Approach Assessment:

Reference compliance assessment for Regulatory Guide 1.28.

Specific Evaluation Reference:

Information was provided at the PSAR stage. Compliance is discussed in the OQAPD.

Similar Application Reference:

Similar application has not been used for other projects.

Regulatory Guide 1.89, Revision 1, June 1984

Qualification of Class 1E Equipment for Nuclear Power Plants

Regulatory Guide Intent:

Regulatory Guide 1.89 Rev. 1 endorses both the requirements and recommendations of IEEE 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations." Additional regulatory position stipulations are also included.

Compliance or Alternate Approach Statement:

CGS complies with this regulatory guide for equipment requiring environmental qualification procured after February 22, 1983.

General Compliance or Alternate Approach Assessment:

For equipment requiring environmental qualification installed prior to February 22, 1983, CGS follows the guidance in NUREG-0588 Cat II.

In view of the NRC Memorandum and Order (CLI-80-21), dated May 23, 1980, all environmental qualifications of Class 1E equipment within the NSSS scope of supply was reevaluated for compliance with NUREG-0588, Category II. Where significant deviation from those guidelines was found in specific equipment qualifications, additional testing and/or analysis was performed to demonstrate the adequacy of the equipment to perform its safety-related function.

Specific Evaluation Reference:

Delineation of the degree of compliance is contained in Section 3.11.

Regulatory Guide 1.92, Revision 1, February 1976

Combination of Modes and Spatial Components in Seismic Response Analysis.

Regulatory Guide Intent:

This guide describes methods acceptable to the NRC for combining the values of the response spectrum nodal dynamic analysis and in combining maximum values (in case of time history dynamic analysis) or the representative maximum values (in case of spectrum dynamic analysis).

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and/or equipment used in this facility is in compliance with the intent of this regulatory guide through the incorporation of the alternate approach cited.

General Compliance or Alternate Approach Assessment:

Three Components of Earthquake Motion

Response Spectrum Method

The use of three components of earthquake motion was not a design basis requirement of the construction permit for this plant. The total seismic response is predicted by combining the response calculated from analyses due to one horizontal and one vertical seismic input. For this case, where the response spectrum method of seismic analysis is used, the basis for combining the loads from the two analyses is given as follows:

a. The peak of the different modes for the same earthquake excitations do not occur at the same time,

b. The peak responses of a particular mode due to earthquake excitations from different directions do not occur at the same time, and

c. The peak stresses due to different modes and due to different excitations may not occur at the same location nor in the same direction.

To implement the above, the two translation components of earthquake excitations are combined by summing the absolute sum of all responses of interest (e.g., strain, displacement stress, moment, shear, etc.) from seismic motion, the one horizontal (x or z) and one vertical direction (y), i.e., $|x+y|$ or $|y+z|$. The design is made for the larger of the two sums $|x+y|$ or $|y+z|$.

Time History Method

The algebraic sum of contributions (to displacements, loads, stresses, etc.) due to the two earthquake components are calculated for each natural mode for each time interval of analysis. The time interval should be less than or equal to 0.2 of the smallest period of interest. The maximum values of all time intervals are the design displacements, accelerations, loads, or stresses.

It is concluded that the above method adequately demonstrates the integrity of the Seismic Category I subsystems and was found acceptable as a basis of current operating BWR plants.

Combination of Modal Responses

When the response spectra method of modal analysis is used, all modes are combined by the square root of the sum of the squares (SRSS) described as follows:

The SRSS combination of modal responses is defined mathematically as

$$R = \sqrt{\sum_{i=1}^{n} (R_i)^2}$$

where

R = Combined response

R_i = Response in the i^{th} mode

n = Number of modes considered in the analysis

Closely spaced modes are not accounted for as required by the guide because the design was significantly developed prior to issuance of the guide.

Specific Evaluation Reference:

See Sections 3.7.3.6 and 3.7.3.7.

Similar Application Reference:

Similar application was used for LaSalle.

Regulatory Guide 1.99, Revision 2, May 1988

Radiation Embrittlement of Reactor Vessel Materials

Regulatory Guide Intent:

This regulatory guide provides guidance for the prediction of irradiation damage of the reactor vessel belt line materials for the life of the vessel. This information is used to develop the pressure/temperature limit curves for the reactor pressure vessel based on material chemistry and end-of-life neutron exposure.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The reactor pressure vessel pressure/temperature limit curves are in full compliance with the identified requirements in the regulatory guide.

General Compliance or Alternate Assessment:

Compliance is achieved by using a calculated end-of-life fluence for the CGS reactor vessel to evaluate the material damage due to this fluence. This information is used to predict the end-of-life NDT temperature for the limiting belt line material for the vessel. Using linear elastic fracture mechanics, the requirements of Welding Research Council Bulletin 175, the Standard Review Plan, and the requirements of Regulatory Guide 1.99, Revision 2, the pressure/temperature limit curves were developed for CGS. These curves will be used to evaluate the predictions determined by the regulatory guide until the submittal of new curves that incorporate the results of the surveillance capsule test data.

Specific Evaluation Reference:

See Sections 5.3.1.5.2.1 through 5.3.1.5.2.6 and the Technical Specifications.

Similar Application Reference:

Similar application is used on all reactor vessels.

Regulatory Guide 1.100, Revision 1, August 1977

Seismic Qualification of Electric Equipment for Nuclear Power Plants

Regulatory Guide Intent:

Regulatory Guide 1.100 endorses both the requirements and recommendations of IEEE 344-1975, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," when such qualification is performed in conjunction with Regulatory Guide 1.89, and subject to the regulatory position stipulations.

Compliance or Alternate Approach Statement:

General Compliance or Alternate Approach Assessment:

All Class 1E equipment seismic qualifications are evaluated against the requirements set forth within IEEE 344-1975 as clarified in Section 3.10.1.2. The evaluations are documented and demonstrated adequacy of the methods and results of the qualifications as equal or conservative to the requirements of IEEE 344-1975. This qualification documentation includes evaluation of seismic and hydrodynamic load combinations.

Specific Evaluation Reference:

See Section 3.10 and *"WNP-2 Dynamic Qualification Report for Safety-Related Equipment," dated September 1982*.

Regulatory Guide 1.145, Revision 1, November 1982/February 1983

Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants

Regulatory Guide Intent

This guide provides acceptable methodology to determining site-specific off-site air dispersion factors (χ/Q) for assessing the potential offsite radiological consequences of postulated accidental releases of radioactive material to the atmosphere.

Application Assessment

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and equipment used in this facility is in full compliance with the regulatory guide.

General Compliance or Alternate Approach Assessment

Two of the procedures contained in the PAVAN code were implemented. The procedures were run with the desert sigma and with the Pasquill-Gifford sigma enabled. The most conservative χ/Q values were used in the accident analysis.

Specific Evaluation Reference:

See Section 2.3 and Chapter 15.0.

Regulatory Guide 1.183, Revision 0, July 2000

Alternative Radiological Source Terms For Evaluating Design Basis Accidents At Nuclear Power Reactors

Regulatory Guide Intent:

This guide provides guidance to licensees of operating power reactors on acceptable applications of alternative source terms; the scope, nature, and documentation of associated analyses and evaluations; consideration of impacts on analyzed risk; and content of submittals. This guide establishes an acceptable alternative source term (AST) and identifies the significant attributes of other ASTs that may be found acceptable by the NRC staff. This guide also identifies acceptable radiological analysis assumptions for use in conjunction with the accepted AST.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and equipment used in this facility is in compliance with this regulatory guide or through the incorporation of the NRC approved alternate approach cited.

General Compliance or Alternate Approach Assessment:

This regulatory guide is applicable to the analyses for the FSAR. The Columbia analysis methods and assumptions (see Energy Northwest, "Columbia Generating Station Alternative Source Term," CGS-FTS-0168, Revision 0, August 2007) conform to position of this Regulatory Guide with the following specific considerations.

[Guide Section 3.4] Table 5 of the regulatory guide lists the elements in each radionuclide group that should be considered in design basis analyses. The intent of the guidance is met by an alternate approach. The Columbia analyses consider 66 nuclides consisting of 60 identified as being potentially important contributors to TEDE in NUREG/CR-4691 plus seven additional noble gas isotopes and Ba-137m.

[Guide Section 4.3] Columbia conforms with guide section 4.3 with the exception that the TID-14844 source term continues to be used as the radiation dose basis for equipment qualification.

[Guide Section 3.3 of Appendix A] The intent of the guidance is met by the conservative approach used in the Columbia analysis. The SRP 6.5.2 model is used. Elemental iodine is assumed to be removed at the same rate as particulate. The approach of treating elemental iodine as particulate is a conservative representation of the situation in which some elemental iodine would be removed by diffusion to spray water droplets and some elemental iodine would adsorb onto particulate. A reduction of 10 in iodine removal lambda is taken when 98% of the particulate has been removed. The method results in a conservative dose.

Specific Evaluation Reference:

See Chapter 15.4.9, 15.6.4, 15.6.5, 15.7.4.

Similar Application Reference:

Similar application was used for Grand Gulf and Brunswick.

Regulatory Guide 1.190, Revision 0, March 2001

Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence

Regulatory Guide Intent:

This Regulatory Guide has been developed to provide state-of-the-art calculations and measurement procedures that are acceptable to the NRC staff for determining pressure vessel fluence.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The methodology for the neutron flux calculation for the CGS reactor vessel conforms to Licensing Topical Report (LTR) NEDC-32983-P-A. In general, the methodology described in the LTR adheres to the guidance in Regulatory Guide 1.190 for neutron flux evaluation and was approved by the U.S. NRC in the Safety Evaluation Report (SER) for referencing in Licensing submittals.

General Compliance or Alternate Assessment:

Reference compliance assessment for Regulatory Guide 1.99.

Specific Evaluation Reference:

See Section 4.3.2.8.

Similar Application Reference:

Similar application is used for Browns Ferry Nuclear Plant, Units 2 and 3, reactor vessels.

Regulatory Guide 1.194, Revision 0, June 2003

Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants

Regulatory Guide Intent:

This guide provides guidance on determining atmospheric relative concentrations (χ/Q) values in support of design basis control room radiological habitability assessments at nuclear power plants. This guide describes methods acceptable to the NRC staff for determining χ/Q values that will be used in control room radiological habitability assessments performed in support of applications for licenses and license amendment requests.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified NSSS scope of supply analysis, design, and equipment used in this facility is in compliance with this regulatory guide or through the incorporation of the NRC approved alternate approach cited.

General Compliance or Alternate Approach Assessment:

This regulatory guide is applicable to the analyses for the FSAR. The Instantaneous Puff Release alternative method provided by this guide is used to calculate χ/Q for the Main Steam Line Break accident.

Specific Evaluation Reference:

See Section 15.6.4.

Similar Application Reference:

1.8.3 BALANCE OF PLANT SCOPE OF SUPPLY EVALUATION

The following evaluations of implementation of regulatory guides are relative to BOP scope of supply. Thus, reference to CGS in the following evaluations is restricted to the BOP scope of supply portions of CGS. For NSSS scope of supply implementation of regulatory guides, see Section 1.8.2.

Conformance to the regulatory guides falls under either of the two following categories:

a. Compliance with the guidance set forth in this regulatory guide as described in this FSAR or

b. Compliance with the intent of the guidance set forth in this regulatory guide by an alternate approach.

The second category is based on NRC rules which state:

> Regulatory guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the assurance or continuance of a permit or license by the NRC.

Regulatory guides and their revisions are addressed in the following.

Regulatory Guide 1.6, Revision 0, March 1971

Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The compliance assessments given below correspond numerically to the Regulatory Positions as enumerated in Section C of Regulatory Guide 1.6, Revision 0.

1. The electrically powered safety loads, both ac and dc, are separated into redundant load groups such that loss of any one group will not prevent the minimum safety function from being performed.

2. Each ac load group has a connection to the preferred offsite power source and to a standby onsite power source. The standby power sources have no automatic connection to any other redundant load groups.

3. Each dc load group is energized by a battery and battery charger. The battery-charger combination has no automatic connection to any other redundant dc load group.

4. When operating from the standby sources, redundant load groups and the redundant standby sources are independent of each other.

5. A single generator driven by two prime movers in tandem is the standby power source for the Division 1 and 2 ac load groups. The Division 3 ac load group power is supplied by a single generator driven by a single prime mover.

Specific Evaluation Reference:

See Sections 8.1.5.2, 8.3.1.1.7, 8.3.1.2.1.3, 8.3.1.2.1.4, 8.3.1.3, 8.3.1.4, 8.3.2.1.1, 8.3.2.2.1.2, 8.3.2.3, and 8.3.2.4.

Regulatory Guide 1.8, Revision 1-R, May 1977

Personnel Selection and Training

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The Regulatory Position of Regulatory Guide 1.8, Rev. 1-R (May 1977) will be implemented.

Specific Evaluation Reference:

See Sections 13.1.3, 13.2.1, and the OQAPD.

Regulatory Guide 1.9, Revision 0, March 1971

Selection of Diesel Generator Set Capacity for Standby Power Supplies.

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The compliance assessments given below correspond numerically to the regulatory positions as enumerated in Section C of Regulatory Guide 1.9, Revision 0.

1. Both the Division 1 and Division 2 diesel generator sets were selected to have a continuous load rating equal to or greater than the sum of the conservative estimated loads needed to be powered at any one time.

2. The predicted loads on both the Division 1 and the Division 2 diesel generator sets do not exceed the 2000-hr rating of either set, respectively, or 90% of the 30-minute rating of either set, respectively.

3. Predicted loads on Division 1 and Division 2 were verified by tests during preoperational testing.

4. The Division 1 and Division 2 diesel generator sets are capable of starting and accelerating to rated speed, in the required sequence, all the needed engineered safety feature and emergency shutdown loads.

   The Division 1 and Division 2 diesel generator sets are within the limits of undervoltage, under-frequency, overspeed and voltage and frequency restoration time limits, set forth in the regulatory guide.

5. The suitability of each diesel generator set of the standby power supply was confirmed by prototype qualification test data and preoperational tests.

The scope of Regulatory Guide 1.9, Revision 0 does not include recommendations for surveillance testing. The surveillance requirements for demonstrating the operability of the diesel generators are consistent with the recommendations of Regulatory Guide 1.9 Revision 3 as described in the Bases for Technical Specification B 3.8.1. Compliance with Regulatory Guide 1.9 Rev. 0, as an acceptable basis for the selection of diesel generator sets of sufficient margin to implement General Design Criterion 17, remains as described herein.

Specific Evaluation References:

See Sections 8.1.5.2, 8.3.1.1.7, and 8.3.1.2.1.3.

Regulatory Guide 1.10, Revision 1, January 1973

Mechanical (Cadweld) Splices in Reinforced Bars of Category I Concrete Structures.

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The requirements of the guide have been included in the appropriate specifications for the project construction. Compliance with the guide is ensured by testing and control procedures and reporting program. The program includes splicing crew qualifications, visual inspection of each splice, tensile testing of splice samples, tensile test frequency program, and a procedure for evaluating substandard test results. The procedure for testing and sampling of mechanical splices have been implemented.

Specific Evaluation Reference:

See Sections 3.8.3.2 and 3.8.4.2 and Table 3.8-4.

Regulatory Guide 1.11, Revision 0, March 1971

Instrument Lines Penetrating Primary Reactor Containment.

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

CGS design includes flow restriction orifices and/or excess flow check valves with position indication in instrument lines which penetrate primary reactor containment. In the event of an instrument line rupture outside primary containment, the integrity and functional performance of the secondary containment system and its associated filtration systems are maintained.

Specific Evaluation Reference:

See Sections 7.1.2.4 and 6.2.4.

Regulatory Guide 1.12, Revision 1, April 1974

Instrumentation for Earthquakes

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Triaxial strong-motion accelerographs are installed at appropriate locations to provide data on the seismic input to containment; data on frequency, amplitude, and phase relationship of the seismic response of the containment structure; and data on the seismic input to other Category I structures, systems, and components.

Specific Evaluation Reference:

See Section 3.7.4.

Regulatory Guide 1.13, Revision 1, December 1975

Spent Fuel Storage Facility Design Basis

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

A controlled leakage building is provided enclosing the fuel pool. The building is not designed to withstand extremely high winds, but leakage is suitably controlled during refueling operations. The building is equipped with a ventilation and filtration system which is designed to limit the potential consequences of the release of radioactivity specified in Regulatory Guide 1.183 to those requirements set forth in 10 CFR 50.67.

The movement paths of heavy objects such as the reactor pressure vessel head, containment vessel head, and the spent fuel cask are designed not to pass over the spent fuel racks. Furthermore, the reactor building crane and its auxiliary hoist are prevented by means of interlocks from passing over any of the spent fuel pool except the spent fuel cask area. Bypassing of the interlocks is permitted only during fuel handling and storage operations and is administratively controlled.

The fuel pool is designed so that no pipe break will drain water from the fuel pool.

Specific Evaluation Reference:

See Section 9.1.

Regulatory Guide 1.15, Revision 1, December 1972

Testing of Reinforcing Bars for Category I Concrete Structures

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The requirements of the guide have been included in the appropriate specifications for project construction. Compliance with the guide is assured by the implementation of qualified testing and control procedures and reporting. Included are qualified control procedures and reporting for the yield strength and tensile strength tests and deformation inspections recommended by the guide.

Specific Evaluation Reference:

See Sections 3.8.3.2, 3.8.4.2, and 3.8.5.2 and Table 3.8-4.

Regulatory Guide 1.16, Revision 4, August 1975

Reporting of Operating Information - Appendix A Technical Specifications

Compliance or Alternate Approach Statement:

This regulatory guide was withdrawn in August 2009 and is no longer applicable.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.17, Revision 1, June 1973

Protection of Nuclear Power Plants Against Industrial Sabotage

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

This information is considered proprietary and is subject to limited distribution. All specifics have been forwarded to the NRC as part of the Energy Northwest proprietary physical security plan for CGS.

Specific Evaluation Reference:

See proprietary physical security plan.

Regulatory Guide 1.18, Revision 1, December 1972.

Structural Acceptance Test for Concrete Primary Reactor Containments

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable since CGS does not have a concrete primary containment.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.19, Revision 1, August 1972

Nondestructive Examination of Primary Containment Liner Welds

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable since CGS does not have a concrete primary containment with a steel liner.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.21, Revision 1, June 1974

Measuring, Evaluating, and Reporting of Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance established in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

The following categories of monitoring systems incorporated into the CGS design fulfill the requirements for monitoring in Regulatory Guide 1.21.

a. Gaseous effluents,
b. Liquid effluents, and
c. Solid Waste.

The above categories of monitoring systems adequately monitor effluent discharge paths for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.

Columbia Generating Station complies with Section C.11.b (Quality Controls) requirements for blind duplicate analysis by an alternate approach. An intralaboratory blind sample program is performed on selected samples. The blinds are prepared from samples sent from a cross check laboratory and split between several analysts as determined by the Chemistry Operations Supervisor or designee. This process allows evaluation of individual analysts' performance while at the same time satisfying the blind duplicate and cross check laboratory requirements.

Section C.11.c (Calibrations) suggests that appropriate standards be used to calibrate continuous radioactivity monitors and that the relationship be established between monitor readings and concentration over the full range of the readout device. In those cases where mixed fission gases or corrosion and activation products are not available, vendor instrument performance data or calculations will be used. Subsequent inservice calibrations will be performed using the specific radionuclide analytical results from grab samples taken from the effluent release path.

Appendix A, Section A.3.a (1) and Section A.3.a (3), analytical frequencies are not consistent with standard sampling and analytical techniques. Improved sensitivities and

more realistic quantity measurements can be made by performing ^{140}Ba-La, $^{89\text{-}90}$Sr, and gross alpha measurements on a monthly composite sample of weekly samples.

Exception is taken to the Appendix A, Section B.1.c, requirement for a special sample and analysis of one liquid waste batch per month for entrained fission and activation gases. The gamma spectrum analysis performed prior to the release of any waste liquid batch will identify such gases without performing a separate or special analysis.

The sensitivity slated in Appendix A, Section B.3, for gamma-emitting radionuclides (5 x 10^{-7} μCi/ml) will be applied in the case of principal gamma-emitting nuclides.

Specific Evaluation Reference:

See Section 11.5.

Regulatory Guide 1.22, Revision 0, February 1972

Periodic Testing of Protection System Actuation Functions

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The CGS protection system and the systems whose operation it initiates are designed to permit periodic testing of the actuation devices during reactor operation. The periodic tests will duplicate, as closely as practical, the performance that is required of the actuation devices in the event of an accident. The tests will be performed in overlapping portions so that an actual reactor scram will not occur as a result of the testing.

Specific Evaluation Reference:

See Section 7.3.2.1.3.

Regulatory Guide 1.23, Revision 0, February 1972

Onsite Meteorological Program

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

Where conflicts exist between the recommendations specified in Regulatory Guide 1.23, Revision 0 and those recommended in Regulatory Guide 1.97, Revision 2, the Columbia Generating Station will comply with the recommendations of Regulatory Guide 1.97, Revision 2 unless noted in the text discussions as meeting Regulatory Guide 1.97, Revision 3 requirements (see Section 7.5.2.2.3).

General Compliance or Alternate Approach Assessment:

The requirements of this regulatory guide for a meteorological program to provide the meteorological data required to estimate potential radiation doses to the public have been and are being implemented for CGS.

Specific Evaluation Reference:

See Sections 2.3.2, 2.3.3, 7.7.1, and the Emergency Plan.

Regulatory Guide 1.26, Revision 3, February 1976

Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste Containing Components of Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The definition of quality group classifications for CGS was provided in the PSAR in accordance with ASME B&PV Code, Sections III and VIII. Quality group classifications have been maintained during design and construction. Quality group classifications are maintained during plant operations and modifications by plant administrative procedures and the plant modification control process. The quality group classifications are commensurate with the safety functions performed by the safety-related components.

The turbine stop valves and bypass valve, which are classified Quality Group D, are subject to an enhanced quality assurance program comparable to that of Quality Group B.

Specific Evaluation Reference:

See Section 3.2.

Regulatory Guide 1.27, Revision 2, January 1976

Ultimate Heat Sink for Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Energy Northwest complies with Regulatory Guide 1.27, Revision 2, without any exceptions and with one clarification.

The clarification is that the tower makeup system (TMU) water supply is only an ultimate heat sink feature in the event of a design basis tornado. Since Regulatory Guide 1.27 states that we need not consider two or more most severe natural phenomena occurring simultaneously, the TMU was designed to be tornado proof but was not designed and constructed to withstand the effects of the operating basis earthquake (OBE) and water flow based on severe historical events in the region.

Specific Assessment Reference:

See Section 9.2.5.

Regulatory Guide 1.28, Revision 0, June 1972

Quality Assurance Program Requirements (Design and Construction)

Compliance or Alternate Approach Statement:

CGS *complies with the guidance set forth in this regulatory guide as described below.*

General Compliance or Alternate Approach Assessment:

Procurement documents issued after November 1973 required compliance with ANSI N45.2. Prior to that time, an "explanative version" of 10 CFR 50 Appendix B was used. The design and construction activities initially complied with 10 CFR 50 Appendix B. In November 1974, reference to ANSI N45.2 was added to the construction specifications.

ANSI N45.2 does not apply to the activities covered by Section III and Section XI of the ASME Code; however, the quality assurance program requirements may be extended to these activities based on project requirements.

Specific Evaluation Reference:

None

Regulatory Guide 1.29, Revision 3, September 1978

Seismic Design Classification

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

CGS classifications are consistent with Regulatory Guide 1.29 with the following clarification:

Cooling of the spent fuel storage pool is accomplished by the spent fuel cooling and cleanup system or by the seismic category RHR cross connection. The spent fuel pool cooling portion which is used normally to cool the spent fuel pool water was Seismic Category I by the first refueling outage. The cleanup portion of the system is not Seismic Category I. However, all structures, systems, and components required for maintaining water cover for the spent fuel are Seismic Category I. The spent fuel cooling system uses some common pump suction and discharge piping which is embedded in concrete. Prior to the first refueling outage, the Seismic Category I RHR system cross connection would have been used in case of core offload (see Section 9.1.3).

Specific Evaluation Reference:

See Sections 3.2.1, 3.7, 3.8, 3.9, 3.10, 9.1.3, and the OQAPD.

Regulatory Guide 1.30, Revision 0, August 1972

Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electrical Equipment.

I Design and Construction Phase

Compliance or Alternate Approach Statement:

CGS generally complies with the guidance set forth in this regulatory guide. In a few cases, CGS complied with the intent of this guidance by an alternate approach.

General Compliance or Alternate Approach Assessment:

Procurement documents require compliance with ANSI N45.2.4 for the installation, inspection, and testing activities performed, except in those isolated instances where requirements were entered directly in the specification with limited or no reference to ANSI N45.2.4 or IEEE 336.

Specific Evaluation Reference:

None

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.31, Revision 3, April 1978

Control of Ferrite Content in Stainless Steel Weld Metal

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

CGS complies fully with Revision 3 of this guide on all contracts initiated after the date of its publication. Prior to issuance of Revision 3, CGS conformed to Revision 2 of this regulatory guide.

Specific Evaluation Reference:

See Sections 4.5.2.4, 5.2.3.3, and 5.3.1.4.

Regulatory Guide 1.32, Revision 2, February 1977

Criteria for Safety Related Electric Power Systems for Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in Revision 0 of this regulatory guide.

(Revisions 1 and 2 are not applicable to CGS since they are for use in evaluations of construction permits docketed after November 1, 1976, and April 15, 1977, respectively.)

General Compliance or Alternate Approach Assessment:

The CGS design is in full compliance with both Revision 0 of this regulatory guide and with Revision 2 of this regulatory guide, with the exception of those sections of the regulatory guide which require compliance with Regulatory Guides 1.93, Revision 0, and 1.75, Revision 0. See Section 8.3.1.2.1.1 for analysis of the CGS design relative to Regulatory Guide 1.75, Revision 0.

Specific Evaluation References:

See Sections 8.1.5.1, 8.1.5.2, 8.2.2.4, 8.3.1.1.7.1, 8.3.1.2.1.3, 8.3.1.3, 8.3.1.4, 8.3.2.1.1, 8.3.2.2.1, 8.3.2.3 and 8.3.2.4.

Regulatory Guide 1.33, Revision 2, February 1978

Quality Assurance Program Requirements (Operation)

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

Compliance or Alternate Approach Assessment:

Compliance is discussed in the OQAPD.

Specific Evaluation Reference:

See Section 13.5.1.1 and the OQAPD.

Regulatory Guide 1.34, Revision 0, December 1972

Control of Electroslag Weld Properties

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since electroslag welding has not been used for welding of Class 1 or 2 vessels or components fabricated of low alloy or austenitic steel.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.35, Revision 2, January 1976

Inservice Inspection of Ungrouted Tendons in Prestressed Concrete Containment Structures

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since CGS does not have a prestressed concrete containment structure with ungrouted tendons.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.36, Revision 0, February 1973

Nonmetallic Thermal Insulation for Austenitic Stainless Steel

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Thermal insulation on stainless steel piping conforms to requirements of this regulatory guide.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.37, Revision 0, March 1973

Quality Assurance Requirements for Cleaning of Fluid Systems and Associated Components of Water-Cooled Nuclear Power Plants

I Design and Construction Phase

Compliance or Alternate Statement:

CGS generally complies with the guidance set forth in this regulatory guide. In a few cases, CGS complied with the intent of this guidance by an alternate approach.

General Compliance or Alternate Approach Assessment:

Procurement documents generally required compliance with ANSI N45.2.1. Whether or not reference to ANSI N45.2.1 was provided, a detailed specification section supplied comprehensive instructions on cleaning and cleanliness.

Specific Evaluation Reference:

None

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.38, Revision 2, May 1977

Quality Assurance Requirement for Packaging, Shipping, Receiving, Storage, and Handling of Items for Water-Cooled Nuclear Power Plants

I Design and Construction Phase

Compliance or Alternate Approach Statement:

CGS generally complies with the guidance set forth in Revision 0 of this regulatory guide. In a few cases, CGS complied with the intent of this guidance by an alternate approach.

The changes to the regulatory positions of Revision 1 and 2 of this regulatory guide, which specify additional detailed requirements and make certain nonmandatory sections of ANSI N45.2.2 mandatory, are not implemented.

General Compliance or Alternate Approach Assessment:

Procurement documents required compliance with ANSI N45.2.2, Revision 0, and/or contained a generic specification packaging section and/or specified directly requirements for these functions.

The regulatory positions contained in Revision 1 and 2 of this regulatory guide changed significantly from the original issue. Revision 1 and 2 contain additional detailed requirements and make nonmandatory sections of ANSI N45.2.2 mandatory. Some, but not all, of the changes to the regulatory positions are included in procurement documents. Since these changes were made after award of the applicable procurement documents, Revision 1 and 2 are not fully implemented.

Specific Evaluation Reference:

None

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.39, Revision 1, October 1976

Housekeeping Requirements for Water-Cooled Nuclear Power Plants

I Design and Construction Phase

Compliance or Alternate Approach Statement:

CGS generally complies with the guidance set forth in this regulatory guide. In some cases, CGS complied with the intent of this guidance by an alternate approach.

General Compliance or Alternate Approach Assessment:

Procurement documents required compliance with ANSI N45.2.3 or with selected portions of ANSI N45.2.3 or specified directly applicable housekeeping requirements.

Specific Evaluation Reference:

None

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.40, Revision 0, March 1973

Qualification Tests of Continuous Duty Motors Installed Inside the Containment of Water-Cooled Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in the regulatory guide.

General Compliance or Alternate Approach Assessment:

Containment fans have been qualified for in containment use in accordance with IEEE 334-1974.

Specific Evaluation Reference:

See Section 9.4.11.3.

Regulatory Guide 1.41, Revision 0, March 1973

Preoperational Testing of Redundant On-Site Electrical Power Systems to Verify Proper Load Group Assignments

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in the regulatory guide.

General Compliance or Alternate Approach Assessment:

As part of the preoperational test program, the onsite electric power systems will be tested in order to verify the existence of independence among redundant onsite power sources and their respective load groups.

Specific Evaluation Reference:

See Sections 8.1.5.2, 8.3.1.2.2 and 14.2.

Regulatory Guide 1.43, Revision 0, May 1973

Control of Stainless Steel Weld Cladding of Low-Alloy Steel Components

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since CGS does not use stainless steel cladding on coarse grain low-alloy steel for safety class components.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.44, Revision 0, May 1973

Control of the Use of Sensitized Stainless Steel

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

CGS conforms fully to the recommended welding controls for stainless steel welding. All materials are purchased to the latest ASME and ASTM specifications at time of order, and the cleaning requirements set forth in the guide are implemented during document review of vendor cleaning procedures.

Specific Evaluation Reference:

See Sections 4.5.2.4 and 5.3.1.4.

Regulatory Guide 1.46, Revision 0, May 1973

Protection Against Pipe Whip Inside Containment

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

Pipe break location criteria is based on guidelines provided in this regulatory guide, as well as the NRC Branch Technical Positions ASB 3-1, Appendix B, and MEB 3-1. The criteria is applicable to all piping systems inside as well as outside containment. Pipe whip protection for the recirculation system is provided by the NSSS supplier. Pipe whip protection for all other piping systems, including the NSSS-furnished main steam piping, is provided by the architect-engineer.

Specific Evaluation Reference:

See Section 3.6.2.1.

Regulatory Guide 1.47, Revision 0, May 1973

Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

The alternate approach is provided in Section 7.1.2.4.

Specific Evaluation Reference:

Not applicable.

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Regulatory Guide 1.48, Revision 0, May 1973

Design Limits and Loading Combinations for Seismic Category I Fluid System Components

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Implementation of this regulatory guide is discussed in Section 3.9.3.1.1.7.

Specific Evaluation Reference:

See Section 3.9.3.1.1.7.

Regulatory Guide 1.50, Revision 0, May 1973

Control of Preheat Temperature for Welding Low-Alloy Steel

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

CGS complies with the guidance set forth in the regulatory guide by maintaining the preheat temperature of low alloy steel welds until the post-weld heat treatment has been performed. For welds which were made without this “keep hot” requirement, Regulatory Position C4 for determining the soundness of the weld by acceptable examination procedures, has been enforced.

Specific Evaluation Reference:

See Section 5.3.1.4.

Regulatory Guide 1.51, Revision 0, May 1973

In-Service Inspection of ASME Code Class 2 and 3 Nuclear Power Plant Components

Compliance or Alternate Approach Statement:

This regulatory guide has been withdrawn and is no longer applicable.

General Compliance or Alternate Approach Assessment:

Inservice inspection of CGS is based on ASME Section XI for Classes 1, 2, and 3.

Specific Evaluation Reference:

See Section 3.9.6.

Regulatory Guide 1.52, Revision 2, March 1978

Design, Testing, and Maintenance Criteria for Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance given in Revision 2 of this regulatory guide with the exception that the operation identified in C-4.d, Revision 2 is modified by Technical Specification Amendment 239 which adopts the testing criteria identified in Regulatory Position 6.1 of Revision 3.

General Compliance or Alternate Approach Assessment:

Standby gas treatment filter units and the control room emergency filter units are required to perform safety-related functions. A comparison of the engineered safety feature air filtration systems with respect to the regulatory position of Regulatory Guide 1.52, Revision 2, Article C, is as follows:

Paragraph Number	SGTS	Control Room System
C-1. "Environmental Design Criteria"		
1.a	In compliance	In compliance
1.b	In compliance	In compliance
1.c	In compliance	In compliance
1.d	In compliance	In compliance
1.e	In compliance	In compliance

C-2. "System Design Criteria"

2.a	In compliance	See Note 1
2.b	In compliance	In compliance
2.c	In compliance	In compliance
2.d	See Note 2	See Note 2
2.e	In compliance	In compliance
2.f	In compliance	In compliance
2.g	See Note 3	See Note 3
2.h	In compliance	In compliance
2.i	In compliance	In compliance
2.j	See Note 4	See Note 4
2.k	In compliance	In compliance
2.1	In compliance	In compliance

C-3. "Component Design Criteria and Qualification Testing"

3.a	See Note 5	See Note 5
3.b	In compliance	In compliance
3.c	In compliance	In compliance
3.d	See Note 6	See Note 6
3.e	In compliance	In compliance
3.f	In compliance	In compliance
3.g	See Note 7	See Note 7
3.h	In compliance	In compliance
3.i	See Note 8	See Note 8
3.j	In compliance	In compliance
3.k	In compliance	In compliance
3.1	In compliance	In compliance
3.m	In compliance	In compliance
3.n	In compliance	In compliance
3.o	In compliance	In compliance
3.p	In compliance	In compliance

C-4. "Maintenance"

4.a	See Note 9	See Note 9
4.b	See Note 10	See Note 10
4.c	In compliance	In compliance
4.d	See Note 11	In compliance
4.e	In compliance	In compliance

C-5. "In-Place Testing Criteria"

5.a	In compliance	In compliance
5.b	See Note 13	In compliance
5.c	See Note 14	See Note 14
5.d	See Note 14	See Note 14

C-6. "Laboratory Testing Criteria For Activated Carbon"

6.a	See Note 12	See Note 12
6.b	See Note 12	See Note 12

Note 1 (C-2.a) Demisters are not provided in the control room filter units due to the absence of entrained moisture during normal and abnormal conditions. High-efficiency particulate air (HEPA) filters are not provided after the charcoal filter because filter unit discharges into control room air conditioning unit on intake side of medium efficiency filters.

Note 2 (C-2.d) Both units of the standby gas treatment system are located in secondary containment and are not subject to containment pressure surges during accidents. Redundant Seismic Category I valves in series isolate and protect these units from containment DBA pressures. Both units of the control room emergency filter system are not subject to containment pressure surges during accidents.

Note 3 (C-2.g) Abnormal pressure drops across critical components of the SGTS and control room filter units cause an alarm in the main control room, however, no facilities to record the pressure drops are provided. A record of pressure drop across individual components and the total SGTS system would be of no value because the SGTS is a variable flow system, with flow modulated to maintain the reactor building at a fixed negative pressure. Flow through the system, which is the pertinent parameter, is recorded in the main control room, and computer input is provided to record high pressure alarms across critical components.

Note 4 (C-2.j) SGTS filter units are not designed to be removable from the building as an intact unit. The size of the units precludes removal in one section. In the event the units become radioactively contaminated they will be permitted to decay in place until radiation levels are sufficiently low to permit the removal of all internals for disposal.

Note 5 (C-3.a) SGTS system demisters furnished by FARR Company, are not in complete conformance with ANSI N509-1976 because they were not qualified by testing in accordance with AEC report MSAR-71-45. A moisture eliminator study performed by FARR Company in 1970, which did not conform to the MSAR-71-45 test setup, indicated that the installed demisters will protect the HEPA filters in the system from blinding under conditions far more severe than those hypothesized for the SGTS system. Since, under the accident mode, entrained water droplets will not be in the inlet air stream, the FARR tests and qualification are considered adequate.

Note 6 (C-3.d) HEPA filters are not subjected to iodine removal sprays, therefore, aluminum separators are used.

An alternate approach to determine acceptable design and qualification testing of HEPA filters is the use of Regulatory Guide 1.52, Revision 3, Section 4.4.

Note 7 (C-3.g) Access doors into SGTS units are 50 x 20 in. Vacuum breakers are not provided on doors of SGTS and control room units. Unit fans are normally off.

Note 8 (C-3.i) Test 4, Activity (Ref. Table 5-1, ANSI N509-1976)

Base carbon (unimpregnated) activity test was not previously required. Because all available carbon was of the impregnated type this was not run.

Test 5, Radioiodine Removal Efficiency (Ref. Table 5-1, ANSI N509-1976)

New carbon will be tested in accordance with ASTM D3803-1989.

Average atmosphere resident time in each SGTS unit is greater than 0.5 sec.

Note 9 (C-4.a) Doors provided on SGTS Units are 50 x 20 in. Access panels are provided on control room units. Vacuum breakers are not provided on any of the units since they are normally not operational.

Note 10 (C-4.b) Control room filter units have approximately 18 in. between prefilter and HEPA filter frames, and approximately 4 ft are provided between HEPA and charcoal filter frames. SGTS filter units have a minimum of three feet provided between demister, heater, prefilter, HEPA and charcoal filter frames.

Note 11 (C-4.d) Strip heaters are provided in the charcoal filter plenum of the SGTS units to maintain charcoal beds moisture free, therefore, operation of the fans is not required for that purpose. Testing of the blast coil heaters is performed in accordance with the requirements of Regulatory Position 6.1 of Revision 3 of the Regulatory Guide 1.52

Note 12 (C-6.a C-6.b) — The laboratory testing criteria for the carbon adsorber section of the SGTS and CREF System meets the objectives of this section of the guide. Twelve representative test samples of four-inch length are provided across each of the two 4 in. deep beds in each SGTS filter unit. At least once per 30 months one sample from across each SGT and CREF adsorber bed is removed and sent to a laboratory for testing. For the SGTS, samples are tested in series to represent the 8-inch total bed depth. Laboratory tests are performed in accordance with ASTM D3803-1989 with methyl iodide at 30°C and 70% relative humidity with a penetration of less than 0.5% for the SGTS and less than 2.5% for the CREF System as an acceptance level. The SGTS will also be tested at a face velocity of 75 ft per minute. In the event that a sample fails this test, the carbon adsorber in its bed will be replaced.

Note 13 (C-5.b) — The flow distribution tests developed by the designer combined with the series filter design at CGS adequately meet the intent of this test. The results of the flow distribution tests as set forth in ANSI N51 are difficult to interpret with the 'U' shaped charcoal beds installed due to air flow disturbance caused by the measuring apparatus. This is particularly true on the parallel legs of the 'U' shaped beds, where the flow measuring device must be placed in the rather narrow air passage. Flow distribution criteria was developed by the designers based on the ±20% variation criteria established in Regulatory Guide 1.52 and has been met in field tests. In addition, each of the filter trains has two separate charcoal beds in series. This allows mixing of the filtered gas between the beds and further reduces the effects of variations in charcoal packing distribution.

Note 14 (C-5.c C-5.d) — The inplace leak testing of the SGT and CREF HEPA and carbon filters meets the objectives of this section of the guide with the exception that testing is performed in accordance with ASME N510-1989, Sections 10 and 11, respectively.

<u>Specific Evaluation Reference</u>:

See Section 6.5.1.

Regulatory Guide 1.53, Revision 0, June 1973

Application of the Single-Failure Criterion to Nuclear Power Plant Protective Systems

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in the regulatory guide.

General Compliance or Alternate Approach Assessment:

Regulatory Guide 1.53 provides guidance for the application of the single-failure criterion as discussed in IEEE 379-1972. The regulatory guide recommends the application of IEEE 379-1972 with four supplemental conditions. The design of the CGS electrical system is in conformance with IEEE 379-1972 and the four supplemental conditions noted in Regulatory Position C.

Specific Evaluation Reference:

See Section 8.1.5.2.

Regulatory Guide 1.54, Revision 0, June 1973

Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide as described below.

General Compliance or Alternate Approach Assessment:

Special decontaminable coatings in primary containment areas are manufactured and applied in accordance with quality assurance requirements of ANSI N101.4.

Specific Evaluation Reference:

See Section 6.1.2.

Regulatory Guide 1.55, Revision 0, June 1973

Concrete Placement in Category I Structures

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The requirements of the guide have been included in the appropriate construction contract specifications. Compliance with the guide is assured by the application of appropriate concrete specifications, construction practices, codes and standards, including the documents recommended by the guide, for the placement of concrete; by the implementation of approved communications procedures between qualified design and construction forces; and by implementation of an approved QA program which ensures design control and coordinated quality control of concrete material, placement, inspection and testing between applicant, designer and constructor.

Specific Evaluation Reference:

See Sections 3.8.3.2, 3.8.3.6, 3.8.4.2, 3.8.4.6, and 3.8.5.2 and Table 3.8-4.

Regulatory Guide 1.56, Revision 0, June 1973

Maintenance of Water Purity in Boiling Water Reactors

I. Design and Construction Phase

Compliance or Alternate Approach Statement:

The design of CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

CGS design complies with the guidance of this regulatory guide by providing for the following:

a. Conductivity measurement and recording of the condenser hotwell and condensate flow discharge to the condensate demineralizer system,

b. Flow measurement and recording of flow through each condensate demineralizer unit,

c. Conductivity measurement, recording, and alarming of the condensate effluent discharge from each condensate demineralizer unit and from the combined system effluent,

d. Conductivity measurement, recording, and alarming of the inlet and outlet coolant to and from the RWCU system,

e. Extensive sampling of reactor coolant and auxiliary systems,

f. Full flow condensate demineralizer system, and

g. Excess condensate demineralizer capacity to permit recharging of resin beds during normal plant operation.

Specific Evaluation Reference:

See Section 5.2.3.2.2.

II. Operations Phase

Compliance or Alternate Approach Statement:

Operation of CGS RWCU and condensate demineralizer system complies with the general guidance set forth in Revision 1, July 1978, of this regulatory guide.

General Approach or Alternate Approach Assessment:

Operation of CGS complies with the guidance of the regulatory guide by providing the following:

a. Operating limits are prescribed for condensate filter demineralizers. Plant operating conductivity limits are defined for the RWCU demineralizers. Effluent conductivity for the individual demineralizers is recorded and a main control room alarm is triggered when conductivity limits are reached or exceeded;

b. Condensate filter demineralizer conductivity and flow instrumentation are used in the general assessment of individual demineralizer unit performance and capacity;

c. An operational limit is set for hotwell conductivity which triggers a main control room alarm. Hotwell conductivity, in conjunction with precalculated assessment of condenser inleakage rates and demineralizer performance permits appropriate action to be taken on exceeding the operating limit setpoint;

d. Laboratory analyses are performed for chloride, pH, and conductivity at intervals appropriate to the plant operating status. Sampling and analysis frequency is described in the LCS and plant procedures; and

e. Not applicable exception is taken to item C.4.d which applies to bead-type, deep-bed demineralizer systems, which are not incorporated into the CGS design. The general guidance of this item will, however, be applied to the pressure precoat filter demineralizer systems. Each lot of precoat resins will be analyzed for capacity and impurity levels. Frequency of precoat changeout will be staggered and is initially dictated by pressure drop associated with suspended solids. Subsequent to pressure drop limitations, frequency of sequential precoat changeout is established based on dissolved chemical constituents and flow throughput parameters.

Regulatory Guide 1.57, Revision 0, June 1973

Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

The structural design criteria for the primary containment vessel is consistent with the provisions of this regulatory guide, except with respect to the stress limits specified in Section C-1-b(2) of the guide, for the load combination of accident recovery flooding plus OBE. For this load combination, the stress limits used for CGS are within the limits set forth in the NRC Standard Review Plan Section 3.8.2, Table 3.8.2-1.

This exception has precedent as stated in GESSAR, paragraph 3.8.2.3.12, "Accident Recovery Evaluation," Page 3.8-9b, and has been accepted by the NRC, as documented in paragraph 3.8.2, page 3-14, of the NRC Safety Evaluation Report for the GESSAR-328 Nuclear Island Standard Design dated December 1975.

Specific Evaluation Reference:

See Section 3.8.2.3.10.

Regulatory Guide 1.58, Revision 1, August 1980

Qualification of Nuclear Power Plant Inspection, Examination, and Testing Personnel

I Design and Construction Phase

Compliance or Alternate Approach Statement:

As of November 1980, CGS complies with the guidance set forth in this regulatory guide via an alternate approach described below.

General Compliance or Alternate Approach Assessment:

Prior to issuance of Revision 1 of this Regulatory Guide, personnel performing quality-related activities were provided indoctrination and training in the requirements of the applicable quality assurance program, procedures, instructions and drawings affecting their work. Documented evidence of the above training was maintained. The indoctrination and training complied with the requirements of Appendix B, 10 CFR Part 50, and ANSI N45.2.

As of November 1980, in addition to the indoctrination and training requirements noted above, requirements which meet this regulatory guide were imposed on site contractors for personnel performing inspections, examinations, and tests. These requirements specify that initial evaluations of education, experience, and qualifications are to be performed and documented; however, formal certificates are not required to be issued because specific inspections, examinations, and tests are performed in accordance with approved procedures. Therefore, specific capability identification and levels of certification are not required.

Specific Evaluation Reference:

None

II Operational Phase

Compliance is discussed in the OQAPD. Also see Section 14.2.

Regulatory Guide 1.59, Revision 1, April 1976

Design Basis Floods for Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

All the requirements that are specified in Regulatory Guide 1.59 are followed in the design of CGS.

Based on Regulatory Guide 1.102, the plant site is classified as "Dry Site." Therefore, CGS is considered to be in compliance with Regulatory Guide 1.59 and its Appendix A.

Specific Evaluation Reference:

See Section 2.4.

Regulatory Guide 1.60, Revision 1, December 1973

Design Response Spectra for Seismic Design of Nuclear Power Plants

Compliance or Alternate Approach Statements:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

CGS meets the seismic requirements previously acceptable to the NRC as discussed in Section 3.7.1.1.

Specific Evaluation Reference:

See Section 3.7.1.1.

Regulatory Guide 1.61, Revision 0, October 1973

Damping Values for Seismic Design of Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The damping values recommended by Regulatory Guide 1.61 are greater, and therefore less conservative, than the values used for CGS. The more conservative CGS design satisfies the requirements of Regulatory Guide 1.61.

Specific Evaluation Reference:

See Section 3.7.1.3.

Regulatory Guide 1.62, Revision 0, October 1973

Manual Initiation of Protective Actions

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Means are provided in the main control room for the manual initiation of BOP engineered safety feature systems or supporting systems at the division level by the operation of a minimum of equipment.

Specific Evaluation Reference:

See Section 7.3.2.1.3.

Regulatory Guide 1.63, Revision 2, July 1978, and Revision 3, February 1987

Electric Penetration Assemblies in Containment Structures for Light-Water-Cooled Nuclear Power Plants

Compliance or Alternate Approach Statement:

Revisions 2 and 3 are not applicable to CGS since they apply to the evaluation of construction permit applications docketed after August 31, 1978 and February 28, 1987, respectively. CGS complies with the guidance set forth in IEEE 317-1972 as modified by Revision 0 of Regulatory Guide 1.63.

General Compliance or Alternate Approach Assessment:

The compliance assessment given below correspond numerically to the regulatory positions as indicated in Section C of Regulatory Guide 1.63, Revision 0, October 1973.

1. Capability of withstanding maximum fault I^2T heating in the case that overload protective devices fail:

   CGS is in compliance with this requirement. In all cases, the overcurrent protective devices in circuits subject to short circuit are backed up by other overcurrent protective devices which are also designed to limit the fault current I^2T heating experienced by the penetration conductors to levels below the conductor ratings.

2. The maximum containment pressure specified for CGS complies with the safety margins required by the ASME B&PV Code, Article N3000, footnote 1.

3. The position refers to specific applicability or acceptability of other codes, standards, and guides covered separately in other regulatory guides.

4. CGS complies with the requirement of IEEE 336 and ANSI N45.2 concerning the QA.

Specific Evaluation Reference:

See Sections 3.8.6, 7.1.2.3, and 8.1.5.2.

Regulatory Guide 1.64, Revision 2, June 1976

Quality Assurance Requirements for the Design of Nuclear Power Plants

I. Design and Construction Phase

Compliance or Alternate Approach Assessment:

Regulatory Guide 1.64, Revision 0, Revision 1, and Revision 2 do not apply to CGS since they apply to construction permits docketed after September 1973.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

II. Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.67, Revision 0, October 1973

Installation of Overpressure Protection Devices

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since the reactor coolant system pressure boundary safety/relief valve relieves to a closed discharge system.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.68, Revision 1, January 1977

Initial Test Programs for Water-Cooled Reactor Power Plants

Compliance or Alternate Approach Statement:

> *This regulatory guide is not applicable to the CGS initial test program since Revision 0 of this regulatory guide is committed to in Section 14.2.7. However, CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.*

General Compliance or Alternate Approach Assessment:

> *See Section 14.2 for description of initial testing program and to Sections 14.2.7 and 1.8.2 for statements concerning compliance with Regulatory Guide 1.68, Revision 0. Revision 1 of this guide in general clarifies Revision 0 and therefore there are no exceptions to the intent of this procedure.*

Specific Evaluation Reference:

> *See Sections 14.2.7 and 1.8.2 for a discussion of Regulatory Guide 1.68, Revision 0.*

Regulatory Guide 1.68.1, Revision 1, January 1977

Preoperational and Initial Startup of Feedwater and Condensate Systems for Boiling Water Reactor Power Plants.

Compliance or Alternate Approach Statements:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessments:

The preoperational testing and the initial Startup testing as described in Section 14.2 complies with the intent of this regulatory guide. However, due to the limitations of the auxiliary steam supply system, the confirmation that the feedwater pumps satisfy required head, flow rate and suction head will not occur until the startup phase of the initial test program when the normal steam supply is available to the feedwater pump turbines.

Specific Evaluation Reference:

See Section 14.2.12.1.1.

Regulatory Guide 1.68.2, Revision 0, January 1977

Initial Startup Test Program To Demonstrate Remote Shutdown Capability For Water-Cooled Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate approach assessment:

The startup test described in Section 14.2.12.3.28 complies with the regulatory guide with the following exceptions:

a. The test will be initiated by scramming plant from the control room versus a location outside the control room as described in Section C.3 of the regulatory guide. This exception is made to better simulate the actual procedure which would be followed if a control evacuation were to occur. The capability to scram the reactor outside the control room exists; for example, tripping the RPS motor generator (MG) sets.

b. The cold shutdown demonstration procedure as described in Section C.4 of the Regulatory Guide may not be performed immediately following the demonstration of achieving and maintaining safe hot standby from outside the control room. Rather this cooldown portion may be performed when cooldown is required during the course of the normal power ascension test program. Although this is an exception to Regulatory Guide 1.68.2, Revision 0, Revision 1 of this Guide contains provisions for a delay in the demonstration of cooldown.

Specific Evaluation Reference:

See Sections 14.2.12.3.28 and 7.4.1.4.

Regulatory Guide 1.69, Revision 0, December 1973

Concrete Radiation Shields for Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

Although the regulatory guide was promulgated after design and specification implementation of the engineering criteria, the recommended design and construction practices specified in the regulatory guide are documented in codes and specifications which were used in the development of the engineering criteria and contract specifications.

Specific Evaluation Reference:

See Section 12.3.2.

Regulatory Guide 1.70, Revision 2, September 1975

Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants - LWR Edition

Compliance or Alternate Approach Statement:

This FSAR complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The FSAR has generally been prepared to satisfy the requirements of Regulatory Guide 1.70, Revision 2. This includes both format and content.

Specific Evaluation Reference:

The balance-of-plant (BOP) portions of this FSAR.

Regulatory Guide 1.71, Revision 0, December 1973

Welder Qualifications for Areas of Limited Accessibility

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

There are few incidents where welding accessibility is limited during fabrication. Where accessibility to any weld joint was restricted to a degree which prevented the welder from direct visual observation of the arc and the puddle in any area of the weld, or which required the use of mirrors or extensions to the torch handle or electrode holder, the contractor notifies the welding engineer. All limited access welds are determined by a welding engineer. For ASME Section III, Class 1, 2, and 3 components and Subsection NF and NE, a performance qualification test that simulates the limited access condition is required by the welding engineer. For welds in the pressure retaining components the welder's test weld is radiographed in accordance with and shall conform to the acceptance standards of ASME Section VIII, Division 1, U.W.-51. Alternately, the weld may be examined ultrasonically in accordance with ASME Section VIII, Division 1, Appendix U.

Specific Evaluation Reference:

See Sections 4.5.2.4, 5.2.3.3, and 5.3.1.4.

Regulatory Guide 1.72, Revision 0, December 1973

Spray Pond Plastic Piping

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS because CGS does not use plastic piping in its spray ponds.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.73, Revision 0, January 1974

Qualification Tests of Electric Valve Operators Installed Inside the Containment of Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Auxiliary equipment associated with valve operators are tested in accordance with the subject standards. Designed service conditions are implemented in the tests. Conservative values of the environmental variables during and after a design basis accident are used in the tests to assure that the testing is carried out under more severe environmental conditions than those expected.

Specific Evaluation Reference:

See Sections 3.11 and 8.1.5.2.

Regulatory Guide 1.74, Revision 0, February 1974

Quality Assurance Terms and Definitions

I Design and Construction Phase

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The terms used in describing and implementing quality assurance programs for CGS have complied with ANSI N45.2.10-1973 or were clarified at the point of application.

Specific Evaluation Reference:

None

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.75, Revision 1, January 1975

Physical Independence of Electric Systems

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed after February 1974. However, CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

See Section 8.3.1.4.2.7 for an assessment of CGS relative to this regulatory guide.

Specific Evaluation Reference:

See Section 8.3.1.4.2.7.

Regulatory Guide 1.76, Revision 0, April 1974

Design Basis Tornado for Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

The tornado design criteria for Columbia Generating Station were revised based on design basis tornado characteristics in NUREG-1503. The design basis tornado characteristics used are less severe than those specified in Regulatory Guide 1.76 for Region III. In January 1996, the revised criteria were found acceptable by the NRC.

Specific Evaluation Reference:

See Section 3.3.2.

Regulatory Guide 1.78, Revision 0, June 1974

Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The main control room habitability during a postulated hazardous chemical release evaluation complies with assumptions and toxicity limits in Revision 0 of this regulatory guide. The evaluation uses toxicity limits presented in Revision 1 for those chemicals not discussed in Revision 0. The results are presented in Chapter 6.

Specific Evaluation Reference:

See Sections 2.2.3 and 6.4.

Regulatory Guide 1.80, Revision 0, June 1974

Preoperational Testing of Instrument Air Systems

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The primary containment instrument air system preoperational test procedure incorporated the requirements of this regulatory guide.

Specific Evaluation Reference:

See Sections 14.2.7.3 and 14.2.12.1.34.

Regulatory Guide 1.82, Revision 0, June 1974

Sumps for Emergency Core Cooling and Containment Spray Systems

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since no sumps are used for ECCS and containment spray.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.84

Design, Fabrication, and Materials Code Case Acceptability, ASME Section III

Regulatory Guide Intent:

This guide lists all Section III Code Cases that the NRC has approved for use. It is updated on a regular basis to reflect the changes to the ASME Code Cases and the current position of the NRC on acceptability for use. The guide contains tables that detail the NRC acceptance requirements for current, annulled, and superseded Code Cases. Code Cases that the NRC determined to be unacceptable are listed in Regulatory Guide 1.193, “ASME Code Cases Not Approved for Use”.

Application Assessment:

Assessed capability in design.

Compliance or Alternate Approach Statement:

The current version of the Regulatory Guide is utilized to determine acceptable Code Cases for all new and existing plant applications. The FSAR does not track individual Code Cases and revision numbers. Not all acceptable Code Cases listed in the regulatory guide are used. The Code Cases that are utilized for Columbia are referred to in the plant design/installation documentation.

General Compliance or Alternate Approach Assessment:

Code Cases are utilized in accordance with the requirements of the regulatory guide provisions for acceptance. Section III Code Cases that are not yet endorsed may be utilized via submittal to the NRC for approval in accordance with the regulatory guide. The plant scope of supply is in full compliance with this regulatory guide.

Specific Evaluation Reference:

See Section 3.8.2.2.

Similar Application Reference:

None.

Regulatory Guide 1.85, Revision 31, 1998*

Materials Code Case Acceptability - ASME Section III, Division 1

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide as described below.

General Compliance or Alternate Approach Assessment:

The use of an ASME Section III, Division 1, code case applicable to materials use on CGS is approved by Energy Northwest only after evaluating its technical acceptability and confirming that its use is acceptable to the NRC. This confirmation is by ascertaining that the code case is listed in this regulatory guide (or applicable earlier revision) or by specific written acceptance by the NRC.

Specific Evaluation Reference:

See Section 3.8.2.2.

* Regulatory Guide 1.85 was withdrawn in 2004. See Regulatory Guide 1.84 for NRC acceptance of current Materials Code Cases.

Regulatory Guide 1.88, Revision 2 October 1976

Collection, Storage and Maintenance of Nuclear Power Plant Quality Assurance Records

I Design and Construction Phase

Compliance or Alternate Approach Statement:

I Design and Construction Phase

Prior to the original issue of this regulatory guide and construction of the CGS records facility, Project Quality Assurance complied with the intent of 10 CFR Part 50, Appendix B, by duplicate storage of records. Project Quality Assurance also complied with the original issue and revisions of this regulatory guide by duplicate storage. Since March 1977, Project Quality Assurance has complied with Revision 2 of this regulatory guide as described below.

General Compliance or Alternate Approach Assessment:

Since March 1977, the collection, storage, and maintenance of quality assurance records by Project Quality Assurance has been in compliance with ANSI N45.2.9 and NFPA No. 232-1975 for fire protection as imposed by this regulatory guide. The record facility has a minimum of a 2-hr rating.

Procurement documents directly specify requirements for collection, storage, and maintenance of records. The requirements generally meet the intent of ANSI N45.2.9 except that storage facilities or cabinets are only required to meet a 1-hr rating.

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.89, Revision 1, June 1984

Qualification of Class 1E Equipment for Nuclear Power Plants

Regulatory Guide Intent:

Regulatory Guide 1.89 endorses both the requirements and recommendations of IEEE 323-1974, "IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations." Additional regulatory position stipulations are also included.

Compliance or Alternate Approach Statement:

CGS complies with this regulatory guide for equipment requiring environmental qualification procured after February 22, 1983.

General Compliance or Alternate Approach Statement:

For equipment requiring environmental qualification installed prior to February 22, 1983, CGS follows the guidance in NUREG-0588 Cat II.

In view of the NRC Memorandum and Order (CLI-80-21), dated May 23, 1980, all environmental qualifications of Class 1E equipment located in harsh environments are reevaluated for compliance with NUREG-0588, Category II. Where significant deviation from those guidelines is found in specific equipment qualifications, additional testing and/or analysis is performed to demonstrate the adequacy of the equipment to perform its safety-related function. *For equipment whose qualification program has not been completed, a justification for interim operation in accordance with 10 CFR 50.49 is performed as described in the "WNP-2 Environmental Qualification Report for Safety-Related Equipment," Reference 3.11-1.*

Specific Evaluation Reference:

See Section 3.11.

Regulatory Guide 1.90, Revision 0, November 1974

In-Service Inspection of Prestressed Concrete Containment Structures with Grouted Tendons

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable because CGS does not have a prestressed concrete containment structure with grouted tendons.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.91, Revision 0, January 1975

Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plant Sites

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed on or after March 14, 1975. However, CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

It has been determined that the peak overpressures produced by postulated explosions occurring on transportation routes near the plant are no greater than the wind pressures caused by the design basis tornado. Therefore, postulated explosions will not cause an accident or prevent the safe shutdown of the plant.

Specific Evaluation Reference:

See Sections 2.2.1, 2.2.2.2, and 2.2.2.4.

Regulatory Guide 1.92, Revision 1, February 1976

Combining Modal Responses and Spatial Components in Seismic Response Analysis

Compliance or Alternate Approach Statement:

This regulatory guide is not a requirement for CGS since it applies to the evaluation of construction permit applications docketed after February 1976. CGS complies with the intent of the guidance set forth in this regulatory guide by implementing the regulatory guide criteria or by an alternate approach.

General Compliance or Alternate Approach Assessment:

The method of combining modal responses has been implemented in accordance with the guide's recommendations.

The combining of spatial components was performed prior to the issuance of the guide and follows the method presented in the PSAR. The method used is an industry-accepted alternate method. The method considers the combination of the maximum structural responses to the more critical one of the two horizontal components and the vertical component of earthquake motion, using the absolute sum method. Alternatively, when the regulatory guide is followed, two horizontal components and one vertical component of earthquake motion are combined by the square root sum of the squares method.

Specific Evaluation Reference:

See Sections 3.7.2.6 and 3.7.2.7.

Regulatory Guide 1.93, Revision 0, December 1974

Availability of Electric Power Sources

Compliance or Alternative Approach Statement:

CGS complies with the regulatory position for operating the plant whenever the available electric power sources are less than the limiting conditions for operation (LCO) as defined in the regulatory guide.

General Compliance or Alternate Approach Assessment:

Operating procedures incorporate the requirements of this guide.

Specific Evaluation Reference:

See the Technical Specifications.

Regulatory Guide 1.94, Revision 1, April 1976

Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants.

I Design and Construction Phase

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permits docketed after October 15, 1976. However, CGS complies with the intent of the guidance set forth in the guide.

General Compliance or Alternate Approach Assessment:

The guidelines included in ANSI 45.2.5-1974 for installation, inspection and testing of structural concrete and structural steel, including nonpressure vessel elements of the primary containment vessel during the construction phase of CGS are reflected in the structural concrete and structural steel contract specifications for project construction. The QA requirements of ANSI 45.2 were incorporated in these specifications.

Specific Evaluation Reference:

See Sections 3.8.3.2, 3.8.4.2, 3.8.5.2, and Table 3.8-4.

II Operational Phase

Compliance is discussed in the Topical Report referenced in the OQAPD.

Regulatory Guide 1.95, Revision 1, January 1977

Protection of Nuclear Power Plant Control Room Operators Against an Accidental Chlorine Release

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since chlorine gas is not stored at CGS or nearby facilities and the expected quantities of chlorine shipped within five miles is less than the threshold volumes specified in Regulatory Guide 1.78.

Specific Evaluation Reference:

See Section 6.4.4.2.

Regulatory Guide 1.97, Revision 2, December 1980

Instrumentation for Light Water Cooled Nuclear Power Plants to Assess Plant Conditions During and Following an Accident

Compliance or Alternate Approach Statement:

The CGS safety-related display instrumentation meets the intent of Regulatory Guide 1.97.

General Compliance or Alternate Approach Assessment:

Instrumentation is provided in the main control room to monitor plant variables and systems during and following an accident. The instrumentation is qualified to remain functional as required by the regulatory guide.

Portable multichannel gamma-ray spectrometer instrumentation provided for use by field teams during emergencies is not used at CGS, contrary to the recommendation contained in Regulatory Guide 1.97, Revision 2, Table 2, Plant and Environs Radioactivity (portable instrumentation). Regulatory Guide 1.97, recommends the use of these instruments for release assessment and analysis. Alternative methods that produce more reliable indication of fuel failure during a radioactive release are used instead, such as air sample analysis and validation of dose projections using field team sample results.

Deviations relative to RG 1.97 category for O2 and H2 as discussed in Section 7.5.2.2.3.

Specific Evaluation Reference:

See Section 7.5.

Regulatory Guide 1.100, Revision 1, August 1977

Seismic Qualification of Electric Equipment for Nuclear Power Plants

Regulatory Guide Intent:

Regulatory Guide 1.100 endorses both the requirements and recommendations of IEEE 344-1975, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," when such qualification is performed in conjunction with Regulatory Guide 1.89, and subject to the regulatory position stipulations.

Compliance or Alternate Approach Statement:

This regulatory guide is applicable to CGS as clarified in Section 1.8.3 for Regulatory Guide 1.89, Revision 1 and Section 3.10.1.2.

General Compliance or Alternate Approach Assessment:

All Class 1E equipment seismic qualifications are evaluated against the requirements set forth within IEEE 344-1975 as clarified in Section 3.10.1.2. The evaluations are documented and demonstrate adequacy of the methods and results of the qualifications as equal or conservative to the requirements of IEEE 344-1975. These include evaluations of seismic and hydrodynamic load combinations.

Specific Evaluation Reference:

See Section 3.10.

Regulatory Guide 1.101, Revision 1, March 1977

Emergency Planning for Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the intent set forth in this regulatory guide.

General Compliance or Alternate Approach Statement:

See NUREG-0654.

Specific Evaluation Reference:

See the CGS Emergency Plan.

Regulatory Guide 1.102, Revision 1, September 1976

Flood Protection for Nuclear Power Plants

Compliance or Alternate Approach Statement

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The safety-related buildings and spray ponds are located far above the water level estimated for the largest historical flood. Based on the criteria stipulated in Regulatory Guide 1.102, the CGS plant site is classified as a "Dry Site."

Specific Evaluation Reference:

See Section 2.4.

Regulatory Guide 1.103, Revision 1, October 1976

Post-Tensioned Prestressed Systems for Concrete Reactor Vessels and Containments

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable since CGS does not have a concrete reactor vessel or containment.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.104, Revision 0, February 1976

Overhead Crane Handling Systems for Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach

The following safeguards are included in the design of the overhead crane:

a. Redundant low limit, main hoist,

b. Redundant equalizer bar limit switch,

c. "Critical Control Path" series of limit switches for the spent fuel cask handling mode, and

d. Main hoist "paddle" type upper limit switch to prevent the inadvertent "two-blocking" condition.

Specific Evaluation Reference:

See Sections 3.8.4.1.1.5 and 9.1.4.2.2.

Regulatory Guide 1.105, Revision 1, November 1976

Instrument Setpoints

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed after December 15, 1976.

General Compliance or Alternate Approach Assessment:

Instrumentation is provided in a main control room to monitor plant variables and systems. The range of instrumentation is selected to cover the anticipated ranges of variables for the following plant conditions:

a. Normal operation,
b. Anticipated operational occurrences, and
c. Accident conditions.

To ensure adequate safety, the following plant parameters and systems are monitored and provided with appropriate controls to maintain them within prescribed operating ranges:

1. Variables and systems that affect the fission process,
2. Variables and systems that affect the reactor core,
3. Reactor coolant pressure boundary, and
4. Containment and associated systems.

Specific Evaluation References:

See Section 7.1.2.5.

Regulatory Guide 1.106, Revision 1, March 1977

Thermal Overload Protection for Electric Motors on Motor Operated Valves

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed after July 15, 1976. However, CGS design complies with the intent of the guidance set forth in Section C.2 of the regulatory guide.

General Compliance or Alternate Approach Assessment:

Class 1E motor-operated valve (MOV) overloads are chosen two sizes above those which would be required based on normal full load running current. The resultant overload protection (approximately 140%) permits MOV motors to operate for extended periods at moderate overloads; tripping occurs just prior to motor damages.

Specific Evaluation Reference:

See Section 8.3.1.1.9.

Regulatory Guide 1.107, Revision 1, February 1977

Qualifications for Cement Grouting for Prestressing Tendons in Containment Structures

Compliance or Alternate Approach Statement

This regulatory guide is not applicable to CGS because CGS does not have a prestressed concrete containment structure with grouted tendons.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.108, Revision 0, August 1976

Periodic Testing of Diesel Generators Used as Onsite Electric Power Systems as Nuclear Power Plants.

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since the method described for compliance with the regulations indicated in the guide are applicable to plants having construction permit applications docketed after April 1, 1977.

General Compliance or Alternate Approach Assessment:

Preoperational and periodic testing of the diesel generators is performed as referenced in Sections 14.2.12.1.40 and the Technical Specifications. As discussed in Section 8.3, provisions for testability are included in the design of the standby power system.

For periodic testing, the surveillance requirements for demonstrating the operability of the diesel generators are consistent with the recommendations of Regulatory Guide 1.9 Revision 3 as described in the Bases for Technical Specification B 3.8.1. Regulatory Guide 1.9 Revision 3 includes pertinent guidance for periodic testing previously addressed in Regulatory Guide 1.108.

Specific Evaluation Reference:

See Sections 8.3 and 14.2.12.1.

Regulatory Guide 1.109, Revision 0, March 1976

Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents.

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide using an alternate approach.

General Compliance or Alternate Approach Statement:

CGS is meeting the guidance of this regulatory guide by using Battelle Northwest models which are acceptable to the NRC.

Specific Evaluation Reference:

See Sections 11.2.3.3, 11.3.3.3, and 5.2 of the Environmental Report.

Regulatory Guide 1.110, Revision 0, March 1976

Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since a cost-benefit analysis, as described in Appendix I of 10 CFR 50 Section II-D is not required for CGS.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

See Section 11.2.3.4.

Regulatory Guide 1.111, Revision 1, July 1977

Method for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

Analyses of atmospheric transport and dispersion of gaseous effluents at CGS are performed using the standard NRC diffusion models in NUREG/CR-2919, XOQ/DOQ: Computer Program for the Meteorological, Evaluation of Routine Effluent Releases at Nuclear Power Stations, September 1982.

Specific Evaluation References:

See Section 2.3.5.

Regulatory Guide 1.112, Revision 0-R, May 1977

Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water Cooled Power Reactors.

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

The methods for calculating annual average releases of radioactive material in liquid and gaseous effluents from the plant were originally based on the GALE Code as suggested in this regulatory guide. See the sections referenced below for discussions of the methods currently used.

Specific Evaluation Reference:

See Sections 11.2.3.2 and 11.3.3.3.

Regulatory Guide 1.113, Revision 1, April 1977

Estimating Aquatic Dispersion of Effluents From Accidental and Routine Reactor Releases For the Purpose of Implementing Appendix I.

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide using an alternate approach.

General Compliance or Alternate Approach Assessment:

Routine and accidental releases of radioactive liquid, heat, and chemical discharges to the Columbia River via the CGS cooling tower blowdown line are discussed in Section 2.4.12. CGS final Environmental Report (ER) 6.1.1.1 describes in detail the advection/diffusion equations used in the near-field thermal analysis. This analysis provides dispersion characteristics, presented in ER 5.1, to 500 ft below the point of discharge. A simplified and conservative approach to estimating the far-field concentrations of routine releases is presented in ER 5.2.2. The affects of an accidental release of radioactive liquid to the ground within the CGS site area were investigated and are discussed in Section 2.4.13.3.

Specific Evaluation Reference:

See Sections 2.4.12 and 2.4.13.3 and Environmental Report Sections 5.1, 5.2.2, and 6.1.1.1.

Regulatory Guide 1.114, Revision 1, November 1976

Guidance to Operator at the Controls of a Nuclear Power Plant.

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Plant administrative procedures implement the requirements of this regulatory guide.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.115, Revision 0, March 1976

Protection Against Low-Trajectory Turbine Missiles

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed after November 15, 1976.

General Compliance or Alternate Approach Assessment:

Extensive amounts of concrete used in the construction of CGS serve as radiation shielding and formidable barriers protecting essential systems from low trajectory missiles.

Specific Evaluation Reference:

See Section 3.5.1.3.

Regulatory Guide 1.116, Revision 0, June 1976

Quality Assurance Requirements for Installation, Inspection, and Testing of Mechanical Equipment and Systems

I Design and Construction Phase

Compliance or Alternate Approach Statement:

CGS complied with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

The requirements for installation, inspection, and testing are specified in procurement documents which require a quality assurance program in compliance with ANSI N45.2.

Specific Evaluation Reference:

None

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.117, Revision 0, June 1976

Tornado Design Classification

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed after February 15, 1977.

General Compliance or Alternate Approach Assessment:

Essential systems are protected from tornadoes by structures designed for design basis tornadoes (DBT). See Regulatory Guides 1.27 and 1.76.

Specific Evaluation Reference:

See Sections 3.3.2.4 and 9.2.5.

Regulatory Guide 1.118, Revision 0, June 1976

Periodic Testing of Electric Power and Protection Systems.

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since the construction permit for CGS was issued prior to February 15, 1977.

General Compliance or Alternate Approach Assessment:

Electric power and protection systems are tested periodically as specified in the Technical Specifications. As described in Section 13.5.2, surveillance procedures have been prepared for periodic testing of these systems.

Specific Evaluation Reference:

See the Technical Specifications.

Regulatory Guide 1.120, Revision 0, June 1976

Fire Protection Guidelines for Nuclear Power Plants

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed after February 28, 1977. However, the NRC requested a reevaluation of the fire protection program of CGS and a comparison with the guidelines in Appendix A to Branch Technical Position APCSB 9.5-1, “Guidelines for Fire Protection For Nuclear Power Plants, Docketed Prior to July 1, 1976.” CGS complies with the intent of the guidance set forth in Appendix A to Branch Technical Position APCSB 9.5-1.

General Compliance or Alternate Approach Assessment:

Appendix F includes the fire hazard analysis and compares in detail the fire protection provisions for CGS with the guidelines in Appendix A to Branch Technical Position APCSB 9.5-1.

Regulatory Guide 1.122, Revision 0, September 1976

Development of Floor Design Response Spectra for Seismic Design of Floor Supported Equipment or Components

Compliance or Alternate Approach Statement:

CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

CGS complies with some of the regulatory positions and where not in compliance, alternate methods are used as discussed in Sections 3.7.2.5 and 3.7.2.6.

Specific Evaluation Reference:

See Sections 3.7.2.5 and 3.7.2.6.

Regulatory Guide 1.123, Revision 0, October 1976

Quality Assurance Requirements for Control of Procurement of Items and Services for Nuclear Power Plants

I Design and Construction Phase

Compliance or Alternate Approach Statement:

CGS complied with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

ANSI N45.2.13-1976, the subject of this regulatory guide, requires certain supplier selection, evaluation, and pre- and post-award activities.

Prequalification of suppliers was generally not performed. The procurement documents required prospective suppliers to submit information pertaining to experience, facilities, personnel, and quality program with their bids for evaluation prior to award of a contract.

Pre-award evaluations were restricted to the information submitted with bid and selected clarifications when an adequate evaluation could not be accomplished with the information supplied. Post-award evaluations were performed in conjunction with the quality assurance program evaluation and approval after award of a contract.

Inspection and hold points were not established through agreement with the bidder but through contract requirements to notify Energy Northwest of all inspections and tests which were selectively witnessed by Energy Northwest.

Specific Evaluation Reference:

None

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.124, Revision 0, November 1976

Design Limits and Loading Combinations for Class 1 Linear Type Component Supports

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed after July 1, 1977. However, CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

Design and fabrication requirements for CGS, including those requirements for linear type components supports, are in accordance with the ASME Code Section III Subsection NF, Winter 1973 Addenda. The actual design criteria were established prior to Winter 1973 Addenda and are conservative with respect to the Winter 1973 Code. Regulatory Guide 1.124 provides design limits and appropriate combinations of loadings which reflect the requirements set forth in the 1974 Edition of the ASME Code Section III, Subsection NF, along with additional requirements. Although the detailed requirements of the regulatory guide have not been incorporated as project criteria, review of the design criteria used for CGS indicates that the intent of this regulatory guide is met.

Specific Evaluation Reference:

See Sections 3.9.3.4 and 5.4.14.

Regulatory Guide 1.125, Revision 0, March 1977

Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants

Compliance or Alternate Approach Statement:

The guide is not applicable to CGS since it applies to the evaluation of construction permit application docketed on or after November 1, 1977. Furthermore, the guide is not applicable to CGS for reasons stated below.

General Compliance or Alternate Approach Assessment:

Physical hydraulic model testing is not used for CGS for predicting the performance of hydraulic structures, systems, and components located outside the primary containment vessel or provided for the prevention of accidents and the mitigation of the consequences of accidents. Therefore, the details and documentation of data and studies required by the guide to support such testing is not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.127, Revision 0, April 1977

Inspection of Water-Control Structures Associated With Nuclear Power Plants

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since water-control structures as defined in this regulatory guide do not exist.

General Compliance or Alternate Approach Assessment:

Not applicable.

Specific Evaluation Reference:

Not applicable.

Regulatory Guide 1.128, Revision 0, April 1977

Installation Design and Installation of Large Lead Storage Batteries for Nuclear Power Plants.

Compliance or Alternate Approach Statement:

This regulatory guide is not applicable to CGS since it applies to the evaluation of construction permit applications docketed after December 1, 1977. However, CGS complies with the intent of the guidance set forth in this regulatory guide by an alternate approach.

General Compliance or Alternate Approach Assessment:

Safety-related battery installation design criteria conforms to IEEE 484-1975.
A Class 1E ventilation system is also provided which is capable of limiting hydrogen concentrations to 1%.

Storage prior to installation was not in strict compliance with Section 5.1.3 of this regulatory guide. However, preoperational tests established whether or not any damage or loss of capacity resulted from storage.

Specific Evaluation Reference:

See Sections 8.3.2.1.5, 8.3.2.1.6, 8.3.2.2.1.1, and 8.3.2.2.1.2.

Regulatory Guide 1.129, Revision 0, April 1977

Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Nuclear Power Plants

Compliance or Alternate Approach Statement:

Although Regulatory Guide 1.129 is not directly applicable to CGS, Energy Northwest's maintenance procedures conform to IEEE 450- 2002, "IEEE Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations." The frequency for "service" testing is in accordance with Technical Specifications or Licensee Controlled Specifications.

General Compliance or Alternate Approach Assessment:

See Section 8.3.2.1.7.

Specific Evaluation Reference:

See Section 8.3.2.1.7.

Regulatory Guide 1.137, Revision 1, October 1979

Fuel Oil Systems for Standby Diesel Generators

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this guide with the exception of the following:

Piping on the engine skid is ANSI B 31.1, Seismic Category I, Quality Class I, as noted in Section 9.5.4.1.

Item 11, cathodic protection surveillance. The standby diesel fuel oil storage tanks are protected with cathodic protection by anodes which are located in the near vicinity, but there are no pigtails connected to the fuel oil system piping, thus no leads to maintain. CGS does not perform the 90% distillation test before putting the fuel in the tanks as noted in Section 9.5.4.4 and the Technical Specifications.

The diesel fuel oil supply is gravity feed down to the low fuel oil alarm level. The pump suction, however, is 2.3 ft higher than the bottom of the tank. Therefore, if the transfer pump fails, the last few hours of running before the day tank is empty would be at a pump suction lift of up to 2.3 ft.

The auxiliary boiler storage tank is considered part of the diesel fuel oil system in that it is an additional diesel fuel oil storage tank. This deviates from the ANSI N195-1976 standard because of the permanent interconnection between the standby power system and the auxiliary boiler system. The auxiliary boiler storage tank and its connective piping are not Safety Class 3. The auxiliary boiler storage tank and its connecting auxiliary boiler system are not in a vital area, although ANSI N195-1976 specifies that the fuel oil system is a vital system and shall be located in a vital area. However, loss of the stored fuel oil in the auxiliary boiler storage tank or its connective piping will not affect the safety function of the diesel fuel oil system.

The diesel storage minimum required volume does not include volume for testing, as specified by ANSI N195-1976. Instead, Energy Northwest procedurally provides for makeup, as needed, during testing activities to ensure that the minimum required volume is maintained.

Specific Evaluation Reference:

See Section 9.5.4.4.

Regulatory Guide 1.143, Revision 1, October 1979

Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

CGS began implementing the guidance set forth in this regulatory guide in July 1982. Prior to this time the solid, liquid, and gaseous radioactive waste systems were being designed and fabricated as ASME Section III, Class 3, systems. Therefore, although the guidance in the regulatory guide does not call for N-stamped components, in many cases N-stamped components are found in the radwaste systems. To avoid the confusion which may result from the implementation of this regulatory guide these systems, and components which follow the guidance found in the regulatory guide are indicated as Quality Class II+ and Code Group D+.

Specific Evaluation Reference:

See Sections 3.2.4 and 3.2.6.

Regulatory Guide 1.144, Revision 1, September 1980

Auditing of Quality Assurance Programs for Nuclear Power Plants

I Design and Construction Phase

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide as described below.

General Compliance or Alternate Approach Assessment:

Contractors and suppliers complied with the requirements imposed by procurement documents.

Energy Northwest, the architect-engineer (Burns and Roe), and the construction manager (Bechtel) complied with the guidance set forth in this regulatory guide except for the following.

The requirements of ANSI N45.2.12-1977 as modified and interpreted by the regulatory position were applied to the Bechtel quality program for safety-related items except as modified or interpreted below:

a. Reference: Standard Sections 4.3.2.4 and 4.5.1 (Investigation). As an equivalent alternative to the requirement for the audited organization to investigate any adverse audit finding to determine and schedule appropriate corrective action, Bechtel's auditing organization may determine the investigatory action and corrective action including action to prevent recurrence pertinent to adverse audit finding. These actions are agreed to by the audited organization. Further, in Section 4.5.1, as equivalent alternative to the 30-day response time, a response time appropriate to the finding is agreed to by the audited and auditing organizations.

b. Reference: Regulatory Section C.7, Standard Section 5.2 (Audit Records). Audit records shall include documents as defined in the standard and other documents if necessary to support audit findings.

Early project procurements specified audit program requirements in terms of Appendix B to 10 CFR 50 and ANSI N45.2. As appropriate, future procurements required that audit programs comply with ANSI Standard N45.2.12.

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.145, Revision 1, November 1982/February 1983

Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants

Regulatory Guide Intent

This guide provides acceptable methodology to determining site-specific relative concentrations for assessing the potential offsite radiological consequences of postulated accidental releases of radioactive material to the atmosphere.

Application Assessment

Assessed capability in design.

Compliance or Alternate Approach Statement:

Identified BOP scope of supply analysis, design, and/or equipment used in this facility is in full compliance with the regulatory guide.

General Compliance or Alternate Approach Assessment

Two of the procedures contained in the PAVAN code were implemented. The procedures were run with the desert sigma and with the Pasquill-Gifford sigma enabled. The most conservative χ/Q values were used in the accident analysis.

Specific Evaluation Reference:

See Section 2.3 and Chapter 15.0.

Regulatory Guide 1.146, Revision 0, August 1980

Qualification of Quality Assurance Program Audit Personnel for Nuclear Power Plants

I Design and Construction Phase

Compliance or Alternate Approach Statement:

CGS complied with the guidance set forth in this regulatory guide as described below.

General Compliance or Alternate Approach Assessment:

Energy Northwest, the architect-engineer (Burns and Roe), and the construction manager (Bechtel) complied with the guidance set forth in this regulatory guide.

Contractors and suppliers comply with the requirements imposed by procurement documents.

Early project procurements specified audit program requirements in terms of Appendix B 10 CFR 50 and ANSI N45.2. Where appropriate, future procurements required that auditor qualification comply with ANSI Standard N45.2.23.

II Operational Phase

Compliance is discussed in the OQAPD.

Regulatory Guide 1.147

Inservice Inspection of Code Case Acceptability ASME Section XI Division I.

By the reference below, the NRC approved application of Code Case N416 for CGS which at that time was not addressed in Regulatory Guide 1.147. The approval letter required that Energy Northwest document application of the code case in the FSAR.

The code case was first used for CGS in 1988 for deferral of hydrostatic testing of main steam drip line modifications.

As the code case has now been accepted by Regulatory Guide 1.147, Energy Northwest does not plan to document future use of the code case.

Reference:

Letter from T. M. Novak (NRC) to G. C. Sorensen (SS), "Use of ASME Code Case N-416 for the WNP-2, WPPSS Nuclear Project No. 2 (WNP-2)," dated August 8, 1985.

Regulatory Guide 1.155, Reissued August 1988

Station Blackout

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

Compliance or Alternate Approach Assessment:

Regulatory Guide 1.155 was issued to describe a method acceptable to the NRC staff for complying with the NRC regulation that requires nuclear power plants to be capable of coping with a station blackout for a specified duration. The NRC acceptance of the CGS proposed plan for providing this capability is provided in the reference.

Specific Evaluation Reference:

See Appendix 8A.

Reference:

Letter from R. R. Assa to G. C. Sorensen, "Supplemental Safety Evaluation (SSE) of the Washington Public Power Supply System Nuclear Project No. 2 (WNP-2) Station Blackout Analysis (TAC M68626)," dated June 26, 1992.

Regulatory Guide 1.160, Revision 3, May 2012

Monitoring the Effectiveness of Maintenance at Nuclear Power Plants

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Compliance with the guidance provided is ensured by the implementation of a maintenance program and implementing procedures at CGS.

Specific Evaluation References:

Not applicable.

Regulatory Guide 1.196, May 2003

Control Room Habitability at Light-Water Nuclear Power Reactors

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Compliance with the guidance provided is ensured by the implementation of a Control Room Envelope Habitability (CREH) Program and implementing procedures at CGS.

Specific Evaluation References:

Not applicable.

Regulatory Guide 1.197, May 2003

Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors

Compliance or Alternate Approach Statement:

CGS complies with the guidance set forth in this regulatory guide.

General Compliance or Alternate Approach Assessment:

Compliance with the guidance provided is ensured by the implementation of a Control Room Envelope Habitability (CREH) Program and implementing procedures at CGS.

Specific Evaluation References:

Not applicable.

Chapter 2

SITE CHARACTERISTICS

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Chapter 2

SITE CHARACTERISTICS

2.1 GEOGRAPHY AND DEMOGRAPHY

2.1.1 SITE LOCATION AND DESCRIPTION

2.1.1.1 Specification of Location

Columbia Generating Station (CGS) is located in the southeast area of the U.S. Department of Energy's (DOE) Hanford Site in Benton County, Washington. The site is approximately 3 miles west of the Columbia River at River Mile 352, approximately 10 miles north of north Richland, 18 miles northwest of Pasco, and 21 miles northwest of Kennewick (Figures 2.1-1 and 2.1-2).

The reactor is located at 46° 28' 18" north latitude and 119° 19' 58" west longitude. The approximate Universal Transverse Mercator coordinates are 5,148,840 meters north and 320,930 meters east.

2.1.1.2 Site Area Map

The CGS site area is that real estate over which Energy Northwest has the legal right to control access. It is the area enclosed by the exclusion area boundary plus the plant property lines as shown in Figure 3-1 of the Offsite Dose Calculation Manual (ODCM). The property line and nearby industrial facilities are shown in Figure 2.1-3. Industrial facilities located in the site area are the H. J. Ashe Substation and Energy Northwest's Nuclear Projects 1 and 4 (WNP-4 was terminated in January 1982, and WNP-1 was terminated in May 1994). Highway and railway facilities located within the site area are shown in Figure 2.1-3. The relative locations of the plant structures are shown in Figure 1.2-1.

The boundary of the exclusion area is a circle with its center at the reactor and a radius of 1950 m. Ownership and control of the land outside the CGS property line but within the site exclusion area are discussed in Section 2.1.2.

The site is situated near the middle of the relatively flat, essentially featureless plain, which is best described as a shrub steppe with sagebrush interspersed with perennial native and introduced annual grasses extending in a northerly, westerly, and southerly direction for several miles. The plain is characterized by slight topographic relief of approximately 20 ft across the plant site.

The dominant topographic features in the area are the Rattlesnake Hills, 13 to 15 miles west southwest, 3200 ft above the elevation of the plant site; Gable Mountain, approximately

10 miles northwest of the site and about 670 ft above the site grade; and the steep river cut bluffs forming the east bank of the Columbia River, approximately 3.5 miles east of the site (Figure 2.1-1).

2.1.1.3 Boundaries for Establishing Effluent Release Limits

The boundary for establishing effluent release limits (unrestricted area boundary as defined in 10 CFR Part 20) is the site area boundary as shown in the ODCM, Figure 3-1. The site area is the area enclosed by the exclusion area boundary and the plant property lines that fall outside the exclusion area. All area within the site area boundary is considered a controlled area as defined by 10 CFR 20.1003.

A number of restricted areas (as defined in 10 CFR 20.1003) are associated with CGS. The primary CGS restricted area is located within the plant security fence which also is the boundary of the protected area (as defined in 10 CFR 73.2). This is shown as the double fence line in Figure 1.2-1. Unescorted access to the protected area is controlled by CGS security staff. Other restricted areas include the Independent Spent Fuel Storage Installation, stormwater ponds, Plant Support Facility calibration laboratory, Warehouse No. 5, the cooling tower sediment disposal area, and Building 167 on the WNP-4 site. Access to these secondary restricted areas is controlled by locks and fences. Temporary restricted areas may be established and removed as dictated by activities at CGS.

2.1.2 EXCLUSION AREA AUTHORITY AND CONTROL

2.1.2.1 Authority

Energy Northwest leased 1089 acres from the DOE, within the DOE Hanford Site, to be used for CGS. A letter from the DOE Richland Operations office to the Managing Director of Energy Northwest (Reference 2.1-1) advises that the DOE has the authority to sell or lease land on the Hanford Site and the letter further states

> 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.

The 1950-m radius exclusion area extends beyond the CGS property lines and overlaps DOE lands as well as the additional land leased by Energy Northwest for the construction of the WNP-1 and WNP-4 projects (see Figure 2.1-3 and ODCM Figure 3-1). All land outside the Energy Northwest leased property but within the exclusion area is managed by the DOE.

In recognition of the requirement specified in 10 CFR 100.3(a) [Now 100.3] that a licensee have control over access to the exclusion area, the following terms have been incorporated as Article 7 of the site property lease agreement between Energy Northwest and the DOE (as modified in 1975):

> Nothwithstanding any provisions of this lease to the contrary, the Administration [Energy Research and Development Administration -- now DOE] agrees that the Supply System [now Energy Northwest] has the authority to determine all activities within the exclusion area within the meaning of 10 CFR Section 100.3(a) [Now 100.3], including the authority to remove a personnel and property from the area. The Supply System agrees that it will exercise such authority in a manner so as not to preclude the Administration from undertaking any action or activity within the exclusion area that is permissible under the provisions of 10 CFR Section 100.3(a) [Now 100.3]. As used herein, the term “exclusion area” includes both the leased and nonleased portions of the exclusion area.

Therefore, any actions such as public access and actions concerning mineral rights and easements taken within the exclusion area but outside the leased property are under the control of the DOE with the provision that Energy Northwest has the legal right to control access of individuals to the exclusion area if necessary. All rail shipments on the track which traverses the property (Figure 2.1-3) are also under control of the DOE and are also subject to the above provision and controls imposed by Energy Northwest Security.

The only paved roads that traverse the exclusion area of CGS are the CGS, WNP-1, and WNP-4 facility access roads shown in Figure 2.1-3. Access by land from outside of the Hanford Site to the plant site is over DOE roads. Travel within the exclusion area on the access roads will be under the authority of Energy Northwest.

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-Energy Northwest originated activities.

The above provisions provide the necessary assurance that the exclusion area is properly controlled. If Energy Northwest should decide that an easement would be useful in ensuring continued control, there is a provision in Article 5(b) of the lease as follows:

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

Pursuant to this provision Energy Northwest could obtain an easement over the exclusion area in question from the DOE, which would ensure that no permanent structures or other activities inconsistent with the exclusion area would be carried on therein.

2.1.2.2 Control of Activities Unrelated to Plant Operation

In accordance with, and as defined by 10 CFR 100.3, Energy Northwest has the authority to determine all activities within the exclusion area, including the authority to remove all personnel and property from the area. The following activities unrelated to plant operation are permitted within the exclusion area:

2.1.2.2.1 Industrial Development Complex

Energy-Northwest is conducting site restoration and economic development (such as leasing of excess facilities for office space and manufacturing) activities at the WNP-1 and WNP-4 sites (the WNP-1 and WNP-4 sites are also leased from the DOE and controlled by Energy Northwest). The number of personnel at the WNP-1 and WNP-4 sites varies. However, coordination of activities within the exclusion area is under the control of Energy Northwest and the CGS emergency plan. This includes notification and evacuation considerations in the event of an emergency at CGS.

2.1.2.2.2 618-11 (Wye) Waste Burial Ground

The 618-11 site is a DOE waste burial ground, encompassing an eight-acre parcel directly adjacent to Energy Northwest leased land (see Figure 2.1-3) and located wholly within the CGS exclusion area. All 618-11 site activities are controlled by DOE in accordance with 10 CFR Chapter III. DOE has responsibility for the 618-11 site in accordance with 10 CFR 830.204. The soil overburden covering the caissons and vertical pipe units at the 618-11 site is identified as a passive design feature that serves a mitigative function. Existing soil overburden shall not be removed.

Following non-intrusive surveillance and characterization activities, the site was returned to inactive status.

2.1.2.3 Arrangements for Traffic Control

The only roads within the exclusion area are the Energy Northwest access roads. These roads are normally used only by employees and visitors associated with the CGS, WNP-1, and WNP-4 facilities, DOE, and DOE contractors. The security force, with offsite assistance as required, controls traffic during emergencies.

2.1.2.4 Abandonment or Relocation of Roads

There were no public roads transversing the exclusion area that had to be abandoned or relocated as a result of the construction of CGS.

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 2.1-4 and 2.1-5, which show the sectors and major population centers within 10 and 50 miles of the site. As can be seen in Figure 2.1-6, population centers, within 50 miles of the site include the Tri-Cities area of Richland, Pasco, and Kennewick; Moses Lake; Hermiston; and the communities lying along the Yakima River from Prosser to Toppenish. Figure 2.1-4 shows that there are no towns located within 10 miles of the site, with the exception of a small part of Richland.

The 1990 to 2030 forecasts presented here (Reference 2.1-2) 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. (References 2.1-3 and 2.1-4).

Table 2.1-2 presents the compass sector population estimates for 2010 based on U.S. Census Bureau data (Reference 2.1-5). See also Figures 2.1-4 and 2.1-5.

2.1.3.1 Population Within Ten Miles

An estimated 3000 people live within 10 miles of the site. 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 3 miles of the site.

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

* Population estimates out to 50 miles were derived to serve the licensing requirements of WNP-1, CGS, and WNP-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 CGS and has coordinates longitude 119° 19’ 18” west, latitude 46° 28’ 19” north. This shift does not affect the overall accuracy or applicability of the population distribution projections.

about the maximum amount practicable. The primary increase in population within the 10-mile radius is expected to be in the area south and south-southeast of the plant (see Figure 2.1-4).

2.1.3.2 Population Between Ten and Fifty Miles

As indicated in Table 2.1-2, about 450,000 people were estimated to be living within a 50-mile radius of CGS in 2010. Projections for the 10-50 mile region are shown in Table 2.1-1 which is based on earlier (1979-1980) population counts.

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, and sportsmen engaged in hunting, fishing, and boating. A description of the transient population is discussed in Section 5.6 of the CGS Emergency Plan.

2.1.3.4 Low Population Zone

The low population zone (LPZ) [see 10 CFR 100.3(b)] for CGS is defined as all land within a 3-mile radius of the reactor. This LPZ was selected on the basis that it is not expected to have a large population in the future and that effective protective measures could be established. As shown in Table 2.1-2, no permanent residents are located within a 3-mile radius of the reactor, and none are anticipated in the future.

There are no public facilities or institutions such as schools and hospitals within a 3-mile radius of the plant. The transportation facilities and topographic features of the LPZ are shown in Figure 2.1-7.

2.1.3.5 Population Center

The nearest population center is the City of Richland, 12 miles to the south.

2.1.3.6 Population Density

In 2000, the population densities within the 10, 20, and 30-mile radii were 9, 96, and 73 people per square miles, respectively. In 2030, the densities out to the same distances are estimated to be 13, 123, and 84, respectively, based on the projections in Table 2.1-1.

2.1.4 REFERENCES

2.1-1 Letter from Atomic Energy Commission, Richland Operations Office, to Managing Director of the Supply System, Washington Public Power Supply System, Subject: Appendix 2P, November 25, 1970.

2.1-2 Yandon, K. E., Projections and Distributions of Populations Within a 50-Mile Radius of Washington Public Power Supply System Nuclear Projects Nos. 1, 2, and 4 by Compass Direction and Radii Intervals, 1970-2030, October 1980.

2.1-3 Bonneville Power Administration, U.S. Department of Energy, Washington, Subject: Population, Employment and Household Projections to 2000 by County, July 1979.

2.1-4 Bonneville Power Administration, U.S. Department of Energy, Oregon Population, Employment and Household Projections to 2000 by County.

2.1-5 Washington State Office of Financial Management, Forecasting Division (2012). Small Area Estimate Program: Census Block Groups [SAEP_ColGenFac_Sectors_2000-2012.xls]. Via communication with M. Mohrman, Washington Office of Financial Management, July 2013; Oregon Population Data Estimates 2010 provided by Portland State University, Population Research Center, C. Rynerson, in collaboration with the M. Mohrman at Washington State Office of Financial Management, March 2014.

LDCN-03-023

Table 2.1-1

Projected Population Distribution by Compass Sector and Distance from the Site

Distance Cumulative (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
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	40112	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	4360	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

Projected Population Distribution by Compass Sector and Distance from the Site (Continued)

Distance Cumulative (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	230615	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

LDCN-03-023

Table 2.1-1

Projected Population Distribution by Compass Sector and Distance from the Site (Continued)

Distance Cumulative (miles)	Direction (compass segment)	1980		1990		2000		2010		2020		2030	
		Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total	Number	Cumulative Total
40-50 (cont.)	SE	2084	207963	2245	25557	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	22176	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

LDCN-14-009, 13-067

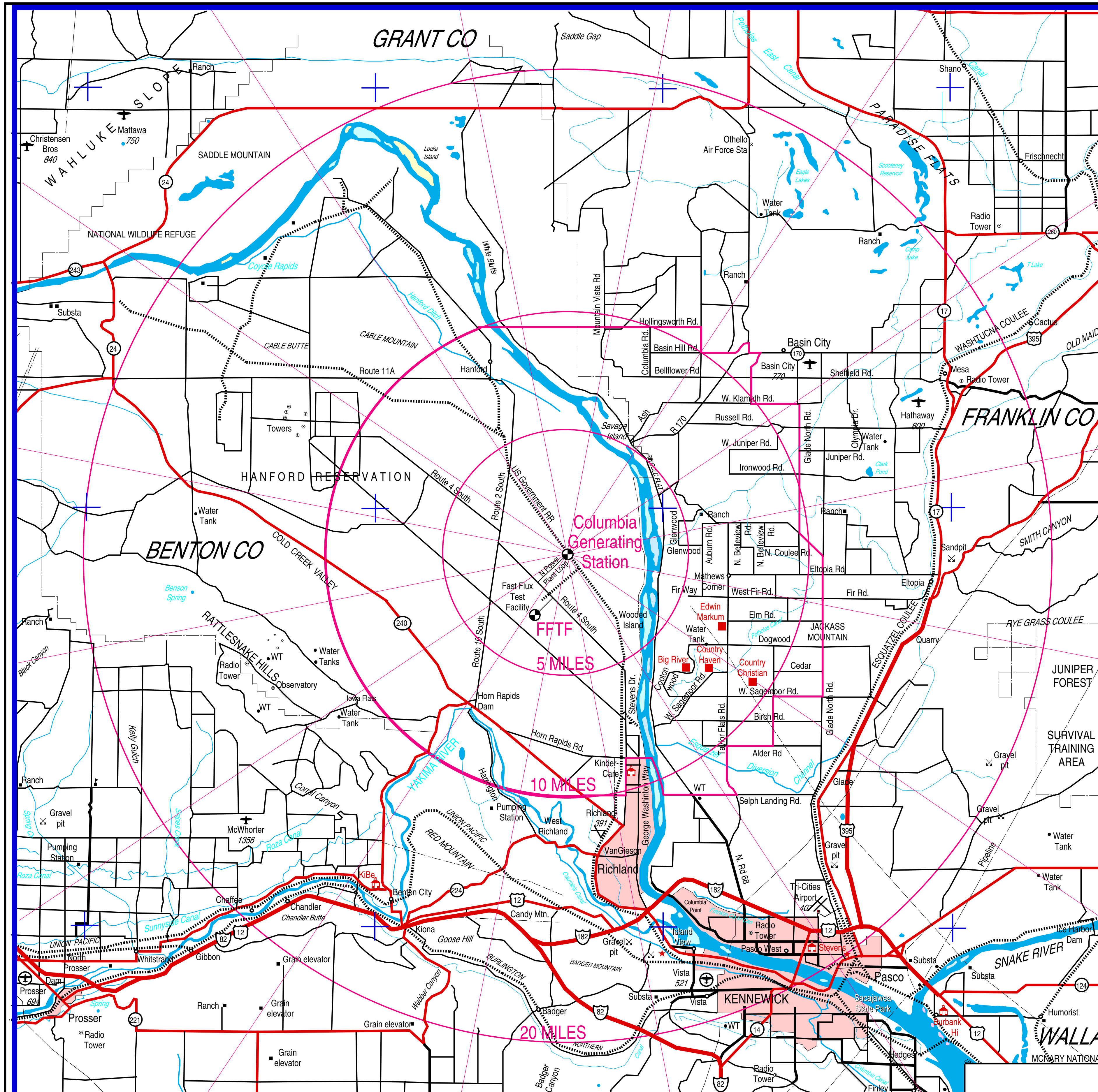
Table 2.1-2

2010 Population Distribution by Compass Sector and Distance from the Site

Distance (miles)	Direction (compass segment)	2010 Population	Distance (miles)	Direction (compass segment)	2010 Population	Distance (miles)	Direction (compass segment)	2010 Population
0-3	ALL	0	5-10	N	16	10-20	N	136
			5-10	NNE	78	10-20	NNE	742
3-4	NNE	0	5-10	NE	248	10-20	NE	1699
3-4	ENE	0	5-10	ENE	213	10-20	ENE	934
3-4	E	1	5-10	E	298	10-20	E	680
3-4	ESE	0	5-10	ESE	308	10-20	ESE	513
3-4	SE-NNW	0	5-10	SE	588	10-20	SE	16219
			5-10	SSE	239	10-20	SSE	95379
4-5	NNE	1	5-10	S	376	10-20	S	38669
4-5	NE	18	5-10	SSW	548	10-20	SSW	7516
4-5	ENE	19	5-10	SW	16	10-20	SW	1232
4-5	E	27	5-10	WSW-NW	0	10-20	WSW	11
4-5	ESE	25	5-10	NNW	1	10-20	WNW	0
4-5	SE	0				10-20	NNW	1
4-5	SSE-NNW	0				10-20	NW - W	0
0-5	TOTAL	91	0-10	TOTAL	3020	0-20	TOTAL	166751
20-30	N	1098	30-40	N	1138	40-50	N	37171
20-30	NNE	13285	30-40	NNE	3802	40-50	NNE	782
20-30	NE	1237	30-40	NE	210	40-50	NE	705
20-30	ENE	3638	30-40	ENE	302	40-50	ENE	164
20-30	E	53	30-40	E	121	40-50	E	48
20-30	ESE	509	30-40	ESE	686	40-50	ESE	188
20-30	SE	18611	30-40	SE	343	40-50	SE	1415
20-30	SSE	50050	30-40	SSE	201	40-50	SSE	310
20-30	S	1710	30-40	S	8330	40-50	S	30053
20-30	SSW	131	30-40	SSW	236	40-50	SSW	5441
20-30	SW	11225	30-40	SW	1552	40-50	SW	217
20-30	WSW	1475	30-40	WSW	41107	40-50	WSW	4428
20-30	W	50	30-40	W	934	40-50	W	22691
20-30	WNW	205	30-40	WNW	6111	40-50	WNW	26
20-30	NW	611	30-40	NW	2478	40-50	NW	619
20-30	NNW	443	30-40	NNW	3870	40-50	NNW	1622
0-30	TOTAL	271082	0-40	TOTAL	342503	0-50	TOTAL	448383

Table based on April 2010 Census Bureau counts.

Amendment 55
May 2001



SCALE

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometers

LEGEND

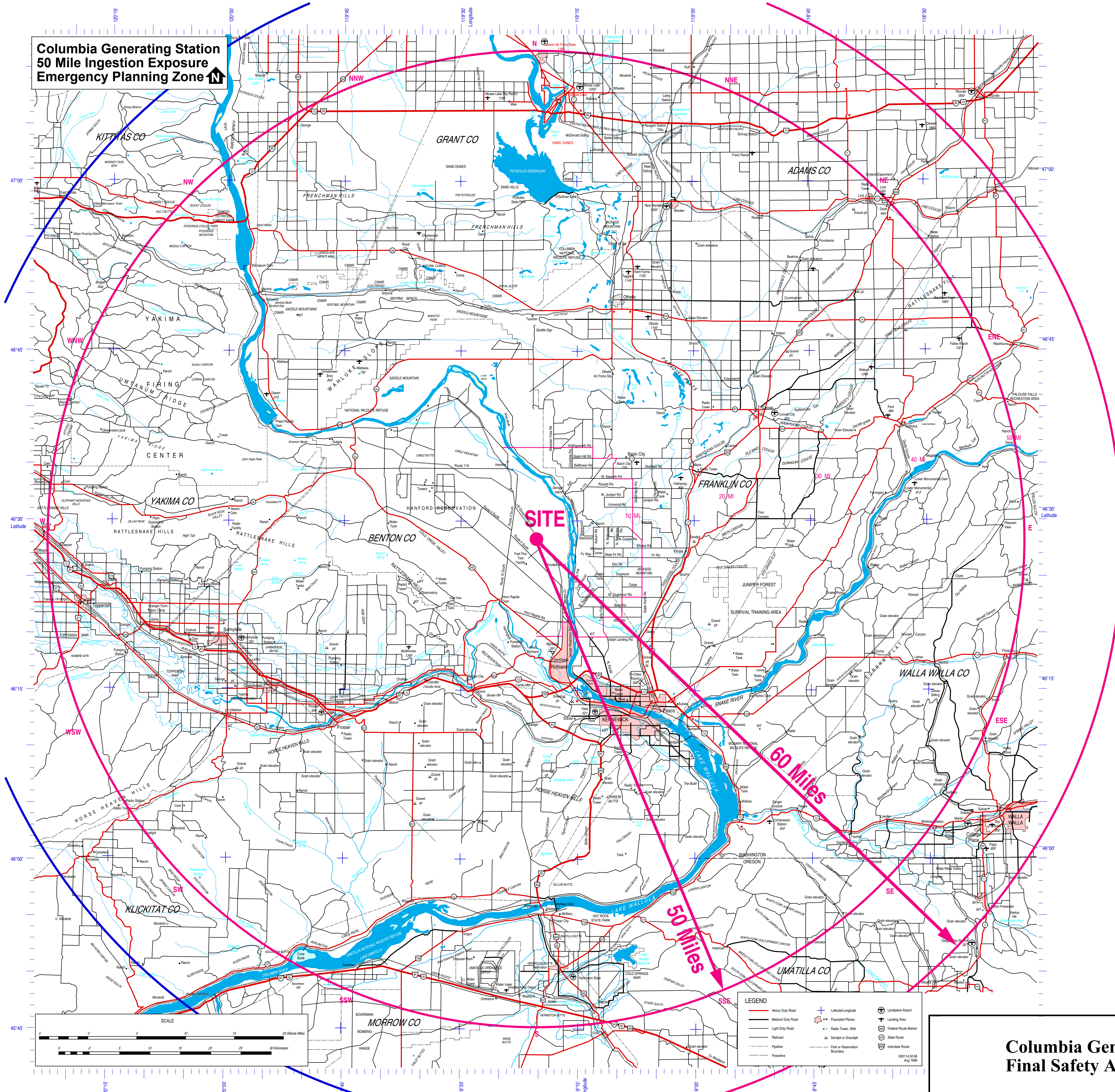
Heavy Duty Road	Latitude/Longitude	Landplane Airport
Medium Duty Road	Populated Places	Landing Area
Light Duty Road	Radio Tower, Well	Federal Route Marker
Railroad	Sandpit or Gravelpit	State Route
Pipeline	Park or Reservation Boundary	Interstate Route
Powerline		Emergency Center

Columbia Generating Station
Final Safety Analysis Report

General Area, 0 - 20 Miles

Draw. No. 990306.20 | Rev. | Figure 2.1-1

Form No. 960690

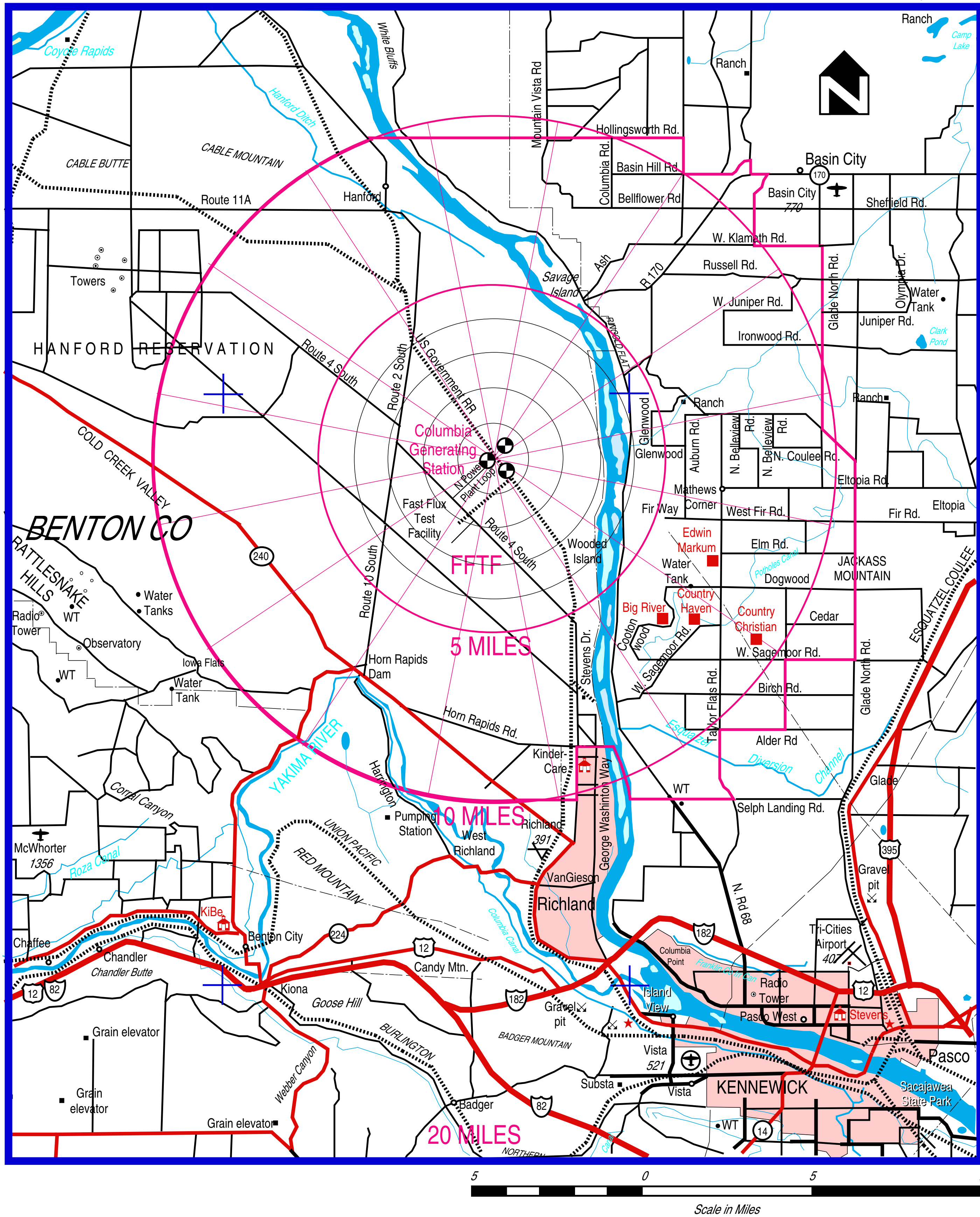


Form No. 960690

Columbia Generating Station
Final Safety Analysis Report

General Area, 0 - 50 Miles

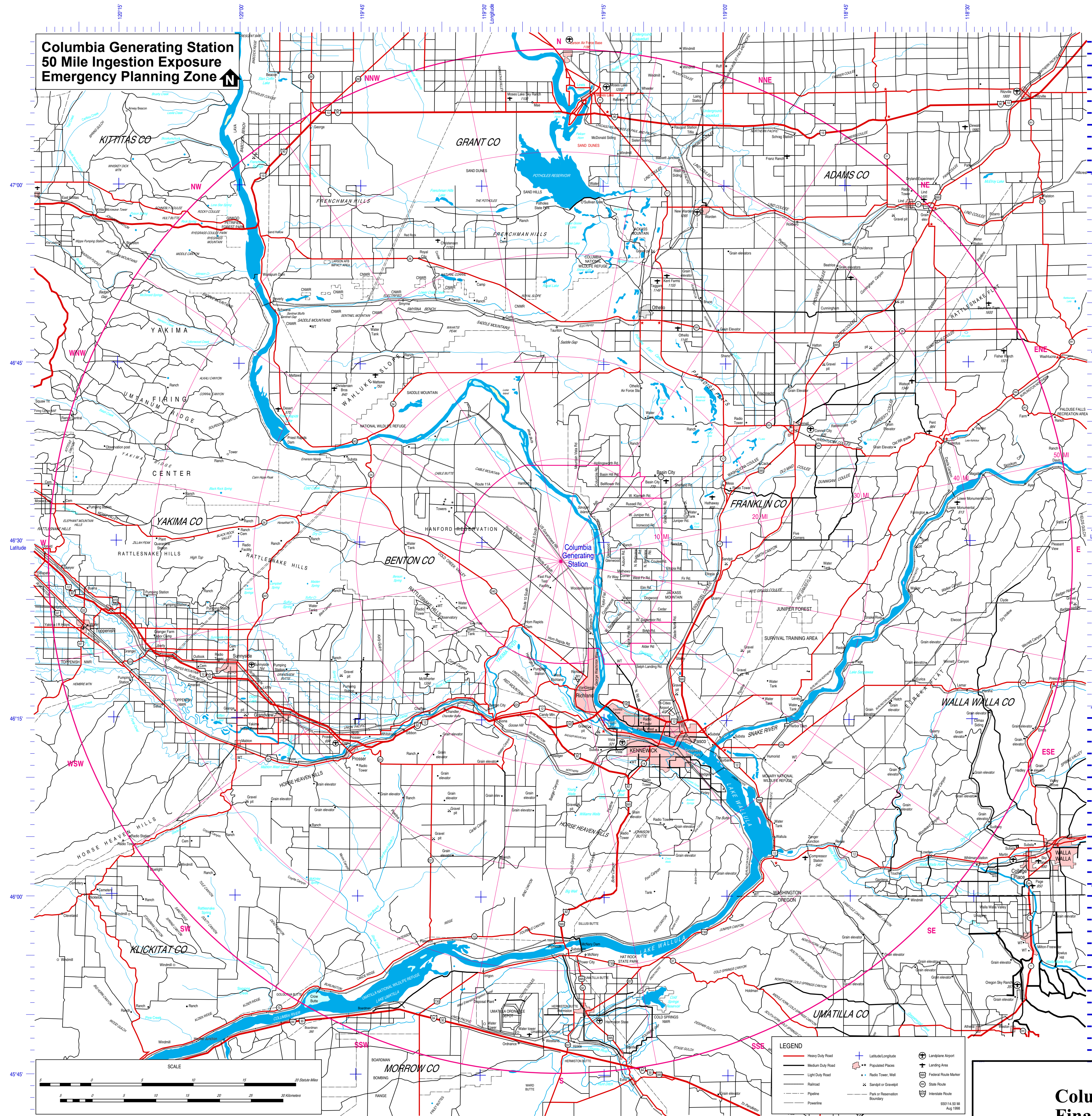
Draw. No. 990306.60	Rev.	Figure 2.1-2



Columbia Generating Station
Final Safety Analysis Report

Project Area Map - 10 Mile Radius

Draw. No. 990306.10	Rev.	Figure 2.1-4

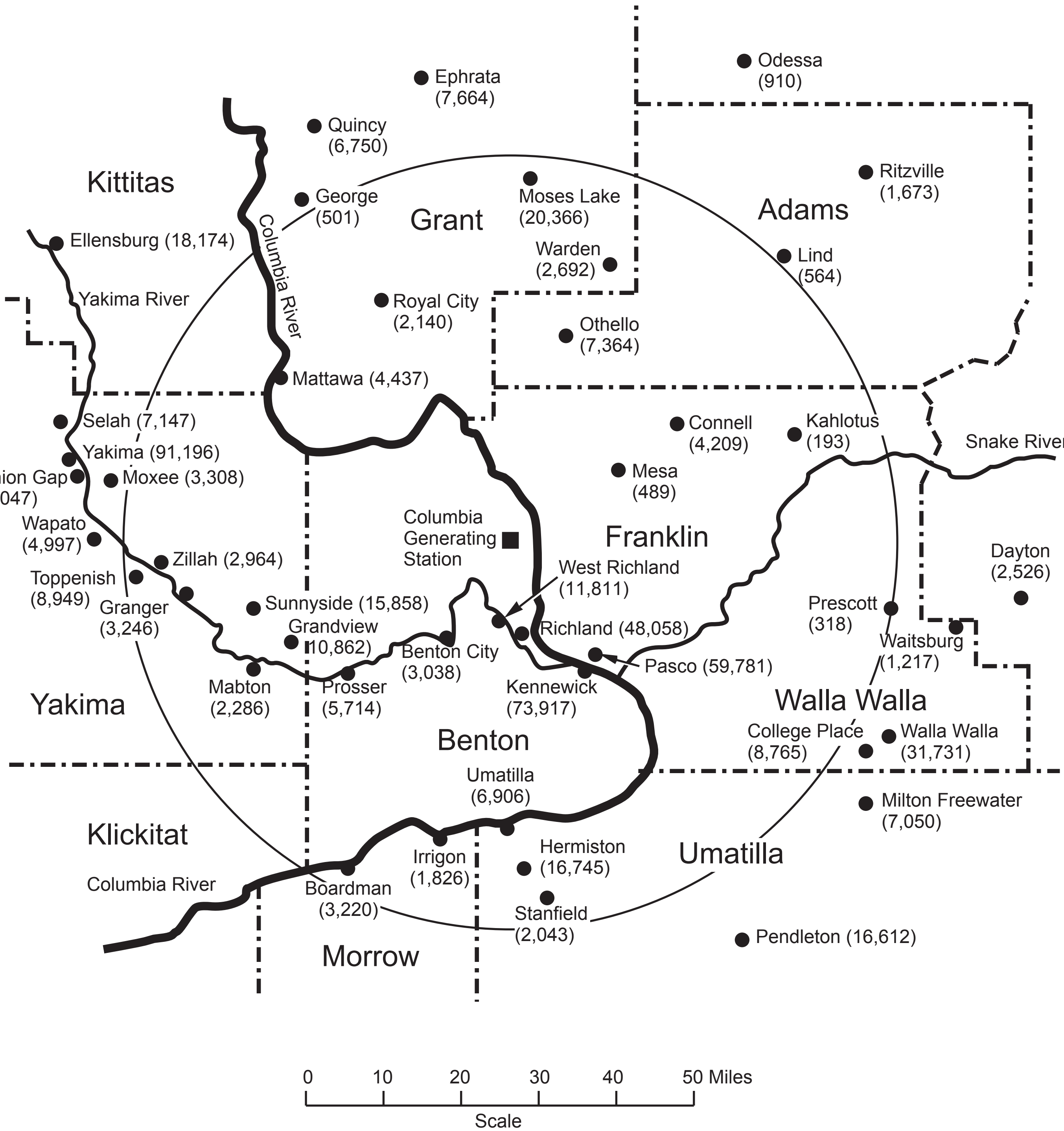


Columbia Generating Station
Final Safety Analysis Report

Project Area Map - 50 Mile Radius

Draw. No. 990306.50	Rev.	Figure 2.1-5

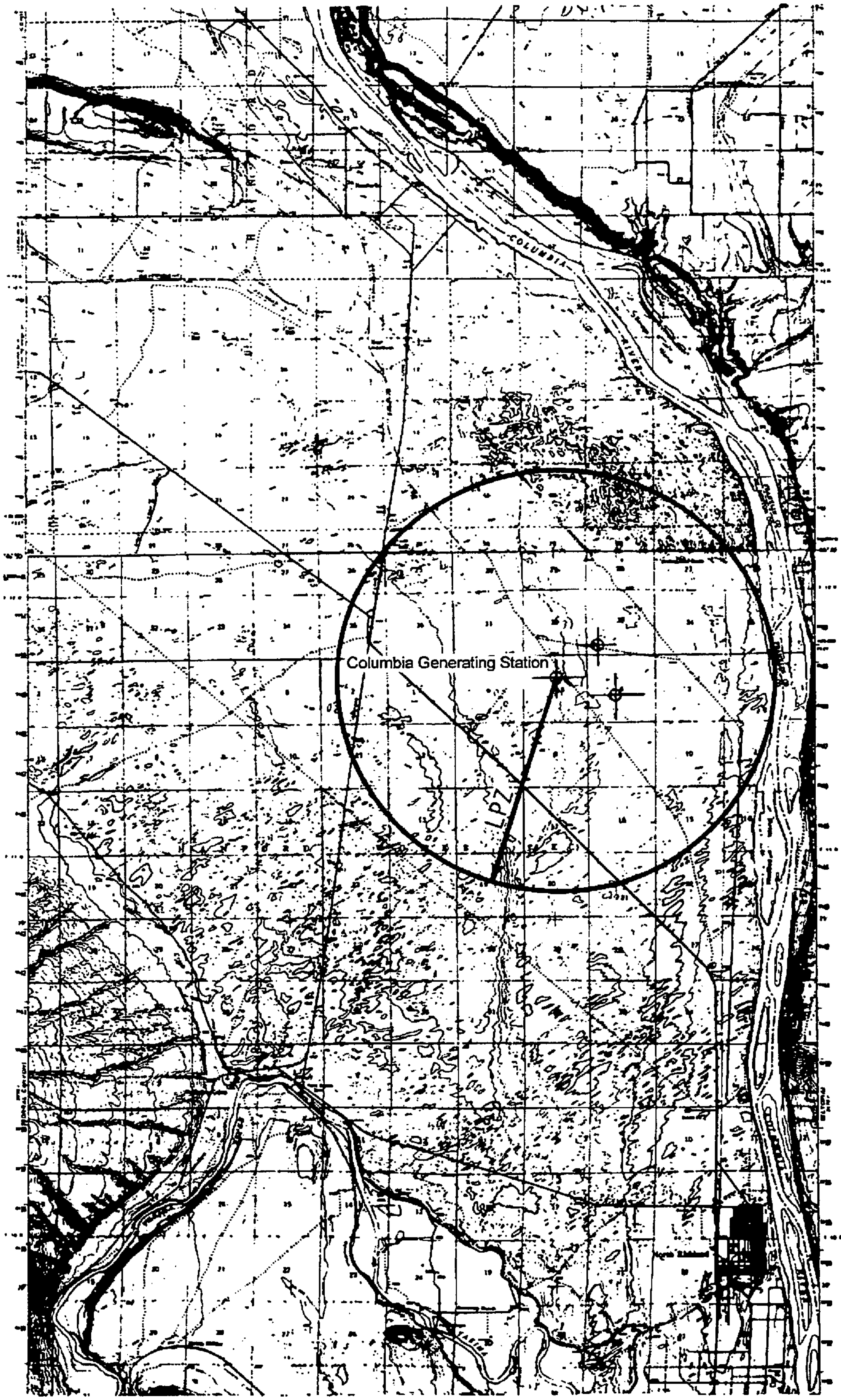
Form No. 960690



Columbia Generating Station
Final Safety Analysis Report

2010 Population in Communities Around Site

Draw. No. 970187.14 | Rev. 1 | Figure 2.1-6



Columbia Generating Station
Final Safety Analysis Report

Transportation and Topographic Features of Low Population Zone

Draw. No. 020361.01 | Rev. | Figure 2.1-7

2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

This section describes the industrial, transportation, and military installations and operations in the vicinity of the site which may have a potential effect on the safe operation of Columbia Generating Station (CGS).

2.2.1 LOCATION AND ROUTES

There are no military bases, missile sites, manufacturing plants, chemical plants, commercial chemical storage facilities, or airports within a 5-mile radius of the site. A security barrier completely surrounds the station and its major supporting facilities to keep unauthorized vehicles a safe distance from critical structures.

According to the Richland Operations Office of the Department of Energy (DOE) (Reference 2.2-1), there are no plans for petrochemical storage facilities, airports, oil and gas pipelines, or petrochemical tank farms on the Hanford Site. Plans for modifications to or new radiological material treatment or storage facilities are discussed in Section 2.2.2.

As shown in Figure 2.1-3, the following facilities are located at or near the CGS site:

- Energy Northwest Plant Engineering Center,
- H. J. Ashe Substation,
- DOE Fast Flux Test Facility (FFTF),
- WNP-1 and WNP-4 sites,
- DOE 618-11 (Wye) radioactive waste burial ground,
- Permanent meteorological tower,
- Independent Spent Fuel Storage Installation (ISFSI), and
- Hydrogen Storage and Supply Facility.

Other facilities that are located within a 5-mile radius of the site include:

- The Plant Support Facility/Emergency Operation Facility which is located 0.75 miles southwest of CGS on Energy Northwest property,
- The Benton Substation which is located 3 miles east-southeast of CGS on DOE property,
- The Laser Interferometer Gravitational-Wave Observatory (LIGO) which is located approximately 3.3 miles west-southwest of CGS on DOE property, and
- The DOE 618-10 (300 North) radioactive waste burial ground which is located approximately 3.5 miles south of CGS on DOE property.

Transportation needs of CGS can be met by existing barge, rail, and highway facilities. Barges of up to 3000 tons capacity can be accommodated on the Columbia River within the Hanford Site. A barge unloading facility 9 miles south of the plant was used for delivery of large construction items for the DOE FFTF and Energy Northwest nuclear projects. These materials were transported by truck or rail to the construction sites from the Port of Benton landing.

The CGS site is serviced by a two-lane paved access road connected to Hanford Site Route 4, which is a paved four-lane major artery located 1.6 miles west of the station. Route 4 is part of the DOE road system. The DOE-owned road system connects the areas of the Hanford Site with paved two-lane and four-lane primary roads, secondary gravel roads, and unimproved roads. State Highway 240 traverses the Hanford Site from the southeast to the northwest. The highway passes within about 7 miles of CGS in the southwest quadrant. The highway connects into State Highway 24, which goes west to Yakima, Washington, and across the Vernita Bridge on the Columbia River 22 miles to the northwest (see Figure 2.2-1).

The Hanford Site (DOE) railroad system (see Figure 2.2-2) connects with commercial rail systems in Richland and Kennewick, Washington. Railroad operations that pass through CGS property are restricted to only those trains that have been authorized by Energy Northwest Security. The rail line is physically blocked at the two points where the plant vehicle barrier crosses the tracks.

Heavy barge traffic north of the Port of Benton dock is not feasible because the river channel is too shallow and the current is too swift. The environmental impact and economic cost of constructing a new barge slip at some upstream location and channeling the river cannot presently be justified with the availability of land transportation between the Port of Benton facility and the Hanford Site.

Making the Columbia River navigable for barges from north of Richland to Wenatchee would result in barge traffic past the CGS site at River Mile 352. However, this situation would not likely occur. Locks or other lift facilities would have to be constructed at the Priest Rapids, Wanapum, and Rock Island Dams. Furthermore, in 2000, a presidential executive order created the Hanford Reach National Monument, protecting the 51-mile Hanford Reach of the Columbia River (Reference 2.2-2). The protected area includes a ¼-mile-wide corridor on the west side of the river in the vicinity of CGS.

Airports, military facilities, low-level Federal airways, and airport instrument approaches in the vicinity of CGS are discussed in Section 3.5.1.6 and shown in Figure 2.2-3.

An explosives and ordinance test site operated by Pacific Northwest National Laboratory approximately 13 miles northwest of the site was abandoned in mid-1975 (Reference 2.2-3). Explosives for operations such as quarrying or seismic studies on the Hanford Site are brought to the blasting site as needed and unused quantities are removed. Normally the only explosives

stored on the Hanford Site are small arms ammunition for use by the security patrols. A small arms firing range used for training by the DOE security patrol is located 8 miles due south of the plant (Reference 2.2-3). Another range, used by Energy Northwest security personnel, is located 1.5 miles east-northeast of CGS on Energy Northwest lease property.

2.2.2 DESCRIPTIONS

2.2.2.1 Description of Facilities

Energy Northwest's Plant Engineering Center is located west of the CGS turbine generator building as shown in Figure 1.2-1. It is a two-story, 100,000 ft^2 facility designed to house approximately 470 CGS plant staff personnel.

The H. J. Ashe Substation is located approximately 0.5 mile north of CGS and is operated by the Bonneville Power Administration as part of its transmission system.

The Energy Northwest permanent meteorological tower is located less than 0.5 mile west of the plant site. The tower is automated so that the only personnel at the tower are those required to make adjustments to the instruments or to perform repairs to the system. There are no permanent personnel at the facility.

The ISFSI is located immediately north-northwest of the plant. Confinement of all radioactive materials at the ISFSI is provided by the required use of NRC certified spent fuel storage casks listed in 10 CFR 72.214. The ISFSI storage cask system consists of an inner stainless steel multi-purpose canister (MPC) and an outer storage overpack. The MPC contains the spent fuel. It is a welded pressure vessel with no bolted closure or mechanical seals. Primary closure welds are examined and leakage tested to ensure their integrity. The MPC redundant closures are designed to maintain confinement integrity during normal conditions of storage, and off-normal and postulated accident conditions. The outer storage overpack is fabricated from concrete and structural steel components that are classified as important to safety. A fully loaded spent fuel storage cask weighs approximately 185 tons. The spent fuel loaded storage casks are located within the Energy Northwest ISFSI protected area which is surrounded by a fence and topped with barbed wire. The ISFSI access gates are locked except when in use.

The Hydrogen Storage and Supply Facility is located 0.6 miles south-southeast of the plant site. The facility is part of a hydrogen water chemistry system to prevent and mitigate intergranular stress corrosion cracking in reactor internal structures and piping welds. The facility consists of a fenced gravel yard with concrete pads constructed to accommodate a liquid hydrogen tank, nitrogen tank, gaseous hydrogen tubes, and all supporting piping and equipment necessary to supply CGS with gaseous hydrogen. The liquid and compressed gases are delivered to the facility by truck.

Within the exclusion area radius of 1950 m is Energy Northwest's 1250-MWe WNP-1 project. Construction of the PWR plant, located 1500 m (4925 ft) east-southeast of CGS, was suspended in April 1982. In May 1994 the Energy Northwest Board of Directors voted to terminate WNP-1. The construction of twin unit WNP-4, located 1250 m (4100 ft) east-northeast of CGS, was terminated in January 1982. These projects have a separate access road that ties into the Hanford Site Route 4, 1.6 miles south of the CGS access road. Support activities at either the WNP-1 or WNP-4 sites do not interfere with operation of CGS. These may include activities associated with site restoration and economic development (such as leasing of excess facilities for office space and manufacturing). Within the exclusion area, Energy Northwest has the authority to determine all activities within the meaning of 10 CFR 100.3(a), including the authority to remove all personnel and property from the area.

The Laser Interferometer Gravitational-Wave Observatory (LIGO) is located approximately 3.3 miles west-southwest from the plant site. The mission of this research facility is to observe gravitational waves of cosmic origin. The facility houses laser interferometers, consisting of mirrors suspended at each of the corners of an L-shaped vacuum system measuring 2.5 miles on a side. The materials and activities at this facility do not impact the operation of CGS.

As discussed in Section 2.1.1 and shown in Figure 2.1-1, CGS is located on the DOE Hanford Site. In reviewing the plant site and the vicinity for potential external hazards or hazardous material, the Hanford facilities currently operating, recently operating, or with the potential for operating were screened. The facilities discussed below are those believed to pose the most risk to the safe operations of CGS. The safety analysis reports and accident analysis prepared for those facilities were reviewed to determine possible hazards. No accidents evaluated present a physical challenge to the CGS buildings. Releases with the potential to impact the operation of CGS were radioactive particulate that would be effectively mitigated within General Design Criterion (GDC) 19 limits by the control room high-efficiency particulate air (HEPA) filters. Considered but not included were the 200 East Burial Grounds, the Critical Mass Laboratory, the Liquid Effluent Retention Facility, and the Effluent Treatment Facility in the 200 East Area. In the 200 West Area, the T Plant, U Plant, Reduction-Oxidation Plant, and the 222-S Laboratory were considered but not included. These facilities have insufficient radiological or toxicological inventories in a dispersible form to represent a risk to CGS operation. The specific facilities included are discussed in Table 2.2-1.

Three DOE facilities are located within a 5-mile radius of the plant site. These are the Fast Flux Test Facility (FFTF) and two radioactive waste burial grounds. The specific hazards associated with these facilities are summarized in Table 2.2-1 and the specific activities are listed below:

- The FFTF is a deactivated sodium cooled breeder reactor located approximately 3 miles southwest of CGS. All fuel has been removed and shipped to the Idaho National Laboratory. All sodium has been removed, solidified, and is stored on-site. The facility has been placed in a long-term, low-cost surveillance and maintenance condition.

- The 618-10 (300 North) Waste Burial Ground is approximately 3.5 miles south of CGS. DOE has initiated remediation activities at the site.

- The 618-11 (Wye) Waste Burial Ground is directly west of CGS, outside of Energy Northwest leased land, but within its 1950-meter exclusion area radius and security perimeter. The site received low- to high-activity waste, fission products, some plutonium-contaminated waste, and non-radiological hazardous waste from March 1962 to December 1967 from the Hanford 300 Area. The waste is buried in 3 trenches, 50 Vertical Pipe Units (VPUs), and four caissons. The site was covered with an overburden of soil when it was closed. The surface was stabilized in 1982 with an additional 2 ft of soil. Since surface stabilization, activities at the site have been limited to monitoring and surveillance. DOE completed non-intrusive surveillance and characterization activities at the site in 2011 to obtain data information and information for planning remediation activities.

The DOE 300, 200 East, and 200 West Areas are located within a 10-mile radius of the site. The current waste management activities (storage, disposal, and treatment) conducted in these areas are discussed in Table 2.2-1. The 300 Area is approximately 7 miles southeast of CGS. The only hazard presented to CGS from this site is from the spent nuclear fuel and other radioactive material stored there. There is an unknown quantity of miscellaneous reactor fuel material in the 300 Area. This quantity is not publicly available information.

The DOE 200 East and 200 West Areas are approximately 10 miles northwest of CGS. Originally these facilities were constructed to support the extraction of weapons grade plutonium for the defense program. However, as the Hanford mission has changed from production to environmental cleanup, so has the purpose of the facilities discussed. This change in mission has, in some cases, resulted in a change in the hazards presented to CGS plant site and personnel.

A private (non-DOE) low-level radioactive waste disposal area is adjacent to 200 East Area. There are also plans to build private waste vitrification facilities adjacent to 200 East. These facilities are also discussed in Table 2.2-1.

Several plutonium production reactor facilities are located approximately 20 miles north-northwest of CGS. All of the reactors were water cooled, graphite moderated. The last operating reactor, the N Reactor, was permanently shut down in 1991. The N Reactor also provided steam for the Energy Northwest Hanford Generating Station until 1987. The fuel has been removed from the reactors for storage or treatment. The current activities at these reactor sites are also discussed in Table 2.2-1.

The nearest petroleum product storage tanks are located 22 miles southeast of the site: approximately 23 million gal capacity at the Chevron Pipeline Company and approximately 20 million gal capacity at the Tidewater Barge Lines.

2.2.2.2 Description of Products and Materials

The existing Hanford Site railroad track (owned by the DOE and operated by a private contractor in support of the Hanford Operations), and the CGS, the WNP-1, WNP-4, and the FFTF railroad spurs all run within the exclusion area of the plant site. Shipments of large quantities of hazardous materials on this track that existed during initial licensing of CGS are no longer made (Reference 2.2-4).

The DOE has no plans for railroad shipments of explosives in the foreseeable future. However the DOE's Richland Operations Office has agreed to notify Energy Northwest prior to transporting any explosive shipments of more than 1800 lb past CGS (Reference 2.2-5). Energy Northwest will provide an analysis to the NRC of the potential consequences prior to the start of such shipping (Reference 2.2-6).

Hazardous material is also transported on Hanford Route 4 by DOE. Chlorine is the only material of concern transported on Route 4 with the potential for impacting CGS operation. Section 6.4.4.2.1 provides additional information on control room habitability assessments for CGS.

The Yakima Training Center, a sub-installation of Fort Lewis, is 30 miles northwest of the site. The center consists of 327,000 acres. The center provides training facilities and logistical support and it is used for firing of all types of ordnance, both in a direct mode and by indirect artillery and mortars. Weapons to 155mm are fired. This type firing occurs frequently. Other types of live ordnance use at the center include aerial delivery by high performance aircraft of ordnance to include 2,000-lb bombs, helicopter weapons which include automatic weapons and

2.75-in. folding fin rockets, and anti-aircraft missiles. These latter activities are significant as to occurrence. The majority of the ordnance impacts a 20,000-acre area which is generally located in the central portion of the center. All activities are confined to the geographical limits of the center and/or its restricted air space unless special arrangements are made with affected agencies. Mechanized units (i.e., tanks and armored personnel carriers) from Fort Lewis and reserve components conduct extensive maneuvers on all accessible areas of the Training Center and use specially designed ranges to practice firing their weapons. Infantry and engineer units that support the mechanized units also train at the center. Training activity is greatest from March to November. War games sometimes involve troop and equipment deployment at the Richland Airport and along Highway 243 west of Vernita Bridge. Helicopters may fly near the Hanford Site, or military vehicles may travel over Highway 240 (Reference 2.2-7).

2.2.2.3 Pipelines

There are no commercial oil or gas pipelines in the vicinity of CGS. The nearest major natural gas transmission pipeline to the site is about 12 miles. A 20-in. gas transmission line of the Northwest Pipeline Corporation is located east and essentially parallel to U.S. Highway 395 between Pasco and Ritzville, Washington. A second pipeline system consisting of parallel 36-in. and 42-in. lines, owned by Pacific Gas Transmission Company, passes through Wallula, approximately 24 miles from the site (Reference 2.2-8). These distances eliminate any potential hazard to plant operations due to a natural gas fire or explosion. The Energy Northwest Hydrogen Storage and Supply Facility is located 0.6 miles south-southeast of the plant and is connected to the plant with a 2-in NPS gas pipeline. The pipeline runs north from the facility approximately 400 ft east of the plant and then turns and runs west approximately 400 feet north of the plant then south approximately 200 ft west of the plant to its connection point on the west side of the Turbine Building. Fire and explosion risks to the plant involving this pipeline are discussed in Appendix F and Section 3.5.1.5.

2.2.2.4 Waterways

Makeup water inlet structures are located in the Columbia River 315 ft from the shoreline at low river flow (36,000 cfs; el. 341.73 ft) at river mile 351.75.

A significant amount of Columbia River barge traffic moves as far upstream as the Ports of Pasco and Kennewick. Also, a docking facility established by the Port of Benton in North Richland (approximately 9 miles downstream of the CGS site) is accessible by barges with a maximum 16 ft of draft (normally 2500 to 3000 tons). The first use of this facility was in April 1973 when the FFTF reactor vessel was off-loaded. Traffic to the North Richland dock is very infrequent in comparison to that in Pasco and Kennewick due to the lack of large industrial concerns in the region between Richland and Priest Rapids Dam. This facility is most often used to off-load dismantled nuclear components. On several occasions in the past,

lightly loaded barges have transported material to the vicinity of the Hanford Site. This required maintenance of an adequate flow from Priest Rapids Dam during the transit period.

2.2.2.5 Airports

Three commercial airports are within 20 miles of CGS. The closest is Richland Airport 11 miles south of the plant. This general aviation airport has two 4000-ft runways, one with a 010°/190° orientation and the other with a 070°/250° orientation. Visual flight rule landings are standard for Federal Aviation Administration (FAA) non-control-tower airports.

The Tri-Cities Airport 17 miles southeast near Pasco is the largest airport within 40 miles. The FAA operates the air traffic tower and airport radar approval control facility. The airport has two 7700-ft crossing runways with 120°/300° and 030°/210° orientations. The latter has a 4430-ft parallel runway. Runway 30 has a very high frequency omnirange (VOR) instrument approach and Runway 21R has an instrument landing system and is an instrument approach runway.

The Vista Airport operated by the Port of Kennewick is a general aviation airport located 18 miles south-southeast. It has a 4000-ft runway with a 20°/200° orientation. All operations are under visual flight rules.

Information relative to the flight paths and activity at these three commercial airports, the Yakima Training Center, and the nearby private airstrips is discussed in Section 3.5.1.6.

2.2.2.6 Projection of Industrial Growth

There is no projected growth of waterway traffic nor plans for oil and gas pipelines within 10 miles of CGS.

2.2.3 EVALUATION OF POTENTIAL ACCIDENTS

2.2.3.1 Determination of Design Basis Events

Energy Northwest has investigated the resistance of plant structures to explosions. The reactor building is a reinforced-concrete structure up to the refueling floor and is designed to withstand the worst probable combination of wind velocity and associated pressure drop due to a design basis tornado. A differential pressure of 3 psi between the exterior and interior of the building is also considered in the design. At its nearest point, the railroad is 510 ft from the reactor building.

From the above criteria, it has been determined that the reactor building can resist an explosion of 20,000 lb of dynamite on a railway car 510 ft from the reactor building. The performance of the reactor building structure for this blast loading condition will be similar to that for the

original design basis tornado loading condition based on the 3 psi differential pressure used in the original tornado analysis.

In the unlikely event of an explosion or fire on the railroad affecting the 115-kV shutdown power supply, the 230-kV power supply or the diesel generators would fulfill that function.

It is extremely unlikely that an explosion or fire on the mainline railroad would compromise the safe shutdown of the facility. As noted in Section 2.2.2.2, DOE has no plans to ship explosives on the railroad, and the agency will notify Energy Northwest prior to the shipment of explosives in a quantity greater than 1800 lb. Energy Northwest Security controls access to the rails that pass near the plant. The only explosives on the Hanford Site are small arms munitions. As described in Section 2.2.2.2, this represents no hazard to the operation of CGS. The Yakima Training Center does not endanger the site. Hydrogen gas stored in the gas bottle storage building and in a trailer parked adjacent to the gas bottle storage building will not pose any fire or explosion problem because of the light weight properties and dispersal qualities of the gas and the distances (approximately 400 ft) between the storage areas and any safety-related equipment. Hydrogen gas stored at the Hydrogen Storage and Supply Facility (HSSF) and transported to the plant by pipeline does not pose a significant fire or explosion risk to the plant as discussed in Appendix F and Section 3.5.1.5. Habitability considerations for the control room and quantities of hydrogen gas stored in/adjacent to the gas bottle storage building and at the HSSF are discussed in Section 6.4.4.2.3.

Table 2.2-1 summarizes the potential events at the Hanford Site facilities that could present a radiological or chemical hazard or hazardous situation to the continued safe operation of CGS. The cesium and strontium capsules stored at the Waste Encapsulation and Storage Facility (WESF), the fuel stored at the K Basins, and the high level waste stored in the tank farms present contributions to risk at CGS due to presence of ^{137}Cs, ^{90}Sr, and ^{241}Am. However, based on consideration of the radionuclide inventory at risk, the ability to transport this inventory, and the proximity of the storage facility, the risk is dominated by the inventory stored at WESF. The probability of the loss of cooling in the capsule storage pool is extremely low, but the potential dose to unprotected CGS personnel due to the release is significant. Any required evacuations would be performed as discussed in the Emergency Plan. The design basis accident at WESF would not result in a condition at CGS which would challenge the criteria established in 10 CFR 100.

In each event evaluated, the radiological dose resulting from particulate releases would be adequately filtered by the control room HEPA filters, mitigating any challenge to the habitability of the control room. None of the facilities present a chemical exposure risk to CGS. Radiological exposures for postulated events on the Hanford Site are characterized by the contribution from gaseous radionuclides because of the short half-life of ^{131}I and because the other noble gases were released during the spent fuel processing.

The Yakima Training Center, discussed in Section 2.2.2.2, is used for military maneuvers and weapons training and is the only significant military activity in the vicinity of the Hanford Site. The only weapon currently in use at the Yakima Training Center known to present a hazard to the Hanford Site is the multiple launch rocket system (MLRS). With a range in excess of 25 miles, the MLRS could potentially impact the CGS site. However, the MLRS is only fired from the perimeter of the Yakima Training Center into a centrally located impact zone and is only fired with dummy warheads. Given this information, additional safety features, and the administrative controls in place at the Yakima Training Center, a weapons accident having an impact on CGS is very improbable.

As stated in Section 2.2.2.1, confinement of all radioactive materials at the ISFSI is provided by the required use of NRC certified spent fuel storage casks listed in 10 CFR 72.214. Pursuant to the 10 CFR 72.212 report, evaluations performed in support of the ISFSI have demonstrated the reactor site-specific parameters are bounded by the safety analysis for the generically approved cask. Accordingly, activities associated with the facility do not adversely impact operation of CGS (Reference 2.2-10).

Brush fires have occurred on the Hanford Site and have presented no potential hazard to existing facilities. Areas adjacent to CGS major buildings and auxiliary facilities are maintained to prevent weed growth by landscaping, gravel, ground cover, and weed control spraying. The Hydrogen Storage and Supply Facility (HSSF) is landscaped with gravel beyond the perimeter of the site, exceeding the code required clearance distance, to keep the area free from dry vegetation and combustible materials. These or similar methods of weed control minimize brush fire hazards to CGS facilities.

The potential effects of fires that involve materials used in the operation of the plant are discussed in Appendix F.

The formation of unconfined vapor clouds caused by the accidental release of flammable or toxic liquids or vapors stored at the plant site is discussed in Section 6.4 and addressed by the Emergency Plan.

The non-safety-related makeup water intake consists of two sets of paired perforated pipe sections. One set is capable of supplying the full makeup water requirements of the plant. Extreme low river flow (36,000 cfs) will provide about 0.5 ft of water over the top of the intake pipes. The probability of damage to both sets of intakes as a result of a pleasure boat or barge accident is extremely remote given the infrequency of both extreme low flows and large boat and barge traffic. In the unlikely event that such an accident might occur, destruction of the makeup water intake structure would be comparable in effect to loss of offsite power to the makeup water pumps. The Seismic Category I spray ponds provide for 30-day cooling without makeup. This is ample time to restore makeup from either the river or wells.

There are no upstream industrial facilities for which waterborne deliveries of significant quantities of petroleum products, corrosive chemicals, or other hazardous materials are expected. Fuel oil, diesel oil, acids, and caustics are stored at the N-Reactor site. The oil storage facilities are protected by dikes, and the chemical storage facilities are far enough from the river to avoid direct discharge. Thus, there is no possible hazard to the plant due to spillage of such materials into the river. There are no upstream releases which may be corrosive, cryogenic, or coagulant.

2.2.3.2 Effects of Design Basis Events

As discussed in Section 2.2.3.1, the activities of nearby industrial, transportation, and military facilities will have no adverse effect on the plant.

2.2.4 REFERENCES

2.2-1 Holmes, D. B., Energy Northwest, personal communication with Steve Burnam, Site Infrastructure Division, Department of Energy, July 31, 1998.

2.2-2 Presidential Proclamation 7319, Establishment of the Hanford Reach National Monument, 65 FR 37253, June 9, 2000.

2.2-3 Chasse, J. P., Energy Northwest, personal communication with B. J. Rokkan, Safeguards and Security Division, DOE, Richland Operations Office, December 6, 1977.

2.2-4 Note, D. A. Marsh, Westinghouse Hanford, to D. E. Larson, Supply System, dated January 22, 1993.

2.2-5 Memorandum, C. A. Hansen, Assistant Manager for Waste Management, DOE-RL to Alice Q. Murphy et al., 98-WPD-032, February 20, 1998.

2.2-6 NUREG 0892, Safety Evaluation Report Related to the Operation of WPPSS Nuclear Project No. 2, Section 2.2.1, March 1982.

2.2-7 Arbuckle, J. D., Energy Northwest, personal communication with J. Reddick, Executive Officer, Yakima Training Center, July 29, 2003.

2.2-8 Hosler, A. G., Contact with Local Organizations to Support CSB SAR Chapter 1 (Memo 042AGH.96 to Canister Storage Building Report File), Science Applications International Corporation, May 6, 1998.

2.2-9 Deleted.

2.2-10 Energy Northwest, Independent Spent Fuel Storage Installation 10 CFR 72.212 Evaluation, Docket Number 72-35, Revision 1, September 2002.

Table 2.2-1

Hanford Site Nuclear Facilities

Facility	Description	Hazard	Design Basis Event	Impact on CGS
Fast Flux Test Facility (FFTF) Ref: Surveillance and Maintenance Plan for FFTF, Rev. 0, DOE/RL-2009-26	Deactivated sodium cooled breeder reactor	Activated solid sodium	1) 180,000 lb sodium spill - 2-hr dose at 1.5 mi = 0.015 mrem, 24-hr dose at 4.5 mi = 0.26 mrem	Particulate release, effectively mitigated by distance
DOE 618-10 (300 North) Waste Burial Ground Ref: Final Hazard Categorization for the 618-10 Burial Ground Remediation, Rev.2, February 2011, WCH-390	Disposal site with broad spectrum of low- to high-level solid radioactive wastes buried in caissons or pipe	Radioactive waste	Caisson penetration with fire — unmitigated dose at 5 km = 10.2 mrem	Particulate release, effectively mitigated by distance (>5 km)
DOE 618-11 (Wye) Waste Burial Ground Ref: 618-10 and 618-11 Waste Burial Grounds Basis for Interim Operation, Rev. 1, WCH-183	Disposal site with broad spectrum of low- to high-level solid radioactive wastes and non-radiological hazardous materials buried in caissons or pipe	Radioactive waste inventories, primarily Cs-137, Sr-90, and Pu-239 and non-radiological hazardous materials bounded by beryllium	Caisson penetration with fire and explosion: control room doses are less than 0.1 rem; beryllium oxide concentration of 4.6×10^{-3} mg/m^3 at 100 m from 618-11 site boundary	Particulate release, effectively mitigated by credited 618-11 Waste Burial Ground project controls. The soil overburden covering the VPUs and caissons in the 618-11 Waste Burial Ground is credited for reducing releases and is designated as a passive design feature. No missiles are postulated for this event.

Table 2.2-1

Hanford Site Nuclear Facilities (Continued)

Facility	Description	Hazard	Design Basis Event	Impact on CGS
B Plant Ref: B Plant Basis for Interim Operation, March 6, 1997, HNF-SD-BIO-003	Process to remove cesium and strontium from radioactive waste, deactivated, currently in surveillance and maintenance mode	Residual radionuclide inventories on cell filters (^{137}Cs, ^{90}Sr, and ^{241}Am)	Flooding cell 291-B HEPA filters - 0.368 rem max. public dose	Particulate release effectively mitigated by distance
Plutonium-Uranium Extraction Facility (PUREX). PUREX End State Basis for Interim Operation (BIO) 1997, HNF-SD-CP-15B-004 (Draft)	Currently shut down, in preparation for decommissioning and decontamination	Residual plutonium and uranium contamination	Design basis earthquake, dose @ 100 m - 1.9 rem; 12 km - 7.4 x 10^{-4} rem	Particulate release, mitigated by distance
Plutonium Finishing Plant (PFP) Ref: Plutonium Finishing Plant Final Safety Analysis Report, 1995, WHC-SD-CP-SAR-021	Receipt and storage of SNM, reactive material stabilization, radioactive and mixed waste handling	Stored SNM, and residual plutonium contamination	Design basis earthquake, 8-hr dose of 15.2 rem @550 m 24-hr dose of 0.31 rem @12,500 m	Particulate release, mitigated by distance
Tank Waste Remediation System (TWRS) Facilities Ref: Tank Waste Remediation System Basis for Interim Operation, 1997, HNF-SD-WM-BIO-00, Revision 0	Mixed radioactive and chemical wastes storage in 149 single shell tanks (SST) and 28 double shell tanks (DST) in 12 tank farms Associated support facility: 242-A-Evaporator	SSTs contain combinations of sludge, saltcake, and interstitial and pooled liquids DSTs contain liquid and slurry waste with small amounts of sludge		

Table 2.2-1

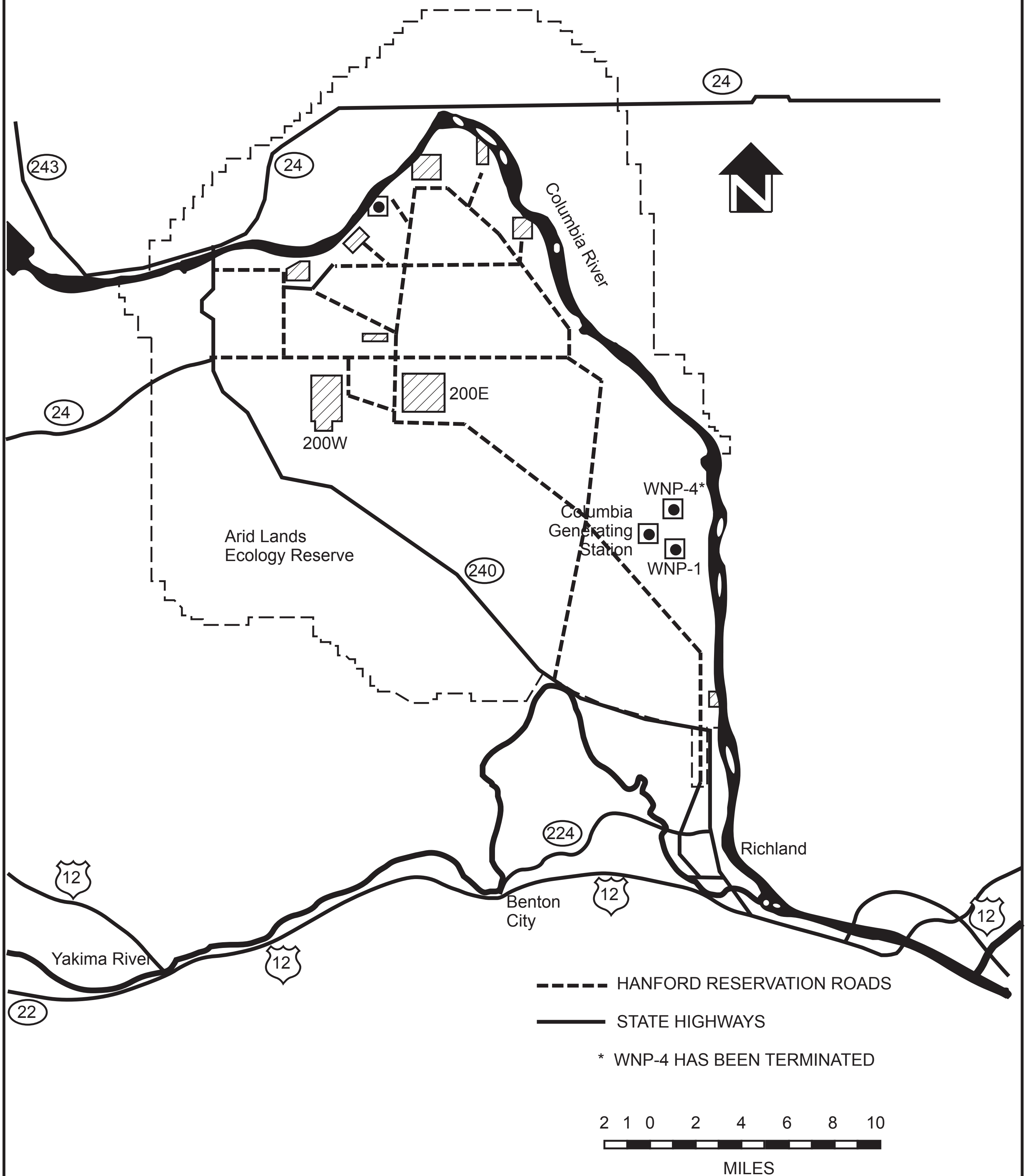
Hanford Site Nuclear Facilities (Continued)

Facility	Description	Hazard	Design Basis Event	Impact on CGS
Tank Waste Remediation System- Project (TWRS-P) (private facilities, proposed for construction in 2000) Ref: DOE/RL-96-0006	Vitrify low level, high level, and transuranic mixed waste	High level radioactive waste	Requirements for authorization limit to less than 25 rem/event in an accident. Releases are projected to be airborne particulate.	HEPA filter system would protect CGS control room operators, in accordance with the limits of GDC 19
Waste Encapsulation and Storage Facility (WESF) Ref: Waste Encapsulation and Storage Facility Basis for Interim Operation, 1997, HNF-SD-WM-BIO-002	Conversion process for cesium and strontium has halted	Cesium chloride and strontium fluoride salts, encapsulated in double-walled metal containers stored in water-filled cooling basin	Capsule rupture following loss of water from storage pool - 24 hr exposure to public, 9 rem	Control room exposure mitigated by HEPA filters; potential evacuation of other personnel
Low-Level Waste Disposal Site (Private)	Buried storage of low-level radioactive waste in lined containers	Low-level buried waste, monitored as required by NRC license	No credible event	None
Canister Storage Building (CSB) Ref: Letter; DOE to H. J. Hatch, Flour Daniel Hanford, 28 May 97	Storage of spent nuclear fuel (SNF) from the K Basins in sealed multi-canister overpacks (MCO)	2100 metric tons of spent fuel, from production reactors	Requirements for authorization limit to less than 5 rem/event in an accident. Releases are projected to be airborne particulate	HEPA filter system would protect CGS control room operators, in accordance with the limits of GDC 19
Cold Vacuum Drying Facility (CVDS) Ref: Letter; DOE to H. J. Hatch, Flour Daniel Hanford, 28 May 97	Draining and vacuum drying to remove water from MCOs in preparation for interim storage at CSB	Spray release	Requirements for authorization limit to less than 5 rem/event in an accident. Releases are projected to be airborne particulate.	HEPA filter system would protect CGS control room operators, in accordance with the limits of GDC 19

Table 2.2-1

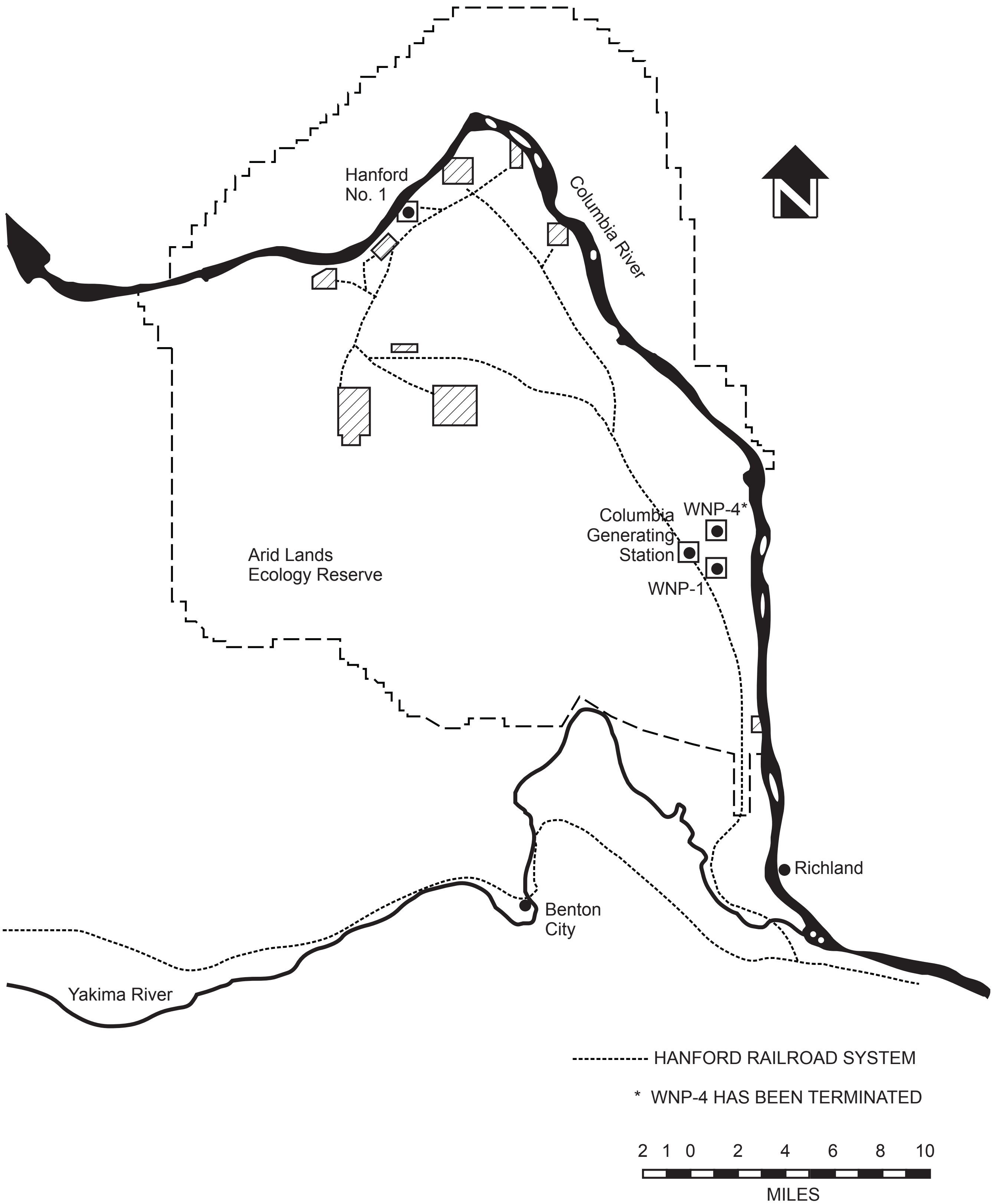
Hanford Site Nuclear Facilities (Continued)

Facility	Description	Hazard	Design Basis Event	Impact on CGS
B, C, D, DR, F, and H Reactors (shutdown since 1969) Ref: WHC-EP-0619, Vol. 1.	Single-pass, water-cooled, graphite-moderated reactors	The onsite hazards involve personnel injury, primarily falls and electric shock. No significant offsite risks	No credible event	None
K East and West reactors (shutdown since 1971) Ref: WHC-EP-0619, Vol. 1.	Single-pass, water-cooled, graphite-moderated reactors	The onsite hazards involve personnel injury, primarily falls and electric shock. No significant offsite risks	No credible event	None
K East and West Basins Ref: WHC-EP-0619, Vol. 1.	Storage basins for spent fuel, some severely degraded	Approximately 2100 metric ton inventory of irradiated reactor fuel	Dropping and overturning of a transfer cask containing reactor fuel. (Bounding event; but transfer is administratively prohibited)	None
N reactor (shutdown since 1987) and N Basin Ref: WHC-EP-0619, Vol. 1. and BHI-00866, Rev 0	A pressure tube, water-cooled, graphite-moderated reactor with fuel assemblies removed for decontamination and decommissioning	The onsite hazards involve personnel injury, primarily falls and electric shock. No significant offsite risks	No credible event	None



Columbia Generating Station Final Safety Analysis Report	Hanford Reservation Road System		
	Draw. No. 990306.15	Rev.	Figure 2.2-1

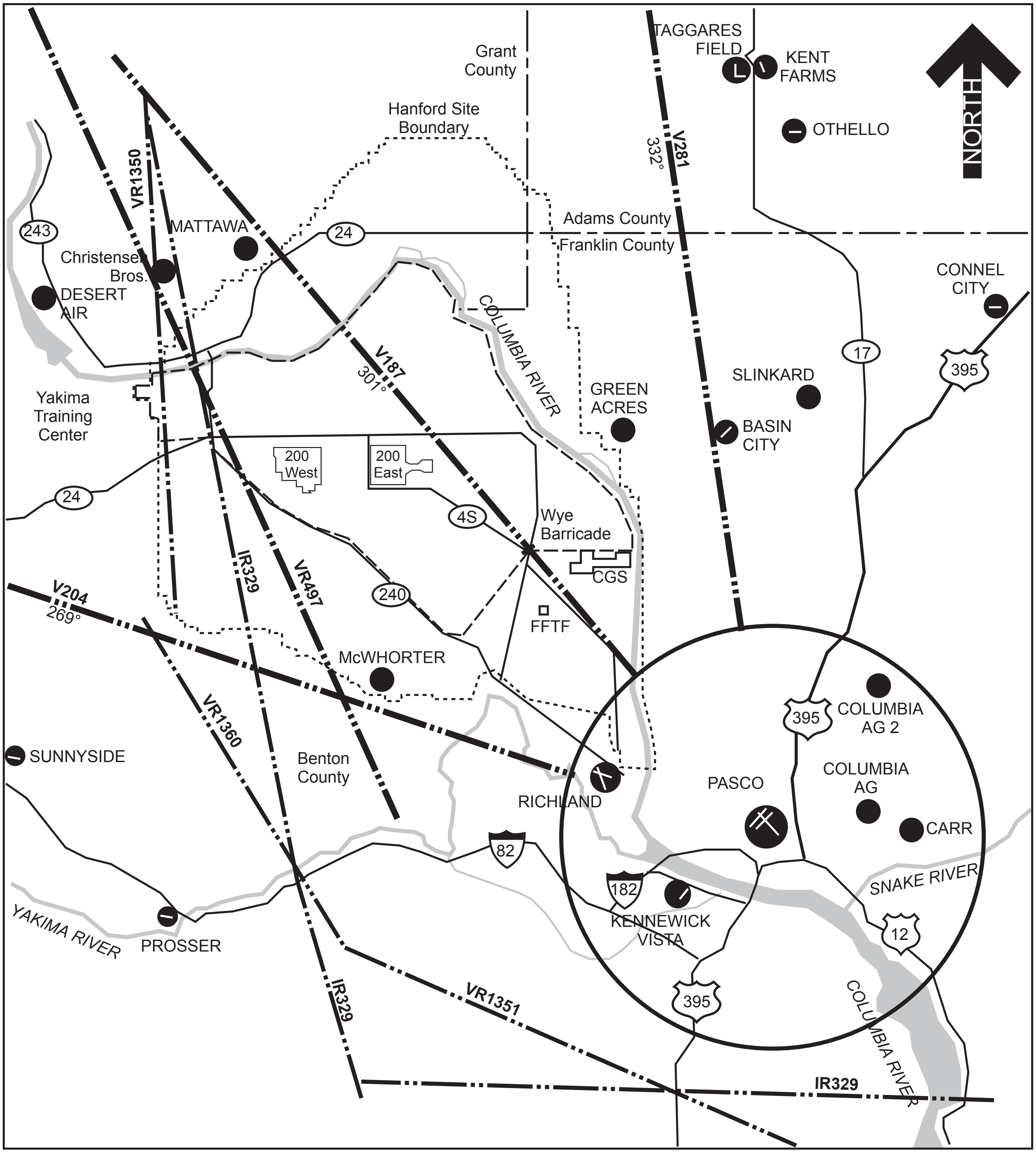
Form No. 960690



Columbia Generating Station
Final Safety Analysis Report

Hanford Reservation Railroad System

Draw. No. 990306.16 | Rev. | Figure 2.2-2



Columbia Generating Station
Final Safety Analysis Report

Federal Airways and Instrument Approaches/Departures

Draw. No. 900547.96	Rev.	Figure 2.2-3

2.3 METEOROLOGY

The italicized information, including associated tables and figures, is historical and was provided to support the application for an operating license.

*2.3.1 REGIONAL CLIMATOLOGY**

2.3.1.1 General Climate

The site is located in a mid-latitude semi-arid (steppe) climatic region in the Lower Columbia Basin which is the lowest elevation of any part of central Washington. A major factor influencing this climatological region is its location in the continent, well away from the windward coast and protected to the west by the 4,000 to 7,000-ft average elevation Cascade Mountains. Dominant air masses affecting the region are of maritime polar origin as modified by the presence of these mountains. Modified continental tropical and polar air masses also periodically affect the climate. In winter, there is a succession of cyclones as the westerlies and the polar front prevail in these latitudes. The mountain barriers commonly induce these storms to occlude by delaying air mass movement. Fewer frontal passages occur during the summer months since subtropical oceanic high cells reach their highest latitudes thereby diverting cyclonic storms poleward. Along the eastern margin of the Pacific anticyclone, an out-flow of stable subsiding air brings distinctly drier conditions to the North American Pacific coast.

The regional temperatures, precipitation, and winds are greatly affected by the presence of the mountain barriers. The Rocky Mountains and ranges in Southern British Columbia are effective in protecting the inland basin from the more severe winter storms and associated cold polar air masses moving southward across Canada. Occasionally, an outbreak of cold air will pass through the Basin and result in low temperatures or a damaging spring or fall frost. Maritime polar air traveling eastward from the coastal zone cools as it rises along the western slope of the Cascade Range. These orographic effects cause heavy precipitation on the windward and light precipitation on the leeward slopes. The prevailing westerly. winds are normally strongest during winter and spring due to the presence of cyclonic scale disturbances and associated frontal activity. During those months, foehn or chinook winds (a warm dry

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** This section is based on records kept at the Hanford Meteorology Station (14 miles northwest of the site, elevation 733 ft MSL) from 1945 to 1980 (2) and 100-N area sites (1) (supplemented with precipitation and temperature data taken by U.S. Weather Bureau cooperative observers at a site about 25 miles north of the present station location during the period from 1912 to 1944 (2,3) and regional climatological data gathered during the period from 1931 to 1960). (4) Other references are as indicated.*

wind on the lee side of a mountain range; the warmth and dryness of the air is due to adiabatic compression upon descending the mountain slopes) occur whenever cyclonic circulation is sufficiently strong and deep to force air completely across the cascades in a short period of time. At other times during the winter, warm front occlusions can force moist air over the Cascade Range. The mixing of this moist air with relatively cooler air in the Basin results in considerable cloudiness and fog. The percent of possible sunshine ranges from 20 to 30 percent in winter, 50 to 60 percent in spring and fall, and 80 to 85 percent in mid-summer.

Because the site is in the rain shadow of these mountains, annual average precipitation decreases from about 100 inches near the summit of the Cascades to about 6 or 7 inches in the Basin. Approximately 70 percent of the annual total precipitation occurs from November through April and about 10 percent occurs during July through September. Rainfall amounts are normally light in the summer and gradually increase in late fall, reaching a peak of about one inch each month in midwinter due to cyclonic storm and frontal activity. Rainfall amounts decrease in Spring, increase somewhat in June, and again sharply decrease in July. During mid-summer, it is not uncommon to have 3- to 6-week periods with trace rainfall. There are only two occurrences per year of 24-hour amounts of 0.50 inch or more, while occurrences of 24-hour amounts of 1.00 inch or more number only four in the entire 25 years of record (1946 to 1970). One of these was the record storm of October 1 through 2, 1957, in which rainfall totaled 1.08 inches in three hours, 1.68 inches in six hours, and 1.88 inches in twelve hours. At the other extreme, there have been 81 consecutive days without measurable rain (June 22 through September 10, 1967), 139 days with only 0.18 inch (June 22 through November 7, 1967), and 172 days with only 0.32 inch (February 24 through August 13, 1968).

About 45 percent of all precipitation during the months of December, January, and February is in the form of snow. Regional annual total snowfall amounts have ranged from less than 1/2 inch in 1957 to 1958 to 56.1 inches for the winter of 1992-1993; the annual average total is about 14 inches.

Snow rarely remains on the ground longer than two to four weeks or reaches a depth at any time in excess of four to six inches, as rapid melting, which often contributes to local stream flooding, can occur from rain or Chinook winds. The record greatest depth of 24.5 inches occurred in February 1916.

Thunderstorms have been observed in the area in every month except November. Although severe ones are rare, lightning strikes have occasionally ignited grass fires which burned thousands of acres of the Hanford Reservation and resulted subsequently in considerable wind erosion of soil. The most notable of these occurrences were in August 1961, July 1963, and July 1970, and August 1984.

The continental-type climate not only affects precipitation in the Basin but also results in wide ranges and variations in annual temperature conditions. While the regional annual average temperature is about 53°F, the coldest month, January, has a mean of about 29°F; the

warmest month, July, has a mean of about 76°F. Although the presence of the cascades contributes to the wide differences in monthly average temperatures, other mountain ranges shield the area from many of the arctic surges, and half of all winters are free of temperatures as low as 0°F. However, six winters in 58 of record have contributed a total of 16 days with temperatures of -20°F or below; and in January to February 1950, there were four consecutive such days. There are ten days of record when even the maximum temperature failed to rise above zero. At the other extreme, in the winter of 1925 to 1926, the lowest temperature all season was +22°F.

Although winter minima have varied from -27°F to +22°F, summer maxima have varied only from 100°F to 115°F. However, there is considerable variation in the frequency of such maxima. In 1954, for example, there was only one day with a maximum as high as 100°F. On the other hand, there have been two summers (1938 and 1967) when the temperature went to 100°F or above for 11 consecutive days.

Although temperatures reach 90°F or above on about 56 days a year, there are only about seven annual occurrences of overnight minima 70°F or above. The usual cool nights are a result of gravity winds.

The channeling of air by the Cascade Mountains and surrounding terrain produces a prevailing WNW and NW regional flow. Local topographic features can cause other channeling effects and formation of local diurnal wind circulation systems which produce a greater degree of variability in winds at locations within the Basin. For example, the Columbia Generating Station (CGS) site experiences a bimodal wind direction distribution from approximately south and also northwest; at the Hanford Meteorological Station (HMS) about 14 miles northwest, the direction distribution displays a single peak at approximately WNW to NW (refer to 2.3.2).

Drainage (gravity) winds channeled by topographic features produce a marked effect on diurnal range of wind speed and cause the highest monthly average speeds of about 9 mph to occur during the summer months. In July, for example, hourly average speeds range from a low of 5.2 mph from 9 to 10 a.m. to a high of 13.0 mph from 9 to 10 p.m. In contrast, the corresponding speeds in January are 5.5 and 6.3 mph. These warm season diurnal winds, resulting from relatively cold air draining from the Cascade Mountains, occur in response to pressure gradients created between surface-heated warm, dry basin air and cooler air situated over the mountains and coastal region. This favors an outbreak of stronger winds during the afternoon and evening hours. Although the gravity wind occurs with regularity in summer, it is never strong unless reinforced by frontal activity. In June, the month of highest average speed, there are fewer instances of hourly averages exceeding 31 mph than in December, the month of lowest average speed. A complete summary of the monthly averages and extremes of climatic elements at the Hanford Reservation appears in Table 2.3-1.

2.3.1.2 Regional Meteorological Conditions for Design and Operating Bases

2.3.1.2.1 Severe Weather Phenomena

2.3.1.2.1.1 Heavy Rain, Snow, and Ice. Glaze is a coating of ice, generally clear and smooth, but with some air pockets. It is formed on exposed objects by the freezing of super-cooled drizzle or rain drops. Glaze is denser, harder, and more transparent than either rime or hoar frost. Although the record shows an average of seven glaze days per year, many of these cause little or no inconvenience to the public. Two outstanding exceptions occurred on February 11 to 12, 1954, and on November 23 to 24, 1970. There was serious disruption to Hanford traffic in each instance although there was no known damage to transmission lines. In each instance, rising temperatures soon melted the ice.

Precipitation frequency (rain and snow), intensity, and quantity statistics are presented in Figures 2.3-1 and 2.3-2 and Tables 2.3-2 and 2.3-3. For the winter of 1992-93, the following snowfall records were set: greatest winter snowfall (56.1 inches); most days with greater than 1, 6, and 12 inches on the ground (71, 41, and 9, respectively); and greatest 24-hour snowfall (10.2 inches) on February 18 and 19. Probable maximum precipitation is given in 2.4.3.1.

2.3.1.2.1.2 Thunderstorms and Hail. Thunderstorms may occur during any month of the year at Hanford. A thunderstorm day is one in which thunder is heard. If a thunderstorm should begin in late evening and last past midnight, it is counted as two thunderstorm days even though only one storm event occurred. Similarly, should there be two or more distinct thunderstorms in a day - and this sometimes happens - it is counted as a single thunderstorm day. The table below shows the monthly frequency of thunderstorms.

HMS THUNDERSTORM DAYS: 1945-1970

	J	F	M	A	M	J	J	A	S	O	N	D	SUM
Total	0	1	7	18	53	64	46	54	24	5	0	0	272
Average	0	#	#	1	2	3	2	2	1	#	0	0	11
% of Total	0	#	3	7	19	23	17	20	9	2	0	0	100

 # = Less than 0.5

Although the table above shows 0 for the months of November through January, a thunderstorm occurred at HMS on December 22, 1971. In Richland, one occurred on January 18, 1953. However, the thunderstorm season essentially includes only the months of April through September. Although the average is eleven days per year, the number has varied from three to twenty-three. In June 1948, there were eight thunderstorm days during the month; and this record was repeated in August 1953. The records show that cold fronts probably constitute the greatest single cause of thunderstorms at HMS. During the years of 1947 to 1955, 43 percent of all thunderstorm days during the months of May through August

were directly associated with cold frontal passages. On several occasions (notably on August 7, 1953), lightning has struck the HMS tower.

Peak gust data are not available for the 50-, 200-, and 400- ft levels prior to 1952. Of the 185 thunderstorm days occurring during the period of 1952 to 1970, the speed classification of peak gusts on these days is as follows:

	Number of Cases			% of Total		
mph	50 ft	200 ft	400 ft	50 ft	200 ft	400 ft
< 21	18	9	5	10	5	3
21 -30	75	45	42	40	24	23
31 -40	63	80	73	34	43	39
41 -50	23	34	46	12	19	25
51 -60	4	11	12	2	6	8
61 -70	1	4	5	1	2	3
> 70	1	2	2	1	1	1
	185	185	185	100	100	100

Precipitation was not measured during 1945 and 1946 in which 26 thunderstorm days occurred. During the period of 1947 to 1970, 246 thunderstorm days were recorded. The daily precipitation distribution during these days was as follows:

Amount - Inches	Number of Cases	% of Total
None or trace	110	45
0.01 - 0.10	87	35
0.11 - 0.25	29	12
0.26 - 0.50	15	6
> 0.50	5	2
	246	100

Precipitation intensities are defined in Reference 2.3-5.

The record for rainfall intensity during a thunderstorm is 0.55 inch in 20 minutes (1.65 inches per hour) on June 12, 1969. This storm included hailstones of 1/4-inch diameter.

Hail was reported on fourteen, or 5 percent, of the total thunderstorm days. Blowing dust or dust was reported on sixteen thunderstorm days and both hail and blowing dust or dust on six days.

Hail is a rare phenomenon at Hanford. For all years of record, hail has not occurred more than twice in any year. Of the 272 thunderstorm days from 1945 to 1970, hail was reported on fourteen or 5 percent of these days. Hail was also reported on two days without occurrence

of either a cold frontal passage or a thunderstorm on the same day. The distribution by months of days on which hail occurred is as follows:

	J	*F*	*M*	*A*	*M*	*J*	*J*	*A*	*S*	*O*	*N*	*D*	*Total*
Number	*0*	*1*	*1*	*4*	*2*	*1*	*2*	*2*	*1*	*0*	*0*	*0*	*14*
% of Total	*0*	*7*	*7*	*30*	*14*	*7*	*14*	*14*	*7*	*0*	*0*	*0*	*100*

Where size was reported, all except two reports indicated sizes in the 0.2- to 0.3-inch range. The exceptions were May 26, 1954, and July 1, 1955, when the size reported was 0.4 inch.

There is no known case of local damage from hail.

2.3.1.2.1.3 Tornadoes

The State of Washington experiences, on the average, less than one tornado each year. Within a one hundred mile radius of the site, only fourteen tornadoes have been reported since 1916. These tornadoes are listed in Table 2.3-4. Of these fourteen recorded tornadoes, only five had any damage associated with them. A more extensive survey of tornadoes in the three northwestern states (Washington, Oregon, and Idaho) was performed by Fujita (6). His results indicate that tornadoes and hailstorms in this area occur primarily in "alleys". The locations of these "alleys" are shown in Figure 2.3-3 along with locations of tornadoes which have been recorded in the tri-state area during the twenty-year period from 1950 to 1969.

Jaech (7) has analyzed the data of Fujita (6) to determine the probability of a tornado striking the Jersey Nuclear Company Fuel Facility (now Siemens Power Corporation), which is located about eight miles from the site. His analysis estimates the probability of occurrence of a tornado in the vicinity of the Exxon site as six chances in a million during any given year or about one chance in four thousand during a forty-year plant life.

The peak tornado wind velocity estimated for the site is 214 mph (Reference 2.3-7). This includes an estimated maximum rotational and translational wind velocities (at a 95-percent confidence level). Daubek (Reference 2.3-8) estimates the maximum translational velocity to be 30 mph. The maximum pressure drop in the center of the tornado relative to the environment is estimated to be up to 1.5 psi (Reference 2.3-6).

These values are equal to or less than those tornado parameters listed for a Class III region (which includes the site location) in Regulatory Guide 1.76, issued April 1974. Prior to the issuance of this guide, CGS was designed to withstand some of the most stringent NRC tornado criteria presented for a site located within a Class I region.

A comparison between criteria used for CGS and those applicable to Class I and III regions are given below:

Design Basis Tornado Characteristics

	Maximum Wind Speed (mph)	Rotational Speed (mph)	Translational Speed (mph) Maximum	Translational Speed (mph) Minimum
Class I Region	360	290	70	5
Class III Region	240	190	50	5
CGS	360	300	60	-

	Radius of Maximum Rotational Speed (ft)	Pressure Drop (psi)	Rate of Pressure Drop (psi/sec)
Class I Region	150	3.0	2.0
Class III Region	150	1.5	0.6
CGS	264 - 880	3.0	1.0

Wind and tornado loading criteria used in the CGS structural design are discussed in Section 3.3.

2.3.1.2.1.4 Strong Winds. *The Hanford region experiences high wind speeds due to squall lines, frontal passages, strong pressure gradients and thunderstorms.[*] The Hanford Reservation has experienced only one recorded tornado (June 1948) and has not been known to be affected by typhoons. No complete statistics are readily available which present frequency of occurrence of high winds produced or accompanied by a particular meteorological event. However, the highest winds produced by any cause are tabulated for HMS in Tables 2.3-5 and 2.3-6. Figure 2.3-4 indicates the return probability of any peak wind gust, again due to any cause.*

The speed-direction summary (Table 2.3-6) shows that daily peak gusts of at least 40 mph have occurred from all but four of the sixteen compass points indicated. The SW octant, however, accounts for 65 percent of such cases. The SSW octant accounts for 83 percent of daily peak gusts of 50 mph or over and 100 percent of those 60 mph or over. Since WNW and NW are the most frequently observed directions at HMS, they account for almost half of all daily peak gusts. However, less than 3 percent of these are at speeds of 40 mph or more. By contrast, 23 percent of daily peak gusts from the SSW and SW attain this speed. Although the winter season has a lower average wind speed than any other, it also has the greatest frequency of days with peak gusts 40 mph or over (10 percent). This compares with 8 percent for spring, 7 percent for fall, and 5 percent for summer. However, reflecting the frequent periods of stagnation in winter, this season also has the highest frequency of days with peak gusts under

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[*]*Peak wind gust data associated with thunderstorm activity are given in 2.3.1.2.1.2.*

10 mph (16 percent). This compares with 10 percent for fall and 1 percent for spring. In summer, such days are virtually non-existent with only one being tabulated in 1,102 days of record. About 60 percent of the days from May through August experience drainage winds of at least 13 mph from the west direction for at least two hours daily during the period of 1600 to 2400 PST.

The annual extreme fastest mile of wind speed* for a given region has been commonly used as the best available measure of wind for design purposes (Reference 2.3-9). The standard reference speed level is normally chosen at the 30-ft elevation, and wind speed is assumed to vary with the one-seventh power of height.

All CGS structures have been designed to withstand a basic wind (fastest mile) velocity, including gusts of 100 mph at an elevation of 30 ft above the site grade. *This design speed value is conservative for the CGS site since the 100 year return period peak gust as shown in Figure 2.3-4 at HMS is 86 mph at an elevation of 50 ft (as given in Tables 2.3-5 and 2.3-6 at that level peak gusts have not exceeded 80 mph during the period 1945 to present). The 100 year return period fastest mile of wind would be less than 86 mph since by definition gust velocity divided by an appropriate gust factor provides the velocity of the fastest mile of wind.* Although not recorded in historical records the 100 year fastest mile of wind can be expected to be in the range of 66 to 78 mph. These values are based on the application of gust factors of 1.3 and 1.1 (Reference 2.3-10) for gusts of one and 10 sec durations** respectively to the estimated historical value of 86 mph.

2.3.1.2.1.5 High Air Pollution Potential (APP) and Dust Storm Potential. Larson (11) has concluded that "consideration of the general weather parameters indicates a significantly high average annual APP over southeastern Washington." Holzworth (12) has estimated that the mean maximum January mixing depth in the Hanford area is about 250 meters, which is nearly the lowest in the contiguous United States, and for July about 2,000 meters. Hosler (13) has indicated a significantly high frequency of low-level inversion in winter over this area - on the order of 43 percent with bases below 150 meters. The occurrence of very stable and moderately stable conditions between the surface and 60 meters in winter at the Hanford Meteorology Tower is 66.5 percent.

Stagnation is defined by Huschke (14) as "the persistence of a given volume of air over a region, permitting an abnormal buildup of pollutants from sources within the region". Defining the establishment of stagnation as an uninterrupted period of daily average wind speed of 5.0 miles per hour or less and/or a peak gust of 15 miles per hour or less, Jenne (15)

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* Fastest mile of wind is generally defined as either the fastest speed associated with 1 mile of passing wind or fastest observed 1 minute wind speed.

** According to Huschke (Glossary of Meteorology, 1959), the duration of a gust is usually less than 20 seconds.

compiled a 15-year summary of Hanford stagnation periods covering the months of November through February (1947-48 through 1961-62).

Both of the two most notable Hanford stagnation periods experienced during this time occurred in November and December 1952. The first period was from November 15 to December 3 (19 days). Then, after five days of ventilation, stagnation set in again December 9 and lasted through December 28 (20 days). Average wind speeds during the two periods were respectively, 2.6 and 2.9 miles per hour. Eleven days during the first period and eight during the second had peak gusts under 10 miles per hour. One day during the first period and two during the second had average speeds less than 1.0 miles per hour with peak "gusts" of 4 miles per hour. There were 13 days of fog in each period.

Although stagnation lasting for 20 days can be expected only one season in twenty, a 10-day stagnation period can be expected every other season. Only one season in three will fail to produce a stagnation period of at least eight days.

Air quality in the Hanford area, in terms of sulfur dioxide, nitrogen dioxide, and suspended particulates, is routinely measured by the Hanford Environmental Health Foundation. (18,29)

For the year 1971, SO2 measurement in Richland averaged less than 0.02 ppm. At other sampling stations, the concentrations were below the detection limit of 0.01 ppm. In 1974, all 24 hour sequential samples of SO2 measured in the vicinity of Richland, North Richland, and Hanford 300 Area had concentrations below the detection limit of 0.005 ppm which is 25% of the annual average ambient air standard of 0.02 ppm. The 1971 and 1974 measurements for NO2 and suspended particulates are shown below:

Air Quality Measurements-Annual Averages for 1971 and 1974 (18, 29)*
(these data are based on 24 hour integrated samples)

	NO2 (pom)			
Location	*No. of Samples*	*Max.*	*Min.*	*Avg.*
Richland (747 Building)	*49*	*6.8*	*0.06*	*0.86*
Opposite Richland	*170*	*0.019*	*<.001*	*0.005*
(Hobkirk Ranch)	*(78)*	*(0.022)*	*(0.001)*	*(0.006)*
Opposite N. Richland	*157*	*3.0*	*<.001*	*0.024*

* *Concentrations in parentheses are for 1974.*

** *High value due to a local dust storm.*

(Gilliam Ranch)	*(130)*	*(0.020)*	*(0.001)*	*(0.006)*
Opposite 300 Area	*170*	*0.025*	*0.001*	*0.005*
(Sullivan Ranch)	*(77)*	*(0.014)*	*(0.001)*	*(0.005)*
Ringold (Keys Ranch)	*166*	*0.028*	*0.001*	*0.006*
White Bluffs (McLane Ranch)	*149*	*0.028*	*0.001*	*0.006*

	Suspended Particulate ($\mu g/m+3$)			
Location	*No. of Samples*	*Max.*	*Min.*	*Avg.*
Richland (747 Building)	*42* *(125)*	*440* *(572)***	*25* *(8)*	*120* *(57)*
Opposite Richland (Hobkirk Ranch)	-	-	-	-
Opposite N. Richland (Gilliam Ranch)	-	-	-	-
Opposite 300 Area (Sullivan Ranch)	-	-	-	-
Ringold (Keys Ranch)	-	-	-	-
White Bluffs (McLane Ranch)	-	-	-	-

The major cause of air pollution in the Hanford area is dust occurring during windy periods. The most significant sources are cultivated fields in the surrounding area. A limited amount of information is available regarding atmospheric dust loading in the Hanford area. Hilst and Nickola (16) conducted limited dust investigations over a range of wind speeds and to heights of 400 feet in the Hanford area. A portion of their findings is presented in Figure 2.3-5. Other investigations which have been made in the Hanford area and reported by Sehmel and Lloyd (17) demonstrate the dependence of airborne concentrations on wind speed as shown in Figure 2.3-6.

Measurements of the particulate burden in air at a specific observation point in the 200 Areas at Hanford showed values of around 100 micrograms per cubic meter of air when the wind was less than 8 mph. The particulate content increased when higher winds were present, averaging 1,000 micrograms per cubic meter with winds of 12 mph, and 3,000 micrograms per cubic meter with winds of 16 mph.

Additional considerations regarding the August 11, 1955 and January 11, 1972 dust storms shown in Figures 2.3-5 and 2.3-6 and other climatological dust storm characteristics at Hanford are contained in the following paragraphs.

2.3.1.2.1.5.1 Evaluation of August 11, 1955 and January 11, 1972 Dust Storms at Hanford. The wind speeds at 1.25 ft., 50 ft. and 400 ft. heights for the August 11, 1955 observation period were 14, 24, 31 mph respectively. Figure 2.3-5 represents atypical conditions for the site region. The case was originally selected for study as a situation with considerable airborne dust conditions compared to average conditions.

A Hanford climatological summary of dust storms is given in Table 2.3-40 for 1953-1970 (30). Dust dependence on wind speed and direction (50 ft.) at the Hanford Meteorological Station is given in Table 2.3-41 for the same period (30). Approximate values of dust concentrations are computed based on an empirical relationship using visibility observations (31). The relationship is

$$C6 = \frac{56}{v1.25}\, mg/m^3$$

where V is horizontal visibility in km. This is based on data from the Great Plains with visibilities 7 to 9 miles and wind speeds greater than 12 mph. Hourly weather observations at the Hanford Meteorological Station were used as input criteria to define a wind resuspension or dust storm period. Hours satisfying dust storm criteria at Hanford (1953-1970) had either visibilities less than 7 miles and dust reported, or visibilities between 7-14 miles, wind speeds greater than 5.8 m/s, and relative humidities less than 70%. Since the above empirical concentration - visibility relationship was based on observed dust concentrations at approximately 5-6 feet above the surface, any measured dust data should be interpolated to that height when comparing the measurements to the calculated 1953-1970 results of Table 2.3-41. (30)

The frequency of the hourly data satisfying the dust storm criteria at Hanford is given in Table 2.3-42. (30)

The August 11, 1955 dust storm has an interpolated 5-ft value of 17 mg/m^3 compared with the climatological average of about 7 mg/m^3. Further inspection of the climatological values in Table 2.3-41, supports a conclusion that the storm is an example of the more severe type of dust storm that occurs in this region.

Care must be taken in interpretation of Tables 2.3-40 to 2.3-42 to allow for certain limitations. Estimates based on visibilities and/or wind speeds outside the range used in formulation of Equation 1 are of unknown reliability. The average visibilities within each wind speed class were within the range of empirical validity except for the high wind cases. Another source of errors is the fact that the visibility observations are taken at specific times and are not hourly averages. Considering these limitations Tables 2.3-40 to 2.3-42 may be taken to represent overall aspects of the Hanford dust storm climatology. Individual values must be considered approximate estimates - particularly those based on only a few data points.

The extreme value in Table 2.3-41 in the 53 to 66 mph class (988 mg/m^3) represents a single observation of 0-1/16 miles visibility for a few minutes. Typically at the onset of a dust storm very low visibilities with high winds occur for a few minutes. The very limited visibility and high winds for such a period were coded for the data for that hour. The station log reveals that five minutes after the onset of this dust storm, the winds had dropped to 37 mph and visibility was 3/8 mile. The phenomenon was generated by a thunderstorm passing close to the station. Hence, the extreme value in Table 2.3-41 represents an occurrence of very short duration which was the onset of a dust storm that had a duration of about one hour. Qualitative observation indicates that this is not an atypical scenario. Over the 40 minute duration of the storm, the average calculated average dust concentration was 60 mg/m^3. It should be noted, however, that the onset concentration (988 mg/m^3) is of unknown validity because it is calculated from a visibility value for which the empirical model has not been validated.

The visibility during the January 11, 1972 storm was initially less than one mile, changing to four miles during the last half hour of the reported episode. The January 11, 1972 dust storm had winds at 50' WSW in the range 31 to 43 mph. Wind storms with peak gusts recorded at 50' on the Hanford Tower during this period have a three to four year return period at Hanford.

Actual particulate loading depends on other factors such as surface conditions and atmospheric stability. Hence, the wind gust return period does not necessarily apply to particulate loading although it is reasonable to assume the return period is not less than that for wind.

Detailed estimates of the particulate size and total mass concentrations cannot be accurately made for the January 11, 1972 dust storm as a result of the lack of any particle size distribution data. In addition, only one height of mass concentration datum (189 mg/m^3 at 0.2m) was made in the steep gradient region of the vertical profile. An indication of size distribution and mass loading profiles can be obtained from other data collected at Hanford. Sehmel (32) reports an April 1972 storm which has mass loadings near the surface which are similar to the January 11, 1972 storm. Although adjacent meteorological observations are not available for this episode, the fact that the mass loadings at the lower levels are of the same order as the January 11, 1972 dust storm provides a basis for comparison of the storms. The April 1972 storm has well documented mass loading profiles as a function of particle size. The table shown below contains the profiles of airborne soil concentrations as a function of particle diameter for the dust storm. These are based on optical measurements for smaller particles (.16 to 5 μm) at 0.9m and, impacter-cowl measurements for larger particles (1 to 230 μm) at the indicated heights. The mass loading is dominated by the larger particle data.

Soil Mass Loading for the April 1972 Dust Storm (mg/m³)

Particle Diameter Range (µm)	*Height (m)*					
	0.3	*1.0*	*2.0*	*3.0*	*10.*	*32.*
0.9 - 5.0	*0.21*	*0.11*	*	*	*0.058*	*.0038*
5 - 20	*0.83*	*0.28*	*0.26*	*.25*	*0.070*	*.0056*
20 - 60	*14.*	*4.4*	*2.9*	*1.5*	*.81*	*.29*
60 - 240	*220.*	*6.6*	*2.8*	*1.3*	*.19*	*.11*
Total	*235*	*11.4*	*~6.0*	*~ 3.1*	*1.13*	*0.41*

Comparison of the dust loading of 6.0 mg/m³ at 2 meters with the climatological summaries in Tables 2.3-41 and 2.3-42 indicates that this is a typical dust storm for the region.

The particle size distribution for the August 11, 1955 storm is shown in the following table for comparison.

Airborne Dust Loadings of Particles Greater Than 0.9µ For August 11, 1955 Dust Storm (mg/m³)

Particle Diameter Range (µm)	*Height (m)*			
	0.38	*2.0*	*15.2*	*30.5*
0.9 - 5.0	*0.015*	*0.012*	*0.012*	*0.0079*
5 - 20	*0.39*	*0.32*	*0.23*	*0.17*
20 - 60	*3.1*	*2.2*	*1.1*	*0.77*
60 - 240	*18.*	*12.0*	*2.3*	*0.78*
Total	*22.*	*14.5*	*3.7*	*1.7*

The April 1972 dust storm has higher mass loadings near the surface in all size ranges. The August 11, 1955 dust storm had higher dust loadings above 1 to 2 m heights in the ranges greater than 5µ diameter. One interpretation of these profiles is that the 1972 storm had a source nearby and the 1955 data represents advection of airborne dust from more remote sources (33).

2.3.1.2.1.5.2 Hanford Dust Storm Climatology for Design and Operating Bases. *The Hanford climatological study of dust storms for 1953-1970 (30) (discussed in the previous subsection) was re-examined for the purpose of establishing the "worst case" dust storm which may have occurred during that period (33*). The worst case dust storm, i.e., that storm which had the largest calculated time integrated dust loading (mg-hr/m³), is considered to be

* *No value in reference.*

160 mg-hr/m^2, duration of 18 hr, and average dust loading of 8.9 mg/m^3 at a height of 5 to 6 ft. The design basis dust storm is bounded by a postulated volcanic ashfall event (see Section 2.5.1.2.6) in the evaluation of the design and performance of HVAC systems and diesel generators. *Results of this worst case dust storm investigation are listed below. As mentioned above, these loadings would apply for a height of 5 to 6 feet above the ground.*

Detailed Estimates of the Dust Loadings for the Six Worst Storms Based on Surface Observations of the Hanford Meteorology Station, 1953-1970

Storm Number	Total Dust Loading (mg-hr/m^3)	Actual Duration (hr)	Average Dust Loading (mg/m^3)
1	40*	0.67	60
2	100	1.0	100
3	160	18**	8.9
4	44	2.6	17
5	90	3.1	29
6	80	7	11

The worst storm of these was storm No. 3. While it was also shown in this study that once a given dust storm terminated, there existed a 5% probability that another one would occur within 10 hours and a 50% probability that another one would occur within 30 days, none of the above six worst case dust storms had occurred within 30 days of each other. Most had occurred in different years during the 1953-1970 study period.

The dust loading for storm No. 3 is conservative in terms of its being considered as the worst case storm for use in plant design evaluations. As a result of the shorter storm durations of the measured August 11, 1955, January 11, 1972, and April 1972 dust storms, their time integrated dust loadings at 5-6 feet above the ground are not worse than that computed for storm No. 3 (33).

2.3.1.2.2 Design Snow Load

The American National Standards Institute (ANSI) in "Building Code Requirements for minimum Design Loads in Buildings and other Structures" (19) provides weights of 100-year return period ground level snow packs for the site region. The ANSI (Reference 2.3-19) value

* *Value is less than actual dust loading as a result of less than 1 hour duration.*

** *The detailed investigation yielded 18 hours as opposed to a range of 1-16 hours given in Table 2.3-40 of 2.3.1.2.1.5.1 for the range in duration of dust storms using the same 1953-1970 data.*

of 20 lb/ft^2 was used as the design snow load for all CGS structures.* Assuming a specific gravity of 0.1 or snow density 6.24 lb/ft^3, this design value corresponds to a snow depth of 3.2 ft. *The above snow load is conservative for the site as snow depth seldom exceeds six inches, and the greatest depth of 24.5 inches was recorded in February 1916. (4) The weight of the 48-hour probable maximum winter precipitation can be determined from the data presented in Table 2.3-3. Since the greatest snowfall in 24 hours was 10.2 inches (February 1993) and a record depth of approximately 12 inches lasted four days (December 1964) these depths would correspond to snow loads of 5.3 and 6.24 lb/ft^2 respectively.*

2.3.1.2.3 Meteorological Data Used for Evaluation of Ultimate Heat Sink

The ultimate heat sink is evaluated in Section 9.2.5.

The meteorological data presented in Figure 2.3-7 and Tables 2.3-1, 2.3-5, and 2.3-7a-7h was used to evaluate the performance of the CGS spray ponds in 9.2.5 with respect to (1) maximum evaporation and drift loss and (2) minimum water cooling. In accordance with Regulatory Guide 1.27, Rev. 1 "Ultimate Heat Sink for Nuclear Power Plants", the worst one-day and 30-day periods of meteorological record which resulted in minimum heat transfer to the atmosphere were established. The worst recorded 30-day period (30-day average) of maximum difference between dry-bulb and dewpoint temperature and highest simultaneously recorded wind speeds which resulted in the maximum evaporation and drift loss were also established.

Climatological moisture and temperature data presented as a function of time of day for each month in Figure 2.3-7, and wind statistics given in Table 2.3-5 were used to establish the maximum initial pond temperature for the ultimate heat sink analyses in 9.2.5. It was determined in 9.2.5 using these meteorological data, solar radiation formulas contained in ASHRAE Handbook of Fundamentals, and techniques outlined in the John Hopkins University Report "Cooling Water Studies" (Edison Electric Institute Research Report No. 5, Project RP-49, November 1969) that the month of July contained the worst average meteorological data which resulted in the maximum initial pond temperature.

The worst day meteorological data was considered to be the given combination of meteorological parameters in a particular consecutive twenty-four hour period which resulted in the worst pond thermal performance. The following recorded episodes of extreme wet bulb temperatures experienced at the CGS and/or HMS sites were evaluated in 9.2.5 to establish the worst pond thermal performance:

1) *August 7-9, 1972 at CGS and HMS, presented in Table 2.3-7a (20),*

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* Ice loading is included in this CGS estimate.

2) *July 4-12, 1975 at CGS, presented in Tables 2.3-7b to 2.3-7e from the onsite FSAR meteorological monitoring program,*

3) *August 4, 1961 at HMS, presented in Table 2.3-7f (21).*

The meteorological conditions which occurred on July 10, 1975 at CGS resulted in the worst pond thermal performance as determined in 9.2.5.

The following worst month meteorological data were used in 9.2.5 to establish the second through thirtieth day worst pond thermal performance and worst 30-day drift loss and evaporation (Reference 2.3-21):

a) *July 9 - August 8, 1961 at HMS, presented in Table 2.3-7a (minimum heat transfer)*

b) *July 2 - August 1, 1960 at HMS, presented in Table 2.3-7h (maximum evaporation and drift loss)*

Diurnal variations in dry bulb and wet bulb temperatures for both 30-day periods assumed that the hourly temperature variation approximated a sine wave of one cycle in 24 hours (Reference 2.3-21). The average wind speeds during both 30-day periods was approximately 5.5 mph. The root mean square average of the hourly wind speed data for the 30-day mass loss period is 6.91 mph.

For conservatism in the thermal analysis, the worst day data for thermal performance was assumed to repeat in the analysis until pond temperature peaked (three days repetition). For conservatism in the mass loss analysis, an upper bound curve was fit to the drift loss data taken during spray pond testing. The drift loss value was obtained from this curve. See 9.2.5 for details.

2.3.2 LOCAL METEOROLOGY

2.3.2.1 Data Comparisons

The local meteorology prior to CGS plant operation at the CGS site can be described from FSAR meteorological data procured during the period April 1, 1974 to March 31, 1976 from the permanent onsite 7-ft and 245-ft meteorological towers. Data collected from the 245-ft CGS tower had been used for the short-term (accident) and long-term (routine) diffusion estimates. Onsite meteorological data were also obtained from a temporary 23-ft tower which commenced operation in April 1972 for the purpose of determining optimum cooling tower geometric orientation for performance during high wet bulb periods. The 23-ft meteorological tower data were also used with other regional data to establish the potential impact of proposed mechanical draft cooling tower atmospheric releases in the vicinity of CGS

(Reference 2.3-22). The permanent tower data have been compared where appropriate and possible, with simultaneously recorded and historical data obtained from the Hanford Meteorological Station (HMS) for the purpose of documenting the representativeness of the two years of onsite meteorological measurements. For the months of April through August 1974, comparisons have also been made with data from the onsite temporary tower; this tower and instrumentation were dismantled in September 1974. Monthly and annual average comparisons between simultaneously recorded and historical data for all the aforementioned meteorological tower sites have indicated that agreement between the data sources is reasonably good.

When comparing sources of data, it should be recognized that at any given time, significant differences can exist between the reported meteorological conditions at the CGS and HMS sites (see, for example, Table 2.3-7a). Differences in the frequencies of occurrence of various meteorological conditions at a given site can also exist from year to year or from one elevation to another elevation at a site for coincident observation times. Any discrepancies between summarized data sources can also be attributed (in addition to site separation and instrument height above ground) to differences in types and accuracies of instrumentation used and procedures considered for acquiring, processing, and analyzing raw meteorological data. Details regarding the onsite meteorological measurement program are presented in 2.3.3.

For the following data comparisons, the following definitions are used:

CGS[*]	*Data obtained from the permanent 7' and 245' towers at the CGS site; summarized here for April 1, 1974 - March 31, 1976.*
CGS (temp).	*Data obtained from the temporary 23' tower at the CGS site; summarized here for April 1, 1974 - August 31, 1975.*
HMS:	*Data obtained from the Hanford Meteorological Station; used here for April 1, 1974 - March 31, 1976.*
HMS (hist):	*Data obtained from the Hanford meteorology tower at the Hanford Meteorological Station, used here for various periods identified in the data comparison listings. The source is AEC Research and Development Report "Climatography of the Hanford Area", June 1972, BNWL-1605.*
Wind Variable:	*At CGS an hour of data which contains less than 15 minutes of any one direction sector; at Hanford, the same but for 20 minutes.*

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[*]Data obtained at the 33 foot (10 meter) elevation is presented since these data have been subsequently used in the site diffusion studies for postulated ground-level release cases.

Wind Calm: *At CGS, an hour of data for which the average speed is 0.22 miles per hour or less; at Hanford, average speed less than 1 mph (as decided by weather observer, corresponds to no motion of strip-chart recorded pen).*

Sense of Delta T: *Positive values imply relative stability, negative values imply relative instability.*

The first annual cycle of CGS onsite meteorological data which covered the period April 1, 1974 through March 31, 1975 has been presented in detail. Local meteorological data collected during the second annual cycle (April 1, 1975 through March 31, 1976) generally portrayed the same characteristics as indicated by comparison with the first annual cycle data. Except for the high wet bulb episode experienced at CGS during July 1975 (refer to 2.3.1.2.3 and 2.3.2.3), no monitored onsite data proved to be more severe in terms of the design and operation of CGS than those data presented in 2.3.1.2. Hence, only the second annual cycle monthly averages have been presented in Table 2.3-8a which summarizes the two years of monitored on-site data with concurrently measured and historical HMS data. Any significant differences noted between first and second annual cycle onsite data and concurrently measured CGS and HMS data are discussed in 2.3.2.1. Otherwise, conclusions stated herein for the first annual cycle of data similarly apply to the second annual cycle data. It is observed in Table 2.3-8a that any year to year differences in the summarized monthly mean meteorological data at tend to parallel the differences in the means summarized for the HMS site for corresponding months during the two year monitoring period.

Summaries of joint frequency distributions of wind direction and wind speed by atmospheric stability class and results from accident and routine diffusion estimates for both annual cycles of CGS onsite meteorological data are presented in subsequent sections.

Magnetic tape files of the two years of hourly onsite data have been transmitted to the NRC.

2.3.2.1.1 Winds

Table 2.3-8b presents monthly and annual CGS joint wind speed and direction data for the first annual cycle of monitoring. Similar data for the HMS site are given in Table 2.3-9. The CGS data presented in the above tables were collected at an elevation of 33 feet above local grade for the one year period of record whereas the HMS historical data were collected at an elevation of 50 feet above local grade during the period 1955 through 1970 (HMS is approximately 280 feet higher in elevation than the CGS site). Additional wind direction frequency statistics are presented in Table 2.3-10.

The CGS 33 ft and CGS (temp) 23 ft wind direction data given in Table 2.3-10 have similar distributions of direction frequency and show a bimodal wind direction distribution from approximately South and also Northwest. These distributions differ from that given for the HMS site where the direction distribution displays a single peak at approximately West

Northwest to Northwest. Further, the wind direction distribution at the CGS site is much more uniform around the compass than it is at the HMS site. The differences in these distributions may be attributed to the influence of terrain features, causing variability of air flow at the CGS site. This conclusion is strengthened by the observation that the CGS monthly wind frequency distributions are similar through-out the period of data acquisition.

Tables 2.3-11 and 2.3-12 provide the 20 longest occurrences of wind direction persistence at CGS for an elevation of 33 feet. Table 2.3-11 shows persistence in one (22.5 degree) sector while Table 2.3-12 shows persistence within two (45 degrees) adjoining sectors; the corresponding stability class distributions and average wind speed within each stability class are also provided.

It is noted that the majority of the periods of high direction persistence at CGS are associated with unstable, neutral, and moderately stable atmospheric conditions and moderate to strong wind speeds. These represent relatively good diffusion conditions. Table 2.3-12a summarizes the longest persistences of wind direction in one and two sectors at CGS measured during the first and second annual cycles. The annual frequency and duration of episodes of high wind direction persistence at CGS depend upon the frequency and intensity of weather systems which result in regional large scale gradient flow. For example, during the first annual cycle, the longest persistence in one and two sectors lasted 14 hours (NW) and 26 hours (NW, NNW) respectively. During the second annual cycle, the longest persistence in one and two sectors lasted 33 hours (NNE) and 35 hours (N, NNE) respectively. Whereas the longest persistence in one sector during the first annual cycle lasted 14 hours, the duration of the first three longest persistences in one sector during the second annual cycle (33 hours from NNE, 20 hours from SSW, and 16 hours from NW) exceeded that longest duration.

Table 2.3-13 presents monthly frequency distributions and averages of wind speed measured at the CGS and HMS sites. Considering site separation, elevation of sensors, and instrumentation and procedural differences, the CGS wind data appear meteorologically reasonable and demonstrate consistency among data sources.

2.3.2.1.2 Moisture and Temperature

Diurnal variation and averages of dry-bulb, wet-bulb, and dew-point temperatures for the first annual cycle of monitoring at the CGS and HMS sites are given in Tables 2.3-14 to 2.3-16. Tables 2.3-17 to 2.3-19 present frequency distributions of dry-bulb, wet-bulb, and dewpoint temperatures, summarized for the first year of CGS site observations. Table 2.3-20 contains additional climatological summaries of monthly normals and extreme values of temperature and humidity measured at HMS.

Considering the 280 ft difference between the CGS and HMS sites and assuming a dry adiabatic lapse rate of 5.48°F/1000 ft, one can expect a temperature difference of about 1.5°F between the dry-bulb temperature data measured at both sites.

Higher monthly average wet-bulb and dewpoint temperatures occurred at CGS since the CGS site experienced air of slightly higher moisture content than the HMS site. The higher moisture content may be attributed to Columbia River proximity and irrigation of the fields in the vicinity of CGS. This conclusion is strengthened by the fact that moisture enhancement at CGS was at a minimum for the months of January, February, and March during the first annual cycle of CGS site observations.

During the second annual cycle of monitoring, it was observed that the CGS site experienced air of essentially the same moisture content as did the HMS site. The absence of the moisture enhancement at CGS, which was noted during the first annual cycle, may be attributed to reduced evaporation from the proximate river and irrigated fields. The periodic occurrences (during the second annual cycle) of cooler dry-bulb temperatures and precipitation deficits when high dry-bulb temperatures prevailed may have resulted in reduced evaporation.

2.3.2.1.3 Monthly Precipitation

Diurnal variation of precipitation intensity at CGS and monthly total precipitation at CGS and HMS for the first annual cycle of monitoring are given in Table 2.3-21. Frequency of occurrence of precipitation intensity data from April 1974 through March 1975 at CGS are presented in Table 2.3-22. Frequency of occurrence of wind speed and direction versus precipitation intensity for the same year of data is given in Table 2.3-22a. The data show that the CGS site experienced less precipitation than did the HMS site. The difference can be attributed to site separation and the incidence of precipitation falling in the form of showers of quite limited spatial extent. The precipitation deficit at CGS may also result from a rain shadow effect from Rattlesnake Mountain. A precipitation gradient is known to exist along the slope of this terrain feature.

2.3.2.1.4 Fog

Fog data are unavailable for the site. Although fog has been observed in every month of the year at HMS, it is essentially a seasonal phenomenon with 95 percent of it observed during the months of November through February. Inclusion of March and October fog would increase this percentage to 99.7. Tables 2.3-23 and 24 summarize the duration and persistence statistics for fog occurrences at HMS. Because of the relative proximity of the site to the Columbia River, it is expected that the frequency of occurrence, intensity and duration of fog would be somewhat greater than these data indicate (refer also to 2.3.2.1.5).

Most fog in the Hanford region is of the radiation type and hence occurs mostly in conjunction with light wind, inversion or stable atmospheric conditions. The occurrence of fog at the site can therefore be considered as one visual indicator of poor atmospheric diffusion conditions. Advection and frontal fogs occur occasionally at both HMS and the Tri-City stations of Richland and Pasco. In addition, at Richland and Pasco, there are occasional occurrences of

steam fog from the Columbia River. These are not usually deep and many would be classified as ground fog.

Statistics on fog persistence are limited to those at HMS. Although most dense (visibility 1/4 mile or less) fogs do not last longer than 3 hours, a few run for much longer periods as shown in Table 2.3-23. After a period of fog, there frequently follows a period of atmospheric stagnation with a low stratus overcast and light winds. Such conditions may persist for many days.

2.3.2.1.5 Stability Summaries

For the purposes of comparison, the t Δ (temperature difference) and sigma theta (standard deviation of the horizontal wind direction fluctuations) stability classifications which are used in diffusion studies at Hanford are given below with the t Δ"Pasquill" and sigma theta classes identified in NRC Regulatory Guide 1.23:

REGULATORY GUIDE 1.23

Pasquill Class		*Δt/ΔZ (°F/200 FT)*	*Sigma* Theta*
Extremely unstable	*A*	*Less than -2.1*	*25.0*
Moderately unstable	*B*	*-2.1 to -1.9*	*20.0*
Slightly unstable	*C*	*-1.9 to -1.6*	*15.0*
Neutral	*D*	*-1.6 to -0.6*	*10.0*
Slightly stable	*E*	*-0.6 to 1.6*	*5.0*
Moderately stable	*F*	*1.6 to 4.4*	*2.5*
Extremely stable	*G*	*greater than 4.4*	*1.7*

HANFORD RESERVATION CLASSIFICATION

Pasquill Class	*Δt/ΔZ (°F/200 FT)*	*Sigma Theta Groupings** (Degrees)*
Very unstable	*Less than -2.5*	*greater than 22.5*
Unstable	*-2.5 to -1.5*	*25.5 to 17.5*
		17.5 to 12.5

* *Period of 15 minutes to 1 hour.*

** *Note that these sigma theta groupings do not necessarily correspond to any particular Hanford Stability Class on the left, i.e., there can be a maximum of 35 group combinations of Δt/ΔZ and sigma theta although some combinations are unlikely to occur.*

Neutral	*-1.5 to 0.5*	*12.5 to 7.5*
		7.5 to 3.75
Moderately Stable	*0.5 to 3.5*	*3.75 to 2.1*
Very Stable	*greater than 3.5*	*less than 2.1*

Joint frequency distributions of wind speed and direction by atmospheric stability class (temperature difference and sigma theta combinations) for the first and second annual cycles of monitoring are presented in Section 2.3.3. Percent frequency of occurrence of stability (Δt distribution) at CGS and HMS are given in Table 2.3-25. Although the heights over which Δt was measured are similar for both sites, it is observed in Table 2.3-25 that CGS experiences air of greater thermal stability than HMS. This discrepancy between site stabilities may be accounted for because of terrain differences. The CGS site serves as a drainage basin for relatively cool air (especially at night), resulting in strong thermal low-level stratification and the formation of persistent temperature inversions. This conclusion is strengthened by the observation that the difference between the sites is much more pronounced during July, August, September and October than during all other months. It is during these months that pooling of relatively cool air is at a maximum due, partly, to minimum cloudiness and therefore, enhanced nocturnal cooling occurs at the ground. It is noted in Table 2.3-25 that the percent frequencies of stability types for both annual cycles of monitoring at CGS are very similar.

Frequencies of occurrence of Δt and sigma theta versus time of day for the first year of onsite meteorological measurements are given in Table 2.3-26 and 2.3-27. Although frequency of occurrence and duration of inversion conditions were not analyzed for the site, stagnation and inversion information contained in 2.3.1.2.1.5 and 2.3.2.1.5 for HMS should be representative for the site (except for the fact that the above data indicates that CGS experiences a greater frequency of surface-based inversions than does HMS). Figure 2.3-8 shows probabilities of inversion persistence at HMS from 1952-1969 (2).

2.3.2.2 Potential Influence of the Plant and Its Facilities on Local Meteorology

The shapes and sizes of the buildings erected on the plant site will produce a disturbed air flow which alters the initial distribution pattern and diffusion rates of plant release airborne contaminants. In the diffusion calculations this effect is considered.

Electrical power generation by steam turbines requires dissipation of large quantities of low grade thermal energy. Waste heat produced from the operation of CGS is dissipated by means of six circular mechanical draft cooling towers. These evaporative cooling towers release waste heat directly to the atmosphere in the form of sensible and latent heat. An extended visible plume consisting of liquid water droplets can occur principally during the winter months when periods of cold weather and high relative humidity prevail. Fogging is defined as occurring if visible plumes intersect the ground, buildings, or other elevated structures.

Fog occurs naturally in this region, and any cooling tower fog is an extension of the naturally occurring phenomenon. When air temperatures of 0°C or lower prevail, the additional potential exists for icing on these surfaces. At times, small cumulus clouds could form above or remote from the plant, depending on the atmospheric temperature and moisture conditions in the first several thousand feet above the cooling towers. No significant environmental or atmospheric impacts arising from CGS cooling tower operation have been observed or are foreseen based on dispersion meteorological studies performed by Battelle Northwest Laboratories (Reference 2.3-22). Details covering potential environmental impacts arising from CGS cooling tower operation are given in the CGS Environmental Report.

2.3.2.3 Local Meteorological Conditions for Design and Operating Bases

The regional long term meteorological conditions provided in Section 2.3.1.2 are applicable for use in establishing the plant design and station operating bases. Except for the high wet bulb episode experienced at CGS during July 1975 (refer to 2.3.1.2.3), none of the local short term meteorological data presented in 2.3.2.1 proved to be more severe in terms of the design and operation of CGS than those presented in 2.3.1.2. Data collected since January 1, 1984 form the revised long-term design and operating basis for dispersion calculation.

2.3.2.4 Topographic Description

As shown in Figures 2.1-1 and 2.1-2, the plant is located at a grade elevation of 441 feet MSL in a basin area formed by the Saddle Mountains to the northwest, bluffs and hills rising to about 900 feet MSL to the north and east, the Horse Heaven Hills to the south and the Rattlesnake Hills and Yakima, Umtanum and Manastach ridges to the west. Topographic cross-sections plotted out to 10 kilometers by sector from the plant are given in Figure 2.3-9. Except for the cliffs toward the east across the Columbia River, the region within this circumference is basically flat and featureless and slopes gradually toward the Columbia River. Additional details regarding the regional topography and geology are given in 2.5. The effects of regional topography on local meteorology are discussed in 2.3.1.1, 2.3.2.1.1 and 2.3.2.1.5. The need to consider plume height relative to land elevations has been obviated by the assumption of a ground-level release for the accident and routine station release cases which are presented in 2.3.4 and 2.3.5.

2.3.3 ONSITE METEOROLOGICAL MEASUREMENT PROGRAM

The permanent onsite meteorological data collection system in use since January 23, 1974 consisted of a 240 ft main tower, an auxiliary seven ft instrument mast, sensors with associated

electronics and recording devices, and a meteorological shelter.[*] *A 23 ft onsite temporary tower was also used during the period April 1, 1972 through August 31, 1974.*

The Battelle Memorial Institute, Pacific Northwest Laboratories, had been conducting a continuing two year program of acquisition, processing, and analysis of meteorological data for Energy Northwest Columbia Generating Station in a contractual arrangement with Burns and Roe, Inc.

The first and second annual cycles of reliable meteorological data were collected during the periods April 1, 1974 through March 31, 1975 and April 1, 1975 through March 31, 1976, respectively. The accuracy of these data had been established primarily through calibrations conducted at quarterly intervals as required through a formal program of quality assurance. The data were examined for meteorological reasonableness, after corrections were applied per the calibration Reports, through computer edit programs. No data were found to be unreasonable. The annual summaries were compared with the monthly summaries and all were found to be consistent. The computer summarization programs (identical for monthly and annual purposes) were tested at quarterly intervals by application to dummy data per the quality assurance program. (23) The computer calculation programs for x/Q were similarly tested. Comparisons between CGS meteorological data and concurrently measured and historical HMS data have been presented in 2.3.2.1.

2.3.3.1 Permanent Onsite Meteorological Tower and Instrumentation Characteristics

The meteorological tower, which is located approximately 2,500 feet west of the CGS plant site with its base at 455' MSL, consists of a 240 ft high primary tower with a five ft mast extending above it. The primary tower is triangular in shape and of open lattice construction to minimize tower interference with meteorological measurements. Wind and temperature measurements were made at the top of the mast and at the 33 ft level. The dewpoint temperature was measured at the 33 ft level. At the lower level the instruments were mounted on an eight ft horizontal boom extending southwest of the tower. Wind and temperature measurements were also made at the top of a seven ft mast which was located approximately 80 feet southwest of the 245 ft tower.

Wind speed measurements were made using conventional cup anemometers (Climet Instruments, Model 011-1 Wind Speed Transmitter) which have a response threshold of about 0.6 mph and a distance constant of less than five feet. Over a calibrated range of 0.6 to 90 mph the accuracy of these instruments is ± 1% or 0.15 mph (whichever is greater).

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[*] *Data collection on the 240 foot and seven foot towers was terminated on June 1, 1976 subsequent to the collection of two years of reliable tower data ending March 31, 1976, required for the CGS FSAR. Data collection on the Primary and backup towers began on July 1, 1984.*

Wind direction measurements were made using lightweight vanes (Climet Instruments, Model 012-10 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 feet, respectively. Dual potentiometers in the Wind Direction Transmitter produce an electrical signal covering 540° in azimuth with an accuracy of ±3°. In addition, electronics had been included to provide signals which were proportional to the standard deviation of the wind direction fluctuations at each level.

Temperature instrumentation had been installed to provide measurements of both the ambient air temperature at the 245, 33 and 7 ft levels, as well as the temperature differences between these levels. The ambient air temperature and the temperature difference measurement systems were independent of each other to provide for reliability. Atmospheric stability delta - T classes were determined solely on the basis of the data from the electronic differencing bridge and not by subtracting the ambient air temperature measurements. All temperature measurements for both systems were made in aspirated radiation shields (Climet Instruments Model 016-1 or -2) using platinum resistance temperature detectors (Rosemount Engineering Co., Model 104 MB6ABCA). These instruments provided an ambient temperature range from -30°F to ±130°F and a temperature difference range of ±15°F. The accuracy of the instruments is ±.09°F in the measurement of temperatures and ±0.18°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 015-12) housed in an aspirated radiation shield (Climet Instruments Model 016-2). Precipitation was measured at ground level using a tipping bucket rain gage (Meteorology Research Incorporated, Model 302) located about 40 feet west of the main tower. This instrument is accurate to within 1% at rainfall rates up to 3 in./hr and has a resolution of 0.01 in. The instrument building provided a semi-controlled environment near the tower to house the instrument electronics and record the data. Analog strip chart and digital magnetic tape recorders were used to provide redundant data recording capability. The primary data recording system was a seven-track digital magnetic tape recorder (Kennedy, Model 1600) which used 1/2 inch tape. Logarithmically time-averaged wind speed, wind direction, temperature, temperature difference and dewpoint temperature signals were recorded at five minute intervals. The time constant of the averaging process was five to ten minutes. The standard deviation of wind direction fluctuations during the preceding five 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 also recorded on strip charts which provided a backup data record to enhance data retrievability. In addition, since the strip charts contained an essentially instantaneous record of the signal from each instrument, they provided a rapid means of identifying instrument malfunctions and were useful in system calibration. These strip charts and magnetic tapes were changed weekly.

In summary, the total system accuracies for the measured meteorological parameters meet or exceed the following specifications:

air temperature	*±0.5°C*
temperature difference	*±0.2°C*
humidity (dew point)	*±2.8°C*
wind speed	*±0.5 mph from 0.5 to 5 mph, ±10% of reading above 5 mph per RG 1.97, Rev. 3.*
wind direction	*±5°*

These are verified by the end-to-end calibrations. Data recovery was better than 90%.

2.3.3.2 Quality Assurance Program

To ensure the quality of the meteorological data collected by the monitoring system, an extensive quality assurance program had been 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 had been instituted. These periodic checks ranged from daily inspection of the strip charts to semiannual calibration of the complete system. All checks, calibrations and maintenance were fully documented, including traceability of test and calibration equipment to the National Bureau of Standards where necessary. Once collected, the data were protected from loss to the maximum extent possible; the digital tapes were examined to identify possible instrumentation malfunctions; and the data were then copied onto two master tapes. The original weekly tape and one master tape were stored in vaults for safekeeping while 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 using a standard data input. The computer output from these tests was then saved to document computer operation.

The various phases of the quality assurance program pertaining to the two years of permanent onsite meteorological monitoring and data processing are discussed in the following subsections.

2.3.3.2.1 Data Recovery During April 1, 1974 - March 31, 1976

The meteorological data acquisition system was put into operation during January 1974. Outages in the digital system precluded an initiation date for the acquisition of reliable data prior to April 1, 1974 because the processing of an inordinate amount of data from strip charts

would have been required. The data utilized in the production of the monthly and annual summaries have been obtained exclusively with the primary data recording equipment (magnetic tape digital system) since August 1, 1974.

Recourse to data recorded on strip charts was required at times prior to August 1974 to assure, as viewed at the time, a recovery rate of 90% representative data as required by Nuclear Regulatory Guide 1.23. The percentages of monthly data read from strip charts is listed below:

April 1974	-	*23.3%*
May 1974	-	*8.3%*
June 1974	-	*49.5% (W/S 33' - 59.1%)*
July 1974	-	*1.6%*

From routine and anticipated causes (system maintenance and calibration) modest data losses were experienced on the order of 2% and 1.2% for the first and second annual cycles of onsite data collection respectively. A comparable amount, for some of the meteorological quantities, was caused by circumstances beyond Battelle's control (power outages, delay in receipt of spare parts, etc.). The percentages of missing annual data for various meteorological quantities are listed below:

	April 1, 1974- March 31, 1975	*April 1, 1975 March 31, 1976*
Wind Speed 33'	*4.0%*	*2.7%*
Wind Direction 33'	*4.0%*	*1.5%*
Dry Bulb Temperature 33'	*2.5%*	*1.2%*
Wet Bulb, Dewpoint Temperature 33'	*2.7%*	*1.2%*
Differential Temperature 33' - 245'	*3.1%*	*1.5%*

These percentages are representative of missing data for all meteorological quantities except precipitation. During the first annual cycle of monitoring, data recovery for precipitation was 100%. Precipitation data recovery was complete during the second annual cycle of monitoring, except possibly during December 1975 when a sand plug was discovered in the rain gauge funnel. As a result, it was estimated that less than 0.1 inch of precipitation was not recorded during that month. For the first annual cycle of monitoring, the data recovery rate was 96% or better for all meteorological quantities; this rata was 97% or better during the second annual cycle of monitoring.

2.3.3.2.2 Maintenance and Calibration

Assurance of quality data rests primarily with the calibrations performed at quarterly intervals and reported for July and October 1974; January, April, July and October 1975; and January and April 1976.

All evidence to date obtained through formal calibrations and routine daily and weekly inspection had demonstrated that the meteorological system remained electronically stable in terms of obtaining data of sufficient quality to meet the requirements in Regulatory Guide 1.23. The calibration corrections required are tabulated in the response to NRC question 6.4 on the FER. The calibrations established any system inaccuracies by comparisons to standards. These inaccuracies were corrected by appropriately adjusting the data at the data processing stage as opposed to adjusting the system electronics. The calibrations before and after each calibration period were used to determine if corrections were required to account for drift or if offset had occurred. No drift corrections were required. The offsets were discussed in the FER response. For corrections that were not constant throughout the range of a given parameter, a calibration table or curve was used to correct the data. Calibration corrections were applied as part of the computer programs used to edit and translate the data from the original raw-data tapes to a master file of hourly values.

2.3.3.2.3 Data Processing and Analysis

For the two years (1974-1976) of onsite FSAR meteorological monitoring at CGS, all data (magnetic tape and strip chart where required) were run through computer edit programs. No data were found to be unreasonable except for known causes as documented in Nonconformance Reports. Data corrections, per the Calibration Reports, were applied in the computer programs. Summarization of data has been accomplished only at such times as calibration information was available to bracket in time the acquired data.

The data for each hour is represented by an average of the data for the last 30 minutes in the hour. The averaging period of 30 minutes was selected for consistency with 1) the data used to formulate the Hanford Diffusion Model used for routine and accident dose calculations, 2) the recommendations in Regulatory Guide 1.23, and 3) computational economy. The only exception was wind direction which was averaged over one-hour to facilitate the formulation of wind direction persistence summaries.

One thirty-minute period per hour is considered adequate for climatological summaries consisting of averages of many hours. In addition, x/Qs based on thirty-minute averages will be conservative for estimates of the one-hour averages. All data products were based on these "hourly" averages.

Wet bulb from the permanent tower was obtained from standard psychrometric formulas presented in the Smithsonian Meteorological Tables, 1971 issue.

The above descriptions relate to data collected and used in FSAR submittals through Amendment #36. Data collection and processing since July 1, 1983 is described in 2.3.3.2.4. The Kennedy Tape Recorder has been replaced with a floppy disk recorder for increased reliability.

In several of the monthly summary reports, the computer programs as applied to dummy data have been compiled as called for in the Quality Assurance Manual (Reference 2.3-23) for the purpose of documenting proper programming and proper computer performance.

These computer computations have been verified with hand calculations made with the dummy data. The computational programs for x/Q were similarly tested.

2.3.3.2.4 Meteorological Monitoring Program During Plant Operation

The meteorological tower, which is located approximately 2500 ft west of the CGS plant site with its base at 455 ft msl consists of a 240-ft high primary tower with a 5-ft mast extending above it. This tower is triangular in shape and of open lattice construction to minimize tower interference with meteorological measurements. Wind and temperature measurements are made at the top of the mast and at the 33-ft elevation by duplicate sets of instruments. One set of instruments is the primary measurement system and the other set constitutes the backup instrumentation. The lower elevation wind speed/direction instruments are mounted on a horizontal boom, extending southwest of the tower.

Wind speed and wind direction measurements are made with a single instrument package that combines a wind speed propeller on the leading (upwind) end of the instrument and a wind direction vane, or tail, on the opposite end. Wind speed measurement range is 0.5 to 90 mph with a threshold sensitivity of about 1 mph. The wind direction measurements are made by the wind passing over the wind vane portion of the instrument. In addition, electronic modules process the data from these instruments and provide output data which is proportional to the standard deviation of the wind direction fluctuations over 15 minutes.

Temperature instrumentation provides measurements of the ambient air temperature at the 245 and 33-ft elevations. Temperature measurements are made in aspirated radiation shields using platinum RTDs. These instruments provide an ambient temperature range from -50°F to +150°F. Each set of RTDs (one from 33 ft level and one from 245 ft level) are calibrated together in the same temperature bath and electronic modules process the data from these instruments to provide a temperature difference range of ±15°F.

The relative humidity is measured at the 33-ft elevation of the tower using an intercap sensor with a range of 0 to 100% RH housed in an aspirated radiation shield. Precipitation is measured at ground level using a tipping bucket rain gauge located about 40-ft west of the main tower. The barometric pressure is measured by a pressure transmitter located inside the

Met Tower building. The Met Tower building provides a semi-controlled environment near the tower to house the instrument electronics. Signal conditioning is provided in the Met Tower by two GE FANUC PLC controllers, one for the primary instrumentation and one for the backup instrumentation. The primary controller feeds data to the Supervisory System and the PDIS via the LAN. The backup controller feeds data only to the PDIS via the LAN. Information will be available to all locations for both the primary and backup instruments on the LAN. The backup system does not provide data for the barometric pressure or the rain gauge. Wind speed, wind direction, temperature, temperature difference and relative humidity signals are averaged by the controllers using a 15 minute time constant device before sending the information to the control room. In the control room are three recorders which record 245-ft and 33-ft wind speed, wind direction, delta temperature, and ambient temperature at 33-ft elevation. The system accuracies for the measured meteorological parameters are demonstrated to meet or exceed the following specifications by performance of instrument loop calibrations:

Air temperature	±0.5°C (±0.9°F)
Temperature difference	±0.2°C (±0.36°F)
Humidity (dew point)	±2.8°C (±5.0°F)
Wind speed	±0.50 mph from 0.5 to 5 mph, ±10% of reading above 5 mph per RG 1.97, Rev. 3.
Wind direction	±5.0°

This data is processed by the Supervisory System which forms the primary communication vehicle for the meteorological system. The supervisory system located at the meteorological tower building and the control room digitizes and multiplexes the data to the control room where it is restored to analog format and sent to recorders and the PPCRS, as required, on a real-time basis. The data input to the supervisory system is 15-minute average analog values. Longer period averages will also be computed for trend analysis and report generation. These data are routed to satisfy display and processing requirements of the onsite technical support centers (TSC) and the emergency operations facility (EOF). The primary meteorological tower data is stored by the plant data acquisition system. Instrument calibrations and maintenance procedures meet the data recovery and system accuracy requirements of Regulatory Guide 1.23 except as noted above.

The Emergency Dose Projection system provides redundant data communication paths with remote access and redundant power sources as required for routine or emergency preparedness support. The near real time access to both the primary and backup meteorology systems, via the supervisory system or the LAN, thus satisfies the emergency preparedness requirements of Regulatory Guide 1.23.

These two systems are designed to meet or exceed data unavailability statements of Regulatory Guide 1.23. If offsite meteorological data is needed, data can be obtained from a network of meteorological towers located on the Hanford Site using methods described in the Emergency

Preparedness Plan. The accuracy, calibration, and reliability of all data not directly controllable by Energy Northwest is determined by the private/governmental controlling agency.

2.3.3.3 Other Meteorological Measurement Programs Considered for the Data Comparisons

2.3.3.3.1 CGS Temporary Tower

A temporary 23-ft onsite tower was used during the period April 1, 1972, through August 31, 1974, to obtain data input for CGS environmental studies and to provide a comparative overlap with the initially measured permanent tower data.

The temporary tower was located in the vicinity of the permanent towers with its base at approximately 448 ft msl. Wind data from the temporary tower were obtained at the 23-ft level while temperature data were acquired at the 3-ft level. Wet bulb data from the temporary tower were established from techniques and data contained in the U.S. Department of Commerce, Weather Bureau Office Document, Relative Humidity and Dewpoint Table. As a special quality assurance program was not initiated for the temporary tower installation, it is not possible to assert that this tower's data complied with the requirements contained in Regulatory Guide 1.23.

2.3.3.3.2 Hanford Meteorological Station

The Hanford Site maintains a network of meteorological towers, which can be accessed for data by telephone or electronic form.

2.3.3.4 Joint Stability - Wind Frequency Summaries

Joint frequencies of wind direction and wind speed by atmospheric stability class (sigma theta by Δt classes), collected at the 33 ft level of the permanent tower during the period from January 1, 1984 to December 31, 1989 are presented in Table 2.3-28A.

The sigma theta/Δt stability classification approach (see 2.3.2.1.5) has been used by Battelle to maintain consistency with the longer term HMS data to which existing data is compared and to satisfy the data requirements of the Hanford Diffusion Model (HDM) the HDM requires joint measurements of sigma theta and Δt for the more restrictive stable diffusion cases and utilizes the Sutton method with locally derived parameters for neutral and unstable cases (21). The HDM differs from the standard NRC diffusion models as a result of the incorporation of empirically derived diffusion coefficients based on historical experiments performed at Hanford. As a result of the extensive experimental data that were used in deriving the HDM, itis appropriate to consider this model when performing diffusion analysis at the Hanford Reservation.

In 2.3.2.1, comparisons between measured CGS onsite data and simultaneously recorded and historical HMS data illustrated the following differences between sites:

a. The CGS site experienced a small air moisture enhancement during the first annual cycle of monitoring. During the second annual cycle, the CGS site experienced air of essentially the same moisture content as did the HMS site.

b. The CGS site experiences a biomodal wind direction distribution from approximately south and also northwest. At HMS, the direction distribution displays a single peak at approximately west northwest to northwest.

c. The CGS site experiences air of greater thermal stability than does HMS.

Reasons for these differences were given in 2.3.2.1.

2.3.4 SHORT TERM DIFFUSION ESTIMATES

2.3.4.1 Objective

In this section brief descriptions of the sources, the receptors, and the methodologies used to calculate the air dispersion factors, χ/Q, for the Exclusion Area Boundary (EAB), the Low Population Zone (LPZ), and the control room are presented.

2.3.4.2 Exclusion Area Boundary

The EAB is located at a distance of 1950 m (approximately 1.2 miles) from the site. The χ/Qs were calculated using site-specific meteorological data from 1996 to 1999, (Reference 2.3-38). The Joint Frequency Distributions (JFDs), Table 2.3-28, were used as an input to the computer code PAVAN, (Reference 2.3-25) and the χ/Q results are presented in Table 2.3-37.

The χ/Q values at the EAB are calculated for each hour of data. The cumulative probability distribution of these values are determined for each of the wind direction sectors.
Two distributions are calculated, Pasquill-Gifford (P-G) with meander sigmas and desert sigmas (includes meander). The distributions represent the annual probabilities that the given χ/Q values will be exceeded in each wind direction sector at the exclusion area distance. Table 2.3-34 incorporates the P-G meander effect and Table 2.3-33 has desert sigmas. From each of the sixteen sector distributions, the χ/Q value which is exceeded 0.5 percent of the total time was selected. This value was selected based on the percentage of total observations rather than the percentage of observations that the wind direction is within the appropriate sector. These 16 sector χ/Q values are given in Tables 2.3-33 through 2.3-34. The highest of these sixteen values is defined as the maximum sector χ/Q value.

2.3.4.3 Low Population Zone

The LPZ is located at a distance of 4827 m (approximately 3 miles) from the site. The χ/Qs were calculated using site specific meteorological data from 1996 to 1999, (Reference 2.3-38), the JFDs, Table 2.3-28, were used as an input to the computer code PAVAN, (Reference 2.3-25) and the χ/Q results are presented in Table 2.3-37.

The sector χ/Q values at the LPZ have been estimated for various fixed time intervals of a 30-day period. These time intervals are 0 - 2 hours, 2 - 8 hours, 8 - 24 hours, and 1 - 30 days. The estimates for these time periods are made by interpolation on a log-log plot of the two-hour and annual average values as described by Regulatory Guide 1.145. These interpolations are carried out for the value which is exceeded 5 percent of the time, and 0.5 percent of the time. The interpolations are displayed in Tables 2.3-35 (Desert) through 2.3-36 (P-G, meander). For these interpolations the 2-hour values are assumed equivalent to the 1-hour values. These depictions and interpolation schemes are identical to those specified in Regulatory Guide 1.145.

2.3.4.4 Control Room

The control room air dispersion factors χ/Q were calculated using the 1996 to 1999 site-specific hourly meteorological data, (Reference 2.3-37). The meteorological data and the input parameters were used as input to the computer code ARCON96, (Reference 2.3-36), and the χ/Q results are presented in Table 2.3-37.

2.3.4.5 Description of Sources

There are 4 sources at CGS that could release radioactivity to the environment following an accident. These sources are described below:

a. The roofline source is a vent (short stack) on top of the reactor building at a height of 70 m (approximately 229 ft) above the ground through which routine releases take place. Following an accident, the exhaust air from the reactor building passes through the SGT filtration system before exiting through the roofline stack. This source is treated as a ground level point source in the χ/Q calculations.

b. The reactor building railroad bay doors are located at the ground level on the eastside wall of the reactor building. It is assumed that some leakage to the environment takes place through these doors.

c. The reactor building walls from the 606 ft level to the 670 ft level (top of reactor building) are made of metal sheets and therefore they are assumed to be

a diffuse source capable of leaking radioactive materials to the atmosphere, this source is also treated as a ground level release source.

d. The Turbine Building Exhaust System (TBES) is a set of four circular vents (short stacks) located on top of the radwaste building roof. Air from the turbine building is exhausted to the atmosphere through these 4 vents.

2.3.4.6 Control Room Intakes

There are three intakes at CGS which draw air into the control room during normal operation as well as post accident. A description of these intakes is given below:

a. Local intake point: The local intake point is a vent located on the west side of the radwaste building wall at an elevation of 527 ft (26.5 m above the ground).

b. Remote intakes: there are two ground level remote intake points which are approximately 180 degrees from each other. One remote intake is located to the north-west side of the turbine building and is labeled remote-1, the other is located to the south-east side of the reactor building and is labeled remote-2.

2.3.4.7 Calculations

Formulations for calculating short term χ/Q values have been developed for licensing of nuclear power plants and are described in Regulatory Guide 1.145, (Reference 2.3-26) "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants." For the CGS configuration, it is assumed that accidental releases are made at ground level. This assumption provides a conservative estimate of downwind χ/Q values. NRC code PAVAN (Reference 2.3-25) is used to produce dispersion estimates with the desert sigma option enabled.

Based on the guidance given in Regulatory Guide 1.145 the χ/Q values are calculated using three separate equations. The particular equation which is used depends upon the existing meteorological conditions. The equations are:

(1) $$\chi / Q = \frac{1}{U_{10}(\pi \sigma y \sigma z + A/2)}$$

(2) $$\chi / Q = \frac{1}{U_{10}(3\pi \sigma y \sigma z)}$$

(3) $$\chi / Q = \frac{1}{U_{10}\pi \Sigma y \sigma z}$$

Where χ/Q is relative concentration (sec/m^3)

π is 3.14159

U_{10} is the wind speed at the 10 meter level (m/sec)

σy is the horizontal desert diffusion parameter (m) determined from downwind distance and stability category.

σz is the vertical desert diffusion parameter (m) determined from downwind distance and stability category.

ΣY represents plume meander and building wake effects (m) and is a function of stability category, wind speed, and downwind distance.

A is the smallest vertical plane cross-sectional area of the reactor building (m^2).

During neutral or stable atmospheric stability conditions, the results of all three equations are used to determine dosages. The values from Equations (1) and (2) are compared and the larger is selected. This value is compared with that computed in Equation 3 and the lower value is selected as the appropriate χ/Q value.

During all other meteorological conditions (unstable and/or wind speeds of 6 m/sec or more), only equations (1) and (2) are considered. The appropriate χ/Q value is the larger of the two.

Values of σY and σz, the horizontal and vertical diffusion parameters are taken from Regulatory Guide 1.145 for the applicable stability category and downwind distance. For extremely stable condition (Category G), the following equations are applied:

$$\sigma Y(G) = 2/3\ \sigma Y(F)$$

$$\sigma z(G) = 3/5\ \sigma z(F)$$

2.3.5 LONG-TERM (ROUTINE) DIFFUSION ESTIMATES

2.3.5.1 Objectives

The joint wind direction and wind speed by atmospheric stability class data presented in Subsection 2.3.3 was used to assess annual average normalized concentrations, X/Q, for 16 radial sectors extending from the site boundary to a distance of 50 miles from the source. Tables 2.3-38 provides X/Q and D/Q concentrations for a mix mode release assuming desert

sigmas no decay, no plume depletion, recirculation, and a building wake (building height - 70.4 m). D/Q is normalized deposition.

2.3.5.2 Calculations

The calculational techniques used are consistent with the guidance provided in Regulatory Guide 1.111 "Methods for Estimating Atmospheric Transport and Dispersions of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors". The joint frequency data presented in Subsection 2.3.3 were used in conjunction with the following equation to obtain X/Q values at appropriate downwind distance in each of the 16 sectors.

$$\frac{X(x,\kappa)}{Q} = \frac{2.032\Sigma_{ij} f_{ij\kappa} \exp\left[-h_e^{2} \Big/ 2\sigma_{zj}^2(x)\right] R_{fx}(x)}{x\bar{u}_i(x)\left[\sigma_{zj}^{2}(x) + \frac{0.5D^2}{\pi}\right]^{1/2}}$$

Where:

$\frac{X(x,\kappa)}{Q}$ = *average effluent concentration in Ci/m*^{3} *normalized by source release rate (Ci/sec) at distance x and direction k.*

x = *downwind distance from release point.*

$\overline{u}_i$ = *midpoint value of ith wind speed class.*

h_e = *effective plume height.*

$\sigma_{zj}(x)$ = *vertical standard desert deviation of effluent spread at distance x for the jth stability class.*

R_{fx} = *factor to account for air recirculation and stagnation.*

f_{ijk} = *joint probability of the ith wind speed class, jth stability, class, and kth wind direction.*

π = *3.1416*

D = *maximum building height of adjacent buildings (D = 70.4 m)*

The building wake correction Equation 1 must not reduce the X/Q estimate by more than a factor of 3 or

$$\left(\sigma^2 xj\ (x) + \frac{0.5D^2}{\pi}\right)\ 1/2 \leq \left(3\sigma^2 zj(x)\right)\ 1/2$$

Equation 1 assumes a long-term continuous release whose effluent is distributed evenly across a 22.5° sector. The release was assumed to be ground level (i.e., he = 0 in Equation 1). Computer code X0QD0Q, with the Desert sigma option enabled described in NUREG-0324, was used to make two sets of calculations.

The nearest residences where maximum individual doses with single sector contributions occur at distances of 4.0 miles ENE (Ringold) and 4.2 miles ESE (Taylor Flats) of CGS. The annual average χ/Q values for these locations are calculated in Table 2.3-38c, 38f and 39c, 39f. The Columbia bluffs rise to an elevation of 878 ft just south of Taylor Flat. If it is considered that the low level sigma Z is less than 100 m out to 6 km for the P-G stability classes D-G, which are prevalent most of the winters and that low-level winds deflect either north or south near the bluffs (Reference 2.3-2), it is estimated that the total doses for these locations may be once again as large due to contributions of favorably oriented wind sectors.

The total dose in the channeling area of the Columbia River should include contributions from four other sectors with deflected winds and other channeling effects. The individual doses in that location could be twice as large as for the single sector, constant wind computations. The drift from the cooling towers should remove some of the effluent and deposit it on the site with the salts and counteract the bluff effect. The mechanical draft cooling towers should entrain part of the effluent, lift it with the plume and thus also make the χ/Q values over-predictive. Reasons for these differences were given in Subsection 2.3.2.1.

The results reported by Start and Wendell ("Regional Effluent Dispersion Calculation Considering spatial and Temporal Meteorological Variation," Preprint volume, Symposium on Atmospheric Diffusion and Air Pollution of the American Meteorological Society, September 9-13, 1974) indicate an average value at these distances of about 0.65 and a minimum single point value of about 1.75. If these factors are multiplied by the fraction of plume remaining at the distances in question, about 0.75, to account for the conservatism of the nondepleting model used to arrive at the dose estimates provided in 5.2 of the CGS Environmental Report, it is found that the most critical dose of 9.2 mrem to a child's thyroid (at Taylor Flat) is still within the 10 CFR Part 50 Appendix I design objective limit of 15 mrem. For example, 1.75 x 0.75 x 9.2 = 12.1 mrem. This value would still be conservative because the above recirculation factors do not account for the existence of a bluff line immediately downwind of Taylor Flat which will under the more stable conditions turn the plume before it reaches Taylor Flat. This effect would further reduce the effective recirculation factor.

At the nearest point of the nearest population center, about 9 miles, the average recirculation factor value from Start and Wendell, 1974, appears to be about 0.3 with the maximum single point value about 0.8. In addition to this effect, the effect of topographic channeling has been evaluated by conservatively hypothesizing that under stable conditions that winds blowing anywhere from the east to west (through north) sector might end up in the four sectors containing the majority of the population, SE through WSW (Pasco through Benton City). Including the effects due to channeling results in an estimated maximum factor of approximately 1.6. Applying the factors for recirculation and fraction of plume remaining after deposition results in a maximum effective factor of (1.6 x 0.8 x 0.67 = 0.86) less than one.

It therefore appears reasonable to conclude that the methodology employed to estimate doses is sufficiently conservative for the subject site to ensure that the doses to individuals and the general population have not been substantially underestimated due to the inherent assumptions.

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Table 2.3-1

Averages and Extremes of Climatic Elements at Hanford
(Based on all Available Records to and Including the Year 1980)

TEMPERATURE (°F)

	1912-1980 AVERAGES							1912-1980 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	36.6	21.9	29.3	42.5	1953	12.1	1950	72	1971	-2	1950	53	1971	-23	1934
Feb	45.4	27.3	36.3	44.5	1958	21.4	1929	71	1924	-3	1950	55	1932	-23	1950
Mar	56.5	33.7	45.1	49.8	1926	39.4	1955	83	1960	24	1960	54	1942	6	1955
Apr	66.2	40.0	53.1	59.6	1934	47.5	1955	95	1934	41	1945	60	1956	12	1935
May	75.5	47.8	61.7	68.8	1947	56.6	1933	103	1936+	49	1918	70	1956	23	1954
June	83.2	55.3	69.3	75.4	1922	63.0	1953	110	1912	55	1966	81	1924	33	1933
July	91.8	61.0	76.4	81.8	1960	72.4	1963	115	1939	59	1966	82	1925	39	1979
Aug	89.3	59.2	74.3	81.5	1967	69.8	1964	113	1961	63	1920	81	1961+	40	1918
Sept	79.6	50.8	65.2	71.7	1967	58.8	1926	102	1976+	52	1934	72	1955	25	1926
Oct	65.4	40.6	53.0	59.0	1952	48.8	1930	90	1933	31	1935	60	1945+	6	1935
Nov	48.4	31.3	39.8	46.0	1954	31.3	1955	75	1975	14	1955	52	1959+	-1	1955
Dec	39.4	26.0	32.7	38.5	1957	18.5	1919	69	1980	-3	1919	56	1975	-27	1919
Year	64.8	41.2	53.0	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 1945-1980 TOTALS					COOLING 1960-1980 TOTALS				
	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR
Jan	1104	1640	1950	694	1953	0	0	------	0	------
Feb	781	1147	1956	576	1958	0	0	------	0	------
Mar	638	794	1955	476	1947	0	0	------	0	------
Apr	381	522	1955	253	1977	2	24	1977	0	1978+
May	156	258	1977	36	1947	43	94	1971	3	1962
June	35	90	1953	3	1938	183	310	1969	57	1980
July	4	22	1955	0	1975+	384	518	1960	232	1963
Aug	6	32	1960	0	1979+	323	508	1967	171	1964
Sept	70	179	1972	10	1979+	102	216	1967	27	1970
Oct	376	479	1946	200	1952	2	10	1971	0	1977+
Nov	758	1008	1955	567	1954	0	0	------	0	------
Dec	990	1224	1964	822	1957	0	0	------	0	------
Year	5299	1640	Jan 1950	0	Aug 1979+	1039	518	July 1960	0	Apr 1978+

PRECIPITATION (INCHES) 1912–1980 TOTALS

	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR	MAX. IN 24 HOURS	YEAR	SNOW, ICE PELLETS (SLEET)						
								MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MAX. IN 24 HOURS	YEAR	MAXIMUM DEPTH	YEAR
Jan	0.92	2.47	1970	0.08	1977	1.08	1948	5.3	23.4	1950	7.1	1954	12.0	1969
Feb	0.60	3.08	1940	T	1967	1.24	1916	2.3	26.0	1916	18.0	1916	24.5	1916
Mar	0.37	1.86	1957	0	1942+	0.59	1949	0.3	4.2	1951	2.2	1957	2.3	1957
Apr	0.39	1.22	1969	0	1933+	0.58	1980	T	T	1968+	T	1968+	0	------
May	0.48	2.03	1972	0	1931	1.39	1972	T	T	1960	T	1960	0	------
June	0.54	2.92	1950	0	1919	1.50	1934	0	0	------	0	------	0	------
July	0.15	0.81	1966	0	1939+	1.25	1942	0	0	------	0	------	0	------
Aug	0.24	1.36	1977	0	1955+	0.89	1977	0	0	------	0	------	0	------
Sept	0.31	1.34	1947	T	1976+	0.82	1947	0	0	------	0	------	0	------
Oct	0.56	2.72	1957	0	1917+	1.91	1957	T	1.5	1973	1.5	1973	1.5	1973
Nov	0.85	3.05	1926	T	1976+	0.78	1966	1.4	12.7	1955	8.3	1978	9.1	1978
Dec	0.89	2.53	1931	0.11	1976+	1.00	1958	3.9	19.1	1964	5.4	1965	12.1	1964
Year	6.30	3.08	Feb 1940	0	Aug 1955+	1.91	Oct 1957	13.2	26.0	Feb 1916	18.0	Feb 1916	24.5	Feb 1916

	WIND (mph) 1945-1980 AVERAGES						PEAK GUSTS			RELATIVE HUMIDITY (%) 1946-1980 AVERAGES					1946-1980 EXTREMES			
	PREVAILING DIRECTION	MEAN MONTHLY SPEEDS	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	SPEED	DIRECTION	YEAR	MEAN	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	HIGHEST	YEAR	LOWEST	YEAR
Jan	NW	6.4	10.3	1972	3.1	1955	80	SW	1972	76.4	88.8	1960	60.0	1963	100	1980+	13	1963
Feb	NW	7.1	10.8	1976	4.6	1963	65	SW	1971	70.7	86.9	1963	54.0	1967	100	1980+	14	1962
Mar	WNW	8.5	10.7	1977+	5.9	1958	70	SW	1956	55.9	65.9	1950	44.0	1965	100	1979+	12	1965+
Apr	WNW	9.0	11.1	1972+	7.4	1958	73	SSW	1972	46.9	64.5	1963	36.9	1966	100	1978+	9	1954
May	WNW	8.9	10.5	1965+	5.8	1957	71	SSW	1948	43.0	61.9	1948	31.2	1966	100	1978+	7	1953
June	WNW	9.2	10.7	1949	7.7	1950+	72	SW	1957	39.7	53.5	1950	30.0	1949	100	1977+	10	1964+
July	WNW	8.7	9.6	1963	6.8	1955	69	WSW	1979	32.2	40.5	1955	21.9	1959	99	1972	6	1951
Aug	WNW	8.0	9.1	1946	6.0	1956	66	SW	1961	35.6	47.8	1976	24.5	1967	100	1972+	7	1951
Sept	WNW	7.5	9.2	1961	5.4	1957	65	SSW	1953	41.6	55.5	1977	33.2	1974	100	1978+	10	1962+
Oct	WNW	6.6	9.1	1946	4.4	1952	63	SSW	1950	56.8	74.2	1962	42.5	1952	100	1980+	10	1952+
Nov	NW	6.1	8.2	1977	2.9	1956	64	SSW	1949	73.6	88.7	1979	62.8	1976	100	1980+	16	1976+
Dec	NW	6.1	8.3	1968	3.9	1963+	71	SW	1955	80.0	90.5	1950	69.0	1968	100	1980+	26	1972
Year	WNW	7.7	11.1	Apr 1972+	2.9	Nov 1956	80	SW	Jan 1972	54.3	90.5	Dec 1950	21.9	July 1959	100	Dec 1980+	6	July 1951

	SKY COVER (SCALE 0-10) 1946-1980 AVERAGES (SUNRISE TO SUNSET)					SOLAR RADIATION (LANGLEYS)* 1953-1980 AVERAGES DAILY TOTALS					1953-1980 EXTREME DAILY TOTALS			
	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR
Jan	7.9	9.2	1978	4.3	1949	116	136	1973	78	1978	277	1969	16	1976+
Feb	7.6	9.3	1980	5.9	1964	194	238	1970	128	1980	422	1958	21	1976
Mar	6.8	8.5	1978	4.9	1965	335	388	1965	293	1978	542	1968	44	1979
Apr	6.4	8.1	1963	3.7	1951	469	535	1973	374	1963	704	1972	75	1974
May	5.9	7.7	1977+	4.5	1945	569	634	1970	472	1980	838	1977	67	1962
June	5.3	7.0	1950	2.8	1961	627	698	1960	537	1980	821	1971	112	1965
July	2.9	4.7	1976	0.9	1953	650	714	1973	588	1955	808	1974	118	1972
Aug	3.4	5.9	1968	0.6	1955	548	613	1955	475	1968	721	1957	107	1959
Sept	4.1	6.7	1978	1.4	1975	415	463	1975	326	1977	591	1970	61	1957
Oct	5.8	8.0	1975	3.9	1952	262	303	1976	216	1975	434	1973	33	1974
Nov	7.7	9.1	1972	6.2	1957	130	180	1957	97	1979+	295	1971	14	1969
Dec	8.1	9.2	1962	6.4	1978	89	116	1970	57	1980+	196	1972	9	1973
Year	6.0	9.3	Feb 1980	0.6	Aug 1955	367	714	July 1973	57	Dec 1980+	838	May 1977	9	Dec 1973

* CALORIES/cm^2
+ALSO ON EARLIER YEARS

EXTREME AVERAGES OR TOTALS
AND YEAR OR SEASON OF OCCURRENCE

1912-1980 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	70.2	(1980)
HIGHEST FALL (S-O-N)	56.6	(1963)
LOWEST FALL	49.5	(1978)

1912-1980 PRECIPITATION TOTALS (IN.)

GREATEST ANNUAL	11.45	(1950)
LEAST ANNUAL	2.99	(1976)
SNOW, ICE PELLETS (SLEET) GREATEST SEASONAL	43.6	(1915-16)
LEAST SEASONAL	0.3	(1957-58)

1945-1980 WIND SPEED AVERAGE (MPH)

HIGHEST ANNUAL	8.3	(1968+)
LOWEST ANNUAL	6.3	(1957)

1945-1980 RELATIVE HUMIDITY AVERAGE (%)

HIGHEST ANNUAL	58.9	(1978)
LOWEST ANNUAL	49.4	(1967)

1945-1980 SKY COVER AVERAGES
(SUNRISE TO SUNSET, SCALE 0-10)

HIGHEST ANNUAL	6.6	(1978+)
LEAST ANNUAL	5.1	(1949)

1953-1980 SOLAR RADIATION
AVERAGE DAILY TOTAL (LANGLEYS)

HIGHEST ANNUAL	390	(1973)
LOWEST ANNUAL	324	(1980)

Table 2.3-1

Averages and Extremes of Climatic Elements at Hanford
(Based on all Available Records to and Including the Year 1980) (Continued)

	NUMBER OF DAYS (1954-1980)											NUMBER OF DAYS (1945–1980) *																			
	CLEAR					PTLY CLDY	CLOUDY					THUNDERSTORMS					HEAVY FOG (VIS. 1/4 MI. OR LESS)					PRECIPITATION 0.10 INCH OR MORE					SNOW 1.0 INCH OR MORE				
	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	MONTHLY MEAN	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan	3	7	1963	0	1955+	5	22	28	1978	17	1963	0	0	------	0	------	6	15	1976	0	1949	3	8	1970	0	1977+	2	10	1950	0	1977+
Feb	4	9	1968+	0	1980+	5	19	26	1980+	12	1964	#	1	1972+	0	1980+	3	11	1963	0	1977	2	5	1980+	0	1979+	1	4	1975+	0	1979+
Mar	6	12	1979+	1	1978+	8	17	23	1977	9	1979+	#	1	1969+	0	1980+	1	5	1951	0	1980+	2	8	1957	0	1980+	#	2	1957+	0	1980+
Apr	6	12	1962	1	1963	9	15	21	1979+	6	1956	1	3	1979+	0	1977+	#	1	1975+	0	1980+	1	5	1948	0	1977+	0	0	------	0	------
May	8	14	1973	1	1977	11	12	19	1977+	6	1958	2	7	1956	0	1977+	#	1	1958	0	1980+	2	4	1980+	0	1979+	0	0	------	0	------
June	10	21	1961	5	1972+	10	10	15	1980+	5	1979+	2	8	1972+	0	1963+	#	1	1971	0	1980+	2	8	1950	0	1979+	0	0	------	0	------
July	19	26	1960	13	1976+	7	5	12	1976	0	1967	2	7	1975	0	1973+	0	0	------	0	------	1	3	1974+	0	1980+	0	0	------	0	------
Aug	18	30	1955	9	1978	7	6	13	1968	0	1969+	2	8	1953	0	1974+	#	1	1959	0	1980+	1	4	1976+	0	1980+	0	0	------	0	------
Sept	15	27	1975	6	1978	7	8	16	1977	1	1975	1	4	1959	0	1976+	#	1	1977	0	1980+	1	5	1977+	0	1978+	0	0	------	0	------
Oct	10	14	1980+	1	1975	7	14	22	1973	9	1970	#	2	1976	0	1980+	1	7	1980	0	1978+	2	8	1950	0	1978+	1	1	1973	0	1980+
Nov	4	10	1957	1	1973+	5	21	25	1973+	15	1961	0	0	------	0	------	6	13	1965	0	1960	3	10	1973	0	1976+	1	6	1955	0	1980+
Dec	3	9	1978	1	1980+	5	23	28	1962	17	1978	#	1	1971	0	1980+	8	17	1950	2	1968+	3	9	1964	0	1976+	2	6	1964	0	1976+
Year	106	30	Aug 1955	0	Feb 1980+	86	172	28	Jan 1978+	0	Aug 1969+	10	8	June 1972+	0	------	25	17	Dec 1950	0	------	23	10	Nov 1973	0	Aug 1980+	6	10	Jan 1950	0	------

	NUMBER OF DAYS (1945-1980)										NUMBER OF DAYS (1912 – 1980)																								
	3" OR MORE SNOW ON GND.					PEAK GUST 40 MPH OR GREATER					MAX. TEMP 90 OR ABOVE					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	MEAN MONTHLY	GREATEST MONTLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLYY	YEAR
Jan	5	23	1969	0	1977+	3	11	1972	0	1979+	0	0	------	0	------	0	0	------	0	------	11	30	1979	0	1967+	27	31	1980+	9	1953	2	14	1950	0	1977+
Feb	3	16	1950	0	1978+	2	10	1976	0	1978+	0	0	------	0	------	0	0	------	0	------	3	15	1956	0	1976+	21	28	1944+	5	1958	1	9	1929	0	1980+
Mar	0	0	------	0	------	3	9	1956	0	1978	0	0	------	0	------	0	0	------	0	------	#	2	1960	0	1980+	15	25	1944+	6	1968+	0	0	------	0	------
Apr	0	0	------	0	------	3	7	1972	0	1979+	#	4	1926	0	1980+	0	0	------	0	------	0	0	------	0	------	5	15	1935	0	1974+	0	0	------	0	------
May	0	0	------	0	------	2	6	1971+	0	1977	3	11	1924	0	1980+	#	1	1966+	0	1980+	0	0	------	0	------	#	3	1938	0	1980+	0	0	------	0	------
June	0	0	------	0	------	2	6	1973	0	1980+	9	20	1940+	0	1980+	2	9	1970	0	1980+	0	0	------	0	------	0	0	------	0	------	0	0	------	0	------
July	0	0	------	0	------	1	4	1979+	0	1977+	20	29	1941	8	1963	7	16	1971+	0	1963+	0	0	------	0	------	0	0	------	0	------	0	0	------	0	------
Aug	0	0	------	0	------	1	5	1951	0	1980+	18	29	1915	7	1948	4	16	1942	0	1980+	0	0	------	0	------	0	0	------	0	------	0	0	------	0	------
Sept	0	0	------	0	------	1	4	1946	0	1980+	5	16	1938	0	1977+	#	2	1955+	0	1980+	0	0	------	0	------	#	4	1933+	0	1980+	0	0	------	0	------
Oct	0	0	------	0	------	2	8	1967	0	1979+	#	1	1933	0	1980+	0	0	------	0	------	#	2	1935	0	1980+	5	12	1916	0	1962+	0	0	------	0	------
Nov	1	12	1978	0	1980+	2	5	1973+	0	1979+	0	0	------	0	------	0	0	------	0	------	2	15	1955	0	1976+	17	30	1936	4	1949	#	1	1955+	0	1980+
Dec	2	14	1955	0	1980+	3	8	1957+	0	1969+	0	0	------	0	------	0	0	------	0	------	8	19	1914	0	1974+	25	31	1978+	14	1933	1	14	1919	0	1980+
Year	11	23	Jan 1969	0	------	25	11	Jan 1972	0	------	55	29	July 1941	0	------	13	16	July 1971+	0	------	24	30	Jan 1979	0	------	115	31	Jan 1980+	0	------	4	14	Jan 1950+	0	------

REFERENCE NOTES

* 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 DOE CONTRACTORS.

NUMBER OF DAYS

CLEAR (0-3 TENTHS SKY COVER, SR TO SS)		
GREATEST ANNUAL (1954-80)	121	1960
LEAST ANNUAL (1954-80)	80	1977
CLOUDY (9-10 TENTHS SKY COVER, SR TO SS)		
GREATEST ANNUAL (1954-80)	193	1978
LEAST ANNUAL (1954-80)	85	1966
THUNDERSTORMS		
GREATEST ANNUAL (1945-80)	23	1948
LEAST ANNUAL (1945-80)	3	1949
HEAVY FOG (VIS. 1/4 MILE OR LESS)		
GREATEST SEASONAL (1945-80)	42	1950-51
LEAST SEASONAL (1945-80)	9	1948-49
PRECIPITATION 0.10 INCH OR MORE		
GREATEST ANNUAL (1946-80)	39	1950
LEAST ANNUAL (1946-80)	10	1965
SNOW 1.0 INCH OR MORE		
GREATEST SEASONAL (1946-80)	15	1955-56
LEAST SEASONAL (1946-80)	0	1976-77
3 IN. OR MORE SNOW ON GROUND		
GREATEST SEASONAL (1946-80)	40	1978-79+
LEAST SEASONAL (1946-80)	0	1976-77
PEAK GUST 40 MPH OR GREATER		
GREATEST ANNUAL (1945-80)	41	1961
LEAST ANNUAL (1945-80)	10	1978
MAX. TEMPERATURE 90 OR ABOVE		
GREATEST ANNUAL (1912-80)	85	1940+
LEAST ANNUAL (1912-80)	29	1980
MAX. TEMPERATURE 100 OR ABOVE		
GREATEST ANNUAL (1912-80)	32	1942
LEAST ANNUAL (1912-80)	1	1954
MAX. TEMPERATURE 32 OR BELOW		
GREATEST SEASONAL (1912-80)	53	1955-56
LEAST SEASONAL (1912-80)	1	1937-38
MIN. TEMPERATURE 32 OR BELOW		
GREATEST SEASONAL (1912-80)	141	1916-17
LEAST SEASONAL (1912-80)	75	1957-58
MIN. TEMPERATURE 0 OR BELOW		
GREATEST SEASONAL (1912-80)	18	1949-50
LEAST SEASONAL (1912-80)	0	1976-77

Table 2.3-2

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)							Intensity (Inches per Hour)						
	Time Period							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	2.68	2.4	1.11	0.67	0.48	0.37	0.212	0.112

* 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 0.01 inch occurred between 1855 and 1910 to account for the record 60-minute amount of 0.59 inch.

Table 2.3-3

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) 38
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 % 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 2.3-4

Tornado History Within 100 Miles of CGS

Date	Location
June 26, 1916	Walla Walla, Washington
April 15, 1925	Condon, Oregon
September 2, 1936	Walla Walla, Washington
May 20, 1948	Yakima, Washington
May 29, 1948	Yakima, Washington
June 11, 1948	Ephrata, Washington
June 16, 1948	Hanford Reservation
May 9, 1956	Kennewick, Washington
April 12, 1957	Ione, Oregon
April 30, 1957	Yakima, Washington
May 6, 1957	Harrington, Washington
April 24, 1958	Walla Walla, Washington
June 26, 1958	Wallula Junction, Washington
March 14, 1966	Little Goose Dam, Washington

Note: No major damage or loss of life was associated with any of the tornadoes.

Table 2.3-5

Monthly and Annual Prevailing Directions, Average Speeds, and
Peak Gusts: 1945-1970 at HMS
(50 ft level)

	Prev	Avg	Highest		Lowest		Peak Gust		
Month	Den	Speed	Avg	Year	Avg	Year	Speed	Den	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	1943
June	WNW	9.2	10.7	1949	7.7	1950+	72	SW	1957
July	WNW	8.6	9.6	1963	6.8	1955	55	WSW	1963
Aug	WNW	8.0	9.1	1946	6.0	1956	66	SW	1961
Sept	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	June 1957

* 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 2.3-6

Speed and Direction of Daily Peak Gusts*

	Speed Class (mph)									Extreme High and Date of Occurrence **	
Direction	Under 10	10-19	20-29	30-39	40-49	50-59	60-69	70 or over	Total	mph	Date
NNE	0.2	0.8	1.3	0.2	0.1	0	0	0	2.6	47	Feb. 5, 1948
NE	0.3	1.0	1.0	0.2	0	0	0	0	2.5	38	July 10, 1951
ENE	0.2	0.6	0.3	0.1	0	0	0	0	1.2	37	May 27, 1947
E	0.2	0.7	0.2	0.1	#	0	0	0	1.2	44	June 11, 1950
ESE	0.1	0.4	0.1	0	0	0	0	0	0.6	26	June 2, 1958
SE	0.7	2.0	0.4	#	#	#	0	0	3.1	53	Aug. 29, 1947
SSE	0.7	1.8	0.5	0.1	0.1	#	0	0	3.2	52	Dec. 4, 1952
S	0.3	0.8	1.0	0.7	0.3	0.2	#	0	3.3	58	Dec. 23, 1957
SSW	0.1	0.9	1.5	1.4	0.8	0.4	0.1	#	5.2	71	May 26, 1948
SW	0.2	0.7	3.6	3.4	1.7	0.4	0.1	0.1	10.2	72	June 5, 1957
WSW	0.2	1.5	2.7	2.4	1.1	0.2	0	0	8.1	58	Nov. 3, 1958 L
W	0.3	2.2	2.1	1.0	0.3	#	0	0	5.9	52	Nov. 4, 1958 L
WNW	1.0	9.6	8.0	5.4	0.6	#	0	0	24.6	50	July 19, 1953
NW	1.5	9.6	6.8	5.1	0.8	0	0	0	23.8	49	April 6, 1952

Table 2.3-6

Speed and Direction of Daily Peak Gusts* (Continued)

Direction	Speed Class (mph) Under 10	10-19	20-29	30-39	40-49	50-59	60-69	70 or over	Total	Extreme High and Date of Occurrence ** mph	Date
NNW	0.4	0.8	0.3	#	0	0	0	0	1.5	38	May 8, 1955
N	0.2	1.1	1.4	0.2	0.1	0	0	0	3.0	46	Aug. 27, 1951
Summary	6.6	34.5	31.2	20.3	5.9	1.2	0.2	0.1	100.0	---	---

* Based on 12 years of observations (1947–58). Tabular values under speed classes denote percent of all daily observations made during the period.

L Denotes the latest of several occurrences.

\# Denotes less than .05%.

** A new record was set on January 11, 1972, when a peak gust of 80 mph was recorded at the 50 foot level at the Hanford Meteorology Station. Reference Document BNWL-1640 "The Hanford Wind Storm of January 11, 1972." dated February 1972, issued by Battelle Pacific Northwest Laboratories.

Table 2.3-7a

CGS and HMS Hourly Meteorological Data, August 7-9, 1972
(Ultimate Heat Sink Studies)

Day/Hour	CGS Site					HMS Tower Site			
	Wind Direction (degrees)	Wind Speed (mph)	Dry Bulb (°F)	Relative Humidity (percent)	Wet Bulb (°F)	Wind Direction (degrees)	Wind Speed (mph)	Dry Bulb (°F)	Wet Bulb (°F)
Elevation	23 feet	23 feet	3 feet	3 feet	3 feet	50 feet	7 feet	7 feet	7 feet
7/1	30	5	76	35	60	220	6	78	57
7/2	50	5	72	36	58	270	6	76	56
7/3	160	5	71	44	59	300	5	78	57
7/4	80	5	69	48	58	270	5	74	54
7/5	50	5	65	51	55	180	4	72	55
7/6	70	4	61	64	54	110	2	67	53
7/7	100	5	61	64	54	300	1	76	57
7/8	70	4	59	68	53	320	5	81	60
7/9	70	4	67	66	59	320	3	85	61
7/10	100	5	77	54	65	Variable	1	92	64
7/11	130	5	85	46	69	40	3	93	64
7/12	140	5	91	38	71	Variable	3	98	66
7/13	360	6	96	35	73	90	5	102	68
7/14	80	8	99	32	74	110	5	104	68
7/15	110	8	102	30	76	90	4	105	69
7/16	110	9	106	28	77	Variable	4	107	69
7/17	90	9	107	25	77	90	8	108	69
7/18	60	9	108	24	77	90	8	106	68
7/19	50	12	106	23	75	110	7	103	67
7/20	50	12	106	23	75	90	8	97	64
7/21	40	8	103	22	73	130	7	90	62
7/22	60	6	96	22	69	220	6	84	60
7/23	100	5	89	26	66	300	8	82	58
7/24	30	4	85	34	66	270	5	81	58
8/1	360	6	79	36	63	270	4	78	57
8/2	130	5	72	39	58	270	4	77	57
8/3	40	5	70	42	58	200	4	78	57
8/4	20	7	71	46	59	240	1	71	53
8/5	40	6	71	46	59	200	4	70	53
8/6	80	5	67	46	56	300	5	69	53
8/7	100	5	65	52	55	320	5	79	60
8/8	140	4	62	54	53	20	3	85	63
8/9	130	5	67	56	57	140	2	87	63
8/10	130	5	77	53	64	110	3	91	65
8/11	120	7	85	46	69	110	4	93	65
8/12	70	7	90	40	71	60	4	97	67
8/13	70	6	95	37	73	90	4	103	69
8/14	40	6	98	34	74	90	4	104	69
8/15	60	7	101	32	76	130	4	106	70
8/16	70	7	104	30	77	110	6	108	70
8/17	30	8	106	28	77	220	10	108	70
8/18	30	8	108	27	78	270	16	106	68
8/19	90	8	106	26	77	300	20	102	70
8/20	110	8	106	25	76	300	21	96	66
8/21	320	19	108	26	78	300	21	91	66
8/22	320	21	100	26	73	300	22	90	63
8/23	320	15	95	28	71	300	16	87	64
8/24	320	15	91	28	68	270	16	85	63
9/1	320	17	90	32	69	270	9	83	63
9/2	320	10	89	32	68	240	6	82	61
9/3	180	7	84	34	65	300	7	78	60
9/4	Variable	5	77	35	61	240	6	80	62
9/5	150	6	72	46	60	270	11	82	63
9/6	140	5	70	54	59	240	10	82	63
9/7	160	5	71	57	61	240	8	82	63
9/8	200	7	68	58	59	220	6	87	65
9/9	190	7	73	60	63	240	10	89	65
9/10	200	8	81	56	68	320	9	94	65
9/11	180	6	89	50	72	320	6	96	66
9/12	170	5	94	44	74	220	5	99	67
9/13	190	7	98	38	76	220	10	101	68
9/14	200	10	100	34	76	220	15	101	67
9/15	160	8	100	30	74	220	15	101	67
9/16	300	13	102	30	76	240	13	103	68
9/17	250	13	104	28	76	300	16	102	68
9/18	300	17	104	26	75	300	20	97	67
9/19	310	14	104	27	76	300	20	93	65
9/20	320	20	102	26	74	300	17	88	63
9/21	320	22	96	27	71	300	16	83	61
9/22	320	17	93	29	70	300	18	80	60
9/23	320	13	87	30	66	300	19	79	60
9/24	320	16	84	30	64	300	14	78	60

Table 2.3-7b

CGS Hourly Meteorological Data, July 4-12, 1975 (33 ft Level)
(Ultimate Heat Sink Studies)

Day/Hour	Wind Speed mph	Dry Bulb °F	Dewpoint °F	Wet Bulb °F
4/1	3.56	66.13	53.17	58.41
4/2	3.66	64.91	54.85	58.86
4/3	1.71	64.16	53.92	58.07
4/4	4.88	62.69	53.41	57.22
4/5	2.96	61.87	53.57	56.99
4/6	2.76	65.60	55.20	59.30
4/7	5.21	72.51	55.95	62.22
4/8	3.33	77.12	54.84	63.26
4/9	6.02	81.71	55.52	65.16
4/10	5.97	83.95	57.71	67.00
4/11	12.36	90.00	55.57	67.88
4/12	9.67	94.48	57.09	69.99
4/13	9.55	97.15	57.97	71.21
4/14	8.89	99.57	58.00	71.93
4/15	6.28	102.37	56.77	72.17
4/16	5.85	103.49	54.77	71.63
4/17	6.13	104.27	52.40	70.88
4/18	3.55	104.77	51.20	70.56
4/19	3.41	103.68	49.57	69.61
4/20	5.64	95.64	59.28	71.39
4/21	3.88	91.49	57.55	69.30
4/22	3.61	86.72	56.56	67.32
4/23	3.97	83.92	58.68	67.50
4/24	4.81	79.60	57.84	65.66
5/1	4.96	76.83	57.17	64.37
5/2	3.90	74.83	55.47	62.79
5/3	3.30	71.68	55.41	61.64
5/4	6.61	70.93	54.56	60.92
5/5	6.06	71.15	55.57	61.54
5/6	5.00	72.99	55.89	62.36
5/7	5.28	77.84	57.41	64.84
5/8	2.94	81.95	58.51	66.78
5/9	4.87	87.01	57.89	68.07
5/10	8.24	92.11	56.24	68.85
5/11	5.82	96.69	54.80	69.61
5/12	5.69	98.96	57.68	71.60
5/13	6.13	100.80	60.27	73.36
5/14	4.74	103.79	54.99	71.81
5/15	7.52	105.36	54.77	72.18
5/16	6.43	105.81	55.09	72.44
5/17	4.65	104.53	53.25	71.31
5/18	6.93	103.48	52.80	70.80
5/19	6.48	101.04	57.15	71.97
5/20	6.79	96.64	57.79	70.97
5/21	5.25	93.63	57.23	69.80
5/22	6.05	89.23	56.43	68.05
5/23	3.95	87.41	57.25	67.88
5/24	6.34	83.80	58.84	67.55
6/1	2.68	81.71	59.17	67.05
6/2	6.15	79.55	59.15	66.33
6/3	4.87	76.13	59.73	65.54
6/4	6.08	73.41	59.47	64.49
6/5	5.55	72.83	59.39	64.24
6/6	2.14	74.56	61.28	65.91
6/7	2.35	80.99	63.33	69.16
6/8	4.21	85.01	61.95	69.61
6/9	2.96	86.61	63.65	71.04
6/10	5.10	89.49	61.49	70.70
6/11	13.07	86.75	62.85	70.63
6/12	12.58	83.84	63.47	70.10
6/13	6.00	87.87	60.85	69.87
6/14	4.56	88.69	61.47	70.45
6/15	5.09	91.49	60.59	70.83
6/16	6.27	94.56	59.57	71.21
6/17	9.89	92.59	60.03	70.87

Table 2.3-7c

CGS Hourly Meteorological Data, July 4-12, 1975 (33 ft Level)*
(Ultimate Heat Sink Studies)

Day/Hour	Wind Speed mph	Dry Bulb °F	Dewpoint °F	Wet Bulb °F
6/18	7.70	93.44	59.81	71.00
6/19	3.03	92.59	59.17	70.43
6/20	5.58	90.53	59.57	70.02
6/21	12.41	87.60	60.93	69.83
6/22	8.22	82.43	58.69	67.03
6/23	3.64	79.72	56.40	64.94
6/24	3.82	79.49	55.65	64.48
7/1	8.39	75.23	54.69	62.52
7/2	7.41	73.55	54.69	61.94
7/3	8.64	72.88	53.95	61.31
7/4	7.31	72.67	53.68	61.10
7/5	7.31	71.28	53.36	60.43
7/6	8.75	74.37	55.44	62.61
7/7	10.86	76.77	57.23	64.38
7/8	8.77	79.63	58.96	66.26
7/9	10.34	83.07	59.71	67.77
7/10	12.46	86.32	60.35	69.13
7/11	9.95	89.15	61.49	70.60
7/12	10.70	90.61	60.37	70.45
7/13	6.33	92.80	59.71	70.76
7/14	3.98	95.65	59.57	71.53
7/15	8.95	95.01	58.67	70.90
7/16	12.70	96.85	59.31	71.76
7/17	5.17	96.51	59.49	71.75
7/18	3.60	97.15	58.72	71.56
7/19	8.61	96.40	57.76	70.88
7/20	5.68	91.52	58.85	69.94
7/21	4.75	86.08	61.33	69.58
7/22	4.06	84.35	55.89	66.22
7/23	8.93	81.39	59.31	67.02
7/24	16.32	81.47	60.35	67.62
8/1	10.89	80.08	58.21	66.01
8/2	10.13	79.65	56.69	65.07
8/3	11.19	78.05	55.33	63.83
8/4	9.25	76.72	54.43	62.91
8/5	8.42	74.67	54.53	62.25
8/6	8.80	76.45	55.55	63.40
8/7	14.06	79.23	56.88	65.03
8/8	13.55	80.37	57.60	65.79
8/9	M	M	M	M
8/10	M	M	M	M
8/11	M	M	M	M
8/12	M	M	M	M
8/13	M	M	M	M
8/14	M	M	M	M
8/15	M	M	M	M
8/16	5.38	101.23	59.09	72.92
8/17	5.44	102.03	58.00	72.64
8/18	3.66	102.16	56.56	72.02
8/19	3.50	100.85	55.28	71.07
8/20	6.68	97.09	56.61	70.54
8/21	7.28	92.64	56.40	69.09
8/22	9.70	89.25	55.25	67.49
8/23	9.48	87.49	53.71	66.21
8/24	6.22	83.73	54.29	65.24

*M – Missing data

Table 2.3-7d

CGS Hourly Meteorological Data, July 4-12, 1975 (33 ft Level)*
(Ultimate Heat Sink Studies)

Day/Hour	Wind Speed mph	Dry Bulb °F	Dewpoint °F	Wet Bulb °F
9/1	7.99	81.52	55.81	65.25
9/2	5.26	79.12	56.45	64.76
9/3	3.95	74.91	58.32	64.35
9/4	4.58	73.12	58.69	63.94
9/5	3.78	72.37	57.92	63.25
9/6	4.00	75.28	59.49	65.12
9/7	4.67	79.79	60.16	66.98
9/8	9.88	83.38	60.06	68.06
9/9	12.03	85.49	60.00	68.69
9/10	10.18	88.13	61.28	70.18
9/11	8.76	92.13	62.85	72.20
9/12	5.78	95.52	64.40	74.02
9/13	7.10	99.49	63.17	74.46
9/14	4.77	102.61	62.72	75.01
9/15	5.17	106.40	58.77	74.23
9/16	5.12	108.03	55.28	73.15
9/17	3.24	109.47	55.49	73.65
9/18	6.10	109.15	53.07	72.58
9/19	6.18	107.44	52.35	71.79
9/20	7.80	101.47	57.87	72.42
9/21	13.30	99.31	53.15	69.69
9/22	25.82	94.16	61.36	72.01
9/23	17.04	94.61	59.49	71.19
9/24	11.05	92.37	57.57	69.58
10/1	8.36	90.91	58.03	69.35
10/2	12.16	85.92	59.17	68.39
10/3	9.19	84.24	57.28	66.88
10/4	5.08	80.61	56.21	65.14
10/5	1.56	80.24	58.48	66.21
10/6	6.53	78.27	59.55	66.15
10/7	7.10	83.25	62.99	69.65
10/8	4.15	86.77	62.91	70.67
10/9	3.89	90.64	61.09	70.83
10/10	5.12	92.64	62.00	71.90
10/11	3.77	95.23	63.36	73.38
10/12	5.74	98.32	62.40	73.73
10/13	5.89	100.91	59.41	72.98
10/14	5.27	103.09	59.39	73.58
10/15	5.30	105.20	58.91	73.96
10/16	5.90	105.71	56.00	72.80
10/17	9.37	104.93	54.11	71.78
10/18	12.21	102.48	55.88	71.81
10/19	8.55	101.15	56.05	71.50
10/20	5.54	98.27	56.13	70.68
10/21	4.26	96.21	56.59	70.27
10/22	3.14	90.72	60.53	70.57
10/23	7.36	91.33	57.68	69.31
10/24	12.76	91.49	60.48	70.77
11/1	7.86	89.61	61.65	70.83
11/2	12.03	86.81	62.03	70.20
11/3	14.22	88.56	61.48	70.42
11/4	6.62	87.60	59.81	69.25
11/5	8.70	85.47	60.11	68.74
11/6	7.13	85.28	60.37	68.82
11/7	12.45	82.37	61.23	68.39
11/8	M	M	M	M
11/9	10.14	83.96	62.40	69.53
11/10	12.86	83.57	62.53	69.49
11/11	14.68	82.51	63.97	70.00

*M – Missing data

Table 2.3-7e

CGS Hourly Meteorological Data, July 4-12, 1975 (33 ft Level)*
(Ultimate Heat Sink Studies)

Day/Hour	Wind Speed mph	Dry Bulb °F	Dewpoint °F	Wet Bulb °F
11/12	13.48	84.13	64.96	71.06
11/13	11.16	87.73	62.91	70.96
11/14	11.36	87.76	63.12	71.08
11/15	8.17	89.92	61.81	71.00
11/16	4.60	94.72	59.97	71.46
11/17	4.39	96.19	59.89	71.85
11/18	4.27	96.16	58.85	71.33
11/19	11.57	89.28	64.05	72.05
11/20	9.70	84.99	61.07	69.10
11/21	8.24	83.01	60.69	68.28
11/22	6.89	82.00	61.09	68.20
11/23	10.12	81.97	59.39	67.25
11/24	10.69	78.83	57.81	65.38
12/1	10.37	77.65	57.01	64.57
12/2	7.69	76.64	56.85	64.14
12/3	3.17	75.87	56.32	63.59
12/4	2.34	75.71	56.99	63.89
12/5	5.74	73.92	58.64	64.18
12/6	6.75	70.51	56.51	61.81
12/7	6.57	73.07	57.71	63.38
12/8	4.62	76.88	59.63	65.73
12/9	4.23	79.71	60.93	67.38
12/10	4.51	82.69	61.44	68.61
12/11	5.53	84.13	61.01	68.81
12/12	5.53	86.43	61.65	69.86
12/13	5.93	88.75	62.40	70.98
12/14	6.81	90.69	62.93	71.85
12/15	10.87	91.31	61.73	71.37
12/16	12.07	87.20	60.19	69.32
12/17	15.02	86.96	62.24	70.36
12/18	12.21	87.39	61.36	70.00
12/19	15.39	83.63	62.45	69.46
12/20	13.48	81.47	60.80	67.87
12/21	8.45	81.76	58.77	66.86
12/22	7.23	81.36	54.43	64.51
12/23	9.74	79.41	44.32	59.39
12/24	5.68	77.73	43.97	58.63

Table 2.3-7f

24 Hour HMS Meteorological Profile for August 4, 1961

Hour	Dry Bulb Temp °F	Wet Bulb Temp °F	Dew Pt °F	Wind (mph) °F
0	82.0	61.0	45.0	4
1	84.0	62.0	46.0	5
2	86.0	63.0	48.0	5
3	85.0	63.0	49.0	5
4	85.0	63.0	48.0	5
5	85.0	62.0	46.0	3
6	86.0	61.0	43.0	8
7	91.0	63.0	42.0	7
8	92.0	63.0	42.0	6
9	96.0	64.0	41.0	6
10	99.0	65.0	42.0	7
11	103.0	67.0	44.0	6
12	107.0	69.0	45.0	6
13	110.0	70.0	46.0	5
14	112.0	71.0	48.0	6
15	112.0	71.0	48.0	5
16	113.0	72.0	49.0	5
17	110.0	70.0	45.0	8
18	108.0	68.0	43.0	14
19	100.0	66.0	45.0	19
20	98.0	66.0	45.0	20
21	96.0	66.0	46.0	18
22	94.0	65.0	46.0	16
23	93.0	64.0	45.0	12

24 Hour Average:

Dry Bulb = 96.96 °F
Wet Bulb = 65.62 °F
Dew Point = 45.29 °F
Wind = 8.37 mph

Table 2.3-7g

Diurnal Variation in Dry Bulb and Wet Bulb Temperature for Use in Analyzing Second Through Thirtieth Day Pond Thermal Performance (Based On July 9 - August 8, 1961 Hourly Hanford Meteorological Station Data)

Hour	Dry Bulb (°F)	Wet Bulb (°F)
1	70.2	56.5
2	68.8	56.0
3	68.3	55.8
4	68.8	56.0
5	70.2	56.5
6	72.5	57.3
7	75.6	58.4
8	79.0	59.6
9	82.8	61.0
10	86.6	62.3
11	90.1	63.6
12	93.1	64.7
13	95.4	65.5
14	96.8	66.0
15	97.3	66.2
16	96.8	66.0
17	95.4	65.5
18	93.1	64.7
19	90.1	63.6
20	86.6	62.3
21	82.8	61.0
22	79.0	59.6
23	75.6	58.4
24	72.5	57.3
Daily Average and Variation	82.8 ± 14.5°F	61.0 ± 5.2°F

Table 2.3-7h

Diurnal Variation in Dry Bulb and Wet Bulb Temperature for Use in Analyzing First Through Thirtieth Day Maximum Mass Loss (Based On July 2 - August 1, 1960 Hourly Hanford Meteorological Station Data)

Hour	Dry Bulb (°F)	Wet Bulb (°F)
1	69.4	53.3
2	67.8	52.6
3	67.3	52.4
4	67.8	52.6
5	69.4	53.3
6	71.9	54.3
7	75.1	55.7
8	78.9	57.3
9	82.9	59.0
10	86.9	60.7
11	90.7	62.3
12	93.9	63.7
13	96.4	64.7
14	98.0	65.4
15	98.5	65.6
16	98.0	65.4
17	96.4	64.7
18	93.9	63.7
19	90.7	62.3
20	86.9	60.7
21	82.9	59.0
22	78.9	57.3
23	75.1	55.7
24	71.9	54.3
Daily Average and Variation	82.9 ± 15.6°F	59.0 ± 6.6°F

Table 2.3-8a

Summary of CGS Onsite Meteorological Data Collected During the First and Second Annual Cycles as Compared to Corresponding Hanford Meteorological Station Data (Historical HMS Data Indicated for Each Month)

	April		May		June		July		August		September		October	
Site and Sensor Elevation	'74	'75	'74	'75	'74	'75	'74	'75	'74	'75	'74	'75	'74	'75
1. Prevailing Wind Direction														
CGS 33'	WNW	SSW	SSW	NW	WNW	NW	S	S	S	S	N	N	WNW	S
HMS 50'	WNW	N/A	WNW	N/A	WNW	N/A	WNW	N/A	WNW	N/A	NW	N/A	NW	NW
HMS (hist) 50' (1955-1970)	WNW		WNW		WNW		WNW		WNW		NW		WNW	
2. Mean Wind Speed (mph)														
CGS 33'	9.8	8.0	8.4	8.7	8.5	9.3	7.2	7.6	6.8	7.9	6.5	5.7	4.8	7.2
HMS 50'	10.3	9.0	9.0	9.6	9.0	10.5	8.1	8.5	7.5	9.0	7.1	6.8	5.6	7.1
HMS (hist) 50' (1955-1970)	9.0		8.8		9.2		8.6		8.0		7.5		6.7	
3. Mean Dry Bulb Temp. (°F)														
CGS 33'	52.2	47.6	57.4	59.6	72.5	66.1	73.6	78.7	74.7	70.3	66.9	66.2	51.7	52.1
HMS 3'	52.5	48.4	57.9	60.7	73.3	67.3	74.8	80.0	76.3	71.2	68.3	67.9	52.0	52.3
HMS (hist) 3' (1950-1970)	52.5		61.8		69.9		77.5		75.3		67.0		53.2	
4. Mean Wet Bulb Temp. (°F)														
CGS 33'	44.7	39.7	47.2	48.2	56.0	52.7	57.4	61.5	58.0	55.7	52.6	52.0	43.8	45.3
HMS 3'	43.9	40.0	46.5	49.0	54.5	54.0	56.3	62.0	57.0	56.0	52.0	52.0	42.0	45.0
HMS (hist) 3' (1950-1970)	42.8		49.1		54.5		57.9		57.3		52.6		45.4	
5. Mean Dew Point Temp. (°F)														
CGS 33'	36.6	29.8	36.6	36.9	43.0	40.8	44.9	50.2	45.6	44.2	39.9	39.5	35.0	38.2
HMS 3'	33.3	30.0	34.0	38.6	38.2	42.4	41.0	50.1	43.2	44.6	38.9	38.2	31.0	37.2
HMS (hist) 3' (1950-1970)	30.4		36.0		41.2		42.3		42.8		39.5		36.9	
6. Total Precipitation (inches)														
CGS	.55	.53	.44	.47	.06	.46	.45	.09	0.0	1.17	.06	0.0	.10	.74
HMS	.46	.42	.28	.38	.12	.14	.71	.32	Trace	1.16	.01	.03	.21	.87
HMS (hist) 1946-1970 Mean Total	.44		.50		.66		.16		.21		.30		.61	

N/A - Not Available

Table 2.3-8a

Summary of CGS Onsite Meteorological Data Collected During the First and Second Annual Cycles as Compared to Corresponding Hanford Meteorological Station Data (Historical HMS Data Indicated for Each Month) (Continued)

Site and Sensor Elevation	November '74	November '75	December '74	December '75	January '75	January '76	February '75	February '76	March '75	March '76	First Annual Cycle April '74–March '75	Second Annual Cycle April '75–March '76
1. Prevailing Wind Direction												
CGS 33'	SSW	S	S	NW	NNW	NW	NW	SSW	NNW	SSW	NW	NW
HMS 50'	NW	NW	NW	NW	NW SW	NW	NW	NW SW	WNW	NW SW	N/A	N/A
HMS (hist) 50' (1955-1970)	NW		NW		NW		NW		WNW		NW ('55 –'70)	
2. Mean Wind Speed (mph)												
CGS 33'	5.8	7.8	6.4	7.1	6.4	5.0	7.8	10.4	8.7	9.1	7.2	7.8
HMS 50'	5.5	7.7	5.9	7.2	6.4	4.9	7.5	10.8	8.9	9.6	9.1	10.1
HMS (hist) 50' (1955-1970)	6.2		6.0		6.4		7.0		8.4		7.6 ('55 – '70)	
3. Mean Dry Bulb Temp. (°F)												
CGS 33'	42.1	39.5	36.8	34.2	32.3	32.4	33.8	37.7	41.9	40.8	53.1	52.1
HMS 3'	42.1	39.3	35.7	34.5	32.0	31.5	33.6	37.3	42.0	40.6	53.4	52.6
HMS (hist) 3' (1950-1970)	40.1		33.4		30.3		37.5		44.0		53.5 ('50 – '70)	
4. Mean Wet Bulb Temp. (°F)												
CGS 33'	39.3	35.5	34.5	31.9	30.0	30.6	30.9	32.9	36.2	34.4	44.3	43.4
HMS 3'	38.0	35.0	33.0	32.0	30.0	30.0	31.0	33.0	36.0	35.0	43.4	43.6
HMS (hist) 3' (1950-1970)	36.4		31.2		27.9		33.6		37.3		43.8 ('50 – '70)	
5. Mean Dew Point Temp. (°F)												
CGS 33'	36.3	30.6	31.4	28.9	26.3	28.1	26.5	25.4	27.9	24.8	35.9	34.8
HMS 3'	33.9	30.0	29.2	28.1	26.0	27.6	25.5	25.5	26.0	25.0	33.4	34.8
HMS (hist) 3' (1950-1970)	31.1		27.5		23.2		27.4		27.3		33.8 ('50 – '70)	
6. Total Precipitation (inches)												
CGS	.56	.70	.67	.03	.93	.08	.67	.11	.52	.16	4.92	4.54
HMS	.71	.60	.97	.70	1.43	.56	.98	.36	.33	.23	6.21	5.87
HMS (hist) 1946-1970 Mean Total	.80		.81		.97		.58		.38		6.53 ('46 – '70)	

N/A - Not Available

Table 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975)

APRIL
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	176	131	45	13	64	720

MAY
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

JUNE
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 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975) (Continued)

JULY
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

AUGUST
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

SEPTEMBER
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 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975) (Continued)

OCTOBER
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

NOVEMBER
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

DECEMBER
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 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975) (Continued)

JANUARY
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

FEBRUARY
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

MARCH
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 2.3-8b

Frequency of Occurrence of Wind Direction Versus Speed for CGS 33-ft Level (1974-1975) (Continued)

ANNUAL

	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	0	2005	3332	1945	801	258	64	354	8760

Table 2.3-9

Percentage Frequency Distribution of 50-ft Wind Direction Versus Speed at HMS (1955-1970)

JANUARY
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.8	1.2	0.2	0.3	0.2					4.7	4.3
NNE	2.0	0.8	0.4	0.1	0.1	#				3.4	4.6
NE	1.8	0.7	0.2	0.1	0.1	#				2.9	4.4
ENE	1.3	0.5	0.1	#	#					1.9	3.0
E	1.8	0.6	0.1	#						2.4	3.0
ESE	1.8	0.7	0.2	0.1	#					2.8	3.4
SE	2.7	1.5	0.4	0.2	#	#				4.8	4.0
SSE	1.6	0.8	0.3	0.1	0.1					2.9	5.4
S	1.4	0.9	0.4	0.5	0.2	0.1	0.1	#		3.6	7.7
SSW	1.2	1.0	0.6	1.0	0.6	0.3	0.1	#		4.8	11.5
SW	1.4	1.4	1.4	1.6	0.7	0.3	#			6.8	10.7
WSW	1.4	1.5	1.7	0.8	0.4	0.2	#			6.0	8.9
W	1.8	2.3	1.3	10.6	0.1					6.1	6.3
WNW	2.4	5.6	5.1	0.9	#	#				14.0	7.1
NW	3.6	7.8	6.6	1.2	0.1	#				19.3	6.9
NNW	3.0	2.8	0.6	0.1	#					6.5	4.2
VAR	1.3	0.1								1.4	1.8
CALM	5.4									5.4	
TOTAL	38.7	30.1	19.6	7.6	2.6	0.9	0.2	#		100.0	6.2

# DENOTES LESS THAN 0.05%

FEBRUARY
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.6	1.6	0.4	0.2	#	#				4.8	4.5
NNE	1.8	1.3	0.8	0.4	0.1	0.1				4.5	6.3
NE	2.2	0.9	0.2	0.2	#					3.5	3.8
ENE	1.3	0.6	0.1							1.9	3.3
E	1.3	0.7	#							2.0	3.0
ESE	1.3	0.7	0.1							2.1	3.3
SE	1.9	1.1	0.3	0.1						3.4	4.0
SSE	1.2	0.8	0.4	0.2	#					2.6	5.2
S	1.3	0.7	0.4	0.3	0.1	0.1				2.9	6.6
SSW	1.0	1.0	0.8	0.6	0.5	0.2	0.1	#		4.2	10.5
SW	1.0	1.6	1.3	1.8	1.1	0.5	0.1	#		7.4	12.6
WSW	0.9	2.1	2.1	1.4	0.5	0.3	0.1	#		7.4	10.5
W	1.6	3.4	2.9	1.1	0.2	0.1				9.3	7.8
WNW	1.9	4.9	6.8	1.5	0.3	0.1				15.5	8.3
NW	3.3	6.9	6.4	1.5	0.2	0.1				18.4	7.3
NNW	2.3	2.5	0.8	0.1	#					5.7	4.8
VAR	1.3	0.2	#							1.5	1.8
CALM	2.4									2.4	
TOTAL	30.6	31.0	23.8	9.4	3.0	1.5	0.3			100.0	7.1

# DENOTES LESS THAN 0.05%

MARCH
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.9	1.8	1.0	0.2	#					4.9	5.4
NNE	1.4	1.6	0.9	0.6	#	#				4.5	6.8
NE	1.7	1.2	0.3	0.2	0.1	#				3.5	4.8
ENE	0.7	0.8	0.1	#	#	#				1.6	5.0
E	0.9	0.8	0.2	#	#					1.9	4.2
ESE	1.0	1.1	0.2	0.1						2.4	4.4
SE	1.4	1.7	0.5	0.1	#					3.7	5.0
SSE	0.6	1.1	0.8	0.3	#					2.8	7.1
S	1.0	1.4	0.7	0.4	0.2	#				3.7	7.4
SSW	0.6	1.3	1.1	1.2	0.7	0.3	0.1			5.3	12.1
SW	0.8	2.0	2.0	2.5	1.5	0.8	0.2	#	#	9.8	13.5
WSW	0.8	2.5	3.0	2.5	1.0	0.4	0.2			10.4	11.7
W	1.1	3.9	3.1	1.2	0.2	0.1				9.6	8.2
WNW	1.1	4.4	5.8	2.2	0.8	0.1				14.4	9.5
NW	1.5	4.4	5.3	1.8	0.6	0.1				13.7	8.9
NNW	1.4	2.4	1.1	0.2	#					5.1	5.6
VAR	1.3	0.2	#							1.5	2.1
CALM	0.7									0.7	
TOTAL	19.9	32.6	26.1	13.5	5.1	1.8	0.5			100.0	8.6

# DENOTES LESS THAN 0.05%

APRIL
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.6	1.6	0.7	0.3	#					4.2	5.5
NNE	1.0	1.3	0.6	0.3	0.1	#				3.3	6.8
NE	1.4	1.2	0.4	0.2	#	#				3.2	5.3
ENE	0.6	1.0	0.2	0.1						1.9	5.2
E	0.8	1.0	0.5	#						2.3	5.0
ESE	0.8	1.0	0.2	#						2.0	4.5
SE	1.0	1.5	0.5	0.1						3.1	5.2
SSE	0.5	1.0	0.8	0.2						2.5	6.8
S	0.7	1.4	0.7	0.3	0.1	#				3.2	6.7
SSW	0.7	1.5	1.1	0.9	0.4	0.1				4.7	9.6
SW	0.7	2.3	2.1	2.1	1.6	0.6	0.1			9.5	12.7
WSW	0.8	2.6	3.8	2.5	1.1	0.4	0.1			11.3	11.4
W	1.1	4.2	4.3	1.7	0.5	0.1	#			11.9	8.8
WNW	0.8	3.9	6.0	4.2	1.3	0.3				16.5	11.0
NW	1.2	3.7	4.2	3.2	1.5	0.4	#			14.2	11.0
NNW	0.9	1.9	0.6	0.2	#					3.6	5.8
VAR	1.6	0.5								2.1	2.7
CALM	0.5									0.5	
TOTAL	16.7	31.6	26.7	16.3	6.6	1.9	0.2			100.0	9.1

# DENOTES LESS THAN 0.05%

Table 2.3-9

Percentage Frequency Distribution of 50-ft Wind Direction Versus Speed at HMS (1955-1970) (Continued)

MAY
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.2	1.7	0.9	0.1						3.9	5.7
NNE	0.6	1.4	0.7	0.3	#					3.0	6.7
NE	1.0	1.5	1.0	0.1	0.1					3.7	6.4
ENE	0.8	1.1	0.3	0.1						2.3	5.0
E	0.9	1.2	0.3	#						2.4	4.7
ESE	0.9	1.0	0.3	#						2.2	4.6
SE	1.0	1.5	0.6	0.1						3.2	5.4
SSE	0.6	1.3	0.6	0.2	#					2.7	6.4
S	0.6	1.7	0.5	0.1	#					2.9	5.6
SSW	0.7	1.3	0.8	0.4	0.1	#				3.3	7.4
SW	0.6	2.4	1.7	1.1	0.5	0.1	#			6.4	9.6
WSW	0.9	2.7	3.5	1.8	0.7	0.2	#			9.8	10.1
W	1.2	4.0	4.4	1.6	0.2	#				11.4	8.3
WNW	0.8	3.9	6.7	4.7	1.7	0.2	#			18.0	11.2
NW	1.2	3.6	4.9	4.4	2.6	0.5	#			17.2	12.0
NNW	1.0	1.8	0.7	0.1						3.6	5.5
VAR	1.9	1.3	#							3.2	3.2
CALM	0.6									0.6	
TOTAL	16.5	33.4	27.9	15.1	5.9	1.0	#			100.0	8.7

# DENOTES LESS THAN 0.05%

JUNE
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	0.9	2.0	0.9	0.2						4.0	6.0
NNE	0.6	1.8	0.8	0.4	#					3.6	7.1
NE	0.8	1.4	0.8	0.5	0.1	#				3.6	7.5
ENE	0.4	1.0	0.4	0.1	#	#				1.9	6.5
E	0.5	1.3	0.3	#	#					2.1	5.6
ESE	0.6	1.3	0.3	#						2.2	5.0
SE	0.7	1.6	0.4	#						2.7	5.2
SSE	0.5	1.1	0.4	0.1	#					2.1	5.8
S	0.6	1.7	0.3	0.1						2.7	5.5
SSW	0.4	1.5	0.7	0.2	0.1	#				2.9	7.3
SW	0.7	2.5	2.0	1.0	0.3	#				6.5	8.8
WSW	0.6	2.5	3.5	1.5	0.4	0.1	#			8.6	9.7
W	0.7	4.1	4.4	1.6	0.3	#				11.1	8.8
WNW	0.6	3.5	6.9	6.2	2.1	0.4	#			19.7	12.1
NW	0.7	3.7	5.1	5.4	3.4	0.7	#			19.0	13.0
NNW	0.6	2.0	0.8	0.1	#	#				3.5	6.3
VAR	1.6	1.7	#							3.3	3.4
CALM	0.3									0.3	
TOTAL	11.8	34.7	28.0	17.4	6.7	1.2				100.0	9.3

# DENOTES LESS THAN 0.05%

JULY
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.1	2.6	0.6	0.1						4.4	5.3
NNE	0.7	2.1	0.8	0.2	#					3.8	6.0
NE	0.9	2.1	0.5	0.2	#					3.7	5.7
ENE	0.5	1.2	0.2	#						1.9	5.0
E	0.7	1.5	0.3							2.5	4.9
ESE	0.7	1.3	0.3	#						2.3	4.9
SE	0.9	1.7	0.3	#						2.9	4.9
SSE	0.4	1.0	0.4	#	#	#				1.8	5.6
S	0.7	1.5	0.2	0.1	#	#				2.5	5.3
SSW	0.5	1.3	0.5	0.2	0.4	#				2.5	6.5
SW	0.8	2.3	1.7	1.0	0.4	0.1	#			6.3	9.1
WSW	0.7	3.0	2.8	1.4	0.1	0.2	#			8.5	9.5
W	1.0	4.4	3.5	0.9	1.8	#				9.9	7.7
WNW	0.7	4.2	7.7	4.8	3.0	0.2				19.4	11.2
NW	0.9	3.8	5.6	5.1	#	0.5				18.9	12.4
NNW	0.8	2.0	0.7	0.1						3.6	5.8
VAR	2.6	1.8	#							4.4	3.3
CALM	0.4									0.4	
TOTAL	15.0	37.8	26.1	14.1	5.7	1.0				100.0	8.6

# DENOTES LESS THAN 0.05%

AUGUST
SPEED CLASS (MPH)

DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.3	2.5	0.4	0.1						4.3	5.0
NNE	1.0	1.8	0.5	0.1						3.4	5.1
NE	1.3	1.6	0.3	0.1	#					3.3	4.4
ENE	0.7	1.1	0.1	#						1.9	4.3
E	0.9	1.3	0.2	#						2.4	4.5
ESE	0.8	1.6	0.3							2.7	4.7
SE	1.1	1.8	0.5	#						3.4	4.8
SSE	0.7	1.1	0.6	#	#					2.4	5.5
S	0.8	1.4	0.3	#						2.5	4.8
SSW	0.6	1.6	0.7	0.2	0.1					3.2	6.6
SW	1.0	2.7	1.6	0.8	0.2	0.1	#			6.4	8.1
WSW	0.9	3.2	2.9	1.4	0.1	0.1				8.6	8.5
W	1.3	5.1	4.1	0.7	#					11.2	7.5
WNW	0.9	4.1	7.6	4.1	1.3	0.2				18.2	10.6
NW	1.2	3.8	5.1	4.5	2.3	0.5				17.4	11.8
NNW	1.0	2.3	0.5	0.1	#					3.9	5.4
VAR	2.8	1.3								4.1	3.0
CALM	0.6									0.6	
	18.9	38.3	25.7	12.1	4.0	0.9	#			100.0	7.9

# DENOTES LESS THAN 0.05%

Table 2.3-9

Percentage Frequency Distribution of 50-ft Wind Direction Versus Speed at HMS (1955-1970) (Continued)

SEPTEMBER

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	1.9	2.4	0.9	0.3	#	#				5.5	5.3
NNE	1.5	1.8	1.0	0.4	0.1	#				4.8	6.4
NE	1.8	1.8	0.6	0.3	0.1	#				4.6	5.6
ENE	1.3	0.9	0.1	0.1						2.4	3.9
E	1.6	1.1	0.2	#						2.9	3.7
ESE	1.2	1.5	0.2							2.9	4.1
SE	1.4	2.1	0.4	#						3.9	4.6
SSE	0.9	1.3	0.5	0.1						2.8	5.3
S	0.9	1.3	0.3	0.1	#					2.6	5.2
SSW	0.8	1.6	0.5	0.2	0.1	0.1				3.3	7.0
SW	0.8	2.1	1.3	1.0	0.5	0.3	#			6.0	9.9
WSW	1.0	3.0	2.7	1.3	0.6	0.1	#			8.7	9.4
W	1.3	4.9	3.7	0.8	0.3	0.1				11.1	7.6
WNW	1.2	4.0	5.6	2.9	0.9	0.1				14.7	9.8
NW	1.4	3.6	4.9	3.3	1.4	0.2				14.8	10.5
NNW	1.3	2.6	0.9	0.2	#					5.0	5.7
VAR	2.0	0.6								2.6	2.6
CALM	1.2									1.2	
TOTAL	23.5	36.6	23.8	11.0	4.0	0.9				100.0	7.5

# DENOTES LESS THAN 0.05%

OCTOBER

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.6	1.7	0.4	0.1						4.8	3.9
NNE	2.1	1.1	0.3	0.1						3.6	3.9
NE	2.4	0.8	0.2	0.1	#					3.5	3.5
ENE	1.4	0.7	0.1	#	#					2.2	3.6
E	1.8	0.9	0.1							2.8	3.1
ESE	1.8	1.4	0.1							3.3	3.6
SE	2.5	1.9	0.6	0.1						5.1	4.2
SSE	1.0	1.5	0.7	0.1	#					3.3	5.7
S	1.1	1.4	0.5	0.3	0.2	#				3.5	6.7
SSW	1.0	1.4	0.7	0.7	0.5	0.2	#	#		4.5	9.7
SW	1.0	2.0	1.5	1.4	1.0	0.4	#			7.3	11.3
WSW	1.0	2.8	3.0	1.6	0.6	0.1	#			9.1	9.5
W	1.7	4.6	3.6	0.7	0.1	#				10.7	7.1
WNW	1.7	4.7	5.0	1.4	0.4	#				13.2	8.1.
NW	2.4	4.4	4.0	1.6	0.4	0.1	#			12.9	8.0
NNW	2.1	2.5	0.6	0.1	#	#				5.3	4.7
VAR	1.6	0.1	#							1.7	1.8
CALM	2.7									2.7	
TOTAL	31.9	33.9	21.4	8.3	3.2	0.8	#	#		100.0	6.7

# DENOTES LESS THAN 0.05%

NOVEMBER

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.7	1.3	0.4	0.2						4.6	4.0
NNE	2.2	0.7	0.4	0.2	#					3.5	4.0
NE	1.9	0.5	0.1	#						2.5	2.8
ENE	1.8	0.4	#							2.2	2.5
E	1.9	0.6	#							2.5	2.6
ESE	2.0	1.0	0.1							3.1	3.1
SE	2.5	1.4	0.3	0.1						4.3	3.9
SSE	1.4	1.2	0.4	0.2	0.1	#				3.3	5.3
S	1.7	1.2	0.5	0.5	0.3	#				4.2	6.8
SSW	1.4	1.2	0.8	0.9	0.7	0.2	0.1			5.3	9.9
SW	1.6	1.6	1.4	1.5	0.8	0.3	0.1	#		7.3	10.5
WSW	1.3	2.1	1.9	1.3	0.4	0.1	#	#		7.1	9.1
W	2.1	3.4	1.9	0.6	0.1	0.1	#			8.2	6.8
WNW	2.5	4.6	4.9	1.0	0.3	0.1				13.4	7.5
NW	3.6	5.9	4.7	0.7	0.1	0.1	#			15.1	6.6
NNW	3.0	2.8	1.0	0.2						7.0	4.6
VAR	1.4	0.1								1.5	1.6
CALM	4.7									4.7	
TOTAL	39.7	30.0	18.8	7.4	2.8	0.9	0.2	#		100.0	6.1

# DENOTES LESS THAN 0.05%

DECEMBER

DIRECTION	SPEED CLASS (MPH) 0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.7	1.0	0.3	0.2						4.2	3.5
NNE	1.6	0.6	0.2	#						2.4	3.6
NE	1.7	0.5	#	#						2.2	2.6
ENE	1.5	0.5	#							2.0	2.4
E	1.6	0.6	0.1	#	#					2.3	2.9
ESE	1.9	0.7	0.2	0.1	#					2.9	3.6
SE	2.6	1.2	0.4	0.1	#					4.3	3.6
SSE	1.7	1.2	0.2	0.2	0.1					3.4	4.7
S	1.7	0.8	0.4	0.4	0.2	0.1	#			3.6	6.7
SSW	1.3	0.7	0.6	0.8	0.5	0.4	0.1	#		4.4	11.1
SW	1.5	1.3	1.2	1.4	1.0	0.5	0.1	#	#	7.0	11.8
WSW	1.6	1.8	1.7	1.1	0.4	0.1	#			6.7	8.6
W	2.1	2.7	1.5	0.5	0.1	#				6.9	6.0
WNW	2.9	5.7	5.3	0.8	0.1	#				14.8	6.9
NW	3.8	7.3	6.0	1.0	0.1					18.2	6.7
NNW	2.9	2.4	0.9	0.1						6.3	4.3
VAR	1.5	0.1								1.6	1.7
CALM	6.8									6.8	
TOTAL	41.4	29.1	19.0	6.7	2.5	1.1	0.2	#	#	100.0	5.9

# DENOTES LESS THAN 0.05%

Table 2.3-9

Percentage Frequency Distribution of 50-ft Wind Direction Versus Speed at HMS (1955-1970) (Continued)

COMPOSITE OF ALL MONTHS

	SPEED CLASS (MPH)										
DIRECTION	0-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	46	TOTAL	AVG SPEED
N	2.0	1.8	0.6	0.2	#	#				4.6	4.9
NNE	1.4	1.4	0.6	0.3	#	#				3.7	5.7
NE	1.6	1.2	0.4	0.2	#	#				3.4	4.9
ENE	1.0	0.8	0.2	#	#	#				2.0	4.1
E	1.2	1.0	0.2	#	#					2.4	3.9
ESE	1.2	1.1	0.2	#	#					2.5	4.0
SE	1.6	1.6	0.4	0.1	#	#				3.7	4.5
SSE	0.9	1.1	0.5	0.1	#	#				2.0	5.7
S	1.0	1.3	0.4	0.2	0.1	#	#	#		3.0	6.4
SSW	0.9	1.3	0.7	0.6	0.3	0.2	#	#		4.0	9.5
SW	1.0	2.0	1.6	1.4	0.8	0.3	0.1	#	#	7.2	10.9
WSW	1.0	2.5	2.7	1.6	0.5	0.2	#	#		8.5	9.9
W	1.4	3.9	3.2	1.0	0.2	#	#			9.7	7.7
WNW	1.5	4.5	6.1	2.9	0.9	0.1	#			16.0	9.7
NW	2.1	4.9	5.2	2.8	1.3	0.3	#			16.6	9.6
NNW	1.7	2.3	0.8	0.1	#	#				4.9	5.1
VAR	1.7	0.7	#							2.4	2.7
CALM	2.2									2.2	
TOTAL	25.4	33.4	23.8	11.5	4.1	1.1	0.1	#	#	100.0	7.6

# DENOTES LESS THAN 0.05%

Table 2.3-10

Percent Frequency of Occurrence of Wind Direction at the Hanford Reservation*

WIND DIRECTION

MONTH/YEAR/SITE/ELEVATION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VARIABLE	CALM
4/74 CGS 33'	2.64	3.06	0.42	0.83	1.53	3.19	7.50	8.89	13.06	7.78	5.69	8.75	17.08	9.31	4.17	3.19	0.97	0.00
4/74 CGS (temp) 23'	2.64	3.61	1.11	1.81	3.75	4.72	6.81	10.42	6.11	4.31	4.72	10.28	16.11	7.50	2.36	2.92	3.19	0.00
4/74 HMS 50'	1.53	2.36	1.25	1.53	1.94	2.64	2.50	1.81	3.61	6.81	15.28	13.19	22.08	17.08	2.78	1.53	1.67	0.42
April (1955-1970) HMS (hist) 50'	3.2	3.2	2.0	2.3	2.0	3.1	2.5	3.2	4.7	9.5	11.2	11.8	16.6	14.3	3.7	4.2	2.1	0.4
5/74 CGS 33'	2.15	1.75	1.21	1.88	2.02	2.42	8.06	12.37	14.25	6.99	9.27	10.62	12.90	6.32	3.09	1.61	2.02	0.00
5/74 CGS (temp) 23'	0.94	2.69	0.94	2.82	2.28	4.57	8.20	11.83	9.14	6.32	7.53	8.20	8.06	5.24	2.55	1.48	6.05	0.13
5/74 HMS 50'	1.88	1.34	0.81	1.75	3.36	1.88	1.75	2.15	4.70	8.47	14.92	14.25	21.24	13.31	1.75	1.88	3.90	0.67
May (1955-1970) HMS (hist) 50'	3.1	3.7	2.3	2.4	2.2	3.3	2.7	2.8	3.3	6.4	9.8	11.4	18.1	17.2	3.6	3.9	3.2	0.6
6/74 CGS 33'	2.50	2.92	4.31	3.33	3.61	5.14	7.22	7.64	7.08	4.03	3.89	7.22	9.31	7.36	3.61	2.50	0.69	0.00
6/74 CGS (temp) 23'	3.06	4.72	3.75	4.44	7.22	7.50	7.78	6.67	6.53	5.42	3.61	4.86	10.0	10.0	4.72	2.22	7.50	0.00
6/74 HMS 50'	1.94	2.92	2.22	2.50	3.75	4.03	2.64	2.36	3.06	4.44	7.22	6.25	24.03	19.58	4.72	2.36	5.56	0.42
June (1955-1970) HMS (hist) 50'	3.6	3.7	2.0	2.2	2.2	2.8	2.1	2.6	3.0	6.5	8.5	11.2	19.6	18.9	3.5	3.9	3.3	0.4
7/74 CGS 33'	2.42	3.23	2.42	4.03	3.36	5.38	7.66	9.41	7.26	6.72	4.70	6.59	8.47	9.01	5.51	4.70	4.30	0.00
7/74 CGS (temp) 23'	3.63	4.30	3.49	3.09	5.51	5.78	8.60	9.14	10.22	3.36	3.76	4.30	5.65	12.50	5.78	3.76	6.99	0.13
7/74 HMS 50'	2.82	1.88	2.96	2.55	3.90	3.76	2.69	3.76	2.96	5.11	12.50	12.90	16.53	11.96	2.96	2.42	8.33	0.00
July (1955-1970) HMS (hist) 50'	3.8	3.8	2.0	2.5	2.3	2.9	1.9	2.5	2.5	6.3	8.4	9.9	19.5	18.9	3.5	4.5	4.4	0.4
8/74 CGS 33'	6.45	5.65	2.02	2.42	2.82	4.30	8.47	10.08	8.87	4.44	3.76	3.49	9.81	9.01	6.59	7.66	2.42	0.00
8/74 CGS (temp) 23'	6.72	8.87	4.03	4.03	3.76	5.38	10.48	10.62	5.51	3.49	2.42	2.69	7.39	8.74	7.12	3.49	4.30	0.40
8/74 HMS 50'	5.65	3.49	2.55	2.42	2.69	2.55	2.55	2.96	3.49	3.36	7.12	10.62	16.80	16.13	5.65	4.97	6.18	0.81
August (1955-1970) HMS (hist) 50'	3.4	2.9	2.0	2.4	2.7	3.4	2.4	2.5	3.2	6.4	8.6	11.3	18.3	17.4	3.9	4.4	4.2	0.6
9/74 CGS 33'	9.58	5.42	5.56	3.33	3.75	2.92	2.92	8.19	5.28	4.03	2.36	5.00	7.78	9.03	8.19	12.92	2.64	0.00
9/73 CGS (temp) 23'	4.72	6.11	3.61	4.86	3.75	5.42	7.92	8.47	5.28	4.72	2.36	3.75	7.36	6.94	7.08	8.47	9.17	0.00
9/73 HMS 50'	7.36	4.86	1.67	3.75	2.50	2.50	2.64	2.92	3.61	4.58	8.61	6.81	15.28	15.97	7.22	4.03	3.06	2.64
September (1955-1970) HMS (hist) 50'	4.9	4.6	2.4	2.9	2.8	3.9	2.7	2.8	3.4	6.0	8.8	11.0	14.7	14.8	4.9	5.6	2.6	1.2
10/74 CGS 33'	5.65	5.78	6.59	3.23	2.28	4.84	6.05	6.85	5.65	3.49	3.76	4.97	8.60	7.12	8.06	8.60	2.69	0.13
10/73 CGS (temp) 23'	3.76	4.70	2.69	4.30	3.63	6.85	9.68	11.96	7.53	5.51	1.75	4.84	7.12	6.85	4.97	3.23	8.20	0.27
10/73 HMS 50'	2.42	3.76	2.15	1.75	3.23	3.63	2.96	3.23	5.65	10.89	11.16	9.27	14.78	11.42	4.84	2.82	1.48	4.57
October (1955-1970) HMS (hist) 50'	3.5	3.6	2.3	2.8	3.3	5.1	3.4	3.5	4.5	7.4	9.2	10.7	13.2	12.9	5.4	4.7	1.8	2.7

* For some months, when concurrent measurements are not available for all sites shown; previous year data is given.

Table 2.3-10

Percent Frequency of Occurrence of Wind Direction at the Hanford Reservation* (Continued)

WIND DIRECTION

MONTH/YEAR/SITE/ELEVATION	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	VARIABLE	CALM
11/74 CGS 33'	5.28	3.61	4.31	1.11	2.08	4.72	7.36	10.42	10.69	6.94	3.33	4.86	7.08	10.42	8.33	6.94	1.81	0.00
11/73 CGS (temp) 23'	2.22	4.86	1.81	1.53	4.44	8.19	9.72	8.19	5.42	2.22	2.22	5.69	16.25	8.06	3.75	2.92	3.61	0.28
11/73 HMS 50'	3.33	1.67	1.81	1.81	3.61	6.11	3.06	5.00	6.25	7.50	4.86	5.42	13.89	19.31	5.97	4.44	0.56	5.42
November (1955-1970) HMS (hist) 50'	3.4	2.6	2.3	2.5	3.1	4.4	3.3	4.2	5.2	7.4	7.1	8.4	13.4	15.1	7.0	4.6	1.4	4.6
12/74 CGS 33'	2.28	2.15	1.21	0.94	1.34	2.82	8.06	13.44	11.02	4.84	6.05	6.99	10.89	12.23	8.33	4.57	1.61	0.00
12/73 CGS (temp) 23'	2.28	5.38	2.28	2.82	3.76	7.53	9.95	10.62	5.24	3.09	2.02	4.30	9.41	10.48	4.84	2.82	7.93	0.67
12/73 HMS 50'	2.02	1.48	2.15	2.28	2.28	3.49	3.49	4.30	4.70	7.12	8.20	9.54	13.84	20.02	4.57	1.75	2.15	6.59
December (1955-1970) HMS (hist) 50'	2.5	2.3	1.9	2.3	2.8	4.2	3.4	3.5	4.4	7.1	6.8	6.9	14.8	18.2	6.3	4.2	1.6	6.8
1/75 CGS 33'	4.57	3.76	4.44	2.42	3.09	3.63	6.45	6.18	6.99	6.45	6.05	3.76	6.85	11.96	13.71	5.91	1.48	0.00
1/74 CGS (temp) 23'	2.28	1.88	1.08	1.88	3.09	4.97	7.12	13.17	17.34	8.20	3.23	3.23	5.51	6.32	3.49	1.88	4.70	1.61
1/74 HMS 50'	2.69	3.09	2.02	1.34	2.55	4.57	4.03	4.03	5.24	16.67	13.04	7.66	7.53	9.81	4.30	3.09	1.21	4.70
January (1955-1970) HMS (hist) 50'	3.4	2.9	1.9	2.4	2.8	4.7	3.1	3.6	4.9	6.7	6.0	6.1	14.2	19.5	6.4	4.6	1.4	5.4
2/75 CGS 33'	4.76	2.38	1.93	0.89	1.64	2.98	7.74	7.89	8.18	4.91	4.61	3.57	5.21	18.76	14.43	8.18	1.19	0.00
2/74 CGS (temp) 23'	1.04	1.79	1.34	1.64	4.32	7.44	9.08	13.54	13.39	6.25	7.14	5.21	8.33	5.65	2.38	1.34	8.93	0.19
2/74 HMS 50'	2.08	2.68	2.08	1.19	4.17	4.46	2.83	5.36	8.63	10.57	12.95	10.86	10.12	10.71	4.91	2.38	2.23	1.79
February (1955-1970) HMS (hist) 50'	4.4	3.5	1.9	2.1	2.2	3.4	2.7	2.9	4.2	7.5	7.4	9.3	15.4	18.4	5.8	5.0	1.5	2.4
3/75 CGS 33'	2.82	1.34	1.21	1.34	2.02	2.42	7.26	10.62	8.33	9.81	4.97	2.15	6.99	11.16	11.56	5.91	1.61	0.00
3/74 CGS (temp) 23'	1.61	2.55	2.02	2.82	1.61	6.59	6.72	10.08	10.08	7.66	4.84	5.65	6.72	6.72	4.57	3.23	9.41	1.08
3/74 HMS 50'	1.75	2.69	2.02	1.61	1.21	4.84	3.76	4.30	7.12	15.05	10.75	9.01	11.16	13.04	5.65	2.82	2.82	0.40
March (1955-1970) HMS (hist) 50'	4.5	3.5	1.7	2.0	2.3	3.7	2.8	3.8	5.4	9.9	10.4	9.6	14.4	13.7	5.0	5.1	1.5	0.7
April 1974-March 1975 CGS 33'	4.25	3.42	2.97	2.16	2.47	3.73	7.07	9.35	8.89	5.88	4.89	5.67	9.27	10.08	7.93	6.04	1.96	0.01
1955-1970 HMS (hist) 50'	3.7	3.4	2.0	2.4	2.6	3.7	2.8	3.2	4.1	7.2	8.5	9.8	16.0	16.6	4.9	4.5	2.4	2.2

* For some months, when concurrent measurements are not available for all sites shown; previous year data is given.

Table 2.3-11

Persistence of Wind Direction in One Sector (22.5 Degrees)
from 4/74 through 3/75 at 33-ft Level
(Stability Based On Temperature Difference)

DATE STARTED DAY	HOUR	WIND DIR	HOURS OF PERSISTENCE	HOURS EACH STABILITY		AVERAGE SPEED (MPH)
400	22	NW	14	0	V UNS	.00
				0	UNSTA	.00
				3	NEUTR	10.30
				11	M STA	11.08
				0	V STA	.00
				0	UNKNO	.00
171	10	S	10	1	V UNS	16.00
				7	UNSTA	18.14
				2	NEUTR	15.00
				0	M STA	.00
				0	V STA	.00
				0	UNKNO	.00
295	15	NNW	10	0	V UNS	.00
				1	UNSTA	19.57
				2	NEUTR	21.18
				7	M STA	9.98
				0	V STA	.00
				0	UNKNO	.00
327	14	NW	10	0	V UNS	.00
				0	UNSTA	.00
				5	NEUTR	3.81
				5	M STA	4.06
				0	V STA	.00
				0	UNKNO	.00
425	6	NNW	10	0	V UNS	.00
				1	UNSTA	5.53
				7	NEUTR	5.84
				2	M STA	6.81
				0	V STA	.00
				0	UNKNO	.00
134	7	SSW	9	0	V UNS	.00
				1	UNSTA	23.78
				8	NEUTR	19.54
				0	M STA	.00
				0	V STA	.00
				0	UNKNO	.00
219	17	WNW	9	0	V UNS	.00
				2	UNSTA	17.34
				2	NEUTR	22.97
				5	M STA	16.69
				0	V STA	.00
393	2	NW	9	0	V UNS	.00
				0	UNSTA	.00
				9	NEUTR	#999.0 (missing data)
				0	M STA	.00
				0	V STA	.00
				0	UNKNO	.00
404	2	NNW	9	0	V UNS	.00
				0	UNSTA	.00
				1	NEUTR	13.63
				8	M STA	11.18
				0	V STA	.00
				0	UNKNO	.00

Table 2.3-11

Persistence of Wind Direction in One Sector (22.5 Degrees) from 4/74 through 3/75 at 33-ft Level (Continued)
(Stability Based on Temperature Difference)

DATE STARTED DAY	HOUR	WIND DIR	HOURS OF PERSISTENCE	HOURS EACH STABILITY		AVERAGE SPEED (MPH)
407	5	SSW	9	0	V UNS	.00
				0	UNSTA	.00
				2	NEUTR	17.20
				7	M STA	20.64
				0	V STA	.00
				0	UNKNO	.00
102	13	WNW	8	0	V UNS	.00
				5	UNSTA	16.67
				1	NEUTR	19.07
				2	M STA	16.91
				0	V STA	.00
				0	UNKNO	.00
132	13	WNW	8	0	V UNS	.00
				6	UNSTA	22.17
				1	NEUTR	22.06
				1	M STA	17.06
				0	V STA	.00
				0	UNKNO	.00
244	11	NNE	8	0	V UNS	.00
				7	UNSTA	15.35
				1	NEUTR	12.87
				0	M STA	.00
				0	V STA	.00
				0	UNKNO	.00
271	16	NW	8	0	V UNS	.00
				1	UNSTA	18.52
				2	NEUTR	16.92
				5	M STA	11.63
				0	V STA	.00
				0	UNKNO	.00
363	10	S	8	0	V UNS	.00
				0	UNSTA	.00
				5	NEUTR	13.70
				3	M STA	13.80
				0	V STA	.00
				0	UNKNO	.00
396	21	NW	8	0	V UNS	.00
				0	UNSTA	.00
				4	NEUTR	9.10
				4	M STA	8.16
				0	V STA	.00
				0	UNKNO	.00
401	12	NNW	8	0	V UNS	.00
				0	UNSTA	.00
				5	NEUTR	12.80
				3	M STA	11.49
				0	V STA	.00
				0	UNKNO	.00
402	6	N	8	0	V UNS	.00
				0	UNSTA	.00
				7	NEUTR	9.04
				1	M STA	9.99
				0	V STA	.00
				0	UNKNO	.00
426	14	SW	8	0	V UNS	.00
				2	UNSTA	18.58
				3	NEUTR	16.88
				3	V STA	15.28
				0	V STA	.00
				0	UNKNO	.00
430	8	NNW	8	0	V UNS	.00
				6	UNSTA	10.54
				1	NEUTR	10.68
				1	M STA	7.82
				0	V STA	.00
				0	UNKNO	.00

Table 2.3-12

Persistence of Wind Direction in Two Sectors (45 Degrees) from 4.74 through 3/75 at CGS for 33-ft Level (Stability Based on Temperature Difference)

DATE STARTED DAY	HOUR	WIND DIRECTIONS		HOURS OF PERSISTENCE	HOURS EACH STABILITY		AVERAGE SPEED (MPH)
400	22	NW	NNW	26	0	V UNS	.00
					0	UNSTA	.00
					8	NEUTR	11.80
					15	M STA	11.05
					3	V STA	6.23
					0	UNKNO	.00
379	12	NW	NNW	23	0	V UNS	.00
					0	UNSTA	.00
					6	NEUTR	3.73
					17	M STA	3.78
					0	V STA	.00
					0	UNKNO	.00
399	23	NW	NNW	22	0	V UNS	.00
					0	UNSTA	.00
					7	NEUTR	15.79
					15	M STA	12.65
					0	V STA	.00
					0	UNKNO	.00
424	21	NW	NNW	20	0	V UNS	.00
					2	UNSTA	4.20
					8	NEUTR	5.88
					10	M STA	7.18
					0	V STA	.00
					0	UNKNO	.00
102	1	NNW	NW	19	0	V UNS	.00
					8	UNSTA	18.20
					2	NEUTR	28.03
					9	M STA	21.20
					0	V STA	.00
					0	UNKNO	.00
400	17	WNW	NW	19	0	V UNS	.00
					0	UNSTA	.00
					3	NEUTR	10.30
					16	M STA	11.44
					0	V STA	.00
					0	UNKNO	.00
244	5	N	NNE	18	0	V UNS	.00
					7	UNSTA	15.35
					7	NEUTR	15.01
					4	M STA	9.66
					0	V STA	.00
					0	UNKNO	.00
404	2	NNW	N	18	0	V UNS	.00
					0	UNSTA	.00
					9	NEUTR	11.56
					9	M STA	10.83
					0	V STA	.00
					0	UNKNO	.00
431	10	NW	NNW	18	0	V UNS	.00
					5	UNSTA	17.79
					5	NEUTR	17.77
					8	M STA	8.45
					0	V STA	.00
					0	UNKNO	.00
171	3	S	SSW	17	1	V UNS	16.00
					8	UNSTA	18.37
					5	NEUTR	16.60
					3	M STA	13.33
					0	V STA	.00
					0	UNKNO	.00
224	17	NNW	NW	17	0	V UNS	.00
					4	UNSTA	10.07
					3	NEUTR	14.39
					10	M STA	12.00
					0	V STA	.00
					0	UNKNO	.00

Table 2.3-12

Persistence of Wind Direction in Two Sectors (45 Degrees) from 4.74 through 3/75 at CGS for 33-ft Level (Continued)
(Stability Based on Temperature Difference)

DATE STARTED DAY	HOUR	WIND DIRECTIONS		HOURS OF PERSISTENCE	HOURS EACH STABILITY		AVERAGE SPEED (MPH)
401	21	NNW	N	17	0	V UNS	.00
					0	UNSTA	.00
					7	NEUTR	9.04
					3	M STA	8.95
					7	V STA	6.78
					0	UNKNO	.00
406	21	SSW	SW	17	0	V UNS	.00
					0	UNSTA	.00
					2	NEUTR	17.20
					15	M STA	21.52
					0	V STA	.00
					0	UNKNO	.00
438	1	SSE	S	17	0	V UNS	.00
					2	UNSTA	7.67
					2	NEUTR	5.47
					7	M STA	7.21
					6	V STA	8.80
					0	UNKNO	.00
396	17	WNW	NW	16	0	V UNS	.00
					0	UNSTA	.00
					10	NEUTR	8.80
					6	M STA	7.94
					0	V STA	.00
					0	UNKNO	.00
423	8	NW	NNW	16	0	V UNS	.00
					0	UNSTA	.00
					10	NEUTR	7.61
					6	M STA	5.58
					0	V STA	.00
					0	UNKNO	.00
98	11	WNW	NW	15	0	V UNS	.00
					3	UNSTA	15.67
					4	NEUTR	14.00
					8	M STA	11.62
					0	V STA	.00
					0	UNKNO	.00
253	15	WNW	NW	15	0	V UNS	.00
					0	UNSTA	.00
					2	NEUTR	16.41
					9	M STA	11.59
					4	V STA	7.27
					0	UNKNO	.00
293	11	W	WNW	15	0	V UNS	.00
					4	UNSTA	16.25
					3	NEUTR	18.27
					8	M STA	9.39
					0	V STA	.00
					0	UNKNO	.00
355	6	WSW	W	15	0	V UNS	.00
					0	UNSTA	.00
					7	NEUTR	25.65
					8	M STA	15.14
					0	V STA	.00
					0	UNKNO	.00

Table 2.3-12a

Longest Persistence of Wind Direction in One (22.5 Degrees) and Two (45 Degrees) Sectors
During First and Second Annual Cycles at 33-ft Level
(Stability Based on Temperature Difference)

First Annual Cycle (April '74 – March '75)						Second Annual Cycle (April '75 – March '76)					
MONTH	WIND DIRECTION	HOURS OF PERSISTENCE	HOURS OF EACH STABILITY		AVERAGE WIND SPEED	MONTH	WIND DIRECTION	HOURS OF PERSISTENCE	HOURS OF EACH STABILITY		AVERAGE WIND SPEED
January	NW	14	0	V UNS	.00	February	NNE	33	0	V UNS	.00
			0	UNSTA	.00				3	UNSTA	30.22
			3	NEUTR	10.30				10	NEUTR	29.04
			11	M STA	11.08				20	M STA	23.15
			0	V STA	.00				0	V STA	.00
			0	UNKNO	.00				0	UNKNO	.00
January	NW, NNW	26	0	V UNS	.00	January	N, NNE	35	0	V UNS	.00
			0	UNSTA	.00				3	UNSTA	30.22
			8	NEUTR	11.86				10	NEUTR	29.04
			15	M STA	11.05				22	M STA	21.84
			3	V STA	6.23				0	V STA	.00
			0	UNKNO	.00				0	UNKNO	.00

Table 2.3-13

Percent Frequency of Occurrence of Wind Speed
at the Hanford Reservation (1)

Month/Year/Site/Elevations	Calm	1-3	4-7	8-12	13-18	19-24	25-Up	Average Speed (mph)
	Wind Speed Range, mph (2)							
4/74 CGS 33'	0.00	9.58	31.11	24.17	18.19	6.25	1.81	9.8
4/74 CGS (temp) 23'	0.00	13.19	37.50	23.47	17.78	4.72	0.42	8.7
4/74 HMS 50'	0.42	9.72	26.11	33.33	19.72	7.64	3.06	10.3
April (1955-1970) HMS (hist) 50'		16.8	31.6	26.6	16.2	6.6	2.2	9.0
5/74 CGS 33'	0.00	12.50	36.16	33.33	12.77	3.63	0.54	8.4
5/74 CGS (temp) 23'	0.13	14.11	38.17	28.23	11.96	2.55	0.67	7.9
5/74 HMS 50'	0.67	12.63	30.11	32.66	18.15	5.38	0.40	9.0
May (1955-1970) HMS (hist) 50'		16.6	33.3	27.9	15.1	6.0	1.1	8.8
6/74 CGS 33'	0.00	11.25	44.03	23.89	9.72	3.61	1.11	8.5
6/74 CGS (temp) 23'	0.00	21.67	47.64	18.06	9.03	3.06	0.56	6.9
6/74 HMS 50'	0.42	13.61	35.42	26.11	15.69	7.64	1.11	9.0
June (1955-1970) HMS (hist) 50'		11.7	34.6	28.1	17.4	6.8	1.4	9.2
7/74 CGS 33'	0.00	16.13	43.95	24.33	8.74	1.61	0.40	7.2
7/74 CGS (temp) 23'	0.13	25.40	45.30	19.89	8.06	1.21	0.00	6.4
7/74 HMS 50'	0.00	16.26	38.44	27.28	13.44	4.57	0.00	8.1
July (1955-1970) HMS (hist) 50'		15.0	37.8	26.2	14.2	5.8	1.0	8.6
8/74 CGS 33'	0.00	21.91	46.37	19.35	7.12	3.36	0.13	6.8
8/74 CGS (temp) 23'	0.40	27.82	46.24	17.20	6.85	1.21	0.00	6.0
8/74 HMS 50'	0.81	16.53	43.28	26.21	7.53	5.11	0.54	7.5
August (1955-1970) HMS (hist) 50'		18.9	38.2	25.6	12.3	4.2	0.8	8.0
9/74 CGS 33'	0.00	27.78	38.06	22.50	8.75	1.39	0.42	6.5
9/73 CGS (temp) 23'	0.00	26.67	42.08	22.50	7.50	1.25	0.00	6.2
9/73 HMS 50'	2.64	20.42	36.25	28.33	8.75	3.19	0.42	7.1
September (1955-1970) HMS (hist) 50'		23.6	36.8	23.8	10.9	4.1	0.8	7.5

(1) For some months, when, concurrent measurements are not available for all sites shown; previous year data is given.

(2) HMS (hist) 50' calm values are included in the 1-3 mph range group.

Table 2.3-13

Percent Frequency of Occurrence of Wind Speed
at the Hanford Reservation (1) (Continued)

Month/Year/Site/Elevation	Calm	1-3	4-7	8-12	13-18	19-24	25-Up	Average Speed (mph)
10/74 CGS 33'	0.13	44.49	34.27	11.16	3.36	0.94	0.00	4.8
10/73 CGS (temp) 23'	0.27	30.91	40.99	16.80	8.87	2.15	0.00	6.2
10/73 HMS 50'	4.57	25.81	34.95	23.39	7.53	3.23	0.54	6.7
October (1955-1970) RMS (hist) 50'		32.1	34.0	21.3	8.3	3.3	1.0	6.7
11/74 CGS 33'	0.00	34.72	39.58	16.11	5.97	1.53	0.00	5.8
11/73 CGS (temp) 23'	0.28	17.92	37.08	21.53	7.78	2.36	0.00	7.1
11/73 HMS 50'	5.42	19.86	33.89	26.67	6.81	5.28	2.08	7.5
November (1955-1970) HMS (hist) 50'		39.7	30.1	18.9	7.5	2.7	1.1	6.2
12/74 CGS 33'	0.00	31.05	37.23	21.51	6.05	1.61	1.21	6.4
12/73 CGS (temp) 23'	0.67	41.53	31.72	15.86	8.74	1.21	0.27	5.7
12/73 HMS 50'	6.59	25.13	31.05	23.79	9.95	3.09	0.40	6.7
December (1955-1970) HMS (hist) 50'		41.4	29.2	18.9	6.7	2.5	1.3	6.0
1/75 CGS 33'	0.00	29.44	36.83	19.76	5.38	2.02	0.67	6.4
1/74 CGS (temp) 23'	2.02	29.97	24.46	15.46	16.40	7.80	3.90	8.7
1/74 HMS 50'	4.70	21.10	26.48	21.24	13.31	7.66	5.51	9.3
January (1955-1970) HMS (hist) 50'		38.8	30.2	19.5	7.6	2.7	1.2	6.4
2/75 CGS 33'	0.00	22.47	36.90	23.36	9.82	5.21	1.49	7.8
2/74 CGS (temp) 23'	1.19	26.64	29.17	22.17	15.03	4.46	1.34	7.6
2/74 HMS 50'	1.79	20.09	33.63	23.66	15.63	4.61	0.60	8.0
February (1955-1970) HMS (hist) 50'		30.8	31.0	23.9	9.3	3.2	1.7	7.0
3/75 CGS 33'	0.00	13.04	31.85	27.02	14.11	4.44	1.08	8.7
3/74 CGS (temp) 23'	1.08	28.90	31.32	18.68	12.77	3.36	3.36	7.8
3/74 HMS 50'	0.40	16.94	33.33	25.81	13.04	7.66	2.82	9.1
March (1955-1970) HMS (hist) 50'		20.0	32.6	26.1	13.5	5.4	2.4	8.4
April 1974 – March 1975 CGS 33'	0.01	22.89	38.04	22.20	9.14	2.95	0.73	7.2
1955-1970 HMS (hist) 50'		25.4	33.3	23.9	11.6	4.4	1.4	7.6

Table 2.3-14

Diurnal Variation of 33-ft Elevation Dry Bulb Temperature (°F) at CGS and Monthly Average Dry Bulb Temperature (°F) at the Hanford Reservation

Month/Year

Hour	April 1974	May 1974	June 1974	July 1974	August 1974	September 1974	October 1974	November 1974	December 1974	January 1975	February 1975	March 1975	Annual Average (April 1974 – March 1975)
01	46.7	51.0	63.7	66.5	66.8	58.2	45.6	40.3	35.3	30.9	30.6	37.5	47.9
02	46.1	49.8	62.1	64.5	64.6	57.1	44.7	40.1	35.3	30.8	30.5	36.6	46.9
03	44.9	48.3	60.3	62.2	63.0	56.3	43.3	39.6	35.1	30.4	30.1	35.9	45.9
04	44.4	46.9	58.1	60.8	61.2	55.3	42.6	39.5	35.0	30.6	30.2	35.0	45.1
05	43.3	45.8	57.5	59.7	60.0	54.1	41.3	39.0	34.9	30.1	30.1	34.9	44.3
06	43.6	47.0	59.6	61.0	59.6	53.0	40.8	38.7	34.1	30.0	29.8	34.7	44.4
07	45.3	50.9	63.8	65.3	63.6	53.9	40.4	38.3	33.8	29.4	29.6	35.1	45.8
08	49.2	54.4	68.0	69.3	68.8	58.9	43.4	38.3	33.8	29.5	29.3	37.4	48.4
09	51.8	56.8	72.7	73.0	72.9	64.8	48.3	39.9	34.4	30.3	31.3	40.6	51.2
10	54.2	59.0	75.3	75.1	76.4	68.6	52.7	41.6	35.8	31.7	33.9	42.9	54.3
11	56.2	61.3	78.0	77.3	79.1	72.0	56.4	43.8	37.9	33.0	35.6	45.2	56.2
12	57.9	63.1	80.5	79.4	81.6	75.2	59.5	45.4	39.6	34.9	37.6	46.9	58.4
13	59.3	64.9	82.3	81.3	84.0	77.8	62.0	46.7	41.0	35.7	38.6	48.6	60.1
14	60.5	66.3	83.8	83.2	86.2	79.8	63.7	47.4	41.7	36.5	39.3	49.4	61.6
15	60.9	67.5	85.1	84.7	87.5	81.0	64.8	47.6	41.5	37.2	39.7	50.3	62.4
16	60.9	67.7	84.6	85.2	88.4	81.6	65.1	46.9	40.5	36.7	39.5	50.8	62.3
17	60.3	67.4	85.1	85.2	88.4	81.2	63.7	45.0	38.8	35.2	38.7	50.0	61.7
18	58.8	66.2	84.1	84.7	87.1	78.4	60.0	43.5	37.7	33.9	36.8	47.9	60.4
19	56.1	63.9	81.9	82.7	83.7	73.6	56.4	42.7	36.8	32.9	35.3	44.9	57.7
20	53.6	60.3	77.8	78.7	79.6	69.4	53.5	42.1	36.8	32.1	34.4	42.7	55.2
21	51.8	57.7	73.7	75.5	75.7	67.1	51.3	41.6	36.8	31.5	33.8	41.2	53.3
22	50.3	56.0	70.7	73.0	73.6	64.5	49.4	41.0	36.1	31.1	32.8	40.1	51.7
23	48.9	54.2	68.0	70.8	71.0	62.3	48.2	40.2	35.2	31.0	32.4	39.2	50.2
24	47.7	52.7	66.0	68.9	69.0	60.4	46.4	40.0	35.1	30.8	31.6	38.1	49.0
Monthly Average Dry Bulb Temperature (°F)* (Site, Elevation)													
CGS 33'	52.2	57.4	72.5	73.6	74.7	66.9	51.7	42.1	36.8	32.3	33.8	41.9	53.1
CGS 7'	52.7	58.3	73.0	74.3	75.0	66.3	50.6	41.9	36.1	32.2	33.9	42.2	53.1
CGS (temp) 3'	53.3	59.6	74.2	75.3	76.3	(65.0)	(51.2)	(39.7)	(37.8)	(29.0)	(40.7)	(45.4)	Not Computed
HMS 3'	52.5	57.9	73.3	74.8	76.3	68.3	52.0	42.1	35.7	32.0	33.6	42.0	53.4
1950-1970 HMS (hist) 3'	52.5	61.8	69.9	77.5	75.3	67.0	53.2	40.1	33.4	30.3	37.5	44.0	

*For some months, when concurrent measurements are not available for all sites shown, former year data is given in parentheses.

Table 2.3-15

Diurnal Variation of 33-ft Elevation Wet Bulb Temperature (°F) at CGS and Monthly Average Wet Bulb Temperature (°F) at the Hanford Reservation

	Month/Year												
Hour	April 1974	May 1974	June 1974	July 1974	August 1974	September 1974	October 1974	November 1974	December 1974	January 1975	February 1975	March 1975	Annual Average (April 1974 – March 1975)
01	41.9	44.4	52.1	54.7	54.9	49.1	40.7	38.0	33.5	29.0	28.9	34.0	41.8
02	41.5	43.8	51.6	54.1	54.1	48.6	40.1	38.0	33.6	29.0	28.7	33.4	41.4
03	40.9	43.3	50.9	53.1	53.5	48.0	39.3	37.6	33.5	28.7	28.5	32.9	40.9
04	40.7	42.6	50.1	52.6	52.8	47.6	38.9	37.6	33.4	28.9	28.4	32.3	40.6
05	40.2	41.9	50.0	52.3	52.5	47.0	38.0	37.3	33.2	28.5	28.3	32.2	40.2
06	40.5	42.7	51.2	53.4	52.3	46.4	37.8	37.1	32.7	28.4	28.0	32.1	40.3
07	41.9	44.9	53.3	55.4	54.5	47.1	37.5	36.8	32.4	27.9	27.8	32.4	41.0
08	44.2	46.1	54.9	56.9	56.8	49.7	39.5	36.9	32.2	27.8	27.6	34.3	42.3
09	45.5	47.5	56.8	57.9	58.2	52.6	42.7	38.2	32.6	28.4	29.5	36.1	43.8
10	46.6	48.1	57.7	58.5	59.7	54.2	44.9	39.3	34.0	29.6	31.2	37.1	45.3
11	47.1	49.1	58.8	59.0	60.6	55..4	46.7	40.8	35.4	30.6	32.1	38.3	46.1
12	47.8	49.7	59.6	59.7	61.2	56.5	48.0	41.6	36.4	31.8	33.2	39.0	47.0
13	48.2	50.3	60.0	60.2	61.7	57.4	49.1	42.3	37.3	32.3	33.9	39.5	47.7
14	48.6	50.7	60.3	60.4	62.2	57.9	49.7	42.6	37.6	32.8	34.2	40.0	48.2
15	48.7	51.0	60.7	60.9	62.4	58.2	50.2	42.8	37.6	33.2	34.5	40.4	48.4
16	48.6	50.9	60.1	61.1	62.6	58.3	50.3	42.4	36.9	32.9	34.4	40.6	48.3
17	48.5	50.8	60.5	61.0	62.6	58.0	49.8	41.4	35.8	31.9	34.0	40.1	48.0
18	48.0	50.4	60.3	60.8	62.0	57.0	48.4	40.5	35.1	30.9	32.9	39.2	47.2
19	46.8	49.7	59.6	60.1	60.9	55.4	46.4	40.0	34.4	30.4	32.0	37.8	46.2
20	45.8	48.5	58.4	59.0	59.6	53.6	44.8	39.6	34.4	29.7	31.4	36.8	45.2
21	44.8	47.4	56.5	58.0	58.0	52.4	43.4	39.0	34.4	29.4	31.1	35.9	44.3
22	43.8	46.6	54.9	57.2	57.3	51.4	42.4	38.5	34.1	29.0	30.5	35.2	43.5
23	43.1	45.8	54.1	56.2	56.6	50.5	41.8	37.8	33.5	29.0	30.3	34.6	42.8
24	42.5	45.1	53.1	55.6	55.8	49.7	41.1	37.7	33.5	28.8	29.6	34.0	42.3
Monthly Average Wet Bulb Temperature (°F)* (Site, Elevation)													
CGS 33'	44.7	47.2	56.0	57.4	58.0	52.6	43.8	39.3	34.5	30.0	30.9	36.2	44.3
CGS (temp) 3'	45.9	49.8	60.0	61.0	62.6	(54.6)	(45.5)	(37.8)	(36.4)	(26.4)	(36.6)	(39.3)	Not Calculated
HMS 3'	43.9	46.5	54.5	56.3	57.0	52.0	42.0	38.0	33.0	30.0	31.0	36.0	43.4
1950-1970 HMS (hist) 3'	42.8	49.1	54.5	57.9	57.3	52.6	45.4	36.4	31.2	27.9	33.6	37.3	

*For some months, when concurrent measurements are not available for all sites shown, former year data is given in parentheses.

Table 2.3-16

Diurnal Variation of 33 ft Elevation Dew Point Temperature (°F) at CGS and Monthly Average Dew Point Temperature (°F) at the Hanford Reservation

Hour	April 1974	May 1974	June 1974	July 1974	August 1974	September 1974	October 1974	November 1974	December 1974	January 1975	February 1975	March 1975	Annual Average (April 1974 – March 1975)
	Month/Year												
01	36.5	37.3	42.0	45.1	45.4	40.5	35.0	35.4	31.2	26.0	26.1	28.6	35.8
02	36.5	37.5	42.5	45.4	45.6	40.6	34.6	35.5	31.4	26.1	26.0	28.6	35.9
03	36.6	37.8	42.7	45.5	45.8	39.9	34.4	35.4	31.4	25.9	25.9	28.3	35.9
04	36.8	37.9	43.1	45.7	45.9	40.1	34.6	35.6	31.4	26.0	25.4	28.4	36.0
05	36.7	37.7	43.3	46.2	46.3	40.1	34.0	35.4	31.0	26.0	25.4	28.4	35.9
06	37.0	38.1	44.1	47.2	46.4	39.8	34.2	35.3	30.8	25.8	25.2	28.2	36.1
07	38.3	38.6	44.6	47.5	47.3	40.4	34.0	35.1	30.5	25.5	24.9	28.5	36.3
08	38.8	37.3	44.3	47.5	47.8	41.0	35.0	35.2	30.0	25.1	24.9	30.0	36.5
09	38.8	37.8	44.4	46.7	47.3	41.8	36.3	36.4	30.3	25.4	26.8	29.6	36.8
10	38.8	37.2	44.2	46.0	47.7	41.7	36.3	36.7	31.7	26.4	27.1	28.8	37.1
11	37.8	36.7	44.2	45.7	47.4	41.4	36.2	37.4	32.2	26.9	26.9	28.3	36.8
12	37.3	36.2	43.8	45.3	46.7	40.9	36.0	37.5	32.3	27.0	26.8	27.6	36.5
13	36.8	35.5	43.3	44.4	46.0	40.4	35.6	37.4	32.5	27.2	27.0	27.2	36.1
14	36.4	35.1	42.6	43.3	45.3	39.7	35.3	37.3	32.1	27.5	27.0	26.6	35.7
15	35.9	34.6	42.3	43.1	44.5	39.4	35.1	37.7	32.4	27.4	27.0	26.3	35.5
16	35.8	34.0	41.5	43.1	44.0	39.0	35.1	37.4	32.1	27.4	27.2	26.3	35.2
17	36.0	34.1	41.9	42.7	44.0	38.5	35.5	37.4	31.8	27.0	27.2	25.9	35.2
18	36.6	34.5	42.4	42.9	43.7	38.6	36.1	37.1	31.5	26.4	27.1	26.7	35.4
19	37.0	35.2	42.8	42.6	44.1	39.4	35.3	37.0	31.1	25.9	27.2	27.6	35.5
20	37.3	36.3	43.5	43.5	44.5	39.2	34.8	36.7	31.0	26.0	27.1	28.3	35.7
21	37.1	36.6	42.7	44.4	44.4	38.8	34.0	36.2	31.3	25.8	27.2	28.3	35.6
22	36.8	36.8	41.7	44.7	44.6	38.9	33.8	35.5	31.2	25.6	27.1	27.9	35.4
23	36.7	37.1	42.4	44.5	45.2	39.2	34.2	35.1	31.1	25.6	27.2	27.9	35.6
24	36.6	37.1	42.1	44.9	45.3	39.5	34.7	35.0	31.2		26.6	27.9	35.6
Monthly Average Dew Point Temperature (°F) (Site/Elevation)													
CGS 33'	36.6	36.6	43.0	44.9	45.6	39.9	35.0	36.3	31.4	26.3	26.5	27.9	35.9
HMS 3'	33.3	34.0	38.2	41.0	43.2	38.9	31.0	33.9	29.2	26.0	25.5	26.0	33.4
1950-1970 HMS (hist) 3'	30.4	36.0	41.2	42.3	42.8	39.5	36.9	31.1	27.5	23.2	27.4	27.3	

Amendment 53
November 1998

Table 2.3-17

Frequency of Occurrence, Dry Bulb Temperature (°F) Versus Time of Day from 4/74 through 3/75 for 33-ft Level

		TIME OF DAY																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	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	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	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	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	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	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	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	0	0	0	0	0	0	0	0	0	0	0	0
10	15	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	5
15	20	2	2	3	3	7	5	7	8	4	3	3	2	1	1	1	1	1	1	1	2	3	3	3	2	69
20	25	11	11	13	13	14	13	17	14	10	7	5	4	4	3	3	3	4	6	7	9	9	9	9	10	208
25	30	22	26	27	29	30	37	28	27	25	17	13	9	9	9	9	8	9	11	10	8	9	11	13	20	416
30	35	44	46	43	44	42	41	41	31	26	26	25	21	12	14	11	14	20	19	29	37	41	40	47	45	759
35	40	42	39	45	46	48	44	46	39	24	27	31	30	32	21	23	26	28	32	37	35	34	45	40	38	852
40	45	40	45	48	54	57	57	45	36	35	28	28	31	28	37	36	34	26	34	35	35	38	33	43	46	929
45	50	51	52	48	46	48	43	42	38	38	37	35	32	34	29	29	29	41	36	33	29	34	39	37	39	919
50	55	33	30	34	40	31	38	28	28	34	35	33	32	32	33	36	39	25	23	26	41	40	34	32	35	792
55	60	31	33	32	31	33	28	34	30	17	24	33	34	33	30	25	21	24	30	31	27	27	26	29	29	692
60	65	27	29	32	32	29	30	28	28	24	20	20	27	22	22	24	24	24	23	21	19	21	33	28	26	613
65	70	25	26	25	21	20	23	25	28	30	31	25	19	27	32	26	24	24	17	25	27	29	23	24	35	611
70	75	26	20	11	3	2	2	18	22	18	33	31	26	27	24	26	27	25	29	16	30	23	26	30	20	515
75	80	7	2	1	0	0	0	2	17	16	18	29	37	20	22	26	24	21	19	31	17	27	23	20	12	391
80	85	0	0	0	0	0	0	0	1	16	15	15	18	37	34	20	17	22	27	16	22	19	14	5	4	302
85	90	0	0	0	0	0	0	0	0	1	10	16	19	12	17	31	30	26	19	23	16	8	2	1	0	231
90	95	0	0	0	0	0	0	0	0	0	1	5	9	20	20	16	21	20	18	13	8	0	0	0	0	151
95	100	0	0	0	0	0	0	0	0	0	0	0	1	3	9	14	14	16	13	7	0	0	0	0	0	77
100	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3	2	1	0	0	0	0	0	11
105	110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UNKNO		3	3	3	3	4	4	4	18	47	33	18	14	12	8	7	6	6	6	3	3	3	3	3	3	217
TOTAL		365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Table 2.3-18

Frequency of Occurrence, Wet Bulb Temperature (°F) Versus Time of Day from 4/74 through 3/75 for 33-ft Level

		TIME OF DAY																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	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	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	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	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	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	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	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	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	0	0	0	0	1	1	1	1	2	2	2	25
15	20	1	2	4	7	9	8	9	8	5	3	3	3	3	3	2	2	2	1	1	3	4	2	2	1	88
20	25	14	15	18	14	14	16	18	15	9	8	8	6	6	6	6	5	7	8	10	9	8	10	9	12	251
25	30	35	33	35	42	41	43	41	34	30	24	14	10	7	7	7	10	11	14	18	18	23	26	35	39	597
30	35	44	51	46	47	50	45	42	37	32	33	39	43	33	26	24	28	31	35	41	48	47	55	47	44	968
35	40	54	51	58	57	60	67	60	51	44	41	45	39	50	49	51	50	50	52	48	46	48	44	56	49	1220
40	45	73	73	65	65	61	56	53	55	52	51	52	50	45	53	51	51	48	44	48	50	62	56	57	65	1336
45	50	43	44	52	54	51	47	51	47	39	49	51	54	52	50	52	48	47	49	52	55	43	52	44	52	1178
50	55	48	50	49	48	51	51	38	39	43	42	39	44	49	49	52	51	51	43	42	49	55	48	49	44	1124
55	60	39	33	27	23	18	23	39	41	36	38	49	50	50	52	47	46	44	51	46	39	45	46	48	44	974
60	65	8	6	5	3	4	3	8	18	23	33	39	43	46	47	45	44	45	44	41	35	22	19	11	9	601
65	70	0	1	0	0	0	0	0	0	3	5	6	8	12	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	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	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	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	8	7	6	6	6	3	3	3	4	4	4	234
TOTAL		365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Table 2.3-19

Frequency of Occurrence, Dew Point Temperature (°F) Versus Time of Day from 4/74 through 3/75 for 33-ft Level

		TIME OF DAY																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
	-40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-40	-35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-35	-30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-30	-25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-25	-20	0	0	0	0	0	0	0	0	0	0	0	0	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	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	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	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	0	0	0	0	0	0	0	0	0	0	0
0	5	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	10
5	10	1	2	1	2	2	3	2	1	1	1	2	3	1	3	3	2	2	2	1	1	1	1	1	1	40
10	15	4	2	5	4	4	2	3	2	3	4	3	3	4	2	3	4	3	4	5	4	2	2	2	3	77
15	20	12	14	12	13	13	16	16	16	8	5	7	10	11	11	11	10	11	13	11	10	12	13	16	13	284
20	25	23	22	24	22	28	23	23	22	17	18	21	20	20	23	25	26	28	24	22	25	26	30	24	28	564
25	30	45	47	44	46	43	44	46	48	48	48	44	44	48	47	48	49	49	45	47	47	45	43	49	48	1112
30	35	74	70	74	67	65	68	60	48	47	45	53	56	59	69	66	66	66	74	76	73	76	76	70	73	1571
35	40	86	77	74	77	81	77	78	81	70	74	87	89	90	80	78	90	92	86	86	88	91	91	88	78	1991
40	45	67	77	73	73	65	66	64	59	56	65	56	66	67	73	78	73	69	71	74	70	68	62	65	67	1626
45	50	38	38	42	44	48	46	42	44	47	48	54	47	42	40	38	30	29	24	27	30	28	33	35	40	934
50	55	7	8	9	10	6	11	21	20	16	15	15	9	8	6	6	7	6	9	10	10	6	8	7	6	238
55	60	3	3	2	2	4	2	4	4	4	5	4	3	3	2	1	1	3	3	3	3	4	1	3	4	71
60	65	1	1	1	1	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	13
65	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	75	0	0	0	0	0	0	0	0	0	0	0	0	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	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	0	0	0	0	0	0	0	0	0	0	0	0
UNKNO		4	4	4	4	5	5	5	18	47	36	18	14	11	8	7	6	6	6	3	3	3	4	4	4	229
TOTAL		365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Table 2.3-20

Monthly Averages of Psychrometric Data Based on Period of Record (1950-1970)

AVERAGES

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
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

MONTHLY AVERAGE EXTREMES

		JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YEAR
	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
DRY BULB	YEAR	1953	1958	1968	1956	1958	1969	1960	1967	1967	1952	1954	1953	1953
	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+
	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
WET BULB	YEAR	1953	1958	1963	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	1970	1955	1964	1955
	HIGHEST	89	87	66	64	*52	54	40	44	55	74	80	90	58
REL HUM.	YEAR	1960	1963	1950	1963	1962+	1950	1955	1968	1969	1962	1956	1950	1950+
	LOWEST	60	54	44	37	31	34	22	24	34	42	64	69	49
	YEAR	1963	1967	1965	1966	1966	1960	1959	1967	1952	1952	1963+	1968	1967
	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
DEWPOINT	YEAR	1953	1958	1961	1963	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 1948

Table 2.3-21

Diurnal Variation of Precipitation Intensity (Inches/Hour) at CGS and Monthly Total Precipitation (Inches) at the Hanford Reservation

HOUR	APRIL 1974	MAY 1974	JUNE 1974	JULY 1974	AUGUST 1974	SEPTEMBER 1974	OCTOBER 1974	NOVEMBER 1974	DECEMBER 1974	JANUARY 1975	FEBRUARY 1975	MARCH 1975	AVERAGE FOR HOUR (APRIL 1974 – MARCH 1975)
01	0.000	0.136	0.000	0.168	0.000	0.000	0.000	0.000	0.016	0.000	0.032	0.040	0.071
02	0.000	0.016	0.000	0.040	0.000	0.000	0.000	0.016	0.040	0.000	0.032	0.000	0.029
03	0.016	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.032	0.020	0.000	0.000	0.026
04	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.020	0.016	0.000	0.000	0.018
05	0.016	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.064	0.000	0.000	0.030
06	0.000	0.048	0.000	0.016	0.000	0.000	0.000	0.000	0.016	0.072	0.000	0.000	0.045
07	0.000	0.072	0.000	0.032	0.000	0.000	0.000	0.016	0.016	0.020	0.016	0.016	0.026
08	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.000	0.024	0.024	0.048	0.029
09	0.000	0.088	0.000	0.000	0.000	0.000	0.000	0.056	0.000	0.024	0.016	0.032	0.039
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.000	0.000	0.072	0.024	0.036
11	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.000	0.056	0.040	0.028	0.034
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.024	0.016	0.024	0.022
13	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.036	0.016	0.024	0.032
14	0.032	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.020	0.024	0.000	0.000	0.024
15	0.016	0.000	0.032	0.000	0.000	0.064	0.000	0.032	0.036	0.032	0.000	0.000	0.033
16	0.016	0.000	0.000	0.016	0.000	0.000	0.000	0.036	0.024	0.048	0.024	0.000	0.029
17	0.024	0.000	0.000	0.056	0.000	0.000	0.000	0.040	0.032	0.040	0.064	0.000	0.038
18	0.016	0.000	0.000	0.000	0.000	0.000	0.016	0.028	0.000	0.032	0.036	0.000	0.026
19	0.020	0.000	0.000	0.024	0.000	0.000	0.000	0.052	0.040	0.032	0.000	0.000	0.034
20	0.000	0.000	0.000	0.000	0.000	0.000	0.064	0.028	0.000	0.020	0.024	0.048	0.032
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.024	0.016	0.088	0.040
22	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.021
23	0.080	0.000	0.000	0.032	0.000	0.000	0.000	0.000	0.024	0.048	0.020	0.016	0.040
24	0.036	0.048	0.000	0.000	0.000	0.000	0.016	0.000	0.048	0.024	0.032	0.080	0.038
MONTHLY TOTAL PRECIPITATION (INCHES)													
CGS	0.55	0.44	0.06	0.45	0.00	0.06	0.10	0.56	0.67	0.93	0.67	0.52	4.92
HMS	0.46	0.28	0.12	0.71	trace	0.01	0.21	0.71	0.97	1.43	0.98	0.33	6.21
HMS (hist) 1946-1970 Mean Total	0.44	0.50	0.66	0.16	0.21	0.30	0.61	0.80	0.81	0.97	0.58	0.38	6.53

Table 2.3-22

Frequency of Occurrence, Precipitation (Inches/Hour) Versus Time of Day
from 4/74 through 3/75 at CGS

	Time of Day																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
016	6	5	7	4	5	5	8	5	6	4	5	5	6	6	8	7	9	8	7	8	4	3	8	10	149
050	2	0	0	0	1	1	1	0	2	1	1	0	1	0	2	0	2	1	1	1	1	0	2	1	21
100	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.3-22a

Annual Frequency of Occurrence of Wind Direction and Wind Speed Versus Precipitation Intensity

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .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	4	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	36	10	3	1	1	149

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .050 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

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .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	1	0	0	0	0
SSE	0	0	0	0	0	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 2.3-22a

Annual Frequency of Occurrence of Wind Direction and Wind Speed Versus Precipitation Intensity (Continued)

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .250 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

FREQUENCY OF OCCURRENCE, WIND DIRECTION VS SPEED FROM 4/74 THROUGH 3/75 AT WPPSS2 FOR 33 FOOT LEVEL
RAIN INTENSITY GREATER THAN OR EQUAL .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	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 2.3-23

Statistic on Fog at the Hanford Meteorology Station (Based on 1945-1970 Data)*

	All Fog (viz 0-6 Miles)						Dense Fog (viz 1/4 Mile or Less)						Greatest No. of Hours of Persistence	
	No. of Days			No. of Hours			No. of Days			No. of Hours			(9)	(10)
	Avg	Greatest	Least	Avg	Greatest	Least	Avg	Greatest	Least	Avg	Greatest	Least	AF	DF
J	9	19	0	68.3	193.4	0	6	14	0	20.4	52.4	0	58.1	15.0
F	6	20	0	36.4	206.2	0	3	11	0	12.7	86.7	0	58.0	16.7
M	1	6	0	4.4	20.6	0	1	5	0	1.8	7.8	0	12.2	5.0
A	#	1	0	0.3	2.8	0	#	1	0	0.1	1.8	0	2.8	0
M	#	3	0	0.3	2.7	0	#	1	0	0.1	1.6	0	2.7	1.6
J	#	1	0	#	0.5	0	0	0	0	0	0	0	0.5	0
J	#	1	0	#	0.7	0	0	0	0	0	0	0	0.7	0
A	#	1	0	#	1.0	0	#	1	0	#	1.0	0	0.7	0.7
S	#	1	0	0.3	5.5	0	#	1	0	0.1	3.2	0	2.6	1.4
O	2	9	0	7.6	63.6	0	1	6	0	3.1	35.2	0	39.0	15.8
N	8	14	1	55.4	148.0	1.0	5	13	0	21.1	71.4	0	65.4	20.6
D	12	20	2	105.4	193.8	6.5	8	17	2	42.0	119.8	1.3	72.3	47.0
		(1)	(2)		(3)	(4)		(5)	(6)		(7)	(8)		
Y	33	57	22	278.4	462.5	147.7	24	42	2	101.4	201.5	24.3	72.3	47.0

\# Less than 1/2
1. Greatest number of days in a season -- occurred in 1969-70
2. Least number of days in a season -- occurred in 1948-49
3. Greatest number of hours in a season -- occurred in 1964-65
4. Least number of hours in a season -- occurred in 1948-49
5. Greatest number of days in a season -- occurred in 1950-51
6. Least number of days in a season -- occurred in 1948-49
7. Greatest number of hours in a season -- occurred in 1962-63
8. Least number of hours in a season -- occurred in 1948-49
9. AF denotes all fog (viz 0-6 miles)
10. DF denotes dense fog (viz 1/4 mile or less). Records for persistence of dense fog did not begin until 1953.

*Summation for the year does not necessarily reflect the summation of individual months.

Table 2.3-24

Percent Frequency Distribution of Wind Speeds During Hourly Observations of Fog at Pasco (1966-1970) and at HMS (1960-1970)

	Speed Class*					
Station	Calm	1-3	4-7	8-12	12	Total
HMS(1)	29	44	25	2	0	100
Pasco(2)	61	8	24	6	1	100

* Speed classes are in units of mph for HMS, and in units of knots for Pasco.

(1) Statistics for HMS are only for hourly observations of fog restricting visibility to 1/2 mile or less.

(2) Statistics for Pasco are for all hourly observations of fog (visibility 0-6 miles).

Table 2.3-25

Percent Frequency of Occurrence of Stability (ΔT Distribution) at the Hanford Reservation (1)

			t Range (°F/200 ft)		
Month/Year/Site	Very Unstable Less Than -2.5	Unstable -2.5 to -1.5	Neutral -1.5 to -0.5	Moderately Stable -0.5 to +3.5	Very Stable Greater Than 3.5
4/74 CGS	0.14	15.69	27.78	43.33	12.36
4/74 HMS	3.61	25.28	26.94	40.83	3.19
APRIL 1955-1970 HMS (hist)	5.10	20.88	30.22	39.19	4.61
5/74 CGS	0.27	23.39	30.51	35.89	8.06
5/74 HMS	6.18	33.20	26.34	32.39	1.88
MAY 1955-1970 HMS (hist)	8.33	22.56	30.18	34.71	4.22
6/74 CGS	1.25	35.42	17.36	30.42	5.42
6/74 HMS	7.36	33.33	24.72	31.39	3.19
JUNE 1955-1970 HMS (hist)	8.60	26.25	30.75	31.45	2.95
7/74 CGS	0.00	28.23	25.81	27.02	14.11
7/74 HMS	6.72	30.78	28.90	30.51	3.09
JULY 1955-1970 HMS (hist)	8.74	26.31	27.69	33.42	3.84
8/74 CGS	0.00	28.09	20.83	23.79	25.54
8/74 HMS	8.20	32.12	18.28	33.74	7.66
AUGUST 1955-1970 HMS (hist)	7.33	23.73	26.55	37.65	4.74
9/74 CGS	0.00	21.67	20.83	21.25	35.14
9/74 HMS	6.94	25.69	17.64	33.06	16.67
SEPTEMBER 1955-1970 HMS (hist)	5.05	19.90	25.11	40.89	9.05
10/74 CGS	0.00	14.38	18.15	25.81	38.98
10/74 HMS	3.36	20.16	17.74	41.26	17.47
OCTOBER 1955-1970 HMS (hist)	2.23	11.82	27.03	48.87	10.06
11/74 CGS	0.00	4.58	28.06	52.22	14.44
11/74 HMS	0.00	5.00	30.42	57.22	5.83
NOVEMBER 1955-1970 HMS (hist)	0.76	6.82	31.74	53.37	7.30
12/74 CGS	0.00	1.75	22.72	56.18	18.15
12/74 HMS	0.13	5.24	22.72	60.89	11.02
DECEMBER 1955-1970 HMS (hist)	0.40	4.35	36.53	50.98	7.74

(1) Δt at CGS is computed from 33 to 245 foot levels; at HMS, Δt is computed from 50 to 250 foot level.

Table 2.3-25

Percent Frequency of Occurrence of Stability (ΔT Distribution)
at the Hanford Reservation (1) (Continued)

			t Range (°F/200 ft)		
Month/Year/Site	Very Unstable Less Than -2.5	Unstable -2.5 to -1.5	Neutral -1.5 to -0.5	Moderately Stable -0.5 to +3.5	Very Stable Greater Than 3.5
1/75 CGS	0.00	2.55	30.51	53.90	10.62
1/74 HMS (1975 Not Available)	0.13	5.65	29.30	59.54	5.11
JANUARY 1955-1970 HMS (hist)	0.34	4.73	34.78	52.23	7.91
2/75 CGS	0.00	8.78	30.51	49.40	10.57
2/74 HMS (1975 Not Available)	0.30	14.43	26.93	51.19	7.14
FEBRUARY 1955-1970 HMS (hist)	1.51	9.29	28.24	52.05	8.90
3/75 CGS	0.13	20.03	17.34	42.07	11.96
3/74 HMS (1975 Not Available)	1.48	19.09	26.34	47.04	6.05
MARCH 1955-1970 HMS (hist)	3.49	15.84	28.22	45.25	6.61
April 1974 - March 1975 CGS	0.14	17.17	24.25	38.21	17.17
1955-1970 HMS (hist)	4.32	16.04	29.80	41.84	6.49
April 1975 - March 1976 CGS	0.59	21.31	21.85	37.20	17.51

(1) Δt at CGS is computed from 33 to 245 foot levels; at HMS, Δt is computed from 50 to 250 foot level.

Table 2.3-26

Frequency of Occurrence ΔT (°F/200 ft) Versus Time of Day from 4/74 through 3/75
at CGS between 245 and 33 ft Levels

Time of Day

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
LT-2.5	0	0	0	0	0	0	0	0	0	0	3	2	2	1	2	1	1	0	0	0	0	0	0	0	12
GE-2.5 LT-1.5	0	0	0	0	0	0	3	43	98	137	156	175	213	217	196	148	90	27	1	0	0	0	0	0	1504
GE-1.5 LT-0.5	17	16	16	16	18	37	97	137	134	150	168	158	123	123	145	168	181	167	111	52	33	21	18	18	2124
GE-0.5 LT-3.5	216	202	193	197	187	188	177	131	76	40	20	16	14	14	14	42	85	156	203	236	235	242	238	225	3347
GE-3.5	124	141	148	143	150	133	84	36	9	5	1	1	1	1	1	0	2	8	41	71	91	95	102	116	1504
UNKNO	8	6	8	9	10	7	4	18	48	33	17	13	12	9	7	6	6	7	9	6	6	7	7	6	269
TOTAL	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Average for Hour

3.008 3.261 2.714 .243 -1.104 -1.432 -1.502 -1.240 -.155 1.656 2.228 2.685

2.899 3.226 3.227 1.499 -.654 -1.303 -1.521 -1.441 -.835 .762 2.144 2.383 .883

Table 2.3-27

Frequency of Occurrence, Sigma (°) Versus Time of Day from 4/74 through 3/75
at CGS for 33 ft Level

Time of Day

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
GE22.5	111	110	105	104	104	112	96	117	124	139	144	152	152	153	137	109	62	44	52	51	79	88	107	98	2550
LT22.5 GE17.5	30	33	32	38	33	32	34	29	32	35	39	44	33	36	46	39	32	20	21	28	36	26	27	41	790
LT17.5 GE12.5	43	48	54	52	52	47	54	48	46	58	70	55	68	60	50	59	50	36	34	39	43	51	47	41	1205
LT 12.5 GE7.5	104	91	87	74	94	97	112	114	81	79	71	79	83	80	94	107	144	151	113	112	105	96	98	88	2354
LT7.5 GE3.75	60	61	64	75	62	56	58	31	31	18	19	17	13	23	27	39	65	92	121	112	90	86	68	77	1365
LT3.75 GE2.1	0	5	7	5	4	6	1	0	0	0	1	0	0	0	0	1	1	11	13	8	5	8	5	6	87
LT2.1	8	8	8	7	5	5	0	2	0	0	0	0	0	0	0	0	0	0	3	7	5	2	4	5	69
UNKNO	9	9	8	10	11	10	10	24	51	36	21	18	16	13	11	11	11	11	8	8	8	8	9	9	340
TOTAL	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	365	8760

Average for Hour

22.406 23.575 22.421 23.031 27.390 27.768 28.298 21.895 14.198 14.656 18.667 20.997
23.638 22.506 22.794 21.730 27.378 28.124 28.874 27.136 17.011 15.285 17.978 20.985 22.384

Table 2.3-28

Joint Frequency Distribution of Wind Speed and Direction

PLANT NAME: COLUMBIA GENERATING STATION
METEOROLOGICAL INSTRUMENTATION
DATA PERIOD: JFD 1996-1999
WIND SENSORS HEIGHT: 10.0 METER
TYPE OF RELEASE: GROUND LEVEL RELEASE
DELTA-T HEIGHTS: 10 - 75 METERS
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS A

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.029	.035	.027	.021	.024	.022	.025	.014	.024	.017	.013	.016	.013	.020	.022	.024	.348
1.01	1.01	.101	.123	.095	.073	.085	.079	.088	.051	.085	.060	.044	.057	.047	.070	.079	.085	1.223
2.03	2.03	.231	.190	.161	.114	.095	.123	.247	.180	.224	.155	.098	.063	.095	.098	.155	.269	2.497
3.02	3.02	.190	.145	.130	.035	.032	.095	.158	.247	.209	.107	.073	.054	.028	.054	.085	.171	1.811
4.00	4.00	.168	.117	.060	.022	.016	.028	.139	.262	.180	.107	.076	.038	.035	.016	.060	.085	1.410
5.03	5.03	.114	.088	.035	.006	.013	.013	.070	.114	.196	.117	.073	.025	.025	.019	.013	.098	1.018
6.01	6.01	.051	.028	.016	.003	.000	.003	.019	.047	.180	.079	.035	.013	.016	.019	.016	.054	.578
8.02	8.02	.079	.057	.032	.000	.000	.000	.003	.022	.196	.092	.066	.041	.028	.035	.019	.035	.705
10.04	10.04	.003	.003	.006	.000	.000	.000	.000	.006	.063	.016	.035	.025	.022	.019	.013	.000	.212
13.03	13.03	.000	.006	.000	.000	.000	.000	.000	.003	.022	.006	.003	.009	.009	.022	.009	.003	.095
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.003	.000	.000	.000	.000	.000	.003	.006
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		.96	.79	.56	.27	.26	.36	.75	.95	1.38	.76	.52	.34	.32	.37	.47	.83	9.90

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS B

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.007	.008	.001	.005	.007	.005	.006	.006	.005	.005	.003	.003	.004	.003	.008	.012	.092
1.01	1.01	.022	.025	.003	.016	.022	.016	.019	.019	.016	.016	.009	.009	.013	.009	.025	.038	.278
2.03	2.03	.063	.041	.035	.013	.019	.035	.038	.025	.070	.057	.051	.028	.028	.025	.038	.063	.629
3.02	3.02	.085	.057	.047	.013	.009	.016	.063	.076	.095	.025	.032	.016	.016	.022	.028	.070	.670
4.00	4.00	.047	.057	.032	.006	.006	.022	.038	.085	.076	.047	.022	.019	.019	.022	.038	.032	.569
5.03	5.03	.035	.032	.025	.003	.000	.006	.009	.051	.092	.047	.032	.013	.019	.019	.016	.025	.424
6.01	6.01	.019	.006	.003	.003	.000	.000	.006	.019	.047	.041	.016	.000	.028	.022	.013	.009	.234
8.02	8.02	.013	.006	.006	.009	.000	.000	.009	.013	.066	.060	.051	.006	.032	.016	.006	.013	.307
10.04	10.04	.003	.000	.000	.000	.000	.000	.000	.003	.009	.025	.025	.013	.003	.006	.003	.000	.092
13.03	13.03	.000	.006	.000	.000	.000	.000	.000	.000	.000	.013	.025	.000	.013	.013	.000	.000	.070
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		.29	.24	.15	.07	.06	.10	.19	.30	.48	.34	.27	.11	.17	.16	.18	.26	3.36

Table 2.3-28

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS C

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.007	.011	.009	.005	.003	.004	.005	.002	.007	.008	.008	.003	.003	.003	.003	.007	.088
1.01	1.01	.019	.032	.025	.016	.009	.013	.016	.006	.019	.022	.022	.009	.009	.009	.009	.019	.256
2.03	2.03	.076	.060	.035	.013	.019	.009	.025	.047	.044	.057	.028	.044	.022	.028	.051	.054	.613
3.02	3.02	.079	.057	.035	.028	.022	.003	.063	.098	.082	.044	.028	.019	.028	.038	.054	.079	.759
4.00	4.00	.054	.047	.009	.003	.006	.013	.035	.076	.092	.044	.044	.022	.025	.009	.022	.051	.553
5.03	5.03	.051	.035	.016	.000	.000	.006	.022	.057	.063	.047	.047	.035	.022	.022	.022	.035	.480
6.01	6.01	.022	.009	.009	.000	.000	.000	.003	.035	.063	.057	.022	.016	.022	.022	.013	.022	.316
8.02	8.02	.022	.006	.006	.000	.000	.000	.016	.016	.047	.063	.054	.028	.032	.016	.009	.028	.345
10.04	10.04	.000	.006	.000	.000	.000	.000	.000	.000	.019	.032	.041	.044	.013	.028	.022	.003	.209
13.03	13.03	.000	.000	.000	.000	.000	.000	.000	.000	.006	.019	.009	.003	.003	.025	.000	.003	.070
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		.33	.26	.14	.07	.06	.05	.19	.34	.44	.39	.30	.22	.18	.20	.21	.30	3.69

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS D

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.035	.025	.020	.018	.012	.010	.021	.018	.025	.015	.031	.019	.027	.030	.028	.031	.363
1.01	1.01	.142	.101	.082	.073	.051	.041	.085	.073	.101	.060	.126	.079	.111	.123	.114	.126	1.489
2.03	2.03	.332	.215	.168	.104	.117	.101	.205	.322	.322	.243	.136	.123	.158	.158	.471	.405	3.581
3.02	3.02	.420	.231	.171	.079	.073	.092	.193	.401	.338	.212	.168	.149	.092	.202	.468	.455	3.742
4.00	4.00	.218	.186	.126	.060	.057	.082	.218	.395	.398	.205	.161	.079	.101	.202	.414	.408	3.312
5.03	5.03	.193	.101	.107	.019	.016	.022	.133	.303	.326	.281	.142	.054	.126	.149	.310	.265	2.547
6.01	6.01	.130	.047	.051	.000	.000	.016	.051	.136	.228	.240	.107	.082	.092	.171	.231	.149	1.729
8.02	8.02	.032	.038	.013	.006	.000	.003	.013	.120	.335	.370	.202	.155	.107	.326	.161	.155	2.035
10.04	10.04	.003	.025	.019	.000	.000	.000	.003	.009	.123	.215	.142	.133	.057	.161	.088	.047	1.027
13.03	13.03	.003	.003	.013	.000	.000	.000	.000	.000	.041	.120	.101	.035	.016	.057	.051	.009	.449
18.04	18.04	.000	.000	.006	.000	.000	.000	.000	.000	.006	.022	.016	.000	.006	.006	.006	.009	.079
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		1.51	.97	.78	.36	.33	.37	.92	1.78	2.24	1.98	1.33	.91	.89	1.59	2.34	2.06	20.35

Table 2.3-28

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS E

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.037	.029	.019	.021	.018	.013	.025	.029	.051	.043	.045	.043	.051	.074	.066	.045	.607
1.01	1.01	.142	.111	.073	.082	.070	.051	.095	.111	.196	.168	.174	.164	.196	.284	.253	.174	2.342
2.03	2.03	.370	.291	.199	.095	.070	.098	.247	.411	.490	.392	.281	.307	.310	.446	.651	.676	5.332
3.02	3.02	.307	.250	.171	.085	.060	.063	.288	.544	.484	.288	.228	.218	.256	.480	.762	.540	5.022
4.00	4.00	.161	.104	.145	.025	.016	.079	.348	.670	.484	.196	.199	.142	.272	.455	.610	.414	4.320
5.03	5.03	.079	.032	.047	.028	.000	.038	.247	.525	.553	.250	.164	.107	.136	.509	.487	.234	3.436
6.01	6.01	.035	.013	.009	.016	.000	.006	.101	.288	.430	.316	.199	.104	.136	.442	.389	.107	2.592
8.02	8.02	.025	.041	.019	.003	.003	.000	.070	.224	.424	.518	.224	.120	.130	.477	.354	.180	2.813
10.04	10.04	.009	.041	.022	.000	.000	.000	.003	.009	.076	.348	.196	.038	.038	.202	.098	.066	1.147
13.03	13.03	.003	.000	.003	.000	.000	.000	.000	.000	.025	.133	.082	.019	.019	.063	.032	.013	.392
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.006	.025	.016	.000	.000	.006	.000	.000	.054
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		1.17	.91	.71	.36	.24	.35	1.42	2.81	3.22	2.68	1.81	1.26	1.54	3.44	3.70	2.45	28.06

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS F

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.075	.055	.037	.016	.016	.014	.020	.035	.055	.041	.049	.057	.065	.070	.083	.072	.759
1.01	1.01	.272	.199	.136	.057	.057	.051	.073	.126	.202	.149	.177	.209	.237	.256	.303	.262	2.765
2.03	2.03	.531	.446	.221	.095	.044	.076	.209	.512	.629	.455	.303	.265	.322	.442	.733	.670	5.954
3.02	3.02	.307	.205	.126	.051	.025	.032	.174	.604	.733	.389	.205	.183	.164	.319	.512	.528	4.558
4.00	4.00	.041	.025	.070	.032	.006	.013	.269	.582	.578	.288	.117	.088	.142	.326	.442	.177	3.195
5.03	5.03	.006	.003	.009	.009	.000	.006	.111	.414	.297	.120	.051	.051	.101	.171	.161	.073	1.583
6.01	6.01	.009	.000	.000	.000	.000	.000	.028	.092	.130	.107	.032	.016	.051	.088	.063	.013	.629
8.02	8.02	.000	.000	.000	.000	.000	.000	.013	.066	.104	.085	.032	.016	.006	.044	.006	.013	.386
10.04	10.04	.000	.000	.000	.000	.000	.000	.000	.006	.009	.047	.003	.000	.003	.000	.000	.000	.070
13.03	13.03	.000	.000	.000	.000	.000	.000	.000	.000	.006	.009	.006	.003	.000	.000	.000	.000	.025
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		1.24	.93	.60	.26	.15	.19	.90	2.44	2.75	1.69	.97	.89	1.09	1.72	2.31	1.81	19.92

Table 2.3-28

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS G

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
.42	.42	.113	.111	.068	.030	.020	.022	.027	.054	.059	.047	.067	.061	.067	.071	.094	.134	1.046
1.01	1.01	.332	.326	.199	.088	.060	.063	.079	.158	.174	.139	.196	.180	.196	.209	.275	.392	3.066
2.03	2.03	.860	.787	.335	.092	.019	.019	.139	.357	.408	.335	.237	.120	.171	.307	.667	.796	5.648
3.02	3.02	.281	.237	.180	.044	.003	.000	.114	.493	.496	.155	.082	.051	.047	.139	.395	.405	3.123
4.00	4.00	.025	.025	.060	.019	.003	.000	.028	.307	.313	.111	.047	.019	.041	.044	.221	.101	1.365
5.03	5.03	.000	.000	.009	.006	.000	.000	.009	.136	.085	.025	.000	.013	.016	.016	.019	.003	.338
6.01	6.01	.000	.000	.000	.003	.000	.000	.000	.032	.028	.019	.000	.003	.000	.000	.006	.000	.092
8.02	8.02	.000	.000	.000	.000	.000	.000	.000	.006	.009	.003	.000	.000	.000	.000	.000	.000	.019
10.04	10.04	.000	.000	.000	.000	.000	.000	.000	.003	.006	.000	.000	.000	.000	.000	.000	.000	.009
13.03	13.03	.000	.000	.000	.000	.000	.000	.000	.000	.000	.003	.000	.000	.000	.000	.000	.000	.003
18.04	18.04	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.003	.000	.000	.000	.000	.000	.003
44.70	44.70	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
TOTAL		1.61	1.49	.85	.28	.11	.10	.40	1.55	1.58	.84	.63	.45	.54	.79	1.68	1.83	14.71

WIND MEASURED AT 10.0 METERS

WIND SPEED CORRECTED TO THE RELEASE HEIGHT OF 10.0 METERS.

OVERALL WIND DIRECTION FREQUENCY

WIND DIRECTION:	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
FREQUENCY:	7.1	5.6	3.8	1.7	1.2	1.5	4.8	10.2	12.1	8.7	5.8	4.2	4.7	8.3	10.9	9.5

OVERALL WIND SPEED FREQUENCY AS MEASURED ON THE TOWER:

MAX. WIND SPEED (M/S):	.425	1.006	2.034	3.018	4.001	5.029	6.013	8.024	10.036	13.031	18.038	44.704
WIND SPEED FREQUENCY:	3.30	11.42	24.25	19.68	14.73	9.83	6.17	6.61	2.77	1.10	.14	.00

BUILDING AND RELEASE CHARACTERISTICS:

RELEASE HEIGHT: 10.00 METERS

MIXING VOLUME COEFFICIENT: 0.50

BUILDING CROSS-SECTIONAL AREA: 2861.00 SQUARE METERS

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

Table 2.3-28A

Joint Frequency Distribution of Wind Speed and Direction

PLANT NAME: COLUMBIA GENERATING STATION
DATA PERIOD: 1984-1989, AVERAGE HOURLY DATA
TYPE OF RELEASE: GROUND LVL RLS
SOURCE OF DATA: ANNUAL MET DATA COLLECTION 1984-1989
COMMENTS: DATA PROCESSED UNDER-THE SUPPLY SYSTEM QA
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145

METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METER
DELTA-T HEIGHTS: 245FT, 33FT

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS A

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.27	0.27	0.002	0.002	0.002	0.000	0.002	0.000	0.000	0.005	0.005	0.000	0.005	0.002	0.000	0.002	0.005	0.005	0.036
1.34	1.34	0.188	0.102	0.072	0.016	0.038	0.063	0.084	0.138	0.131	0.115	0.100	0.127	0.118	0.129	0.197	0.231	1.850
3.13	3.13	0.460	0.319	0.140	0.025	0.057	0.125	0.226	0.573	0.613	0.312	0.235	0.211	0.136	0.181	0.299	0.410	4.322
5.36	5.36	0.095	0.079	0.052	0.002	0.005	0.005	0.041	0.168	0.389	0.231	0.138	0.109	0.054	0.081	0.111	0.086	1.646
8.05	8.05	0.029	0.061	0.014	0.000	0.000	0.002	0.005	0.034	0.186	0.294	0.213	0.125	0.054	0.104	0.075	0.016	1.211
10.73	10.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.032	0.000	0.007	0.000	0.000	0.002	0.050
11.18	11.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.002
TOTAL		0.77	0.56	0.28	0.04	0.10	0.19	0.36	0.92	1.32	0.96	0.72	0.57	0.37	0.50	0.69	0.75	9.12

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS B

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.27	0.27	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.002	0.000	0.002	0.000	0.000	0.002	0.000	0.009
1.34	1.34	0.038	0.045	0.014	0.007	0.007	0.020	0.027	0.061	0.041	0.050	0.018	0.036	0.054	0.038	0.059	0.043	0.559
3.13	3.13	0.111	0.061	0.029	0.009	0.007	0.041	0.111	0.172	0.190	0.111	0.063	0.066	0.057	0.059	0.095	0.136	1.318
5.36	5.36	0.018	0.016	0.007	0.000	0.002	0.005	0.014	0.043	0.070	0.104	0.041	0.045	0.016	0.048	0.016	0.038	0.482
8.05	8.05	0.016	0.000	0.002	0.000	0.000	0.000	0.002	0.007	0.045	0.072	0.043	0.063	0.020	0.072	0.018	0.011	0.374
10.73	10.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.009	0.000	0.005	0.000	0.000	0.016
11.18	11.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL		0.18	0.12	0.05	0.02	0.02	0.07	0.15	0.28	0.35	0.34	0.17	0.22	0.15	0.22	0.19	0.23	2.76

Table 2.3-28A

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS C

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.27	0.27	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.000	0.005	0.000	0.000	0.011
1.34	1.34	0.095	0.059	0.020	0.029	0.020	0.027	0.043	0.102	0.070	0.059	0.079	0.066	0.075	0.100	0.088	0.109	1.041
3.13	3.13	0.177	0.097	0.070	0.032	0.034	0.059	0.143	0.238	0.188	0.161	0.115	0.136	0.102	0.120	0.170	0.179	2.019
5.36	5.36	0.061	0.027	0.014	0.000	0.002	0.009	0.023	0.079	0.154	0.106	0.100	0.095	0.075	0.041	0.045	0.029	0.860
8.05	8.05	0.032	0.005	0.000	0.000	0.002	0.007	0.000	0.020	0.086	0.052	0.054	0.068	0.045	0.091	0.063	0.023	0.548
10.73	10.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.002	0.007	0.000	0.005	0.000	0.000	0.018
11.18	11.18	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.007
TOTAL		0.36	0.19	0.11	0.06	0.06	0.10	0.21	0.44	0.50	0.38	0.35	0.37	0.30	0.36	0.37	0.34	4.50

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS D

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.27	0.27	0.014	0.011	0.005	0.002	0.000	0.002	0.005	0.005	0.002	0.011	0.002	0.016	0.005	0.016	0.011	0.014	0.120
1.34	1.34	0.469	0.267	0.147	0.081	0.093	0.204	0.213	0.287	0.337	0.283	0.263	0.333	0.355	0.448	0.559	0.534	4.874
3.13	3.13	0.623	0.387	0.238	0.095	0.140	0.231	0.441	0.847	0.885	0.627	0.414	0.340	0.407	0.586	0.894	0.996	8.152
5.36	5.36	0.211	0.081	0.038	0.002	0.016	0.048	0.072	0.244	0.414	0.475	0.290	0.201	0.231	0.349	0.240	0.263	3.176
8.05	8.05	0.109	0.052	0.029	0.011	0.011	0.007	0.032	0.068	0.220	0.387	0.283	0.226	0.177	0.387	0.213	0.170	2.381
10.73	10.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.032	0.011	0.005	0.005	0.032	0.020	0.009	0.115
11.18	11.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.002	0.002	0.007	0.005	0.000	0.020
TOTAL		1.42	0.80	0.46	0.19	0.26	0.49	0.76	1.45	1.86	1.82	1.27	1.12	1.18	1.82	1.94	1.99	18.84

LDCN-07-044

Table 2.3-28A

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS E

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.27	0.27	0.016	0.009	0.014	0.014	0.000	0.020	0.011	0.020	0.011	0.020	0.036	0.009	0.014	0.054	0.034	0.043	0.326
1.34	1.34	0.808	0.521	0.328	0.134	0.154	0.285	0.421	0.521	0.738	0.700	0.616	0.718	0.786	1.035	1.184	1.050	9.997
3.13	3.13	0.754	0.552	0.494	0.158	0.168	0.412	0.840	1.720	1.684	1.252	0.912	0.810	0.998	1.648	1.813	1.410	15.627
5.36	5.36	0.125	0.070	0.027	0.034	0.011	0.018	0.127	0.392	0.632	0.580	0.369	0.274	0.441	0.706	0.496	0.310	4.611
8.05	8.05	0.043	0.050	0.005	0.000	0.002	0.000	0.054	0.170	0.396	0.552	0.292	0.177	0.235	0.480	0.303	0.152	2.911
10.73	10.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.059	0.016	0.002	0.011	0.016	0.007	0.000	0.120
11.18	11.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.011	0.000	0.000	0.000	0.000	0.014
TOTAL		1.75	1.20	0.87	0.34	0.34	0.74	1.45	2.82	3.47	3.16	2.24	2.00	2.49	3.94	3.84	2.97	33.61

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS F

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.27	0.27	0.016	0.011	0.005	0.014	0.005	0.009	0.007	0.009	0.018	0.011	0.027	0.020	0.029	0.034	0.014	0.023	0.251
1.34	1.34	0.752	0.552	0.278	0.131	0.100	0.190	0.333	0.550	0.629	0.557	0.537	0.494	0.552	0.772	1.050	1.021	8.498
3.13	3.13	0.441	0.274	0.285	0.104	0.070	0.152	0.573	1.288	1.320	0.643	0.430	0.432	0.405	0.815	1.148	0.747	9.128
5.36	5.36	0.000	0.005	0.009	0.009	0.005	0.005	0.066	0.240	0.242	0.179	0.070	0.034	0.088	0.195	0.113	0.025	1.284
8.05	8.05	0.000	0.000	0.002	0.000	0.000	0.000	0.036	0.079	0.079	0.052	0.020	0.023	0.018	0.050	0.045	0.000	0.405
10.73	10.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.005	0.002	0.000	0.000	0.000	0.000	0.000	0.011
11.18	11.18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.018	0.014	0.036
TOTAL		1.21	0.84	0.58	0.26	0.18	0.36	1.01	2.17	2.29	1.45	1.09	1.00	1.09	1.87	2.39	1.83	19.61

Table 2.3-28A

Joint Frequency Distribution of Wind Speed and Direction (Continued)

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION — ATMOSPHERIC STABILITY CLASS G

WIND SPEED (M/S)

TOWER	RELEASE	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.27	0.27	0.016	0.005	0.007	0.005	0.005	0.011	0.014	0.007	0.009	0.014	0.016	0.014	0.007	0.009	0.020	0.027	0.183
1.34	1.34	0.790	0.686	0.303	0.174	0.091	0.111	0.213	0.385	0.392	0.310	0.267	0.287	0.299	0.473	0.654	0.822	6.257
3.13	3.13	0.312	0.292	0.240	0.084	0.023	0.059	0.272	0.869	0.645	0.310	0.174	0.104	0.115	0.267	0.453	0.450	4.670
5.36	5.36	0.007	0.002	0.029	0.005	0.000	0.007	0.011	0.075	0.050	0.014	0.011	0.005	0.005	0.020	0.018	0.000	0.258
8.05	8.05	0.002	0.009	0.005	0.000	0.000	0.000	0.000	0.014	0.011	0.007	0.000	0.002	0.000	0.005	0.000	0.000	0.054
10.73	10.73	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.016
11.18	11.18	0.032	0.032	0.032	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.125
TOTAL		1.16	1.03	0.62	0.29	0.12	0.19	0.51	1.35	1.12	0.66	0.47	0.41	0.43	0.77	1.15	1.31	11.56

WIND MEASURED AT 10.0 METERS
WIND SPEED CORRECTED TO THE RELEASE HEIGHT OF 10.0 METERS.
OVERALL WIND DIRECTION FREQUENCY

WIND DIRECTION:	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
FREQUENCY:	6.9	4.7	3.0	1.2	1.1	2.1	4.5	9.4	10.9	8.8	6.3	5.7	6.0	9.5	10.6	9.4

OVERALL WIND SPEED FREQUENCY AS MEASURED ON THE TOWER:

MAX. WIND SPEED (M/S):	0.268	1.341	3.129	5.364	8.047	10.729	11.176
WIND SPEED FREQUENCY:	0.94	33.08	45.23	12.32	7.88	0.35	0.20

BUILDING AND RELEASE CHARACTERISTICS:
RELEASE HEIGHT: 10.00 METERS
MIXING VOLUME COEFFICIENT: 0.50
BUILDING CROSS-SECTIONAL AREA: 2766.00 SQUARE METERS
THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

TABLE 2.3-29
THROUGH
TABLE 2.3-32

DELETED

Table 2.3-33

Exclusion Area Boundary Accident χ/Q Desert Sigmas

PLANT NAME: CGS
DATA PERIOD: JFD 1996-1999
TYPE OF RELEASE: GROUND LEVEL RELEASE
METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METERS
DELTA-T HEIGHTS: 10 - 75 METERS
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
COMMENTS: input file: P96-99-F.inp output file: P96-99-F.out
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

RELATIVE CONCENTRATION (χ/Q) VALUES (SEC/CUBIC METER) VERSUS AVERAGING TIME

DOWNWIND SECTOR	DISTANCE (METERS)	0-2 HOURS	0-8 HOURS	8-24 HOURS	1-4 DAYS	4-30 DAYS	ANNUAL AVERAGE	HOURS PER YEAR MAX 0-2 HR χ/Q IS EXCEEDED IN SECTOR	DOWWIND SECTOR
S	1950.	1.68E-04	1.08E-04	8.69E-05	5.39E-05	2.71E-05	1.17E-05	38.6	S
SSW	1950.	1.61E-04	1.02E-04	8.16E-05	5.00E-05	2.48E-05	1.05E-05	389.5	SSW
SW	1950.	1.13E-04	7.01E-05	5.51E-05	3.27E-05	1.55E-05	6.20E-06	22.0	SW
WSW	1950.	5.62E-05	3.38E-05	2.63E-05	1.51E-05	6.88E-06	2.62E-06	10.4	WSW
W	1950.	2.88E-05	1.80E-05	1.42E-05	8.52E-06	4.09E-06	1.67E-06	7.6	W
WNW	1950.	3.14E-05	1.94E-05	1.53E-05	9.06E-06	4.29E-06	1.72E-06	7.5	WNW
NW	1950.	7.22E-05	4.41E-05	3.45E-05	2.02E-05	9.39E-06	3.67E-06	10.0	NW
NNW	1950.	1.19E-04	7.70E-05	6.20E-05	3.87E-05	1.97E-05	8.64E-06	20.3	NNW
N	1950.	1.30E-04	8.49E-05	6.86E-05	4.32E-05	2.23E-05	9.87E-06	23.5	N
NNE	1950.	1.09E-04	6.85E-05	5.45E-05	3.31E-05	1.62E-05	6.73E-06	17.9	NNE
NE	1950.	1.20E-04	7.40E-05	5.81E-05	3.44E-05	1.62E-05	6.46E-06	23.8	NE
ENE	1950.	1.14E-04	6.94E-05	5.41E-05	3.16E-05	1.46E-05	5.66E-06	22.7	ENE
E	1950.	1.25E-04	7.65E-05	6.00E-05	3.53E-05	1.65E-05	6.50E-06	25.1	E
ESE	1950.	1.39E-04	8.76E-05	6.94E-05	4.20E-05	2.04E-05	8.41E-06	27.9	ESE
SE	1950.	1.59E-04	1.04E-04	8.44E-05	5.34E-05	2.77E-05	1.24E-05	34.5	SE
SSE	1950.	1.81E-04	1.18E-04	9.52E-05	5.98E-05	3.07E-05	1.36E-05	43.7	SSE
MAX χ/Q		1.81E-04				TOTAL HOURS AROUND SITE:		724.9	
SRP 2.3.4	1950.	1.69E-04	1.12E-04	9.06E-05	5.76E-05	3.01E-05	1.36E-05		
SITE LIMIT		1.69E-04	1.12E-04	9.06E-05	5.76E-05	3.01E-05	1.36E-05		

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

Table 2.3-33a

Exclusion Area Boundary χ/Q Values
Desert Sigmas w/ Meander

Direction From Site	0.5% Level[a] (10^{-4} sec/m^3)	5% Level[b] (10^{-4} sec/m^3)
S	1.68	2.04
SSW	1.61	2.26
SW	1.13	2.13
WSW	0.562	2.20
W	0.288	2.19
WNW	0.314	1.93
NW	0.722	1.17
NNW	1.19	1.18
N	1.30	1.17
NNE	1.09	1.18
NE	1.20	1.74
ENE	1.14	2.03
E	1.25	2.00
ESE	1.39	1.58
SE	1.59	1.52
SSE	1.81	1.86

[a] Exceeded 0.5% of the total time.

[b] Exceeded 5% of the time that wind blows into the individual sector.

Table 2.3-34

Exclusion Area Boundary Accident χ/Q P-G Sigmas

PLANT NAME: CGS
DATA PERIOD: JFD 1996-1999
TYPE OF RELEASE: GROUND LEVEL RELEASE
METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METERS
DELTA-T HEIGHTS: 10 - 75 METERS
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
COMMENTS: input file: P96-99-F.inp output file: P96-99-F.out
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

RELATIVE CONCENTRATION (χ/Q) VALUES (SEC/CUBIC METER) VERSUS AVERAGING TIME

DOWNWIND SECTOR	DISTANCE (METERS)	0-2 HOURS	0-8 HOURS	8-24 HOURS	1-4 DAYS	4-30 DAYS	ANNUAL AVERAGE	HOURS PER YEAR MAX 0-2 HR χ/Q IS EXCEEDED IN SECTOR	DOWWIND SECTOR
S	1950.	1.67E-04	8.92E-05	6.53E-05	3.32E-05	1.25E-05	3.82E-06	38.9	S
SSW	1950.	1.59E-04	8.36E-05	6.06E-05	3.01E-05	1.10E-05	3.23E-06	385.6	SSW
SW	1950.	1.15E-04	5.89E-05	4.21E-05	2.04E-05	7.20E-06	2.01E-06	21.0	SW
WSW	1950.	5.48E-05	2.81E-05	2.01E-05	9.75E-06	3.45E-06	9.65E-07	8.6	WSW
W	1950.	2.52E-05	1.39E-05	1.03E-05	5.39E-06	2.12E-06	6.80E-07	6.1	W
WNW	1950.	2.85E-05	1.54E-05	1.13E-05	5.80E-06	2.22E-06	6.87E-07	6.3	WNW
NW	1950.	7.40E-05	3.92E-05	2.85E-05	1.43E-05	5.29E-06	1.57E-06	9.2	NW
NNW	1950.	1.30E-04	7.05E-05	5.20E-05	2.68E-05	1.04E-05	3.24E-06	22.8	NNW
N	1950.	1.38E-04	7.60E-05	5.65E-05	2.97E-05	1.18E-05	3.81E-06	25.5	N
NNE	1950.	1.08E-04	5.86E-05	4.31E-05	2.22E-05	8.56E-06	2.67E-06	17.2	NNE
NE	1950.	1.09E-04	5.81E-05	4.24E-05	2.15E-05	8.07E-06	2.44E-06	19.9	NE
ENE	1950.	1.01E-04	5.32E-05	3.87E-05	1.94E-05	7.19E-06	2.14E-06	18.9	ENE
E	1950.	1.10E-04	5.87E-05	4.29E-05	2.17E-05	8.18E-06	2.47E-06	20.7	E
ESE	1950.	1.24E-04	6.83E-05	5.07E-05	2.65E-05	1.05E-05	3.37E-06	23.2	ESE
SE	1950.	1.59E-04	8.86E-05	6.61E-05	3.51E-05	1.41E-05	4.63E-06	35.2	SE
SSE	1950.	1.77E-04	9.68E-05	7.16E-05	3.72E-05	1.45E-05	4.59E-06	43.7	SSE
MAX χ/Q		1.77E-04					TOTAL HOURS AROUND SITE:	702.8	
SRP 2.3.4	1950.	2.86E-04	1.45E-04	1.03E-04	4.91E-05	1.70E-05	4.63E-06		
SITE LIMIT		1.65E-04	9.16E-05	6.82E-05	3.59E-05	1.43E-05	4.63E-06		

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

Table 2.3-34a

Exclusion Area Boundary χ/Q Values
Pasquill-Gifford Sigmar w/ Meander and Building Wake Credit

Direction From Site	0.5% Level[a] (10^{-4} sec/m^3)	5% Level[b] (10^{-4} sec/m^3)
S	1.67	1.99
SSW	1.59	2.18
SW	1.15	2.02
WSW	0.548	1.96
W	0.252	1.93
WNW	0.285	1.71
NW	0.740	1.14
NNW	1.30	1.29
N	1.38	1.25
NNE	1.08	1.17
NE	1.09	1.53
ENE	1.01	1.80
E	1.10	1.77
ESE	1.24	1.38
SE	1.59	1.52
SSE	1.77	1.82

[a] Exceeded 0.5% of the total time.

[b] Exceeded 5% of the time that wind blows into the individual sector.

Table 2.3-35

Low Population Zone Accident χ/Q Desert Sigmas

PLANT NAME: CGS
DATA PERIOD: JFD 1996-1999
TYPE OF RELEASE: GROUND LEVEL RELEASE
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
COMMENTS: input file: P96-99-F.inp output file: P96-99-F.out
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METERS
DELTA-T HEIGHTS: 10 - 75 METERS

RELATIVE CONCENTRATION (χ/Q) VALUES (SEC/CUBIC METER) VERSUS AVERAGING TIME

DOWNWIND SECTOR	DISTANCE (METERS)	0-2 HOURS	0-8 HOURS	8-24 HOURS	1-4 DAYS	4-30 DAYS	ANNUAL AVERAGE	HOURS PER YEAR MAX 0-2 HR χ/Q IS EXCEEDED IN SECTOR	DOWNWIND SECTOR
S	4827.	8.35E-05	4.58E-05	3.39E-05	1.76E-05	6.92E-06	2.20E-06	39.1	S
SSW	4827.	7.96E-05	4.33E-05	3.19E-05	1.64E-05	6.36E-06	1.99E-06	364.8	SSW
SW	4827.	5.52E-05	2.92E-05	2.12E-05	1.06E-05	3.94E-06	1.17E-06	22.2	SW
WSW	4827.	2.18E-05	1.16E-05	8.48E-06	4.28E-06	1.61E-06	4.85E-07	9.8	WSW
W	4827.	7.98E-06	4.64E-06	3.54E-06	1.97E-06	8.46E-07	3.02E-07	7.0	W
WNW	4827.	8.94E-06	5.13E-06	3.89E-06	2.13E-06	8.96E-07	3.11E-07	7.2	WNW
NW	4827.	2.94E-05	1.57E-05	1.15E-05	5.81E-06	2.19E-06	6.61E-07	9.1	NW
NNW	4827.	5.22E-05	2.93E-05	2.20E-05	1.17E-05	4.78E-06	1.59E-06	18.0	NNW
N	4827.	5.78E-05	3.26E-05	2.45E-05	1.31E-05	5.38E-06	1.80E-06	21.1	N
NNE	4827.	5.01E-05	2.71E-05	1.99E-05	1.03E-05	3.95E-06	1.23E-06	16.7	NNE
NE	4827.	5.49E-05	2.92E-05	2.12E-05	1.07E-05	3.98E-06	1.19E-06	22.7	NE
ENE	4827.	5.04E-05	2.66E-05	1.93E-05	9.60E-06	3.53E-06	1.04E-06	21.6	ENE
E	4827.	5.66E-05	2.99E-05	2.17E-05	1.09E-05	4.02E-06	1.19E-06	23.7	E
ESE	4827.	6.26E-05	3.39E-05	2.50E-05	1.28E-05	4.94E-06	1.54E-06	25.3	ESE
SE	4827.	7.62E-05	4.27E-05	3.20E-05	1.70E-05	6.91E-06	2.29E-06	33.4	SE
SSE	4827.	8.91E-05	4.95E-05	3.69E-05	1.95E-05	7.81E-06	2.55E-06	43.7	SSE
MAX χ/Q		8.91E-05					TOTAL HOURS AROUND SITE:	685.7	
SRP 2.3.4	4827.	7.96E-05	4.51E-05	3.39E-05	1.83E-05	7.54E-06	2.55E-06		
SITE LIMIT		7.96E-05	4.51E-05	3.39E-05	1.83E-05	7.54E-06	2.55E-06		

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

Table 2.3-36

Low Population Zone Accident χ/Q P-G Sigmas

PLANT NAME: CGS
DATA PERIOD: JFD 1996-1999
TYPE OF RELEASE: GROUND LEVEL RELEASE
METEOROLOGICAL INSTRUMENTATION
WIND SENSORS HEIGHT: 10.0 METERS
DELTA-T HEIGHTS: 10 - 75 METERS
SOURCE OF DATA: CGS ONSITE MET DATA TAKEN FROM FRAMATOME JFD FILES FOR 96-99
COMMENTS: input file: P96-99-F.inp output file: P96-99-F.out
PROGRAM: PAVAN, 10/76, 8/79 REVISION, IMPLEMENTATION OF REGULATORY GUIDE 1.145, REVISION 1

RELATIVE CONCENTRATION (χ/Q) VALUES (SEC/CUBIC METER) VERSUS AVERAGING TIME

DOWNWIND SECTOR	DISTANCE (METERS)	0-2 HOURS	0-8 HOURS	8-24 HOURS	1-4 DAYS	4-30 DAYS	ANNUAL AVERAGE	HOURS PER YEAR MAX 0-2 HR χ/Q IS EXCEEDED IN SECTOR	DOWNWIND SECTOR
S	4827.	7.65E-05	3.43E-05	2.30E-05	9.64E-06	2.77E-06	6.01E-07	38.9	S
SSW	4827.	7.30E-05	3.21E-05	2.13E-05	8.74E-06	2.43E-06	5.08E-07	379.7	SSW
SW	4827.	5.16E-05	2.22E-05	1.46E-05	5.85E-06	1.57E-06	3.16E-07	20.9	SW
WSW	4827.	2.17E-05	9.52E-06	6.31E-06	2.59E-06	7.19E-07	1.50E-07	9.2	WSW
W	4827.	8.35E-06	4.05E-06	2.83E-06	1.29E-06	4.19E-07	1.06E-07	6.5	W
WNW	4827.	9.39E-06	4.48E-06	3.10E-06	1.39E-06	4.38E-07	1.07E-07	6.7	WNW
NW	4827.	3.16E-05	1.42E-05	9.49E-06	3.97E-06	1.14E-06	2.46E-07	9.1	NW
NNW	4827.	5.63E-05	2.59E-05	1.76E-05	7.56E-06	2.25E-06	5.13E-07	21.4	NNW
N	4827.	6.01E-05	2.81E-05	1.92E-05	8.42E-06	2.58E-06	6.05E-07	24.0	N
NNE	4827.	4.77E-05	2.18E-05	1.48E-05	6.32E-06	1.87E-06	4.21E-07	16.8	NNE
NE	4827.	4.98E-05	2.23E-05	1.49E-05	6.22E-06	1.78E-06	3.84E-07	21.1	NE
ENE	4827.	4.56E-05	2.03E-05	1.35E-05	5.62E-06	1.59E-06	3.40E-07	20.1	ENE
E	4827.	5.08E-05	2.28E-05	1.52E-05	6.37E-06	1.82E-06	3.94E-07	22.1	E
ESE	4827.	5.64E-05	2.61E-05	1.78E-05	7.71E-06	2.32E-06	5.36E-07	23.6	ESE
SE	4827.	7.21E-05	3.38E-05	2.31E-05	1.02E-05	3.12E-06	7.35E-07	34.6	SE
SSE	4827.	8.17E-05	3.74E-05	2.53E-05	1.08E-05	3.21E-06	7.24E-07	43.7	SSE
MAX χ/Q		8.17E-05				TOTAL HOURS AROUND SITE:		698.5	
SRP 2.3.4	4827.	1.15E-04	4.99E-05	3.28E-05	1.33E-05	3.61E-06	7.35E-07		
SITE LIMIT		7.53E-05	3.50E-05	2.39E-05	1.04E-05	3.16E-06	7.35E-07		

THE FIVE-PERCENT-FOR-THE-ENTIRE-SITE χ/Q IS LIMITING.

Amendment 59
December 2007

LDCN-05-009

Table 2.3-37

Control Room, Exclusion Area Boundary and Low Population Zone χ/Qs (S/m^3)

	Control Room[1]								LPZ[2]	EAB[2]
	Filtered				Unfiltered					
	SGT Roofline	Railway Bay doors SC Leakage	RBW SC Leakage	Turbine Building	SGT Roofline	Railway Bay doors SC Leakage	RBW SC Leakage	Turbine Building		
0 - 2 hrs	1.43E-04	3.65E-04	1.99E-04	8.81E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03	4.95E-05	1.81E-04
2 - 8 hrs	1.05E-04	2.89E-04	1.44E-04	3.75E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03	4.95E-05	
8 - 24 hrs	4.14E-05	1.18E-04	5.73E-05	1.93E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03	3.69E-05	
1 - 4 days	3.52E-05	9.83 E-05	5.00E-05	1.50E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04	1.95E-05	
4 - 30 days	3.03E-05	8.61E-05	4.18E-05	1.44E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04	7.81E-06	

(1) Reference 2.3-37
(2) Reference 2.3-38

NOTE:
EAB = Exclusion Area Boundary
LPZ = Low Population Zone
SGT = Standby Gas Treatment
SC = Secondary Containment
RBW = Reactor Building Wall

Table 2.3-38a

CGS Calculation, Terrain Features, Desert Sigmas

CGS TURBINE AND RADWASTE BLDGS
NO DECAY, UNDEPLETED
CORRECTED USING STANDARD OPEN TERRAIN FACTORS

ANNUAL AVERAGE CHI/Q (SEC/METER CUBED)					DISTANCE IN MILES FROM THE SITE						
SECTOR	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	1.170E-04	4.880E-05	2.943E-05	1.612E-05	7.145E-06	4.144E-06	2.767E-06	2.013E-06	1.551E-06	1.246E-06	1.031E-06
SSW	8.738E-05	3.691E-05	2.243E-05	1.234E-05	5.502E-06	3.204E-06	2.146E-06	1.565E-06	1.208E-06	9.718E-07	8.058E-07
SW	5.041E-05	2.119E-05	1.282E-05	7.028E-06	3.117E-06	1.808E-06	1.207E-06	8.781E-07	6.766E-07	5.432E-07	4.497E-07
WSW	2.672E-05	1.129E-05	6.851E-06	3.769E-06	1.679E-06	9.761E-07	6.527E-07	4.753E-07	3.666E-07	2.945E-07	2.439E-07
W	1.743E-05	7.139E-06	4.257E-06	2.314E-06	1.015E-06	5.849E-07	3.886E-07	2.817E-07	2.164E-07	1.733E-07	1.431E-07
WNW	3.424E-05	1.390E-05	8.233E-06	4.450E-06	1.936E-06	1.109E-06	7.331E-07	5.293E-07	4.053E-07	3.237E-07	2.667E-07
NW	5.972E-05	2.452E-05	1.463E-05	7.962E-06	3.496E-06	2.014E-06	1.337E-06	9.689E-07	7.440E-07	5.955E-07	4.917E-07
NNW	1.094E-04	4.499E-05	2.691E-05	1.468E-05	6.471E-06	3.738E-06	2.487E-06	1.805E-06	1.388E-06	1.112E-06	9.193E-07
N	1.148E-04	4.680E-05	2.783E-05	1.514E-05	6.639E-06	3.821E-06	2.536E-06	1.836E-06	1.409E-06	1.128E-06	9.305E-07
NNE	9.052E-05	3.669E-05	2.171E-05	1.174E-05	5.115E-06	2.930E-06	1.937E-06	1.399E-06	1.071E-06	8.551E-07	7.045E-07
NE	7.851E-05	3.196E-05	1.896E-05	1.029E-05	4.493E-06	2.578E-06	1.706E-06	1.233E-06	9.443E-07	7.543E-07	6.216E-07
ENE	7.545E-05	3.053E-05	1.805E-05	9.773E-06	4.260E-06	2.442E-06	1.615E-06	1.167E-06	8.935E-07	7.136E-07	5.881E-07
E	8.001E-05	3.243E-05	1.917E-05	1.038E-05	4.517E-06	2.585E-06	1.708E-06	1.232E-06	9.420E-07	7.514E-07	6.185E-07
ESE	1.238E-04	5.040E-05	2.986E-05	1.617E-05	7.040E-06	4.029E-06	2.662E-06	1.920E-06	1.469E-06	1.172E-06	9.644E-07
SE	1.508E-04	6.203E-05	3.703E-05	2.016E-05	8.853E-06	5.097E-06	3.383E-06	2.449E-06	1.879E-06	1.503E-06	1.241E-06
SSE	1.535E-04	6.378E-05	3.835E-05	2.097E-05	9.262E-06	5.358E-06	3.569E-06	2.593E-06	1.995E-06	1.600E-06	1.323E-06

ANNUAL AVERAGE CHI/Q (SEC/METER CUBED)					DISTANCE IN MILES FROM THE SITE						
SECTOR	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	8.745E-07	4.911E-07	3.377E-07	2.095E-07	1.494E-07	1.150E-07	9.290E-08	7.760E-08	6.641E-08	5.789E-08	5.121E-08
SSW	6.840E-07	3.859E-07	2.662E-07	1.658E-07	1.186E-07	9.147E-08	7.402E-08	6.191E-08	5.304E-08	4.628E-08	4.097E-08
SW	3.812E-07	2.140E-07	1.471E-07	9.121E-08	6.504E-08	5.005E-08	4.042E-08	3.376E-08	2.889E-08	2.518E-08	2.227E-08
WSW	2.068E-07	1.162E-07	7.994E-08	4.960E-08	3.536E-08	2.721E-08	2.197E-08	1.835E-08	1.570E-08	1.368E-08	1.209E-08
W	1.211E-07	6.750E-08	4.618E-08	2.846E-08	2.021E-08	1.550E-08	1.249E-08	1.041E-08	8.897E-09	7.744E-09	6.841E-09
WNW	2.252E-07	1.245E-07	8.474E-08	5.184E-08	3.662E-08	2.799E-08	2.249E-08	1.870E-08	1.595E-08	1.386E-08	1.222E-08
NW	4.159E-07	2.313E-07	1.580E-07	9.714E-08	6.883E-08	5.272E-08	4.242E-08	3.532E-08	3.014E-08	2.621E-08	2.314E-08
NNW	7.782E-07	4.434E-07	2.973E-07	1.832E-07	1.301E-07	9.973E-08	8.032E-08	6.692E-08	5.714E-08	4.927E-08	4.390E-08
N	7.867E-07	4.368E-07	2.979E-07	1.827E-07	1.292E-07	9.881E-08	7.940E-08	6.604E-08	5.630E-08	4.892E-08	4.314E-08
NNE	5.948E-07	3.285E-07	2.234E-07	1.364E-07	9.622E-08	7.345E-08	5.895E-08	4.898E-08	4.172E-08	3.623E-08	3.193E-08
NE	5.248E-07	2.900E-07	1.972E-07	1.204E-07	8.490E-08	6.478E-08	5.196E-08	4.316E-08	3.675E-08	3.189E-08	2.810E-08
ENE	4.965E-07	2.744E-07	1.866E-07	1.140E-07	8.045E-08	6.141E-08	4.929E-08	4.095E-08	3.489E-08	3.029E-08	2.670E-08
E	5.217E-07	2.872E-07	1.947E-07	1.184E-07	8.330E-08	6.343E-08	5.080E-08	4.214E-08	3.584E-08	3.108E-08	2.736E-08
ESE	8.135E-07	4.479E-07	3.038E-07	1.849E-07	1.301E-07	9.912E-08	7.942E-08	6.590E-08	5.607E-08	4.863E-08	4.282E-08
SE	1.049E-06	5.821E-07	3.970E-07	2.435E-07	1.722E-07	1.317E-07	1.059E-07	8.809E-08	7.511E-08	6.527E-08	5.757E-08
SSE	1.120E-06	6.263E-07	4.294E-07	2.653E-07	1.886E-07	1.448E-07	1.168E-07	9.740E-08	8.325E-08	7.248E-08	6.405E-08

Table 2.3-38b

CGS Calculation, Terrain Features, Desert Sigmas

CGS TURBINE AND RADWASTE BLDGS
NO DECAY, UNDEPLETED
CHI/Q (SEC/METER CUBED) FOR EACH SEGMENT

DIRECTION FROM SITE	SEGMENT BOUNDARIES IN MILES FROM THE SITE									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	2.782E-05	7.806E-06	2.832E-06	1.567E-06	1.037E-06	5.081E-07	2.113E-07	1.153E-07	7.771E-08	5.794E-08
SSW	2.117E-05	6.000E-06	2.195E-06	1.220E-06	8.099E-07	3.989E-07	1.671E-07	9.172E-08	6.199E-08	4.631E-08
SW	1.211E-05	3.404E-06	1.236E-06	6.834E-07	4.521E-07	2.214E-07	9.199E-08	5.019E-08	3.381E-08	2.520E-08
WSW	6.468E-06	1.831E-06	6.680E-07	3.702E-07	2.451E-07	1.202E-07	5.001E-08	2.729E-08	1.837E-08	1.369E-08
W	4.034E-06	1.113E-06	3.982E-07	2.186E-07	1.439E-07	6.994E-08	2.873E-08	1.555E-08	1.043E-08	7.751E-09
WNW	7.812E-06	2.127E-06	7.518E-07	4.096E-07	2.682E-07	1.292E-07	5.239E-08	2.809E-08	1.873E-08	1.387E-08
NW	1.386E-05	3.830E-06	1.370E-06	7.517E-07	4.944E-07	2.397E-07	9.809E-08	5.290E-08	3.538E-08	2.624E-08
NNW	2.549E-05	7.081E-06	2.548E-06	1.402E-06	9.242E-07	4.498E-07	1.849E-07	1.001E-07	6.703E-08	4.976E-08
N	2.640E-05	7.275E-06	2.599E-06	1.424E-06	9.356E-07	4.528E-07	1.845E-07	9.915E-08	6.615E-08	4.897E-08
NNE	2.061E-05	5.617E-06	1.986E-06	1.082E-06	7.085E-07	3.410E-07	1.379E-07	7.372E-08	4.906E-08	3.626E-08
NE	1.800E-05	4.929E-06	1.749E-06	9.543E-07	6.251E-07	3.009E-07	1.217E-07	6.502E-08	4.323E-08	3.193E-08
ENE	1.715E-05	4.677E-06	1.656E-06	9.030E-07	5.914E-07	2.848E-07	1.152E-07	6.164E-08	4.103E-08	3.032E-08
E	1.821E-05	4.961E-06	1.751E-06	9.521E-07	6.221E-07	2.982E-07	1.198E-07	6.368E-08	4.221E-08	3.111E-08
ESE	2.834E-05	7.730E-06	2.730E-06	1.484E-06	9.699E-07	4.651E-07	1.870E-07	9.951E-08	6.602E-08	4.868E-08
SE	3.509E-05	9.967E-06	3.466E-06	1.899E-06	1.247E-06	6.035E-07	2.459E-07	1.322E-07	8.823E-08	6.534E-08
SSE	3.628E-05	1.013E-05	3.656E-06	2.015E-06	1.330E-06	6.485E-07	2.677E-07	1.453E-07	9.755E-08	7.255E-08

Table 2.3-38c

CGS Calculation, Terrain Features, Desert Sigmas

CGS TURBINE AND RADWASTE BLDGS – SPECIFIC POINTS OF INTEREST

RELEASE ID	TYPE OF LOCATION	DIRECTION FROM SITE	DISTANCE (MILES)	DISTANCE (METERS)	X/Q (SEC/CUB.METER) NO DECAY UNDEPLETED	X/Q (SEC/CUB.METER) 2.260 DAY DECAY UNDEPLETED	X/Q (SEC/CUB.METER) 8.000 DAY DECAY DEPLETED	D/Q (PER SQ.METER)
A	PROTECTED ARE	SE	6.40	10298.	7.2E-07	6.8E-07	5.1E-07	2.6E-10
A	PROTECTED ARE	ESE	3.90	6275.	1.2E-06	1.2E-06	9.3E-07	7.0E-10
A	PROTECTED ARE	ESE	4.00	6436.	1.2E-06	1.1E-06	8.9E-07	6.6E-10
A	PROTECTED ARE	ESE	4.10	6597.	1.1E-06	1.1E-06	8.5E-07	6.3E-10
A	PROTECTED ARE	ESE	4.20	6758.	1.1E-06	1.0E-06	8.1E-07	6.0E-10
A	PROTECTED ARE	ESE	4.30	6919.	1.0E-06	1.0E-06	7.8E-07	5.7E-10
A	PROTECTED ARE	ESE	4.40	7080.	1.0E-06	9.6E-07	7.5E-07	5.4E-10
A	PROTECTED ARE	ESE	4.50	7241.	9.6E-07	9.2E-07	7.2E-07	5.1E-10
A	PROTECTED ARE	ESE	3.00	4827.	1.9E-06	1.9E-06	1.5E-06	1.3E-09
A	PROTECTED ARE	ESE	3.10	4988.	1.8E-06	1.8E-06	1.4E-06	1.2E-09
A	PROTECTED ARE	ESE	3.21	5159.	1.7E-06	1.7E-06	1.3E-06	1.1E-09
A	PROTECTED ARE	ESE	3.30	5310.	1.6E-06	1.6E-06	1.3E-06	1.0E-09
A	PROTECTED ARE	ESE	3.40	5471.	1.5E-06	1.5E-06	1.2E-06	9.6E-10
A	PROTECTED ARE	ESE	3.50	5632.	1.5E-06	1.4E-06	1.1E-06	9.0E-10
A	PROTECTED ARE	ESE	3.60	5792.	1.4E-06	1.4E-06	1.1E-06	8.4E-10
A	PROTECTED ARE	SE	15.00	24135.	2.4E-07	2.1E-07	1.5E-07	6.0E-11
A	LPZ (4828)	SE	4.80	7723.	1.1E-06	1.1E-06	8.3E-07	4.9E-10
A	LPZ (4828)	ESE	4.20	6758.	1.1E-06	1.0E-06	8.1E-07	6.0E-10
A	LPZ (4828)	ENE	4.10	6597.	6.9E-07	6.5E-07	5.2E-07	3.7E-10
A	LPZ (4828)	NNE	4.30	6918.	7.6E-07	7.3E-07	5.7E-07	5.1E-10
A	LPZ (4828)	ESE	0.10	160.	4.1E-04	4.1E-04	4.0E-04	8.4E-07
A	LPZ (4828)	SE	9.59	15437.	4.2E-07	3.9E-07	2.8E-07	1.3E-10
A	LPZ (4828)	SE	8.29	13346.	5.1E-07	4.7E-07	3.5E-07	1.7E-10
A	LPZ (4828)	NE	4.30	6919.	6.7E-07	6.3E-07	5.0E-07	3.7E-10
A	EAB (1950 M)	S	1.21	1950.	1.1E-05	1.1E-05	9.4E-06	7.9E-09
A	EAB (1950 M)	SSW	1.21	1950.	8.4E-06	8.3E-06	7.2E-06	5.5E-09
A	EAB (1950 M)	SW	1.21	1950.	4.8E-06	4.7E-06	4.1E-06	3.5E-09
A	EAB (1950 M)	WSW	1.21	1950.	2.6E-06	2.5E-06	2.2E-06	1.4E-09
A	EAB (1950 M)	W	1.21	1950.	1.6E-06	1.5E-06	1.3E-06	1.3E-09
A	EAB (1950 M)	WNW	1.21	1950.	3.0E-06	2.9E-06	2.6E-06	2.5E-09
A	EAB (1950 M)	NW	1.21	1950.	5.4E-06	5.3E-06	4.6E-06	5.2E-09
A	EAB (1950 M)	NNW	1.21	1950.	9.9E-06	9.8E-06	8.5E-06	1.1E-08
A	EAB (1950 M)	N	1.21	1950.	1.0E-05	1.0E-05	8.8E-06	1.3E-08
A	EAB (1950 M)	NNE	1.21	1950.	7.9E-06	7.8E-06	6.8E-06	1.0E-08
A	EAB (1950 M)	NE	1.21	1950.	6.9E-06	6.8E-06	5.9E-06	7.3E-09
A	EAB (1950 M)	ENE	1.21	1950.	6.6E-06	6.5E-06	5.6E-06	6.7E-09
A	EAB (1950 M)	E	1.21	1950.	7.0E-06	6.9E-06	6.0E-06	7.0E-09
A	EAB (1950 M)	ESE	1.21	1950.	1.1E-05	1.1E-05	9.3E-06	1.1E-08
A	EAB (1950 M)	SE	1.21	1950.	1.4E-05	1.3E-05	1.2E-05	1.2E-08
A	EAB (1950 M)	SSE	1.21	1950.	1.4E-05	1.4E-05	1.2E-05	1.1E-08

Table 2.3-38d

CGS Calculation, Terrain Features, Desert Sigmas

CGS REACTOR BLDG
NO DECAY, UNDEPLETED
CORRECTED USING STANDARD OPEN TERRAIN FACTORS

ANNUAL AVERAGE CHI/Q (SEC/METER CUBED) — DISTANCE IN MILES FROM THE SITE

SECTOR	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	3.983E-07	5.147E-07	4.459E-07	2.855E-07	1.417E-07	8.546E-08	6.007E-08	4.723E-08	3.955E-08	3.450E-08	3.085E-08
SSW	3.015E-07	3.460E-07	2.917E-07	1.836E-07	8.972E-08	5.399E-08	3.809E-08	3.012E-08	2.537E-08	2.223E-08	1.996E-08
SW	2.241E-07	2.226E-07	1.853E-07	1.175E-07	5.986E-08	3.986E-08	3.227E-08	2.901E-08	2.518E-08	2.229E-08	2.000E-08
WSW	9.654E-08	7.983E-08	7.694E-08	5.258E-08	2.801E-08	1.857E-08	1.473E-08	1.300E-08	1.120E-08	9.892E-09	8.868E-09
W	3.448E-08	7.360E-08	7.682E-08	5.380E-08	2.883E-08	1.888E-08	1.476E-08	1.283E-08	1.088E-08	9.460E-09	8.362E-09
WNW	7.411E-08	1.508E-07	1.476E-07	1.017E-07	5.532E-08	3.697E-08	2.952E-08	2.619E-08	2.256E-08	1.990E-08	1.781E-08
NW	2.513E-07	3.020E-07	2.641E-07	1.670E-07	8.155E-08	4.940E-08	3.530E-08	2.826E-08	2.409E-08	2.133E-08	1.931E-08
NNW	7.930E-07	7.233E-07	5.856E-07	3.550E-07	1.649E-07	9.701E-08	6.783E-08	5.335E-08	4.477E-08	3.913E-08	4.183E-08
N	1.124E-06	8.905E-07	6.762E-07	4.031E-07	1.877E-07	1.113E-07	7.839E-08	6.206E-08	5.232E-08	4.585E-08	4.113E-08
NNE	1.049E-06	7.337E-07	5.603E-07	3.353E-07	1.577E-07	9.422E-08	6.677E-08	5.308E-08	4.498E-08	3.965E-08	4.297E-08
NE	6.008E-07	4.702E-07	3.787E-07	2.340E-07	1.123E-07	6.758E-08	4.829E-08	3.883E-08	4.067E-08	4.490E-08	8.482E-08
ENE	4.892E-07	5.305E-07	4.710E-07	3.229E-07	2.809E-07	3.180E-07	3.667E-07	5.692E-07	1.128E-06	1.019E-06	8.387E-07
E	5.015E-07	5.031E-07	4.747E-07	3.390E-07	3.184E-07	3.702E-07	4.232E-07	6.426E-07	1.325E-06	1.054E-06	8.662E-07
ESE	9.120E-07	7.571E-07	6.975E-07	4.987E-07	4.778E-07	5.635E-07	6.623E-07	1.026E-06	1.950E-06	1.650E-06	1.356E-06
SE	6.666E-07	6.348E-07	5.775E-07	3.846E-07	2.045E-07	1.394E-07	1.150E-07	1.046E-07	2.207E-07	7.638E-07	6.314E-07
SSE	4.473E-07	5.728E-07	5.291E-07	3.498E-07	1.780E-07	1.089E-07	7.782E-08	6.216E-08	5.287E-08	4.674E-08	4.227E-08

ANNUAL AVERAGE CHI/Q (SEC/METER CUBED) — DISTANCE IN MILES FROM THE SITE

SECTOR	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	2.814E-08	2.023E-08	1.577E-08	3.200E-07	2.287E-07	1.764E-07	1.428E-07	1.195E-07	1.024E-07	8.938E-08	7.915E-08
SSW	1.825E-08	1.646E-08	1.027E-08	2.576E-07	1.846E-07	1.427E-07	1.156E-07	9.686E-08	8.309E-08	7.259E-08	6.433E-08
SW	1.814E-08	1.472E-08	6.195E-08	1.393E-07	9.960E-08	7.682E-08	6.218E-08	5.202E-08	4.458E-08	3.891E-08	3.446E-08
WSW	8.058E-09	6.624E-09	2.853E-08	7.526E-08	5.376E-08	4.145E-08	3.353E-08	2.804E-08	2.402E-08	2.096E-08	1.856E-08
W	7.499E-09	4.948E-09	3.627E-09	4.242E-08	3.020E-08	2.323E-08	1.876E-08	1.567E-08	1.341E-08	1.169E-08	1.034E-08
WNW	1.613E-08	1.203E-08	1.269E-08	7.524E-08	5.333E-08	4.089E-08	3.294E-08	2.746E-08	2.346E-08	2.042E-08	1.805E-08
NW	1.778E-08	1.734E-08	1.283E-08	1.423E-07	1.011E-07	7.760E-08	6.258E-08	5.221E-08	4.463E-08	3.888E-08	3.437E-08
NNW	4.509E-08	2.990E-08	2.199E-08	2.697E-07	1.919E-07	1.474E-07	1.190E-07	9.930E-08	8.493E-08	7.401E-08	6.544E-08
N	3.754E-08	4.858E-08	4.276E-07	2.625E-07	1.860E-07	1.425E-07	1.148E-07	9.564E-08	8.168E-08	7.108E-08	6.278E-08
NNE	4.676E-08	4.163E-07	3.178E-07	1.945E-07	1.376E-07	1.053E-07	8.473E-08	7.055E-08	6.022E-08	5.238E-08	4.625E-08
NE	2.656E-07	4.104E-07	2.789E-07	1.705E-07	1.205E-07	9.214E-08	7.408E-08	6.164E-08	5.259E-08	4.572E-08	4.035E-08
ENE	7.075E-07	3.901E-07	2.653E-07	1.623E-07	1.148E-07	8.786E-08	7.067E-08	5.884E-08	5.021E-08	4.367E-08	3.855E-08
E	7.296E-07	4.000E-07	2.710E-07	1.650E-07	1.163E-07	8.872E-08	7.121E-08	5.918E-08	5.043E-08	4.380E-08	3.862E-08
ESE	1.143E-06	6.275E-07	1.652E-07	2.594E-07	1.830E-07	1.398E-07	1.123E-07	9.334E-08	7.958E-08	6.915E-08	6.099E-08
SE	5.345E-07	2.974E-07	2.034E-07	3.525E-07	2.499E-07	1.916E-07	1.544E-07	1.287E-07	1.099E-07	9.568E-08	8.452E-08
SSE	3.896E-08	3.642E-08	2.261E-08	3.975E-07	2.834E-07	2.181E-07	1.762E-07	1.473E-07	1.261E-07	1.099E-07	9.728E-08

Table 2.3-38e

CGS Calculation, Terrain Features, Desert Sigmas

CGS REACTOR BLDG
NO DECAY, UNDEPLETED
CHI/Q (SEC/METER CUBED) FOR EACH SEGMENT

	SEGMENT BOUNDARIES IN MILES FROM THE SITE									
DIRECTION FROM SITE	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	3.899E-07	1.486E-07	6.171E-08	3.982E-08	3.093E-08	2.000E-08	2.118E-07	1.769E-07	1.196E-07	8.944E-08
SSW	2.557E-07	9.471E-08	3.914E-08	2.553E-08	2.000E-08	1.411E-08	1.702E-07	1.431E-07	9.698E-08	7.264E-08
SW	1.635E-07	6.378E-08	3.299E-08	2.517E-08	1.999E-08	3.647E-08	1.045E-07	7.704E-08	5.209E-08	3.894E-08
WSW	6.676E-08	2.927E-08	1.506E-08	1.122E-08	8.872E-09	1.668E-08	5.532E-08	4.156E-08	2.808E-08	2.098E-08
W	6.588E-08	2.996E-08	1.509E-08	1.090E-08	8.368E-09	4.928E-09	2.837E-08	2.330E-08	1.569E-08	1.170E-08
WNW	1.279E-07	5.746E-08	3.018E-08	2.258E-08	1.781E-08	1.324E-08	5.160E-08	4.103E-08	2.750E-08	2.044E-08
NW	2.294E-07	8.625E-08	3.624E-08	2.423E-08	1.934E-08	1.543E-08	9.519E-08	7.785E-08	5.228E-08	3.891E-08
NNW	5.137E-07	1.770E-07	6.982E-08	4.507E-08	4.224E-08	2.976E-08	1.801E-07	1.479E-07	9.945E-08	7.407E-08
N	6.024E-07	2.016E-07	8.063E-08	5.264E-08	4.120E-08	2.146E-07	2.652E-07	1.430E-07	9.579E-08	7.115E-08
NNE	4.988E-07	1.690E-07	6.861E-08	4.526E-08	4.339E-08	2.904E-07	1.966E-07	1.057E-07	7.066E-08	5.243E-08
NE	3.347E-07	1.195E-07	4.965E-08	4.175E-08	1.400E-07	3.198E-07	1.723E-07	9.247E-08	6.174E-08	4.576E-08
ENE	4.184E-07	3.067E-07	4.347E-07	9.267E-07	8.436E-07	4.052E-07	1.641E-07	8.817E-08	5.893E-08	4.371E-08
E	4.207E-07	3.460E-07	4.968E-07	1.027E-06	8.714E-07	4.159E-07	1.669E-07	8.906E-08	5.928E-08	4.385E-08
ESE	6.224E-07	5.205E-07	7.813E-07	1.572E-06	1.364E-06	5.365E-07	2.045E-07	1.403E-07	9.350E-08	6.922E-08
SE	5.045E-07	2.156E-07	1.174E-07	3.944E-07	6.347E-07	3.083E-07	2.738E-07	1.923E-07	1.289E-07	9.576E-08
SSE	4.591E-07	1.855E-07	7.985E-08	5.319E-08	4.237E-08	3.085E-08	2.635E-07	2.188E-07	1.475E-07	1.100E-07

Table 2.3-38f

CGS Calculation, Terrain Features, Desert Sigmas

CGS REACTOR BLDG, SPECIFIC POINTS OF INTEREST

RELEASE ID	TYPE OF LOCATION	DIRECTION FROM SITE	DISTANCE (MILES)	DISTANCE (METERS)	X/Q (SEC/CUB.METER) NO DECAY UNDEPLETED	X/Q (SEC/CUB.METER) 2.260 DAY DECAY UNDEPLETED	X/Q (SEC/CUB.METER) 8.000 DAY DECAY DEPLETED	D/Q (PER SQ.METER)
B	PROTECTED ARE	SE	6.40	10298.	3.7E-07	3.5E-07	3.4E-07	3.2E-10
B	PROTECTED ARE	ESE	3.90	6275.	1.7E-06	1.6E-06	1.3E-06	7.0E-10
B	PROTECTED ARE	ESE	4.00	6436.	1.7E-06	1.6E-06	1.3E-06	6.6E-10
B	PROTECTED ARE	ESE	4.10	6597.	1.6E-06	1.5E-06	1.2E-06	6.4E-10
B	PROTECTED ARE	ESE	4.20	6758.	1.5E-06	1.5E-06	1.2E-06	6.0E-10
B	PROTECTED ARE	ESE	4.30	6919.	1.5E-06	1.4E-06	1.1E-06	5.7E-10
B	PROTECTED ARE	ESE	4.40	7080.	1.4E-06	1.3E-06	1.1E-06	5.5E-10
B	PROTECTED ARE	ESE	4.50	7241.	1.4E-06	1.3E-06	1.0E-06	5.2E-10
B	PROTECTED ARE	ESE	3.00	4827.	1.0E-06	9.9E-07	8.1E-07	1.2E-09
B	PROTECTED ARE	ESE	3.10	4988.	1.2E-06	1.2E-06	9.6E-07	1.2E-09
B	PROTECTED ARE	ESE	3.21	5159.	1.5E-06	1.5E-06	1.2E-06	1.1E-09
B	PROTECTED ARE	ESE	3.30	5310.	1.8E-06	1.8E-06	1.5E-06	1.0E-09
B	PROTECTED ARE	ESE	3.40	5471.	1.9E-06	1.8E-06	1.5E-06	9.4E-10
B	PROTECTED ARE	ESE	3.50	5632.	1.8E-06	1.8E-06	1.4E-06	8.9E-10
B	PROTECTED ARE	ESE	3.60	5792.	1.8E-06	1.7E-06	1.4E-06	8.3E-10
B	PROTECTED ARE	SE	15.00	24135.	3.5E-07	3.1E-07	2.9E-07	7.6E-11
B	LPZ (4828)	SE	4.80	7723.	5.7E-07	5.5E-07	5.5E-07	5.9E-10
B	LPZ (4828)	ESE	4.20	6758.	1.5E-06	1.5E-06	1.2E-06	6.0E-10
B	LPZ (4828)	ENE	4.10	6597.	9.8E-07	9.3E-07	7.7E-07	3.8E-10
B	LPZ (4828)	NNE	4.30	6918.	4.1E-08	4.1E-08	3.9E-08	1.8E-10
B	LPZ (4828)	ESE	0.10	160.	3.1E-06	3.1E-06	3.1E-06	4.0E-08
B	LPZ (4828)	SE	9.59	15437.	2.1E-07	2.0E-07	1.9E-07	1.6E-10
B	LPZ (4828)	SE	8.29	13346.	2.6E-07	2.5E-07	2.4E-07	2.0E-10
B	LPZ (4828)	NE	4.30	6919.	6.8E-08	6.6E-08	6.6E-08	1.3E-10
B	EAB (1950 M)	S	1.21	1950.	1.9E-07	1.9E-07	1.8E-07	1.6E-09
B	EAB (1950 M)	SSW	1.21	1950.	1.2E-07	1.2E-07	1.2E-07	1.0E-09
B	EAB (1950 M)	SW	1.21	1950.	7.9E-08	7.9E-08	7.6E-08	5.7E-10
B	EAB (1950 M)	WSW	1.21	1950.	3.8E-08	3.8E-08	3.6E-08	1.9E-10
B	EAB (1950 M)	W	1.21	1950.	3.8E-08	3.7E-08	3.7E-08	2.4E-10
B	EAB (1950 M)	WNW	1.21	1950.	7.2E-08	7.1E-08	7.0E-08	4.8E.10
B	EAB (1950 M)	NW	1.21	1950.	1.1E-07	1.1E-07	1.1E-07	9.0E-10
B	EAB (1950 M)	NNW	1.21	1950.	2.3E-07	2.3E-07	2.2E-07	2.0E-09
B	EAB (1950 M)	N	1.21	1950.	2.6E-07	2.6E-07	2.5E-07	2.8E-09
B	EAB (1950 M)	NNE	1.21	1950.	2.2E-07	2.2E-07	2.1E-07	2.5E-09
B	EAB (1950 M)	NE	1.21	1950.	1.6E-07	1.6E-07	1.5E-07	1.8E-09
B	EAB (1950 M)	ENE	1.21	1950.	2.7E-07	2.7E-07	2.6E-07	1.8E-09
B	EAB (1950 M)	E	1.21	1950.	2.9E-07	2.9E-07	2.9E-07	1.5E-09
B	EAB (1950 M)	ESE	1.21	1950.	4.4E-07	4.4E-07	4.3E-07	2.4E-09
B	EAB (1950 M)	SE	1.21	1950.	2.7E-07	2.7E-07	2.6E-07	2.0E-09
B	EAB (1950 M)	SSE	1.21	1950.	2.4E-07	2.4E-07	2.3E-07	1.9E-09

TABLE 39 (a through f)

DELETED

Table 2.3-40

Frequency of Wind Resuspension
Periods at Hanford (1953-1970)

Total Dust Hours	476
Total Dust Days	142
Number of Dust Storms	150
Average Dust Hr/Yr.	26.4
Average Dust Days/Yr.	7.9
Average Dust Storms Per Year	8.3
Range in Duration of Dust Storms (hr.)	1-16
Average Duration of Dust Storms (hr.)	3.2
Average Dust Storm Concentration (from Table 2) mg/m^3	6.77

Table 2.3-41

Dust Concentration Dependency on Wind Speed and Direction at Hanford 1953-1970 Predicted Concentration From Visibility, mg/m^3

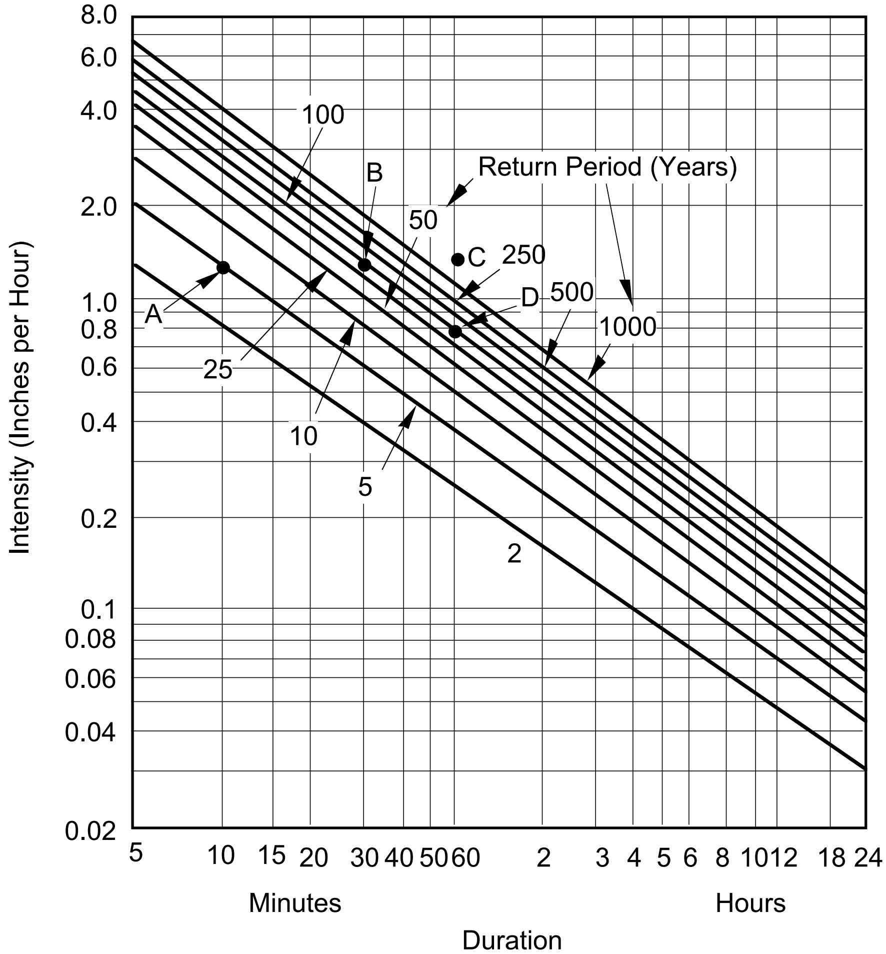
WIND DIRECTION	WIND SPEED CLASS (MPH) 1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47-54	55-63	64-UP	OVERALL AVERAGE
SE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SSE	.00	.00	.00	2.71	1.38	1.25	.00	.00	.00	.00	.00	1.78
S	.00	.00	7.83	1.62	1.38	5.70	15.92	.00	.00	.00	.00	7.17
SSW	.00	.00	.00	2.48	1.62	2.21	3.86	4.13	.00	.00	.00	2.95
SW	.00	.00	2.71	6.34	3.54	2.75	8.83	13.87	.00	988.88*	.00	19.40
WSW	.00	.00	1.74	1.81	4.96	4.13	12.95	48.31	.00	.00	.00	7.67
W	.00	1.74	1.74	1.83	2.89	5.37	2.71	.00	.00	.00	.00	3.54
WNW	.00	.00	3.49	2.64	1.77	1.99	3.29	4.13	.00	.00	.00	2.39
NW	.00	3.29	1.88	2.58	1.50	1.98	2.23	.00	.00	.00	.00	2.08
NNW	.00	2.02	2.60	2.58	4.80	.00	.00	.00	.00	.00	.00	2.77
N	.00	3.29	2.92	3.50	5.06	12.99	.00	.00	.00	.00	.00	3.81
NNE	.00	1.74	3.38	3.41	6.08	7.04	7.83	.00	.00	.00	.00	4.77
NE	.00	4.38	4.60	3.38	4.54	2.81	.00	.00	.00	.00	.00	3.84
ENE	.00	.00	.00	3.05	2.19	.00	.00	.00	.00	.00	.00	2.48
E	.00	.00	3.29	2.44	3.60	2.71	.00	.00	.00	.00	.00	2.78
ESE	.00	2.71	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.71
OVERALL** AVERAGE	.00	2.84	3.00	3.15	4.15	3.71	8.57	22.22	.00	988.88	.00	6.77

.00 NO DATA
*VISIBILITY 0 TO 1/16 MILE DUE TO ONE-HOUR DUSTSTORM
**WEIGHTED AVERAGE BASED ON TABLE 2.3-42

Table 2.3-42

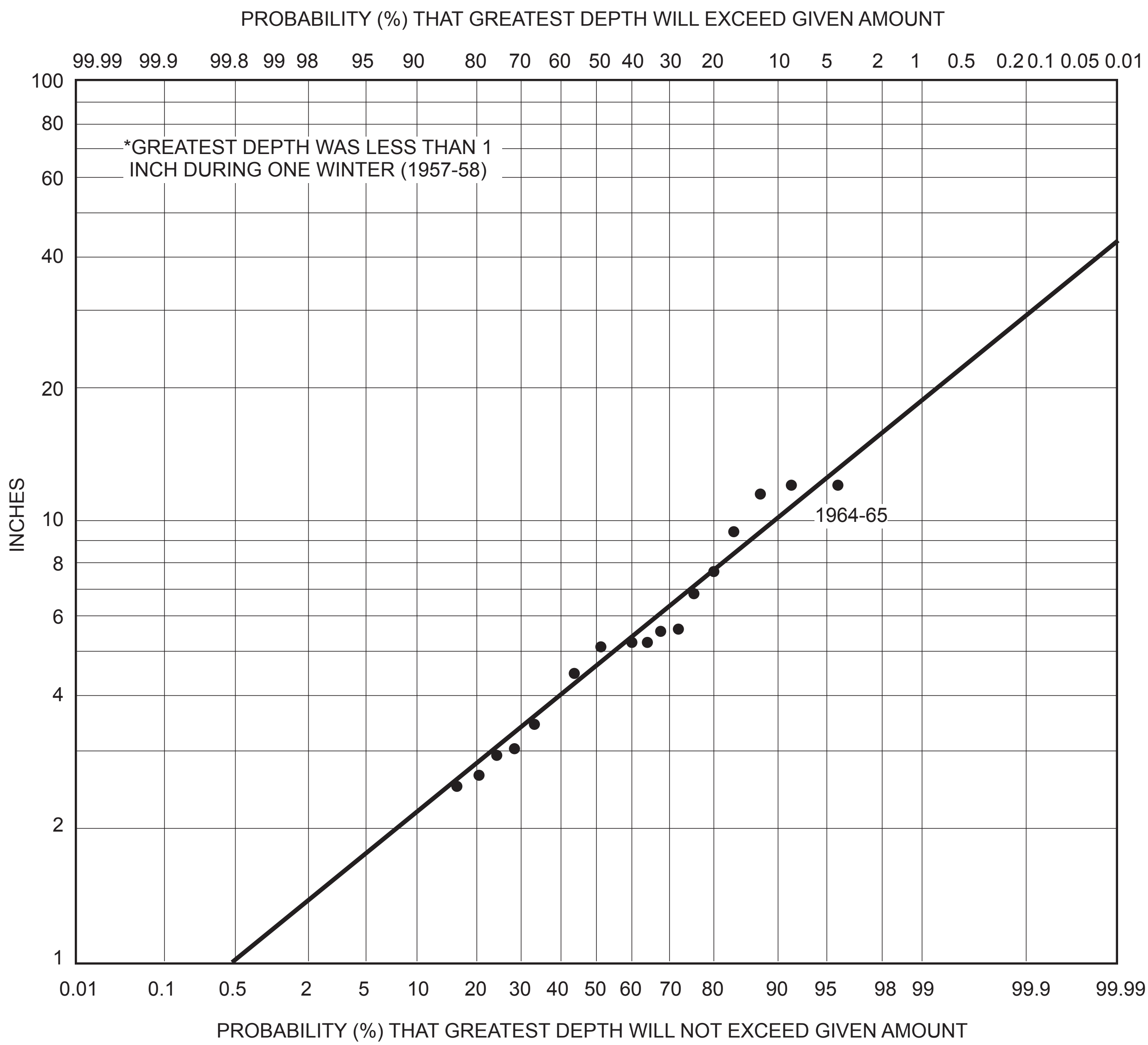
Hours Satisfying Dust Storm Criteria at Hanford (1953-1970)
Hours With (1) Visibility 7 Mile and Dust Reported or (2) Visibility
7 to 14 Miles, Windspeed 5.8 M/Sec: RH 70% Dust Assumed

WIND DIRECTION	WIND SPEED CLASS (MPH) 1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	47-54	55-63	64-UP	TOTAL HOURS
SE	0	0	0	0	0	0	0	0	0	0	0	0
SSE	0	0	0	1	1	1	0	0	0	0	0	3
S	0	0	1	3	1	3	3	0	0	0	0	11
SSW	0	0	0	4	3	11	13	2	0	0	0	33
SW	0	0	1	3	13	24	26	6	0	1	0	74
WSW	0	0	1	7	17	39	13	4	0	0	0	81
W	0	1	1	3	5	7	1	0	0	0	0	18
WNW	0	0	5	5	11	6	1	1	0	0	0	29
NW	0	1	6	4	3	5	2	0	0	0	0	21
NNW	0	2	8	6	2	2	0	0	0	0	0	18
N	0	1	12	34	10	1	0	0	0	0	0	58
NNE	0	1	3	31	23	7	1	0	0	0	0	66
NE	0	2	3	19	15	5	0	0	0	0	0	44
ENE	0	0	0	3	6	0	0	0	0	0	0	9
E	0	0	1	6	2	1	0	0	0	0	0	10
ESE	0	1	0	0	0	0	0	0	0	0	0	1
TOTAL HOURS	0	9	42	129	112	110	60	13	0	1	0	476

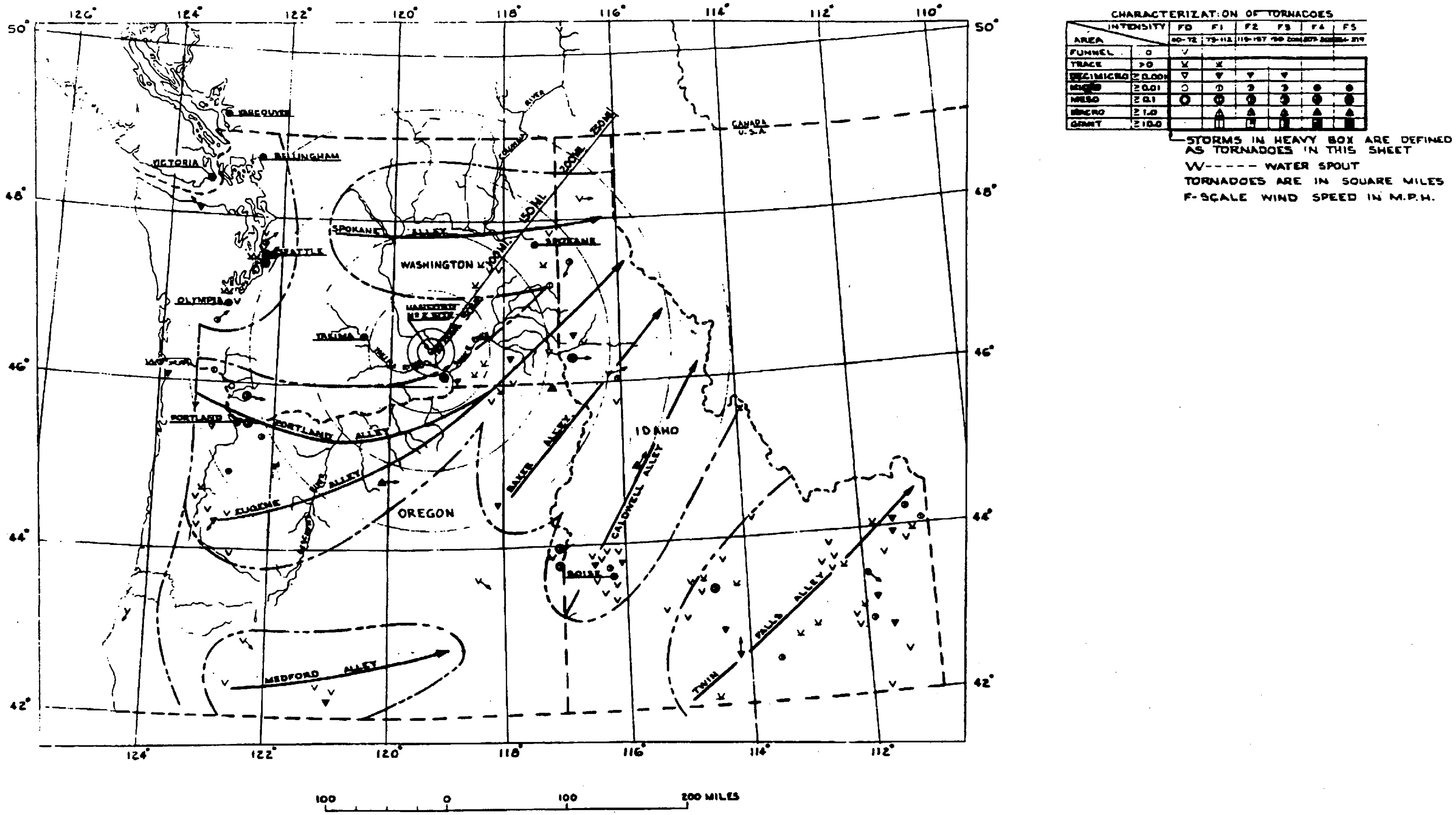


To use this chart, select any desired rainfall intensity and duration and read from the diagonal lines the expected frequency of such intensity and duration. For example, rainfall intensity of 1.3 inches per hour for 10 minutes can be expected to occur, on average, once every five years (point A). However, such intensity can be expected for 30 minutes duration only about once in 100 years (point B). The return period for 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).

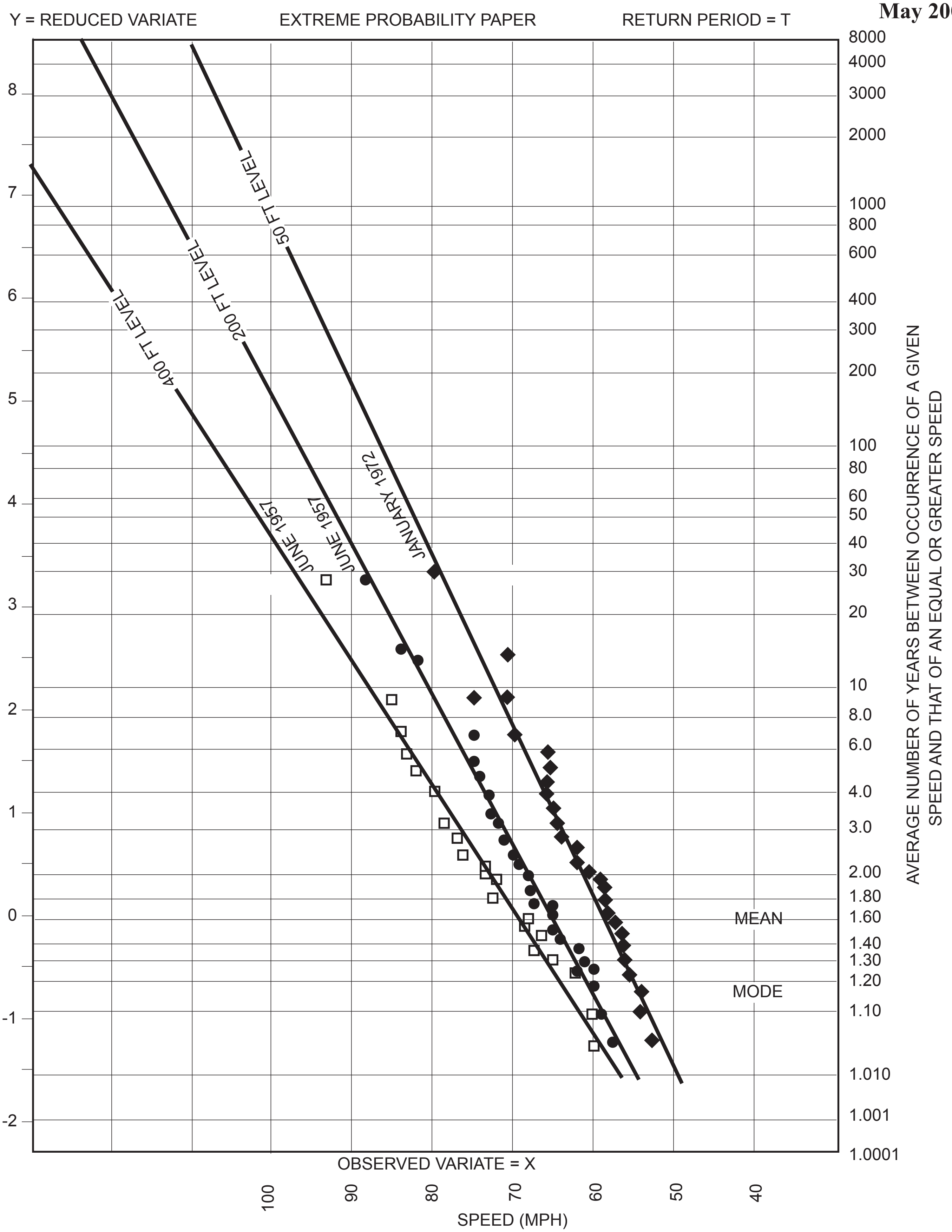


Columbia Generating Station Final Safety Analysis Report	Greatest Depth of Snow on Ground During 24 of 25 Winters of Record at Hanford (1946-47 through 1969-70)		
	Draw. No. 990306.14	Rev.	Figure 2.3-2



DISTRIBUTION OF TORNADOES IN TRI-STATE AREA

Columbia Generating Station Final Safety Analysis Report	Distribution of Characterized Tornadoes in 20-Year Period (1950-1969)
	Draw. No. 020552.01 / Rev. / Figure 2.3-3

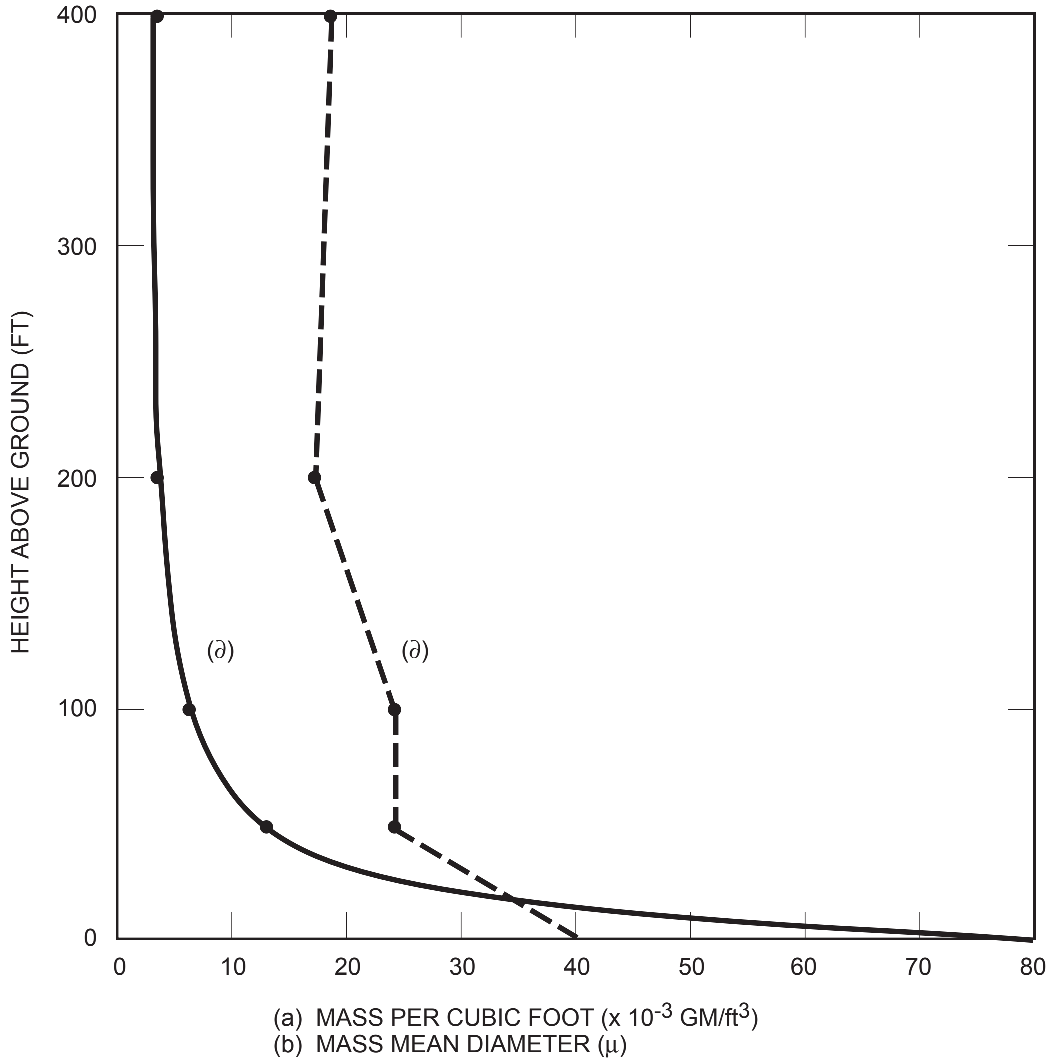


Columbia Generating Station
Final Safety Analysis Report

Peak Wind Gust Return Probability Diagram

Draw. No. 990306.17 | Rev. | Figure 2.3-4

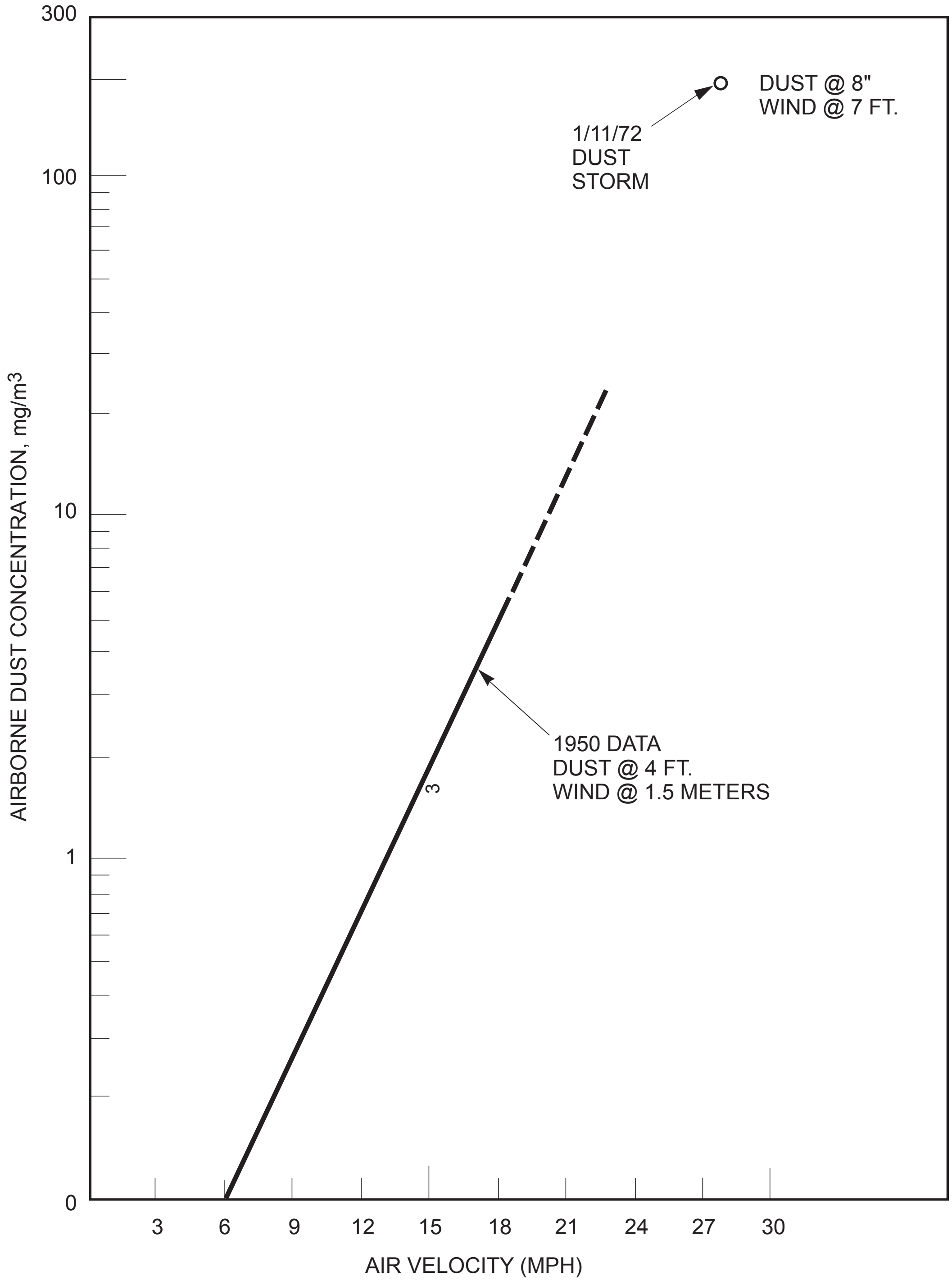
Form No. 960690



(a) AVERAGE MASS OF DUST PER FOOT^3, AND
(b) MASS MEAN DIAMETER OF DUST PARTICLES.
METEOROLOGY TOWER, HAPO. AUGUST 11, 1955

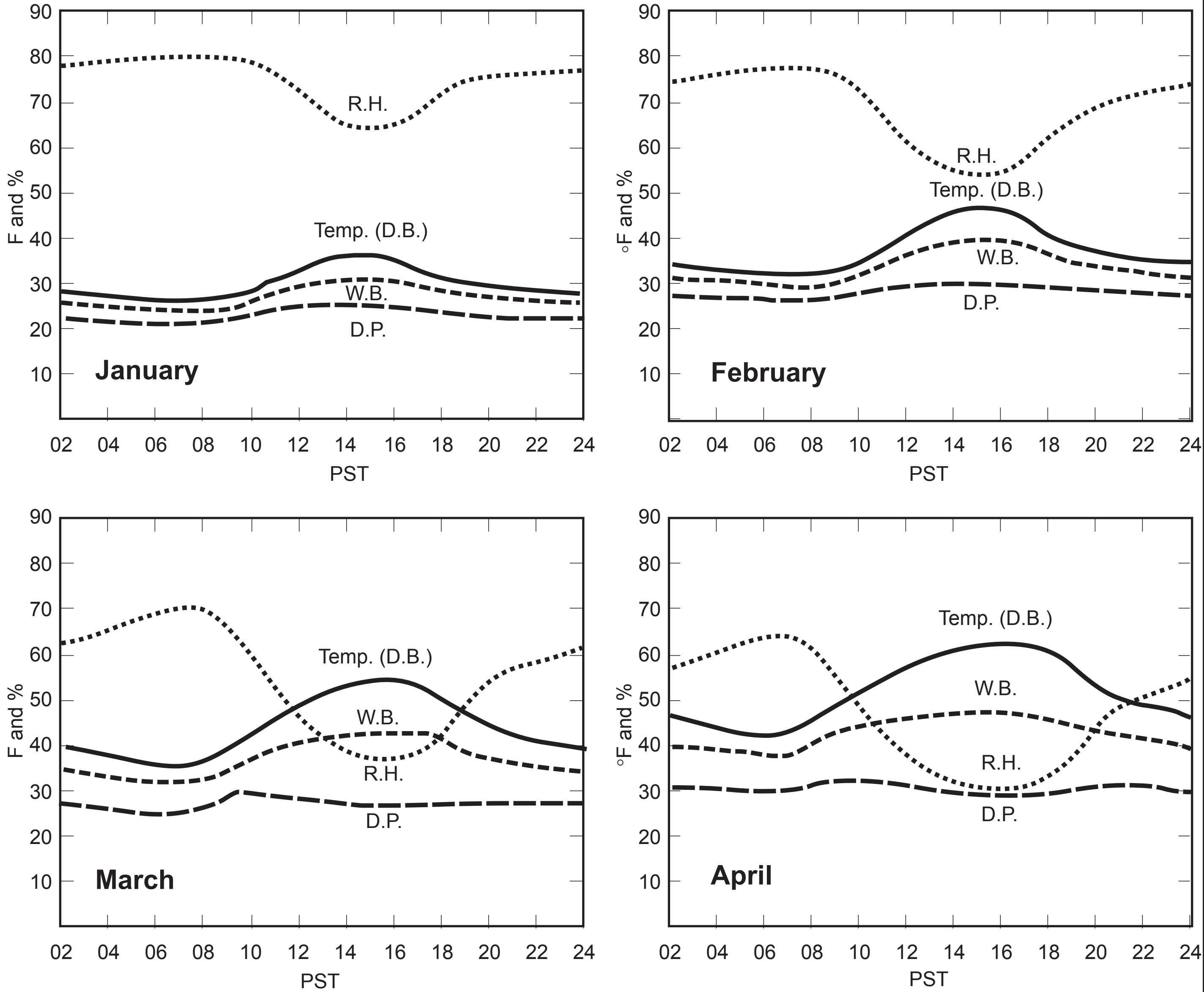
Dust Occurrences Per Wind Speeds to 400 ft Heights

Draw. No. 990306.18 | Rev. | Figure 2.3-5

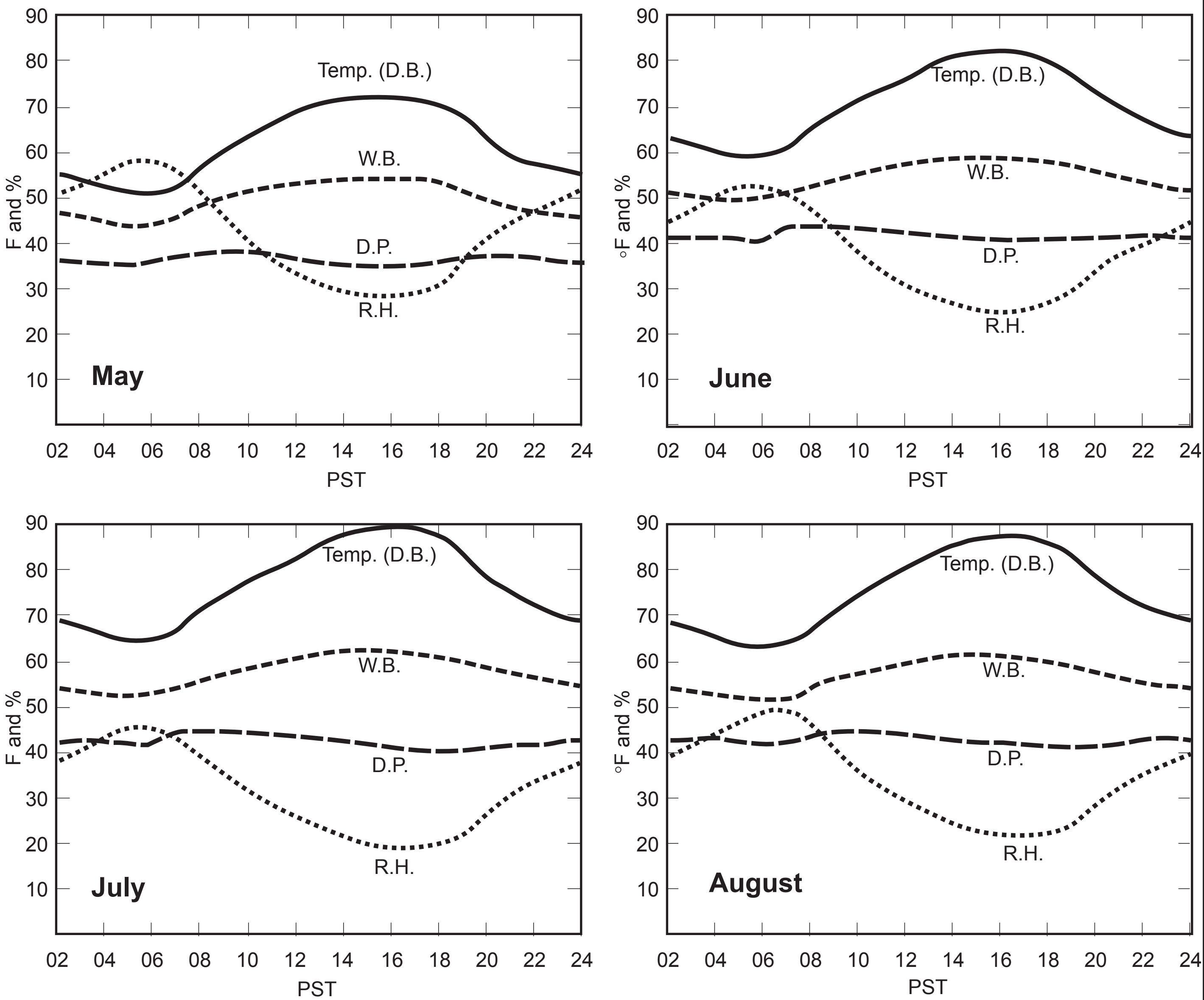


Near-Surface Airborne Dust Concentration as a Function of Average Air Velocity

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)



Monthly Hourly Average of Temperature and Relative Humidity - January thru April



Columbia Generating Station
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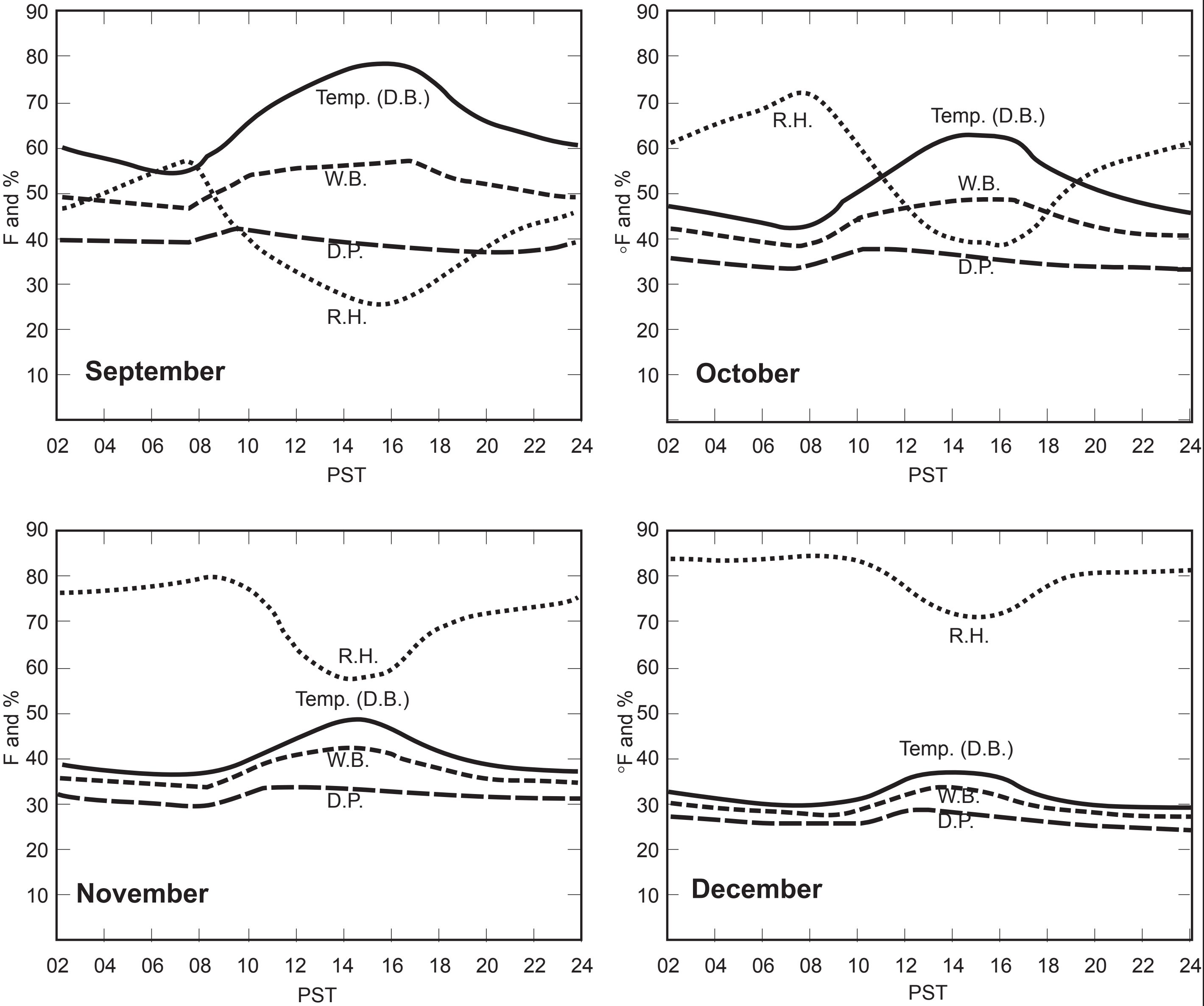
Monthly Hourly Average of Temperature and Relative Humidity - May thru August

Draw. No. 990306.40 | Rev. | Figure 2.3-7.2

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)



Columbia Generating Station
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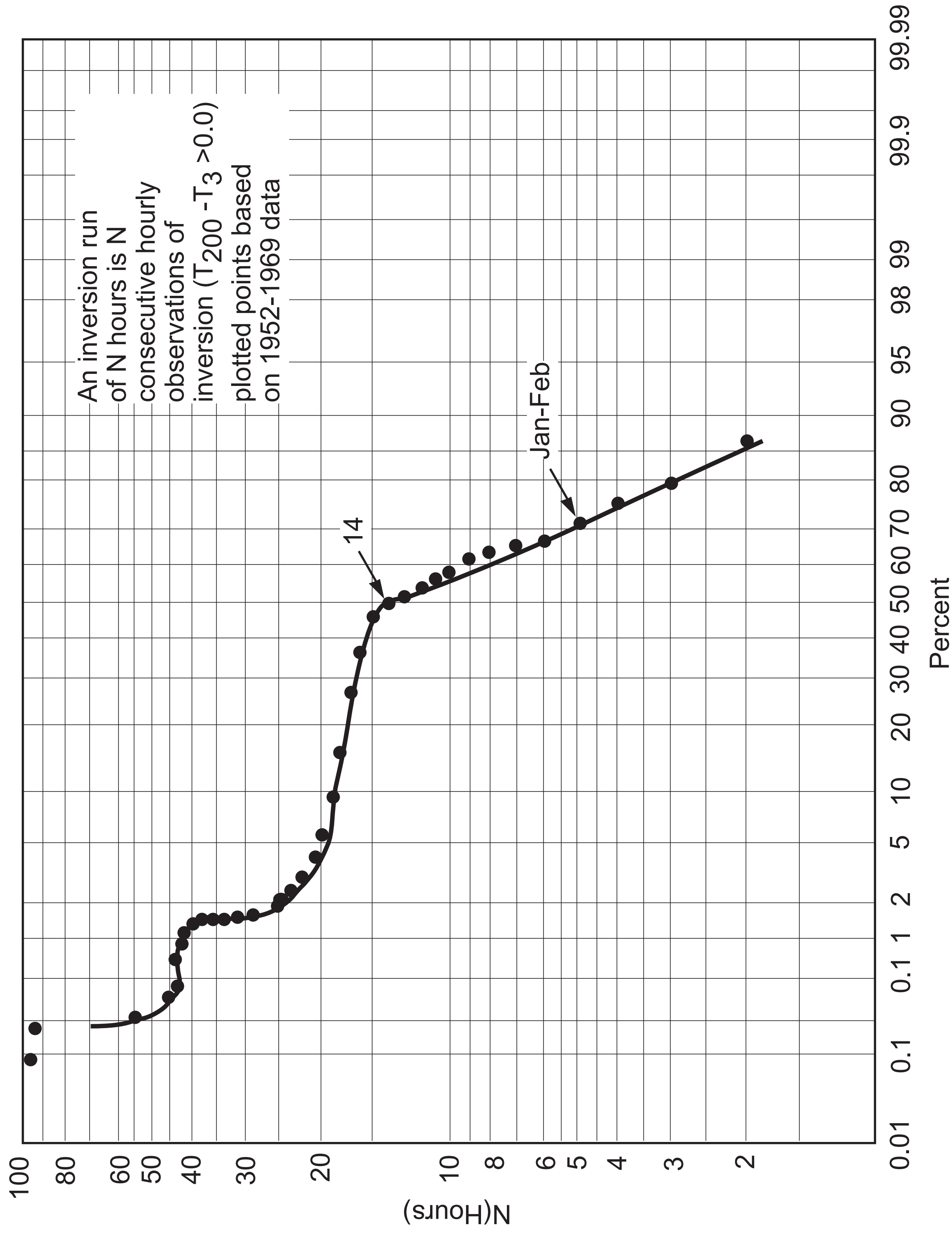
Monthly Hourly Average of Temperature and Relative Humidity - September thru December

Draw. No. 990306.22 | Rev. | Figure 2.3-7.3


An inversion run
of N hours is N
consecutive hourly
observations of
inversion (T_{200} - T_3 >0.0)
plotted points based
on 1952-1969 data
14
Jan-Feb
Percent
N(Hours)
0.01
0.1
0.1 1
1
2
5
10
20
30
40
50
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70
80
90
95
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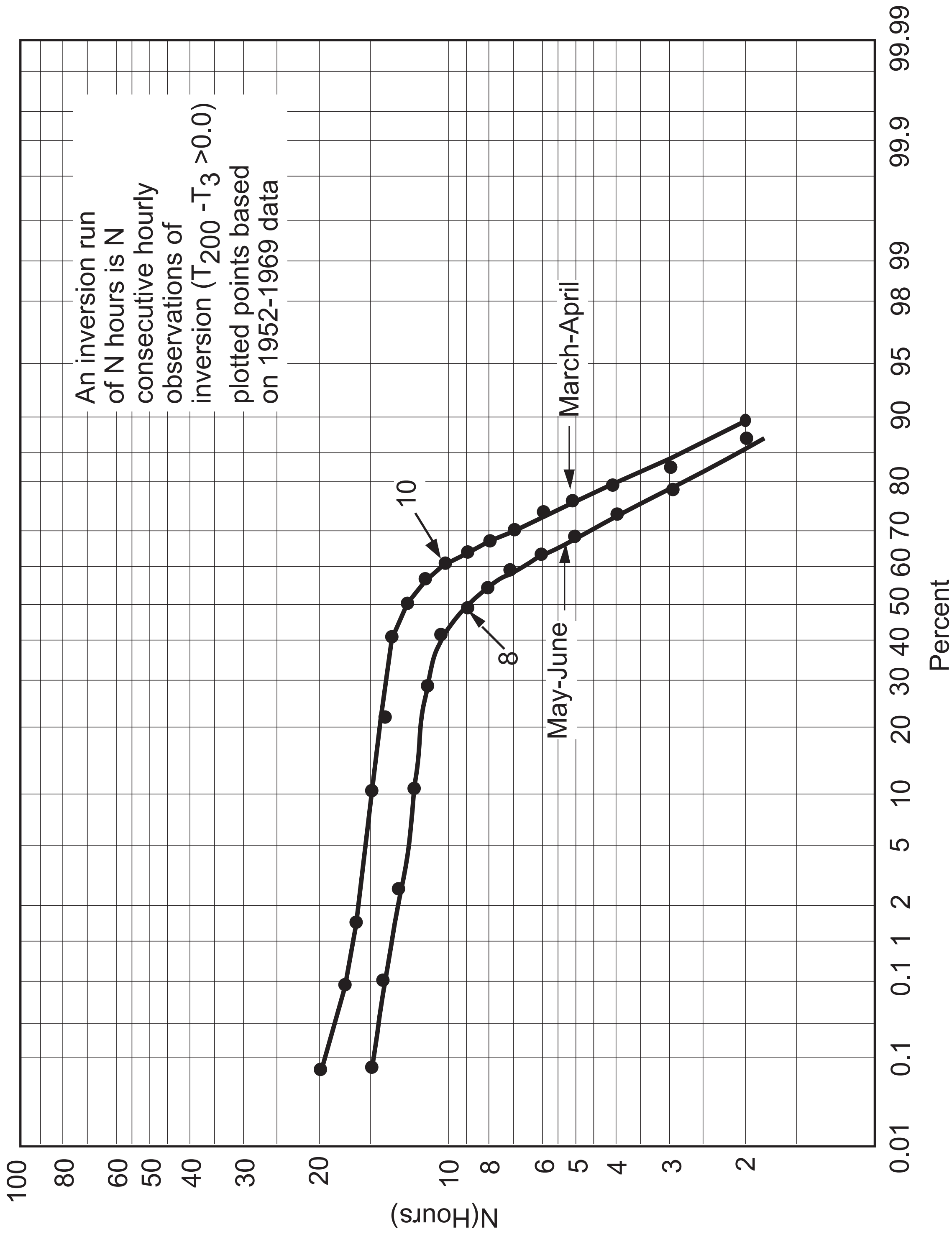
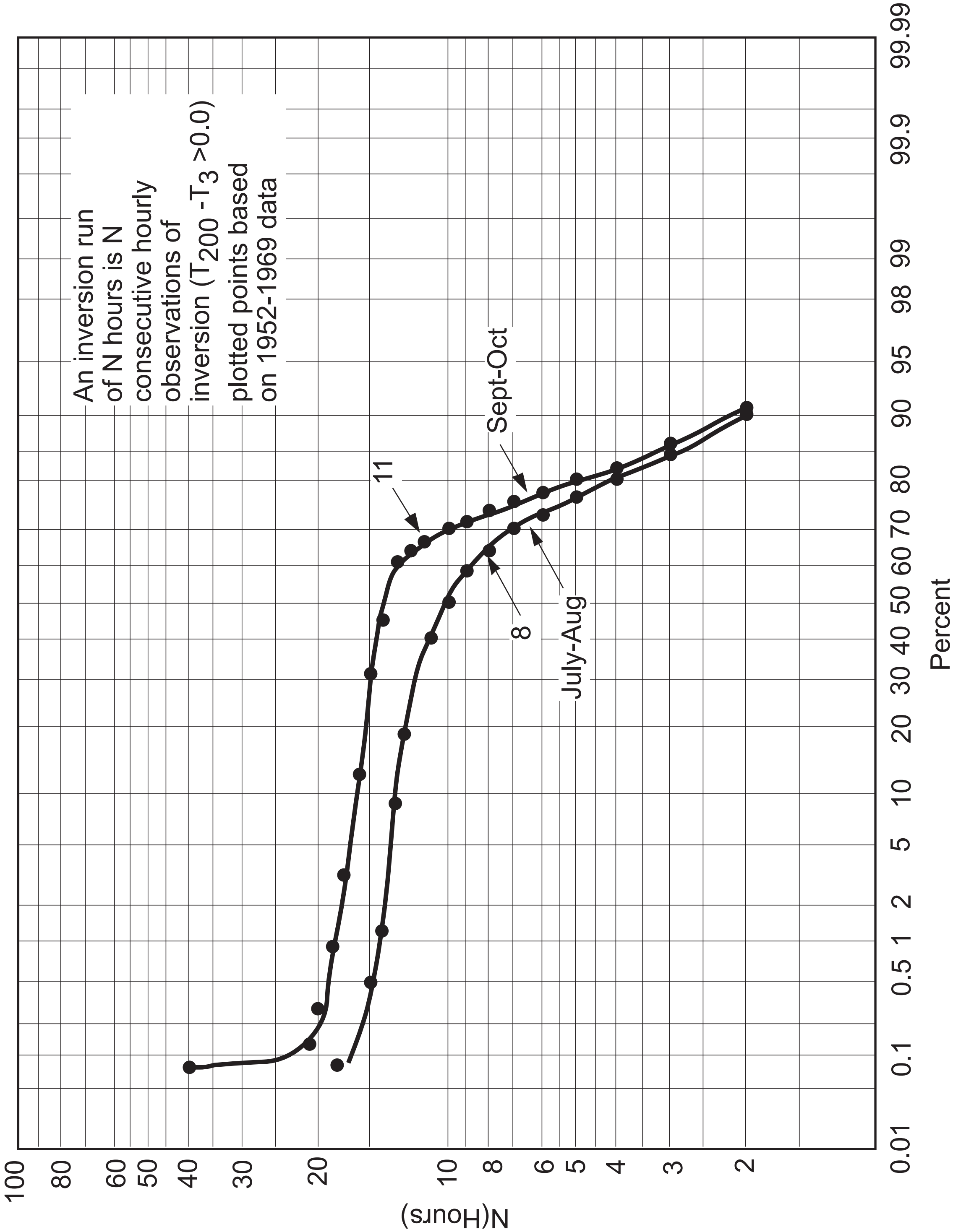


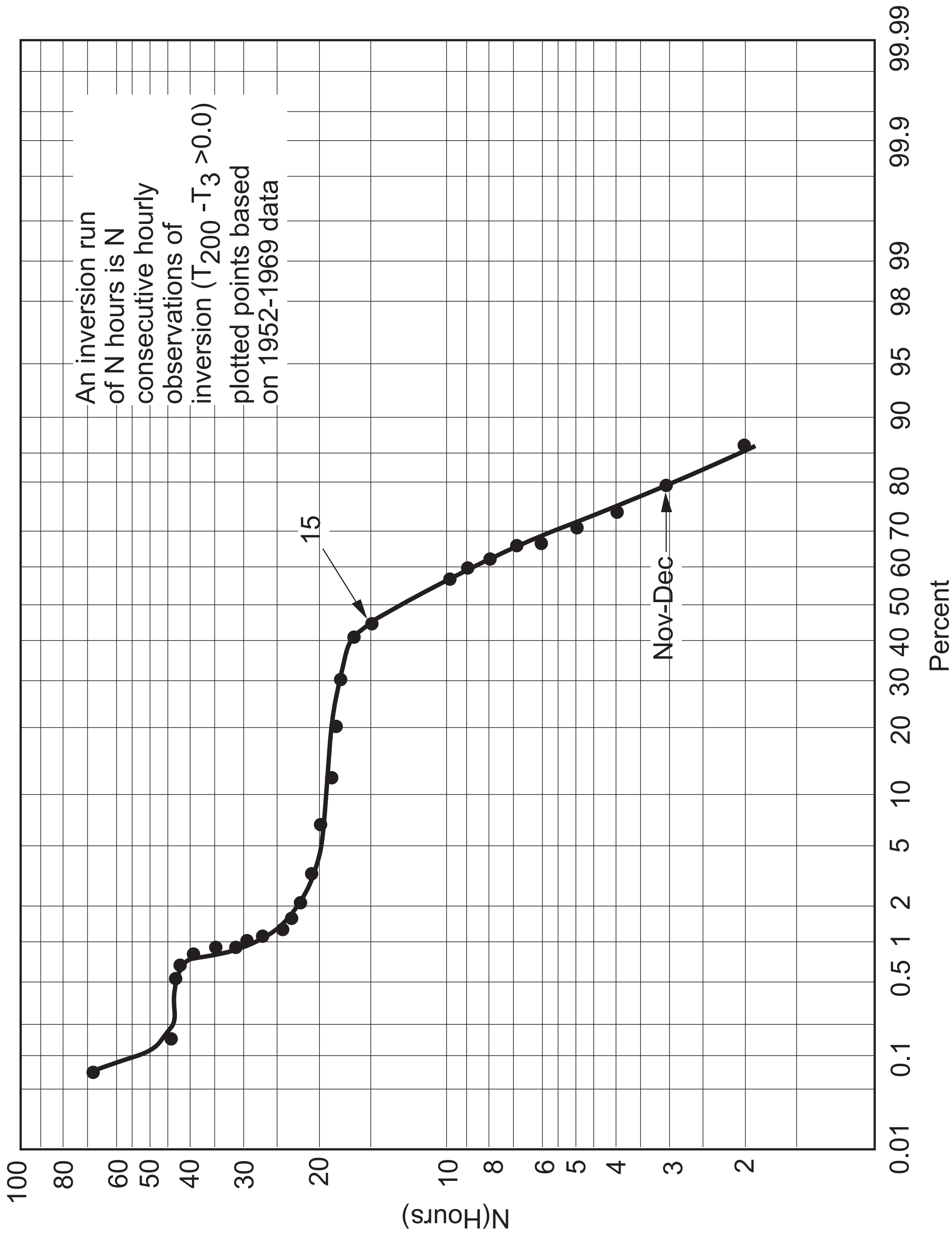
Columbia Generating Station Final Safety Analysis Report	Probability (%) that the First Hourly Observation of an Inversion will Mark the Beginning of an Inversion Run of N Hr
	Draw. No. 990306.02 / Rev. / Figure 2.3-8.2

Form No. 960690



Probability (%) that the First Hourly Observation of an Inversion will Mark the Beginning of an Inversion Run of N Hr

Draw. No. 990306.04	Rev.	Figure 2.3-8.3



Columbia Generating Station
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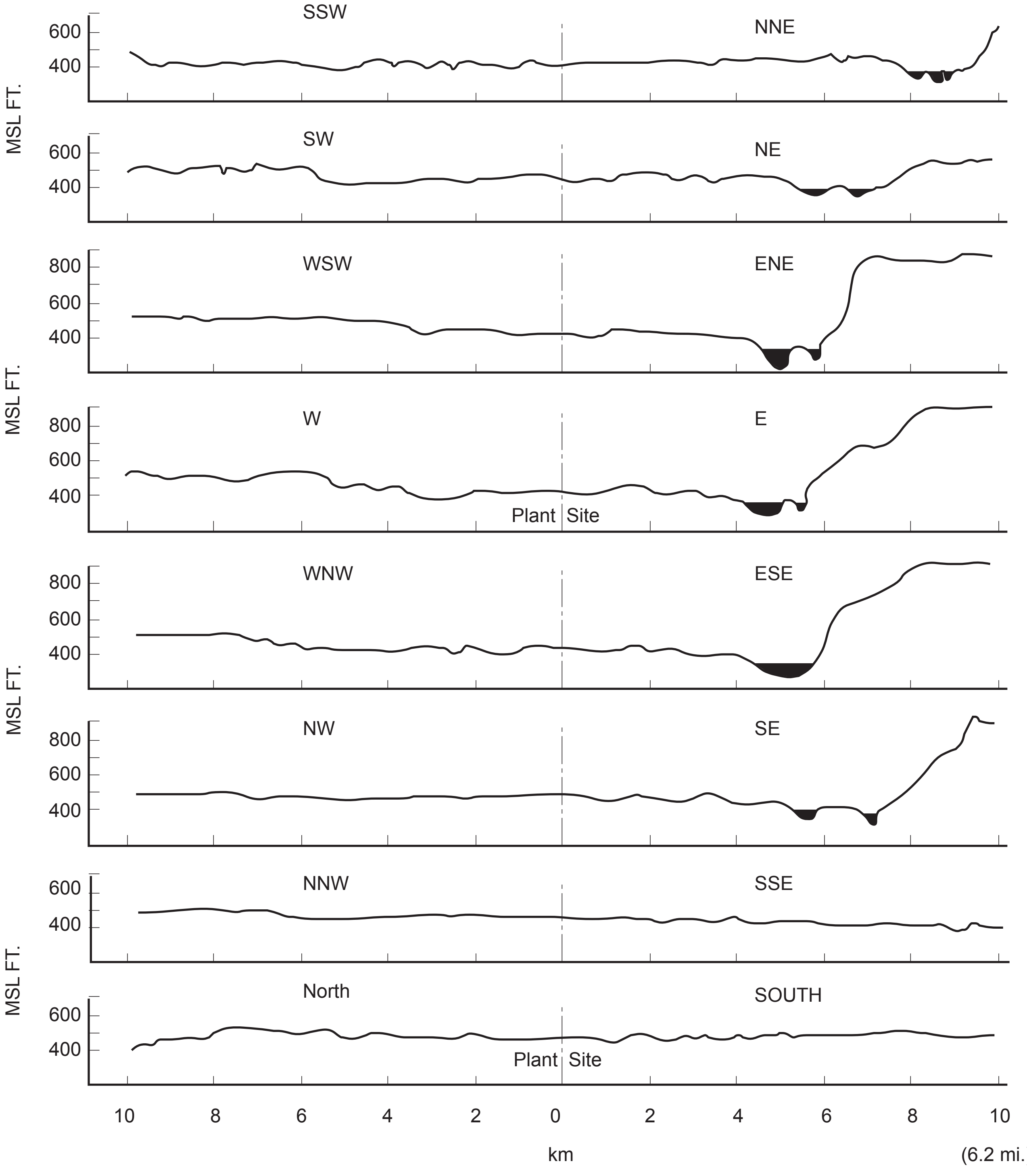
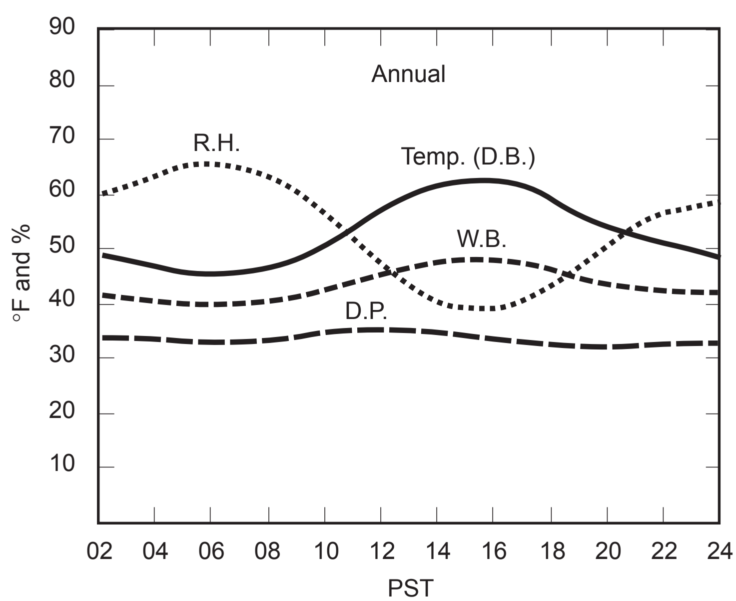
Probability (%) that the First Hourly Observation of an Inversion will Mark the Beginning of an Inversion Run of N Hr

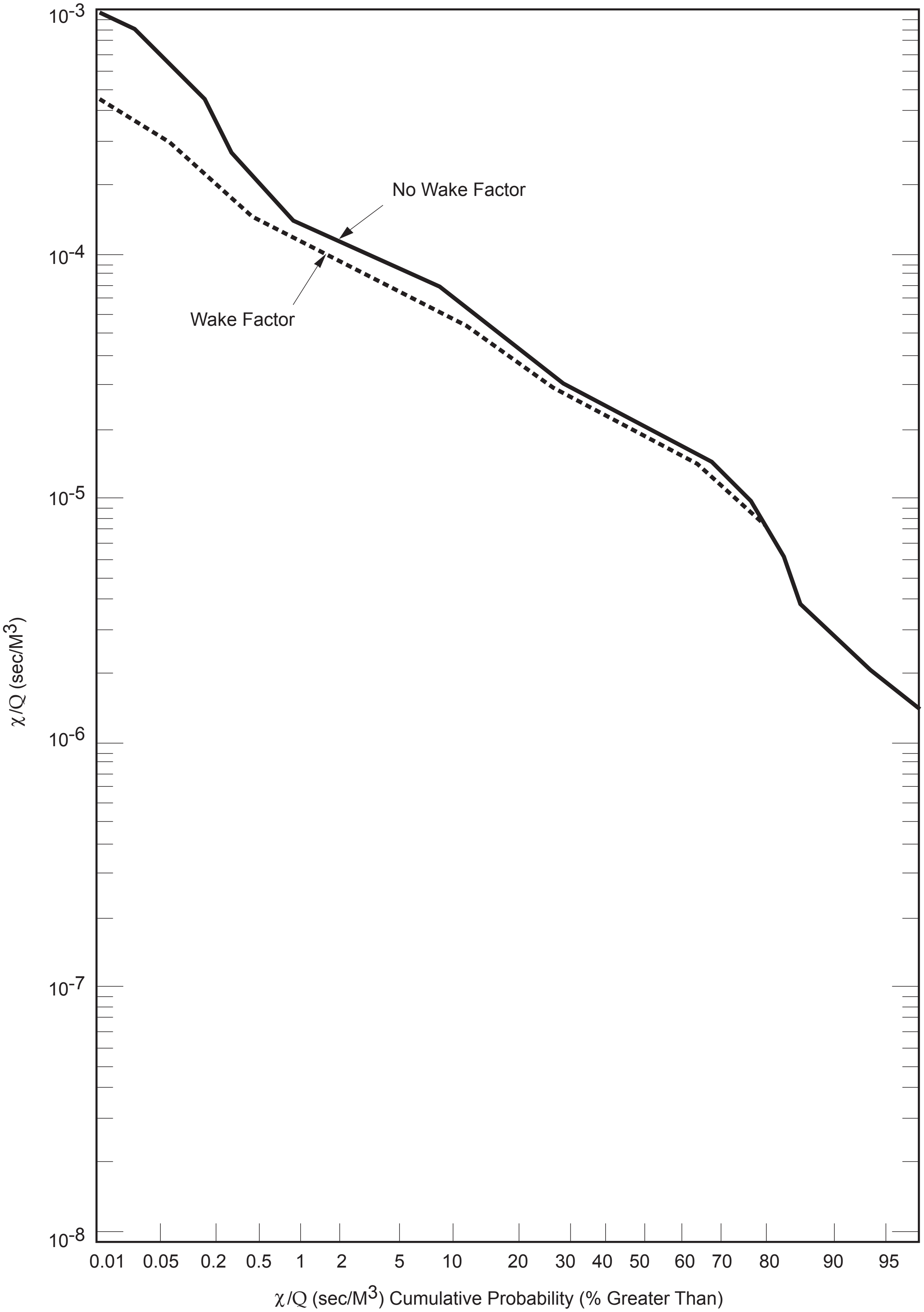
Draw. No. 990306.05	Rev.	Figure 2.3-8.4


SSW
NNE
SW
NE
WSW
ENE
W
E
WNW
ESE
NW
SE
NNW
SSE
North
SOUTH
MSL FT.
600
400
800
Plant Site
10
8
6
4
2
0
km
(6.2 mi.)

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)



Columbia Generating Station Final Safety Analysis Report	Yearly Hourly Average of Temperature and Relative Humidity		
	Draw. No. 990306.24	Rev.	Figure 2.3-10



Columbia Generating Station
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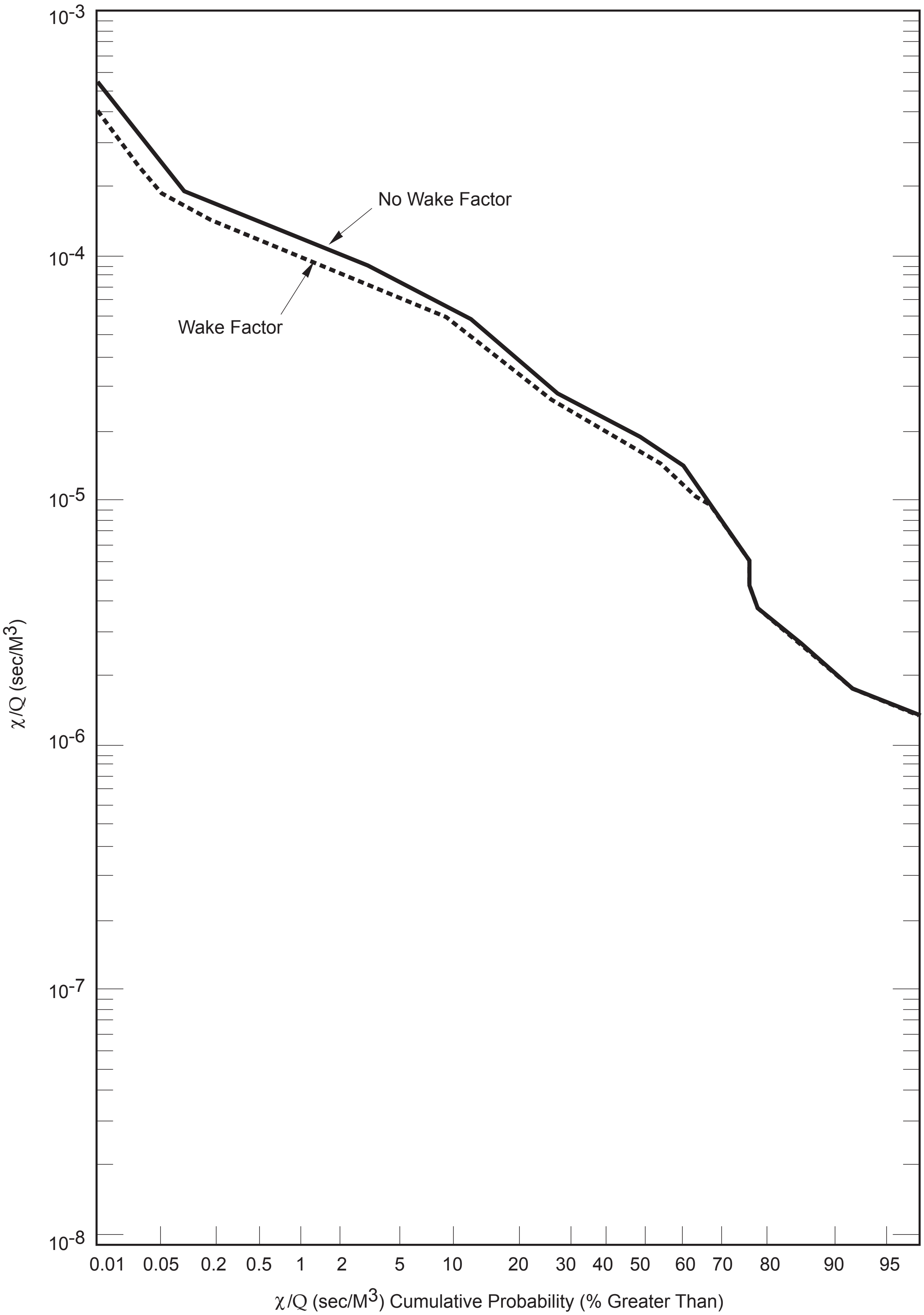
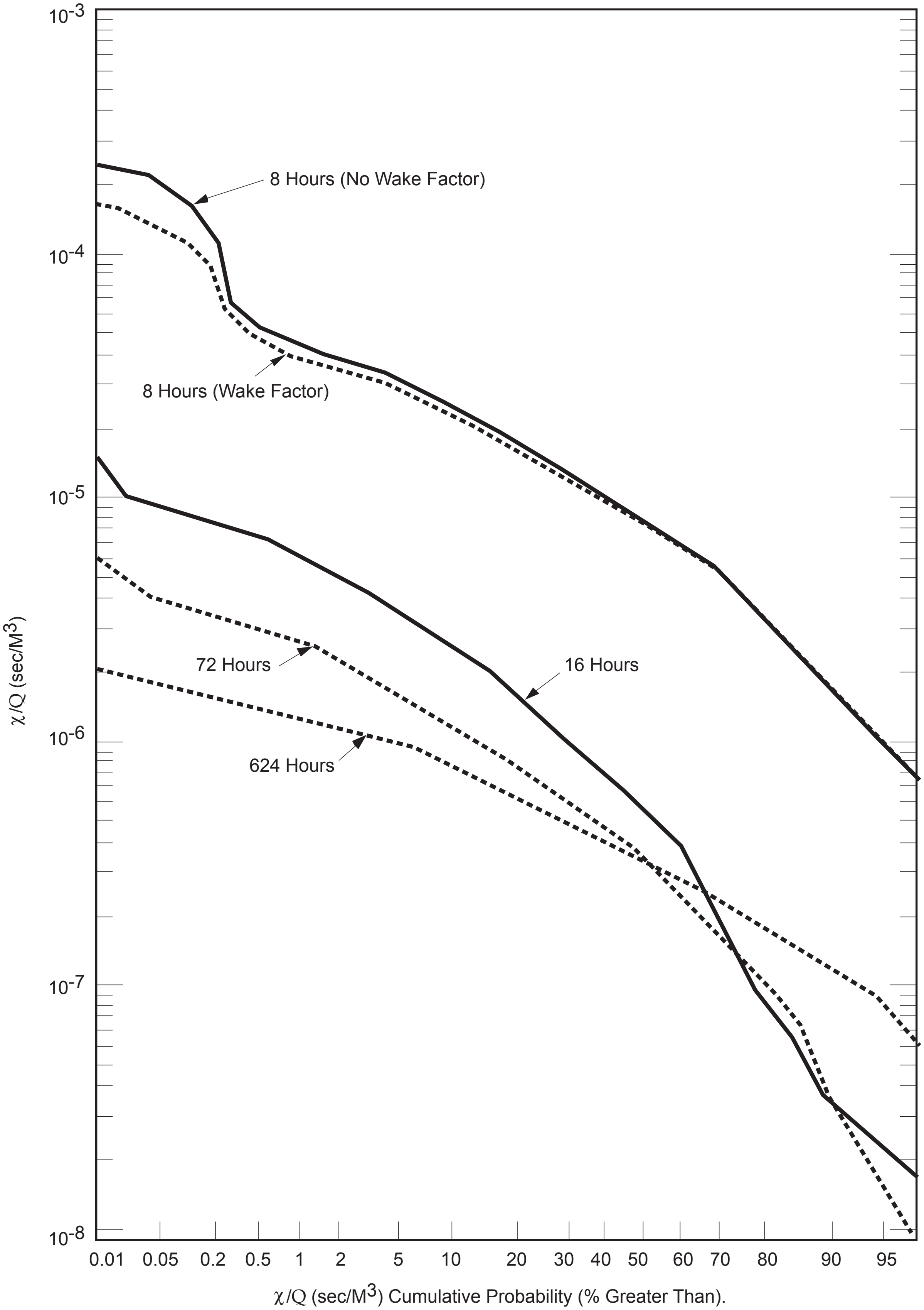
Cumulative (%) Frequency of Hourly Centerline (χ/Q at Site Boundary Circular Distance of 1.212 Miles From Source (April 1974-March 1975)

Draw. No. 990306.25 | Rev. | Figure 2.3-11



Columbia Generating Station Final Safety Analysis Report	Cumulative (%) Frequency of Hourly Centerline (χ/Q at Site Boundary Circular Distance of 1.212 Miles From Source (April 1975-March 1976)	
	Draw. No. 990306.26	Rev.	Figure 2.3-12



Columbia Generating Station
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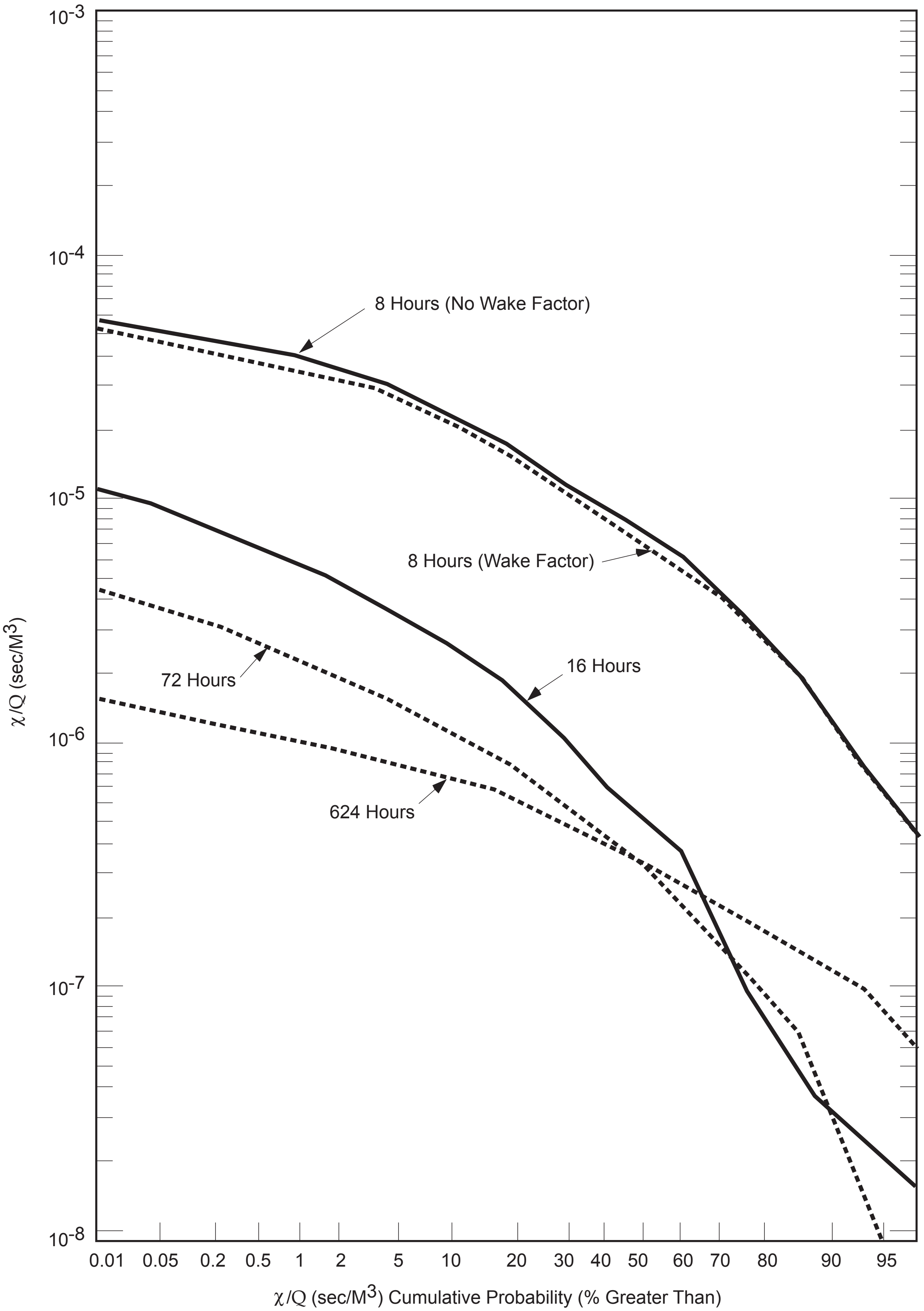
Cumulative (%) Frequency of Occurrence of (χ/Q for Postulated Accidents of 8, 16, 72, and 624 Hr at Outer Boundary of Low Population Zone (3.0 Miles from Source) (April 1974-March 1975)

Draw. No. 990306.27	Rev.	Figure 2.3-13



Columbia Generating Station
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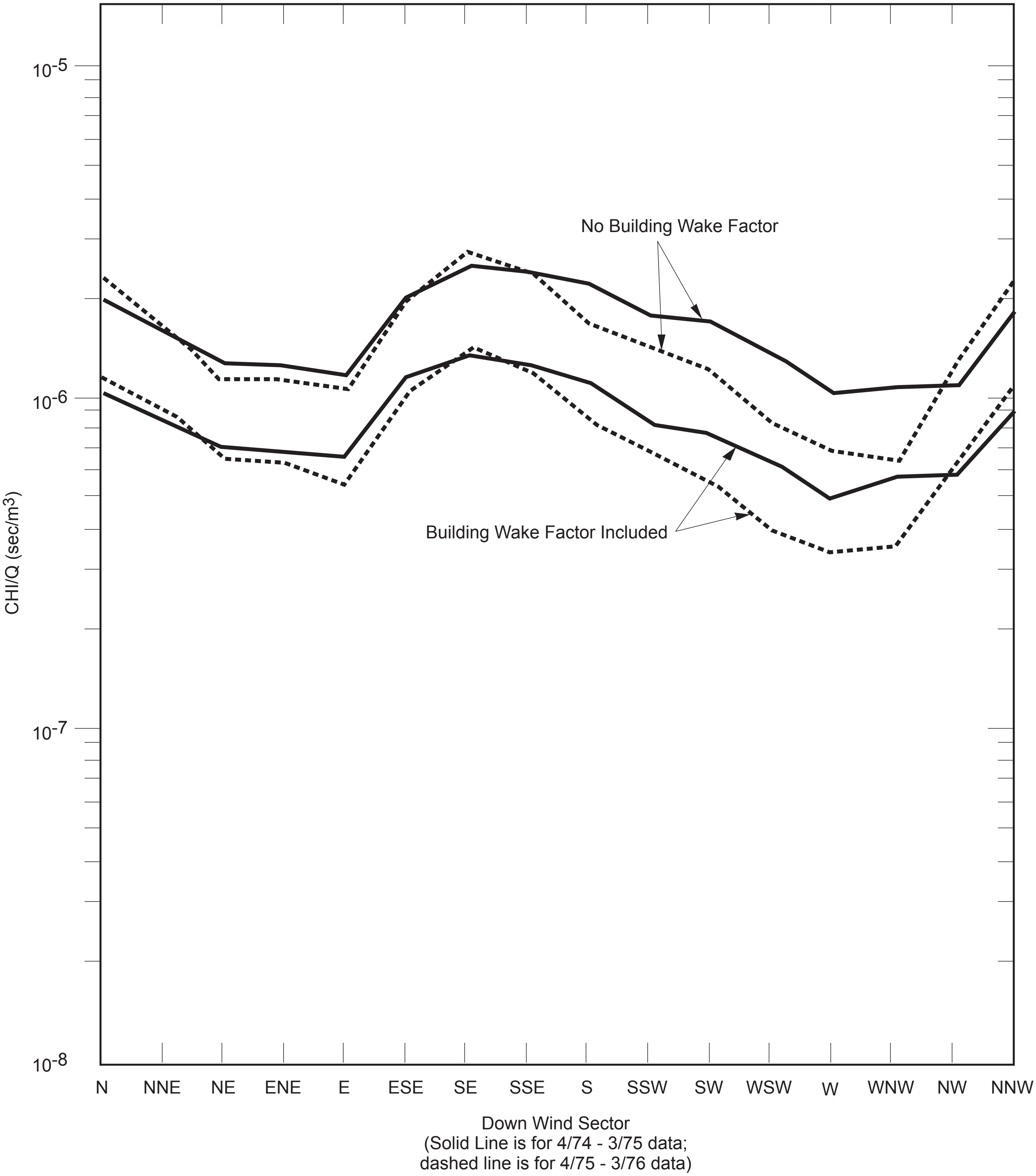
Cumulative (%) Frequency of Occurrence of (χ/Q for Postulated Accidents of 8, 16, 72, and 624 Hr at Outer Boundary of Low Population Zone (3.0 Miles from Source) (April 1975-March 1976)

Draw. No. 990306.28 | Rev. | Figure 2.3-14



Columbia Generating Station
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Annual Average χ/Q by Sector at the Site Boundary for First and Second Annual Cycle Data

Draw. No. 990306.29	Rev.	Figure 2.3-15

2.4 HYDROLOGY ENGINEERING

The italicized information is historical and was provided to support the application for an operating license.

2.4.1 HYDROLOGIC DESCRIPTION

2.4.1.1 Site and Facilities

Columbia Generating Station (CGS) is located in the Hanford Site within Benton County, Washington, approximately 3 miles west of the Columbia River at river mile (RM) 352, 10 miles north of Richland and 45 miles downstream from Grant County PUD Priest Rapids Dam. The site coordinates are approximately 46° 28' North Latitude and 119° 20' West Longitude.

The Columbia River is the predominant hydrologic feature of the area and provides principal drainage for the surrounding area. The riverbed is clearly marked in the terrain and at the proximity of the site the river flows between high banks. The Columbia River approximate riverbed elevation is 328 ft above mean sea level (msl); the ground elevation at the site is approximately 440 ft. Another hydrologic feature of the area is the Yakima River, which at its closest approach flows within 8 miles of the plant site. The river system is shown in the hydrographic map, Figure 2.4-1. Figures 2.1-1 and 2.1-2 show the major hydrologic features of the area.

All Seismic Category I structures are located above maximum postulated flood elevations. For flood elevations refer to Sections 2.4.3 and 2.4.4.

Water for cooling tower makeup water and other plant requirements is withdrawn from the Columbia River. The intake system is designed for a maximum capacity of 25,000 gpm (55.7 cfs). The non-safety-related makeup water intake system is approximately 3 miles east of the plant and is made up of two offshore perforated pipe inlets, two lead-in pipes, and pump house structure.

A topographic map and contour map of the region surrounding the site are shown in Figures 2.4-2 and 2.4-3. The natural drainage features of the surrounding area have not been changed by the construction of CGS.

2.4.1.2 Hydrosphere

The Columbia River, the largest river flowing into the Pacific Ocean from North America, is one of this world's greatest sources of hydroelectric power. Its annual discharge of 18,000,000 acre ft (1 acre-ft = 43,560 ft^3) is exceeded in the North American continent only by the Mississippi, Mackenzie and St. Lawrence Rivers.

The Columbia River drains an area of approximately 258,000 square miles, lying to the west of the Continental Divide in the northwestern part of the U.S. (85%) and southwestern part of Canada (15%). Major tributaries are the Kootenay, Snake, Pend Oreille, Spokane, Okanogan, Yakima, and Willamette Rivers.

In determining the Standard Project Flood (SPF) the drainage area was divided into subbasins. These subbasins can be grouped into six general areas with similar hydrometeorological characteristics.

The six areas are: (1) upper Columbia, which includes the drainage of the area in Canada and the northern part of the United States above Chief Joseph Dam; (2) Middle Columbia, which includes the area between Pasco and Chief Joseph Dam; (3) Upper and Middle Snake River; (4) Lower Snake River, the area between Weiser and Ice Harbor Dam; (5) Lower Columbia, including the area between Bonneville Dam and Pasco; (6) the Columbia below Bonneville Dam, including the Willamette River.

The river basin has five outstanding physical features: the Rocky Mountain System, the Columbia Plateau, the Columbia River Gorge, the Cascade Range and Puget Trough.

The Rocky Mountain System is the major range with elevations from 2000 to over 12,000 ft. There are permanent glaciers and extensive snow fields at higher elevations and deep valleys that provide the principal drainage for the head-waters of the Columbia, Kootenay and other rivers.

The Columbia Plateau is a great, generally treeless, semiarid plateau covering over 100,000 square miles in the central portion of the basin. This plateau is in an area between the Cascade Range and the Rocky Mountains. The plateau was formed by successive flows of lava and filled to a general thickness of approximately 4000 ft. The Columbia River flows 1214 miles from its source in Columbia Lake (el. 2700 ft) in British Columbia, near the crest of the Rockies, to the Pacific Ocean at Astoria, Oregon. It sweeps around the north and northwesterly sides of the Columbia Plateau to central Washington to be joined by the Snake River. The Columbia River flows directly across the axis of the Cascades in a narrow gorge to the Pacific.

The Columbia Gorge is the gateway from the Pacific Ocean to the intermountain Columbia Plateau. Tide flows 140 miles up-river. For most of its length the river flows in deep valleys and canyons.

High flows occur in late spring and early summer with melting of snow on the mountainous watershed. Low flows occur in autumn and winter.

The Columbia River has been regulated by dams and reservoirs over the past 35 years. A large portion of the main stream and major tributaries is developed to meet various

functional requirements, such as flood control, hydroelectric power, irrigation, municipal and industrial supply, etc. The regulation of Columbia River floods is accomplished by use of reservoir storage space provided primarily for irrigation or for hydroelectric power utilization. The volume of usable reservoir storage space is on the order of 20% to 25%.

There are seven dams upstream and four dams downstream of the site on the main stream of the Columbia River within the U.S. These dams are listed in Table 2.4-1. The Columbia River flow in the reach of CGS is controlled by regulation of the upstream reservoir projects, which have a total usable storage capacity of approximately 35 million acre-ft. Some control of flow in the immediate vicinity of the site is by regulation of the nearest upstream hydroelectric projects, Priest Rapids Dam, at RM 397, containing about 45,000 acre-ft of active storage, and Wanapum Dam, at RM 415, containing about 161,000 acre-ft of active storage. Some minimal effect on the river flow in the vicinity of the site is caused by McNary Dam, at RM 292, approximately 60 RM downstream from the site area.

Flows in the Columbia River during the summer, fall, and winter vary from a low of 36,000 ft^3/sec to as much as 160,000 ft^3/sec. During spring runoff high flows ranging from 250,000 ft^3/sec to 450,000 ft^3/sec have been recorded. The average annual flow is 120,000 ft^3/sec; during low flow periods flows may average about 60,000 ft^3/sec (see Figure 2.4-4).

The Grand Coulee and Bonneville dams were put into operation prior to World War II and several dams were built after the war. The four downstream dams include large locks to permit the passage of river vessels. Several of the dams provide emergency floodwater storage. Grand Coulee, the largest and most complex of the dams, augments the low winter flows for the entire system from its 9,402,000 acre-ft of available storage (of which approximately 5,100,000 acre-ft is active storage) and also pumps water to the Columbia River Irrigation Project.

The river channel near the CGS site varies between 400 and 600 yards in width for low water and normal high water level, respectively. The depth varies from about 25 ft to 45 ft for normal high water and flood high water levels, respectively. Velocities vary from 3 ft/sec to over 11 ft/sec depending on section and flow. Average water temperature is 51°F. Temperatures may reach a low of 32°F and a high of 68°F. (See Table 2.4-2 and Figure 2.4-4.)

A list of water usage downstream of CGS, obtained from records of the Department of Ecology, State of Washington, for water rights as of February 1980, is presented in Table 2.4-3. The closest municipal surface water user is the City of Richland with an intake approximately 12 miles downstream. *The location of local groundwater users is discussed in Section 2.4.13.2.*

2.4.2 FLOODS

2.4.2.1 Flood History

Floods in the Columbia River Basin are grouped as:

a. *The interior basin east of the Cascades, caused by melting snowpack and occurring from May through June;*

b. *The Willamette and other basins, west of the Cascades, caused by direct runoff from intense winter rain occasionally augmented by snowmelt.*

There is some overlapping effect within these two groupings. At certain elevations, basins in the interior Columbia drainage area occasionally have significant flood flows resulting from winter rain or snowmelt. These are local floods and do not usually contribute sufficient flow to cause flooding of the main Columbia River. Major floods in the Columbia River Basin result from rapid spring melting of the snowpack over a wide area, generally augmented by rain or by above-normal precipitation in May, accompanied by a major chinook wind which causes rapid area temperature rise. The annual spring snowmelt flood of the main interior basin is characterized by relatively uniform distribution over the basin. The snowfall and individual snow storms may vary, but the integration of all storms over the winter period smoothes the irregularities, with the result that the distribution of the flood runoff is reasonably constant from year to year.

The maximum historical flood of record is that of June 7, 1894, which resulted from a combination of hydrometeorologic conditions, including heavy snowpack and rapid melt plus rainfall. The peak discharge at CGS was 740,000 ft^3/sec for the Columbia River, as estimated from high water marks at Wenatchee, Washington (Reference 2.4-1). *The largest recent flood, occurring in 1948, had an observed peak discharge of 690,000 ft^3/sec at Hanford. These floods were spring floods resulting from the melt of a large snowpack combined with the spring rains (Reference 2.4-2).* Water surface profiles for the Columbia River in the vicinity of the site as derived by the Corps of Engineers (Reference 2.4-2) are given in Figure 2.4-5.

The plant site is located approximately three miles west of the Columbia River at RM 352 with reactor floor elevation of 441 ft msl, which is 68 ft above the water level estimated for the largest historical flood (approximately 373 ft msl). There is no record of flooding in the immediate site area.

2.4.2.2 Flood Design Considerations

Flood protection of safety-related components is based on the highest calculated flood water level including wave effects, resulting from intense local precipitation. Several different probable maximum events were considered, including the Corps of Engineers design-project

flood considered to be "the most severe reasonably possible." Wave action caused by storm winds, the effects of failure of upstream dam surge flooding, and ice flooding were also considered.

The results of these analyses (described in Section 2.4.3) indicate that the CGS site is safe from floods and that no flood protection measures are required. The Hydrogen Storage and Supply Facility located 0.6 miles south-southeast of the plant is subject to flooding due to the PMP flood discussed in Section 2.4.3.1. Equipment storing liquid and gaseous hydrogen has been analyzed for the effects of this flood (Section 2.4.2.3). As discussed in sections that follow, plant safety-related structures are located above high water elevations associated with Columbia River flooding (Sections 2.4.2.1 and 2.4.3), intense local precipitation (Sections 2.4.3.5 and 2.4.3.6), and upriver dam failures (Section 2.4.4).

2.4.2.3 Effects of Local Intense Precipitation

Intense local summer thunder storms can produce short duration rains which have the potential for causing serious flood. Winter precipitation may occur as rain or snow and would be less intense than the worst summer thunderstorm. The probable maximum precipitation (PMP) event for the CGS site has been determined using the methodology developed by the U.S. Weather Bureau and reported in Hydrometeorological Report No. 43, "Probable Maximum Precipitation, Northwest States" (Reference 2.4-3).

The plant area slopes easterly to a broad channel which is adequate to store and drain the PMP. Construction contours of the site are shown in Figure 2.4-28. The reactor building and the spray ponds are located at elevations that are safe from the effect of any flood resulting from the maximum precipitation event.

Winter precipitation may occur as rain or snow. The winter season snowfall has ranged from less than 0.5 in. to a maximum of 12 in. in December 1964. There is no ice accumulation at the site.

To accommodate surface drainage during severe climatic conditions such as rainfall and rapid snow melts, a system of catch basins and dry wells is provided with inlet elevations a minimum of 6 in. lower than the nearest road and a minimum of 12 in. lower than the finished floor elevation of the nearest building(s).

Runoff from the PMP event is accommodated by designing the roadways such that the high point of the road is 6 in. to 1 ft below the finished floor elevation of the adjacent safety-related building(s). Runoff from this event is from the northwest to the southeast across the site plateau to the low area southeast of the plant site. The general plant site is nominally 9 ft above the maximum calculated water surface elevation resulting from the postulated PMP (Section 2.4.3.3). Therefore, the site grading precludes the potential flooding of safety-related structures. The Hydrogen Storage and Supply Facility is subject to the PMP event flooding.

The elevation of the facility is 420 ft msl and the PMP flood level is 431.1 ft msl (Section 2.4.3.5). See Section 10.4.10 for more discussion.

Roofs of buildings are designed to take, with adequate drainage, any instantaneous or local intense precipitation. Discharge from roof drains is carried by means of a storm sewer system to a manhole located southeast of the reactor building. From that point a pipeline with a northeast alignment transfers the discharge to lined evaporation ponds about 1500 ft away from the plant site.

The roofs of safety-related buildings (diesel generator building, radwaste/control building, standby service water pump house) are concrete beam and slab construction except the high roof of the reactor building, which is metal deck on steel framing. The minimum roof slope for all structures is 1/8 in. per ft for adequate drainage and the roof areas are encompassed by curbs or parapet walls up to 3 ft 6 in. high. Roof plans, including details of roof drains and overflow scuppers, are provided in Figure 2.4-6. Assuming that the roof drains are completely blocked during the PMP event, overflow scuppers limit the depth of water to within the design load carrying capability of the roofs. Those safety-related structures that do not have this relief capability structurally can carry the entire PMP accumulations.

2.4.3 PROBABLE MAXIMUM FLOOD ON STREAMS AND RIVERS

Analyses for probable maximum flood (PMF) and SPF on the Columbia River (Reference 2.4-2) are consistent with the requirements of Regulatory Guide 1.59, Revision 2. The SPF for the Mid-Columbia Reach of the highly developed and regulated Columbia River is defined as 570,000 ft^3/sec (Reference 2.4-4). The unregulated SPF for the same reach is 740,000 ft^3/sec. The unregulated PMF at the site is estimated to be 1,600,000 ft^3/sec (References 2.4-2, 2.4-4, and 2.4-5).

Adjustment of the flood profiles for the Hanford region reported in Reference 2.4-4, results in a regulated PMF of 1,440,000 ft^3/sec and a water level of 390 ft at the Seismic Category II makeup water structure. This structure is not designed to function throughout the PMF but is designed for the SPF (unregulated) of 740,000 ft^3/sec.

Although assumed to exist for the purpose of flood hydrograph calculations, Ben Franklin Dam is not a federally authorized project. As originally planned it would have been a low head dam with only a negligible effect on extreme flood flows (Reference 2.4-6).

The design basis flood for the CGS site area results from the PMP event on the adjacent drainage basin and not from flooding of the Columbia River.

2.4.3.1 Probable Maximum Precipitation

The PMP event which was presented in the CGS PSAR was subsequently reevaluated in the preparation of the PSAR for WPPSS Nuclear Project No. 1 (Docket 50-460). The analysis presented here is consistent with the latter document.

Precipitation in the vicinity of the site has been classified by the U.S. Weather Bureau, Reference 2.4-3, as convergence precipitation, orographic precipitation, and thunderstorm precipitation. The methodology for predicting the total amount of precipitation from each of these events, as given in Reference 2.4-3, requires the adding together of the convergence PMP and the orographic PMP to obtain a single precipitation for a general storm. A separate analysis is then required for thunderstorms. Thunderstorms in the vicinity of the site can be locally very intense for short periods of time and hence, have the potential for causing serious flooding. The PMP for both a general storm and a thunderstorm were analyzed as given in Chapters 6 and 5, respectively, of Reference 2.4-3 for a 38.5 mile^2 basin at the site. This basin is shown in Figure 2.4-8 and is described in Section 2.4.3.3. The calculated general storm PMP results in a 24-hr and 48-hr precipitation of 7.9 in. and 10.1 in., respectively. A thunderstorm PMP yields 9.2 in. in a 6-hr period. Therefore, the thunderstorm is considerably more severe. The thunderstorm PMP hydrograph is

Time (hr)	Rain (in.)
1	0.6
2	1.6
3	5.2
4	0.9
5	0.5
6	0.4
Total	9.2

2.4.3.2 Precipitation Losses

Infiltration losses have been estimated in the vicinity of the sites as 1.5 in./hr (Reference 2.4-7). However, for the analysis below, an average antecedent moisture condition (Condition II as defined in Reference 2.4-8) was assumed. As explained in the following section, the 60-minute retention loss rate is 0.15 in./hr.

2.4.3.3 Runoff and Stream Course Models

The drainage basin common to the reactor building and spray ponds is shown in Figure 2.4-8. The entire area drains to a broad channel that extends in a north-south direction for about 7 miles, and ranges from about 2000 ft to over a mile wide. All plant structures are located on

high ground to the west of the channel. At a point about 2.8 miles south of the reactor site, the four-lane Department of Energy (DOE) highway crosses the drainage basin. The area above this section is 33.2 $miles^2$.

To evaluate the effect of the PMP event on the plant area, the peak discharge at the highway crossing, 2.8 miles downstream of the plant, was calculated using the U.S. Bureau of Reclamation procedure for computing design floods on ungauged basins from thunderstorm rainfall in the western U.S. (Reference 2.4-8). Important assumptions used in the triangular hydrograph procedure of Reference 2.4-8 are

a. Hydrologic soil group B,

b. Land use and treatment class - poor pasture or range,

c. Thunderstorm cover-index is brush-sage-grass combination with 50% or less cover density, and

d. Thunderstorm minimum 15-minute retention loss rate of 0.06 in./15 minutes and 60-minute retention loss rate of 0.15 in./hr.

Additionally, no credit was taken in the hydrograph analysis for potential storage in the stream channel or upstream sub-basins.

The time of concentration, T_c, for the watershed above the highway crossing was computed to be 7.5 hr. The PMF hydrograph is shown in Figure 2.4-7 for the 33.2 $mile^2$ drainage basin. A peak discharge of 21,400 ft^3/sec was determined.

Based on this PMF, an upstream water surface profile was determined using the Corps of Engineers HEC Standard-Step Procedure (Reference 2.4-9). A total of eleven cross sections were used (seven downstream, one at the plant, and three upstream as shown in Figure 2.4-3). Details of the channel cross sections are shown in Figure 2.4-9. The Manning roughness coefficient was conservatively taken as n=0.035 in the main channel sections, and n=0.05 in the overbank areas.

Using the computational procedure of Reference 2.4-9, it was determined that the channel restrictions at cross sections 5 and 7 (Figure 2.4-3) do not control the flow. The stillwater elevation at the plant site (cross section 8) was determined to be 431.1 ft msl. The water surface profile is shown in Figure 2.4-10.

2.4.3.4 <u>Probable Maximum Flood Flow</u>

The PMF runoff hydrograph produced by the PMP at cross section 1 (Figure 2.4-3) is shown in Figure 2.4-7. The peak discharge at this location is 21,400 ft^3/sec.

2.4.3.5 Water Level Determinations

As discussed in Section 2.4.3.3, the water elevation of a flood at the plant site generated by the PMP event is 431.1 ft msl. This flood condition has a higher estimated elevation than any flood of the Columbia River.

2.4.3.6 Coincident Wind Wave Activity

Procedures published by the Corps of Engineers (References 2.4-10 and 2.4-11 were used to determine the wind wave activity. The effective fetch for the predominant July wind direction (north) is 3450 ft (0.65 miles). The effective fetch diagram is shown in Figure 2.4-11. The calculated extreme 2-year over water wind for the north-to-south direction, based on area data, is 63.5 mph. This wind results in a maximum wave height of 4.0 ft, with the assumption of a water depth of 12 ft (the average depth in cross sections 8, 9, and 10). The other potential wind directions ENE and ESE were evaluated but found to be less severe.

The wind setup has been computed to be 0.3 ft, and the maximum wave runup is 1.9 ft on a smooth, 1 on 8 slope of compacted naturally occurring sands and gravels. Therefore, the design water surface elevation is 433.3 ft msl. This is less than the east spray pond overflow weir at elevation of 434.5 ft msl.

2.4.4 POTENTIAL DAM FAILURES, SEISMICALLY INDUCED

Analyses of floods resulting from potential dam failures were investigated by the Corps of Engineers for the Columbia River. These studies are consistent with Regulatory Guide 1.59, Revision 2. The flood resulting from the breaching of Grand Coulee Dam is considered in lieu of a seismically induced flood.

In 1951, the Seattle District Corps of Engineers made a confidential study (now declassified) to determine artificial flood hydrographs and the flood profile in the Columbia River Valley resulting from breaching the Grand Coulee Dam by enemy attack. The studies covered a spectrum of conditions in terms of breach openings and hydrologic conditions that might prevail at the time of attack. A postulated seismic failure of Grand Coulee Dam could result in displacement of part of the structure, but it would still act as a restriction or weir and minimize the hydraulic failure. For this reason, the explosion-induced artificial flood represents an upper limit to seismically induced failures. The failure of Grand Coulee Dam would initiate a catastrophic flood, which would be augmented by the failure of the earth portions of downstream dams and subsequent release of the storage pools. Figure 2.4-5 shows water surface profiles for RM 323 to RM 358 for various river flows, including Artificial Flood No. 1. This flood provides a "limiting case" assessment of the conservatism of CGS elevation. This flood would have an outfall peak of 8,800,000 ft^3/sec at Grand Coulee Dam at the moment of breaching and a peak discharge at RM 338 (Richland) of 4,800,000 ft^3/sec.

A base flow of 50,000 ft^3/sec was assumed above the mouth of the Snake for this flood (Reference 2.4-12).

An arbitrarily assumed dramatic failure of Arrow and/or Mica Dams in Canada could result in greater releases of storage in terms of volume than that from the Grand Coulee Dam, but the effects of such postulated releases are mitigated by a combination of valley storage and critical (flow limiting) valley cross sections. The Corps of Engineers states (Reference 2.4-13) that the river channel restrictions at Trail, British Columbia, would restrict river flow to about 3.1 x 10^6 cfs, regardless of the postulated dam failure. A major failure upstream would result in this maximum flow for many days causing overtopping of Grand Coulee Dam. An analysis by the Bureau of Reclamation (Reference 2.4-14) concluded that overtopping which might result from the failure of upstream dams will not cause failure of either the Grand Coulee Dam or the Forebay Dam.

Various studies (References 2.4-12, 2.4-15, 2.4-16 and 2.4-17) made by the Corps of Engineers, and others, since 1951 have considered that breaching of Grand Coulee Dam would represent the worst catastrophic event for downstream Columbia River occupants. Although these studies bear no relationship to flooding from natural causes, they have been used as the basis for a very conservative, limiting case approach.

Figure 2.4-5 shows water surface profiles for RM 323 to RM 395 for artificial and real stage flows, one of which corresponds to Artificial Flood No. 1 noted earlier, which has been established (Reference 2.4-18) as conservative (limiting case) criteria for Columbia River flooding. Since the base flow used to develop these curves was 50,000 ft^3/sec, an additional 570,000 ft^3/sec is added to account for simultaneous occurrence of the regulated SPF.

2.4.4.1 Dam Failure Permutations

The effect of potential dam failure on the water levels at the site is determined using the following assumptions:

a. The Columbia River is at flood stage, with a SPF (570,000 ft^3/sec regulated);

b. The reservoirs in each storage pool are full;

c. A massive hydraulic failure occurs at Grand Coulee Dam, releasing 8,800,000 ft^3/sec;

d. Following the above assumed failure, all downstream dams between CGS site and Grand Coulee Dam suffer some degree of failure and release their storage reservoirs to the flood. [The result of a stability analysis (Reference 2.4-15) showed that all mass concrete portions of the dams will resist sliding and overturning with the possible exception of part of Rock Island Dam.];

e. The explosion-induced failure of Grand Coulee Dam represents a more severe failure than any seismic event because of the failure mechanism;

f. Failure of Arrow and/or Mica Dam could result in greater release of storage volume than Grand Coulee Dam; however, the peak flow is limited to 3,100,000 ft^3/sec due to channel restrictions at Trail, British Columbia; and

g. Overtopping of Grand Coulee Dam would occur with failure of Arrow and/or Mica Dams in Canada. The failure of Grand Coulee, as a result of overtopping, is not considered to be a credible event in view of its concrete construction and rock abutments.

2.4.4.2 Unsteady Flow Analysis of Potential Dam Failures

The flood hydrographs developed by the Corps of Engineers are based on the results of extensive studies of the physical characteristics of the flood route (References 2.4-12 and 2.4-15). Subsequent studies made by the Corps of Engineers verify these results (Reference 2.4-17). Water levels following such a flood would depend on the status of reservoir storage upstream from Grand Coulee Dam but, without regulation of some dams, would approximate the natural seasonal flow conditions.

2.4.4.3 Water Level at Plant Site

The water elevations associated with limiting case flood (LCF) levels are shown in Figure 2.4-5. RM 350 provides the control for backwater flow to the plant area which is sheltered by higher ground east of WNP-1 and WNP-4.

Elevation at RM 350 (dam breach flood 4,800,000 ft^3/sec plus SPF, 570,000 ft^3/sec)	=	422 ft msl
Allowance for simultaneous wind and wave action	+	2 ft
Elevation:		424 ft msl=LCF

An adequate margin exists between the resultant flood elevation and the plant elevation of 441 ft msl.

2.4.5 PROBABLE MAXIMUM SURGE AND SEICHE FLOODING

The location of the CGS site is not close to any water body which experiences seiche flooding. Thus the site is not vulnerable to such flooding.

2.4.6 PROBABLE MAXIMUM TSUNAMI FLOODING

The location of the CGS site is in south-central Washington and it is not adjacent to any coastal area. It is not, therefore, vulnerable to tsunami flooding.

2.4.7 ICE EFFECTS

Historically, the Columbia River has never experienced complete flow stoppage or significant flooding due to ice blockage. Periodic ice blocking has caused reduced flows and limited flooding for only relatively short periods of time. *The most significant icing in recent recorded history occurred during the winter of 1936-37 prior to the construction of the upstream regulating dams. A relatively thick sheet of ice formed across the river. The minimum flow recorded near the Priest Rapids Dam site during this winter was 20,000 cfs. However, the ice forming on the river was caused primarily by the low flow rather than the reverse. The deltaic mouths of many of the tributaries to the Columbia River are frequently blocked by ice causing backup of flood waters. No instance of complete stoppage is known to have occurred.*

Ice blockage is most likely to occur when water temperatures are already low, when flows are small, and when a significant cold spell occurs. With the completion of Grand Coulee and other dams on the Columbia River main stream, the seasonal temperature and flow cycles have drastically changed. These changes will further aid to reduce the intensity and timing of the conditions which may contribute to potential ice blockage and flooding situations. Also average river flow rates, during the winter months, have been increased significantly. The water temperatures have shown a shift in time such that the peak temperatures occur 30-45 days later than formerly. In addition, the low extreme temperatures measured have risen over the years.

The long term trends of temperatures in the Columbia River been studied (Reference 2.4-19) using a 37 year record of measured temperatures. The trends for the maximum, average and minimum temperatures are shown in Figure 2.4-12. The erection of dams on the upper Columbia River has caused the extreme high and low river temperatures measured at Rock Island Dam (Columbia RM 453, 101 miles above the CGS site) to converge toward the average. Winter water temperatures are considerably warmer and summer temperatures cooler with a slightly lowered average of less than 1°F occurring during the 37 years.

On the basis of these studies and the recorded observation of 25 years of operation of the Hanford plutonium production plants, it is concluded that the potential for ice blockage or the combination of blockage and flooding behind ice dams is so low as to be considered insignificant. The erection of Mica, Arrow, and Libby Dams in the Columbia River Basin headwaters is expected to further raise winter water flows and also to increase winter water temperatures somewhat.

In any event, ice flooding will not effect the capability to shut down the reactor in a safe and orderly manner. Also, the daily fluctuating stage of the river at the intake location will discourage formation of sheet ice as well as ice jams. Ice flows, should they occur, will normally pass over intake structure due to relatively high winter discharge in the river.

2.4.8 COOLING WATER CANALS AND RESERVOIRS

There are no cooling water canals. The two spray ponds located southeast of the reactor building designed as Seismic Category I structures, have reinforced concrete side walls, and reinforced concrete base mats at el. 420 ft msl. The finished grade at the spray ponds is approximately at el. 434 ft msl and have top of wall elevations of 435 ft msl. The spray ponds are the ultimate heat sink for normal reactor cooldown and for emergency cooling.

The spray ponds are a part of the standby service water system which is discussed in Section 9.2.7. See also Section 2.4.11.6.

During normal reactor operation, the cooling water necessary for the plant is supplied from the cooling tower basins.

2.4.9 CHANNEL DIVERSIONS

The Columbia River flow in the Hanford reach is controlled to a large extent by regulation of the upstream reservoir projects. The riverbed in the vicinity of the site is well defined and it is very unlikely that the riverbed would be diverted from its present location by natural causes. Any possible effect on water supply to the makeup water pump house from riverbed changes would come from extremely slow changes which can be corrected if and when they occur.

As discussed in Section 2.4.7, the river has not frozen over in Hanford reach during at least the past 25 years, and icing on the river has not been a problem at pump house or outfall structures associated with the plutonium production plants.

2.4.10 FLOODING PROTECTION REQUIREMENTS

The design considerations of safety-related facilities to withstand floods and flood waves are described in Section 2.4.2.2. The PMF is discussed in Section 2.4.3.

All safety-related facilities are housed in Seismic Category I structures protected from flooding and designed to withstand the static and dynamic forces of all postulated floods. Flood considerations are described in Section 3.4 and the design of Seismic Category I structures, for all conditions including flood, is described in Section 3.8.

In the event of a flood at the site, it will be possible to place the plant in a safe shutdown condition.

All non-safety-related facilities with the exception of the makeup water pump house, are above the LCF elevation. The flooding of the makeup water pump house would not affect safety-related equipment and would not affect the safe shutdown of the plant. The approximate finished grade at all Seismic Category I structures except the spray ponds is at elevation 440 ft msl. The finished grade of the spray ponds is 434 ft msl.

The PMF elevation of the Columbia River (described in Section 2.4.3), at the site, is estimated to be 390 ft msl.

Seismic Category I structures are designed to withstand the static and dynamic forces which could result from a flood due to a breach of Grand Coulee Dam. Since this represents the LCF, the structures are also considered secure against the forces due to the lower PMF.

The access openings to all seismic Category I structures are located well above all flood water elevations, including that due to wind and wave action.

2.4.11 LOW WATER CONSIDERATIONS

As described in Section 2.4.1.1, plant water needs are supplied through an intake structure in the Columbia River. The top of the makeup water intake screens (at RM 352) are set below the water surface elevation that would be associated with the minimum allowable flow (36,000 cfs) at the federally licensed Priest Rapids Dam (at RM 397). Water levels at the CGS intake are not influenced by backwater from the downstream McNary Dam (RM 292). The Columbia River Basin upstream of CGS has in excess of 35 million acre-ft of usable reservoir storage capacity. Because of this storage and highly regulated river flows, it is improbable that flows below the licensed minimum will occur. Based on data for 1961 through 1994, 7-day low flow with a recurrence interval of 100 years has been estimated at 44,500 cfs.

Even if some event (e.g., very severe drought) caused the makeup water system to be inoperable, the loss of water would not compromise the safe shutdown of the plant. As is discussed in Sections 9.2.5 and 9.2.7, shutdown cooling water is supplied by the ultimate heat sink which contains a 30-day supply of water in two spray ponds. The only scenario in which the makeup water pump house is called on to supply water in an emergency situation is when a tornado removes a significant quantity of spray pond water (see Section 9.2.5.3). Therefore, the low river water condition is not a situation requiring safety-related features and procedures.

2.4.11.1 Low Flow in Streams

Reservoir projects on the Columbia River Basin upstream of the proposed site have a total usable storage capacity in excess of 35 million acre-ft. This capacity is sufficient to maintain a flow in the Columbia River, at the proximity of CGS, of 36,000 ft^3/sec for over 1 year with absolutely no inflow from other sources. Because of this regulation, the anticipated minimum

and maximum monthly mean flow rates will be 60,000 and 260,000 ft^3/sec in the vicinity of the site. It is improbable that minimum flows below that administratively set for dam operation (36,000 ft^3/sec) will occur due to drought conditions. Columbia River storage measurements have been extrapolated down to 25,000 cfs and are shown in Figure 2.4-13. The river elevation at RM 352, site of the CGS makeup water pump house, is 341.73 ft msl and has a corresponding flow of 36,000 ft^3/sec.

2.4.11.2 Low Water Resulting From Surges, Seiches, or Tsunami

There exists no possibility of low water conditions resulting from meteorological or geoseismic generated surges, seiches, or tsunami unless such natural phenomena effected rapid closure of the Priest Rapids Dam, which is located 45 miles upstream from the proposed site. Rapid closure of the dam would cause a negative surge to be generated downstream.

A complete stoppage of flow is an unlikely event because of the redundant equipment and operational procedure in place at the dam. Provisions to guard against an accidental shut off of Priest Rapids Dam include:

a. *A gate actuation button in the control room of the Dam which is used to maintain at least minimum licensed flow from the facility in the event of one or more turbine shutdowns.*

b. *Independent motors on each gate which have redundant wiring and power supplies.*

c. *Electrical heating on four of the gates to prevent ice buildup which might interfere with gate operation.*

d. *Multiple offsite power sources in addition to an on-site diesel generator power backup for gate operation.*

In the event of a rapid and complete stoppage of flow over Priest Rapids Dam the effect of the negative surge would pass the site in a few hours. Since the Priest Rapids Dam is a run of the river dam with low storage capacity, it is unlikely that its closure can restrict the Columbia River flow for a significant period of time before being topped.

2.4.11.3 Historical Low Water

Historical records of the U.S. Geological Survey gauging station (RM 394.5) located 2.6 miles downstream from Priest Rapids Dam show low daily averaged flows of 20,000 ft^3/sec (January 31, 1937) and low monthly averaged flows of 20,900 ft^3/sec (February 1937). An instantaneous low flow of 4120 ft^3/sec occurred February 10, 1932, due to activities connected with dam regulation of the river near Wenatchee, Washington, before construction of Priest

Rapids Dam. After completion of the Dam in 1956, the minimum flow rate of the Columbia River at RM 352, approximate location of the CGS makeup water pump house site, is 36,000 ft^3/sec. The flow is maintained by the Grant County PUD as operator of the Priest Rapids Dam (RM 397) under FPC license which states:

> *"The licenses shall so regulate the flow from the Project 2114 that it will not result in flows of less than 36,000 cfs of water at the Hanford Works of the Atomic Energy Commission except when conditions are beyond the licensee's control."*

In eighteen years of operation the flow has not dropped below the specified minimum.

The annual average flow of the Columbia River below Priest Rapids Dam is in the range of 115,000 cfs. The effect of use of upstream water for irrigation development on the stream flow has been taken into account and the modified mean monthly discharge variations for the period 1928-58 are shown in Table 2.4-4 and Figure 2.4-14. The discharge for the base period of 1929-58 was adjusted to reflect 1970 levels of water utilization, including water consumption due to activities of flood control, power generation and irrigation. Figure 2.4-15 shows the exceedance frequency for annual low flows for the period 1929 through 1958 with 1970 conditions measured at the gauging station (RM 394.5) immediately below Priest Rapids Dam. Because of the flow regulation on the Columbia River, the anticipated minimum and maximum monthly mean flow rates will approximate 60,000 and 260,000 cfs in the vicinity of the CGS site. The variations of the river flow in this reach are due not only to seasonal fluctuations, but also to the daily regulation of the power producing Priest Rapids Dam. Flow rates during the late summer, fall and winter may vary from a low of 36,000 cfs to 160,000 cfs each day.

The dependable yield for flows in the Columbia River below Priest Rapids Dam for periods of one year through 10 years, as well as the 30-year period 1929-58 is illustrated in Table 2.4-5. The flow duration curve resulting from a plot of Table 2.4-4 is shown by Figure 2.4-14 (Reference 2.4-20). This figure illustrates the percentage of time equaled or exceeded for different amounts of flows below Priest Rapids Dam on a monthly and on an annual basis.

2.4.11.4 Future Controls

Flows in the Columbia River at Hanford are required to be maintained above 36,000 ft^3/sec. This is the licensed minimum flow of Priest Rapids Dam and, as such, is a parameter closely monitored and controlled by the Grant County PUD. The State of Washington has administratively set higher average daily minimum flows (greater than 40,000 ft^3/sec) and will attempt to have the FERC licenses for the dams modified to insure the minimums (Reference 2.4-21).

2.4.11.5 Plant Requirements

All cooling water is supplied to the plant cooling towers via the circulating water system, the plant service water system, or the standby service water system described in Sections 9.2.1.2 and 10.4.5. In the event of an incident rendering the cooling towers inoperative, cooling water is supplied from the spray ponds by the standby service water system, described in Section 9.2.7. These are closed loop systems and the only water loss is through evaporative cooling.

Makeup to the plant cooling towers and spray ponds comes from the Columbia River. Should this capability be lost, the cooling load is taken over by the spray ponds. These ponds have sufficient capacity to provide shutdown cooling water for 30 days without makeup. Other sources of water are available to provide makeup after the initial 30-day period (see Section 9.2.5). Therefore, variation in river flow will not have any adverse affect on the capability to shut down the reactor in a safe and orderly manner.

2.4.11.6 Heat Sink Dependability Requirements

At the minimum river flow of 36,000 ft^3/sec described in Section 2.4.11.3, there is still sufficient submergence at the makeup water pumps to provide full makeup water requirements at full power operation. Sump level indication and low level alarms are provided in the main control room. Should the sump water elevation fall below the minimum submergence level for the makeup pumps, due either to low river flow or blocked inlets, the plant would be shut down if the situation could not be readily corrected with the safety-related standby service water coming from the spray ponds.

Section 9.2.5 discusses the design bases used in designing the two spray ponds which serve as the ultimate heat sink for CGS. Design of the CGS ultimate heat sink is in compliance with the guidelines presented in Regulatory Guide 1.27 Rev. 1, "Ultimate Heat Sink for Nuclear Power Plants," dated March 1974. The CGS spray ponds serve as the suction source and discharge point for the standby service water system. This system is discussed in Section 9.2.7 and identifies the uses and quantities of water drawn from the ultimate heat sink.

2.4.12 DISPERSION, DILUTION, AND TRAVEL TIMES OF ACCIDENTAL RELEASES OF LIQUID EFFLUENTS IN SURFACE WATERS

Small amounts of liquid radioactive wastes, processed within the plant and containing traces of radioactive nuclides, are discharged ultimately to the Columbia River via the plant blowdown line as discussed in Section 11.2.2.2.6 (see Figure 2.4-16). *In the vicinity of CGS, the Columbia River is wide, relatively shallow, and fast flowing. Field measurements have shown river velocities near the CGS discharge to be about 3 ft/sec for minimum flows (Reference 2.4-22) and 4.5 ft/sec for average flows (Reference 2.4-23). At the point of discharge the river is about 5 ft deep at minimum flow. Based on a dye dispersion study (Reference 2.4-22), the local eddy diffusivity at low flow has been conservatively estimated to*

be 4 ft^2/sec (Reference 2.4-24). With a combination of minimum river flow and maximum blowdown, it is estimated that an effluent would be diluted by a factor of about 60 at a distance of 300 ft and a factor of 200 at 3000 ft. Dilution factors and travel times for calculating doses to downstream water users are discussed in the CGS Offsite Dose Calculation Manual (ODCM).

Downstream surface water users are listed in Section 2.4.1.2. The travel time to the nearest withdrawal which could be affected by an accidental release is approximately 1 hr. At that point a radioactive release would be essentially completely mixed with the river resulting in a dilution factor of 1:200,000. It is concluded that water users are sufficiently removed from the release point, and the Columbia River is sufficiently dispersive to preclude adverse impacts due to accidental releases. The dispersion characteristics of the river and the effects of routine releases are discussed in Sections 5.1 and 5.2 of the Environmental Report - Operating License Stage.

2.4.13 GROUNDWATER

2.4.13.1 Description and Onsite Use

Subsurface soil conditions, across the site, have been classified as follows:

a. *Loose to medium dense, fine to coarse sand with scattered gravel (glaciofluvial sediments).*

b. *Very dense, sandy gravel with interbedded sandy and silty layers (Ringold Formation, Middle Member).*

c. *Very dense, interbedded layers of sandy gravel silt and soft sandstone (Ringold Formation, Lower Member).*

d. *Basalt bedrock which forms the bedrock beneath the area.*

The lithologic character and water bearing properties of the geologic units occurring in the Hanford region are summarized in Table 2.4-6. In general, groundwater in the surficial sediments occurs unconfined, although locally confined zones exist. Water in the basalt bedrock occurs mainly under confined conditions. Occasionally, the lower zone of the Ringold Formation occurs as a confined aquifer, separated from the overlying unconfined aquifer by thick clay beds which possess a distinct hydraulic potential.

The unconfined aquifer consists of both glaciofluvial sand and gravel deposits and the Ringold silts, clays, and gravels. Since these materials are very heterogeneous, often greater lithologic differences occur within a given bed than between beds. In the vicinity of CGS the water table is below the top of the Ringold Formation (see Figures 2.5-64 and 2.5-65). The unconfined

aquifer bottom is the basalt bedrock in some areas and silt/clay zones of the Ringold Formation in other areas. Clearly the bottom of the unconfined aquifer is not a continuous lithologic surface.

The Hanford Reservation contains over 2200 wells constructed from pre-Hanford work days to the present). Approximately 600 of these wells are used for groundwater monitoring (Reference 2.4-25). Figure 2.4-17 identifies the well locations in the Hanford Reservation as of September 1975. Figure 2.4-18 shows the December 1975 groundwater contour map. In general, the groundwater gradient resulting from groundwater flowing under the Reservation is the highest in the southwestern area toward Rattlesnake Mountain, and slopes toward the Hanford 200 Areas near the center of the reservation. From the 200 Areas the general slope in the gradient is toward northeast and southeast.

A groundwater contour map based on the potential construction of the Ben Franklin Dam at approximately RM 348 is illustrated by Figure 2.4-19. The CGS design basis groundwater level is based on the possible construction of the Ben Franklin Dam and is taken to be 420 ft msl, whereas the most recent study indicates that the water table would be about 405 ft msl (Reference 2.4-26). The feasibility of constructing Ben Franklin Hydroelectric Dam has been extensively studied. Its proposal was strongly contested by local groups and individuals concerned with environmental protection and preservation. Additionally, the matter of the impact such a facility would have on the DOE Hanford Reservation was believed by some to preclude its construction. Finally, the cost/benefit ratio was believed by many to be too low to make the project viable. The combination of the unresolved impediments to the project has effectively, though not conclusively, relegated it to a very low priority status. Planning studies for the project by the Corps of Engineers were suspended in 1969 and reinitiated in October 1979 as part of the development of a management plan for the Hanford reach. The most recent studies were terminated in November 1981.

Impermeable groundwater boundaries are the Rattlesnake Hills, Yakima Ridge, and Umtanum Ridge on the west and southwest sides of the Hanford Reservation. Gable Mountain and Gable Butte also impede the groundwater flow, as well as other small areas of basalt outcrop above the water table. The Yakima River recharges the unconfined aquifer along its reach from horn Rapids to Richland. The Columbia River forms a hydraulic potential boundary which is a discharge boundary for the aquifer. The major source of natural recharge is precipitation on Rattlesnake Hills, Yakima Ridge, and Umtanum Ridge.

Minor changes would be expected in the groundwater elevations during the summer months because of the charging stage of the Columbia River, which historically reaches peak flood stage in June. Because CGS is located about three miles from the river and because of the permeability characteristics and enormous volume of the Ringold Formation, there is a substantial time lag in changing water levels. For the same reasons, the range in water table fluctuations is very small.

Natural recharge due to precipitation over the lowlands of the Hanford Reservation is not measurable as the evaporation potential during the summer months greatly exceeds total precipitation. Data on migration of moisture from natural precipitation in deep soils (below 30 ft) show movement rates less than 1/2-in./yr at one measurement site (References 2.4-27, 2.4-28 and 2.4-29). The major artificial recharge of ground water to the unconfined aquifer occurs near the Hanford 200 East and 200 West Areas. The large volume of process water (1.35 x 1011 gal) discharged to ground during 1944-1973 has caused the formation of significant groundwater mounds in the water table (Figures 2.4-20 and 2.4-26). Other local groundwater mounds formerly existed along the Columbia River. The present Hanford 100-N Area mound is the only one of these remaining. A minor recharge mound also exists at the Hanford 300 Area.

The unconfined aquifer is characterized by its hydraulic conductivity, the storage coefficient, and the effective porosity. The hydraulic conductivity relates the water flow quantity to the hydraulic potential gradient, while the effective porosity gives the fraction of porous media volume that is available to transmit ground water flow. The storage coefficient relates a change in the water table elevation to a change in the volume of water contained in the aquifer per unit horizontal area. In the limit of no delayed yield, the storage coefficient is equal to the effective porosity of the soil through which the water table moves. These parameters vary widely over the Hanford Reservation.

Qualitatively the hydraulic conductivity, storage coefficient, and effective porosity distributions are a function of the different geologic formations in the unconfined aquifer. Ancestral Columbia River channels which incised in the Ringold Formation are now filled with more permeable glaciofluvial sediments. These channels have been identified extending eastward along the northern and southern flanks of Gable Mountain and extending southeastward from the 200 East Area to the Columbia River (see Figure 2.4-21). These permeable channels are reflected in the groundwater flow pattern of the region.

Quantitative measurements of the hydraulic conductivity of the unconfined aquifer have been made on the Hanford Reservation using a variety of techniques: pumping tests, specific capacity tests, and tracer tests. The most common method has been the pumping tests. Values obtained for the Ringold Formation range between 10 to 650 ft/day with a median of about 130 ft/day. In sharp contrast are the very large hydraulic conductivities of glaciofluvial sediments, ranging from 1,200 to 12,000 ft/day (Reference 2.4-30).

The storage coefficient is much more difficult to measure in the field and estimates are, therefore, less common. For the unconfined aquifer, estimates of the storage coefficient have ranged from 0.01 to 0.1 (Reference 2.4-30). An areal estimate of 0.11 has been provided for the 200 West Area based on the growth of groundwater mounds (References 2.4-30 and 2.4-31). The median specific yield (effective porosity) has been estimated by various researchers at Hanford to range from 4.8% to 11%; most commonly it is assumed to be 10% (Reference 2.4-32).

The unconfined groundwater aquifer is characterized by the contour map of the hydraulic potential or water table. The map for December 1975 appears in Figure 2.4-18. The depth to the water table varies greatly from place to place, depending chiefly on local topography which ranges from less than 1 to more than 300 ft below the land surface. Beneath most of the Hanford 200 Area disposal sites the depth of the water table averages about 250 ft. The current estimate of the maximum saturated thickness of the unconfined aquifer is approximately 230 ft.

The chemical quality of the groundwater in the unconfined aquifer is measured at seven locations. Sodium, calcium, and sulfate ions are measured as well as pH. Chromium and fluoride ions associated with fuel manufacturing operations are analyzed from Hanford 300 Area wells. Nitrate ion, which is a waste product from the manufacturing and chemical separation operations, is monitored over the entire Hanford Reservation. Annual maps of the nitrate ion concentration near the surface of the unconfined aquifer are published (Reference 2.4-33). The map showing nitrate concentration for December 1975 appears in Figure 2.4-22.

The radiological status of the groundwater near the surface of the unconfined aquifer is monitored regularly (Reference 2.4-34) and reported annually. Plots of gross beta (ruthenium) plumes and the tritium plumes are shown in Figures 2.4-23 and 2.4-24 for December 1975 (Reference 2.4-33). Since the nitrate ion is not adsorbed in the soil it can be used as a tracer for groundwater movement. The extent of movement of waste water containing radionuclides can thus be plotted. Respective tritium and nitrate ion concentrations under the CGS site are currently ranging from 30 to 300 pci/ml and 4.5 to 45 mg/l depending on the sampling location. Concentration guide for drinking water is 3,000 pci/ml for tritium and the recommended drinking water standard is 10 mg/l for nitrate ions. Gross beta concentrations do not extend to the site.

From the research that has been done to date, it appears that there are a number of confined aquifers underlying the Hanford Reservation. Relatively impermeable confining beds commonly include the individual basalt flows and the silts and clays of the lower part of the Ringold Formation.

Within the basalt sequence, groundwater is transmitted primarily in the interflow zones, either in sedimentary beds or in the scoria and breccia zones forming the tops and bottoms of the flows (References 2.4-35 and 2.4-36). Basalt flows in the Pasco Basin have been eroded particularly in the anticlinal ridges. In some locations the basalts are highly jointed and contain breccia, pillow and plagonite complexes through which groundwater can move. Consequently, hydraulic potential differences between water bearing zones in the upper part of the basalt sequence are small over hundreds of feet of depth. The lowermost Ringold Formation silts and clays are of variable thickness. Distinct hydraulic potential differences have been observed between aquifers below the silts and clays and the unconfined aquifer.

Groundwater flow in the uppermost confined aquifer is also to the southeast with possible discharge into the Columbia River somewhere below Lake Wallula. However, the flow rates are regarded as quite small due to the low transmissivity range of this water bearing zone. Groundwater in the lower confined aquifers does not appear to cross the major anticlinal divides that define the Pasco Basin.

The piezometric or hydraulic potential map for the confined zones above the basalt (Figure 2.4-25) was based on measurements made in 1970. In general, the hydraulic potential observed in the confined aquifer zones above the basalt is greater than in the overlying unconfined aquifer. The main exception is in the vicinity of the Hanford 200 Area recharge mounds which have raised the potential in the unconfined aquifer.

One recharge area that has been identified is from the Yakima River at Horn Rapids. The piezometric map in Figure 2.4-25 also suggests recharge from the upper Cold Creek Valley with flow toward a potential trough under the Columbia River. The Columbia Basin Irrigation Project to the northeast and east, and the Columbia River behind Priest Rapids and Wanapum Dams to the northwest are other probable recharge sites in both these areas the basalt is exposed and is covered by perennially saturated unconsolidated deposits. A site of possible minor recharge exists adjacent to Gable Butte and Gable Mountain anticline near the center of the Reservation.

Only 90 wells on the Hanford Reservation have been drilled to basalt. Thus data on the confined aquifers in the basalt flows are limited and more would have to be gathered to fully characterize the confined aquifers.

The plant is located on glaciofluvial outwash sands and gravels which are about 50 ft thick. Below this layer occurs very dense gravel. Sandy gravel occurs in a sequence approximately 200 ft thick which is assumed to be the middle member of the Ringold Formation. The lower member of the Ringold Formation consists of a very compact, interbedded gravel, sand, silt, and clay and extends down to a depth of about 500-525 ft. Basaltic bedrock underlies the lower Ringold member, at approximately 550 ft depth.

The water table is about 60 ft below the ground surface level at CGS. The water table elevation is about 378 ±4 ft msl and appears to be stable. The effective bottom of the unconfined aquifer is assumed to be at about 220-260 ft msl at the top of the lower Ringold Formation. Groundwater potentials from the lower Ringold and from the basalt water bearing zones are about 25 ft higher than that of the unconfined aquifer. Test borings down to 925 ft reveal there are water bearing zones in the lower basalt flows and sedimentary interbeds at CGS. Piezometric level in basalt is 10 ft above unconfined water table and hence artesian.

Under the CGS site the unconfined groundwater is moving easterly toward the Columbia River, the nearest discharge boundary. Studies of the uppermost confined aquifer indicate that the

potential gradients at the proposed site are oriented in the same general direct ion as those of the unconfined aquifer.

Three water supply wells are located on the site. Two shallow wells were constructed in the unconfined aquifer (at approximately 240 ft deep) and a third well penetrates a confined aquifer in the underlying basalt flows (at approximately 695 ft deep). Normal water supply is from the river, and the deep well is maintained in the standby mode to provide supplemental makeup water for the potable and demineralized water system as needed. Pumping capability is about 250 gpm. The two shallow wells were used during construction.

2.4.13.2 Sources

Regional use of the unconfined aquifer occurs at two nearby locations. The first is at the DOE's 400 Area located about 3 miles southwest of the CGS site as shown in Figure 2.1-3. *Groundwater to this construction site is supplied from two wells and is used for sanitary and operation purposes. Maximum expected usage rate is between 2 million and 2.5 million gal/month. No data is available on drawdown tests performed on the FFTF water supply wells 699-SO-7 and SO-8.* The second location of ground water use is the WNP-1/4 site about 1 mile east of CGS. Water is drawn from two wells for sanitary and potable water requirements. *Usage rate is approximately 250,000 gal/month.*

The two onsite wells which drew from the unconfined aquifer (699-13-1A and 1B) are 234 and 244 ft deep. Drawdown tests for each well showed 22 and 91 ft of drawdown respectively, at pumping rates of 250 gpm and test durations of about 25 hr. These wells are no longer used. The third well (695 ft deep) is sealed from the unconfined aquifer and draws from confined water in the basalt. Drawdown on this well was 163 ft at a pumping rate of 275 gpm with a test duration of 25 hr.

Water table contours in the vicinity of CGS can be seen in Figure 2.4-26. The aquifer is assumed to be isotropic, therefore, flow occurs along instantaneous streamlines perpendicular to the equipotential contours. The groundwater flow is toward the discharge boundary at the Columbia River to the east of the site. The hydraulic potential gradient in this area is about 8-10 ft/mile in the unconfined aquifer. As described in Section 2.4.13.1, recharge and discharge of riverbank storage occur along the Columbia River with daily fluctuations superimposed on the seasonal variations in river stage. Hydrographs of wells in the vicinity of the plant site (Figure 2.4-27) show that riverbank storage is not detectable even in years of extreme spring runoff at the two wells that are about one mile from the riverbank. Thus no seasonal reversability of the gradients driving the groundwater flow occurs. In other areas of the Hanford Reservation, the seasonal fluctuations of groundwater levels from riverbank recharge can be detected 3-4 miles inland from the riverbank.

During early studies of groundwater in the area (References 2.4-37 and 2.4-31) little information was obtained on specific features at the plant site. The water table for 1944

(pre-Hanford Work conditions) was interpolated using 1948-1952 observation well data (Figure 2.4-20) and showed a water table elevation of about 370 ft msl under the site. The potential gradient was interpolated (References 2.4-31 and 2.4-38) to be about 5-6 ft per mile toward the Columbia River.

The earliest wells in the vicinity (699-2-3 and 17-5) were drilled in 1950. Their hydrographs, presented in Figure 2.4-27, show the gradual rise of the water table to approximately 15 ft above pre-Hanford Operations elevations. The peak rise in 1972 for well 699-2-3 shown on Figure 2.4-27 is believed to be a measurement error. Other wells were drilled in 1958, 1961, 1962 and 1966. Their hydrographs appear in Figure 2.4-27. Wells 669-14-E6-T and -20-E5T also show the gradual rise of the water table at their respective locations. Smaller apparent water table changes at the site between 1944- 1974 (see 2.4.13.1 and Figure 2.4-27, well 699-14-E6-T and 699-20-E5-T) indicated a zone of relatively lower hydraulic conductivity in this area.

Well 699-9-E2 is a deep well perforated in both the unconfined and lower confined aquifer zones. Its historical hydrograph (Figure 2.4-27) reflects a composite of confined and unconfined potentials with discontinuities caused by sanding in an subsequent maintenance operations. The 1962 peak of the hydrograph of well 699-20-E12 (Figure 2.4-27) is due to the influence of the high confined aquifer potential before the installation of piezometer tubes in this deep well. The 1972 peak, could be bank recharge from the high river stage of that year but the lack of previous response to river stage makes the measurement suspicious. Well 699-10-E12, also located within one mile of the river, does not show seasonal bank recharge (Figure 2.4-27). Over the past two years, a decrease in the rate of rise is evident.

Soil test borings and water supply wells drilled in conjunction with the CGS construction site, confirmed the present contouring interpretation of the water table. Recent data from boring at WNP-1 and WNP-4 are not reflected in the water table maps shown in Figures 2.4-18, 2.4-19, 2.4-26, and 2.4-25.

The historical well hydrographs for the uppermost confined aquifer in the vicinity of the plant site are given in Figure 2.4-27. Well number 699-20-E12-P shows a rather rapid rise of the confined aquifer potential in 1962-65. It has been postulated that this rise reflects recharge to the confined zones from irrigation across the river in the Columbia Basin Irrigation Project. The hydraulic potential in the uppermost confined aquifer near the plant site is presently about 390 ft msl, which is about 25 ft higher than the potential of the overlying unconfined aquifer.

The effects of the groundwater withdrawal at the site have been estimated to be local. No drawdown has been detected in the nearest observation wells, numbers 699-17-5 and 699-9-E2. The latter well is perforated over multiple aquifers so it does not give a representative measurement of the water table elevation. The radius of influence (defined to be the radius at which a 0.1 ft drawdown exists) of the CGS wells has been estimated to be about 3500-4500 ft. This is based on the ten months of high rate of withdrawal during compaction

operations taking into account the ambient water table gradient. The subsequent reduction in withdrawal flow rate to 25% of the early value would shrink the radius of influence considerably.

There is no groundwater recharge area within the influence of the plant. The 60-ft depth from the land surface to the water table and the arid condition of sediments above the water table make it virtually impossible to detect any recharge from precipitation over this area.

2.4.13.3 Accidental Effects

An evaluation of a possible radioactive liquid release is postulated due to the rupture of a 700-gal decontamination solution concentrator waste tank within the radwaste building (see Figure 11.2-1). The released effluent was then assumed to reach the soil environment outside the building and to percolate to the water table unimpeded. On entering the groundwater, the postulated radwaste release is dispersed, sorbed, decayed, and diluted along the potential groundwater pathway from the plant towards the Columbia River.

In the unconfined (water table) aquifer, there are no down gradient groundwater users between CGS and the Columbia River. However, the construction water needs at WNP-1/4 are supplied by the two deep wells that withdraw groundwater from the uppermost confined aquifer downgradient from the CGS radwaste building. During operation of WNP-1/4, these wells will be maintained in a standby mode. The uppermost screens in these wells are about 240 ft below the ground surface in the lower Ringold Formation. The effective bottom of the unconfined aquifer is generally assumed to be at the top of the lower Ringold Formation or about 200 ft below the surface. Thus, in all likelihood, any liquid radioactive spill to the groundwater beneath the CGS radwaste building would travel through the unconfined aquifer towards the Columbia River. However, for conservatism, analyses of postulated radionuclide movement assume that the WNP-1/4 wells draw from the unconfined aquifer. The remainder of this subsection provides estimates of travel times of critical radionuclides to move from the postulated spill to receptors and the corresponding concentration reduction factors.

For an assumed one-dimensional groundwater movement, the groundwater travel time, t, is the path length, L, divided by the groundwater velocity (seepage velocity), u. The groundwater velocity is the Darcy (apparent) velocity divided by the effective porosity, $u = Ki/n_e$, *where K is the lateral permeability (hydraulic conductivity) of the aquifer, i is the hydraulic gradient, and ne is the effective porosity of the aquifer material.*

For computational purposes, a conservative value for lateral permeability of 500 ft/day was selected to represent the unconfined aquifer located in the Ringold Formation beneath CGS (see Figure 2.4-21). From 2.4.13.1, effective porosity is taken 0.10. From Figure 2.4-26, the gradient in the water table aquifer between the plant and the Columbia River is about 8 or 9 ft/mile, and is taken conservatively as 10 ft/mile.

Using the above parameter values, groundwater velocities were computed to be 10 ft/day. With path lengths of 3.4 miles to the river and 1.0 mile to the WNP-1/4 wells, the respective travel times are estimated to be 5.2 years and 1.5 years.

Generally, the critical radionuclides of concern for a postulated liquid radwaste spill are ^{3}H, ^{90}Sr, and ^{137}Cs. These three radionuclides are fairly representative in terms of sorption characteristics, of those found in liquid radwaste tanks, since tritium does not sorb onto soil particles at all, strontium is an intermediate sorber, and cesium strongly sorbs to soil particles. The half-life of tritium is 12.3 years, whereas those of $^{90}S_r$ and $^{137}C_s$ are 29.0 and 30.1 years, respectively.

The travel time, t_i, for a particular radionuclide moving through groundwater depends upon the velocity, u_i, of the radionuclide

$$t_i = l/u_i$$

where the radionuclide velocity is

$$u_i = r_f u$$

in which r_f is the velocity reduction factor attributable to sorption

$$r_f = 1/1+\frac{\rho b}{n} k_d$$

In this equation, ρb is the bulk density of the aquifer material, n is the total porosity, and K_d is the equilibrium distribution coefficient for a particular radionuclide. The bulk density and total porosity are further related physically as

$$b = R_s (1 - n)$$

where R_s is the real specific gravity or particle density of the solid particles in the aquifer media.

The particle density, R_s, for Hanford soils is usually taken to be constant at 2.65 gm/cm^3, (Reference 2.4-39). The bulk density ρb, of Hanford soils has been determined to range from about 1.5 gm/cm^3 to about 1.75 gm/cm^3, with a median value of about 1.65 gm/cm^3, (Reference 2.4-40). For the median value of bulk density, the corresponding total porosity is about 0.377.

Using the above value for bulk density and total porosity, radionuclide travel time, ti, through the groundwater beneath WNP-1/4 can be expressed as

$$t_i = (1 + 4.4 K_d)\, t$$

The following summarizes radionuclide travel times (in years) to the WNP-1/4 wells (1.0 miles) and to the Columbia River (3.4 miles):

Nuclide	*Half-life, years*	K_d	t_i *@ 1.0 miles*	t_i *@ 3.4 miles*
^{3}H	*12.3*	*0*	*1.5*	*5.2*
^{90}Sr	*29.0*	*10*	*67.0*	*230.0*
^{137}Cs	*30.1*	*100*	*660.0*	*2300.0*

The radionuclide concentration at the point of water use will be determined by the amount of decay, dispersion, and sorption on the aquifer media. The minimum concentration reduction factor, CRF_{min}, along the centerline of the contaminant plume from an instantaneous point source is given by (Reference 2.4-41)

$$CRF_{min} = \frac{C_o}{C} = \frac{(4\pi t)^{3/2} \; (K_x K_y K_z)^{1/2}}{2V}$$

for an effluent volume, V, with a specific gravity of 1.0 and an initial concentration, C_o, released to soil with dispersion coefficients, K_x, K_y, K_z, in the x, y, and z directions, respectively. This expression neglects the phenomena of sorption and decay which will be considered later.

It is generally accepted that the dispersion coefficients are proportional to groundwater velocity for unidirectional flow, i.e.,

$$K_{x,y,z} = \alpha_{x,y,z} u$$

where $\propto_{x,y,z}$, are constants called dispersivities which are a function of the nonhomogeneity of the material. The range in dispersivities in homogeneous granular aquifers may approach 1000 cm (33 ft) (Reference 2.4-42). Substituting this relationship into the above expression for concentration reduction, and noting that travel time is determined by path length and velocity, results in

$$CRF_{min} = \frac{(4\pi L)^{3/2} \; (\propto_x \propto_y \propto_z)^{1/2}}{2V}$$

For the conservative condition of $\alpha_x = \alpha_y = \alpha_z = 1.0$, then

$$CRF_{min} = \frac{(4\pi L)^{3/2}}{2V}$$

The concentration reduction factors at the WNP-1/4 wells and at the bank of the Columbia River, due only to dispersion, are 9.1 x 10⁴ and 5.7 x 10⁵, respectively, for the 700-gal concentrated waste tank. When sorption and decay are included, the concentration reduction is given by (Reference 2.4-42)

$$CRF = \frac{(4\pi L)3 / 2\ (\propto_x \propto_y \propto_z)^{1/2}}{2V} e^{\lambda t_i}$$

in which λ is the radionuclide decay constant defined in terms of the half-life, T1/2, of a particular radionuclide as

$$\lambda = \frac{1n\ 2}{T_{1/2}}$$

The concentration reduction factor can be expressed as

$$CRF = CRF_{min}\ (e\ \lambda\ t_i)$$

The exponential term accounts for the effects of sorption and decay. The only effect of sorption on concentration reduction is to increase the travel time, thus allowing more time for decay. Concentration reduction factors (CRF) for the radionuclides listed were calculated for path lengths of 1.0 mile (to WNP-1/4 wells) and 3.4 miles (to Columbia River):

Nuclide	CRF (1.0 mile)	CRF (3.4 mile)
^{3}H	1.0×10^{5}	7.7×10^{5}
^{90}Sr	4.5×10^{5}	1.8×10^{8}
^{137}Cs	3.7×10^{11}	5.8×19^{28}

The above factors, derived through the application of conservative parameters, are used in Section 15.7.3 to evaluate concentrations offsite. *The consideration of the WNP-1/4 wells is especially conservative. Groundwater contamination from the 200 Areas which reached CGS over six years ago (see Section 2.4.13.1) has not been detected at WNP-1/4. This substantiates that the WNP-1/4 wells do not draw from the unconfined aquifer or, alternatively, the hydraulic conductivities are much less than assumed.*

It should also be noted that if Ben Franklin Dam were ever constructed, the concentration reduction factors at the river bank would be even larger than those noted above. This would be true, because the groundwater gradient (thus, the groundwater velocity) would be decreased as shown in Figure 2.4-19.

2.4.13.4 Monitoring or Safeguard Requirements

Plant water systems result in releases to the ground at a number of locations. Sanitary wastewater is routed to a central treatment system comprised of lined aeration lagoons and stabilization ponds. This treatment plant also receives wastes from the Plant Support Facility, WNP-1 and WNP-4, and the DOE's 400 Area. Periodically the treated effluent is discharged to percolation beds.

As discussed in Section 2.4.2.3, the storm water drainage system discharges to lined ponds northeast of the plant (see additional description in Section 9.3.3.2.3.1). Such sources as water treatment filter backwashes, heating, ventilating, and air conditioning (HVAC) air wash units, and some building sumps and floor drains (see Section 9.3.3.2.3) also contribute to flow in the storm water system. Periodic testing and flushing of the fire protection system and cleaning of the cooling towers and standby service water ponds result in localized discharges of water to the ground.

Monitoring of groundwater and plant-related discharges to ground is performed as described in the ODCM.

2.4.13.5 Design Bases for Subsurface Hydrostatic Loadings

CGS does not employ permanent dewatering systems. Site groundwater conditions are presented in Section 2.5.4.6 and the design bases for subsurface hydrostatic loadings are given in Section 3.4.

The design-basis groundwater elevation used for subsurface hydrostatic loadings is 420 ft msl and was predicated on the possible future construction of Ben Franklin Dam at RM 348. As noted in Section 2.4.13.1, planning for the dam has been terminated. The same section notes that the water table beneath CGS would rise to less than 405 ft msl if the dam were to be completed. The actual water table beneath the project is about 385 ft msl (see Sections 2.4.13.1 and 2.5.4.6). The design-basis groundwater level is adequate to account for seepage from the ultimate heat sink spray ponds or the rupture of any Seismic Category I or nonseismic pipe. As discussed in Section 3.8.4.1.5, the two, 250-ft^2 reinforced-concrete spray ponds are designed to Seismic Category I requirements and are designed to mitigate any possible water leakage. The bottom of the spray ponds are at 417 ft msl and the ponds are designed for external hydrostatic loading to 420 ft msl. The maximum combined leakage from the two ponds during the initial filling sequences was 120 gpm. It may be inferred from previous studies (Reference 2.4-7) that continued leakage cannot affect the groundwater level

beneath the ponds or other safety-related structures, the closest of which (500+ ft away) is the diesel generator building with a foundation at 434 ft msl. These early CGS hydrologic studies evaluated the effect of cooling pond leakage and cooling tower blowdown at the project site. Equivalent leakage/discharge rates used in these studies were very much greater than leakage from the spray ponds. For example, the continuous discharge of 2700 gpm of cooling tower blowdown to the depression just east of CGS was estimated to raise the water table about 20 ft beneath the point of discharge (Reference 2.4-7). Based on these previous studies, it can be concluded that the minimal amount of spray pond leakage will have no influence on the design-basis groundwater elevation of 420 ft msl.

With respect to a pipe break, the 144-in. circulating water system pipe on the discharge side of the condenser would produce the maximum release of water. The maximum quantity of water released from such a rupture is 199,180 ft^3. This discharge would have a negligible (less than 1 in.) and temporary effect on the groundwater level. Failure of the pipe at its closest proximity to a safety-related building may result in temporary saturation of the backfill. This material has been recompacted to a minimum relative density of 75% and an average relative density of 85%. As discussed in Section 2.5.4.8, these densities are not susceptible to liquefaction for motions associated with the safe shutdown earthquake, and as discussed in Section 2.5.4.10, temporary saturation would not significantly reduce the bearing capacity of the densely compacted backfill. A continuous but undetected leak from any major pipe would not influence the groundwater level enough to affect plant structures. This may be deduced from the time factors and water table rises predicted from a number of scenarios in the above mentioned hydrologic studies (Reference 2.4-7).

2.4.14 TECHNICAL SPECIFICATIONS AND EMERGENCY OPERATION REQUIREMENTS

The worst hydrological condition, as discussed in this section, is a flood caused by a postulated PMP event. This flood does not create an adverse hydrological condition on safety-related equipment. Emergency flood protection procedures are therefore unnecessary.

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Table 2.4-1

Major Columbia River Basin Dams

Location	Dams	River	River Miles from Site	Usable Storage 10^3 ac-ft
Upstream	Mica	Columbia (Can)	666	12,000
	Duncan	Duncan		1,400
	Arrow	Columbia (Can)	429	7,090
	Libby	Kootenai	642	5,000
	Hungry Horse	South Fork Flathead		3,160
	Kerr	Clark Fork		1,219
	Albeni Falls	Pend Oreille	483	1,153
	Grand Coulee	Columbia	245	5,200
	Chief Joseph	Columbia	193	--
	Wells	Columbia	164	117
	Chelan	Chelan	152	677
	Rocky Reach	Columbia	122	120
	Rock Island	Columbia	101	--
	Wanapum	Columbia	64	389[a]
	Priest Rapids	Columbia	45	170[a]
Downstream	McNary	Columbia	60	
	John Day	Columbia	136	
	The Dalles	Columbia	160	
	Bonneville	Columbia	206	

[a] Storage not available for flood regulation.

Table 2.4-2

Columbia River Temperatures Near Columbia Generating Station

MONTHLY AVERAGE WATER TEMPERATURE,
IN °C, AT RICHLAND, WA

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
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	6.9	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 1965-1974	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	--

Records since June 1964.

MONTHLY AVERAGE WATER TEMPERATURE,
IN °C, AT PRIEST RAPIDS DAM, WA

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 1965-1974	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	--

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

Table 2.4-3

Downstream Surface Water Users

Name	Location of Diversion Township	Range	Section	Approximate Miles Downstream	Quantity (cfs)	Type Use[a]
Energy Northwest	11	28	2	--	90	IN
Peter Kewit and Sons	11	28	2	--	1	I
L. L. Bailey	11	28	24	4	2	I
H. D. Loyd	11	28	24	4	0.99	D,I
Central Premix Concrete Company	11	28	27	4	2	IN
Battelle Memorial Institute	10	28	14	8	4.4	I
University of Washington	10	28	23	9	1.75	I
City of Richland	10	28	24	9	0.67	D
City of Richland	10	28	25	12	31	D
City of Richland	10	28	25	12	23.25	D
City of Richland	10	28	25	12	31	D
City of Richland	10	28	35	12	93	D
E. C. Watts	9	28	1	13	0.31	D,I
H. S. Petty	9	28	1	13	0.48	I
N. H. and M. E. Ketchersid	9	28	1	13	1.66	I
G. C. Walkley	9	28	1	13	2.32	I
R. T. Justesen, et al.	9	28	12	15	2.54	I
Central Premix Concrete Company	9	28	12	15	1.10	IN
City of Richland	9	28	13	17	2.0	I
Benton County	9	29	28	19	1.0	I
City of Kennewick	9	30	31	23	55.7	D
City of Pasco	9	30	31	23	35.0	D
F. J. Henckel	8	30	14	27	0.015	I
Allied Chemical	8	30	14	27	3.55	IN
Chevron Chemical	8	30	23	28	3.77	IN
Chevron Chemical	8	30	23	28	40	IN
Phillips Pacific Chemical Company	8	30	24	28	82	IN
Phillips Pacific Chemical Company	8	30	24	28	20	IN
Boise Cascade Corporation	7	31	10	34	24.5	IN
L. D. Hoyte, et al.	7	31	14	35	179.8	I
D. Howe	7	31	23	36	6.4	I
Crawford and Sons	6	30	27	47	32.8	I
Barbarosa Farms	6	30	27	47	20	I
Crawford and Sons	6	30	27	47	7.6	I
Rainier National Bank	6	30	27	47	9.4	I
Anderson and Coffin	5	29	5	49	242	I
Horse Heaven Farms	5	29	6	50	82	I
Horse Heaven Farms	5	29	6	50	550	I
Horse Heaven Farms	5	29	6	50	290	I
Anderson and Coffin	5	29	6	50	242	I

[a] D - Domestic or municipal uses
I - Irrigation and other agricultural uses
IN - Industrial
Includes only those water rights for which a permit or certificate has been issued

Table 2.4-4

Mean Discharges in CFS of
Columbia River Below Priest Rapids Dam,
Modified to 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	98800	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	96900	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	88900	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	163600	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 2.4-5

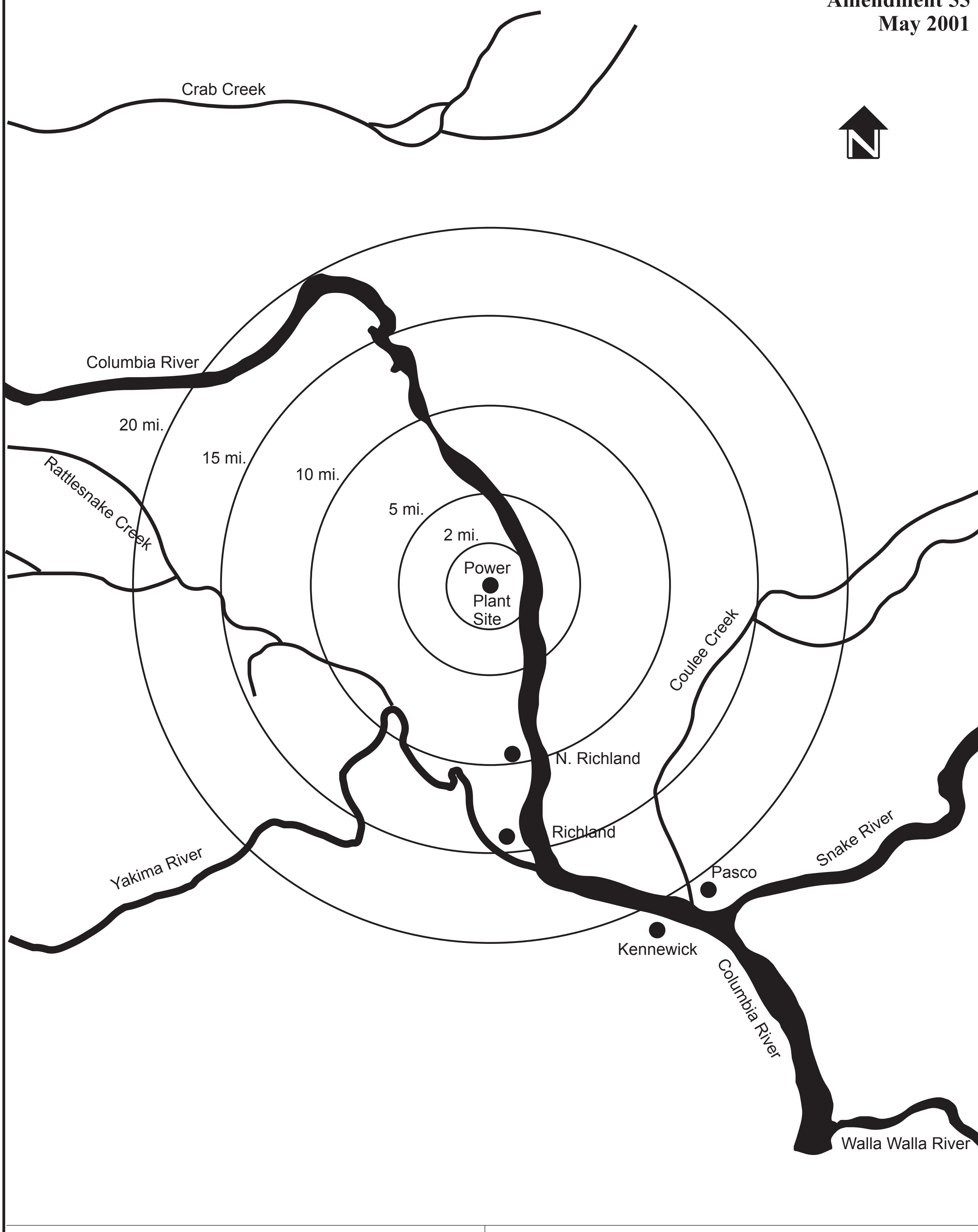
Dependable Yield, Columbia River Below
Priest Rapids Dam, Washington

Consecutive Years of Lowest Mean Flow	Inclusive Years	Lowest Mean Flow (cfs)	Percent of 1929-1958 Mean
1	1937	86,600	75.9
2	1930-31	89,900	78.8
3	1929-31	92,900	81.4
4	1929-32	95,800	84.0
5	1937-41	96,400	84.5
6	1937-42	97,300	85.3
7	1936-42	98,400	86.2
8	1937-44	99,000	86.8
9	1937-45	97,900	85.8
10	1936-45	98,600	86.4
11	1929-58	114,100	100.0

Table 2.4-6

Major Geologic Units in the Hanford Region
and Their Water-Bearing Properties

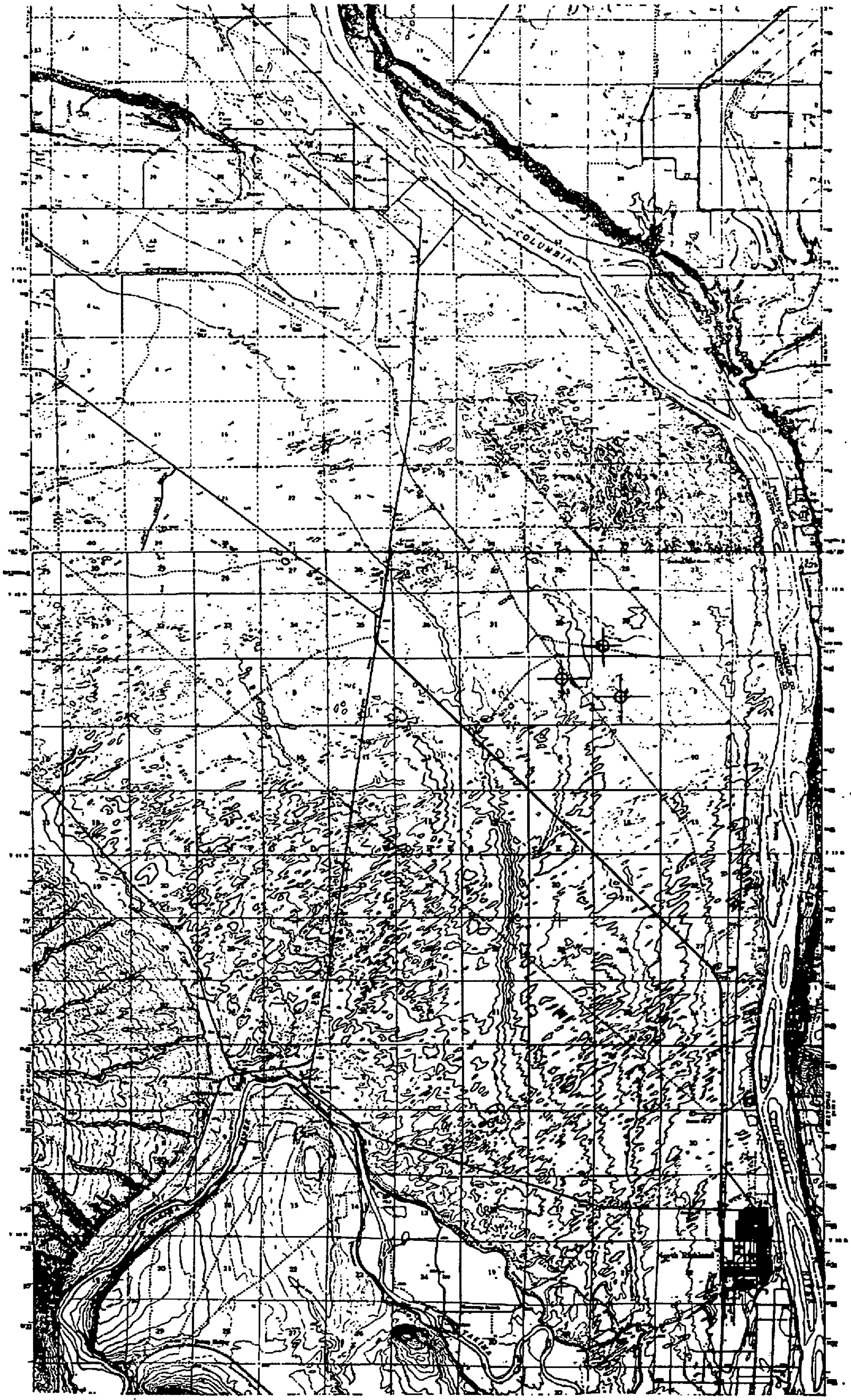
System	Series	Geologic Unit	Material	Water-Bearing Properties
		Fluviatile and glaciofluviatile sediments and the Touchet formation (0-200 ft thick)	Sands and gravels occurring chiefly as glacial outwash. Unconsolidated, tending toward coarseness and angularity of grains, essentially free of fines.	Where 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	Wind deposited silt.	Occurs everywhere above the water table.
Quaternary		Ringold formation (200-1200 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 shrink-age 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)



Columbia Generating Station
Final Safety Analysis Report

Hydrographic Map

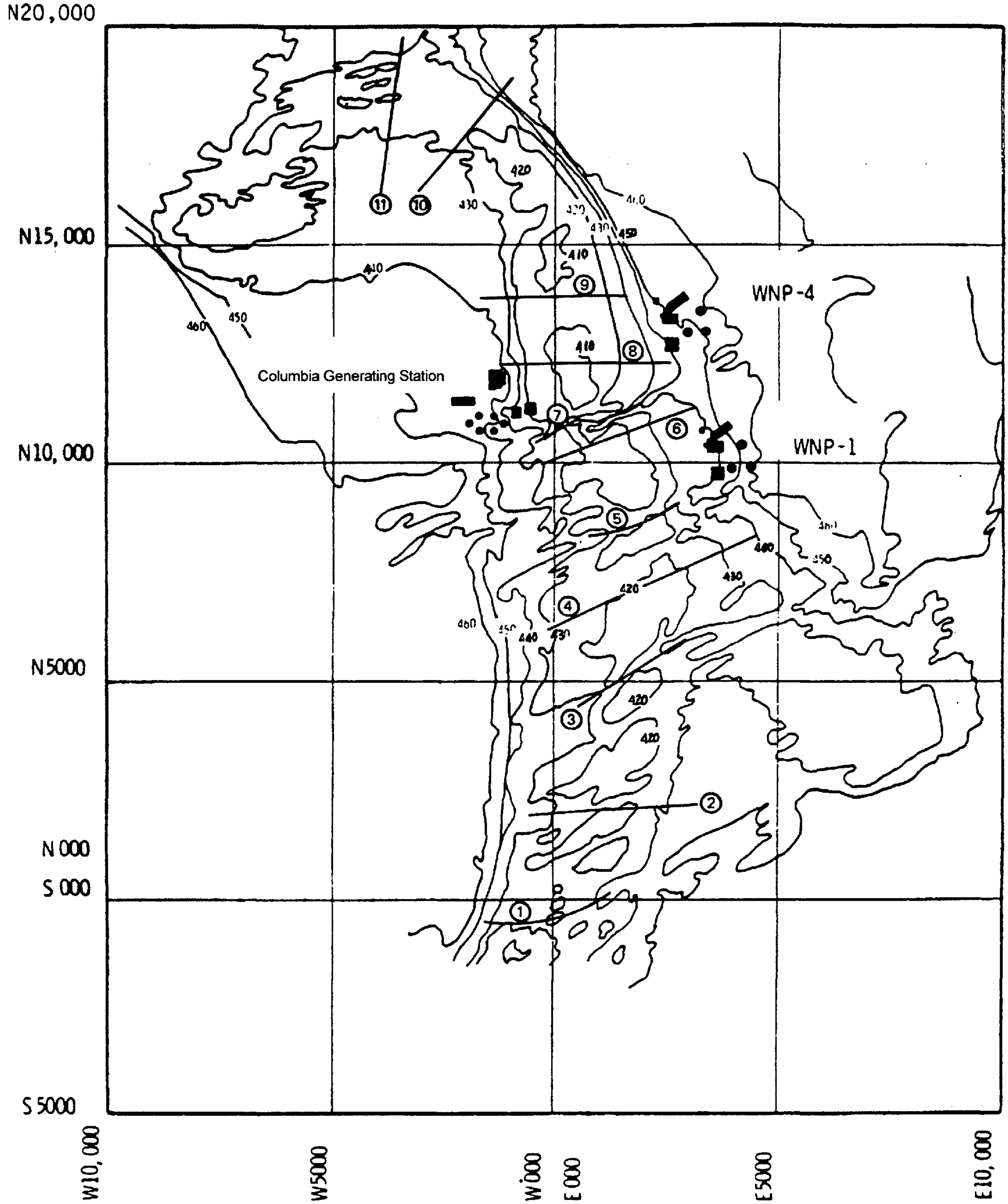
Draw. No. 990306.30 | Rev. | Figure 2.4-1



Columbia Generating Station
Final Safety Analysis Report

Topographic Map of Site and Sounding Area

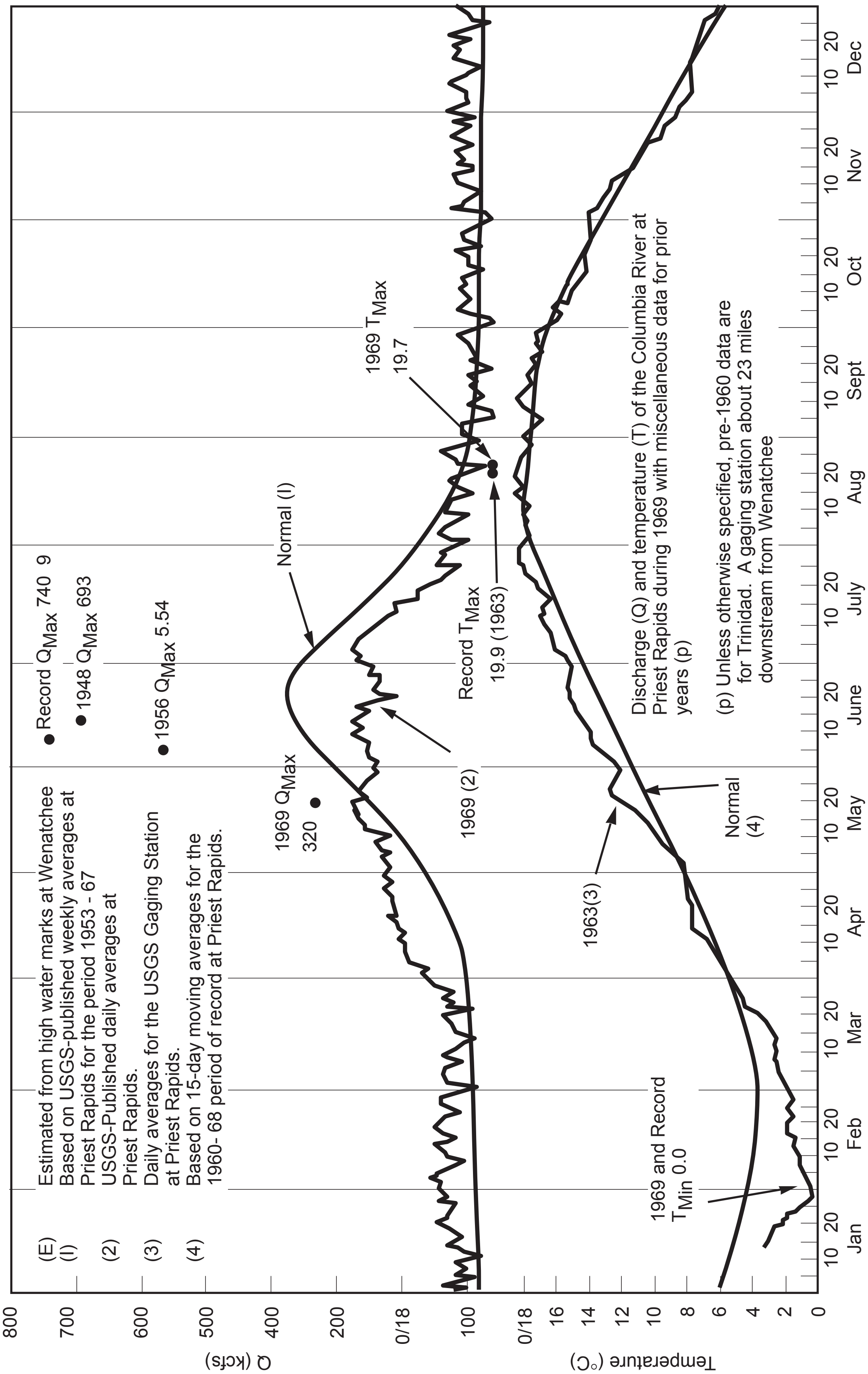
Draw. No. 020361.02 | Rev. | Figure 2.4-2



Columbia Generating Station
Final Safety Analysis Report

Detailed Countours Near the Site

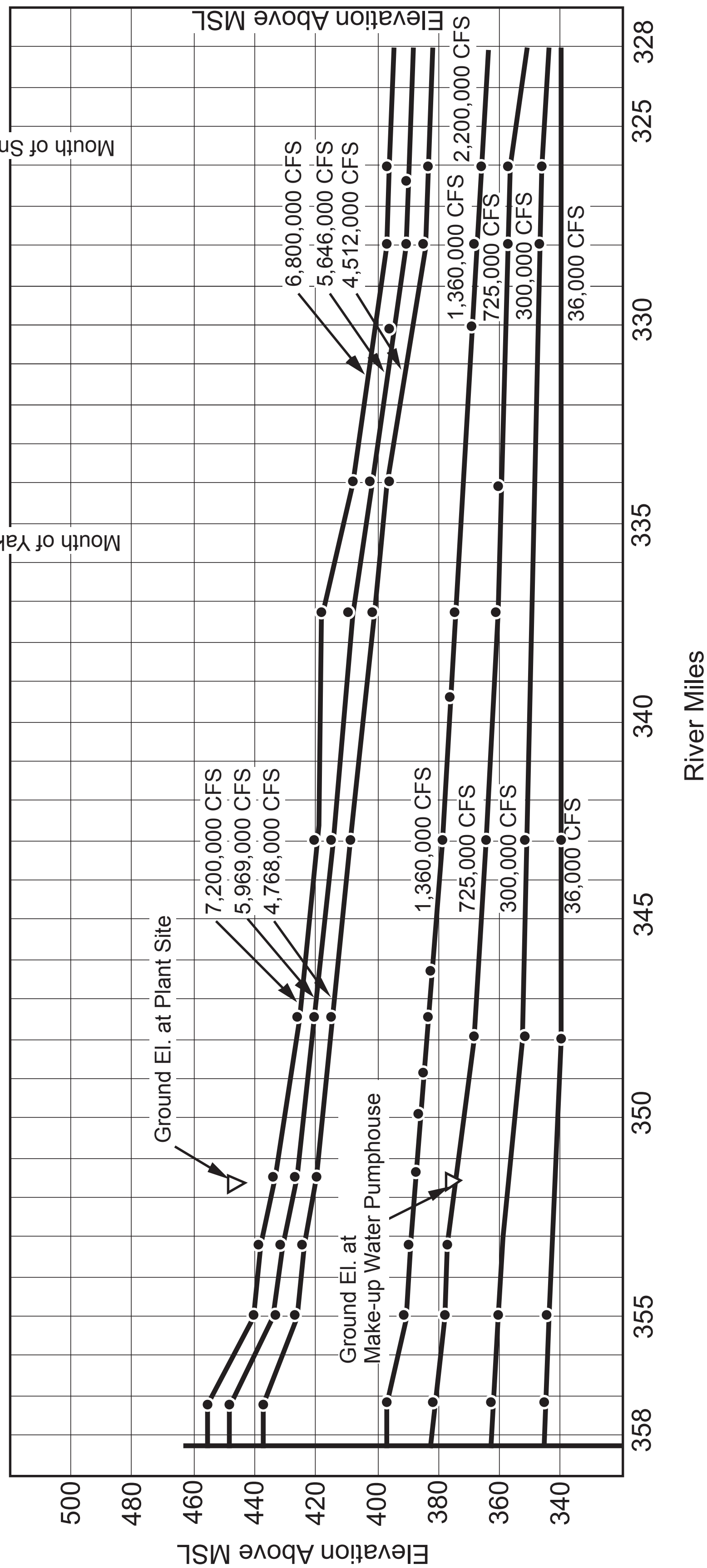
Draw. No. 020361.03 | Rev. | Figure 2.4-3



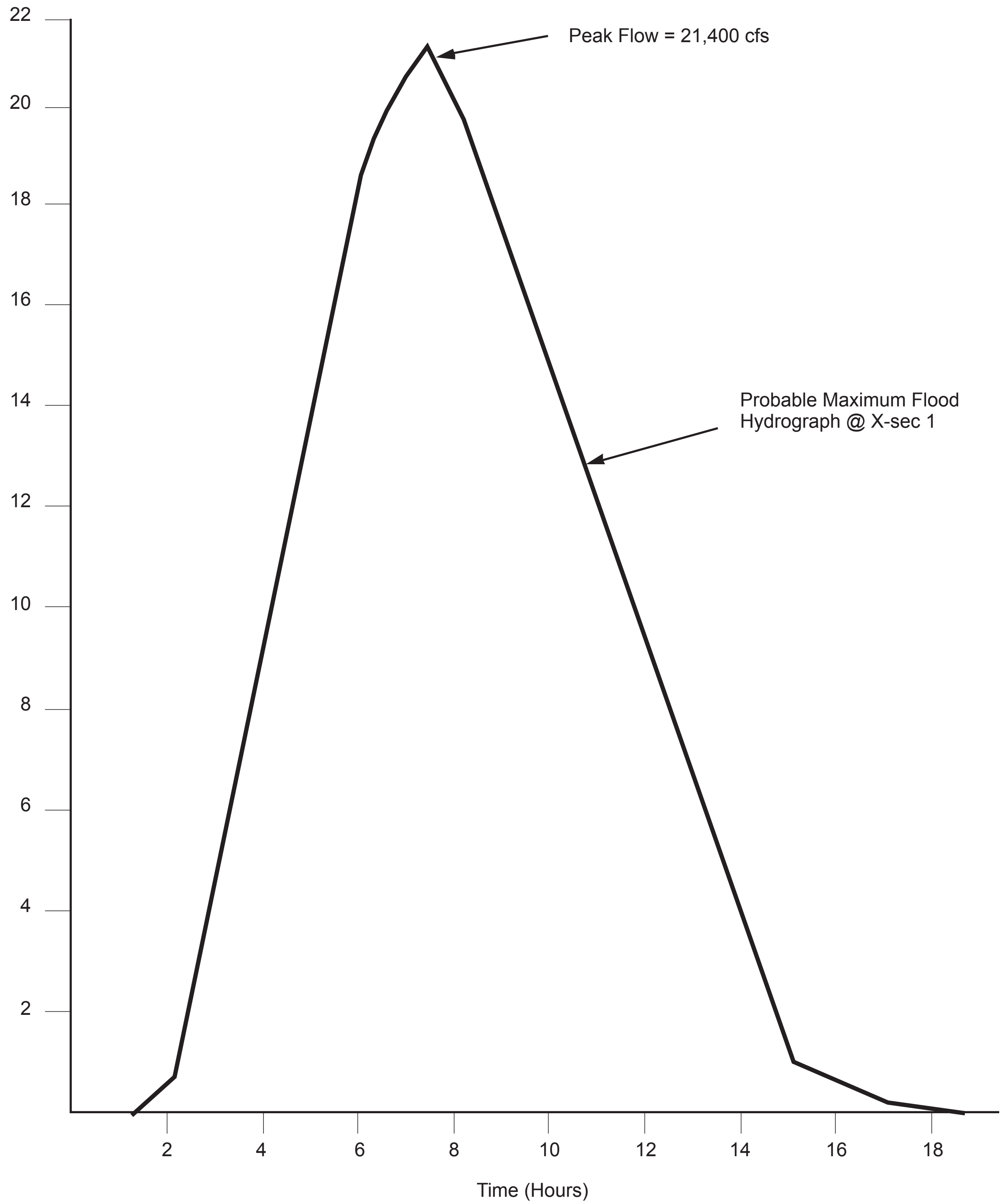
Columbia Generating Station
Final Safety Analysis Report

Discharge and Temperature of the Columbia River at Priest Rapids

Draw. No. 990306.06 | Rev. | Figure 2.4-4



Columbia Generating Station Final Safety Analysis Report	Columbia River Water Surface Profiles River Miles 323 to 358
	Draw. No. 990306.07 | Rev. | Figure 2.4-5



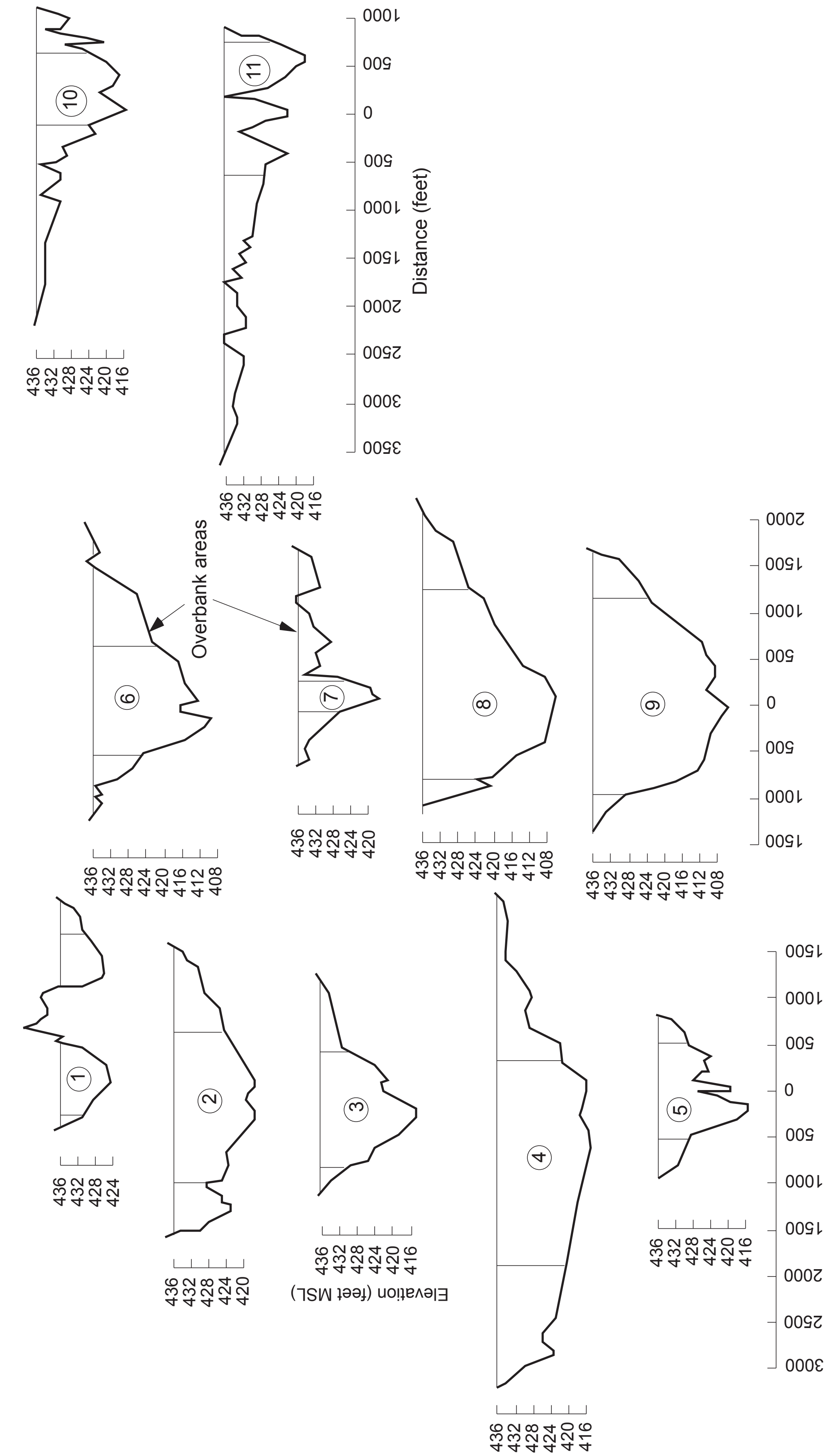
Columbia Generating Station
Final Safety Analysis Report

PMF Hydrograph Due to Thunderstorm PMP

Draw. No. 990306.31	Rev.	Figure 2.4-7

Probable Maximum Precipitation Drainage Basin

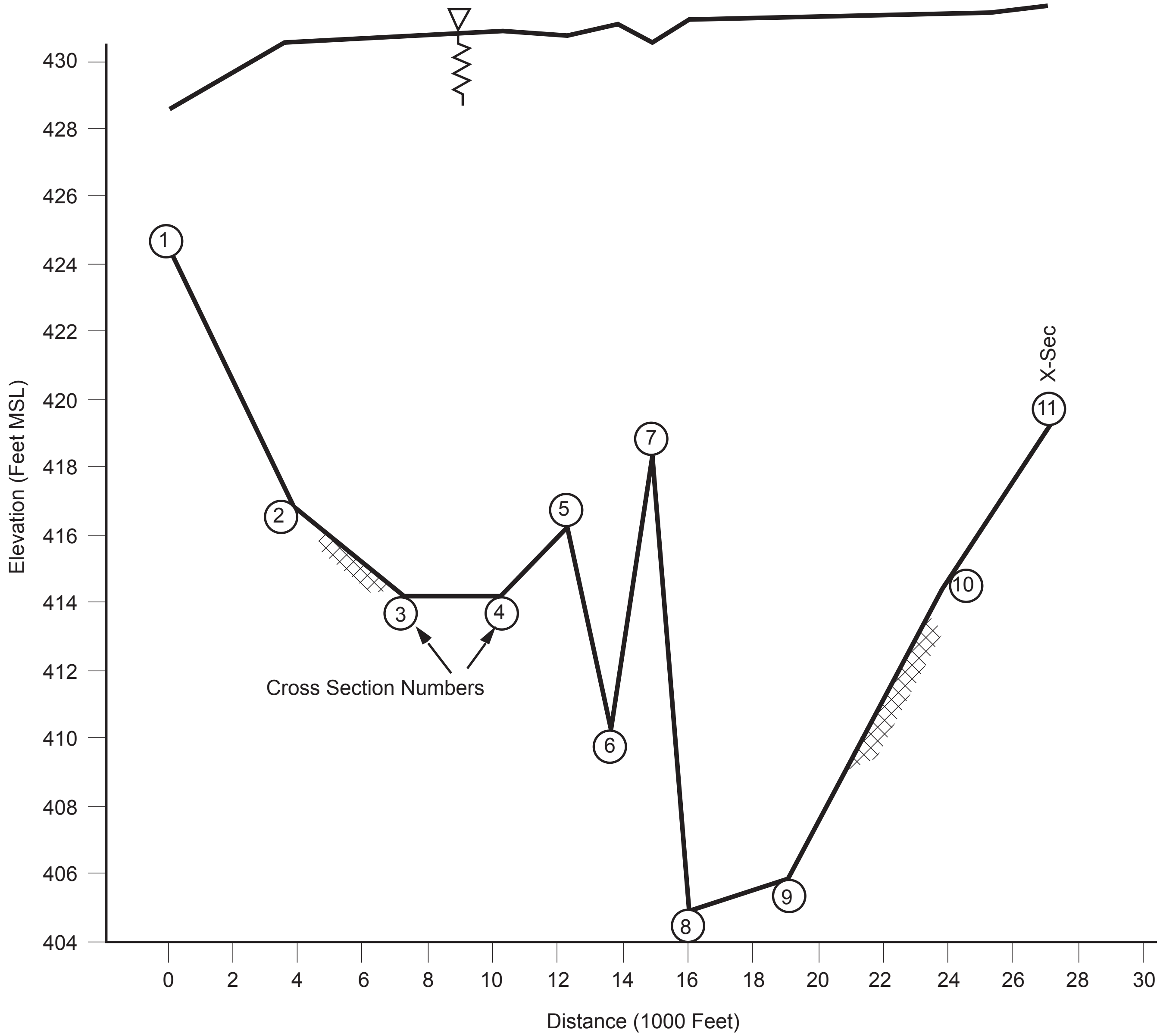
Draw. No. 020361.04 | Rev. | Figure 2.4-8



Columbia Generating Station
Final Safety Analysis Report

Probable Maximum Precipitation Channel Cross Sections

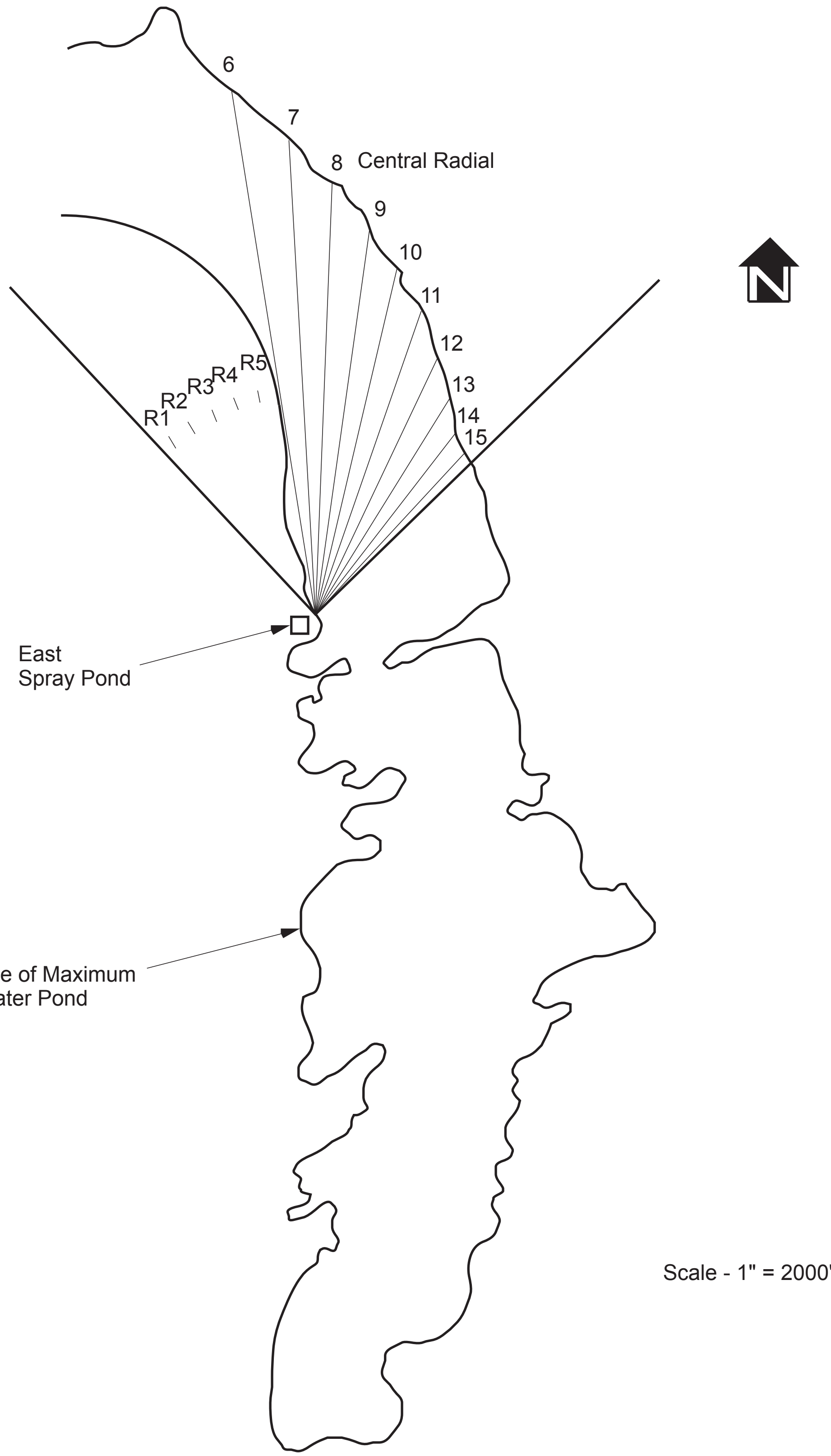
Draw. No. 990306.08	Rev.	Figure 2.4-9



Columbia Generating Station
Final Safety Analysis Report

Water Surface Profile

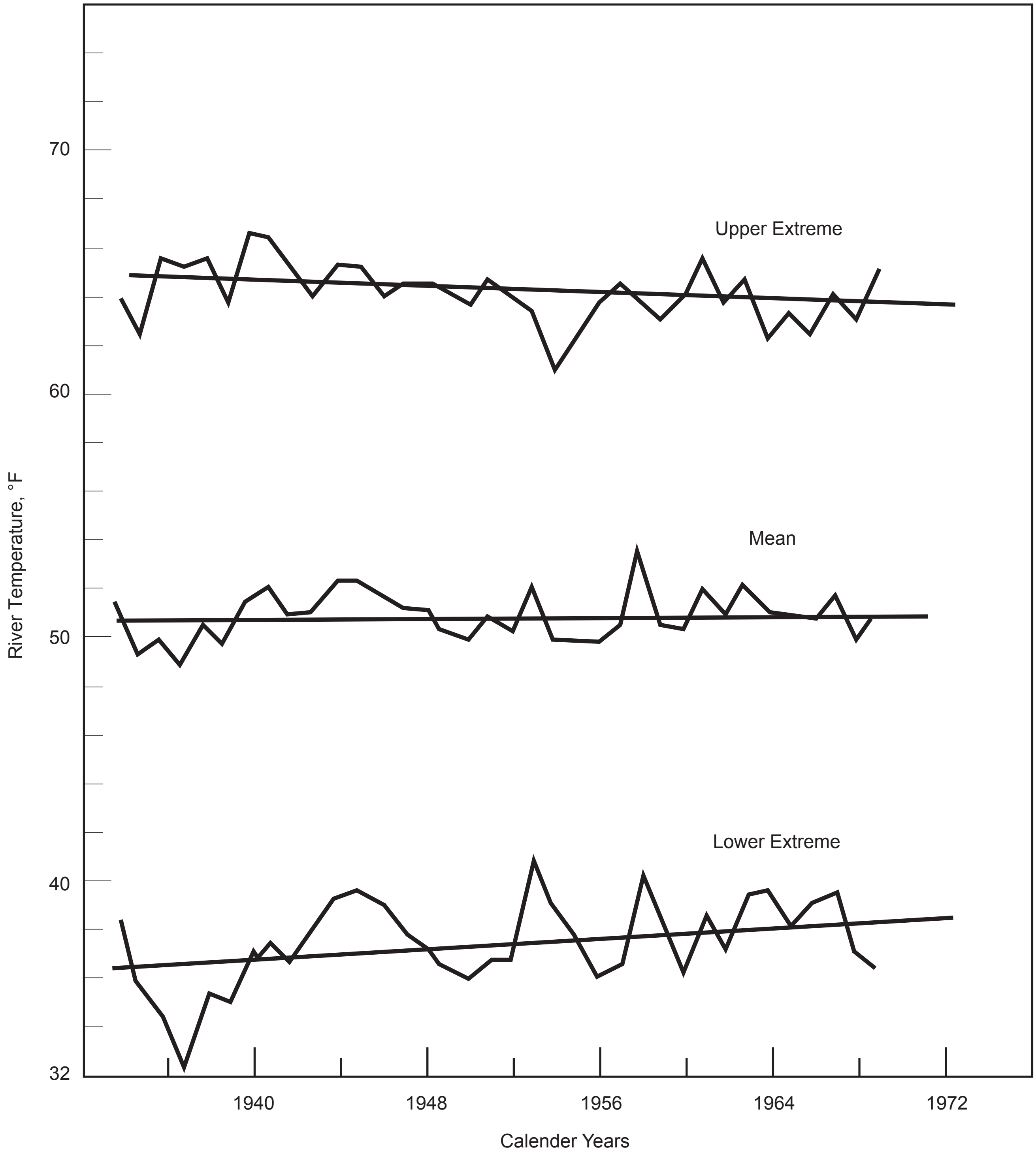
Draw. No. 990306.32 | Rev. | Figure 2.4-10



Columbia Generating Station
Final Safety Analysis Report

Effective Fetch Diagram

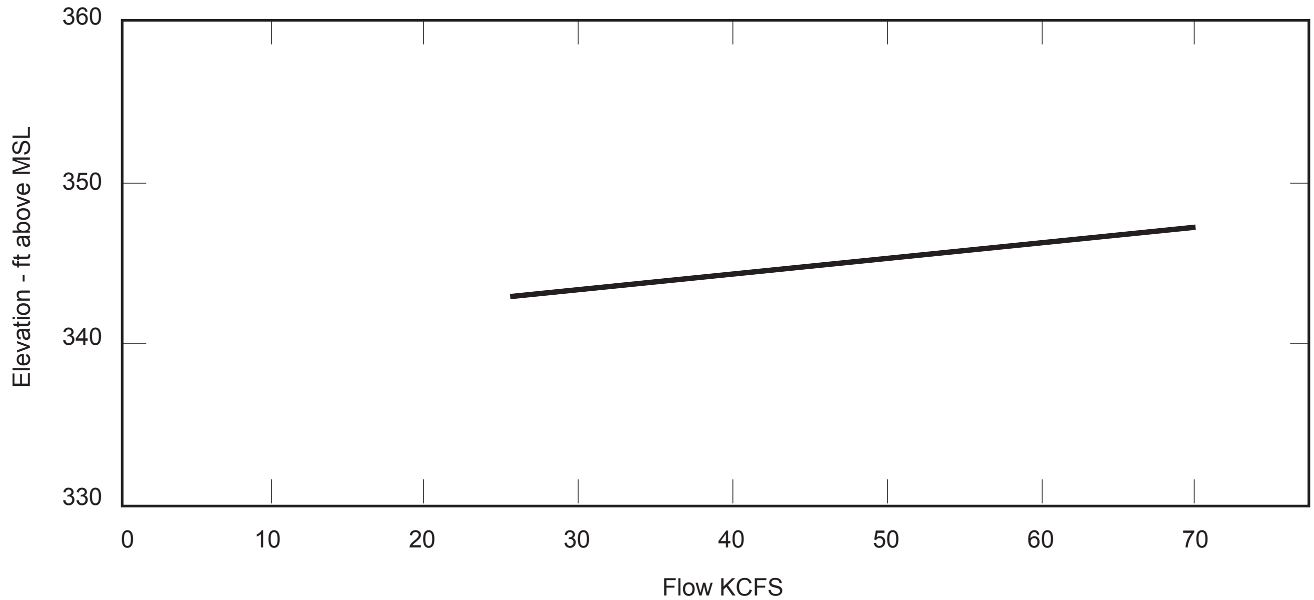
Draw. No. 990306.33	Rev.	Figure 2.4-11



Columbia Generating Station
Final Safety Analysis Report

Computed Long-Term Temperature Trends on the Columbia River at Rock Island Dam (1938 - 1962)

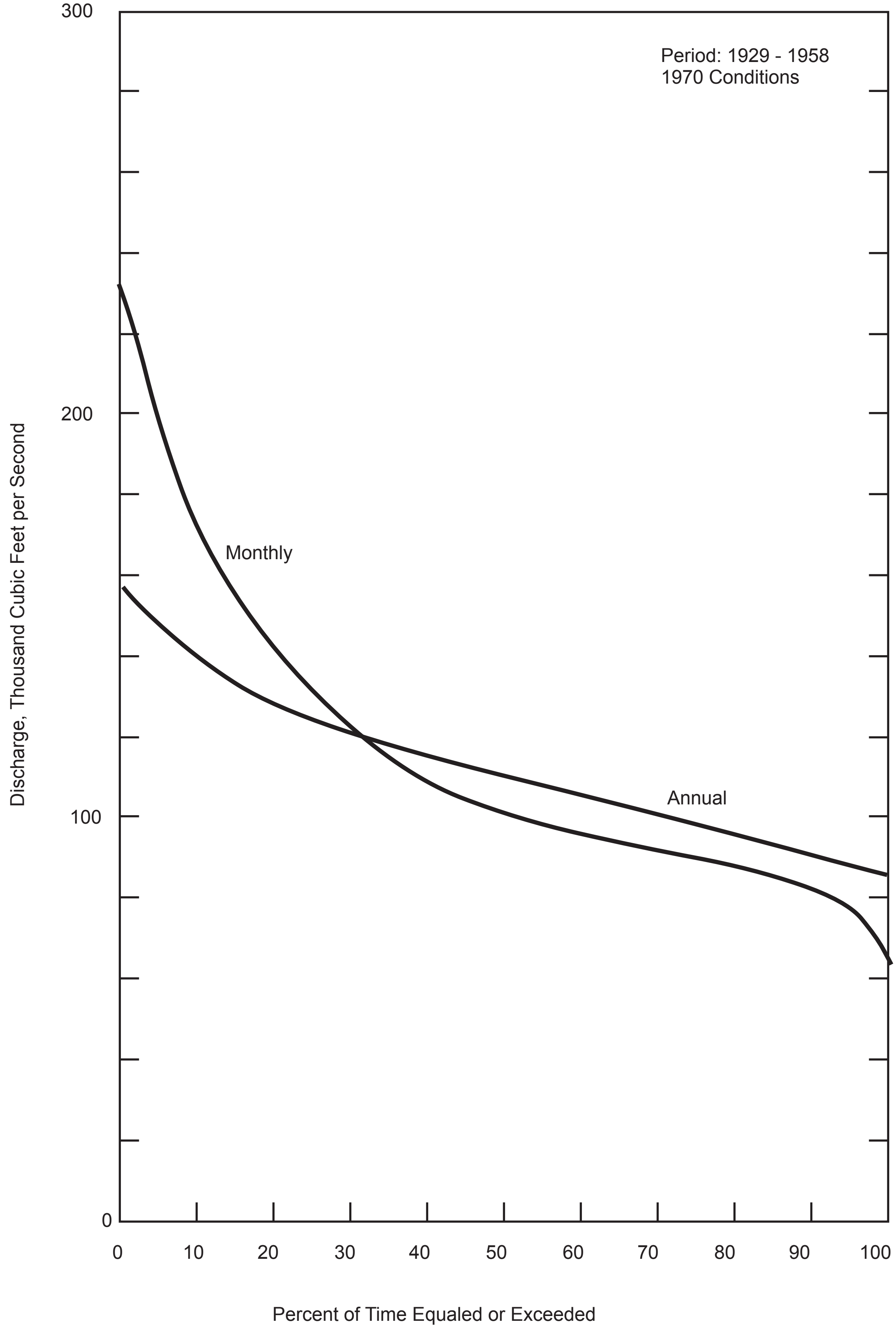
Draw. No. 990306.34 | Rev. | Figure 2.4-12



Columbia Generating Station
Final Safety Analysis Report

River Elevation at Low Flows - River Mile 352

Draw. No. 990306.35 | Rev. | Figure 2.4-13

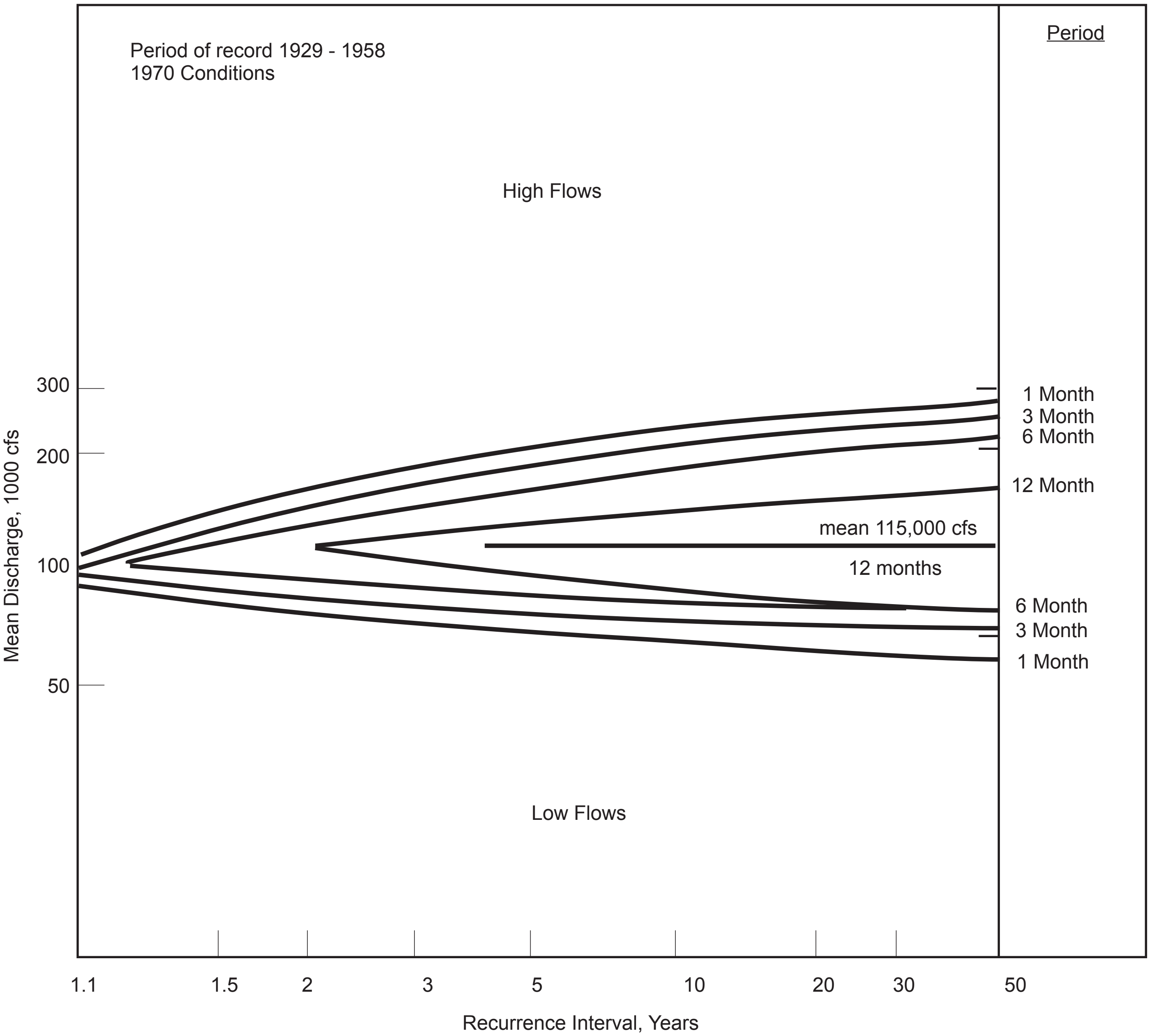


Columbia Generating Station
Final Safety Analysis Report

Duration Curves Columbia River, Priest Rapids Dam

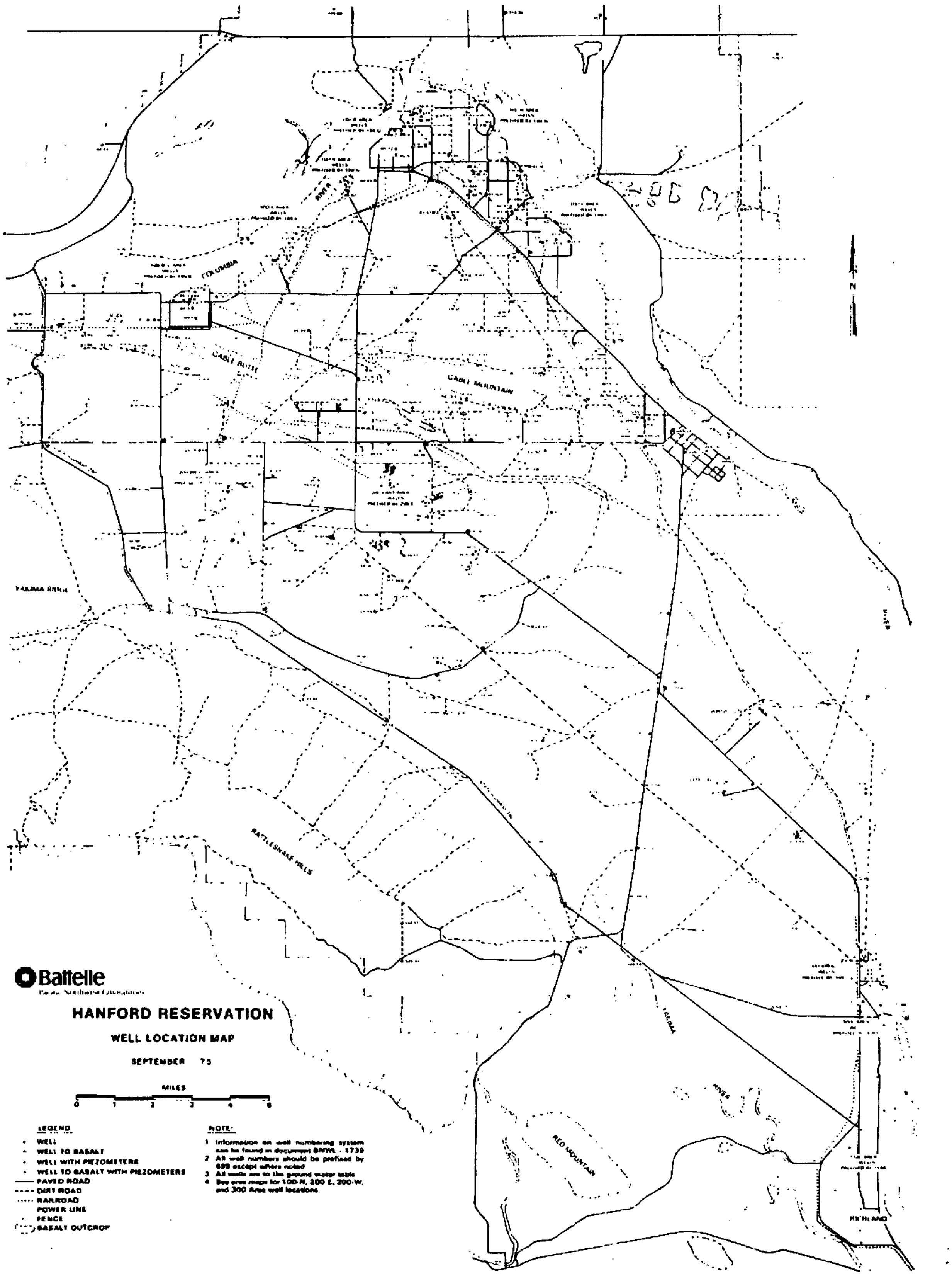
Draw. No. 990306.36	Rev.	Figure 2.4-14

Form No. 960690



Frequency Curves of High and Low Flows for the Columbia River Below Priest Rapids Dam

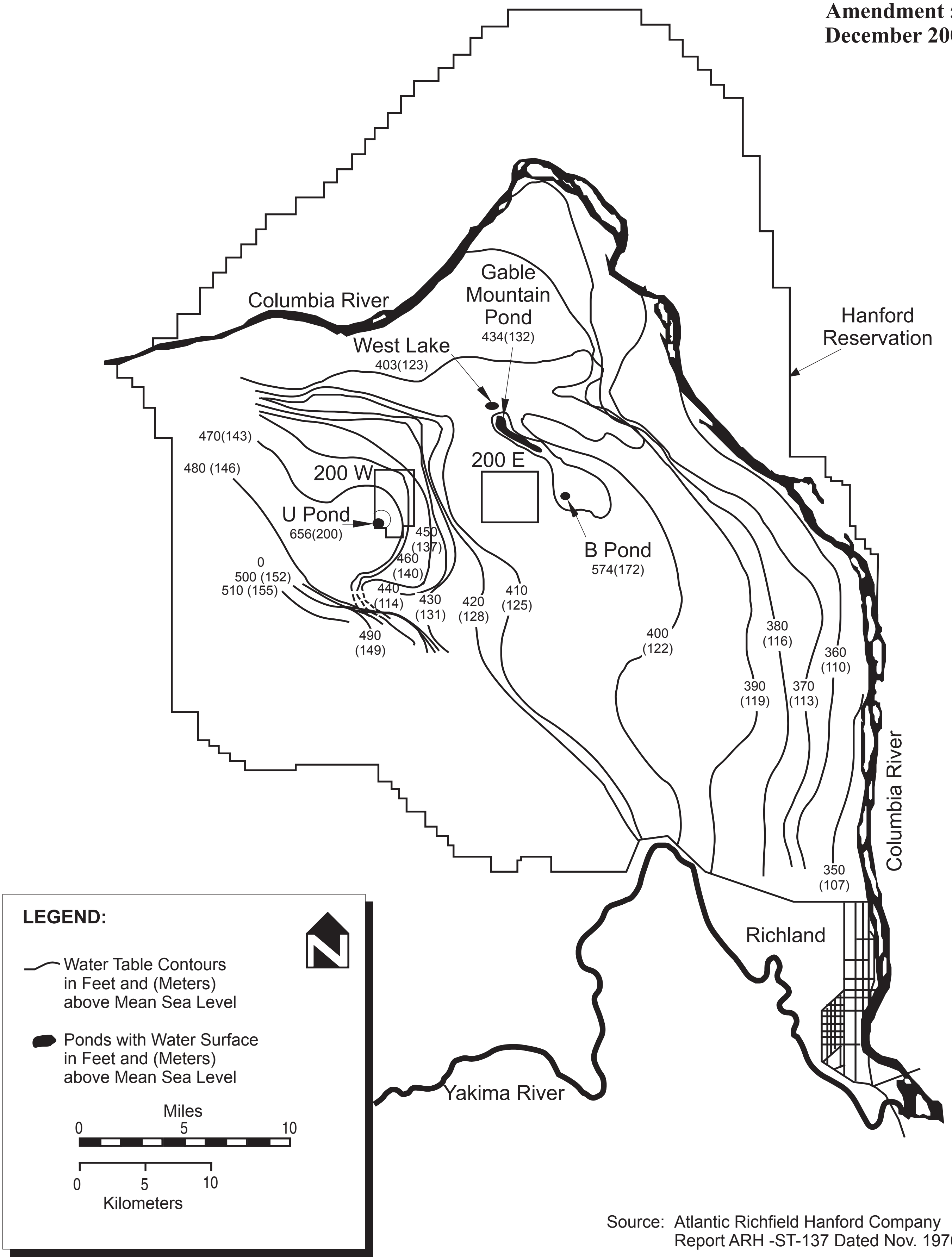
Draw. No. 990306.37 | Rev. | Figure 2.4-15



Columbia Generating Station
Final Safety Analysis Report

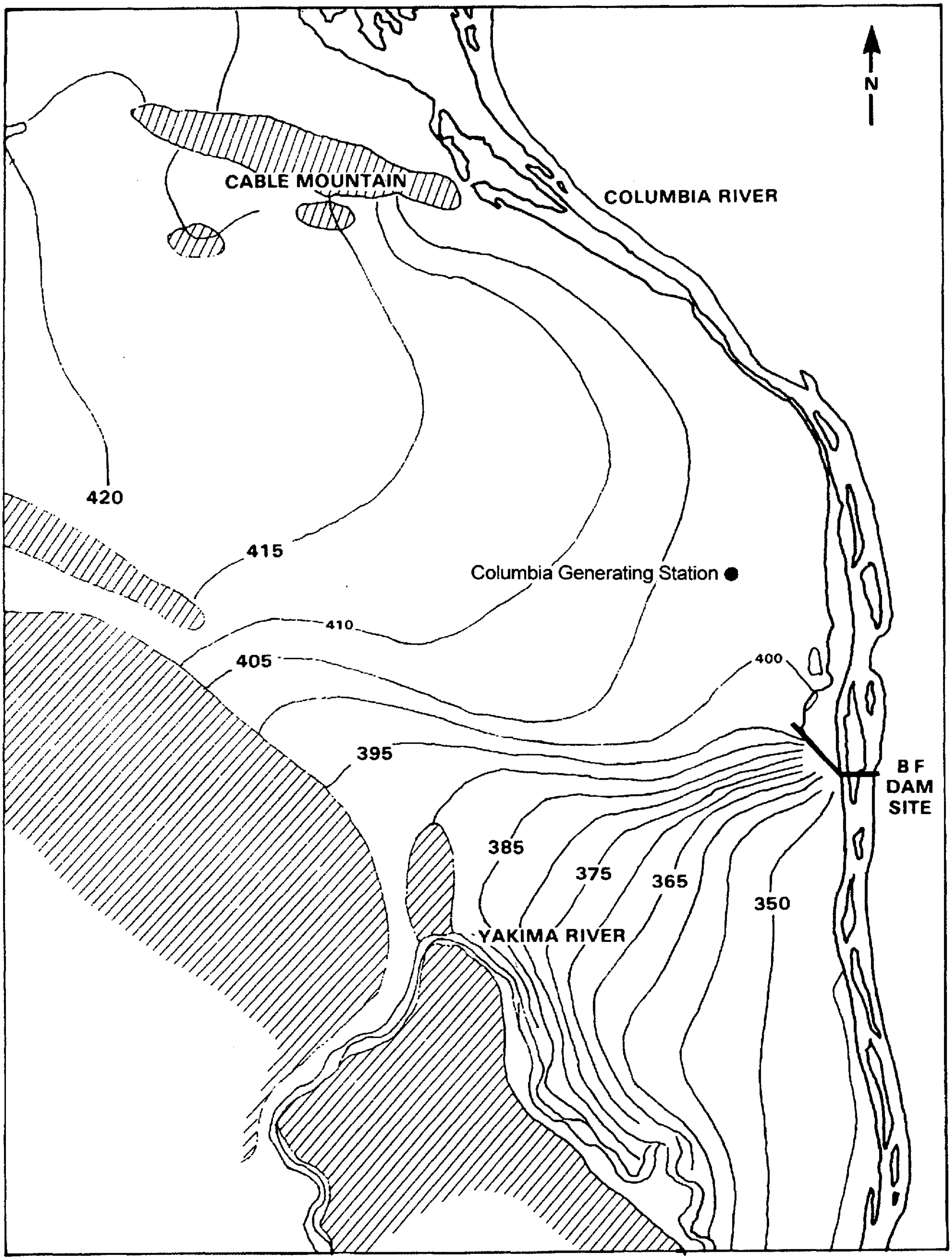
Monitoring Well Locations (September 1975)

Draw. No. 020361.05 | Rev. | Figure 2.4-17



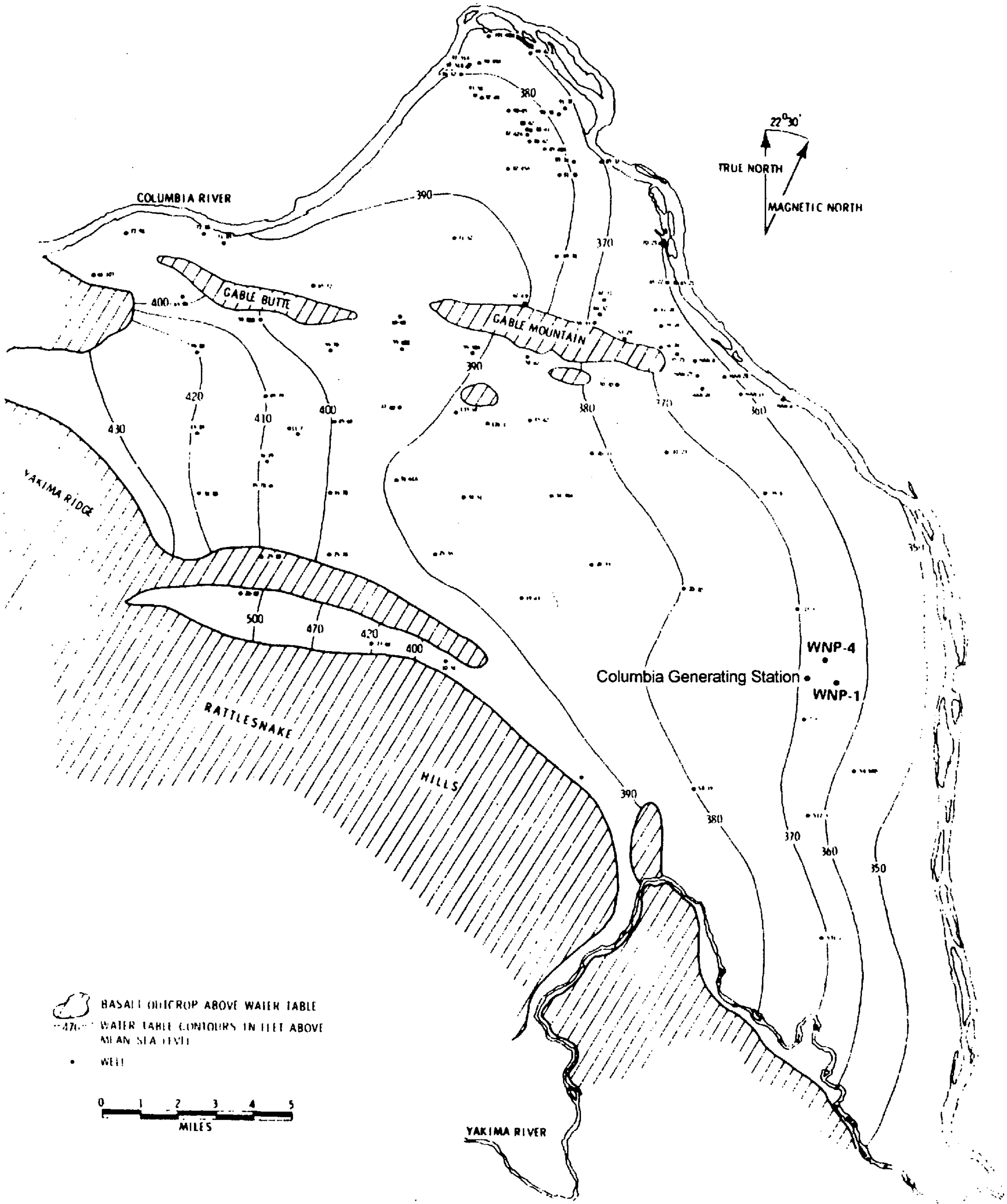
Source: Atlantic Richfield Hanford Company Report ARH -ST-137 Dated Nov. 1976

Columbia Generating Station Final Safety Analysis Report	Hanford Reservation Water Table Map (December 1975)		
	Draw. No. 010126.53	Rev.	Figure 2.4-18

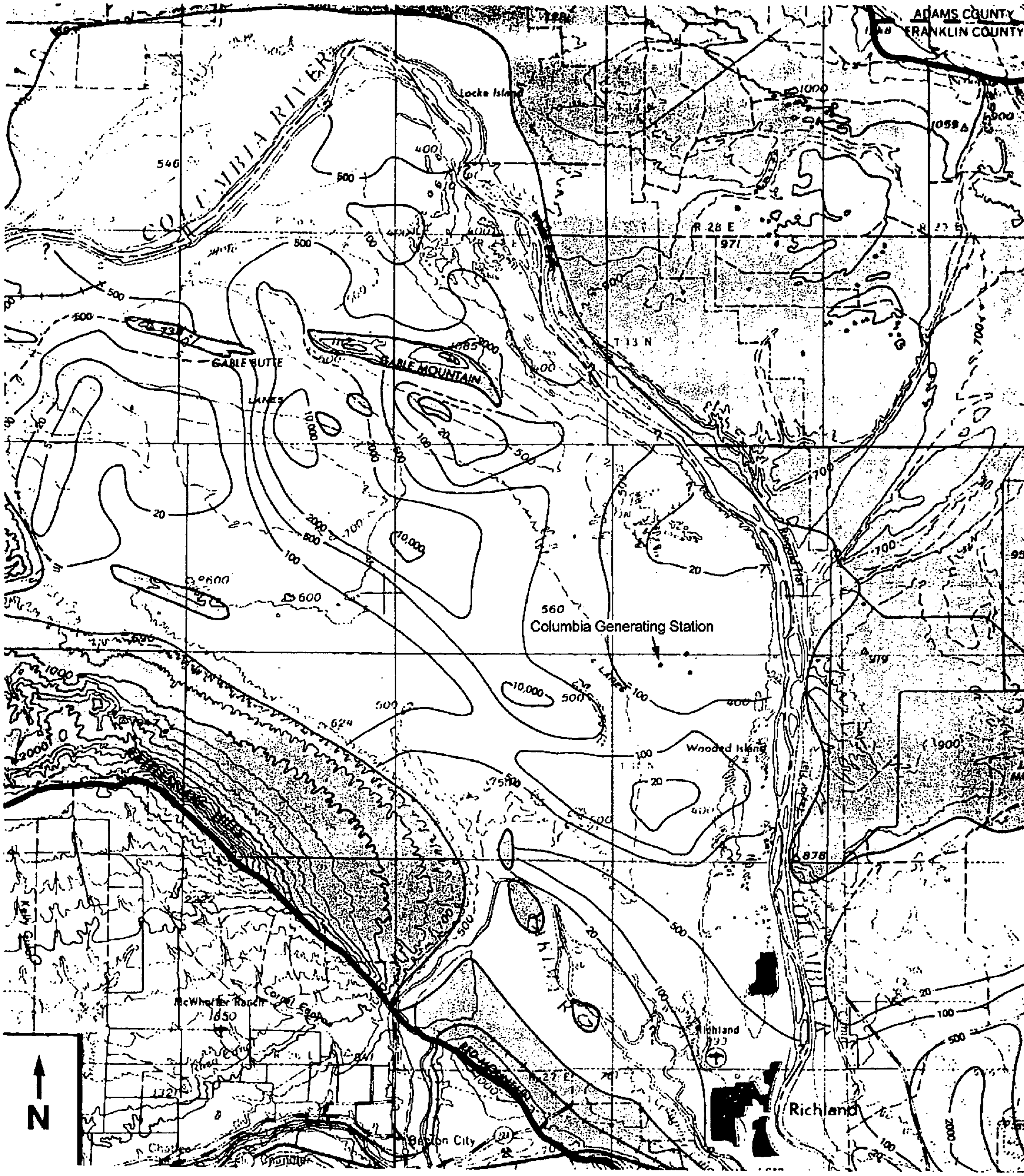


Groundwater Contours Assuming Construction of the Ben Franklin Dam

Draw. No. 020361.06	Rev.	Figure 2.4-19

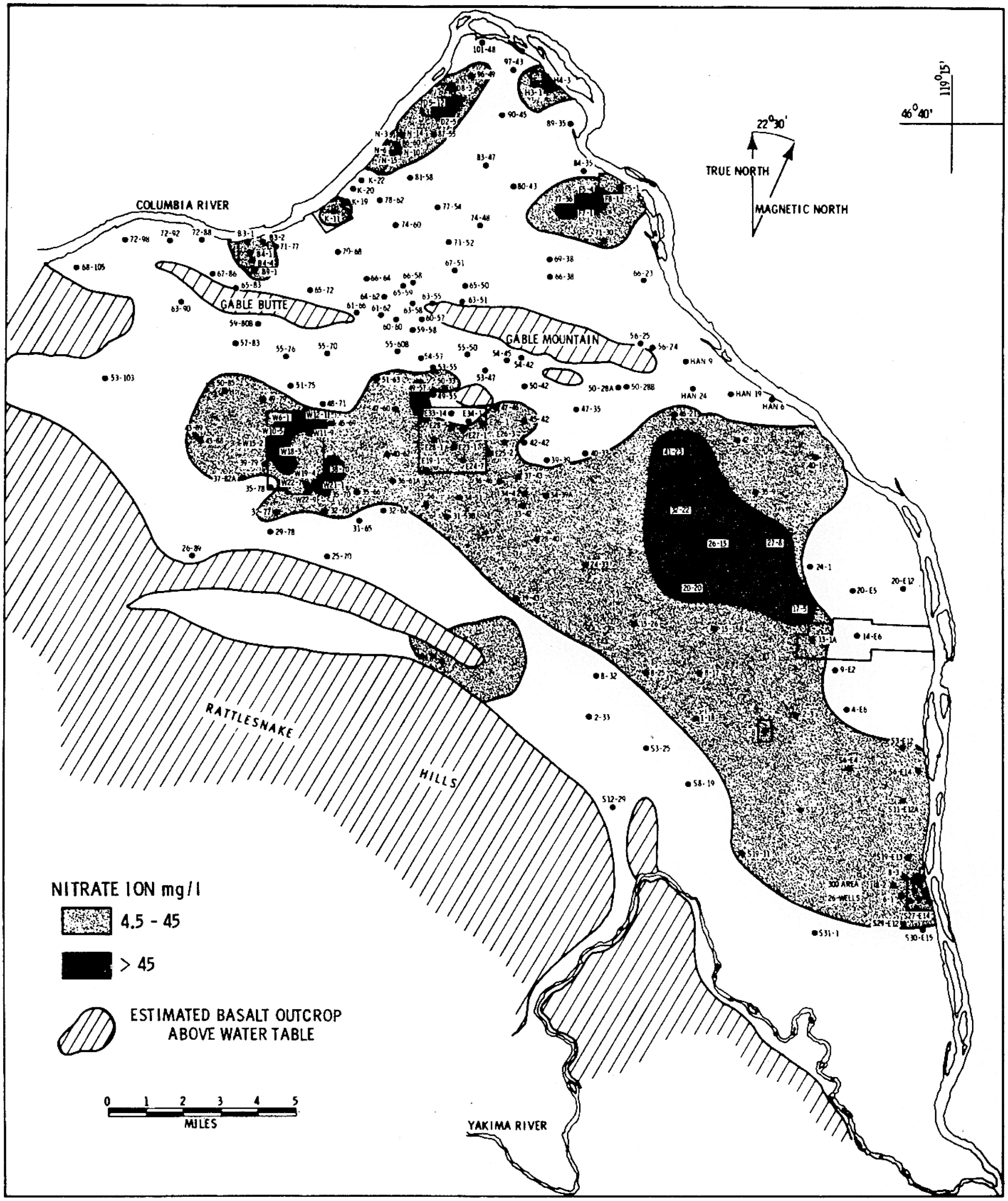


Columbia Generating Station Final Safety Analysis Report	Hanford Reservation Water Table Map (January 1944)		
	Draw. No. 020361.07	Rev.	Figure 2.4-20



HYDRAULIC CONDUCTIVITY ISOPETHS IN FEET PER DAY
SOURCE: PLATE III-5 FROM REFERENCE 2.4-39

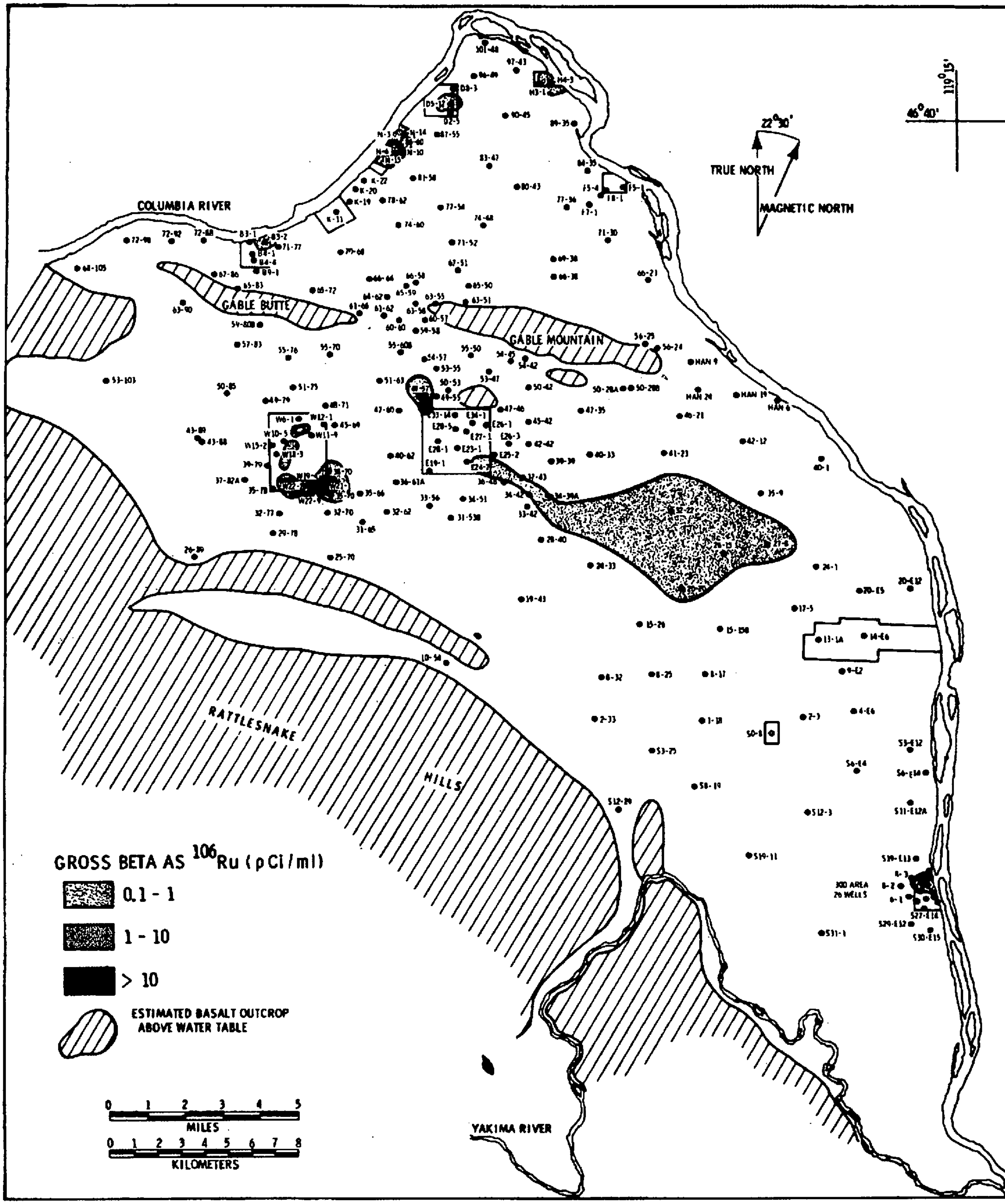
Columbia Generating Station Final Safety Analysis Report	Hydraulic Conductivities in the Unconfined Aquifer		
	Draw. No. 020361.08	Rev.	Figure 2.4-21



Columbia Generating Station
Final Safety Analysis Report

Nitrate (NO3) Concentrations (December 1976)

Draw. No. 020361.09	Rev.	Figure 2.4-22



Columbia Generating Station Final Safety Analysis Report	Gross Beta Concentrations (December 1976)		
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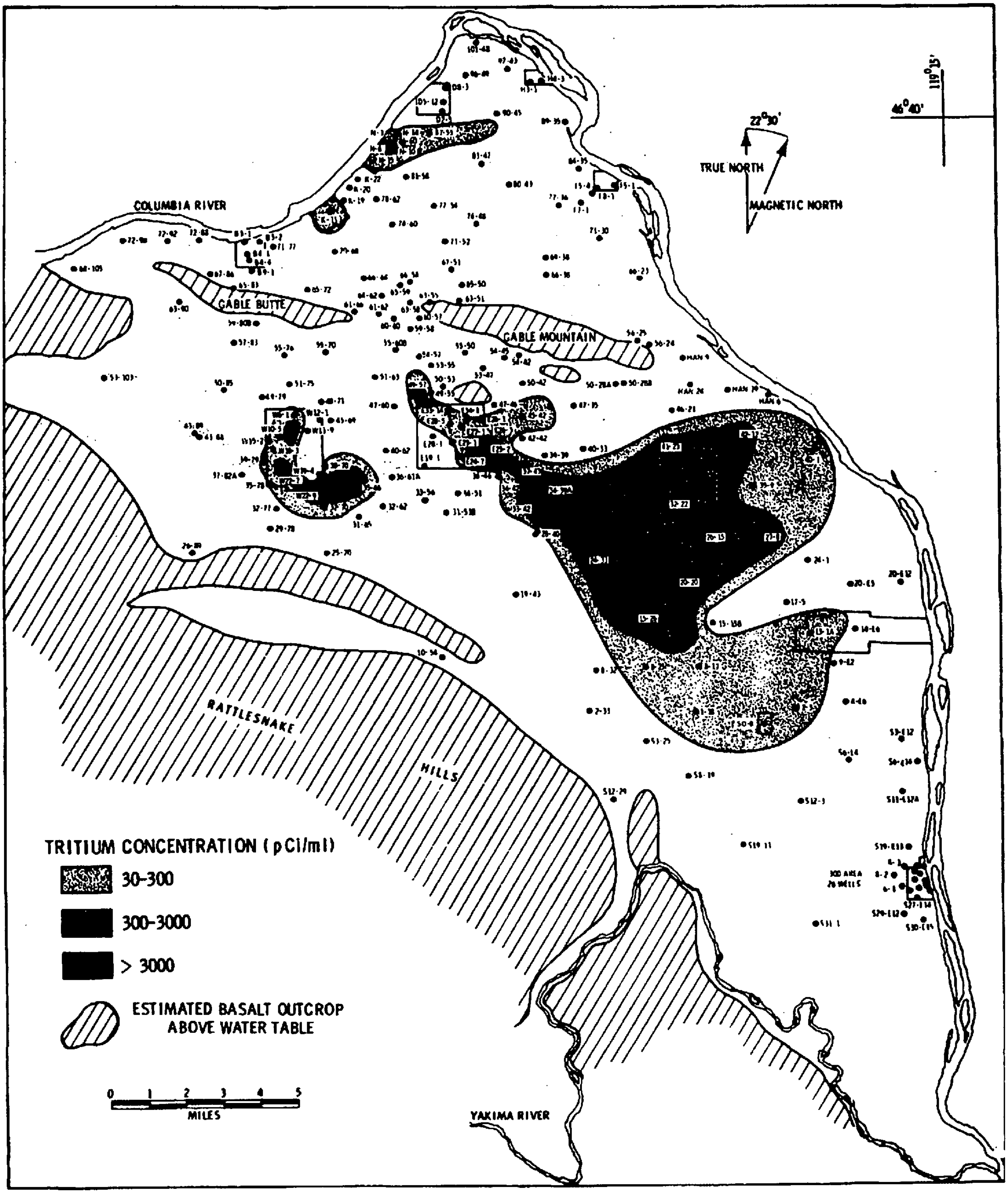
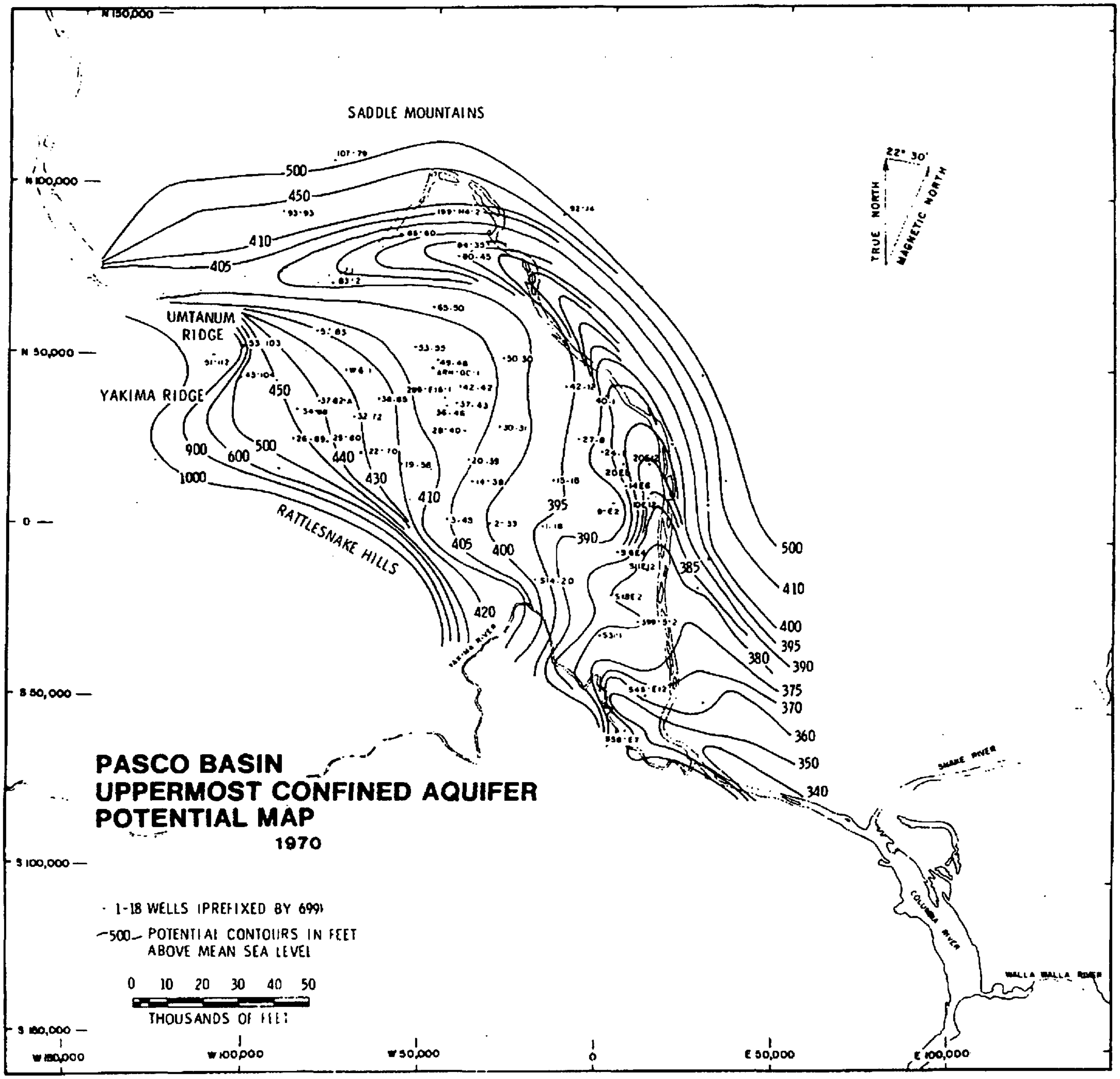
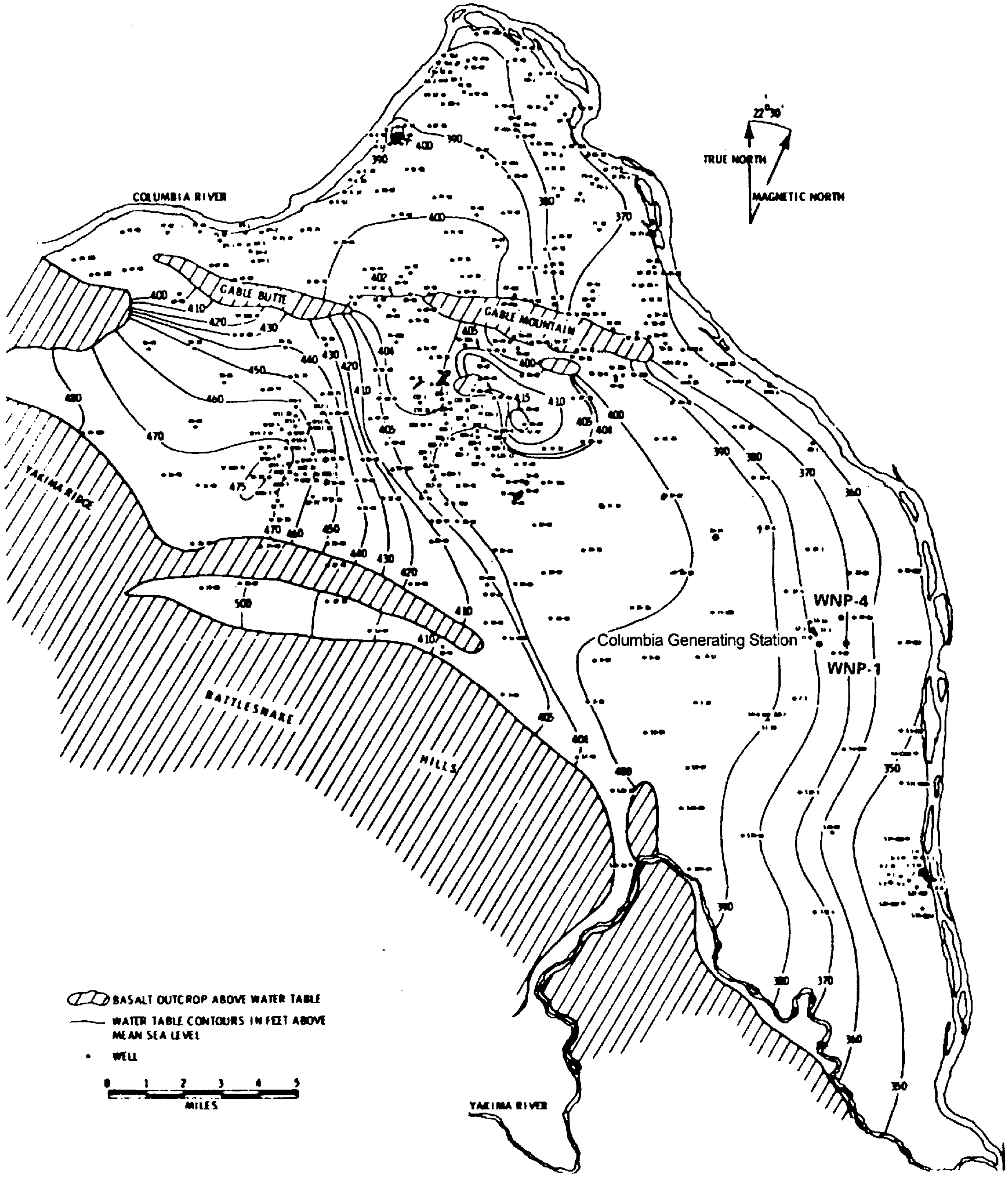


Tritium (^{3}H) Concentrations (December 1976)



Columbia Generating Station Final Safety Analysis Report	Pasco Basin Uppermost Confined Aquifer Potential Map (1970)		
	Draw. No. 020361.12	Rev.	Figure 2.4-25



Columbia Generating Station Final Safety Analysis Report	Hanford Reservation Water Table Map (September 1973)		
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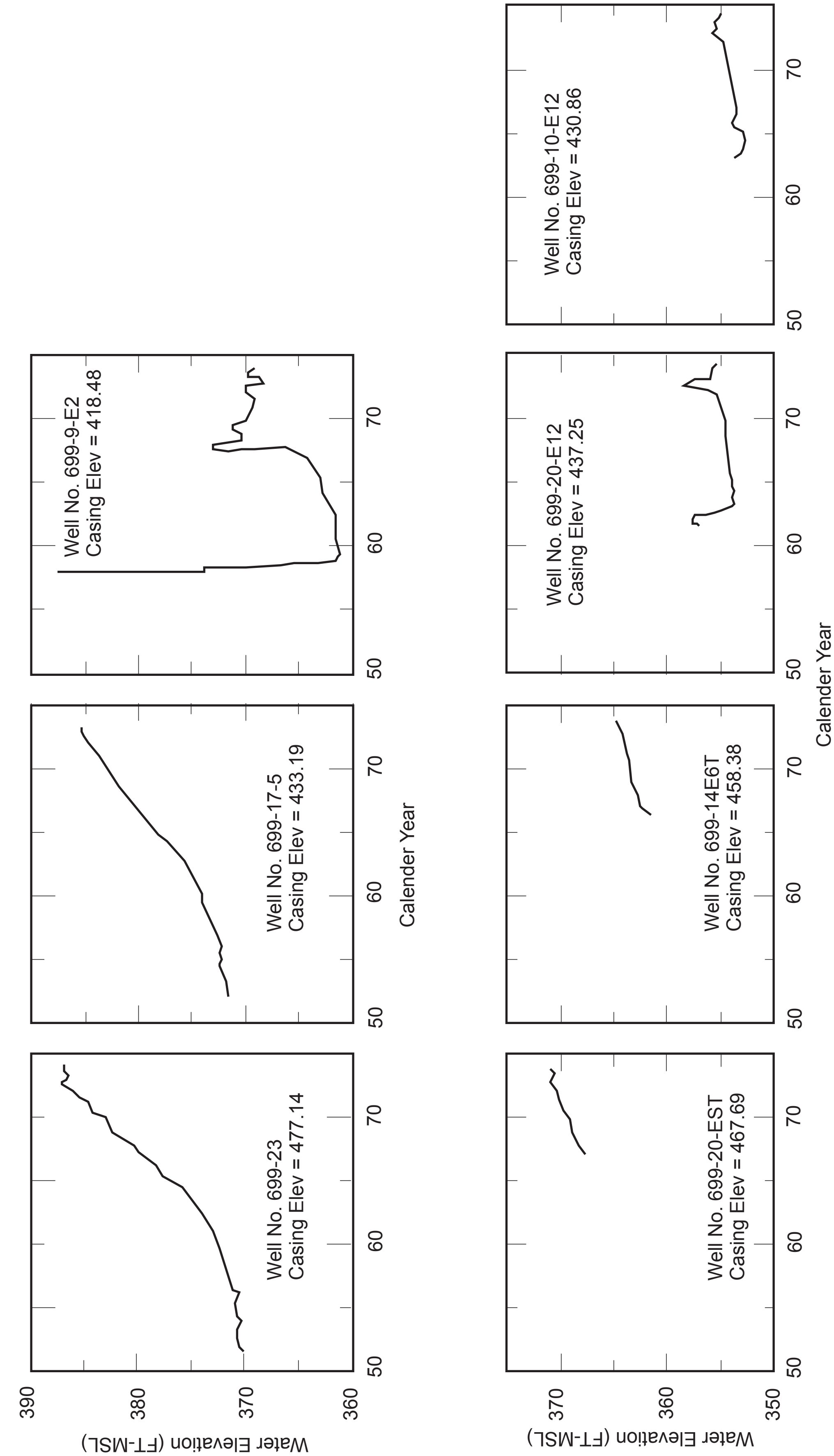

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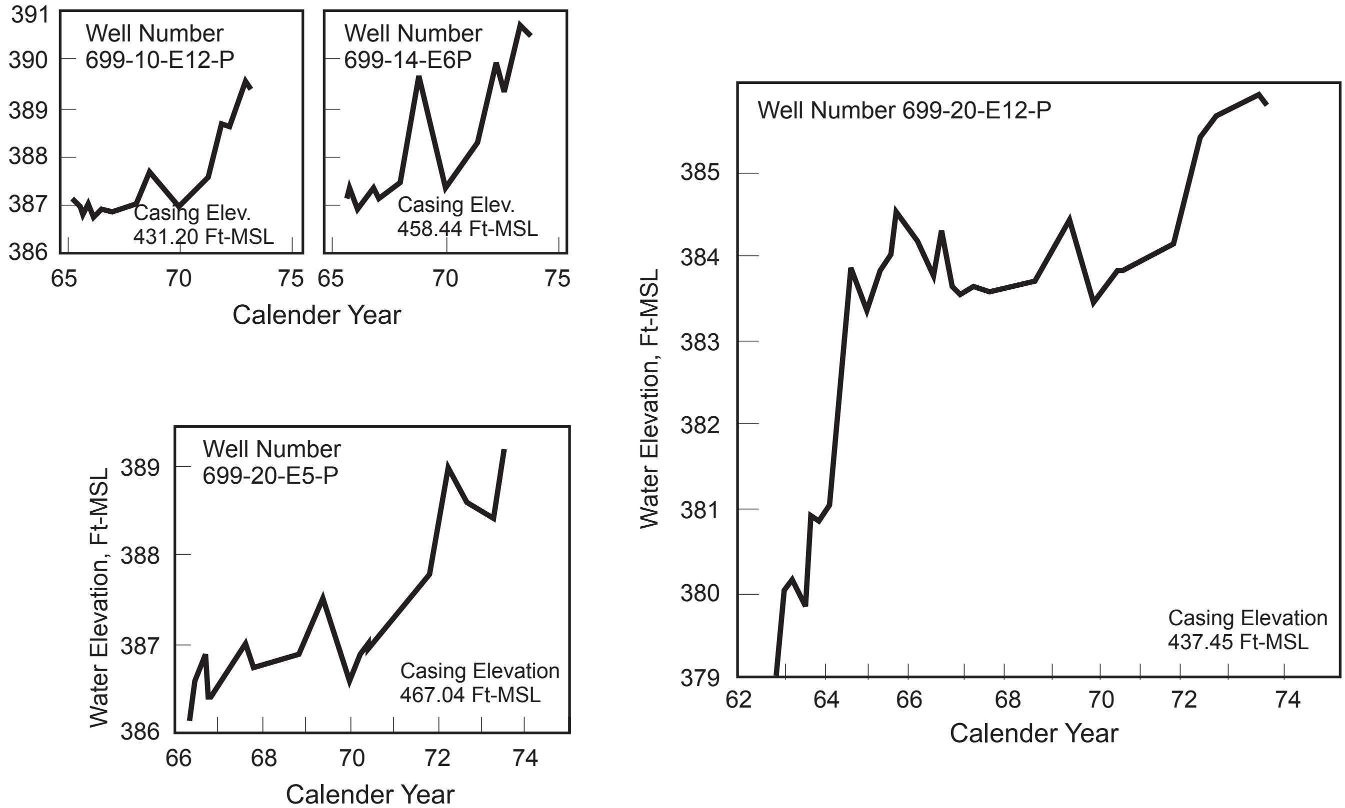
Well Hydrographs

Draw. No.	Rev.	Figure
990306.09		2.4-27.1



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Draw. No. 990306.39 | Rev. | Figure 2.4-27.2

2.5 GEOLOGY, SEISMOLOGY, AND GEOTECHNICAL ENGINEERING

The information discussing the geology, seismology, and geotechnical engineering is contained in a technical memorandum, TM-2143, "Geology, Seismology, and Geotechnical Engineering Report." This report is incorporated by reference into the FSAR and as such is subject to the same controls as the FSAR.