SKAGIT/HANFORD NUCLEAR PROJECT

Application for Site Certification/ Environmental Report

PUGET POWER

Volume 2

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CHAPTER 4.0

ENVIRONMENTAL EFFECTS OF SITE PREPARATION, PLANT AND TRANSMISSION FACILITIES CONSTRUCTION

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ENVIRONMENTAL EFFECTS OF SITE PREPARATION, PLANT AND TRANSMISSION FACILITIES CONSTRUCTION

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ENVIRONMENTAL EFFECTS OF SITE PREPARATION, PLANT AND TRANSMISSION FACILITIES CONSTRUCTION

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CHAPTER 4.0 ENVIRONMENTAL EFFECTS OF SITE PREPARATION, PLANT AND TRANSMISSION FACILITIES CONSTRUCTION

4.1 SITE PREPARATION AND PLANT CONSTRUCTION

The Skagit/Hanford Nuclear Project will be jointly owned by Puget Sound Power & Light Company (Puget), Pacific Power & Light Company, Portland General Electric Company and The Washington Water Power Company. Puget, as the Project sponsor, retains overall responsibility for the design, construction and operation of the Project.

For the Skagit/Hanford Nuclear Project, the Northwest Energy Services Company (NESCO) has the responsibility to perform Project management services and Bechtel Power Corporation (Bechtel) has been selected to perform the architect/engineer, procurement and construction management services. General Electric Company (GE) will design, fabricate and deliver the nuclear steam supply system (NSSS) and nuclear fuel sufficient for the initial core loading. Westinghouse Corporation will design, fabricate and deliver the turbine generator and its auxiliaries. Puget will retain full responsibility for the functional performance of the design of all systems in the Plant. Puget plans to perform startup and testing with Puget employees with technical assistance from GE, Bechtel and NESCO. 4

The Puget Vice President, Generation Resources, reports to the Senior Vice President, Operations, who reports to the President and Chief Executive Officer. The Vice President, Generation Resources, assigns responsibilities to various Puget organizations for the S/HNP.

The Puget Manager, Quality Assurance, is responsible for providing the programmatic directions, and administering policies, goals, objectives and methods which are described in the Puget QA Program. The Puget QA Program describes specific controls to be established by Puget, NESCO and the major contractors on the S/HNP. The Manager, Quality Assurance, reports on all technical and administrative matters directly to the Vice President, Generation Resources. This organizational arrangement provides independence from cost and scheduling influences.

The Puget Director, Environmental and Resource Services, reports to the Vice President, Generation Resources, and is responsible for acquisition of local, State, and Federal permits and approvals; review of PSAR and ER; development and implementation of the environmental program for

construction and operation; and monitoring of compliance with licensing commitments.

The Puget Director, Nuclear Projects, reports to the Vice President, Generaton Resources, and is responsible for coordinating all internal and external matters pertaining to the S/HNP.

The NESCO Director, Quality Assurance, is responsible for providing the programmatic direction, and administering policies, goals, objectives and methods as described in the NESCO QA Program. The NESCO QA Program will interface with the Puget QA Program objectives. This plan will describe the specific QA controls to be established by NESCO and the major contractors on the S/HNP to meet the requirements of the Puget QA Program. The Director, Quality Assurance, reports on all technical and administrative matters directly to the President of NESCO. This organizational arrangement provides independence from cost and scheduling influences.

The NESCO Principal Engineer is responsible for overseeing, coordinating and administering the NESCO Project Engineering effort. Responsibilities of Project Engineering include management of the engineering interface with Bechtel and major equipment suppliers.

The NESCO Manager, Nuclear Licensing and Safety (NL&S), is responsible for licensing of the S/HNP, for ensuring compliance with all licensing commitments. The Manager, NL&S, is responsible for the review of the Project design, construction procedures and schedules for consistency with commitments, obligations, licenses, permits and authorizations, and for review of unreviewed safety questions. The Manager, NL&S, is also responsible for review and identification of important experiences and feedback of pertinent information to those responsible for designing and constructing the S/HNP. 4

The NESCO Site Construction Manager, is responsible for on-Site construction management oversight and maintaining on-Site liaison between NESCO, Bechtel Construction Management and the other Principal Contractors, GE and Westinghouse.

Additional details of the organizational structure for construction management of the S/HNP are provided in S/HNP PSAR Chapter 13.

The S/HNP is compatible with the present and expected future uses of the Hanford Reservation planned by the U.S. Department of Energy (DOE). Since 1943 nine plutonium production reactors and the Fast Flux Test Facility have

been constructed at the Hanford Reservation. Presently Washington Public Power Supply System (Supply System) Nuclear Projects No. 1, 2, and 4 are under construction.

The principal areas of construction activity on the S/HNP Site are shown in Figures 4.1-1 and 4.1-2. The land area and acreages to be disturbed during construction are listed in Table 4.1-1.

An S/HNP construction schedule is shown in Figure 4.1-3. Site preparation for the S/HNP is presently scheduled to begin in 1983, with the first unit complete and operational by 1991. Construction, completion, and operation of the second unit will follow the first by approximately two years. Table 4.1-2 is an estimate of the S/HNP Units 1 and 2 construction work force. Figure 4.1-4 shows total manual manpower requirements by craft during construction for both units.

The impact of construction on the sagebrush-bitterbrush ecosystem will be primarily confined to the acres converted from biological productivity uses, eg, buildings, paved parking lots, outdoor storage, roadways, switchyards, etc. This change in land use is expected to result in the displacement or loss of a few birds, mammals, and reptiles, and the loss of net aboveground primary productivity of about 1,000 lbs of dry matter per acre per year. None of the lost or displaced animal species is considered to be rare, threatened or endangered by the U.S. Fish and Wildlife Service. The converted acres have no ecological features to suggest that they have unusually significant value as breeding grounds, or unusual significance in migration pathways or production of unusual or significant food items as compared to adjacent acres. 4

Bared soil can be expected to create local areas of dust at any time of the year. Most of the discomfort will be borne by construction workers since the Site is remote from residential populations.

Construction traffic is expected to cause some road kills of jackrabbits, reptiles and birds. It is also expected that a few deer will be killed by traffic, particularly night-time traffic.

Many years of experience and much data concerning the effects of construction on the environment and the ecology of the area are available and have been considered in Site construction planning.

4.1.1 LAND USE

Much of the area within a 15 mile radius of the S/HNP can be described as sparsely populated, with the exception of Richland which has a population of 28,500 and which is part of an area of urbanization which begins about 10 miles south of the Site. It is estimated that the Tri-Cities area (Kennewick-Pasco-Richland) includes 35 percent of the total population within 50 miles. There is no resident population within 5 miles of the Site. Thus, there will be no significant adverse effect on the general public attributable to the construction activities.

Existing conditions at the Site have been thoroughly investigated and recorded. Geologic, geophysical and soil investigations have been performed.

The construction program is expected to encompass approximately 7 years for each unit. During this period the problems of dust, noise, and other effects of the high level of activity attendent to any major construction site will be evident. At the conclusion of construction, restoration programs are planned to return those areas not landscaped or utilized for other activities essentially to their natural conditions.

Highways, railroads and communications already exist on the Hanford Reservation. However, 4 miles of access railroad will be constructed to current Department of Energy standards to move materials and equipment to the Site during construction and to transport fuel and other materials after the S/HNP is in operation. Maintenance for the railroad facilities will be provided by the Department of Energy. Rail transportation will consume less fossil fuel than truck transportation, and will reduce truck traffic. Railroad shipments will be delivered to the Hanford Reservation by Burlington Northern Railroad. These shipments will be delivered to the S/HNP by DOE-owned railroad equipment. 4

As shown on Figure 2.1-3, two Site access roads, the North Access and the Preferred South Access totaling 5.5 miles will be constructed to current Washington State Department of Transportation standards for Primary Highways. The North Access will be constructed from the northeast corner of the Site to Route 10 and the Preferred South Access will be constructed from the southwest corner of the Site to State Route 240. In order to avoid impacting traffic density on Route 4, the Preferred South Access will be used for construction workforce access to and from the Site. Maintenance for the two Site access roads will be provided

by Puget or the Department of Energy. An alternate access road, the Alternate South Access, from the southeast corner of the Site to Route 10, was considered for construction workforce access, but was rejected because of higher construction costs, greater environmental impact and less desirable traffic patterns.

In addition to these Site access roads, Puget is considering improvements to State Route 240 from its intersection with the Preferred South Access to the Bypass Highway and intersection improvements on the Bypass Highway.

The road system in the Tri-Cities area has proven capable of handling traffic during the previous large construction projects on the Hanford Reservation and will adequately serve the S/HNP.

Because access to the Site is controlled, recreational opportunities do not normally exist at or near the Site. While the river is open to the general public up to approximately 8 miles north of the Site, public use of land areas within the perimeters of the S/HNP Site will be nonexistent. On the average, 1,500 to 2,000 people presently visit the Supply System Hanford Generating Plant No. 1 each year. Each visitor is badged and escorted and appointments are required. Identification badges will be issued to all regularly assigned Puget personnel and contractor personnel.

Earthwork, involving excavation and fill activities, will begin after clearing and grubbing. Calculations indicate that the excavation and fill volumes will be approximately balanced. Excess excavated material will be disposed of in the spoils area located within the Site Boundary south of the principal Plant structures. Because the soil in the Site area is porous, no significant runoff is expected. It is expected that all refuse or debris will be transported to a disposal area and covered with earth backfill; however, if permitted, some construction debris may be burned. 4

Blasting for excavation work is not anticipated at the S/HNP. Should blasting be required it will be in accordance with the Guides and Specifications for Military and Civil Works Construction, CE-203.

Final yard grading, roads and landscaping to enhance the appearance of the Plant will be completed at the end of the construction period of each unit.

A batch type concrete mix plant will be erected on the Site with storage piles for gravel, sand and cement.

Approximately 445,000 yds^3 of concrete is required for the S/HNP. Gravel and sand will be obtained from gravel pits located in Sections 22 and 27 of T13N R27E. Existing rail facilities may be used to transport the sand and gravel to the S/HNP Site. Stone crushing equipment, conveyors, graders and loaders will be used in the gravel pits. Stockpiles of sand and gravel will be provided for a one-month supply. 4

Cement will be delivered to the Site in bulk in water-tight carriers and unloaded by weather-tight conveyors into dry, weather-tight storage bins which are properly vented.

Construction water will be supplied from the Columbia River via a temporary intake, and the permanent S/HNP discharge line which will be installed early to serve this purpose. Prior to installation of the temporary intake, construction water will be supplied via tank truck. No ground water will be used during the construction of the S/HNP. See Appendix K for additional information on the temporary water intake. 5

Construction power will be supplied from the BPA 115 kV system. A portion of the two lines that will serve as the power supply for the river pumps will be constructed early to supply construction power for the Site.

During the initial phase of construction, chemical toilets will be provided and serviced by a contractor. These toilets do not use an external water supply, nor do they discharge any liquids or solids. The units are self-contained, unbreakable, and leak resistant. The waste from the toilets will be disposed of off-Site by a licensed sanitary disposal contractor. The package sewage treatment plant described in Section 3.7.1.1 will be installed during the initial stages of construction and used to process the majority of the construction sanitary waste. Chemical toilets will continue to be provided for outlying areas. 4

Drinking fountains will flow to French drains and percolate into the sandy soil. Waste flow from all sanitary and drinking facilities is estimated at 13.5 gallons per day per person.

Chemicals from initial cleaning of installed piping systems and equipment will be discharged to a disposal pit in the vicinity of the Plant. Measures will be taken to prevent chemicals from being dispersed by wind.

The S/HNP Site location is well within the boundary of the Hanford Reservation so that the nearest inhabited area is more than seven miles away from the proposed construction

activities. Industrial facilities in proximity to the proposed construction site are the FFTF and WNP-2 (approximately 5 miles away), and WNP-1/4 (over 5 miles away). 4

Because the S/HNP Site is remote from residential areas, highways, and other human activities, it is expected that off-Site impacts of noise, dust, odor or other emission from construction activities will not present an adverse impact to the local population.

Noise measurements made adjacent to the WNP-2 project during construction (see Section 2.7) indicate that the noise levels at off-Reservation locations are well below the measured ambient levels. This was verified by observations during the testing period during which construction noises were heard only at the three locations adjacent to the WNP-2 site.

Workers on the construction site will be exposed to the normal levels of noise associated with a major conatruction project.

There is a possibility of some noise annoyance to the population in the Tri-Cities area (Richland-Kennewick-Pasco) resulting from the movement of trucks to and from the Site during construction. This effect, if any, will be felt primarily in North Richland, and will decrease with distance from the Hanford Reservation.

Construction noise will be prevalent, particularly during the operation of heavy equipment during excavation. Ear protection will be used if required.

One archaeological site is known to be located within the S/HNP Site. This site has been recorded and collected and is discussed in Section 2.6. This site will not be disturbed. An archaeologist will be retained to inspect the Site during the excavation phase and report on the uncovering of any potential archaeological or historical sites. In addition, the consulting archaeologist will recommend means to preserve or interpret any historical or archaeological sites or artifacts uncovered. 4

The primary impact on vegetation will be the direct loss of vegetation from the clearing and excavation required for construction of the S/HNP and associated access roads, railroad, parking, water supply and discharge pipelines, raw water pumphouse, and transmission facilities. Disturbance of some of the construction area will be temporary and vegetation will grow on these areas after the disturbance has ceased. Vegetation loss will be permanent on the remainder of the construction area. The total number of acres on which the vegetation is expected to be disturbed is listed in Table 4.1-1.

The vegetation community types found on the Site and Associated Areas (Section 2.2.1) are common in the Columbia Basin. The area to be disturbed by construction represents less than one tenth of one percent of the Hanford Reservation. Since additional area outside the Hanford Reservation is occupied by each of the vegetation types to be disturbed, the regional impact of the vegetation loss is negligible.

About one acre of riparian vegetation near the intake/discharge location will be disturbed. It is located within an area in which a population of the proposed threatened species Rorippa calycina var. columbiae was found (Section 2.2.1.7). Based on field reconnaissance (see Section 2.2.1), it is probable that the population of Rorippa extends for some distance up and down the river from this location. Although this population might be temporarily reduced by construction activities it should not be threatened by this disturbance.

Two types of wildlife impacts will occur as a result of the S/HNP: habitat loss, and habitat disturbance. Habitat loss occurs when viable wildlife habitat is converted to an area unsuitable for wildlife habitation. Habitat disturbance occurs when: (1) areas are only partially developed such that some wildlife habitat still exists through revegetation or habitat protection, or (2) local wildlife populations are disturbed by increased human activity and noise associated with nearby construction.

The major wildlife habitat loss associated with the S/HNP construction will be approximately 500 hectares of sagebrush-bitterbrush/cheatgrass and sagebrush/cheatgrass habitat within the Site Boundary. The important wildlife species most affected by this loss include: pocket mice, black-tailed hare, badger, mule deer, sage sparrow, horned lark, meadowlark, white-crowned sparrow, loggerhead shrike, long-billed curlew, and burrowing owl. 4

Animals inhabiting this area will attempt to relocate in adjacent areas with similar habitat features. This relocation will be limited by the carrying capacity of the adjacent areas, and in some cases may not be possible. Some animals, such as small mammals and reptiles, will undoubtedly be destroyed during Site preparation.

The major areas of habitat disturbance within the S/HNP Site and Associated Areas are the transmission corridor (see Section 4.2), pipeline corridor, access road corridors and railroad corridor. Typical types of disturbances include increased human activity, noise and operation of construction equipment, dust, and temporary placement of

construction materials and equipment. These impacts primarily occur during construction and greatly subside thereafter. Wildlife species most affected by habitat disturbance include nesting raptors and long-billed curlews, and mule deer during the fawning season. These species have known breeding areas within the Site and Associated Areas.

The old Hanford townsite is an area of special concern. This area supports many nesting raptors and provides valuable fawning habitat for mule deer. The intake/discharge pipelines construction activities in the townsite will temporarily affect the wildlife ecology of this area. A reduction in the breeding activity of these species at the townsite is anticipated during the construction period; however, breeding activity is expected to regain preconstruction levels soon thereafter. Construction activities in this area will be scheduled to minimize disturbance to these species.

Three pairs of nesting long-billed curlews were found within the S/HNP Site and the railroad access corridor. No significant impacts upon the Hanford population are anticipated. Little data exists to predict how these birds will react to construction activities. They probably will avoid construction areas and nest away from such activity, thus developing a buffer zone to protect their young.

4.1.2 WATER 4

The primary effects of S/HNP construction on aquatic resources will be associated with construction of the intake and discharge systems at River Mile 361.5. The intake will be a series of finely screened inlets placed just above the river bottom 750 ft offshore at low flow conditions. Three pipes running along the bottom will connect the inlet sections to an on-shore pumphouse set back approximately 200 ft from the river bank. The discharge pipe will parallel the intake pipes along the river bottom, terminating in a single point discharge approximately 100 ft downstream and 200 ft closer to shore than the screened inlet sections (Figure 3.4-3).

A clamshell bucket or similar equipment will be used for trenching and placing, and bedding and anchoring the pipelines with riprap. Approximately 65,000 yds^3 will be excavated below the high waterline. No coffer dams or channel improvements are planned during construction.

Increases in suspended and settleable materials from excavation and backfill activities may affect water quality in several ways. Materials carried in suspension may create turbid waters with a subsequent reduction in light penetration. Microbial decomposition of organic materials associated with suspended sediments could impose a short-term oxygen demand and thereby decrease dissolved oxygen levels downstream. However, organic content of Hanford Reach bottom sediment is low. The material is mostly mineral, and any increased oxygen demand resulting from suspended sediments would be minimal. Suspended materials may also release or absorb dissolved substances affecting pH, nutrients, trace metals and pesticide concentrations in the water (Ref 1).

Studies performed by Page (Ref 2) on excavation operations in the Hanford Reach indicate that elevated levels of suspended solid concentrations were infrequently observed 500 ft downstream from the construction site during excavation. Deposition of settleable material reduced numbers of periphyton and macroinvertebrates for about 500 ft downstream, however, there were no observable effects on these organisms 2000 ft downstream from construction. The impacts were expected to be transient and the affected area represented approximately 13 percent of the river cross-section.

Since the nearest known salmon spawning area is 7.5 miles downstream, no siltation or oxygen effects on redds are expected from construction. Seasonal and procedural constraints on construction of the intake and discharge facilities will comply with terms of the Site Certification Agreement with the State of Washington Energy Facility Site Evaluation Council (EFSEC). 4

The raw water pumphouse construction is at an on-shore location and will not adversely affect river conditions. The riverbank at RM 361.5 is considered stable and slope protection requirements are not anticipated. During excavation a dewatering system will discharge water into a nearby filtration pond. The local groundwater elevation will be temporarily lowered during dewatering operations. No groundwater users are within the proposed zone of influence. The pumphouse operating floor will be above the Standard Regulated Project Flood elevation.

The Site is located in a shrub steppe region consisting of several shallow rolling hills, with the eastern extremity having a general slope to the river. Surface drainage is good. Due to the open and dry nature of the area (average rainfall is 6.25 in./yr) and sandy granular soil type, precipitation readily infiltrates into the soil and is not

expected to increase runoff volumes from the Site. There are no storm sewers included in the Plant design. Runoff from a severe storm will be controlled by grading away from the power block area and by constructing ditches. During construction, contractors will be required to maintain drainage and erosion control around construction areas and especially in areas of excavation or fill. Dewatering is not expected to be necessary because the water table is below any anticipated excavation point. 4

References for Section 4.1

1. A. J. Cordone and D. W. Kelly, "The Influences of Inorganic Sediment on the Aquatic Life of Streams," California Fish and Game, 47, (2), (1961). 4

2. T. L. Page, Sedimentation and Turbidity Effects From Excavation in the Columbia River at WNP-2, August Through October 1975, Battelle, Pacific Northwest Laboratories, Richland, WA (August 1976).

TABLE 4.1-1

LAND DISTURBED BY S/EMP CONSTRUCTION

Description	Approximate acres
Site	
Permanent S/EMP facilities (Section 2.1)	60
Temporary construction and laydown area	880
Borrow and spoils area	260
Associated Areas*	
Access railroad	80
Access roads	100
S/EMP intake and discharge pipelines	200
Transmission	190
Total	1770

*Assumes the entire easement area and an additional construction zone are distrubed.

4

TABLE 4.1-2

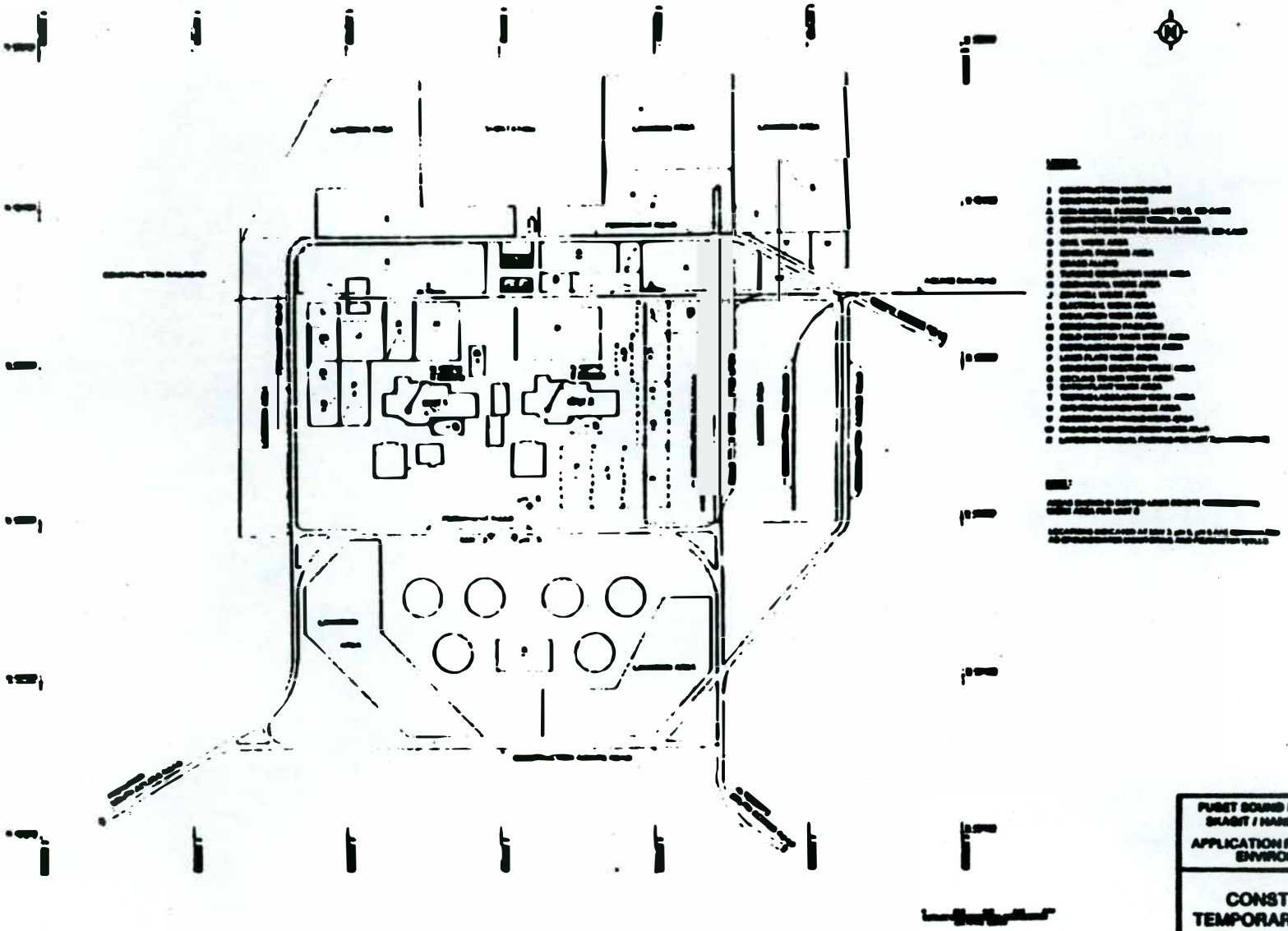
ESTIMATED FIELD CONSTRUCTION PERSONNEL
Unit 1, ~~2 & Common~~

Year	Manual	Bechtel Non-Manual	NESCO Non-Manual	Security	Puget O & M	Total
1983(1)	500	50	13	6	2	571
1984	1,085	125	17	26	4	1,257
1985	2,005	175	22	34	6	2,242
1986	3,020	250	28	66	9	3,373
1987	3,810	330	28	90	29	4,287
1988	4,035	380	31	116	55	4,617
1989	3,450	405	33	116	104	4,108
1990	2,075	330	28	116	168	2,717
1991(2)	1,155	212	19	116	175	1,677
1992	200	87	19	116	179	601
1993(3)				116	179	295

4

NOTE:

(1) Start of Construction - 1/83
(2) Commercial Operation Unit 1 - 1/91
(3) Commercial Operation Unit 2 - 1/93



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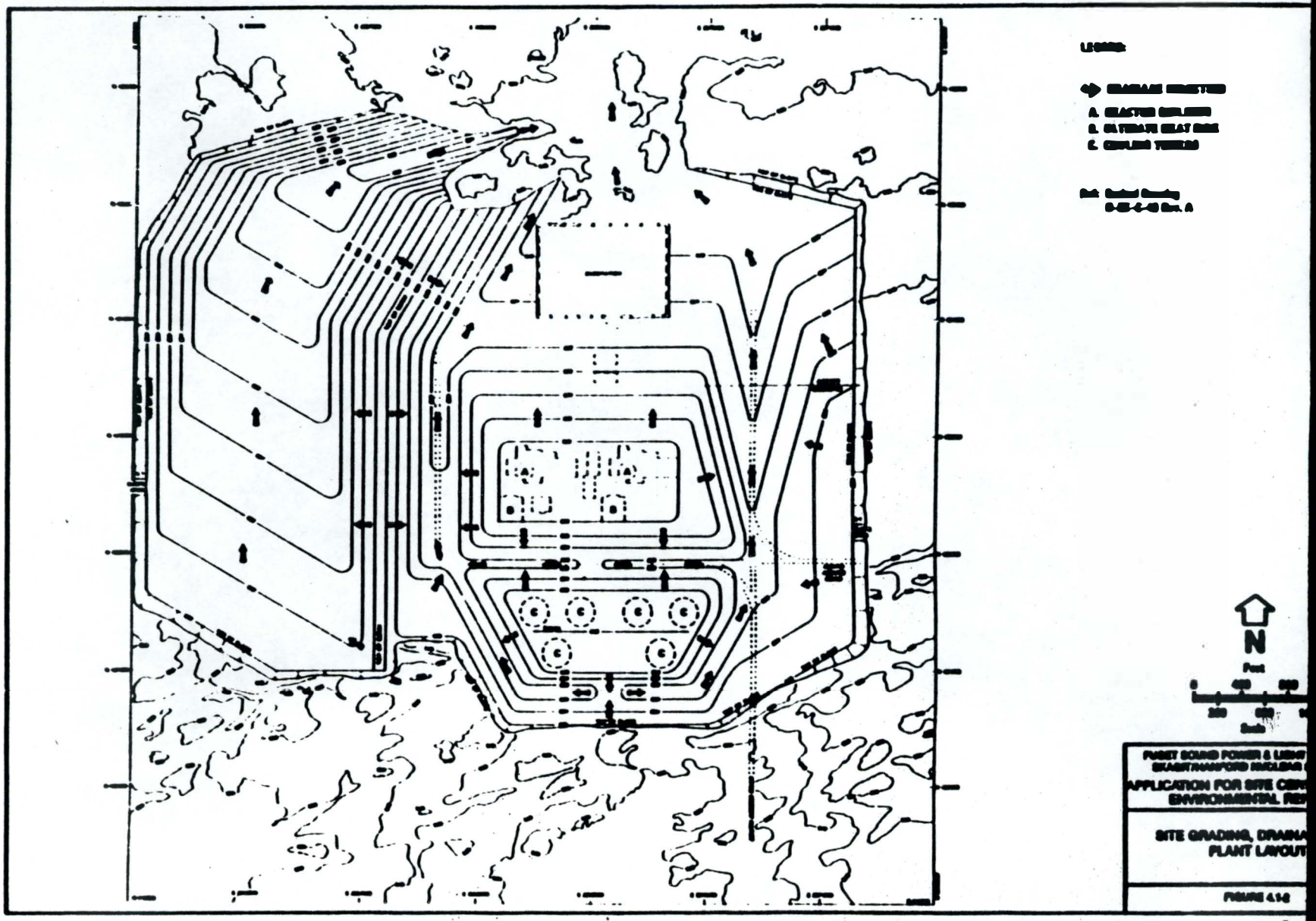
APPLICATION FOR SITE CERTIF
ENVIRONMENTAL REPO

CONSTRUCTION A
TEMPORARY SITE FAC

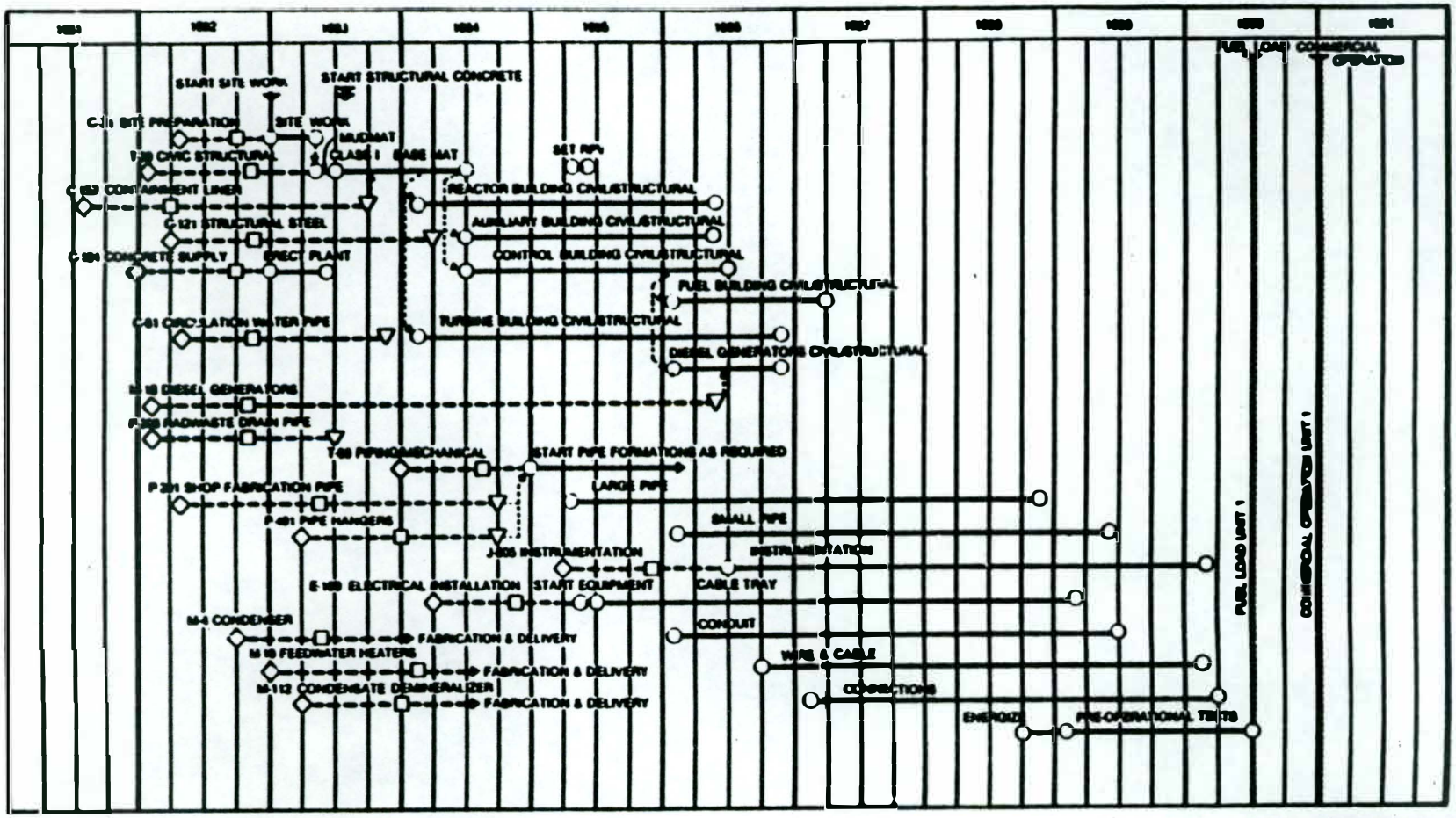
FIGURE 4.1-1



PUGET SOUND POWER & LIGHT
SKAGIT/HANFORD NUCLEAR
APPLICATION FOR SITE CER
ENVIRONMENTAL REP

SITE GRADING, DRAINA
PLANT LAYOUT

FIGURE 4.1-2



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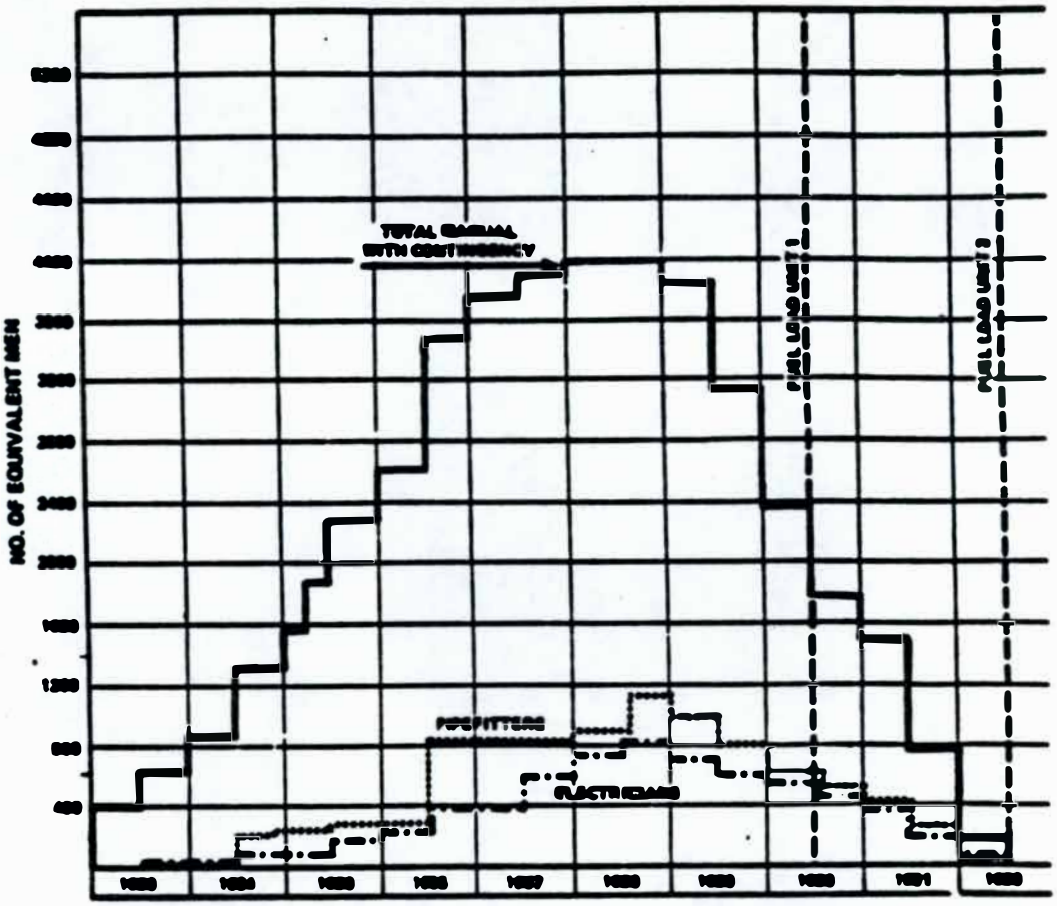
APPLICATION FOR SITE CERTIFICAT
ENVIRONMENTAL REPORT

S/HNP MILESTONE SCHED
UNIT 1 AND COMMON

FIGURE 4.1-6

Amendm



PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT

APPLICATION FOR SITE CERTIFICATION/
ENVIRONMENTAL REPORT

MANUAL MANPOWER
REQUIREMENTS
TOTAL UNITS 1, 2 & COMMON

FIGURE 4.1-4

4.2 TRANSMISSION FACILITIES CONSTRUCTION

This section discusses the environmental effects of construction of the new S/HNP transmission system and the BPA Ashe-Hanford No. 2 transmission line. 4 5

4.2.1 RIGHT-OF-WAY AND THE SUBSTATION CLEARING

Sagebrush will be removed from a 400 square foot area at each 500-kV tower location and on the access roads. The total affected area, including tower locations, access roads, and lay-down areas, will amount to less than 50 acres for the S/HNP lines and 75 acres for the BPA Ashe-Hanford No. 2 line. Grass and other vegetation will be left growing on all portions of the right-of-way (ROW) to the extent possible. 4 5

Clearing for the S/HNP Substation will remove approximately 19 acres of sagebrush-bitterbrush/cheatgrass vegetation and associated wildlife habitat. Because the Site is essentially level except for some microrelief, only minimal grading will be required. Clearing, when necessary, will be done by bulldozer; chemical spraying will not be used.

Mitigation measures that will be employed during construction can be found in the BPA General Construction and Maintenance Program Statement (Ref 1). 4

Because the transmission system (Figure 4.2-1) will not cross any water bodies, aquatic systems will not be impacted.

Distribution lines, that will supply 69-kV power to the pumping plant during operation and 115-kV power during construction, will follow the intake/discharge pipeline route and utilize armless construction (Figure 4.2-2). Bird collisions are not expected to be a problem during construction, because they have not been reported for similar facilities on the Hanford Reservation.

A new access road will be built along the entire 3.2-mile 500-kV line ROW, with short spur roads to individual tower locations. Because the BPA Ashe-Hanford No. 2 route follows an existing right-of-way, the existing access road along this right-of-way will be used with short spur roads developed to each of the new tower locations. 5

4.2.2 EROSION

The wind erosion potential of sandy loam soil in a dry climate like that of the Hanford Reservation is extremely high. When vegetative cover is removed and soil is disturbed, wind erosion can be severe, as evidenced by the 4

blowouts, dunes and other wind-produced features found widely scattered across the area. To minimize wind erosion resulting from transmission system construction, existing roads will be utilized whenever possible. Because well-gravelled roads are more stable, gravel will be placed on the new access road. Spur roads will not be graded unless absolutely necessary. Temporary access roads and tower based locations will be replanted with grass to prevent wind erosion.

The transmission system does not cross any streams or rivers and the water table of the Hanford Reservation is well below ground level. Therefore, construction activities will have no effect on the local water quality.

4.2.3 LOSS OF AGRICULTURAL PRODUCTIVITY

The transmission system will be entirely within the boundaries of the Hanford Reservation. All of the land is a shrub steppe with no other productive (agricultural and other) uses planned by DOE.

4.2.4 FISH AND WILDLIFE, THREATENED AND ENDANGERED SPECIES

Adverse effects upon resident wildlife will be largely limited to the construction period. The route does not cross any streams; therefore, aquatic life will not be affected. 4

Due to clearing of vegetation from the access road and tower locations, wildlife (eg, small and large mammals, songbirds, birds of prey, and upland birds) in the vicinity will be temporarily disturbed and some habitat will be lost.

Species of concern, such as the Long-billed Curlew, could be disturbed slightly during the construction of the transmission system. However, these disturbances would be of a temporary nature and probably would not have any lasting effect.

Two federally listed threatened or endangered animal species, the bald eagle and the peregrine falcon, are known to occur at the Hanford Reservation (see Section 2.2.1.7). Construction of the transmission system is not expected to affect these species.

4.2.5 NOISE

Due to the isolation of the transmission system, noise resulting from construction activities should not impact the general public.

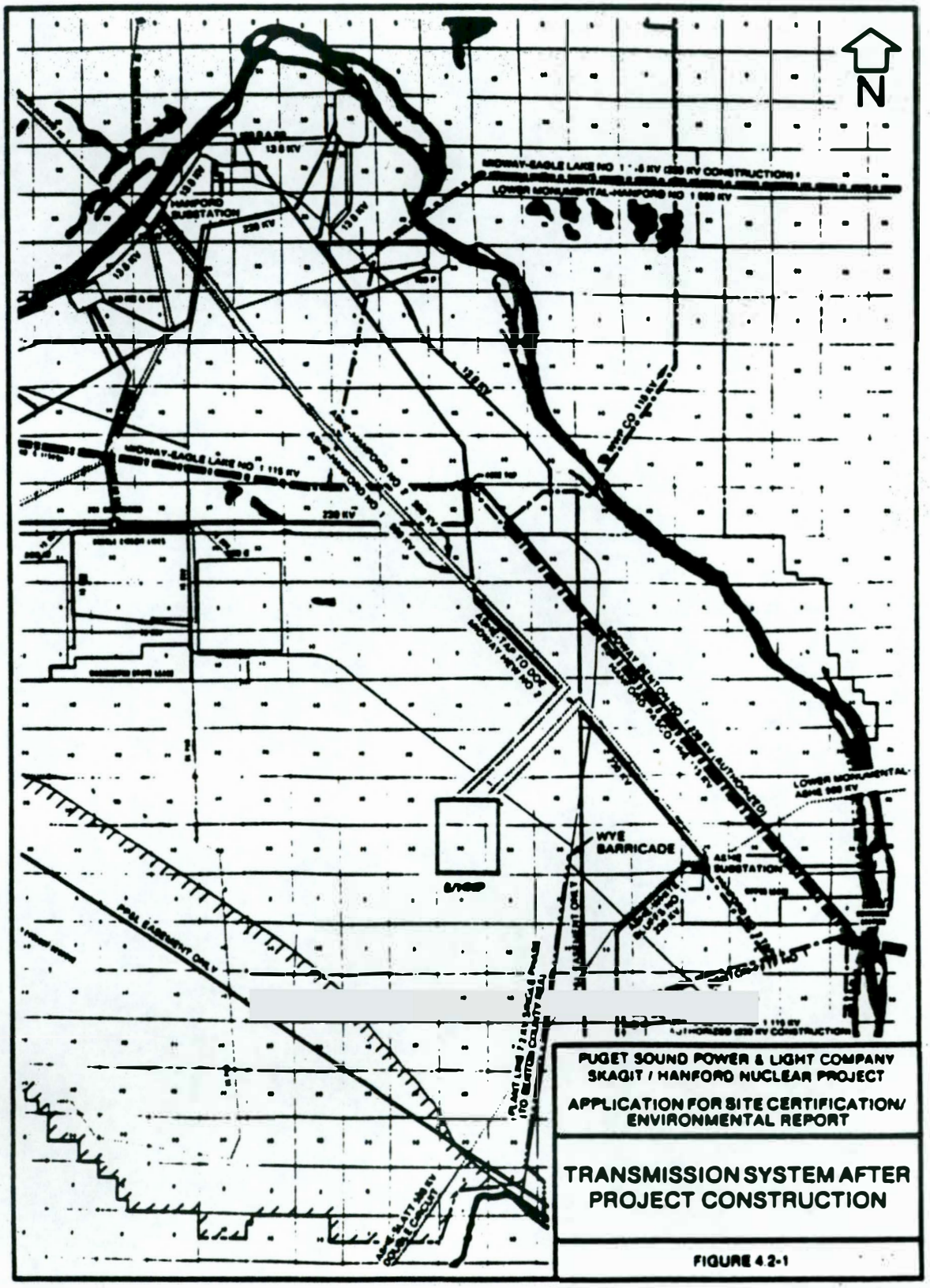
4.2.6 HISTORICAL AND ARCHAEOLOGICAL SITES

The transmission system will not impact any known historical or archeological sites.

4

References for Section 4.2

1. Bonneville Power Administration, Environmental Statement: General Construction and Maintenance Program (August 1974). 4



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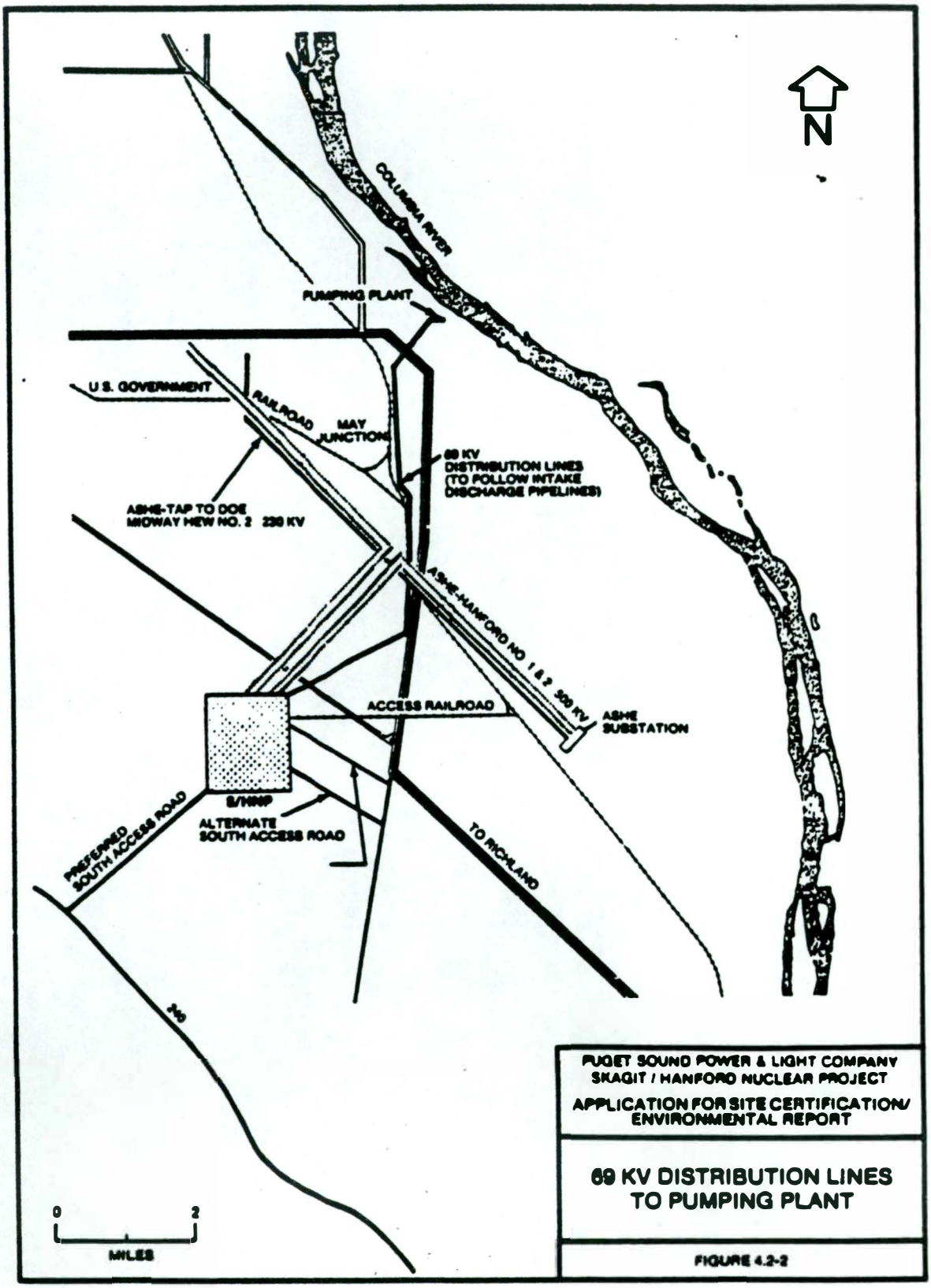
TRANSMISSION SYSTEM AFTER PROJECT CONSTRUCTION

FIGURE 4.2-1



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69 KV DISTRIBUTION LINES TO PUMPING PLANT

FIGURE 4.2-2

4.3 RESOURCES COMMITTED

Construction of the S/HNP will result in some irreversible and irretrievable commitments of resources. The major material resources that will be committed in the construction of the S/HNP include:

a.	Concrete (cement and aggregate)	445,000	cu yd
b.	Reinforcing steel	45,000	tons
c.	Structural steel	25,000	tons
d.	Lumber	2,800,000	bd ft
e.	Piping materials	535,000	lin ft
f.	Electrical wire and cable	13,000,000	lin ft

Section 3.1 contains a descripton of S/HNP facilities. The required acreages corresponding to these facilities on the Site and for construction laydown are shown in Sections 2.1 and 4.1. The construction disturbances do not represent an irreversible commitment of resources since the temporarily disturbed area will revegetate naturally within several years when these facilities are removed. The characteristics of the land for the selected Site are representative of much of the adjacent undeveloped land which is covered with native shrubs, introduced grasses, and forbs. The land is not considered unusual and, in all probability, would otherwise be undeveloped for many years. In general, the land has little agricultural value without irrigation. 4

Construction of the S/HNP will have no significant effect on wildlife. Individuals of some animal species will be lost during S/HNP construction, but the regional impact of this loss will be negligible as these species are common to the area.

4.4 RADIOACTIVITY

The potential exposure paths for construction workers include plant gaseous releases as well as direct exposure due to stored radioactive materials and radioactive Plant equipment. Discussion of estimated annual doses to construction workers including models, assumptions and input data is provided in the S/NMP PSAR, Section 12.1.6. 4

4.5 CONSTRUCTION IMPACT CONTROL PROGRAM

The following paragraphs provide a summary description of the Construction Impact Control Program (CICP) which Puget intends to follow as a means of implementing adherence to environmental quality control limits. A detailed description of the elements of the CICP will be submitted to the Energy Facilities Site Evaluation Council for its review and approval prior to commencement of Site construction activities.

4.5.1 PURPOSE

The purpose of the Construction Impact Control Program (CICP) is to ensure that good construction practices are employed on S/ENP in order to limit adverse impacts on the environment. The CICP is designed to comply with the Site Certification Agreement between the State of Washington and Puget Sound Power & Light Company (Puget) and with the Nuclear Regulatory Commission Construction Permit requirements for the S/ENP. The program will control all construction impact activities, detect unexpected harmful effects or evidence of serious damage, provide for periodic management audits to determine the adequacy of implementation of environmental controls and maintain sufficient records to furnish evidence of compliance with all environmental control requirements. The CICP will ensure compliance with new source performance standards (40 CFR 423) which are applicable to construction activities. 5

4.5.2 PROGRAM DESCRIPTION

The CICP will consist of procedures for (1) ensuring the use of good construction practices for the purpose of limiting adverse environmental effects of construction, (2) evaluating and reporting adverse environmental impacts, and (3) auditing and inspecting environmental and construction activities. These procedures will be implemented and maintained via two primary methods:

a. Written direction to contractors through specifications and correspondence.

b. Routine inspection of the Site by non-construction management representatives to ensure compliance with the Site Certification Agreement and the Construction Permit requirements.

4.5.3 RESPONSIBILITY AND AUTHORITY

The requirements of the State of Washington Site Certification Agreement and the Nuclear Regulatory Commission Construction Permit for S/EMP will be implemented by Puget and its agent, Northwest Energy Services Company (NESCO), through auditable contractual agreements with contractors. Bechtel construction management personnel will inspect construction activities to ensure contract adherence, and NESCO will audit the construction activities through periodic on-Site inspection.

When a construction activity results in a significant adverse environmental impact not previously considered or an impact which will be significantly more adverse than previously considered, or may have such result, work will be stopped or further processing, delivery or installation will be controlled until proper disposition has been approved. The NESCO Site Manager and the Puget Vice President - Generation Resources have the authority to stop work. Work may be restarted when appropriate corrective measures are taken. The on-Site Environmental Compliance Supervisor will also have direct access to the Puget Vice President, Generation Resources. 5

The Puget Vice President, Generation Resources, will notify NRC and EFSEC when such impacts have taken place.

4.5.4 PLAN DESCRIPTION

The CICP plans are divided into 3 categories; Construction Control, Environmental Monitoring, and Restoration.

4.5.4.1 Construction Control Plans

Construction Control plans will be developed in accordance with schedules necessary to meet licensing and construction activity requirements. These plans will include, but not be limited to, the following:

a. Oil and Hazardous Substances, Spill Prevention, Control and Countermeasures

b. Erosion Control

c. Dust Control

d. Noise Control

e. Waste Disposal

f. Vegetation Removal

4.5.4.2 Environmental Monitoring Plans

Predicted environmental impacts from the construction of S/HNP are addressed in Sections 4.1 to 4.4. Commitments were made to monitor specific archaeological, terrestrial and water quality impacts associated with the construction of S/HNP. S/HNP environmental monitoring programs are discussed in Section 6 and are adequate for monitoring construction impacts. 5

4.5.4.3 Restoration Plan

Restoration plans will be developed to return those areas not landscaped or utilized for other activities essentially to their natural conditions.

4.5.5 CONTROL MEASURES

4.5.5.1 Erosion Control

The Project is located in a shrub steppe region consisting of several shallow rolling hills, with the eastern extremity having a general slope to the river. Surface drainage is good. Due to the open and dry nature of the area (average rainfall is 6.25 in. per year) and sandy granular soil type, precipitation readily infiltrates into the soil and is not expected to be a problem. Runoff from a severe storm will be controlled by grading away from the power block area and by constructing ditches if necessary. Dewatering is not expected to be a problem because the water table is below any anticipated excavation point. 4

During construction, contractors will be required to maintain drainage and erosion control around the construction areas and especially in areas of excavation or fill. Areas requiring clearing and grubbing will be sequentially scheduled to accommodate the needs and

schedule of construction. These areas will be marked off and removal of vegetation will be minimized. Controls will be employed to ensure proper embankment slopes. Slopes will not be cut steeper than the natural angle of repose.

On-Site borrow pits will be prepared by grading to minimize wind and water erosion and to conform, where possible, to the natural topography. Any accumulations of precipitation within the excavation area will be allowed to infiltrate into the permeable soils. Where required, wind erosion will be controlled by employing soil stabilization techniques.

4.5.5.2 Dust, Noise, and Emission Control

During construction there will be emissions resulting from the activities of heavy equipment, from permitted open burning, and from operation of the concrete batch plant. Control will be exercised to ensure that these emissions comply with applicable standards. Construction vehicles will be maintained in good mechanical condition so emissions and noise levels will conform to State environmental standards.

After the initial Site preparation work is completed, the primary source of construction-generated dust is expected to be the unpaved construction roads. Permanent roads within the Site (those roads not near construction activity) are completed during the early stages of construction to minimize dust problems. 4

Watering or other approved dust control methods will be used to control fugitive dust generated by construction activities. Site roadways will be watered by sprinkler trucks or covered by protective material such as gravel, crushed stone or pavement, as necessary, to decrease the impact of windblown soil. Parking lots will be gravelled.

During open burning, care will be taken to reduce emissions to a minimum. Applicable burning regulations will be complied with, and precautions will be taken to prevent accidental fires. Smoke which may occur during open burning is not expected to restrict visibility on any public road.

The batch plant, fuel depot(s), sewage plant, welding shop(s) and other such facilities will be constructed and operated to conform with the applicable environmental standards.

Due to the remote location of the Project, which is more than seven miles removed from any inhabited area and nearly

five miles removed from the nearest organized human activity (WNP-2 and FFTF complexes), there should be no off-Site impacts of noise, dust, odor or other emissions resulting from construction activity.

4.5.5.3 Disposal of Construction Waste, Debris & Sanitary Waste

Solid wastes will be generated daily by virtually all phases and elements of construction at the Site. Containers will be located throughout the jobsite and appropriately identified for collection of such items as trash, combustible materials, etc. Combustible materials will be burned or buried on-Site. Salvageable non-combustible materials (scrap metal, etc.) will be accumulated and removed periodically from the Site for recycling. Wastes not burned, buried, or recycled will be collected and stored in containers before removal to an approved disposal area.

Liquid wastes, such as fuels, lubricants, bitumens, and some flushing solutions will be deposited or discharged into tanks for salvage or subsequent removal to off-Site locations.

The concrete batch plant, which will be dismantled and removed from the Plant Site after completion of construction, will have an oil-trap concrete retention tank and a sedimentation box installed to control any inadvertent drainage of batch plant effluent. Washings from concrete transporting equipment will be processed in a waste concrete separator which will provide aggregate recovery and will control the quality of the effluent. Washings from other construction equipment will also be controlled to minimize surface water contamination.

Sanitary sewage during most of construction and during operation will be self-contained within the boundary of the Site by means of a package sewage plant and percolation pond.

Sanitary sewage during Site preparation and early stages of construction will be handled by chemical toilets provided and maintained by a licensed contractor. Chemical toilets will be used during later stages of construction only at remote and non-sewered locations to serve as supplemental facilities.

These toilets do not use an external water supply, nor do they discharge any liquids or solids. The waste from these

toilets will be collected periodically and disposed of off-Site by a licensed disposal contractor.

4.5.5.4 Protection of Plant, Animal and Aquatic Life

Throughout the design, construction, and operation of this Project, every effort will be made to achieve an environmental balance which results in minimal damaging effect upon wildlife, fish or other aquatic species. Removal of vegetation will be minimized. Although the habitat of some animal life will be affected by the construction activities, the surrounding populations will not be adversely affected. Trenching in the Columbia River will be required to bed raw water supply and project discharge lines. Work on these installations will be scheduled to minimize turbidity and endangerment of aquatic life. 4

4.5.5.5 Landscaping

Landscaping and final Site construction will serve to both control dust and improve the Site aesthetics. Landscaping will integrate excess excavated material (spoils) with the Site contours to ensure runoff away from all buildings and auxiliary structures.

During removal of temporary facilities, the superstructures will be completely removed, and the foundations will either be razed flush with the ground or covered with soil which has been suitably placed to blend with area contours.

4.5.6 AUDIT AND INSPECTION

It is the responsibility of the Northwest Energy Services Company (NESCO), Director of Quality Assurance, to conduct audits and surveillances of the Construction Impact Control Program to assure that the program is effectively implemented. 5

An Environmental Surveillance Team will periodically monitor construction activities and prepare inspection reports noting any discrepancies from established environmental control measures. Team membership will include the Puget Site Environmental Compliance representative, NESCO Resident Engineer, a representative from Bechtel's field construction management, and terrestrial and aquatic ecologists as appropriate.

CHAPTER 5.0

ENVIRONMENTAL EFFECTS OF PLANT OPERATION

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CHAPTER 5.0

ENVIRONMENTAL EFFECTS OF PLANT OPERATION

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5.0 ENVIRONMENTAL EFFECTS OF PLANT OPERATION

5.1 EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM

5.1.1 EFFLUENT LIMITATIONS AND WATER QUALITY STANDARDS

5.1.1.1 Federal Effluent Guidelines (40 CFR, Part 423)

Effluent limitations governing discharges from Steam-Electric Power Generating Plants (40 CFR 423, Ref 1) were published by the U.S. Environmental Protection Agency on October 8, 1974. Effluent limitations for "New Sources" restrict the discharge of: total suspended solids, oil and grease, pH, polychlorinated biphenyls, chlorine, and corrosion inhibitors, as well as heat.

The thermal limitation for new source performance standards (NSPS) is not currently in effect because it was remanded by the Appalachian Power vs. Train decision of 1976 (Ref 2).

Washington State has received Environmental Protection Agency approval to administer the National Pollutant Discharge Elimination System (NPDES) permit program (Ref 3). In the case of steam electric power plants, the Washington State Energy Facility Site Evaluation Council (EFSEC) has been designated as the NPDES permitting agency. 4

5.1.1.2 Washington State Water Quality Standards (WAC 173-201)

The Washington State Department of Ecology has established water quality standards for receiving waters based upon designated use (Ref 4). The Department has designated waters of the Columbia River between Priest Rapids Dam (RM 397) and the Washington-Oregon border (RM 309) as Class A-Excellent waters. Water quality of this class (Table 5.3-1) shall meet or exceed the criteria for all, or substantially all, characteristic uses. The following special temperature condition has been established for this section of the river (Ref 4):

> Water temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature

by greater than 0.3°C; nor shall such temperature increases, at any time, exceed:

$$t = 34/(T+9)$$

where: t = permissive temperature change across the dilution zone (°C).

T = highest existing temperature in this water classification outside of any dilution zone (°C).

These standards are applicable in receiving waters except within immediate dilution zones surrounding a wastewater discharge. The total area of a dilution zone is calculated on a case-by-case basis and is described in an NPDES discharge permit. The dilution zone is anticipated to be similar in dimension to the ones granted WNP 1/4 and 2 (Ref 5):

a. The boundaries in the vertical plane shall extend from the receiving water surface to the riverbed

b. The upstream and downstream boundaries shall be 50 ft and 300 ft, respectively, from the centerline of the discharge

c. The lateral boundaries shall be separated by 100 ft. 4

The discharge of wastewaters from the S/HNP is not expected to affect the water quality of the Columbia River within Washington State or any other state (Section 5.1.2). As a result, water quality standards for the State of Oregon (52 miles downstream) do not apply to this discharge.

5.1.2 PHYSICAL EFFECTS

The heat dissipation system is discussed in detail in Section 3.4. Only a few of the operating parameters which determine the environmental effects of operation will be summarized in this section.

The waste heat generated will be dissipated to the environment by two paths: (1) heat transfer to air through the use of mechanical draft wet cooling towers, and (2) cooling tower blowdown discharged to the Columbia River.

The components of the cooling system which might have some effect on the environment are: (1) the intake structure,

(2) the wastewater discharge system, and (3) the cooling tower vapor plume. The environmental effects of these components are discussed in the following sections. The locations of intake and discharge lines are depicted in Figure 3.4-3.

5.1.2.1 Intake Effects

The intake for the makeup water of the cooling system consists of three torpedo shaped tubes placed parallel to the river flow above the river bottom (Section 3.4.2). The top of the tubes will be submerged about 10 ft below the water surface for the lowest regulated flow of 36,000 cfs. The combined maximum pumping rate of 94 cfs is about 0.26 percent of the lowest regulated flow and 0.08 percent of the median river flow (115,752 cfs). The average makeup water requirement will be about 62 cfs. 4 5

Detailed hydraulic model studies of similar intake structures used at WNP 1/4 have been conducted by the Supply System (Ref 6). These studies concluded that a perforated pipe inlet with an internal sleeve would give uniform flow distribution and would offer maximum protection to small fish during all operating conditions. At design conditions, the inlet velocity at the external screen surface is approximately 0.5 fps. However, at a distance of one inch from the outer screen surface, the velocity is approximately 0.1 fps. Intake velocities will generally be below these values since the normal withdrawal rate will be lower than the design rate. Undesirable debris is not expected to pass through the outer perforations at these low velocities.

Biological effects of the intake structure are described in Section 5.1.3. The critical intake approach velocity will be maintained below 0.5 fps, thereby reducing impingement, entrainment and entrapment effects upon aquatic organisms. Riprap will be placed around the intake structures to prevent riverbed erosion and scouring. 4

5.1.2.2 Wastewater Discharge Effects

The wastewater discharge system described in Section 3.4 will convey effluent from the Plant to the Columbia River. A single discharge pipe will be buried in the river bottom and will have an 18-in. round outlet discharging perpendicularly to the river flow direction at an upward angle of 15° from the horizontal (Figure 3.4-3). The exit flow

velocity will be approximately 7.5 fps at the maximum discharge rate of 5,910 gpm, and 3.6 fps at the average discharge rate of 2,817 gpm.

As the effluent enters the river, it will mix with ambient water, resulting in local increases in river temperature, velocity, and chemical concentrations. As the discharge is transported downstream by the river current, progressive mixing of the relatively small discharge flow in comparison to the large river flow will result in local temperatures, velocities, and concentrations which are virtually indistinguishable from ambient conditions.

Mathematical predictions of the discharge plume dispersion for S/HNP were conducted for a combination of conditions which are considered representative of worst-case and average situations. A description of the thermal plume model (HOTSUB3), based upon modifications proposed by Koh and Fan (Ref 7), are given in Appendix C.

Briefly, the model is composed of two sub-models describing the near and far fields. The former consists of the region near the discharge structure where the discharge momentum determines mixing. This model is based on a solution for an infinitely deep quiescent receiving water modified to account for boundary and ambient velocity effects. The far field considers the region removed from the discharge where the river momentum determines the mixing characteristics. For the latter, the river is assumed fully mixed in the vertical direction, a typical condition in the Columbia River. Experimental evidence (Ref 8), approximately 14 miles upstream, confirms this rapid vertical mixing. 4

These regions neglect an intermediate region where mixing is a result of both ambient and discharge momentum. The neglect of this region leads to an underestimate of mixing and, therefore, an overestimate of excess temperatures, as well as other physical and chemical parameters.

Various input parameters (Table 5.1-1) are required for the model. The minimum regulated low river flow is 36,000 cfs. While this flow may be attained for short durations at Priest Rapids Dam, it will rarely if ever occur at the discharge location 35.6 miles downstream. Median river flow was taken as 115,752 cfs. The water depth in the vicinity of the discharge used to determine boundary effects was taken as 14 ft (bottom elevation 337 ft, MSL) during low flow, and 21 ft at median flow. These depths are based on Figure 5.1-1, which shows four cross-sections, looking upstream, that bracket the discharge location. The lateral diffusion coefficient, which determines lateral far field mixing, was chosen as 4.0 ft^2/sec. This value

compares with a range of 3.0-7.0 ft^2/sec for heated effluent measured approximately 19 miles upstream (Ref 9), and a mean value of 7.0 ft^2/sec measured 10 miles downstream from the S/ENP discharge location (Ref 10).

The ambient river temperature was assumed to be 20°C (68°F). Maximum discharge, 5,910 gpm, was assumed to have a temperature of 29.2°C (84.5°F). This temperature corresponds to a wet bulb of 24.4°C (76°F). 4

River velocities in the vicinity of the discharge were measured during May 1981. Maximum velocities of 7.0 fps were recorded over the discharge location near mid-stream at river flows of 143,000 cfs (see Appendix B). Calculations from these measurements indicate that average velocities will range between 2.32 and 4.37 fps for low and median river flows. 5

Both the Plant effluent and ambient river conditions are temporal in nature. The former is described in Section 3.4 and the latter in Section 2.4.1. To account for seasonal changes, yet assure compliance with Washington State Water Quality Standards (Ref 5) under all conditions, three cases were analyzed:

- Case 1 - Regulatory Limiting Case

  This case would occur with a combination of extreme discharge temperature and flow (5,910 gpm), regulated extreme low river flow, and ambient river temperature resulting in the most restrictive regulatory criterion.

- Case 2 - Average Case 4

  This case would occur with a combination of the average discharge temperature and flow, discharged into the average water temperature and median river flow. It is used to illustrate the normal characteristics of the discharge plume.

- Case 3 - Large Excess Temperature Case

  This case is defined as the average discharge temperature and flow in conjunction with the regulated extreme low river flow and winter (January, February, and March) average river ambient temperature. It is used to illustrate the plume characteristics during a period of high excess temperature, that may occur during the winter when the weather suddenly turns warm. This warming would result in an almost immediate change

in the discharge parameters, but a much slower change in the river temperature due to the higher volume to surface ratio of the river.

The S/HNP discharge, ambient river and regulatory limits corresponding to the three cases are shown in Table 5.1-1.

Results of the mathematical simulations are shown in Figures 5.1-2 to 5.1-10. Figures 5.1-2, 5.1-3 and 5.1-4, respectively, illustrate the downstream penetration, surface area and volume of the plume as a function of excess temperature for the three study cases. Case 3 results in the highest (6.33°F) and Case 2 results in the lowest excess temperature (2.45°F) after plume surfacing. However, the plumes will need to travel an additional 22, 0, and 8.0 ft to comply with thermal regulatory criteria for Cases 1, 2 and 3 respectively. The average case results in the greatest plume penetration downstream due to the relatively large water depth and river velocity. The difference in penetration between Case 1 and 3 is accounted for by the difference in buoyant effects. The Case 3 discharge is less buoyant than that of Case 1. To achieve compliance, surface areas of 390, 0 and 14.0 ft^2, and total volumes of 2,000, 150 and 240 ft^3 will be required for mixing in each of the three cases, respectively. The results reflect the fact that Case 1 will occur at high ambient temperatures when regulations assume that the river is already thermally stressed. Under the assumed critical conditions, the temperature increase 300 ft downstream of the discharge is estimated to be 0.09°F, well below the 0.54°F limit specified by the State Water Quality Standards. 4

Surface isotherms for Cases 1, 2 and 3 are shown in Figures 5.1-5, 5.1-6 and 5.1-7, respectively. Subsurface isotherms of the indicated excess temperatures would be even smaller than those at the surface. Figures 5.1-8, 5.1-9, and 5.1-10 show isotherms along the vertical section through the plume trajectory. Maximum excess temperatures, along the river bottom, are approximately 0.45, 0.11, and 0.39°F for Cases 1, 2, and 3, respectively. These temperatures occur at downstream distances from the discharge of 40, 145 and 52 ft for Cases 1, 2 and 3, respectively.

Modeling results indicate that no intake-discharge recirculation, thermal buildup, shoreline plume attachment or thermal block will occur as a result of wastewaters discharged by S/HNP.

The ratio of the discharge velocity to the river velocity is relatively low for the S/HNP. The river dominates the flow regime and no impact from the discharge is expected on

such velocity-induced phenomena as turbidity, scouring, erosion or sedimentation. Even at the highest S/HMP discharge velocity, 7.45 fps, the maximum induced bottom velocity is essentially zero, as a result of the discharge orientation of 15° above horizontal (Appendix C). The maximum plume velocity at the river surface is projected to be 2.76 fps, occurring approximately 36 ft downstream and offshore of the discharge. This maximum velocity is only 19 percent higher than the low flowing river velocity.

Case 1 conditions evaluated above are for conditions worse than any expected to occur. The worst expected conditions would occur in late summer and would create smaller impacts than modeled above.

5.1.3 BIOLOGICAL EFFECTS OF THE HEAT DISSIPATION SYSTEM

Operation of the heat dissipation system (Section 3.4) may affect aquatic biota as a result of two system components: (1) the water intake structure (impingement and entrainment effects) and (2) the cooling tower discharge system (thermal stress). Aquatic biota in the Hanford Reach of the Columbia River are described in Section 2.2.2. Although minimal, the potential environmental effects of intake and discharge systems upon biota are discussed in the following sections. Analyses demonstrate that there will be no significant adverse biological effects. 4

5.1.3.1 Effects of the Intake System

The S/HMP intake structure is located in mid-channel of the Columbia River at RM 361.5. At low flow, the intake is situated 750 ft off the Benton County Shore in 15 ft of water (Figure 3.4-3). The effects of the intake structure upon the aquatic biota are expected to be insignificant. Entrainment of aquatic organisms will not adversely impact Columbia River biota because of the small volume of water withdrawn and because the intake structure will be designed to reduce fish entrainment. Essentially all of the drifting organisms occurring in the water column that are drawn into the intake structure will perish in the recirculating water system. This loss, however, will be slight in comparison to the total populations of these organisms in the river, and the loss will not affect the ecosystem. The maximum water withdrawal will be less then 0.26 percent of the river volume at the lowest regulated flow of 36,000 cfs. Because plankton have been found to be equally distributed both horizontally and vertically in the

Columbia River near the Site (Section 2.2.2), it can be assumed that no greater than 0.26 percent of the total plankton populations will be adversely affected.

There is no mechanism operating at S/HNP that would alter the biomass or relative abundance of Columbia River phytoplankton. Given the rapid population cycling (short replacement time) of algae, any loss of cells or productivity can be expected to be naturally mitigated in a short time and the loss would not persist downstream. Columbia River phytoplankton will not be adversely impacted by the S/HNP intake.

Of greater concern is the potential for impingement or entrainment of the eggs, lavae or juveniles of important fish species. Sport and commercial fish species conceivably affected are the whitefish, smallmouth bass, steelhead trout and the various salmon species. Midstream ichthyoplankton are not abundant. Sculpin larvae are the most numerous organisms collected (Ref 11).

Juvenile chinook salmon and steelhead trout produced in the Hanford Reach upriver from the intake are of particular importance. Since egg and larval development occurs in the gravel, these life stages should not be vulnerable to intake effects. However, young fry that emerge from the gravel are not strong swimmers and are carried downstream. Some of these fry may pass the intake structure and may be vulnerable to entrainment or impingement. Only those small fish unable to escape the approximate maximum intake velocity of 0.5 fps at the 3/8 in. intake screen openings will be impinged and lost. Laboratory tests, conducted to determine the swimming ability and impingment tolerance of young-of-the-year chinook salmon (36-56 mm) and steelhead trout (22-36 mm), demonstrated that juveniles avoided impingement at approach velocities up to 1.0 fps and they were capable of surviving impingement at approach velocities of 2.5 fps for up to six minutes (Ref 12). 4

The design of the intake, similar to the WNP 1/4 and 2 intakes (Section 3.4.2.1), and its offshore location should reduce interaction with downstream migrating salmonids. Most of the juveniles spawned in the Hanford Reach will utilize the shallow nearshore areas as they pass the intake during the spring. Thus, impingement of these fish will be minimal. The very low entrance velocities (no greater than 0.5 fps) and swift river current (greater than 2.3 fps) will tend to sweep clear of the intake juvenile fish that stray into offshore areas. The fact that most young salmon pass through the area of the intake structure during the spring runoff when flows are high further decreases their susceptibility to impingement.

Because of their larger size, juvenile salmonid fishes artificially and naturally reared in areas upstream of the Hanford Reach may frequent offshore waters during outmigration (Section 2.2.2). While these fish may encounter the intake structure, their improved swimming capauilities in comparison to the smaller fry should preclude impingement effects.

Because the whitefish deposit adhesive eggs, only the drifting lavae may encounter the intake structure. Smallmouth bass spawn in nests in quiescent backwater slough areas. Juvenile bass rear from one to three months in the slough prior to dispersing into the main river. Should the small bass stray into the deep swift portion of the river, their size and swimming capability should preclude impingement effects. White sturgeon are known to spawn in deep holes in the main channel of the Columbia River (Section 2.2.2.6.2). Little information is available, however, regarding juvenile life forms and their activity. Yolk sac fry, approximately 0.7 in. in length (Ref 13), should not be drawn into the intake structure. Should impingement effects occur on any fish species, the fact that such a small volume of water is withdrawn for the S/HNP renders any impact negligible.

The Washington Public Power Supply System has conducted entrainment and impingement testing of the WNP 2 offshore, perforated pipe intake (Ref 14). Entrainment sampling during a period when chinook salmon fry were abundant in the river failed to produce evidence of entrainment. Inspections of intake structures by scuba observation likewise revealed no incidents of fish impingement, damage or other irregularities. Since the S/HNP intake will be similiar in design to the WNP-2 stuctures, these data indicate that impingement and entrainment will not result in any significant adverse impact at S/HNP. 4

5.1.?.2 Effects of the Discharge System

The discharge system, as described in Section 3.4.2.2, will be located in 14 ft of water (at low flow), 550 ft offshore. Thermal effects of the WNP-2 blowdown discharge are expected to be negligible from either a thermal increase effect or from cold shock, the sudden cessation of thermal discharge at Plant shutdown.

Maximum instantaneous temperature difference between the S/HNP discharge and the ambient water will occur in winter and will be $\Delta T = 29.9^{o}F$. Extreme temperature differential during the summer will be $16.9^{o}F$. Because the maximum

discharge volume, 13.2 cfs, is insignificant (0.04 percent) in relation to the minimum river flow, dilution and dispersion of the thermal discharge will be rapid.

A preliminary study was conducted to determine the plume characteristics of the S/HNP discharge when two units are in operation. A description of the computational methodologies is presented in Appendix C. Modeling results of the worst-case condition (maximum S/HNP discharge during minimum river flow) suggest that the most restrictive thermal criterion (0.54°F) will be met within 52 ft downstream of the outfall in a plume travel time of 22 sec. Area of the surface plume and volume of the water column encompassed within a 0.54°F isotherm is 390 sq ft and 2000 cu ft, respectively. Maximum excess temperature along the river bottom is estimated to be 0.45°F (Section 5.1.2) at a distance 40 ft downstream from the discharge.

Changes in ambient water temperature can affect the metabolism, development, growth, and reproduction of aquatic organisms. The tolerance of organisms to thermal changes is species specific, dependent on magnitude and duration of the change, and previous thermal acclimation. Potential thermal impacts to all aquatic communities in the Columbia River near the discharge site are assessed in the following sections.

4

5.1.3.2.1 Thermal Effects on Plankton

Prolonged exposure to elevated temperatures in thermal discharges have been reported to affect the growth rate and species composition of phytoplankton and zooplankton (Refs 15, 16, 17). Entrainment of river planktonic organisms in the thermal plume created by the S/HNP discharge, will be too brief to cause significant changes in growth or composition. During low flow with a maximum temperature differential at the discharge point, the transit time that organisms will be exposed in the plume to temperatures greater than 2.5°F above ambient will be approximately 11.0 sec. This brief exposure time is below levels reported to have measurable effects on abundance and composition in plantonic organisms (Refs 15, 16, 17).

Patrick (Ref 16) observed that diatom growth was limited at temperatures below 50.0 to 59.0°F and above 84.0 to 86.0°F. Because the maximum thermal discharge at S/HNP is only 84.5°F, diatom species could live and subsist in 100 percent effluent.

The ecological consequences of the thermal discharge on the planktonic community are neglible. No measurable effect on the abundance and composition of food organisms in the stream drift and no indirect impact upon important fish resources are anticipated to occur.

5.1.3.2.2 Thermal Effects on Periphyton 4

The S/HNP thermal discharge to the Columbia River is not expected to adversely affect the periphyton community in Hanford Reach. The river bottom area exposed to heated water is small. The maximum percentage of the cross-sectional area of the river bed receiving heated water is less than 1.2 percent. The highest excess temperature expected under any conditions on the river bottom is 0.45°F, 40 ft downstream from the discharge point. 5

Periphyton communities in the Hanford Reach are limited in population size by turbulent river flow and seasonally low water temperatures (Section 2.2.2.2). Diatoms are the dominant forms of periphyton in Hanford Reach populations (Ref 18, 19).

The discharge of heated water may cause an increase in growth of periphyton residing on the river bottom in the immediate vicinity of the discharge structure. Algae species have different optimum ranges. Any increased growth may be negated by loss from swift and turbulent river flows. Algal diversity is decreased and biomass is affected when temperatures rise above or below the optimum. Patrick (Ref 6) observed that temperatures exceeding 86.0 to 93.2°F caused a measurable decrease in the number of species and the population size when compared to temperatures between 64.4 and 72.2°F. In Columbia River studies by Coutant and Owen (Ref 20), thermal increments of 18.0°F increased the standing crop of periphyton only during a short winter period. Such data indicate that adverse impacts of the thermal discharge upon periphyton communities near the outfall are not anticipated to occur. 4

5.1.3.2.3 Thermal Effects on Benthos

The S/HNP thermal discharge to the Columbia River is not expected to adversely affect the benthic invertebrate community in the Hanford Reach. Maximum discharge temperature is 84.5°F. The river bottom area receiving heated water is small. Maximum percentage of the cross-sectional area of the river bottom receiving heated water is less

than 1.2 percent. Because the S/HNP discharge is oriented at an angle 15° above horizontal, and because the thermal plume is buoyant, little attachment of the plume to the river bottom is anticipated. Maximum excess temperature along the river bottom is projected to be only 0.45°F (Section 5.1.2); 40 ft downstream from the discharge point. The benthic community in the Hanford Reach is comprised primarily of insect larvae; caddisflies and mayflies are the predominant taxa (Section 2.2.2.5). 5

Jensen et al. (Ref 15) report that the upper-temperature limits for the majority of benthic organisms occurring in the Hanford Reach appear to be in the range of 85.0 to 92.0°F. Tolerance is dependent upon species, stage of development and acclimation temperature.

Becker (Ref 21) reported that caddisfly larvae acclimated to 67.0°F river water had a 50 percent mortality after a 68-hour exposure to an 18.0°F increment, whereas, temperatures 13.5°F above ambient were insignificant. A two-week earlier emergence of insects in heated zones, as compared to water at ambient temperatures, was found by Coutant (Ref 22). These thermal tolerance data and the expected small area of river bottom receiving heated water indicates the benthic community will not be adversely impacted by the S/HNP discharge. 4

5.1.3.2.4 Thermal Effects on Fishes

Temperature is one of the most important parameters influencing the fishery resources in the Columbia River. Temperatures may reduce the success or efficiency of fish in its various life processes. Stress is proportionate to the extent and duration of the thermal input. Any temperature increase may increase the vulnerability of fish to the harmful effects of toxicants or susceptibility to disease. Conversely, cold shock may stress fish acclimated to the thermal increase.

Discharge of heated effluent into the Columbia River may affect both resident and anadromous fish populations. Considerations of thermal requirements, however, vary according to life history stages, differences in physiology, and a variety of other biological characteristics. In Section 5.1.2, the physical effects of the plant effluent are described and a thermal model presented for three cases. Plume characteristics are given according to differences in discharge temperatures, discharge flows, river water temperatures, and river flows. The area encompassed by different isotherms in these models can be

related to potential effects on fish behavior and survival. Calculations and assumptions derived from the model were used to determine possible exposure time of fish to various temperature increments (Tables 5.1-2 and 5.1-3).

5.1.3.2.4.1 Important species. An extensive review of the thermal tolerance of important resident and anadromous fish ~~species~~ indicated salmonids are the most sensitive species to thermal discharges (Ref 23). However, because of their presence near the discharge location, other important fish are discussed in the following sections as well.

Anadromous Salmonids

The Hanford Reach is used extensively by fall chinook salmon and steelhead trout for spawning and rearing. In addition, coho, sockeye, and other of chinook salmon migrate through as juveniles and again as adults (Table 2.2.2-7).

The following temperature ranges are recommended as optimum for the maintenance of salmonid fish resources in the Columbia Basin (Ref 17):

Migration Routes	45.0 to 60.0°F
Spawning Areas	45.0 to 55.0°F
Rearing Areas	50.0 to 60.0°F

4

The preferred temperatures for juvenile salmonids are reported as 41.0 to 62.6°F (Ref 17). Temperatures above 68.0°F are considered to be adverse for juvenile salmonids; 70.0°F is the upper incipient lethal temperature (Ref 24). A minimum of 5.4°F below the ultimate incipient temperature has been recommended as the maximum allowable for juvenile salmonids "to avoid significant curtailment of activity." Temperatures near 62.6°F are considered the upper optimum temperature (Ref 17).

The period of greatest probable effect of thermal discharge on these species is at Case 1, with extreme low flow and high ambient river temperatures. Although Case 3 would result in greater excess temperatures, it would occur in the winter when ambient temperatures are lowest. Therefore, the critical period when maximum combined temperatures in the zone of discharge could exceed levels causing sublethal or lethal effects on anadromous salmonids (70.0°F) is during August and September.

Juvenile salmonids could drift through the effluent plume during downstream migration periods. 0-age fall chinook abundance in the Hanford Reach is greatest in May with only small numbers of fish present in July. Peak movement of steelhead and salmon smolts originating from upstream areas occurs in May. Since ambient water temperatures in May range from about 45.0 to 54.0°F, the thermal plume would have to elevate ambient temperatures 16.0°F for extended exposure periods before detrimental effects to salmonid populations would be expected. Even at the surface where maximum temperatures are expected, ΔT's will not exceed 6.3 °F. Cumulative exposure to a fish passively drifting through the S/HNP discharge plume would not exceed 1.8 sec at a ΔT of 16.0°F. This is about 2 percent of the exposure reported by Snyder and Blahm (Ref 25) to cause mortality to juvenile salmon. Potential exposures for a fish drifting through the plume centerline are less than 18 percent of the duration causing equilibrium loss (Ref 38). 4

A portion of the downstream migrant salmonids move through the Hanford Reach when ambient temperatures are greatest and when additional thermal increments have the greatest likelihood of elevating temperatures in the vicinity of the discharge above lethal limits. Juveniles most likely to encounter these conditions are delayed downstream migrating chinook salmon (Ref 26) and steelhead trout. At ambient temperatures near 64.5°F, if a fish was subjected to a ΔT 5:5°F for extended exposure periods, detrimental effects to salmonid populations would be expected. Cumulative exposure to a fish passively drifting through the discharge plume in August would not exceed 12.9 sec at a ΔT of 6°F. This is only 2 percent of the exposure reported by Snyder and Blahm (Ref 25) to cause mortality to juvenile salmon at 78.8°F. 5

Exposure times would be less if avoidance occurs. Gray et al. (Ref 27) showed 0-age chinook salmon avoided simulated thermal discharges at a plume velocity of 2.0 fps when the Δ T exceeded 16.2 to 19.8°F.

Preference of fish for particular temperature regimes has been documented. Brett (Ref 24) reported juvenile salmon had a preferred range of 54.0-57.0°F when acclimated from 41.0-75.0°F, and avoided temperatures in excess of 59.0°F except when feeding. Cherry et al. (Ref 28) found that rainbow trout selected a preference range from 52.9 to 68.2°F when acclimated at 43.0 to 70.0°F (Table 5.1-4). These data imply that given a choice, fish will avoid potentially lethal temperatures. 4

Water temperatures exceeding 70.0°F are reported to impede or block adult salmonid migrations (Ref 17). Nevertheless,

migration in the Columbia River has occurred at higher temperatures (Ref 17). Studies on adult Columbia River salmon and steelhead trout indicate that over a period of many days, temperatures in excess of 70.0°F also may be lethal (Ref 29).

The primary migration route for adult salmonids is along the eastern shoreline in the Hanford Reach (Refs 30, 37). In addition, returning adults showed a preference for shoreline areas of depth less than 10 ft. Therefore, they are not expected to frequent the discharge area (Ref 30). Adult chinook in the Hanford Reach have been shown to avoid the immediate areas of thermal discharges (Ref 17). 4
Templeton and Coutant (Ref 30) concluded that thermal discharges from the early Hanford reactors had no significant effects on migration.

During periods of peak adult salmonid migration, the worst-case thermal increment at the point of discharge will be $\Delta T = 16.5°F$. Even during low flow conditions and ambient river temperatures of 68.0°F, temperatures in the receiving water would be below lethal temperatures after a time interval of a very few seconds. A thermal differential of 2.0°F would occur at the surface approximately 40 ft downstream of the discharge location and the corresponding surface area for a 2.0°F isotherm would consist of 100 sq 5
ft. A differential of only 0.09°F would occur 300 ft downstream of the outfall (Section 5.1.2). 4

The maximum cross sectional area of the river which would experience thermal increases greater than 0.5°F is less than 1.2 percent of the main channel during worst case 5
conditions. Since approximately 99 percent of the river cross section is available for passage at ambient temperatures, it is evident that free passage of adult migrants will be assured under all conditions.

The discharge of heated effluent from other facilities into the Hanford Reach has not been demonstrated to have a detrimental effect on spawning salmon (Ref 17). However, temperature stresses could indirectly and adversely affect reproductive success through excess energy costs, increased 4
vulnerability to disease or increased vulnerability to toxicants which may be present.

The frequency of fish disease may increase with increased water temperature. Infectious diseases appear less likely to cause mortalities in adult salmonids at temperatures below 60.0°F (Ref 17). There is no evidence of increased incidences of infection by <u>Chondrococcus columnaris</u> in areas below the thermal discharges of early Hanford reactors when compared to areas not influenced by the thermal

plumes (Ref 30). No increased incidences of fish disease are expected to result from S/HNP discharge.

The thermal plume from the S/HNP discharge will not intersect any known spawning areas and will be fully mixed at the nearest chinook or steelhead spawning area, 7.5 miles downstream of the discharge location. Olson (Ref 31) found no adverse effects on different developmental stages of salmon eggs and fry when thermal increments were less than 2.9°F. The worst-case thermal increase at the spawning grounds after mixing, will be less than 0.004°F. No measurable effect on spawning or on the growth and development of egg and larval stages in this area will occur.

Resident Cold Water Species

Thermal tolerances and preferred temperature ranges of mountain whitefish have not been studied in detail, but they are expected to be adapted to a generally lower temperature regime than the thermal plume (Ref 32). Preferred spawning temperatures are near 50.0°F (Ref 13).

Although mountain whitefish are known to be present near the Site, there is evidence (Ref 33) of reduced abundance in the Hanford Reach during summer months. Emergent fry apparently move out of the area to downstream nursury areas by early May. Peak adult abundance typically occurs in early fall through spring, with fish moving upstream to spawn in December and January. Because of these life history characteristics, mountain whitefish should not be significantly impacted by the thermal discharge in this area. 4

Water temperature is thought to initiate seasonal movement patterns in white sturgeon in the Hanford Reach (Refs 34, 35). Long distance and localized shallow movements, assumed to be related to spawning and/or feeding migrations, begin each year in June when water temperatures exceed 55.0°F.

Because sturgeon remain near the river bottom, they should not be influenced significately by the rising plume. Maximum thermal increment along the river bed is less than 0.45°F. The zone of thermal influence is small and the temperature differential is slight. Thus, no effect of the S/HNP discharge upon white sturgeon activity in the Hanford Reach is expected.

Resident Warm Water Species

The thermal tolerances of warm water fish in the Hanford Reach have not been extensively investigated. Maximum temperatures of 90.0°F are near the limit of thermal tolerance for most adult warm water species, including the local game species, smallmouth bass, yellow perch, and bluegill (Section 2.2.2.8). Temperature preferences and scope of activity of warm water fishes are generally closer to their thermal tolerances than cold water species. Because maximum discharge temperataures will be 84.5°F, no thermal stressing of warm water species is expected, even at the point of discharge.

Juveniles of warm water species spawning in Hanford slough upstream of the S/HNP discharge may have a slightly lower thermal tolerance than adults. Smallmouth bass are known to disperse throughout the river following spawning in early summer (Ref 36). Some movement of bass past the S/HNP discharge is expected due to the proximity of Hanford Slough. Downstream velocities are assumed to be essentially that of the river flow, eg, 2.3 to approximately 4.4 fps, during minimum and average flow rates. Thermal increments at the point of discharge and after initial mixing with the river, in relation to potential exposure time at low flow are presented in Tables 5.1-2, 5.1-3. As with cold water species this exposure time is considered too brief to adversely affect the juvenile fish. 4

Thermal discharge effects on warm water species are more likely to occur from cold shock than from temperature increases. The thermal plume issuing from the discharge structure could act as an attractant to warm water fish. Smallmouth bass have shown a preference for water temperatures slightly above ambient (Table 5.1-5). Fish could become acclimated to the increased temperatures and potentially dependent upon elevated temperatures for survival during winter months.

Fish mortalities have occurred at other thermal generation facilities following shutdowns, and considerable effort has been made to devise ways to eliminate losses. Cold shock is not expected to occur at the S/HNP because the thermal increments are so low that a discharge shutdown would not be expected to cause mortality and because the discharge is located in a swiftly flowing reach of the Columbia River. For fish to become acclisated to the warm plume temperatures, they would have to occupy the plume area for several days, which is not expected to happen in strong currents.

5.1.4 EFFECTS OF HEAT DISSIPATION FACILITIES

The environmental impacts that can result from the operation of the round mechanical draft cooling towers at the S/HNP include the formation of ground-level fogging, icing, elevated visible plumes, total solids discharged (drift), increased ground-level temperature, and increased ground-level relative humidity. Table 5.1-6 and Figure 5.1-11 present design values and a performance curve, respectively, for the round mechanical draft cooling towers. The models used in these analyses are described in Section 6.1.3.3.

5.1.4.1 Fogging and Icing

The effects of an evaporative heat dissipation system on the formation of fogging and icing conditions are determined by the quantity and location of added moisture and by the existing ambient air conditions. The significant factors in determining the enhancement of fogging and icing occurrences are the characteristics and quantity of effluent air, the height of the effluent plume, and the downwind dispersion of the plume. 4

Figure 5.1-12 shows the predicted annual mean frequency of occurrence of reduced ground level visibility to less than 1000 meters (5/8 mile). For round mechanical draft cooling towers, the maximum ice accumulations on horizontal surfaces is predicted to be no more than 1 mm beyond the Site boundary in all directions from the cooling towers. The maximum predicted horizontal ice thickness is 10 mm, occurring to the south-southwest of the towers at a distance of 0.25 mile, with an average frequency of less than 15 hrs per winter season.

5.1.4.1.1 Effects on Transportation

Generally, driving conditions can be affected both by visibility reductions caused by fogging, and by icing conditions on roadways caused by moisture emissions from the operation of cooling systems. Table 5.1-7 lists the closest locations and orientations of the roadways within 20 miles of the S/HNP. The predicted maximum annual mean frequencies of reduced ground level visibility to less than 1000 meters (5/8 mile) were less than 1 hr/yr for all major roadways within 10 miles of the S/HNP. In addition, the

predicted annual mean horizontal ice accumulations were less than 1 mm/yr for these roadways.

The closest commercial airport to the Site is at Richland, approximately 14 miles to the south-southeast. The annual mean frequency of reduced ground-level visibility to less than 1000 m (5/8 mile) will be less than 1 hr/yr at the Richland Airport. The predicted horizontal icing will be less than 1 mm/yr.

The closest waterways to the Site are the Columbia River, about 7 miles to the northeast, and the Yakima River, about 7 miles to the south. The maximum frequencies of reduced ground-level visibility to less than 1000 meters (5/8 mile) and horizontal icing, respectively, will be less than 2 hrs/yr and less than 1 mm/yr for the Columbia River, and less than 10 hrs/yr and less than 1 mm/yr for the Yakima River.

5.1.4.2 Elevated Visible Plumes

Figure 5.1-13 shows the predicted annual frequency of elevated visible plumes. The maximum occurrence will be approximately 560 hrs/yr in the immediate vicinity (0.25 mile) of the cooling towers. 4

The annual mean frequency of elevated visible plumes at the Richland Airport will be less than 20 hrs/yr. The closest population center is North Richland, located approximately 12 miles to the southeast of S/HNP. The annual mean frequency of elevated visible plumes will be less than 30 hrs/yr over North Richland.

Table 5.1-8 lists monthly and annual percentages of occurrence of elevated visible plume lengths within 10 miles of the cooling towers. The results indicate a maximum frequency of 28.5 percent during December at downwind distances of 0.25 and 0.50 mile from the towers.

5.1.4.3 Total Solids Discharged From the Cooling Towers

Figure 5.1-14 shows the annual deposition patterns resulting from the total solids discharged from the cooling towers. Total solids deposition is defined as the total amount of solid material deposited as dry particles and in droplet form. The maximum annual total solids deposition will be 37 lb/acre-yr in the immediate vicinity (0.25

miles) of the towers and 8 lb/acre-yr at a location approximately 1.0 mile to the southeast of the towers.

5.1.4.4 Increased Ground-Level Temperature and Relative Humidity

The S/HNP cooling towers will produce a maximum ground-level temperature increase of less than 1°F. The mean annual predicted increases in ground-level relative humidity will be less than 1 percent and will cause no detectable environmental impact.

5.1.4.5 Cooling Tower Plume Behavior

Meteorological data for the months of January and July were considered representative of winter and summer conditions, respectively. Meteorological parameters for morning conditions were assumed to occur typically between the hours of 0400 and 0600 Local Standard Time (LST). Morning conditions were used for the study, because plume-related impacts are expected to be more significant during the morning hours due to lower ambient temperatures and higher relative humidities. 4

For an average winter morning, a strong ground-based inversion (10.8°F/1000 ft) with an average surface temperature of 29.8°F was obtained from the data. The average surface wind speed was 5.4 miles/hr, which increases to 8.5 miles/hr at a height of 245 ft, resulting in an average wind power law exponent of 0.23. The average relative humidity was 86.1 percent for surface conditions. The average dewpoint of 26.2°F was assumed to be invariant with height. The average summer morning conditions also revealed a strong ground-based inversion (14.9°F/1000 ft) with an average surface temperature of 63°F. The average surface wind speed was 5.1 miles/hr, which increases to 7.9 miles/hr at a height of 245 ft, resulting in an average wind power law coefficient of 0.22. The average surface relative humidity was calculated to be 58.5 percent. The surface dewpoint temperature of 48.2°F was considered to be invariant with height.

The initial momentum and buoyancy of the emissions from the cooling towers are expected to raise the vapor plume to a height of approximately 300 m during the average winter morning. The height of maximum penetration is determined to be the height where the vertical velocity of the plume becomes zero. The neutral buoyancy height is approximately

243 m. The neutral buoyancy height (equilibrium level of buoyancy) is defined as the level at which the densities of the plume and the ambient atmosphere are identical. During an average summer morning, a plume was calculated to penetrate to a height of approximately 230 m. Plume buoyancy becomes neutral at 168 m. Figures 5.1-15 and 5.1-16 show some plume parameters as a function of height for winter and summer mornings, respectively.

The excess of ground-level moisture over that contained in the ambient atmosphere near the cooling towers will be insignificant under normal weather conditions. Figures 5.1-17 and 5.1-18 show the vertical profiles of excess relative humidity through the plume centerline at various distances downwind from the cooling towers under average winter and summer morning conditions, respectively. Listed in Table 5.1-9 are the calculated values of relative humidity excess at the center of the plume at selected downwind distances. The operation of the cooling tower system is not expected to cause significant weather modification.

5.1.4.6 Parametric Study of Plume Rise

To examine the expected plume rise, a parametric analysis was performed for average winter and summer morning conditions, using the NUS computer code LVPM (see Section 6.1.3.3). Two major parameters, the ambient vertical temperature gradient and the ambient wind speed, influence the plume rise. 4

Using these parameters, plume rise was examined:

- as a function of vertical temperature gradient, assuming the gradient is constant with height (see Figure 5.1-19), and
- as a function of ambient wind speed at the tower top (see Figure 5.1-20).

In the second analysis, the wind profile was assumed to vary according to the empirical power law:

$$U_z = U_H \left(\frac{Z}{H}\right)^P$$

where

U_z = windspeed at height Z

U_H = windspeed at tower height, H

P = empirical constant, 0.23 for the winter morning and 0.22 for the summer morning determined from the WNP-2 on-site meteorological data.

Average January and July morning conditions were used. The plume height from the cooling tower system will generally exceed 200 m for all seasons, as shown in Figure 5.1-19.

5.1.4.7 Plume Shadowing, Cloud Formation, Increased Precipitation, and Aesthetics

Plume shadowing occurs when the cooling tower plume blocks the direct light of the sun. The degree to which shadowing occurs varies with atmospheric conditions. Areas near the towers will be subject to some plume shadowing, most frequently during the winter months.

Other than visible plumes, no significant amount of increased cloud formation or of increased precipitation will be caused by the cooling tower releases. Additionally, the visual impact of the cooling towers and any visible plumes that they generate will have a negligible aesthetic impact. 4

5.1.4.8 Combined Effects From the Heat Dissipation Facilities of S/HNP Units 1-2 and WPPSS Units 1, 2, and 4

The NUS computer program FOG (see Section 6.1.3.3) was used to predict the expected atmospheric effects resulting from the combined operation of the six round mechanical draft cooling towers associated with S/HNP Units 1-2, the four rectangular mechanical draft cooling towers associated with WNP-1 and -4, and the six round mechanical draft cooling towers associated with WNP-2. The separation distance from the S/HNP Unit 2 to the WNP-2 is approximately 5 miles.

5.1.4.8.1 Fogging and Icing

Figure 5.1-21 presents the annual mean frequencies of occurrence of reduced ground level visibility to less than 1,000 m (5/8 mile).

The predicted icing impacts were localized to the immediate vicinity of the S/HNP. Because the closest WNP cooling towers are located approximately five miles from the S/HNP, there will be no combined icing impacts. Therefore, cooling tower induced icing combined impacts are not addressed.

4

5.1.4.8.1.1 Effects on Transportation. The closest location and orientation of the roadways within 20 miles of the S/HNP are listed in Table 5.1-7.

The combined annual mean frequencies of occurrence of reduced ground level visibility was less than 25 hrs/yr for all major roadways. The combined annual mean frequency of occurrence of reduced ground level visibility was less than 5 hrs/yr at the Richland Airport and the Richland (CAP) Airport. The combined annual mean frequencies of occurrence of reduced ground level visibility were 22 hrs/yr for the Yakima River and less than 10 hrs/yr for the Columbia River. 5

5.1.4.8.2 Elevated Visible Plumes

Isopleths of the predicted annual frequency of occurrence of elevated visible plumes from the S/HNP and WNP units are presented in Figure 5.1-22. The maximum predicted occurrence is approximately 470 hrs/yr in the immediate vicinity (0.25 miles) of the cooling towers associated with S/HNP. The combined annual mean frequency of occurrence of elevated visible plumes at the Richland Airport and the Richland CAP Airport will be 29 hrs/yr and 26 hrs/yr, respectively. The combined annual mean frequencies of occurrence of elevated visible plumes will be less than 40 hrs/yr over any population center. 4

5.1.4.8.3 Total Solids Discharged From the Cooling Systems

The total annual solids deposition pattern resulting from the S/HNP and WNP-1, -2, and -4 cooling tower discharges are shown in Figure 5.1-23. Total solids are defined as the total solid material deposited as dry particles as well as in droplet form. The maximum predicted total annual solids deposition was 270 lbs/acre-yr located in the immediate vicinity (0.25 miles) of the WNP cooling towers.

5.1.4.8.4 Increased Ground Level Temperature and Relative Humidity

The combined effects of the S/WNP and WNP-1, -2, and -4 cooling towers will have a negligible effect on ground level temperature. The maximum predicted increase of ground level temperature is less than 1° F. The combined mean annual predicted increases in ground-level relative humidity will be less than 1 percent and will cause no detectable environmental impact.

5.1.4.8.5 Plume Shadowing, Cloud Formation, Increased Precipitation, and Aesthetics 4

Areas near the towers will be subject to some plume shadowing, mostly during the winter months. Other than visible plumes, no significant amount of increased cloud formation or precipitation is expected to be caused by the combined cooling tower releases. The visual impact of the cooling towers and any visible plumes will have a negligible aesthetic impact.

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TABLE 5.1-1

STUDY CASE PARAMETERS

Title	Case-1 Regulatory Limiting	Case-2 Average	Case-3 Large Excess Temperature
Discharge Parameters			
Temperature - Deg F	84.5	68.9	68.9
Flow - Cfs	13.17	6.28	6.28
Centerline Depth - Ft	12.5	19.5	12.5
Diameter - Ft	1.5	1.5	1.5
Distance from Shore - Ft	550	630	550
Angle with Horizontal - Deg	15	15	15
Angle with Current - Deg	90	90	90
River Parameters			
Temperature - Deg F	68.0	51.4	39.0
Flow - Cfs	36,000	115,752	36,000
Width - Ft	1,390	1,550	1,390
Surface Elevation - Ft above MSL	350.9	358.3	350.9
Velocity - Fps	2.32	4.37	2.32
Regulatory Limits			
Temperature Excess - Deg F - at the edge of a 300 ft mixing zone	0.54	3.09	4.75

4

TABLE 5.1-2

DESCRIPTION OF EXCESS TEMPERATURE ISOTHERMS IN THE COLUMBIA RIVER NEAR THE
IN THE COLUMBIA RIVER NEAR THE PROPOSED THERMAL DISCHARGE ZONE.

		Surface Isotherms				Vertical Isotherms	
	Excess Temperature Isotherms (°F)	Maximum Cross-Sectioned Distance (ft)	Percent of River Cross-Section	Downstream Extent (ft)	Passive Drift Exposure (sec)	Downstream[a] Extent (ft)	Passive Drift[b] Exposure (sec)
Case 1	0.5	17	1.2	35	15	52	23
	1.0	13	0.9	29	13	48	21
River Velocity	2.0	6	0.6	17	7	40	18
at 2.32 FPS	3.0	3	0.1	5	2	32	14
Case 2	0.5	6	0.4	29	7	153	36
	1.0	4	0.3	20	5	148	35
River Velocity at 6.37 FPS	2.0	2	0.1	7	2	139	33
Case 3	1.0	8	0.6	29	13	62	27
	2.0	6	0.4	23	10	58	25
River Velocity	3.0	5	0.4	18	8	54	24
at 2.32 FPS	5.0	2	0.1	8	3	47	21

NOTE: Values estimated from Figures 5.1-5 TO 5.1-10

a) Plume centerline surfaces 31, 134 and 41 feet downstream from discharge for Cases 1, 2 and 3, respectively.

b) Exposure from discharge to plume surfacing is 16, 32 and 18 seconds for Cases 1, 2 and 3, respectively.

Table 5.1-3

ESTIMATED DOWNSTREAM EXTENT OF EXCESS TEMPERATURE NEAR THE PROJECT DISCHARGE DURING PEAK DOWNSTREAM MOVEMENT OF JUVENILE CHINOOK SALMON (CASE 2) AND IN AUGUST-SEPTEMBER (CASE 1)

	Temperature °C	Temperature °F	Extent of Isotherm (ft)	Passive Drift Distance (sec)
Case 1(a)	6	3.3	30*	13.0
	8	4.4	23	9.9
	10	5.6	12	5.2
	12	6.7	8	3.9
	14	7.8	6	2.6
Case 2(b)	6	3.3	33	7.6
	8	4.4	23	5.3
	10	5.6	16	3.7
	12	6.7	13	3.0
	14	7.8	10	2.3
	16	8.9	8	1.8

NOTE: Data is extrapolated from Figure 5.1-4 and is conservative in assuming no vertical or horizontal mixing from initial discharge plume width of 1.5 feet.

* Cannot exceed distance of plume centerline or 30' (Figure 5.1.8)

(a) River Velocity 2.32 fps

(b) River Velocity 4.37 fps

TABLE 5.1-4

PREFERRED TEMPERATURES OF RAINBOW TROUT
AT ACCLIMATION TEMPERATURES
POTENTIALLY PRESENT IN THE COLUMBIA RIVER

Species	Acclimation Temperature (°F)	Preferred Temperature (°F)
Rainbow Trout (*Salmo gairdneri*)	43	52.9
	48	54.7
	54	57.9
	59	62.4
	64	64.6
	70	68.2

Source: Reference 28

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TABLE 5.1-5

PREFERRED TEMPERATURES OF SMALLMOUTH BASS AT ACCLIMATION TEMPERATURES POTENTIALLY PRESENT IN THE COLUMBIA RIVER

Species	Acclimation Temperature (°F)	Preferred Temperature (°F)
Smallmouth Bass (*Micropterus dolmieui*)	59	68.4
	64	73.2
	70	79.7
	75	85.6
	81	86.2
	86	88.3

Source: Reference 28

4

TABLE 5.1-6

DESIGN PARAMETERS OF ROUND MECHANICAL DRAFT COOLING TOWER SYSTEM(a)

Parameter	Value
Heat Rejection Rate, Btu/hr	9×10^9
Circulating Water Flow Rate, gal/min	468,000
Air Flow Rate, ft^3/min	6.2×10^7
Exit Air Temperature, °F	104.8
Ambient Wet Bulb Temperature, °F	80
Approach, °F	6
Cold Water Temperature, °F	86
Hot Water Temperature, °F	124.5
Cooling Range, °F	38.5
Cycles of Concentration	10
Total Dissolved Solids (average), ppm	829
Maximum Drift Loss, Percent of Circulating Water Flow Rate	0.005
Number of Towers	3
Number of Fans/Tower	11
Fan Diameter, ft	40
Diameter at Fan Stack Discharge, ft	44
Tower Height at Discharge, ft	60
Tower Diameter, ft	253

(a) Per-unit basis.

4

TABLE 5.1-7

ENVIRONMENTALLY SENSITIVE AREAS WITHIN 20 MILES OF THE S/ENP UNITS 1-2

Name/Orientation	Closest Distance (Miles)	Direction
Roadways		
St. Route 4/NW-SE	1.2	NE
Army Loop Road/NE-SW	1.7	NW
St. Route 2/N-S	2.2	E
St. Route 10/N-S	2.2	ESE
St. Route 240/NW-SE	4.1	SW
St. Route 11A/W-E	6.2	N
St. Route 170/W-E	10.0	ENE
St. Route 224/W-E	13.2	S
St. Route 24/W-E	14.5	WNW
U.S. Route 410/W-E	16.0	SSE
U.S. Route 395/N-S	19.5	ESE
Waterways		
Columbia River	7	NE
Yakima River	7	S
Airports		
Richland	14	SSE
Richland (CAP)	18	SSE
Towns		
North Richland	12	SE
Benton City	15	S
Richland	14.5	SSE
Chandler	17	SSW
Kiona	16	S
Chaffee	18	SSW

4

TABLE 5.1-8

MONTHLY AND ANNUAL PERCENT FREQUENCY OF OCCURRENCE OF ELEVATED VISIBLE PLUMES WITHIN 10 MILES OF THE S/HNP ROUND MECHANICAL DRAFT COOLING TOWERS

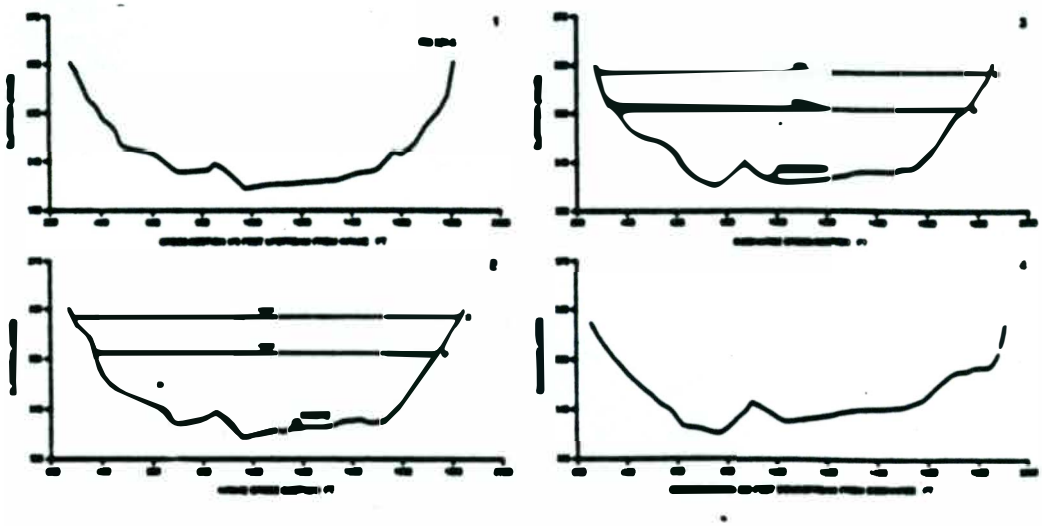
Downwind Distance (Miles)	Month Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
0.25	19.4	9.1	0.8	1.7	0.2	0.0	0.0	0.0	0.0	0.1	14.8	28.5	6.4
0.50	19.4	9.1	0.8	1.7	0.2	0.0	0.0	0.0	0.0	0.1	13.7	28.5	6.3
0.75	18.3	8.6	0.8	1.5	0.2	0.0	0.0	0.0	0.0	0.1	13.7	27.4	6.1
1.00	16.0	7.3	0.8	1.5	0.2	0.0	0.0	0.0	0.0	0.1	12.6	26.3	5.5
1.50	13.7	6.6	0.7	1.4	0.2	0.0	0.0	0.0	0.0	0.1	12.6	25.1	5.1
2.00	11.3	5.8	0.6	1.1	0.2	0.0	0.0	0.0	0.0	0.1	11.4	24.0	4.7
2.50	10.6	5.5	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	10.7	22.8	4.3
3.00	9.9	5.4	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	10.4	22.8	4.3
3.50	9.2	5.1	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	10.3	21.7	4.1
4.00	8.4	5.0	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	10.2	21.7	4.0
4.50	8.0	5.0	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	10.0	21.7	3.9
5.00	7.6	4.6	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	10.0	20.5	3.9
6.00	7.2	4.5	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	9.8	19.4	3.7
7.00	7.0	4.5	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	9.7	19.4	3.7
8.00	7.0	4.5	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	9.6	19.4	3.5
10.00	6.6	4.3	0.4	1.1	0.1	0.0	0.0	0.0	0.0	0.1	9.5	19.4	3.5

4

TABLE 5.1-9

RELATIVE HUMIDITY EXCESS, AT PLUME LEVEL, CAUSED BY OPERATION OF S/ENP COOLING TOWERS

Ambient Condition	Ambient Relative Humidity	Excess Relative Humidity (%)				
		1 km Downwind	3 km Downwind	5 km Downwind	10 km Downwind	4
Average winter morning	86.1	10.8	5.2	3.5	2.0	
Average summer morning	58.5	7.0	3.1	2.0	1.0	



a) Regulated Average Discharge that is Equalled or Exceeded 50% of the Time -115,752 CFS.

b) Administratively Established Minimum Discharge - 36,000 CFS.

c) Cross-Sectional views looking upstream. Distances are in feet from the west bank (Benton County shoreline).

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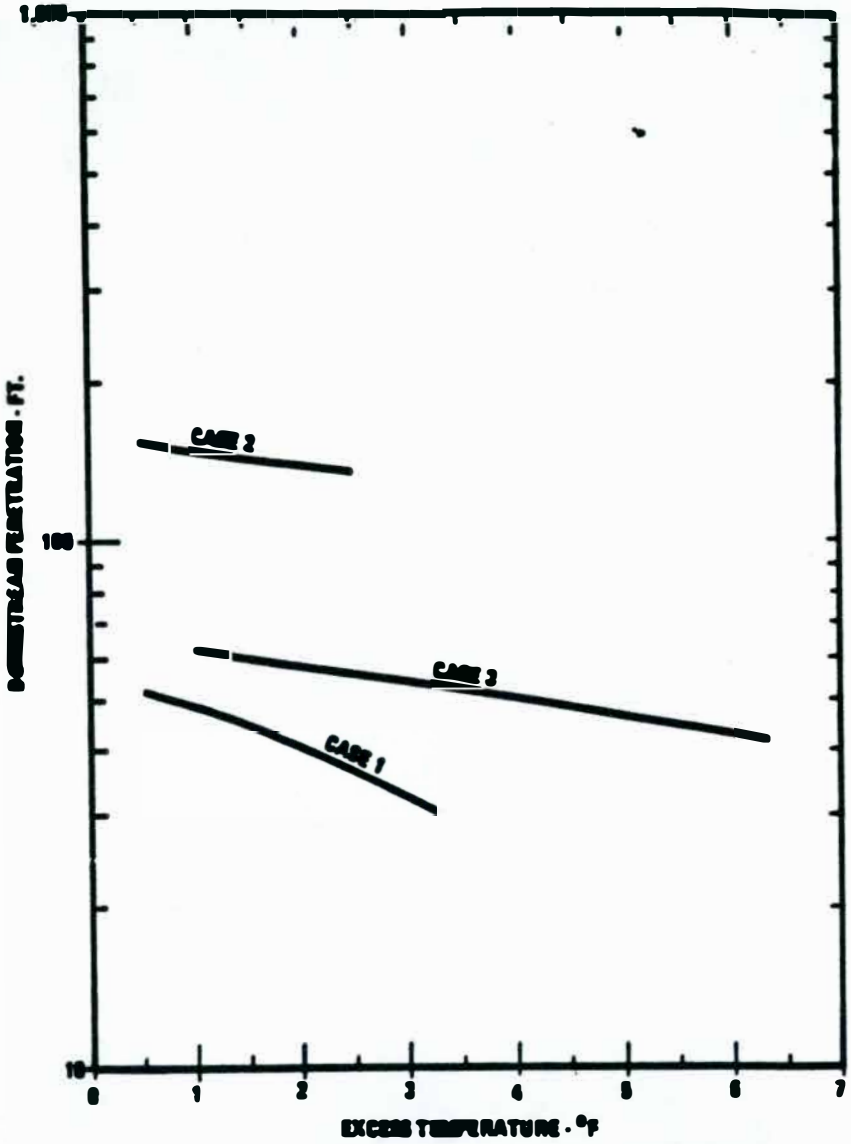
RIVER CROSS-SECTIONS IN THE VICINITY OF THE DISCHARGE

FIGURE 5.1-1



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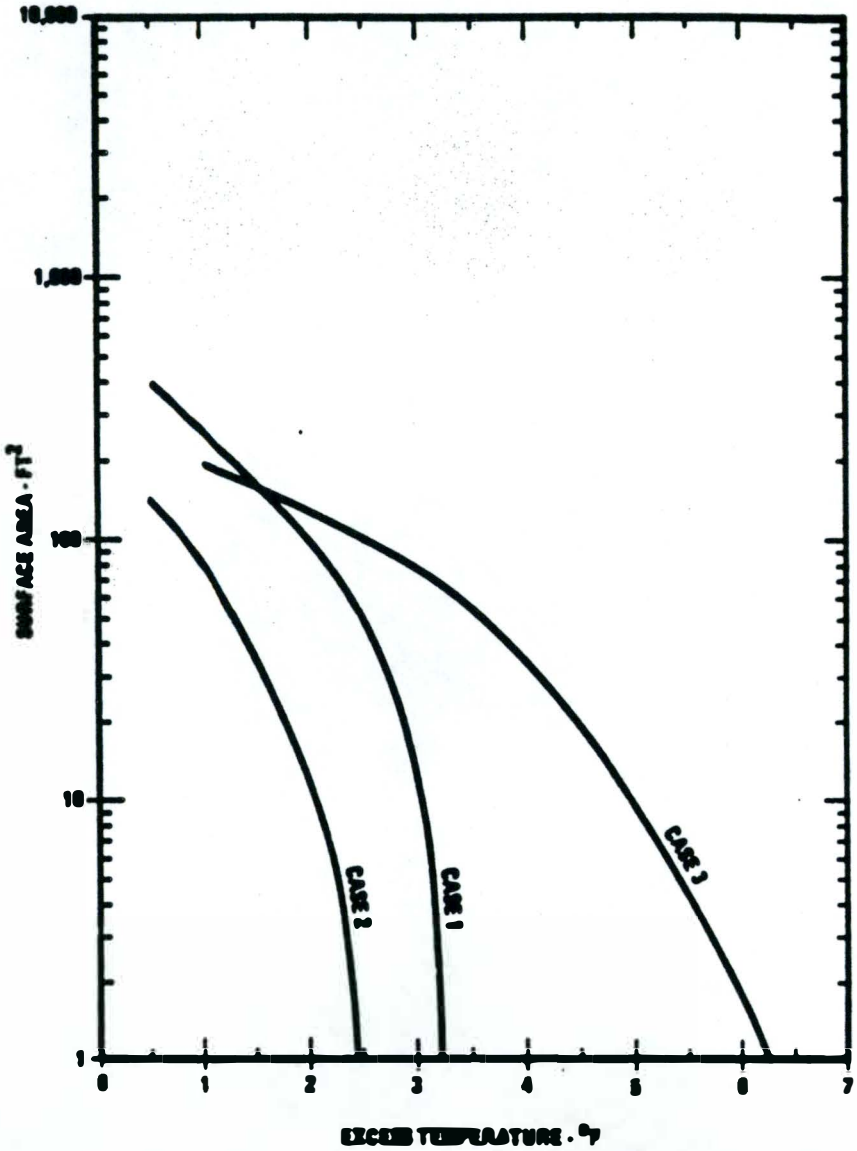
DOWNSTREAM SURFACE
PENETRATION VS.
EXCESS TEMPERATURE

FIGURE 5.1-2



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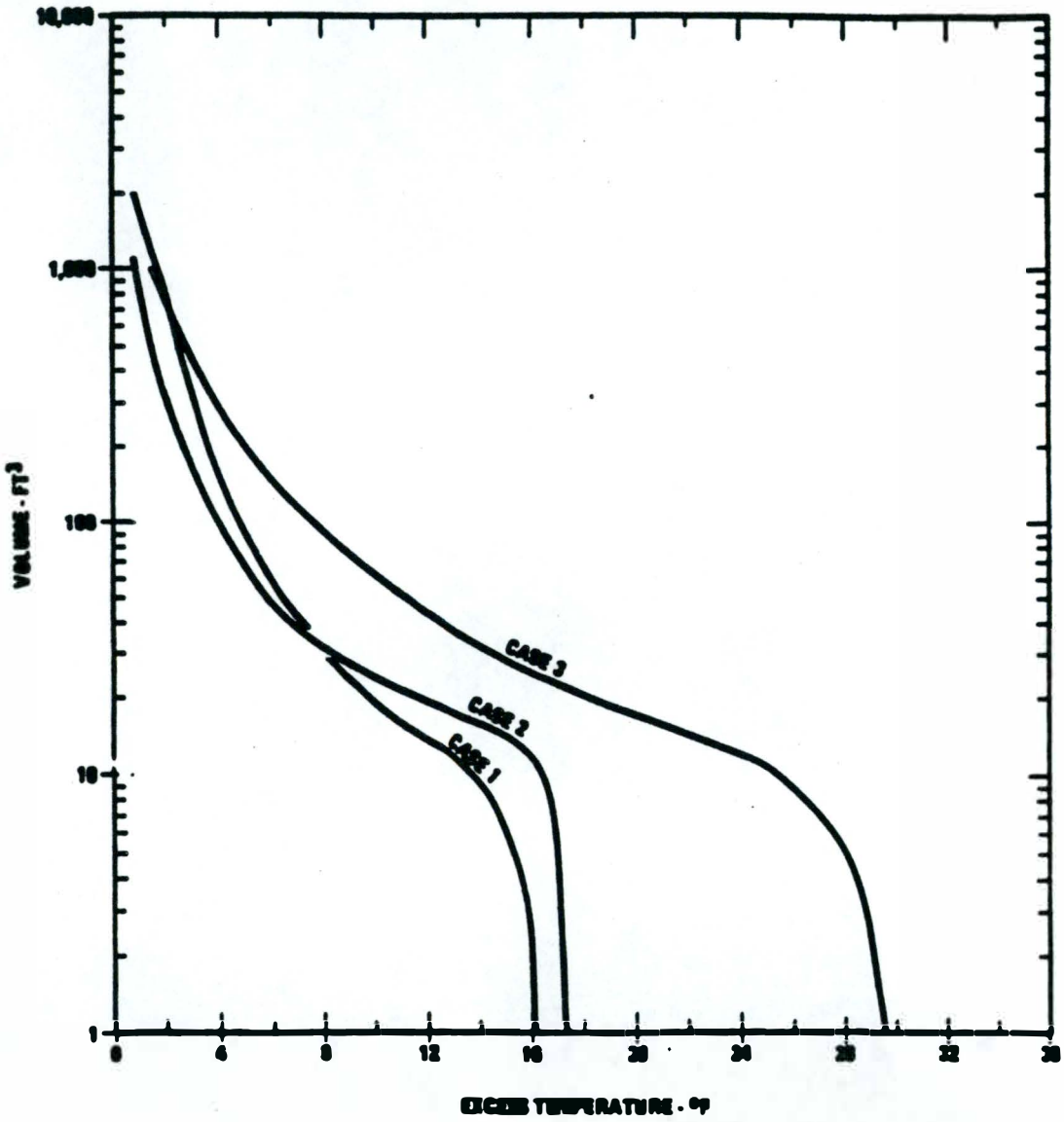
SURFACE AREA VS. EXCESS TEMPERATURE

FIGURE 5.1-3



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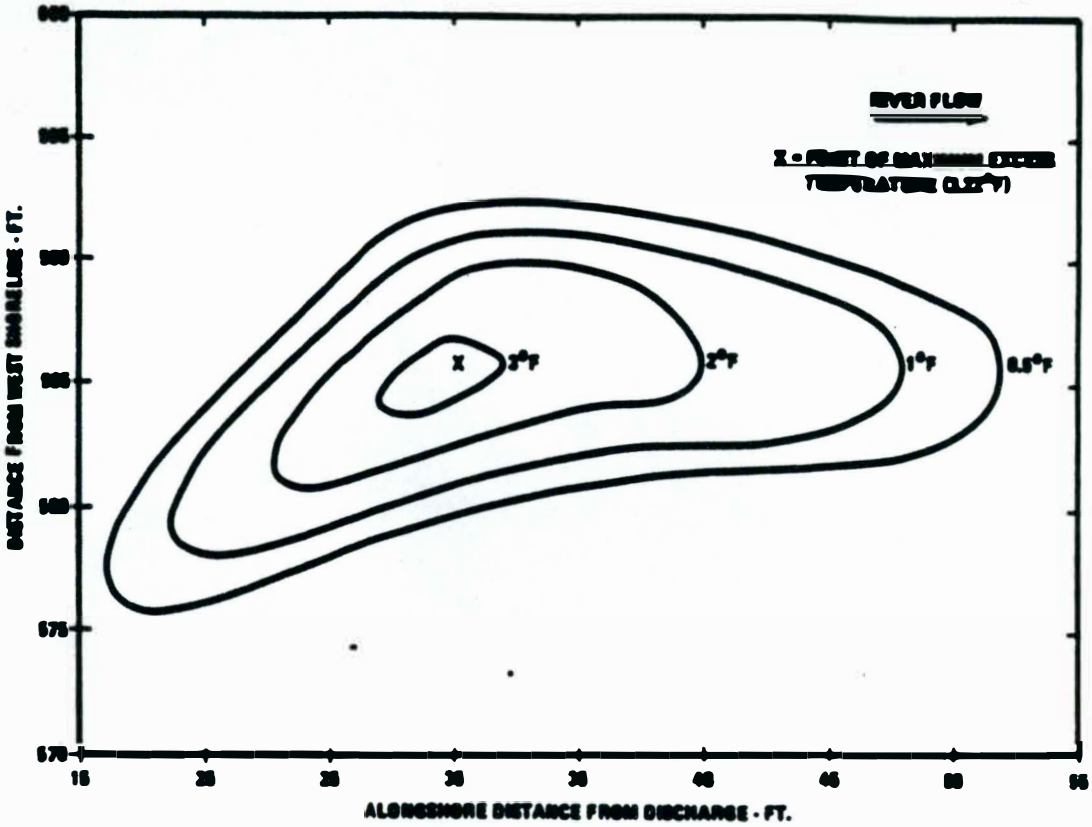
VOLUME
VS.
EXCESS TEMPERATURE

FIGURE 5.1-4



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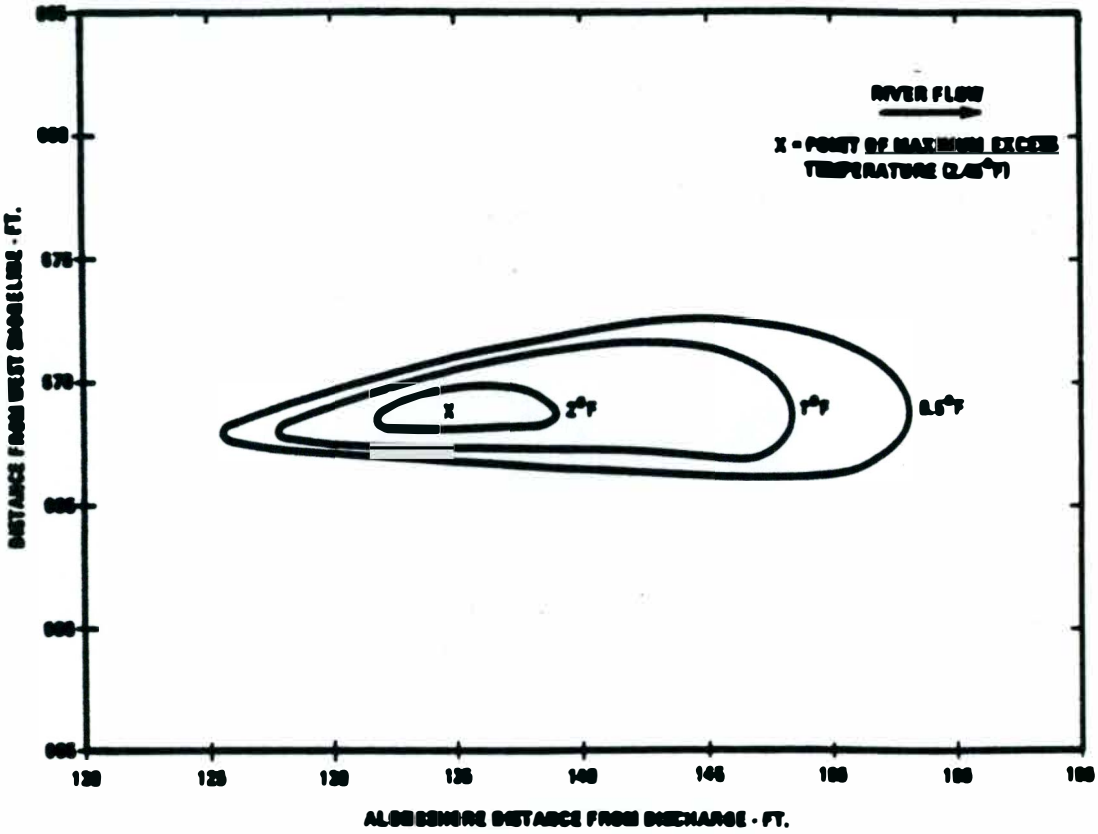
SURFACE EXCESS TEMPERATURE ISOTHERMS – REGULATORY LIMITING CASE (1)

FIGURE 5.1-5



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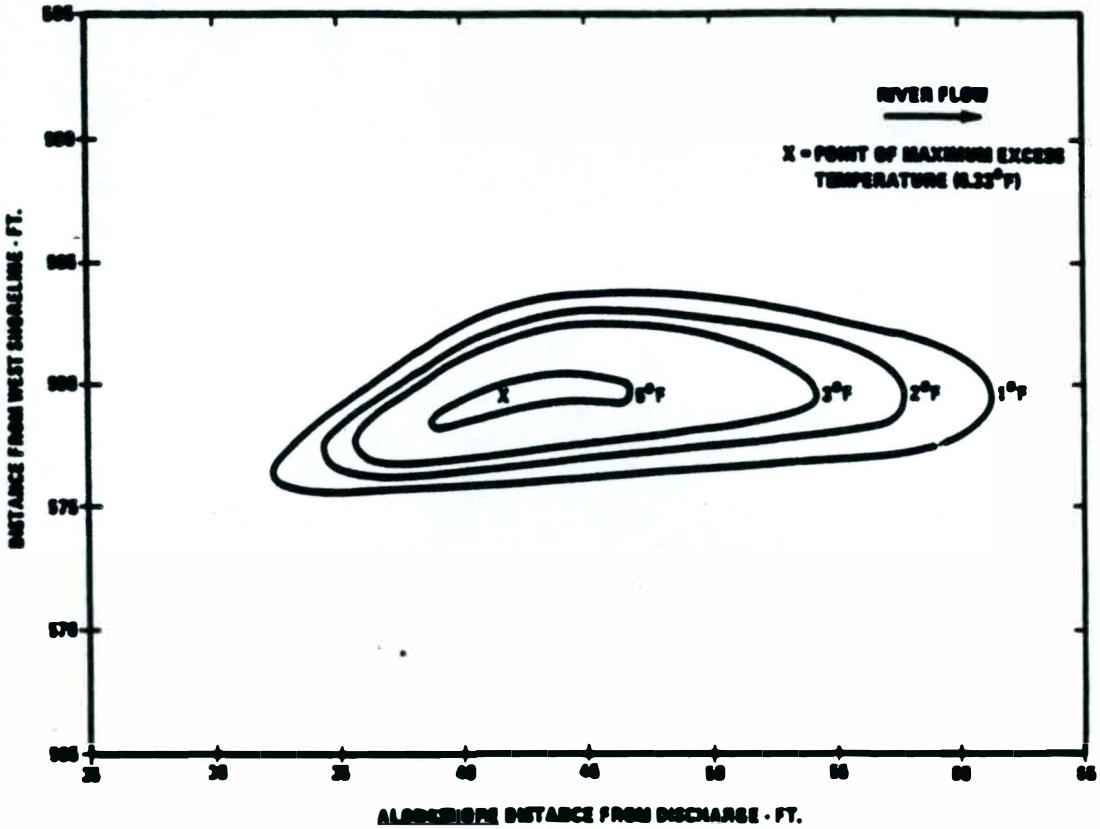
SURFACE EXCESS TEMPERATURE ISOTHERMS – AVERAGE CASE (2)

FIGURE 5.1-6



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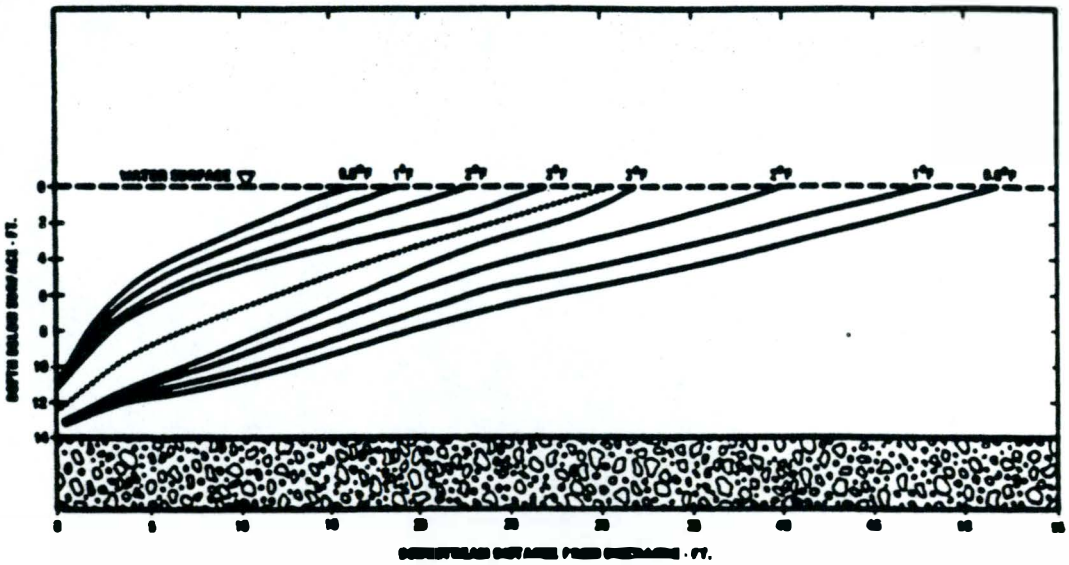
SURFACE EXCESS TEMPERATURE ISOTHERMS – LARGE EXCESS TEMPERATURE CASE (3)

FIGURE 5.1-7



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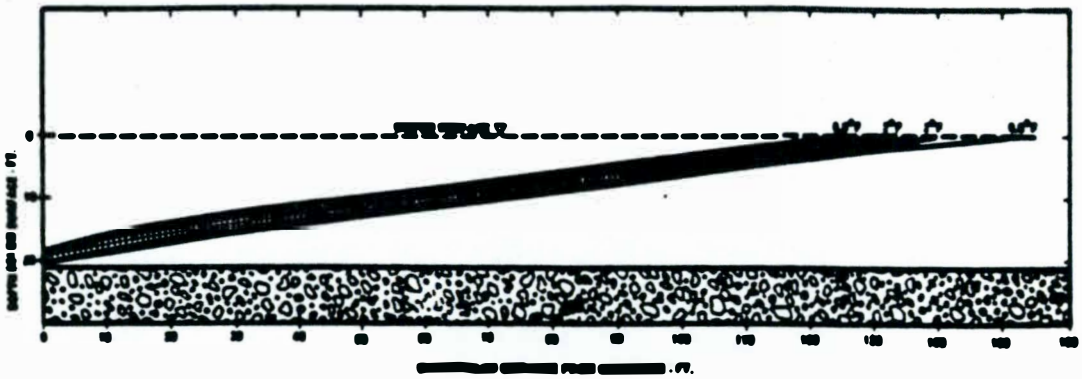
VERTICAL EXCESS TEMPERATURE ISOTHERMS – ALONG PLUME CENTERLINE – REGULATORY LIMITING CASE (1)

FIGURE 5.1-8



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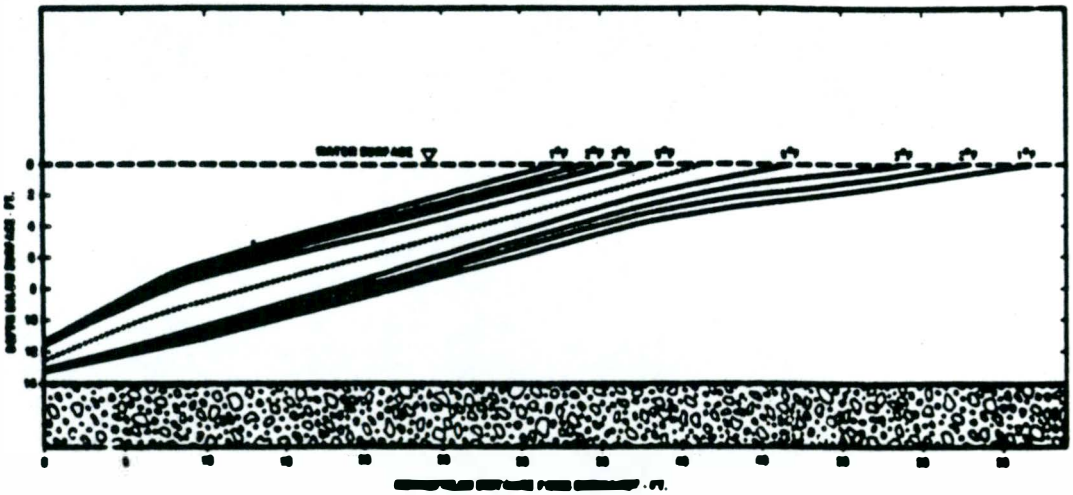
VERTICAL EXCESS TEMPERATURE ISOTHERMS – ALONG PLUME CENTERLINE – AVERAGE CASE (2)

FIGURE 5.1-9



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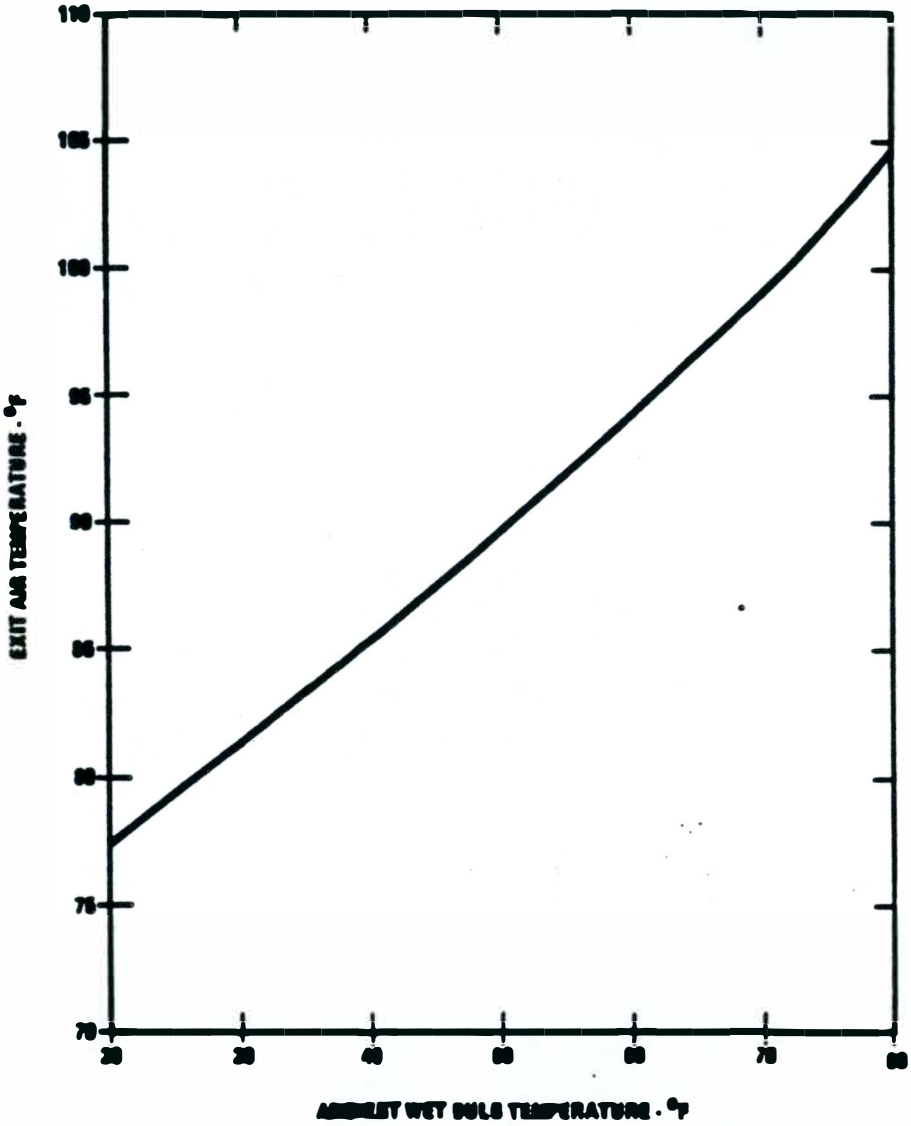
VERTICAL EXCESS TEMPERATURE ISOTHERMS – ALONG PLUME CENTERLINE – LARGE EXCESS TEMPERATURE CASE (3)

FIGURE 5.1-10



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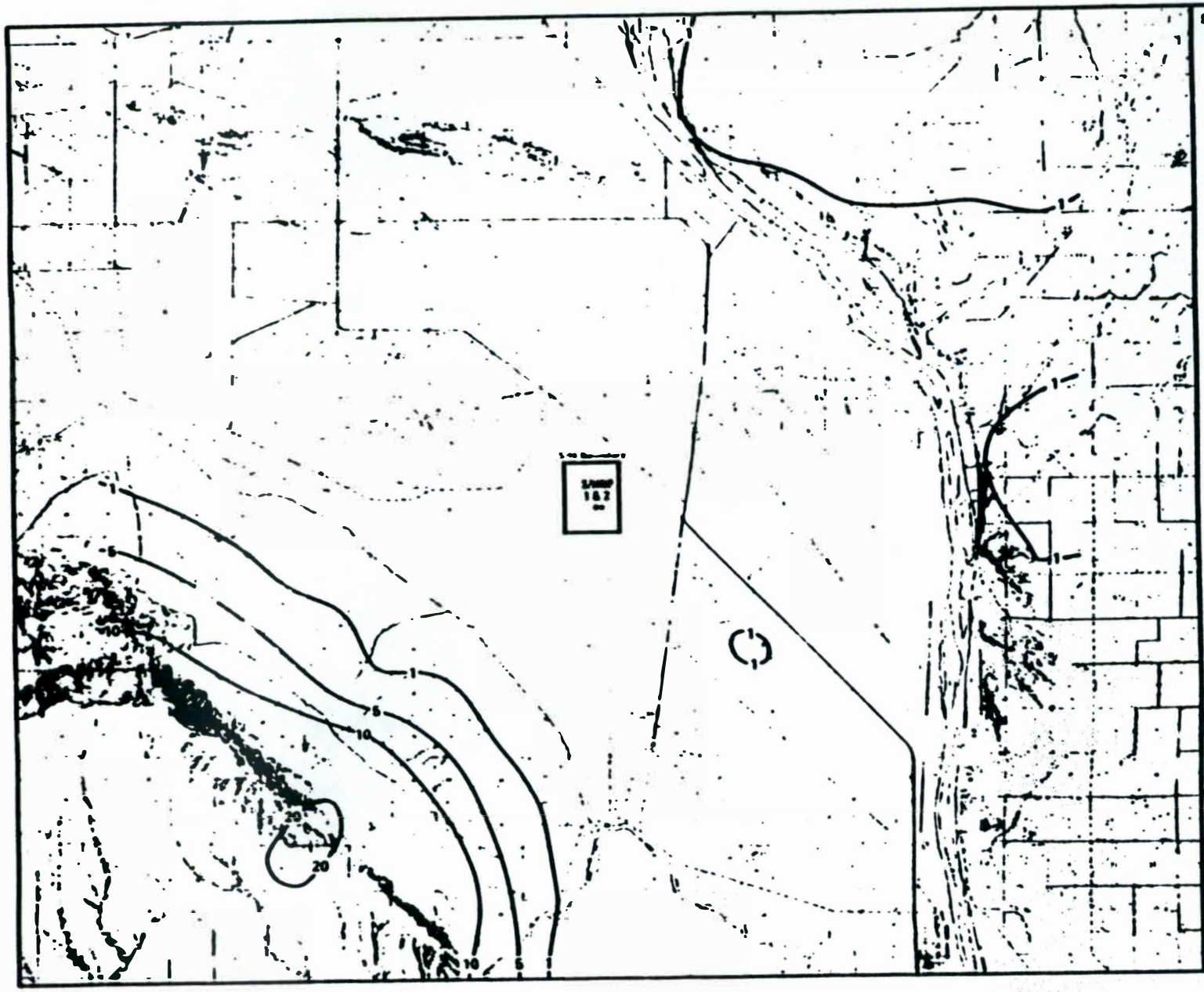
COOLING TOWER
PERFORMANCE CURVE

FIGURE 5.1-11



SOURCE: USGS 1:62,500 MAPS

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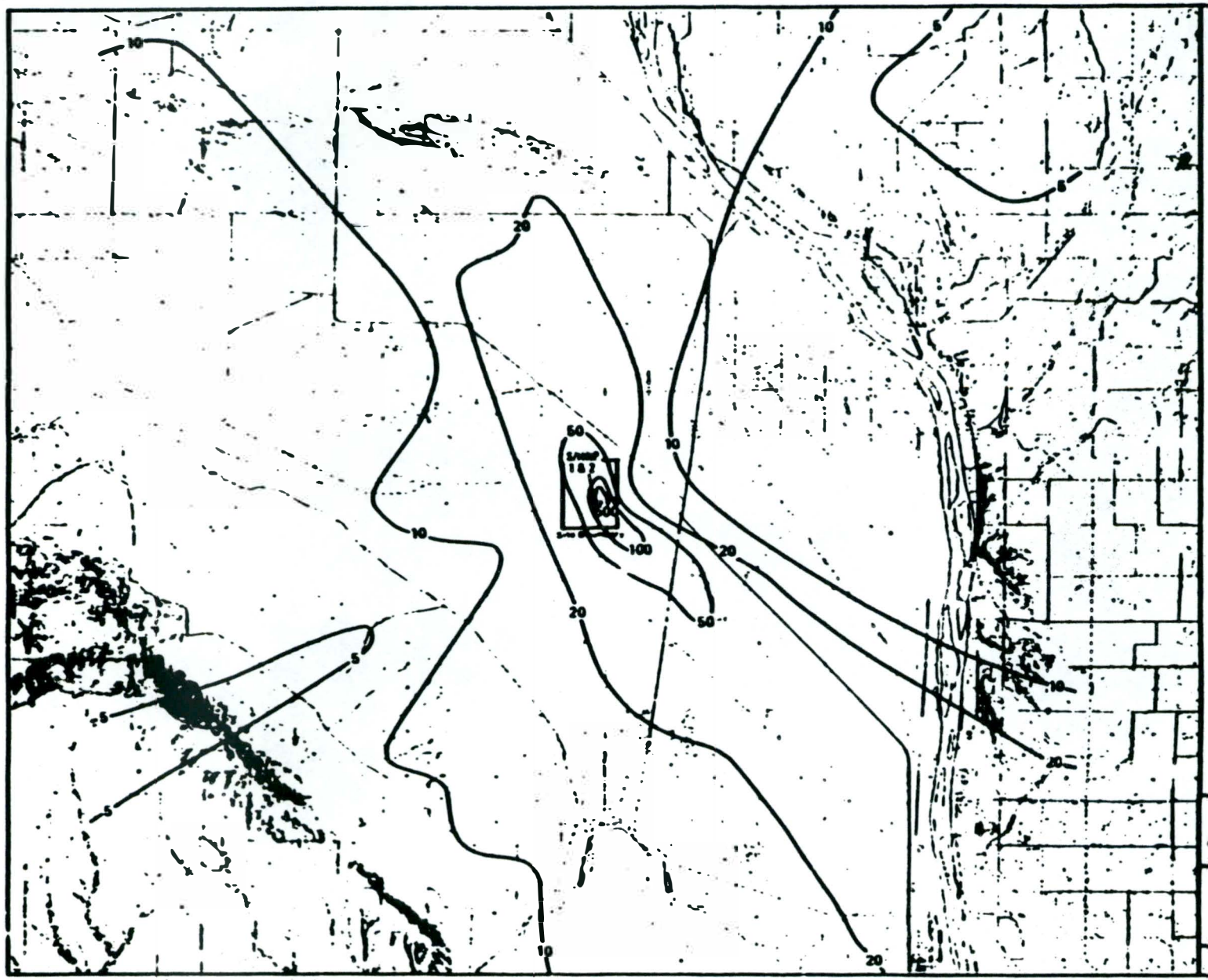
REDUCED GROUND LEVE
VISIBILITY HOURS/YEAR

FIGURE 5.1-12



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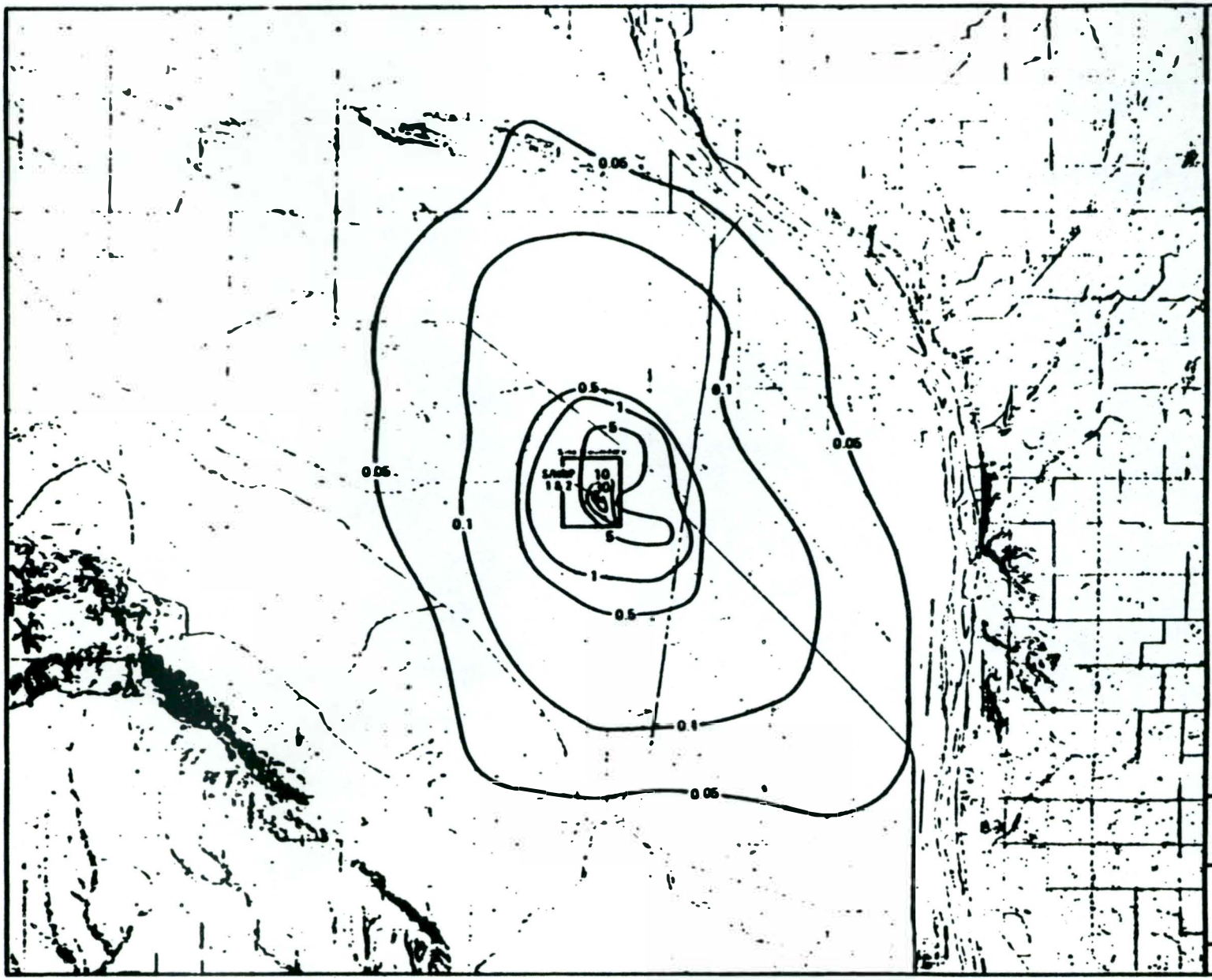
ELEVATED VISIBLE PLU
HOURS/YEAR

FIGURE 5.1-13



SOURCE: USGS 1:62,500 MAPS

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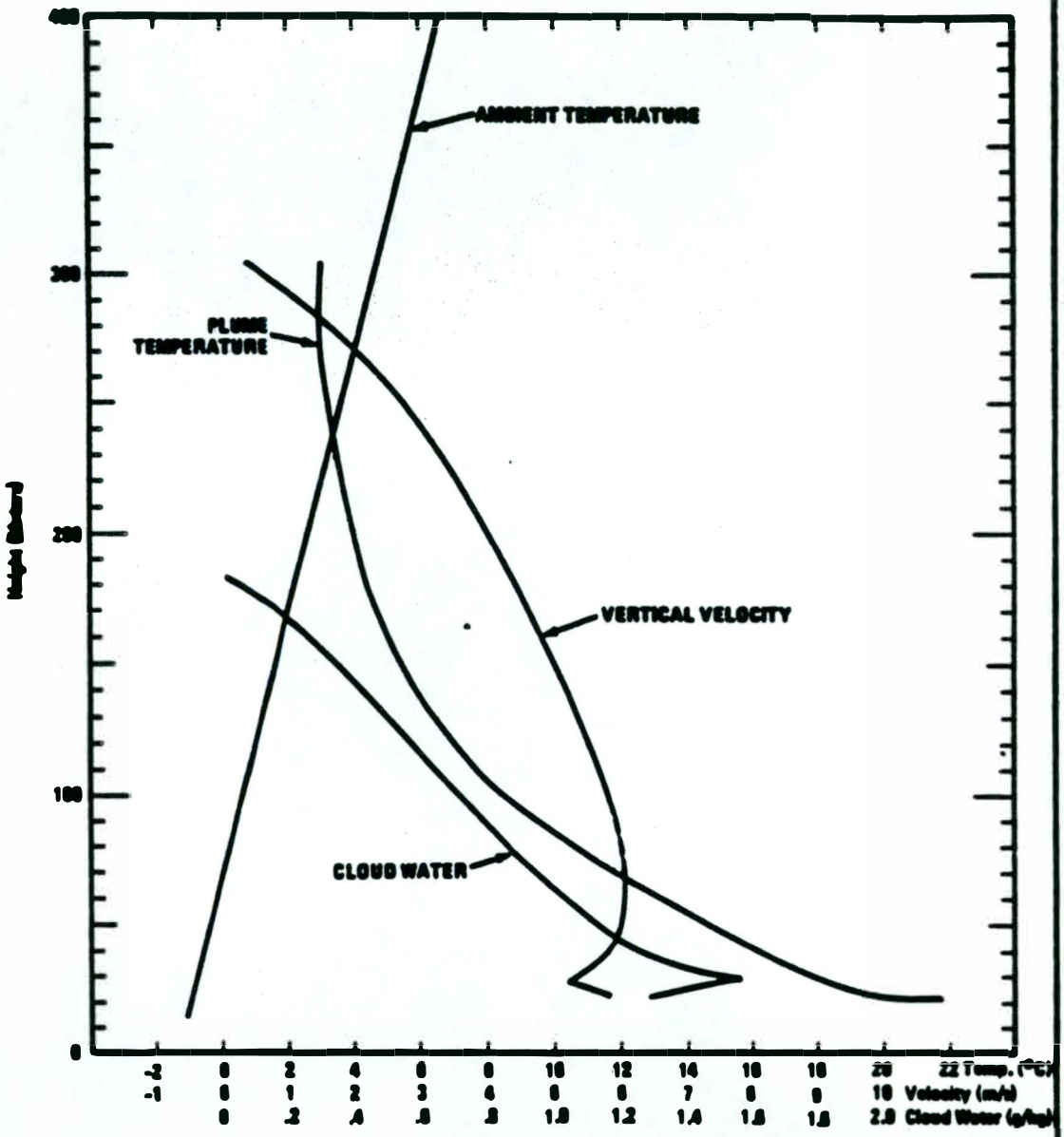
TOTAL SOLIDS DEPOSITI
LB/ACRE-YEAR

FIGURE 5.1-14

Amend



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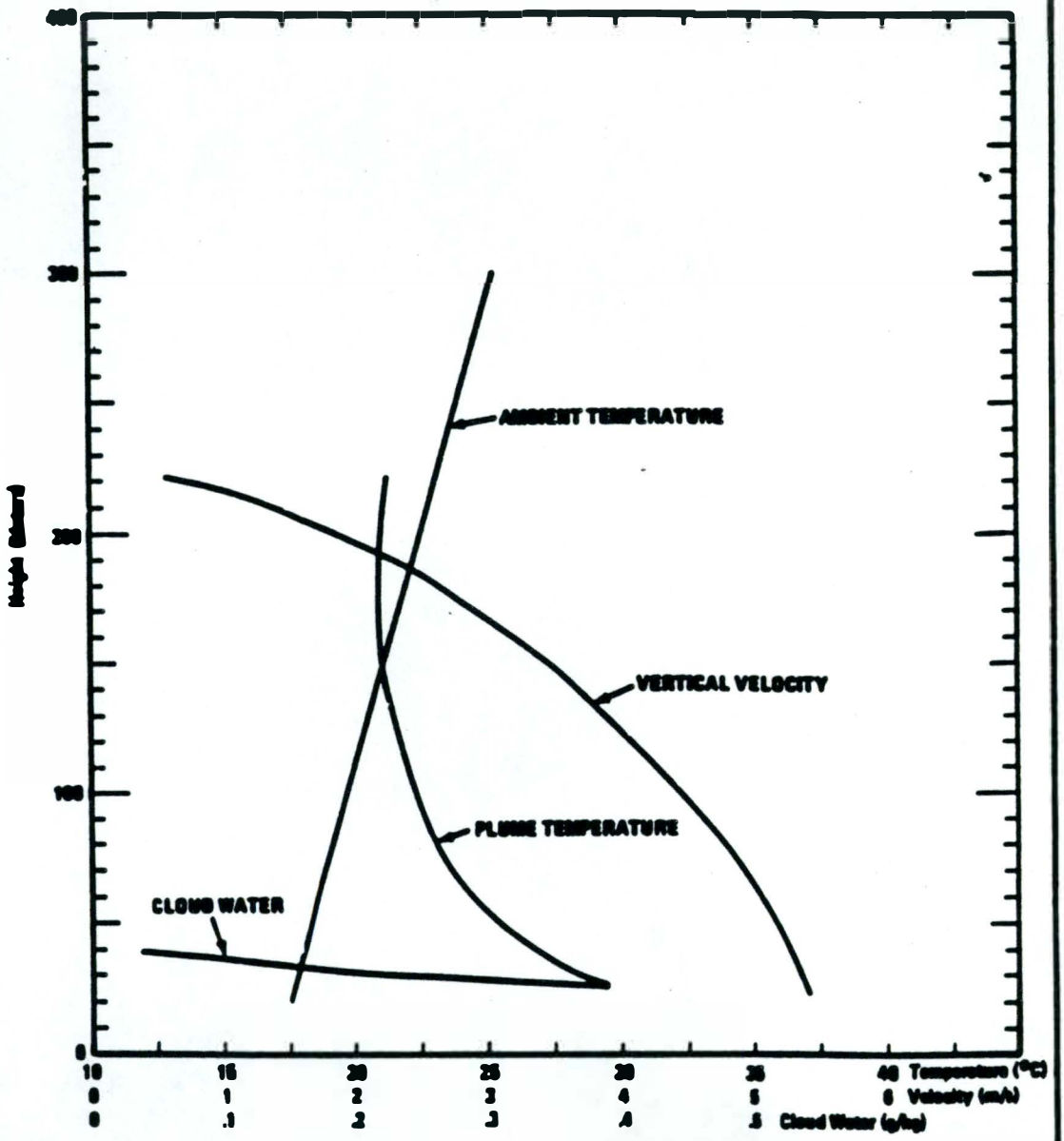
PLUME PARAMETER VARIATIONS, AVERAGE WINTER MORNING CONDITIONS

FIGURE 5.1-15



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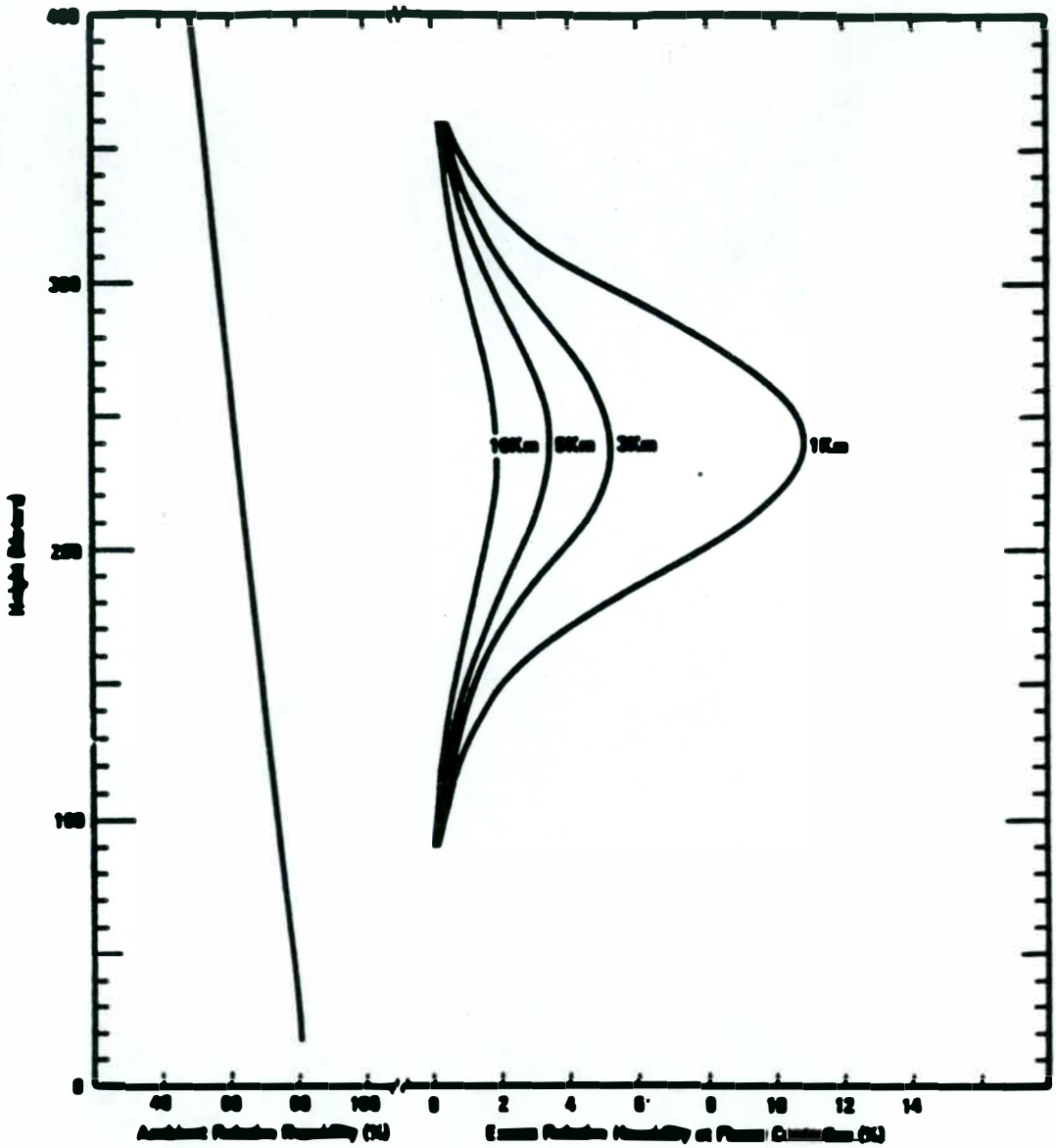
PLUME PARAME TER VARIATIONS,
AVERAGE SUMMER MORNING
CONDITIONS

FIGURE 5.1-16



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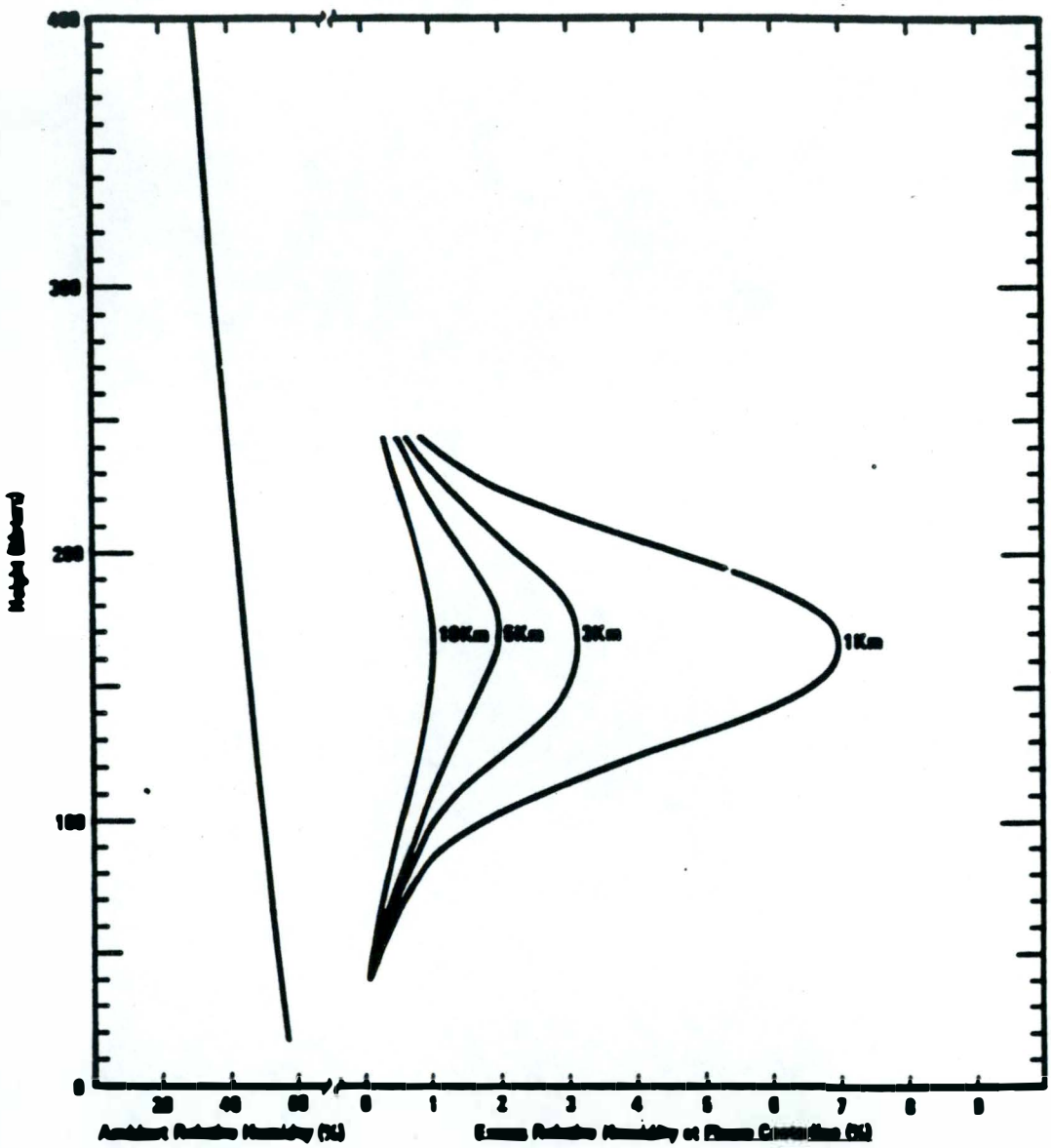
EXCESS RELATIVE HUMIDITY, AVERAGE WINTER MORNING CONDITIONS

FIGURE 5.1-17



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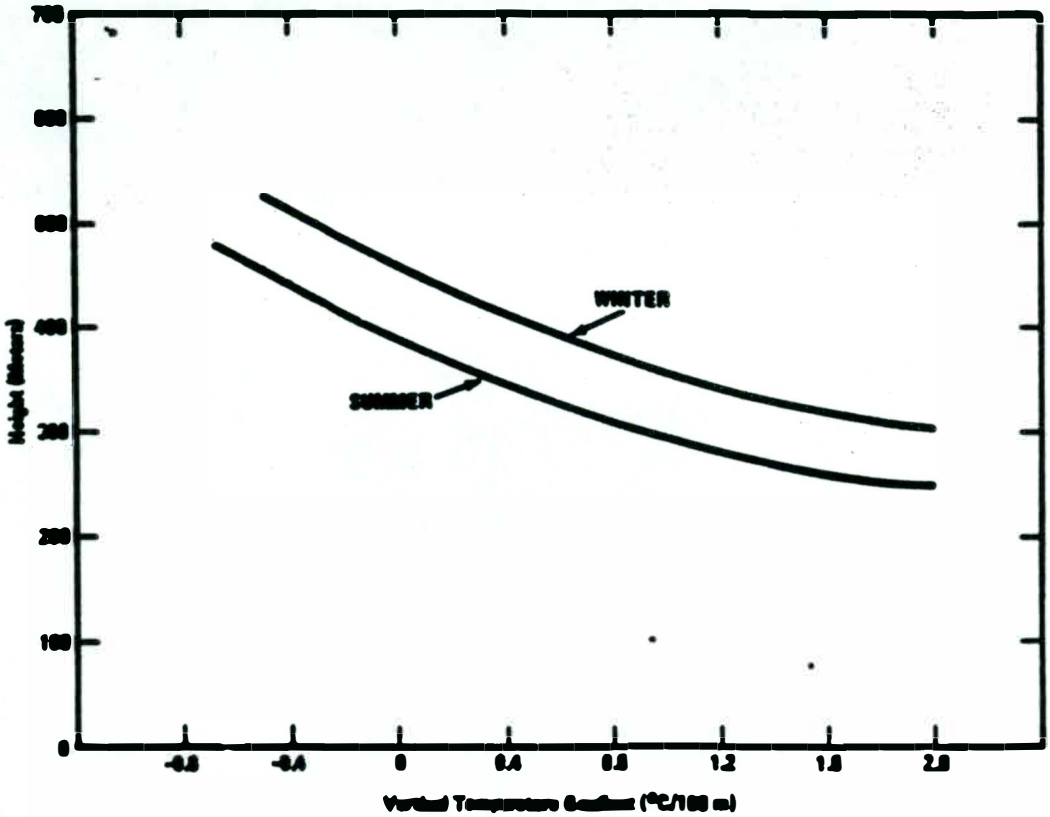
EXCESS RELATIVE HUMIDITY, AVERAGE SUMMER MORNING CONDITIONS

FIGURE 5.1-18



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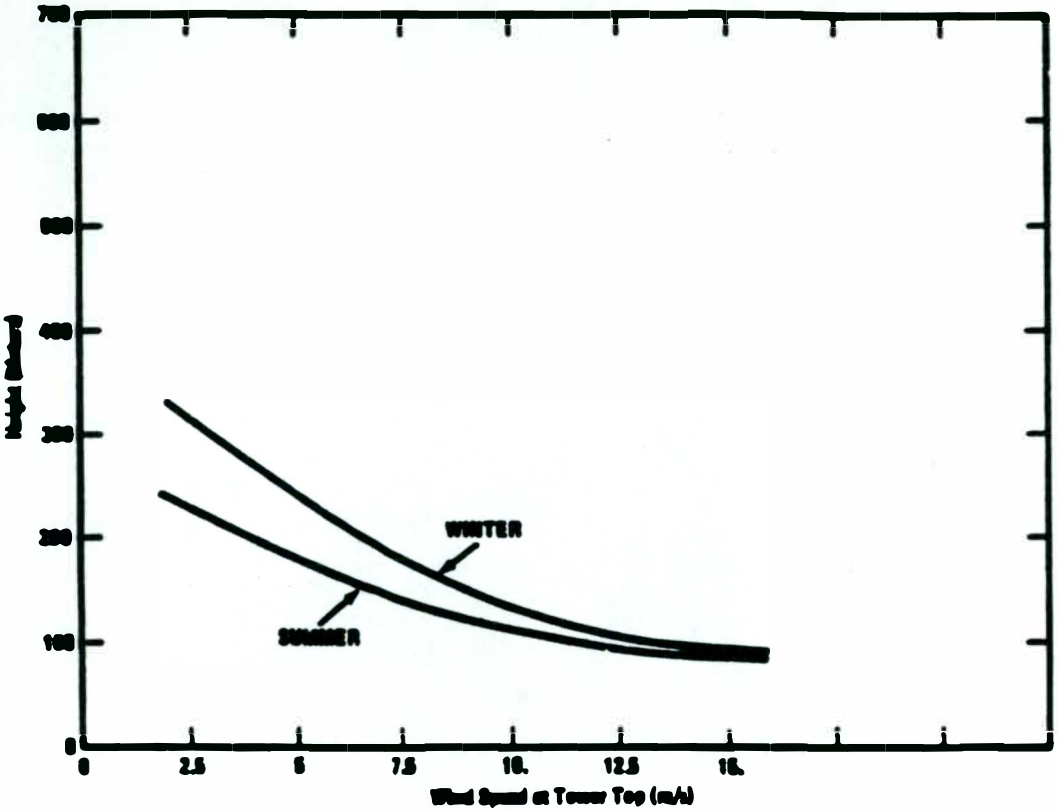
VARIATION OF PLUME HEIGHT AS A FUNCTION AMBIENT VERTICAL TEMPERATURE GRADIENT

FIGURE 5.1-19



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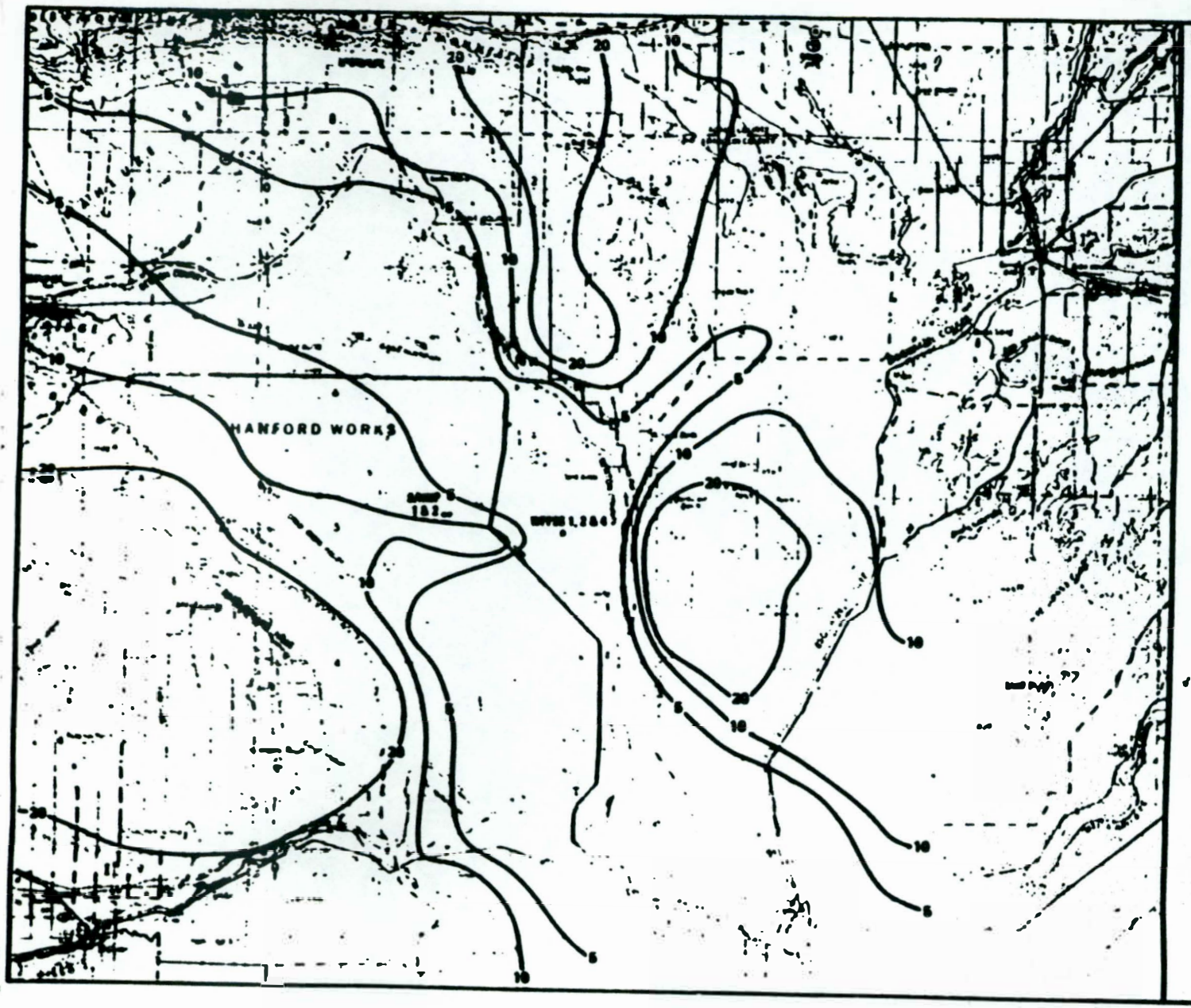
VARIATION OF PLUME HEIGHT AS A FUNCTION OF WIND SPEED

FIGURE 5.1-20



SOURCE: USGS 1:200,000 MAPS

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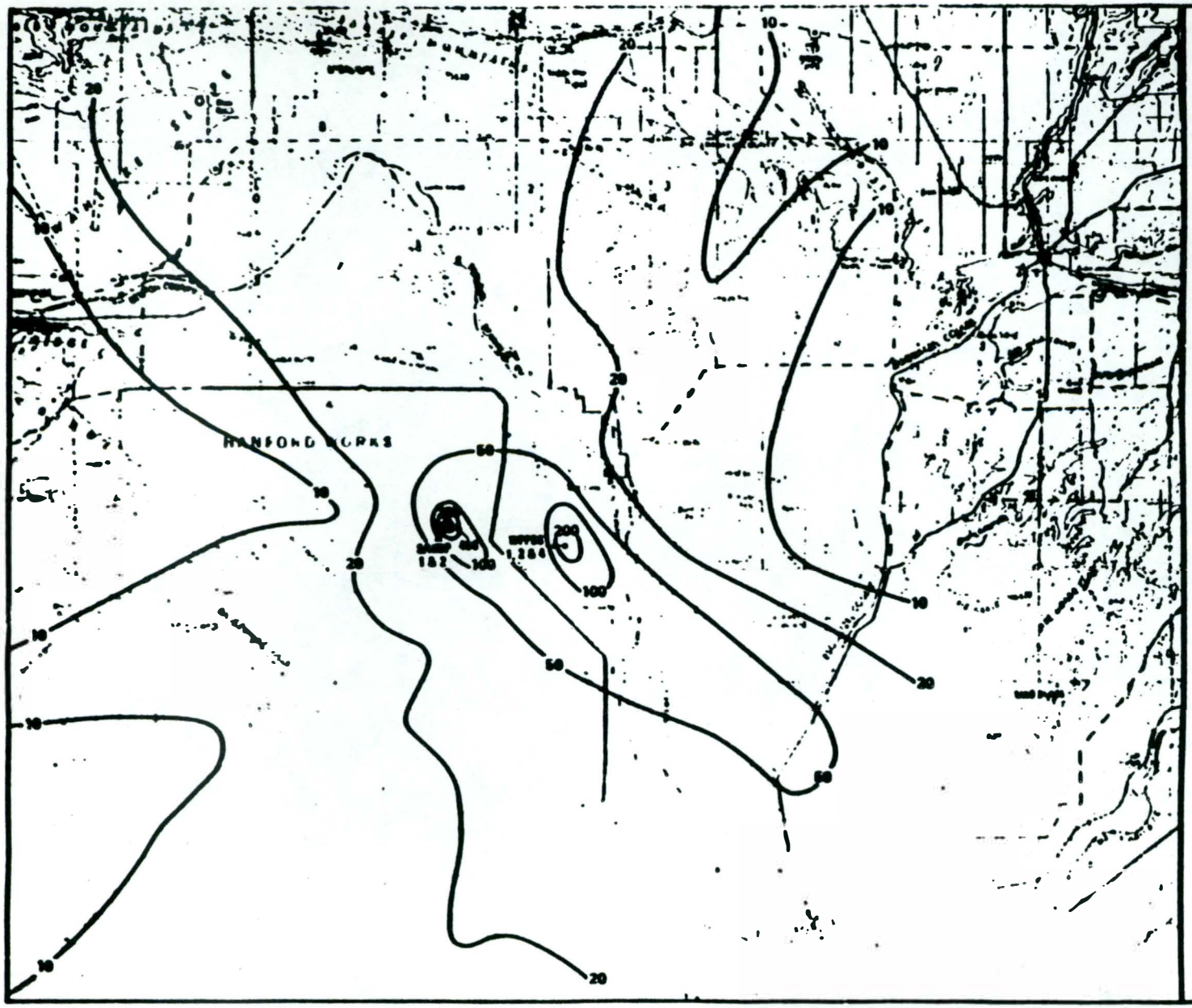
REDUCED GROUND LEV
VISIBILITY HOURS/YEA

FIGURE 5.1-21



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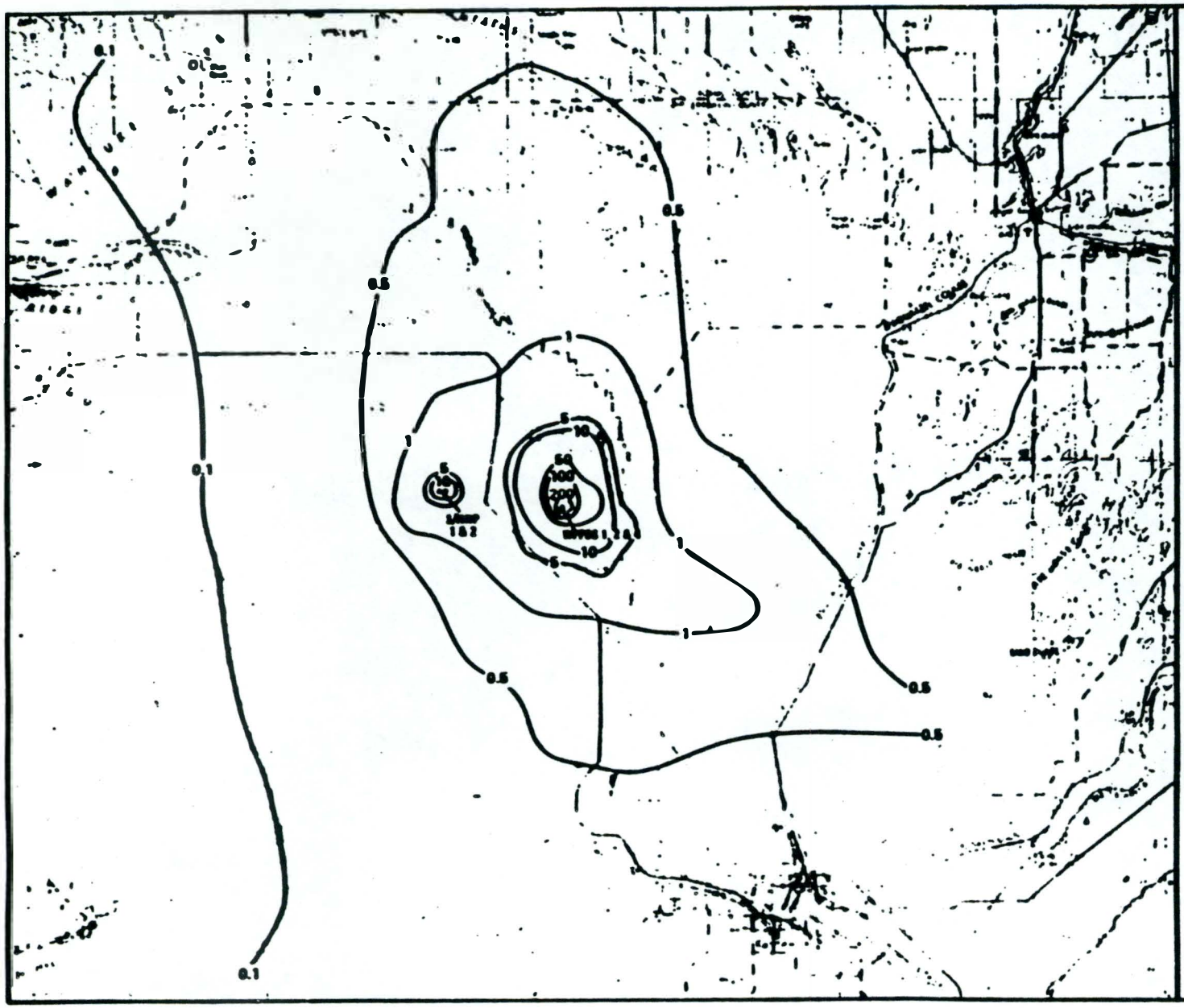
ELEVATED VISIBLE PLUM
HOURS/YEAR

FIGURE 5.1-22

Amendm



SOURCE: USGS 1:250,000 MAPS

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TOTALS SOLIDS DEPOSITION
LB/ACRE-YEAR

FIGURE 5.1-23

5.2 RADIOLOGICAL IMPACT FROM ROUTINE OPERATION

Radioactive materials are routinely released from nuclear plants. Potential radionuclide releases and exposure pathways are identified and evaluated to assure Plant operation within the design criteria of 10 CFR Part 50, Appendix I (Ref 1), and applicable sections of 10 CFR Part 20 (Ref 2), and 40 CFR 190.10 (Ref 3). Appendix G presents the calculational methodology used in the evaluation of the routine radiological impact.

5.2.1 EXPOSURE PATHWAYS

All significant exposure pathways have been considered in the design of these nuclear power plants. Radionuclides released to the atmosphere travel off-Site, impacting the population via external radiation from the plume and/or deposited material on the ground or foliage, inhalation, and ingestion of food products containing radioactive materials. Liquid effluents to the Columbia River impact people via drinking water, irrigated foodstuffs, and recreational activities such as fishing, swimming, boating, and occupying the shoreline.

Radionuclides released from the Plant can be classified according to their most probable off-Site dose impacts. For example, noble gases are primarily an external exposure hazard since they generally do not enter the food chain through deposition on soil or foliage. Radioiodines are most significant through the pasture-cow-milk pathway. Tritium is assumed to behave identically to water. Other radionuclides, such as airborne particulates, are transferred through the environment by complicated relationships involving radionuclide deposition, uptake, accumulation, and transfer. Figures 5.2-1 and 5.2-2 illustrate generalized exposure pathways to man and animals, respectively (Ref 4). 4

5.2.2 RADIOACTIVITY IN THE ENVIRONMENT

Section 3.5 presents the expected annual radioactivity releases into the environment. Based on the atmospheric dispersion parameters given in Section 6.1.3 the maximum concentrations, at mid-Plant life, both in air and on the ground surface are shown in Table 5.2-1.

Atmospheric radionuclide concentrations are calculated using the release estimates of Section 3.5. The continuous release model uses the annual average X/Q. The atmospheric concentrations (C_a) are estimated as:

$$C_{ai}(\bar{r}) = 3.17 \times 10^4 \, Q_i X/Q(\bar{r}) \qquad (1)$$

where

$C_{ai}(\bar{r})$	=	picocuries/m^3 of isotope i at a distance r
3.17×10^4	=	pCi/Ci divided by sec per yr
Q_i	=	Curies of isotope i released per year
$X/Q(\bar{r})$	=	annual average atmosphere dispersion parameter at distance of interest ($\bar{r}$), s/m^3

The ground release model, used for calculating the X/Qs, monatomically decreases as a function of distance from the release point. Therefore higher concentrations will occur closer to the Plant, and lower concentrations will occur farther away from the Plant.

Ground concentrations are calculated on the basis of equilibrium values resulting from continuous deposition and continuous radiological decay. The expression for equilibrium ground concentrations (C_g) is: 4

$$C_{gi}(\bar{r}) = \frac{3.17 \times 10^4 \, Q_i \, D/Q(\bar{r}) \, (1-e^{-\lambda_i t})}{\lambda_i} \qquad (2)$$

where

Q_i	=	curies of isotope i released per year
$D/Q(\bar{r})$	=	annual average atomspheric deposition parameter at distance of interest ($\bar{r}$), m^{-2}
λ_i	=	radiological decay constant of isotope i, s^{-1}
3.17×10^4	=	pCi/Ci divided by sec per yr
t	=	mid-Plant life, 4.78×10^8 sec (15 yr)

Section 6.1.3 presents the relative atmospheric dispersion parameters which were calculated using the computer code XOQDOQ (Section 6.1.3.2 contains the detailed discussion of the methodology used).

5.2.2.1 Surface Water Models

5.2.2.1.1 Transport Models

5.2.2.1.1.1 Mathematical model used for analysis. The thermal plume (dilution) analysis was conducted using a state-of-the-art mathematical model implemented on a high speed digital computer. The computer code, designated HOTSUB3, was adapted from the work of Koh and Fan (Ref 5) and NRC Regulatory Guide 1.113 (Ref 6). With an input of discharge design, discharge flow parameters, and receiving water characteristics, the code generates excess temperature (concentration) profiles in the ambient receiving water. The format of the output is such that isotherms (isopleths) may be plotted for horizontal planes at selected depths. In addition, by using the data from the isotherm (isopleth) contours, the program calculates corresponding surface areas and volumes. A detailed description of the mathematical model used for this analysis is presented in Appendix C. 4

5.2.2.1.1.2 Model Application. The HOTSUB3 model was applied to the dual problems of comparing the discharge plume water quality with state water quality standards and predicting plume centerline dilution factors to a distance of 50 miles downstream from the Site. The former analysis, and the parameters used in that analysis, are described in Section 5.1.2. The latter analysis was performed using the parameters of the average case conditions of Section 5.1.2, with the exception of the horizontal diffusion coefficient. A value of 2 ft^2/sec (Refs 7,8) was chosen to simulate a non-heated effluent, to approximate far field plume conditions for the distances of interest.

Figure 5.2-3 presents plume centerline dilution factor, initial concentration (excess)/concentration (excess), and travel time versus distance from the discharge for the average case using the 2 ft^2/sec horizontal diffusion coefficient. Inflows to the Columbia River from the Yakima River (median flow = 2734 cfs, 26.3 miles downstream from the Plant discharge) and the Snake River (median flow = 44,780 cfs, 37.3 miles downstream from the Plant discharge) have been conservatively neglected. It is seen that the centerline dilution factor at 35 miles is 14,746 which is

within 20 percent of the fully mixed dilution factor (115,752/6.28 = 18,432), while at 50 miles the centerline factor is 16,957 which is only 8 percent below the fully mixed factor.

5.2.2.1.2 Sediment Uptake Models

No credit is claimed for the reduction of radionuclide concentrations in surface waters by the mechanism of sediment uptake.

5.2.2.1.3 Water-Use Models

Since the surface water uses of the Columbia River will not be affected by S/HNP discharges, no water use models were developed.

5.2.2.2 Ground Water Models

Normal operation of the S/HNP will not affect the ground water and therefore no use was made of ground water models. 4

5.2.3 DOSE RATE ESTIMATES FOR BIOTA OTHER THAN MAN

Doses potentially received by biota from S/HNP effluents are very small relative to the natural background dose received. Doses were estimated using the source terms of Section 3.5, Regulatory Guides 1.109 (Ref 9) and 1.111 (Ref 10) and NRC codes XOQDOQ (Ref 11), GASPAR (Ref 12), and LADTAP (Ref 13). Table 5.2-2 summarizes the dose received by several types of biota living in or near the Columbia River from effluents.

Studies at Hanford have shown that irradiation of salmon eggs at a rate of 500 mrad/day did not affect the number of adult fish returning from the ocean or their ability to spawn (Ref 14). Previously, when all the Hanford once-through cooling plutonium production reactors were operating, studies were made on the effect of the released radionuclides on spawning salmon. These studies have shown no discernible effect to these salmon receiving dose rates in the range of 100 to 200 mrad/week (Ref 15).

Animals such as deer, coyotes, and field mice that do not consume aquatic food or spend much time near the rivershore will receive their radiation exposures through direct radiation from the Plant's gaseous effluent plume, inhalation, ingestion of terrestrial vegetation, and external doses to exposure from contaminated ground. The total dose received from all these pathways will be very small. An animal such as a deer, spending 50 percent of its time 2.2 miles east of the Plant near the Wye Barricade, would receive an annual dose of about 0.033 millirads from external radiation. Additional exposure would be received from inhalation and ingestion at a rate of 0.046 millirads per year. Therefore, the total annual dose from all pathways would still be less than 0.1 mrads.

The estimated doses to biota from S/HNP effluents will be orders of magnitude less than the doses experienced by biota from operation of the Hanford plutonium production reactors. Considering that no distinguishable effect on the biota from radiation was observed during operation of these reactors over many years, no perceptible effect from S/HNP operation is expected.

4

5.2.4 DOSE RATE ESTIMATES FOR MAN

Estimated doses to the population within 50 miles of the S/HNP and doses to individuals expected to receive maximum doses because their places of residence or life-styles were calculated using the guidance in Regulatory Guides 1.109 (Ref 9) and 1.111 (Ref 10).

5.2.4.1 Liquid Pathways

People may be exposed to the radioactive material released in the liquid effluent from S/HNP by drinking water, eating fish, eating irrigated farm products, and by participating in recreational activities on or along the Columbia River. Appendix G presents the detailed individual and population dose methodology. Table 5.2-3 summarizes the maximum individual dose estimates to the inhabitants of the Ringold Farms, the nearest user of Columbia River water. Ringold Farm is located about 6 miles downstream of the S/HNP discharge point and about 8.5 miles ENE of S/HNP Unit 1.

5.2.4.2 Gaseous Pathways

Radiation exposure will occur from radioactive material released to the atmosphere via inhalation, external radiation, and ingestion of farm products. The maximum ground level concentration at a possible residence off the government-controlled Hanford Reservation occurs approximately 7.5 miles from Unit 1 in the south sector. This area is immediately south of the Yakima River, slightly southwest of the Horns Rapid Dam, and has essentially continuous occupancy.

Appendix G presents the detailed individual and population dose methodology. Table 5.2-4 summarizes the maximum individual dose estimates.

5.2.4.3 Direct Radiation from Facility

S/[redacted] is located in an area relatively remote form nearby residences, schools, hospitals, etc. The reactors are located in the government-controlled Hanford Reservation and are several miles from the nearest public facilities (schools, hospitals) and private residences. Possible direct radiation from the reactor facilities to the general public would not add measurably to the doses estimated because of the low dose rates expected from the facilities (as described in S/[redacted] PSAR 12.1.3.9) and the relatively large distances involved. 4

5.2.4.4 Annual Population Doses

Using the methods of Appendix G, the population total body and thyroid doses were calculated for several exposure pathways to the people living within an approximate 50-mile radius of the S/[redacted]. These doses are summarized in Table 5.2-5 and 5.2-6. The population distribution projected for the year 2010 (approximately Plant mid-life) was used in the calculations. Assumptions necessary for these calculations are included in Appendix G. Doses received by the population of the contiguous United States beyond 50 miles from S/[redacted] operations would be an immeasurable addition to the dose already received from natural background radiation.

5.2.5 SUMMARY OF ANNUAL RADIATION DOSES

Individual doses are compared with design objectives of 10 CFR Part 50, Appendix I, in Table 5.2-7. In addition to Appendix I, the individual doses were evaluated for compliance with 40 CFR 190.10 and presented in Table 5.2-8. 4

References for Section 5.2

1. Code of Federal Regulations, Title, 10 Part 50, Appendix I, 40 FR 19442.

2. Code of Federal Regulations, 10 CFR 20 (January 1, 1977).

3. Code of Federal Regulations, Title 10 Part 190, 42 FR 2858 (January 13, 1977).

4. Preparation of Environmental Report for Nuclear Power Plants, Regulatory Guide 4.1, Rev. 2, USNRC (July 1976).

5. Koh, R.C.Y. and L.N. Fan, Mathematical Models for the Prediction of Temperature Distribution Resulting from the Discharge of Heated Water into Large Bodies of Water, 16130DWO10/70, Water Pollution Control Research Series, Environmental Protection Agency, Washington, DC (October 1970).

6. Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I, Regulatory Guide 1.113, Revision 1, U.S. Nuclear Regulatory Commission, Washington, DC (April 1977). 4

7. Glover, R.E., Dispersion of Dissolved or Suspended Materials in Flowing Streams, U.S. Geological Survey Professional Paper No. 433-B (1964).

8 Sonnichsen, J.C., D.A. Kottwitz, and R.T. Jaske, Dispersion Characteristics of the Columbia River Between River Miles 383 and 355, BNWL-1477, Battelle Northwest Laboratories, Richland, WA (October 1970).

9. Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, Regulatory Guide 1.109, Rev. 1 (October 1977).

10. Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Roucine Releases from Light-Water-Cooled Reactors, Regulatory Guide 1.111, Rev 1, USNRC (July 1977).

11. XOQDOQ Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations, NUREG-0324 (draft), USNRC (September 1977).

12. Users Guide to GASPAR Code, NUREG-0597, U.S. Nuclear Regulatory Commission (January 1980).

13. User's Manual for LADTAP-II--a Computer Program for Calculating Radiation Exposure to Man from Routine Release of Nuclear Reactor Liquid Effluents, NUREG/CR-1276, Oak Ridge National Laboratory (March 1980).

14. Templeton, W.L., R.E. Nakatani and E.E. Held, "Radiation Effects," Radioactivity in the Marine Environment, Committee on the Oceanography, National Research Council, National Academy of Sciences, pp. 223-239 (1971).

15. Watson, D.G. and Templeton, W.L., "Thermoluminescent Dosimetry of Aquatic Organisms," Proc. Third National Symposium on Radioecology (May 10-12, 1971). CONF 710501-P2, Oak Ridge, TN. pp. 1125-1130, (1973).

4

TABLE 5.2-1

Sheet 1 of 1

MAXIMUM SITE BOUNDARY CONCENTRATIONS COMPARED TO 10 CFR 20 LIMITS

Radionuclide	Maximum Site Boundary Ground Level Air Concentration (pCi/m³) (a)	10 CFR 20 Table II Limits (pCi/m³)	Maximum Site Boundary Ground Surface Concentration (pCi/m²) (b)
Ar-41	2.99E+01	4.0E+04	(c)
Br-85m	2.57E+01	1.0E+05	(c)
Br-85	2.16E+02	3.0E+05	(c)
Br-87	5.23E+01	2.0E+04	(c)
Br-88	7.89E+01	2.0E+04	(c)
Br-89	5.07E+02	(d)	(c)
Xe-131m	3.99	4.0E+05	(c)
Xe-133	1.49E+03	3.0E+05	(c)
Xe-133m	8.22E+02	(d)	(c)
Xe-135	9.97E+02	1.0E+05	(c)
Xe-137	1.00E+03	(d)	(c)
Xe-138	8.11E+02	(d)	(c)
H-3	8.31E+01	2.0E+05	(c)
C-14	7.09	1.0E+05	(c)
I-131	6.06E-02	1.0E+02	2.29E+02
I-133	8.14E-01	4.0E+02	3.32E+02
Cr-51	8.31E-04	8.0E+04	1.00E+01
Mn-54	1.00E-03	1.0E+03	1.50E+02
Co-58	2.33E-04	2.0E+03	7.76
Fe-59	3.07E-04	2.0E+03	6.44
Co-60	3.99E-03	3.0E+02	3.10E+03
Zn-65	3.99E-03	2.0E+03	4.57E+02
Sr-89	8.11E-05	3.0E+02	1.97
Sr-90	7.01E-06	3.0E+01	1.17E+01
Nb-95	8.04E-03	3.0E+03	1.33E+02
Zr-95	7.72E-04	1.0E+03	2.11E+01
Mo-99	5.32E-02	7.0E+03	6.04E+01
Ru-103	3.41E-03	3.0E+03	6.29E+01
Ag-110m	1.91E-04	3.0E+02	2.25E-01
Sb-124	3.90E-05	7.0E+02	1.11
Cs-134	3.74E-03	6.0E+02	1.11E+03
Cs-136	3.90E-04	6.0E+03	2.41
Cs-137	4.02E-03	5.0E+02	7.11E+03
Ba-140	3.74E-02	3.0E+03	1.05E+02
Ce-141	3.89E-04	5.0E+03	1.20E+01

(a) Maximum Site Boundary annual average χ/Q = 2.63 x 10^{-5} sec/m³. Ref Table 6.1-10

(b) Maximum Site Boundary annual average D/Q = 9.88 x 10^{-8} m⁻². Ref Table 6.1-10

(c) Negligible.

(d) Not reported.

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TABLE 5.2-2

DOSES TO BIOTA

	Doses (mrad/year-unit)		
	Internal	External	Total
Fish	9.80E-02	7.59E-03	1.06E-01
Invertebrate	1.00E+00	1.49E-02	1.02E+00
Algae	6.54E-01	3.06E-04	6.54E-01
Muskrat	6.29E-01	4.96E-03	6.34E-01
Raccoon	8.26E-03	3.64E-03	1.19E-02
Heron	2.87E-01	4.91E-03	2.92E-01
Duck	6.24E-01	7.36E-03	6.31E-01
Deer	4.58E-02	3.27E-02	7.85E-02

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TABLE 5.2-3

INDIVIDUAL DOSES FROM LIQUID RADIOACTIVE EFFLUENTS AT RINGOLD FARMS

Pathway	Dose (mrem/yr-unit) Total Body	Bone	Thyroid
Adult			
Ingestion of Fish	2.30E-03	2.51E-02	1.15E-03
Ingestion of Water	3.14E-05	7.66E-06	3.87E-04
Shoreline	5.41E-07	5.41E-07	5.41E-07
Swimming	5.78E-08	5.78E-08	5.78E-08
Boating	1.93E-07	1.93E-07	1.93E-07
Ingestion of Irrigated Vegetables	1.68E-04	1.97E-04	1.20E-03
Ingestion of Irrigated Leafy Vegetables	1.74E-04	2.75E-04	4.74E-03
Ingestion of Cow Milk	6.88E-05	6.07E-05	7.09E-04
Ingestion of Meat	1.44E-05	1.19E-05	3.13E-05
Total	2.76E-03	2.57E-02	8.22E-03
Child			
Ingestion of Fish	1.64E-03	3.51E-02	1.22E-03
Ingestion of Water	4.08E-05	2.02E-05	8.48E-04
Shoreline	6.18E-07	6.18E-07	6.18E-07
Swimming	2.09E-07	2.09E-07	2.09E-07
Boating	1.07E-07	1.07E-07	1.07E-07
Ingestion of Irrigated Vegetables	2.06E-04	7.07E-04	3.48E-03
Ingestion of Irrigated Leafy Vegetables	8.04E-05	4.08E-04	5.76E-03
Ingestion of Cow Milk	9.37E-05	2.61E-04	2.22E-03
Intestion of Meat	9.03E-06	1.81E-05	3.13E-05
Total	2.07E-03	3.65E-02	1.36E-02

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TABLE 5.2-4 Sheet 1 of 2

MAXIMUM INDIVIDUAL DOSES FROM ATMOSPHERIC EFFLUENTS
AT A RESIDENCE 7.5 MILES SOUTH OF S/HNP UNIT 1

Pathway	Dose (mrem/yr-unit) Total Body	Bone	Thyroid
Adult			
Plume Submersion (Noble Gases)	6.37E-03	6.37E-03	6.37E-03
Ground Plane	7.37E-04	7.37E-04	7.37E-04
Vegetable Ingestion	6.15E-03	2.49E-02	8.43E-03
Meat Ingestion	2.17E-03	1.00E-02	2.45E-03
Cow Milk Ingestion	2.73E-03	1.11E-02	1.16E-02
Goat Milk Ingestion	3.42E-03	1.13E-02	1.38E-02
Inhalation	4.23E-04	3.92E-05	7.67E-03
Total from Iodines and Particulates via Cow Milk Ingestion	1.22E-02	4.68E-02	3.09E-02
Total from Iodines and Particulates via Goat Milk Ingestion	1.29E-02	4.70E-02	3.31E-02
Teenager			
Plume Submersion (Noble Gases)	6.37E-03	6.37E-03	6.37E-03
Ground Plane	7.37E-04	7.37E-04	7.37E-04
Vegetable Ingestion	9.67E-03	4.19E-02	1.16E-02
Meat Ingestion	1.79E-03	8.45E-03	1.99E-03
Cow Milk Ingestion	4.70E-03	2.04E-02	1.89E-02
Goat Milk Ingestion	5.47E-03	2.09E-02	2.23E-02
Inhalation	4.28E-04	5.42E-05	9.97E-03
Total from Iodines and Particulates via Cow Milk Ingestion	1.73E-02	7.15E-02	4.32E-02
Total from Iodines and Particulates via Goat Milk Ingestion	1.81E-02	7.20E-02	4.66E-02

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TABLE 5.2-4

Pathway	Dose (mrem/yr-unit) Total Body	Bone	Thyroid
Child			
Plume Submersion (Noble Gases)	6.37E-03	6.37E-03	6.37E-03
Ground Plane	7.37E-04	7.37E-04	7.37E-04
Vegetable Ingestion	2.22E-02	1.02E-01	2.55E-02
Meat Ingestion	3.29E-03	1.59E-02	3.61E-03
Cow Milk Ingestion	1.08E-02	5.01E-02	3.97E-02
Goat Milk Ingestion	1.18E-02	5.12E-02	4.62E-02
Inhalation	3.08E-04	7.23E-05	1.24E-02
Total from Iodines and Particulates via Cow Milk Ingestion	3.74E-02	1.69E-01	8.19E-02
Total from Iodines and Particulates via Goat Milk Ingestion	3.84E-02	1.70E-01	8.84E-02
Infant			
Plume Submersion (Noble Gases)	6.37E-03	6.37E-03	6.37E-03
Ground Plane	7.37E-04	7.37E-04	7.37E-04
Cow Milk Ingestion	2.20E-02	9.79E-02	9.24E-02
Goat Milk Ingestion	2.33E-02	9.97E-02	1.08E-01
Inhalation	2.21E-04	5.30E-05	1.13E-02
Total from Iodines and Particulates via Cow Milk Ingestion	2.30E-02	9.87E-02	1.04E-01
Total from Iodines and Particulates via Goat Milk Ingestion	2.43E-02	1.00E-01	1.20E-01

TABLE 5.2-5

0 TO 50-MILE POPULATION DOSES FROM LIQUID RADIOACTIVE EFFLUENTS

Pathway	Dose (man-rem/yr-unit) Total Body	Thyroid
Ingestion of Water	1.52E-03	1.90E-02
Ingestion of Sport Fish	2.42E-03	5.67E-04
Ingestion of Irrigated Vegetables	6.27E-02	2.74E-02
Ingestion of Irrigated Leafy Vegetables	1.15E-03	2.43E-02
Shoreline Activities	1.14E-03	1.14E-03
Boating	7.94E-06	7.94E-06
Swimming	1.55E-05	1.55E-05
Total	6.90E-02	7.24E-02

4

TABLE 5.2-6

0 TO 50-MILE POPULATION DOSES FROM ATMOSPHERIC EFFLUENTS

Pathway	Dose (man-rem/yr-unit) Total Body	Thyroid
Permanent Population		
Plume Submersion (Noble Gases)	2.76E-01	2.76E-01
Ground Plane	4.15E-02	4.15E-02
Inhalation	4.01E-02	6.85E-01
Vegetable Ingestion	2.43E-01	5.43E-01
Cow Milk Ingestion	8.26E-02	1.54E-01
Meat Ingestion	9.72E-02	9.69E-02
Total from Iodines and Particulates	5.04E-01	1.52
Transient Population		
Plume Submersion (Noble Gases)	9.64E-03	9.64E-03
Ground Plane	1.48E-03	1.48E-03
Inhalation	7.73E-04	1.45E-02
Total from Iodines and Particulates	2.25E-03	1.60E-02

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TABLE 5.2-7

COMPARISON OF MAXIMUM ORGAN DOSES TO APPENDIX I LIMITS

Organ	Dose (mrem/year-unit) Skagit/Hanford	Appendix I Limits
Gaseous Effluents		
Total Body	0.0064	5
Skin	0.017	15
Radioactive Iodine and Particulate Effluents		
Maximum Organ (Child Bone)	0.17	15
Liquid Effluents		
Total Body	0.0028	3
Maximum Organ (Child Bone)	0.037	10

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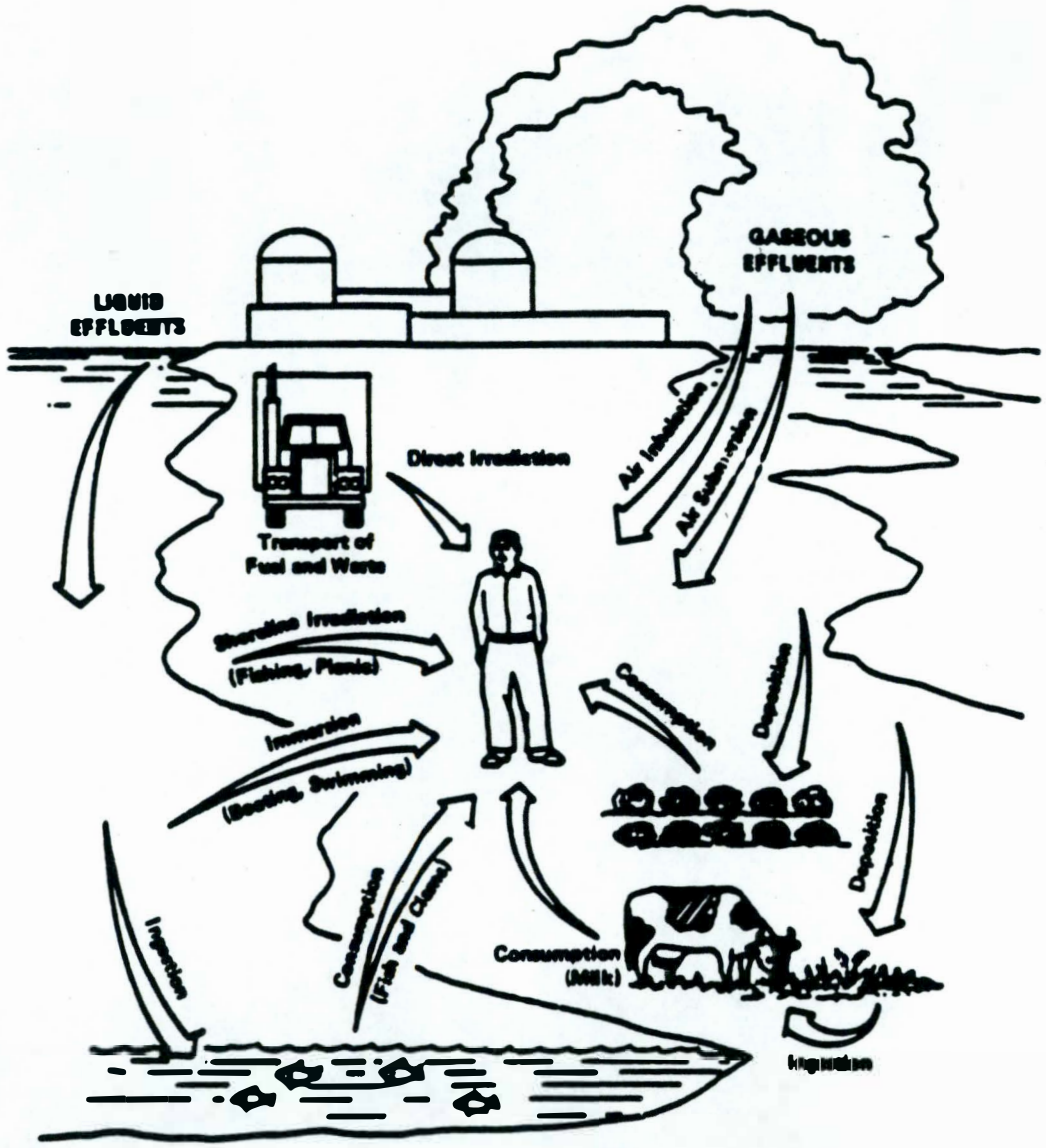
TABLE 5.2-8

MAXIMUM ADULT DOSES FROM THE COMBINED ROUTINE OPERATION OF S/WNP UNITS 1 AND 2, AND WNP 1, 2 AND 4 COMPARED TO 40 CFR 190.10 LIMITATIONS

Pathway	Dose (mrem/year-unit) Total Body	Bone(a)	Thyroid
Combined Operation of S/WNP and WNP	0.60	0.74	2.8
40 CRF 190.10 Dose Limitations	25	25	75

(a) Bone is the maximum organ excluding the thyroid.

4



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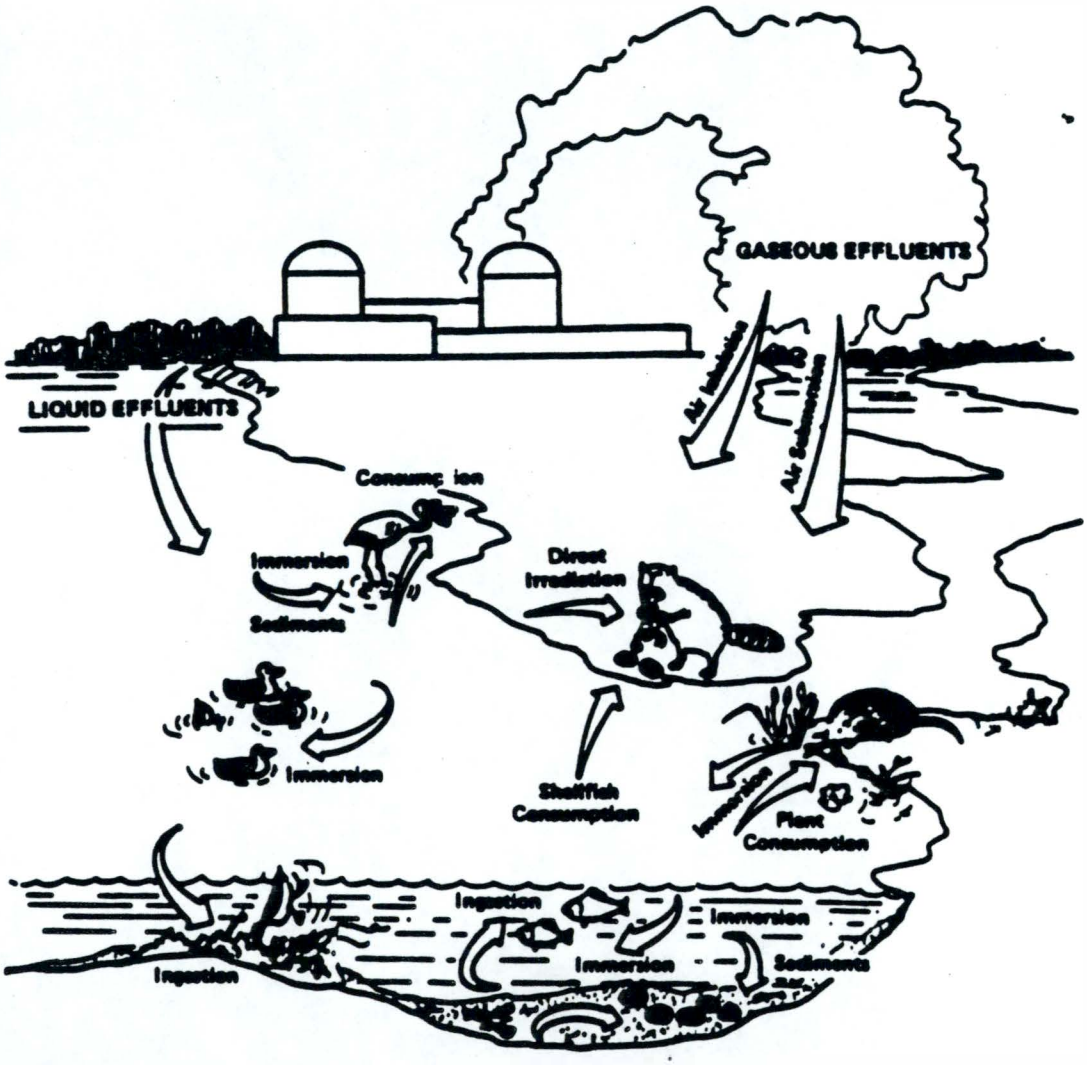
GENERALIZED EXPOSURE PATHWAYS FOR MAN

FIGURE 5.2-1



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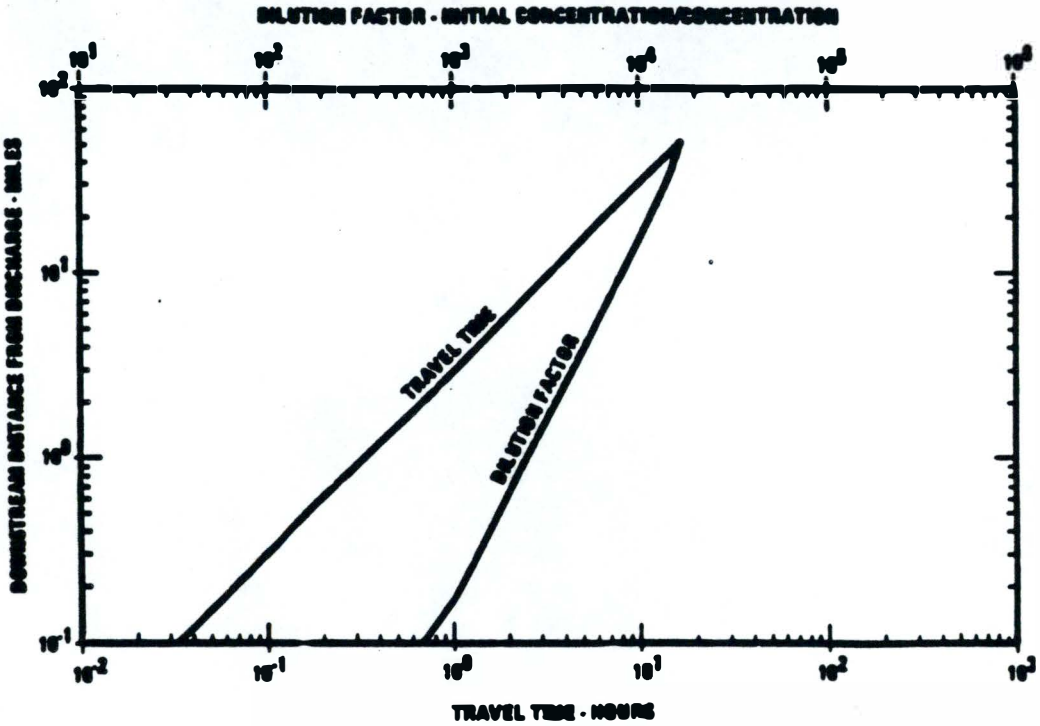
GENERALIZED EXPOSURE PATHWAYS FOR ORGANISMS OTHER THAN MAN

FIGURE 5.2-2



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DILUTION FACTOR AND TRAVEL TIME OF RIVER DISCHARGE PLUME VS. DOWNSTREAM DISTANCE

FIGURE 5.2-3

5.3 EFFECTS OF CHEMICAL AND BIOCIDE DISCHARGES

5.3.1 LIQUID DISCHARGES

The S/HNP wastewater discharge will contain constituents originally present in the river water, as well as chemicals and biocides added for normal Plant operation and other treated wastes generated during operation. An NPDES Application has been filed with the Washington State Energy Facility Site Evaluation Council (EFSEC) for a permit to discharge wastewaters (Appendix F). The following section discusses the environmental impact of the chemicals and biocides of the S/HNP discharge.

Ambient water quality data are presented in Section 2.4. The expected chemical releases to the Columbia River via the S/HNP discharge are described in Section 3.6 and summarized in Tables 3.6-5 and 5.3-1. Discharge concentrations and resulting concentrations in the river at a distance representing the mixing zone boundary are compared to Federal Effluent Limitation Guidelines (Ref 1), to Washington State Water Quality Standards (Ref 2) and to U.S. Environmental Protection Agency Water Quality Criteria (Ref 3) in Table 5.3-1. 4

5.3.1.1 Point Of Discharge

The S/HNP will discharge a maximum of 5910 gpm (13.2 cfs) of water to the Columbia River. Of this amount, approximately 99 percent will be cooling tower blowdown. The remaining 1 percent will be miscellaneous treated wastes from demineralizer regenerant wastes, pretreatment wastes, filter backwash, and Plant Facility floor drainages. The expected discharge levels of the specifically regulated parameters, such as pH, free available chlorine, total suspended solids, and oil and grease, are less than the Federal Effluent Limitation Guidelines (Ref 1) for new source performance standards.

5.3.1.2 Downstream from the Point of Discharge

A preliminary study was conducted to determine the plume characteristics of the S/HNP discharge when two units are in operation (Section 5.1.2). A description of the computational methodologies is presented in Appendix C. Projected

chemical concentrations at the edge of a 300 ft mixing zone are provided in Table 5.3-1.

A comparison between Washington State Water Quality Standards (Ref 2) for Class A-Excellent waters and the chemical concentrations at the mixing zone boundary indicates that all regulated parameters are in compliance. A similar comparison of Columbia River water quality at the mixing zone boundary with U.S. Environmental Protection Agency's Water Quality Criteria (Refs 3, 4) indicates that all regulated parameters are less than the Federal criteria, with the exception of certain trace metals; cadmium, copper, iron, lead and mercury.

Ambient values for these metals in the Columbia River, upstream of the S/HNP intake, occasionally exceed Federal criteria. Trace metals will not be introduced from Plant operation or from corrosion products of the stainless steel condenser tubes. However, the metals originally present in the river will be concentrated ten fold, on the average, in recirculated cooling water prior to being returned to the Columbia River. Following worst-case dilution on the order of 190:1 at the edge of the mixing zone, metal concentrations are estimated to be only six percent above ambient levels. This negligible increase in trace metal concentrations should not affect aquatic biota. 4

Sodium hypochlorite (NaOCl) is the preferred biocide for treatment of the cooling towers. The receiving water criterion for total residual chlorine (TRC) is 0.002 mg/liter, as specified by U.S. Environmental Protection Agency (Ref 3). Assuming worst-case conditions, the total residual chlorine level in the S/HNP discharge would be reduced in the Columbia River to the Federal criterion level within 29 sec (67 ft downstream from the discharge). 5

Research to date does not suggest a major toxic impact on biota as a result of the TRC discharge. An analysis of the chlorine plume (Ref 5) indicates that all aquatic life passing through the plume will remain unharmed. Data suggest that sessil benthic organisms in the path of the S/HNP plume may be adversely affected within a relatively small area immediately downstream of the discharge location. This area, however, is small compared to the total habitat available in the river; therefore, a localized loss in productivity should not affect the aquatic community as a whole. 4

The dissolved solids concentration in the S/HNP discharge will be higher than ambient concentrations in the river as a result of:

a. Concentration in the cooling tower.

b. Sulfuric acid and sodium hypochlorite addition in the circulating water system.

c. Regenerant chemicals (sulfuric acid and sodium hydroxide solution) used in ion exchange regeneration.

Most of the dissolved solids concentrations in the S/HNP discharge (Table 5.3-1) are expected to be greater than the ambient river water by a factor of about ten, except for sodium, bicarbonate, sulfate, and chloride. Bicarbonate concentrations in the S/HNP discharge will be less than ambient river water due to the depletion of bicarbonate through the addition of sulfuric acid. The maximum sodium, sulfate and chloride concentrations in the S/HNP discharge are expected to be greater than ambient water by factors of 38, 57 and 33, respectively. The incremental increases in sodium, sulfate and chloride concentrations in the river at the edge of the mixing zone are not expected to cause detrimental effects to aquatic biota. Increases in any of the dissolved solid concentrations should not cause long-term build up in the sediments or in the biota. The maximum concentration of total dissolved solids (TDS) in the S/HNP discharge (1602 mg/liter) will require dilution on the order of only 3.8:1 to comply with the receiving water TDS criterion (500 mg/liter) established by Washington State Department of Social and Health Services (Ref 6). No osmotic stress on migrating juvenile salmonids or adverse effects on other biota are expected. 4

In view of the negligible increases in chemical constituents near the discharge location, as described in this section, there will be no anticipated chemical or biocide contamination of downstream domestic or agricultural water supplies.

5.3.2 EFFECTS OF DRIFT ON VEGETATION AND WILDLIFE

After approximately 10 cycles of concentration, the circulating water will contain about 829 mg/l of dissolved solids. Drift from the cooling towers will be controlled to 0.005 percent loss of the circulating water flow (Section 5.1.4). Biocides and heavy metals in the drift are anticipated to be at a level so low as not to be distinguishable from normal background levels in the soils (a minute fraction of one percent by weight of solids).

The predicted distribution and amounts of drift from the cooling towers are shown in Figure 5.1-3. The model employed to determine these distributions is described in Section 6.1.3.3. The maximum total solids deposition is calculated to be less than 10 pounds per acre per year (or less than 11 kg/ha-yr). According to NRC Regulatory Guide 4.11: "Chemical analyses of soils, plants, and animals in the drift field of freshwater cooling towers are not usually needed when all of the following apply: (1) the dominant salts are harmless mixtures of biological nutrients as shown in Table 4, (2) the expected peak deposition beyond the site boundary is less than 20 kg/ha-yr (no more than 50% in any 30-day period during the growing season) of mixed salts, and (3) the drift does not contain toxic elements or compounds in amounts that could be hazardous to plants or animals either by direct or indirect exposure over the expected lifetime of the facility." 4

All three of the above conditions apply to the Skagit/-Hanford Nuclear Project cooling tower drift. The expected concentrations are below the level at which effects on vegetation and wildlife can be considered measurable.

References for Section 5.3

1. U.S. Environmental Protection Agency, Effluent Guidelines and Standards for Steam-Electric Power Generating Point Source Category, Code of Federal Regulations, 40 CFR 423 (October 1974).

2. Washington State Department of Ecology, Washington State Water Quality Standards, WAC-713-201, Water Quality Planning, Office of Water Programs, Department of Ecology, Olympia, WA (December 1977).

3. U.S. Environmental Protection Agency, Quality Criteria for Water, EPA 440/9-76-023, U.S. EPA, Washington D.C. 20460 (1976).

4. U.S. Environmental Protection Agency, Ambient Water Quality Criteria for Selected Toxic Chemicals, EPA 440/5-80-001 to 079, Office of Water Regulations and Standards, Criteria and Standards Division, Washington, D.C. (October 1981). 4

5. T. L Page and E. J. Hulsizer, Biofouling Control in Open Recirculation Cooling Water Systems - A Review, Battelle Pacific Northwest Laboratories, Richland, WA (June 1977).

6. Washington State Department of Social and Health Services, Rules and Regulations of the State Board of Health Regarding Public Water Supply, Health Services Division, DSHS, Olympia, WA (March 1973).

TABLE 5.1-1

CHEMICAL CONCENTRATIONS IN THE PROJECT DISCHARGE BEFORE AND AFTER DILUTION COMPARED TO AMBIENT LEVELS

		Ambient Conditions		End of Pipe Conditions				Receiving Water Conditions				
		Columbia River[a] Ambient Conditions		Combined Project Effluent Concentrations[b]		Federal Point Source Effluent Limitations[b]		Concentrations[h] At Edge of Dilution Zone		Washington State WQ Standards For Class A Waters (Ref 2)	U.S. Environmental Protection Agency WQ Criteria (Note 3 and 4)	
Chemical Constituent	Units	Avg	Max	Avg	Max	Avg	Max	Avg	Max		24 hr. Avg	Max
Calcium, as Ca	mg/l	19.3	26.0	196.2	189.6			20.0	25.5			
Magnesium as Mg	mg/l	6.1	5.7	62.0	71.6			6.17	6.1			
Sodium, as Na	mg/l	2.1	1.1	11.1	116.6[c]			2.15	3.7			
Potassium, as K	mg/l	0.0	1.1	7.7	11.9			0.0	1.17			
Bicarbonate, as HCO_3	mg/l	67.5	82.0	16.9	16.6[d]			67.0	81.6			
Sulfate, as SO_4	mg/l	12.0	19.0	659.0	1,080.5[d]			14.0	24.6	250.0[i]	-	250.0[j]
Chloride, as Cl	mg/l	1.5	5.6	21.2	179.1[c]			1.51	6.1	250.0[i]	-	250.0[j]
Silica, as SiO_2	mg/l	6.0	6.6	67.0	85.3			6.08	7.0			
Total Alkalinity, as $CaCO_3$	mg/l	55.3	67.0	11.0	12.1[d]			55.2	66.7			20.0[j]
Hardness, as $CaCO_3$	mg/l	66.0	82.0	664.0	1,076.0			68.0	87.2			
Non-carbonate Hardness, as $CaCO_3$	mg/l	11.6	22.0	-	-			-	-			
Specific Conductance	umhos/cm	135.0	170.0	1,102.0	2,080.0			117.3	182.3			
pH	Units	-	8.0	6.5-8.5	6.5-8.5			-	8.0	6.5-8.5	-	6.5-9.0[j]
Dissolved Solids	mg/l	81.5	109.0	814.0	1,602.0			83.07	116.9	-	1,000.0[j]	
Color	(Pt-Co Units)	10.0	15.0	-	-			-	-			
Suspended Solids	mg/l	3.7	24.0	36.9	309.7[e]			3.76	25.0			
Turbidity	NTU	1.7	4.0	-	-			-	-	5.0 over background		
Fecal Coliform	#/100ml	2.0	11.0	-	-			-	-	100		200.0[j]
Dissolved Oxygen	mg/l	11.0	15.0	0.52[f]	2.76-9.69			11.0	15.0	8.0	5.0	
Total Cadmium, as Cd	mg/l	1.1	3.0	12.0	10.6			1.12	1.19		0.016	2.5
Total Chromium, as Cr	mg/l	1.0	30.0	20.0	257.4			1.05	21.2		-	100.0[j]
Total Copper, as Cu	mg/l	10.1	20.0	102.6	360.4			10.5	29.7	1,000.0[i]	5.6	10.6
Total Iron, as Fe	mg/l	117.0	290.0	1,165.1	1,715.0			118.9	300.1		-	300.0[j]
Total Lead, as Pb	mg/l	16.9	71.0	168.1	919.7			17.2	77.6		1.00	135.0
Total Mercury, as Hg	mg/l	0.17	1.0	1.69	12.07			0.177	1.06		0.00057	0.0017
Total Zinc, as Zn	mg/l	30.2	90.0	300.5	1,159.2			30.0	95.6	5,000.0[i]	47.0	272.6
Ammonia Nitrogen, as N	mg/l	0.01	0.07	0.099	0.9			0.0115	0.104			0.5[j]
Nitrate Nitrogen, as N	mg/l	0.1	0.10	0.996	1.0			0.01	0.15	10.0[i]	-	10.0[j]
Ortho-Phosphate, as P	mg/l	0.01	0.08	0.099	0.51			0.01	0.04		-	0.1[j]
Total Phosphorus, as P	mg/l	0.01	0.11	0.299	1.03			0.01	0.12			
Total Residual Chlorine	mg/l	0.0	0.0	-	0.10			0.0002	0.0001		-	0.002[j]
Oil and Grease	mg/l	0.0	0.0	-	-							

NOTES:
(a) Concentrations of Columbia River water are developed from USGS data, October 1977 to October 1980, for Vernita Bridge near Priest Rapids Dam, Washington.
(b) Effluent concentrations developed by Bechtel, Inc. (see GR Section 1.6).
(c) Includes increase in sodium and chloride due to addition of sodium hypochlorite.
(d) Addition of sulfuric acid increases sulfate and reduces bicarbonate and alkalinity.
(e) Does not include air-borne dust and suspended solids settled in the cooling tower basin.
(f) Dissolved oxygen figure based on 68.9F time weighted average minimum water temperature.
(g) Dissolved oxygen figures based on 86.9F and 59.0F, corresponding to maximum and minimum minimum water temperatures.
(h) At a point 100 feet downstream of the discharge (edge of the mixing zone).
(i) Washington State Department of Social and Health Services, Board of Health regarding public water supply, Health Service Division (Ref 5).
(j) Values from the U.S. E.P.A. "Red Book," 1977 (Ref 1).
(k) Values subject to NPDES Permit, pending before the Washington State Energy Site Evaluation Council (ESSC).

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5.4 EFFECTS OF SANITARY DISCHARGES

This section discusses the environmental effects of sanitary discharges during Plant operation. Sanitary facilities are described in Section 3.7.

Sanitary waste disposal will be by means of a package sewage treatment plant with a percolation pond. Discharge into the percolation pond will average 5 gpm with a peak flow of 10 gpm. Effluent characteristics are described in Section 3.7.1.

Evaporation and percolation due to the arid climate and porous soil in combination with a high degree of treatment result in no significant effect on groundwater quality. Saturated soil conditions will exist within a few feet of the point of disposal. However, much of the water is not expected to enter the water table (approximately 125 feet below the ground surface), because moisture in the upper soil layers moves toward the surface due to evaporation and evapotranspiration (Ref 1). Contamination of groundwater by pathogenic bacteria, if it occurs, will be restricted to within a few feet of the pond where saturated flow conditions exist. 4

Because of the limited zone of potential contamination and the limited use of groundwater in the area, the operation of the treatment facility will have no measurable effect on groundwater resources.

Because there will be no discharge to any surface waters, no measurable effect upon water quality or the biota of the Columbia River will occur. The percolation pond may attract wildlife or waterfowl; however, they will not be adversely affected because wastewater from the aerated treatment plant will be treated prior to discharging into the percolation pond. During normal operation, the aerobic process will not be a source of odors.

Solid wastes will be collected and disposed of in accordance with Federal and State requirements.

References for Section 5.4

1. Washington Public Power Supply System, WNP #2 Environmental Report-Operating License Stage, Docket No. 50-397 Amendment #4 (October, 1980). 4

5.5 EFFECTS OF OPERATION AND MAINTENANCE OF THE TRANSMISSION SYSTEM

The environmental effects of operation and maintenance of the S/ENP transmission system and BPA Ashe-Hanford No. 2 line are expected to be minimal. The vegetation on the right-of-way is principally sagebrush, bitterbrush and cheatgrass. Chemical control will not be required. Once established, the access roads should require very minimal maintenance. 4 5

The transmission lines will be entirely within the Hanford Reservation, and thus, the general public will not have uncontrolled access to any new transmission access roads. Therefore, resident wildlife should receive little additional exposure. 4

In accordance with the recommendations in Reference 1, and as described in Section 3.9, armless construction will be utilized for the 69-kV distribution lines supplying power to the pumping plant. Due to the physical separation and orientation of the conductors, and lack of suitable perches with armless construction, the electrocution hazard to raptors will be minimal.

As discussed in Section 3.9, the acoustic and electrical noise, ground currents, and ozone production resulting from the operation of the transmission system will be insignificant.

References for Section 5.5

1. D. Miller, E. L. Boeker, R. S. Thorsell and R. R. Olendorff, Suggested Practices for Raptor Protection on Powerlines, Raptor Research Foundation, Provo, Utah, and Edison Electric Institute, Washington, D. C. (June 1975). 4

5.6 OPERATIONAL NOISE

The operational noise generated at the S/HNP Site will not be measurable at the nearest residential area, more than 7 miles away, and thus will not present an adverse impact or nuisance to the local population.

Typical predicted noise levels generated by mechanical draft cooling towers are 60 to 90 dBA at 50 feet, and at 2.5 miles 15 to 44 dBA (Ref 1).

Other industrial facilities in proximity to the S/HNP Site are the FFTF, WNP-2, WNP-1, and WNP-4, all about 5 miles away.

The sound level from the WPPSS intake pump, location 5, Table 2.7-1, Figure 2.7-1, was barely audible over the flow noise created by the current of the Columbia River, flowing by the inlet and outlet marker buoys. It is expected that the S/HNP pumps, which will be of similar design, will have about the same noise levels. The levels will be well below any existing regulation (WAC 173-60) as well as the guidelines proposed by the U.S. Environmental Protection Agency.

Transmission line noise is discussed in Section 3.9.2.

The operational noise will be well below the applicable Federal and State standards discussed in Section 2.7.

References for Section 5.6

1. Hanford Number Two Environmental Report, Amendment 4. 4

5.7 RESOURCES COMMITTED

Operation of the S/HNP will result in some irreversible and irretrievable commitments of resources.

Uranium is the principal natural resource irretrievably consumed in S/HNP operation. Other materials consumed, for practical purposes, are fuel-cladding materials, reactor-control elements and other replaceable reactor core components, process chemicals such as water treatment and ion-exchanger chemicals, ion-exchange resins, and the minor quantities of materials used in maintenance and operation. Except for the uranium isotopes U-235 and U-238, the consumed materials have wide-spread usage; therefore, their use in the proposed operation is considered to be reasonable with respect to the use in other industries. The major use of the natural isotopes of uranium is for production of useful energy (Ref 1).

5.7.1 NUCLEAR FUEL

The reactors in each station will be fueled with uranium enriched in the isotope U-235.

As of October 1, 1980, estimates compiled by the U.S. Department of Energy (Ref 2) indicated that the current U.S. reserves of U_3O_8 recoverable at $30 or less per lb totalled 645,000 tons. Additional potential resources of U_3O_8 at $30/lb were estimated to be 1,542,000 tons. A greater reserve exists if more expensively mined ore is considered. 4

Amounts of U_3O_8 recoverable at $30 and $50/lb are:

	$30/lb U_3O_8 (tons)	$50/lb U_3O_8 (tons)
Recoverable reserves as of October 1, 1980	645,000	936,000*
Potential additional resources	1,542,000	2,549,000**
Total	2,187,000	3,485,000

* Includes lower cost reserves.
** Includes lower cost potential resources.

Reserve estimates for the $30/lb category were officially initiated in 1974, and for the $50/lb in 1977. Since those dates, reserve additions from new properties and upward reevaluations of earlier data have kept pace with production and downward reevaluations, so that the resources in both categories have increased by 1.5 percent and 10 percent, respectively (Ref 3).

Other considerations also may increase the estimates of resources available. Foreign reserves of U_3O_8 potentially available to Western Block countries, for example, have been estimated to be 2,360,000 tons at $30/lb and 3,380,000 tons at $50/lb (Ref 4).

About 140,000 tons of U_3O_8 may be produced as a by-product of copper and phosphate mining by the year 2000 (Ref 2). In addition, it has been estimated that there are approximately 10 billion tons of uranium in solution in the oceans (Ref 5). However, recovery of uranium from this source is not economically feasible at present.

It is estimated that each S/HNP unit will consume an average of 1,800 lbs (0.90 short tons) of U-235 annually. In addition, an approximately equal amount of U-238 will be consumed. Because 0.711 percent of natural uranium is U-235, the total potential U.S. resources of U-235 amount to 21,000 short tons at $50 or less per lb of U_3O_8. The S/HNP will annually deplete 0.0086 percent of this known potential U.S. resource of U-235. 4

After use in the S/HNP, the fuel elements will still contain U-235 slightly above the natural fraction. This slightly enriched uranium could, upon separation from plutonium and other radioactive materials (separation takes place in a fuel reprocessing plant), be available for recycling through a gaseous diffusion plant. Scrap material containing valuable quantities of uranium is also recycled through appropriate steps in the fuel production process. Fissionable plutonium recovered in the reprocessing of spent fuel is valuable for fuel in power reactors.

5.7.2 MATERIAL RESOURCES

Material resources, such as gasoline, diesel fuel, nitrogen, sulfuric acid, sodium hydroxide, and others will be consumed during Plant operation. The amount of these materials which will be consumed during the life of the Plant will be small when compared to U.S. or world reserves.

The estimated reactor core materials consumed are listed (by chemical element) in Table 5.7-1. Because of national security needs and limited domestic supplies, most of the materials are included in the national stockpile. In view of the quantities produced yearly, the expenditure of these materials for the S/EHP is justified by the benefits from the electrical energy produced.

5.7.3 NATURAL RESOURCES

Some of the natural production of vegetation and animals on the Plant Site, initially lost during Plant construction (see Section 4.1), will continue to be lost during Plant operation for the life of the Plant. This loss will be negligible when compared to the natural production of the area. 4

Some Columbia River water will be consumed by the Plant during operation; the amount, however, as discussed in Section 3.3, is a small fraction of the mean annual flow of the river. Therefore, the relative impacts and long-term net effects of such water use are minimal.

References for Section 5.7

1. U.S. Department of the Interior, Bureau of Mines, "Mineral Facts and Problems" (1970) p. 230.

2. U.S. Department of Energy, "An Assessment Report on Uranium in the United States of America" (October 1980), GJO-III, 80.

3. U.S. Department of Energy, "Statistical Data of the Uranium Industry" (January 1980) GJO-100, 80. 4

4. Organization for Economic Cooperation and Development and International Atomic Energy Agency, "Uranium: Resources, Production and Demand," OECD and IAEA Report, Paris, (December 1979).

5. W. D. Wilkinson and W. F. Murphy, Nuclear Reactor Metallurgy, D. Van Nostrand (1958), pp. 382

TABLE 5.7-1

ESTIMATED QUANTITIES OF MATERIALS USED IN REPLACEABLE COMPONENTS OF WATER-COOLED NUCLEAR POWER PLANTS(1)

Material	Quantity Used In Plant(2) metric tons	World Production(3) metric tons	U.S. Consumption(3) metric tons	U.S. Reserve(3) metric tons	Strategic And Critical Material(4)
Antimony	0.0816	65,400	37,800	100,000(5)	Yes
Beryllium	0.0024	288	308	72,700	Yes
Boron	2.92	215,000(6)	79,000(6)	33×10^6	No
Cadmium	0.18(7)	17,000	6,800	86,000	Yes
Chromium	94.7	1,590,000	398,000	2×10^6(5)	Yes
Cobalt	0.354	20,200	6,980	25,000(5)	Yes
Gadolinium	2.3	0(8)		14,920(9)	No
Iron	384	974×10^6(10)	128×10^6(10)	2×10^9(5)	No
Nickel	47.9 272.0(7)	400,000(11)	129,000(11)	101,000(5)	Yes
Tin	20.8(12)	240,000	89,000	57,000(5)	Yes
Tungsten	0.300	35,000	7,300	79,000	Yes
Zirconium	959	224,000(6)	71,000(13)	5.7×10^6	No

(1) Table from Draft Environmental Statement, by the Directorate of Licensing, USAEC, Hope Creek Generating Station, Numbers 1 and 2, Docket Nos 50-354 and 50-355.

(2) Except as noted, the "quantities used in plant" are compiled from the Applicant's Environmental Report Construction Permit Stage (Revised), Limerick Generating Station, Units 1 and 2. Philadelphia Electric Co, May 1972. These values are for a two unit boiling water reactor plant rated at 3,293 MWt per reactor.

(3) Production, consumption, and reserves were compiled, except as noted, from the U.S. Bureau of Mines publications Mineral Facts and Problems (1970 ed Burt Mines Bull. 650) and the 1969 Minerals Yearbook. They are expressed in terms of contained element, regardless of the form. "Production" usually includes material recovered from both primary ores and secondary sources such as scrap recovery. Production and consumption figures are for 1969 unless otherwise noted. Estimates of reserves were published in 1969 but are based on data compiled over a number of years. The reserves stated are the quantities extractable at currently competitive prices; they include inferred as well as measured and indicated ores, when such information was available. Usually, resources recoverable with advanced methods or at greater cost are much greater than the reserves listed. 4

(4) Designated by G.A. Lincoln, "List of Strategic and Critical Materials," "Office of Emergency Preparedness," Federal Register, 37(39): 4123 (Feb. 26, 1972).

(5) World reserves are much larger than U.S. Reserves.

(6) Information for 1968.

(7) These quantities are in Hope Creek Generating Station Units 1 and 2 'Applicant's Environmental Report' but it is uncertain whether the total amounts of cadmium and nickel are for replaceable components or partly or totally in fixed components.

(8) Production of gadolinium is estimated for 1971 from data for total separated rare earths, given by J.G. Cannon, Eng. Mining J. 173(3): 187-200, March 1972. Production and reserves of gadolinium are assumed to be proportional to the ratio of gadolinium to total rare earth content of minerals given in Comprehensive Inorganic Chemistry, Vol 4, ed M.C. Sneed and R.C. Brasted, D. Van Nostrand Co, Princeton, N.J., 1955, p. 153.

(9) Reserves include only those at Mountain Pass, Calif., according to the 1969 Minerals Yearbook.

(10) Production of raw steel.

(11) Excludes quantities obtained from scrap.

(12) Computed from the Applicant's data in the Supplemental Environmental Report, April 1972, pp. 6.10-1 to 6.10-4 and Preliminary Safety Analysis Report, Tables 1.6-2 and 3.2-1 and Figure 3.2.1.

(13) Metallic zirconium accounted for 8 percent total U.S. consumption in 1968.

5.8 DECOMMISSIONING AND DISMANTLING

Detailed commitments regarding decommissioning of the S/HNP have not been made at this time and plans for the period after the useful life of the S/HNP can only be speculative. The degree of dismantling and the manner of decommissioning will be a decision made in the future. That decision will be based on information existing at that time, which balances the intended new use of the Site with safety standards and regulations, environmental goals, Plant design, and economic considerations. The environmental impacts (including costs, radiation doses, land requirements, etc) of decommissioning boiling water reactors, similar to those proposed for the S/HNP, are addressed by NUREG-0586, "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities" (Ref 1).

In summary, decommissioning of a nuclear power reactor does not usually involve environmental impacts which are unique to a specific project. The technology for decommissioning nuclear facilities is well in hand, and, although technical improvements in decommissioning techniques are to be expected, at the present time decommissioning can be performed safely and at reasonable cost. Radiation doses to the public as a result of decommissioning activities should be very small and would primarily come from the transportation of decommissioning waste to waste burial grounds. Radiation doses to decommissioning workers should be a small fraction of the worker exposure over the operating lifetime of the facility; these doses usually will be well within the occupational exposure limits imposed by regulatory requirements. Decommissioning costs for reactors are a small fraction of the present-worth commissioning costs. 4

References for Section 5.8

1. NUREG-0586 "Draft Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," U.S. Nuclear Regulatory Commission (January 1981). 4

CHAPTER 6.0

EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

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CHAPTER 6.0

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6.0 EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

This chapter describes the methods used to obtain baseline environmental data presented in Chapter 2.0 and describes programs for monitoring the environmental impacts of Site preparation and S/HNP construction and operation. Section 6.1 discusses the proposed preoperational environmental programs, and Section 6.2 discusses the proposed operational environmental monitoring programs.

6.1 PREOPERATIONAL ENVIRONMENTAL PROGRAMS

Preoperational environmental monitoring programs have been developed to assess the characteristics of the S/HNP Site and the surrounding region prior to S/HNP operation. Portions of these programs will continue through S/HNP operation. However, as data are collected and evaluated, the scope of these programs may change. The purpose of these programs is to establish a reference framework for assessing subsequent effects attributable to Site preparation, S/HNP construction and station operation. Reports which present data and appropriate conclusions of monitoring efforts will be made available to Federal and State agencies at the conclusion of each program. 4

Technical descriptions of procedures, techniques, and instrumentation used in the preoperational studies are discussed below.

6.1.1 SURFACE WATER

No surface water exists in the vicinity of the Site. The Columbia River, 7 miles to the northeast, will serve as the source for cooling water make-up, as well as the receiving body for wastewater discharges. The Yakima River, approximately 7 miles south of the Site, will not be affected by S/HNP construction or operation. Sampling programs to determine preconstruction and preoperational baseline water conditions and the related ecology of the Columbia River are described in the subsequent sections.

6.1.1.1 Physical and Chemical Parameters

This section describes the monitoring programs developed to determine physical and chemical characteristics of the Columbia River in the vicinity of the S/HNP intake and discharge structures (RM 361.5).

6.1.1.1.1 Preapplication Monitoring

The purpose of the preapplication monitoring program is to assess Site acceptability with regard to thermal and chemical impacts that could result from operation of the S/HNP. The following factors were considered in developing the preapplication monitoring programs for physical and chemical characteristics:

a. Existing environmental baseline data

b. Location and number of monitoring stations as required to consider the following factors:

   (1) Bathymetric characteristics in the vicinity of the intake and discharge structures

   (2) Type of cooling system employed and its probable operating modes 4

   (3) Transient hydrological parameters in the vicinity of the intake and discharge structures

   (4) Vertical and horizontal temperature and salinity structure in the vicinity of the intake and discharge structures

c. Sampling frequency and times to ensure that important temporal variations were adequately monitored

d. Duration of monitoring programs

e. Data analysis procedures

The Columbia River in the vicinity of the S/HNP has been studied for the last 36 years. These studies have included both general observations and detailed analyses of the impacts upon the river from plutonium reactor effluents. Study reports have been reviewed and summarized by Becker and Waddel (Ref 1), and by Neitzel (Ref 2), and they

provide a comprehensive historical picture of water quality conditions in the river. Major information sources include publications by the U.S. Geological Survey (Ref 3); The Washington Public Power Supply System (Supply System) (Ref 4); Battelle, Pacific Northwest Laboratories (Ref 5); U.S. Environmental Protection Agency (Ref 6); and the Washington State Department of Ecology (Ref 7). A summary of these data is included in Section 2.4.

Two ongoing water quality monitoring programs in the Hanford Reach (see Section 6.3) are of particular interest to the S/HNP. The U.S. Geological Survey (Ref 3) has collected monthly water quality data since 1974 at a monitoring station located upstream of the S/HNP at Vernita Bridge (RM 388.1). Parameters analyzed include an extensive list of general chemical, thermal, inorganic and organic constituents as well as a full complement of nutrients, trace metals and solid residues. Prior to 1974, samples were collected at Vernita Ferry (RM 394.5); however, this record is incomplete. Downstream of the S/HNP, the Supply System is conducting a one-year water chemistry study at RM 352.1. Their objective is to collect site-specific data and expand the preoperational data base for WNP 1, 2 and 4. Samples are collected on a weekly or monthly basis and analyzed for a full complement of parameters.

Since a comprehensive history of surface water data exists and since water quality sampling programs that bracket the area in the vicinity of the intake and discharge structures are in progress, a specific preapplication water quality monitoring program was unnecessary. 4

An Instream Data Collection Program for bathymetric survey and current velocity measurements was conducted from May 8 through May 11, 1981, along a 2.5 mile portion (66 cross-sections) of the Columbia RM 361.5 where the S/HNP intake and discharge structures will be located (see Appendix B). This program provides field-surveyed input data to various environmental analyses presented in this report, including the thermal plume modeling, the radionuclide dispersion calculations, the intake and discharge structures location, and the aquatic ecology studies.

The river discharge as measured below Priest Rapids Dam (RM 394.5) during the Instream Data Collection Program was 144,500 cfs. The discharge at RM 361.5, computed from the cross section area and depth profiles, was about 143,000 cfs. The maximum recorded velocity at RM 361.5 was about 7.0 ft/sec and was found in midstream. The intake and discharge structures will be located in a channel crossing where the transverse-channel profile is uniform. The main

flow channel upstream of RM 361.5 is located along the east bank of the river and crosses to the west bank downstream of RM 361.5. The minimum bed elevation (maximum depth) in the vicinity of the intake and discharge structures is about 335 ft above National Geodetic Vertical Datum (NGVD).

A Raytheon continuous recording fathometer was used to obtain the hydrographic data. Horizontal positioning was accomplished with a Motorola Mini-Ranger III Navigation System and data processor. A 23-ft MonArk survey vessel was used to collect the instream data. The vertical velocity profiles at RM 361.5 were obtained using a Bendix Q-15 current meter. A complete description of the field work, station locations, equipments and procedures used, and results and discussion are presented in the Instream Data Collection Program Report (Appendix B).

The stage-discharge relationship for the Columbia River at RM 361.5 was developed using the U.S. Corps of Engineers HEC-2 Water Surface Profiles computer program (Ref 8) with input data obtained from the Instream Data Collection Program. The general procedures for applying HEC-2 to the Columbia River, as described in Appendix B, include: a) Columbia River model development, b) model calibrations, and c) computation of water surface profiles. The results of the calculations are presented in Section 2.4.

The thermal plume (dilution) analysis was conducted using a state-of-the-art mathematical model implemented on a high speed digital computer. The computer code, designated HOTSUB3, was adapted from the work of Koh and Fan (Ref 9) and NRC Regulatory Guide 1.113 (Ref 10). With an input of discharge design, discharge flow parameters, and receiving water characteristics, the code generates excess temperature (concentration) profiles in the ambient receiving water. The format of the output is such that isotherms (isopleths) may be plotted for horizontal planes at selected depths. In addition, by using the data from the isotherm (isopleth) contours, the program calculates corresponding surface areas and volumes. A complete description of the thermal plume modeling is presented in Appendix C.

6.1.1.1.2 Site Preparation and Construction Monitoring Program

A water quality monitoring program will be established to detect possible direct or indirect effects of Site preparation and S/HNP construction on surface waters, and to evaluate potential impacts on the Columbia River ecology.

This program will also serve as part of the construction impact control program (Section 4.5) to ensure that construction activities will be performed in a manner to minimize scouring, erosion, runoff, turbidity and toxicity.

A monitoring program will be initiated during excavation and backfilling activities for the intake and discharge structures. The basic program of water quality monitoring during construction will include measurements of total suspended solids (TSS), turbidity, light penetration, pH, oil and grease, temperature, and dissolved oxygen at stations located both upstream and downstream from the excavation Site. Duplicate water samples will be collected at five locations (Table 6.1-1 and Figure 6.1-1).

Water samples will consist of a one-liter aliquot taken from a composite of three subsurface grab samples per station. Samples will be returned to the laboratory for determination of total suspended solids (non-filterable residue) and for various calibration purposes. Water quality measurement for temperature, dissolved oxygen, pH, and turbidity will be conducted. The proposed analytical methods and levels of detection are presented in Table 6.1-2.

In addition, samples of material to be dredged shall be collected and standard bulk sediment and elutriate testing performed (Ref 11). Such tests delineate the type and amount of trace substances and the organic content of the material in question. Should results indicate high levels of contaminating substances, the basic monitoring program can be expanded to incorporate these parameters. 4

6.1.1.1.3 Preoperational Monitoring Program

The objective of the preoperational water quality monitoring program is to provide the data base necessary for identifying and assessing any changes in water quality resulting from Plant operation. The monitoring program, to be initiated one year prior to fuel load, is designed to be compatible with the operational monitoring program (see Section 6.2).

The following factors were considered in developing the preoperational monitoring program for physical and chemical characteristics:

a. The average and extreme extent and enclosed surface area of the limiting excess temperature

isotherms as established by the State, by comparison with background and baseline data

b. Temperatures at positions appropriate to define the extent of the mixing zones

c. Time-temperature relationships at biological monitoring stations.

Water quality characteristics, frequency of sampling, and the methods to be used in sample preservation and analysis are provided in Table 6.1-3. The study includes all of the physical and chemical parameters considered essential to characterize the water quality in the vicinity of the intake and discharge structures. Seven sampling locations, described in Table 6.1-4 and shown in Figure 6.1-1, have been established.

Three stations unique to the S/HNP will be sampled on a weekly or monthly basis depending on the parameter (Table 6.1-3). The stations include the S/HNP intake (WQ-1), the downstream boundary of a legally defined mixing zone (WQ-2), and a station approximately 2.0 miles (3.2km) downstream of the S/HNP discharge in the major axis of the discharge plume (WQ-4). The remaining four stations, WQ-0, 5, 6 and 7, correspond to sampling locations for related monitoring programs (Section 6.3). These stations will be sampled quarterly to ensure that preoperational results can be correlated with other studies in progress. This objective will be accomplished by performing side-by-side sample collection and sample splitting with the various agencies or analytical laboratories involved. 4

The water quality parameters to be monitored were chosen to detect any possible direct effects of S/HNP operation on the thermal regime or water quality characteristics of the Columbia River, and to detect possible synergistic effects that may affect the ecology of the Columbia River. General sampling and analytical procedures are discussed below.

Duplicate grab samples will be collected in the main river current approximately 1.0 ft below the water surface at each station. Samples collected will be filtered on-Site where necessary and stored in ice-filled coolers prior to shipment. Samples will be shipped promptly to a certified analytical laboratory.

In situ instrumentation will be calibrated per manufacturer's instruction immediately prior to and following field sampling. Dual calibration will provide information regarding drift in calibration due to sensor fouling. In addition, a small number of discrete water samples will be

returned to the laboratory for analysis and further verification of in situ instrumentation.

Sampling and analytical methodology will be performed in accordance with the latest guidelines set forth by the U.S. Environmental Protection Agency (Ref 11), the American Public Health Association (Ref 12), and/or the American Society for Testing and Materials (Ref 13). In the event of a conflict, Reference 11 will be used as the principal reference document.

For quality control purposes, standard solutions will be run prior to each sampling effort to ensure accuracy of results. Blind duplicates will be submitted to ensure reproducibility and accuracy. Satisfactory completion of the U.S. Environmental Protection Agency's Sample Audit Program (Ref 14) will also be accomplished. All work related to this program will be stringently recorded in: (a) bound field notebooks; (b) bound laboratory notebooks, including worksheets and copies of standard curves; and (c) final data reports.

6.1.1.2 Ecological Parameters

This section describes the monitoring programs to determine aquatic ecological characteristics of the Columbia River in the vicinity of the S/HNP intake and discharge structures (Rm 361.5). 4

6.1.1.2.1 Preapplication Program

Studies at the Hanford Reservation over a 36-year period have provided a substantial amount of qualitative and quantitative information useful for impact assessment. In addition, the Supply System has conducted literature reviews (Ref 2, 15) and field studies on the Columbia River since 1973 (Ref 16-22). These studies provide comprehensive baseline information on the composition, structure and function of the aquatic ecosystem of the Hanford Reach of the Columbia River. The information was used to describe the existing ecological conditions (Section 2.2.2) in the vicinity of the S/HNP intake and discharge locations at RM 361.5.

Predictions of nonlethal physiological and behavioral responses as described in Sections 4.1.2, 5.1.3 and 5.3.1 are based upon:

a. Knowledge of local aquatic ecosystems (Section 2.2.2)

b. A thorough review of literature on tolerance levels and nonlethal physiological and behavioral responses of local aquatic organisms to thermal, physical and chemical stresses

c. Predicted stresses of construction and operation activities.

6.1.1.2.2 Site Preparation and Construction Program

A potential ecological concern may arise during S/HNP construction as a result of the excavation and backfilling activities associated with construction of river intake and discharge structures. Increases in suspended and settleable materials may affect aquatic biota in several ways. An increase in suspended particles may decrease light penetration and reduce photosynthetic activities of macrophytes, phytoplankton and periphyton. A reduction of plant growth may be reflected in all food web levels. Additions of suspended and settleable materials may mechanically abrade and clog gills of fish and sessile organisms, as well as interfere with the feeding processes of filter feeding organisms (Refs 23, 24). Settling and shifting of solid materials on the river bottom may fill substrate interstices, eliminating micro- and macro-invertebrate habitats and thus altering the benthic community structure (Ref 25). 4

The Supply System evaluated these possiblities during installation of WNP-2 make-up and circulating water blowdown lines (Ref 27). Results indicated that, after backfilling was completed, settled material covered approximately 6.9 acres (or 13 percent of the river cross section), to a point approximately 1000 ft downstream from the WNP construction activities. Periphyton growth and macroinvertebrate numbers were markedly reduced in the affected area. The river, however, continued to wash the area, dissipating the deposits within a few weeks. Other researchers have noted that the recolorization of bottom substrates is usually rapid and can occur in as little as a few days (Ref 26). It was concluded that the impacts from the installation of the intake and discharge structures are inconsequential to the aquatic community (Ref 27).

The Supply System study provided sufficient data to address biological considerations of construction in the river.

Therefore, no aquatic monitoring is proposed during the S/HNP Site preparation and construction program.

6.1.1.2.3 Preoperational Program

The objective of the preoperational aquatic ecology monitoring program will be to augment the historical and confirmatory data used for identifying and assessing potential ecological changes resulting from S/HNP operation. Accordingly, preoperational monitoring will be concentrated on that portion of the river immediately adjacent to the Plant intake/discharge facilities, and will emphasize organisms most likely to be affected by S/HNP operation (ie, benthic biota and fish).

The following factors were considered in developing the preoperational monitoring program for aquatic ecology:

a. Alteration of Habitat. The composition of bottom substrates, movement of material, and the size of affected areas in relation to intake and discharge velocities and ambient environmental conditions were considered.

b. Entrainment, Impingement, Entrapment. The distribution and abundance of important species and their various life stages susceptible to entrapment, entrainment, and impingement were considered so that estimates of potential losses and predictions of the effects of these losses could be made. 4

c. Thermal and Chemical Stress. The distribution and abundance by life stage of important species in the cooling water body to be influenced by thermal and chemical discharges were considered so that estimates of potential losses and predictions of the effects of these discharges could be made. Water quality monitoring pertinent to determining the impact of S/HNP operation was considered.

The seasonal cycles found in ecosystems may require long-term studies to detect perturbations. Therefore, the preoperational program will collect field data for two years prior to fuel load to provide additional information on natural variations in the seasonal occurrences and abundance of important aquatic species near the S/HNP intake and discharge location. A knowledge of the extent of natural variations will permit evaluation of changes in the abundance of important aquatic species in the intake

and discharge vicinity before and during operation. A comparison of changes in species abundance in the vicinity of the intake and discharge, and in control areas outside the influence of the S/HNP, will also be made before and during operation. The following monitoring program was designed to be consistent and compatible with data collected in the preapplication program as well as with data from other locations in the Hanford Reach.

Benthic Organisms: Alterations of Columbia River aquatic biota due to the influence of Plant effluent should be most readily indicated by changes in the structure of the benthic community in the immediate vicinity of the discharge. The preoperational benthic program will focus on characterizing the benthic flora and fauna in the area of expected impact.

Sampling locations for preoperational benthic studies are shown in Figure 6.1-2 and described in Table 6.1-5. Stations will be sampled four times per year (in March, June, September, and December) to establish baseline information on community composition and abundance. To sample benthic fauna, rock-filled baskets will be incubated on the bottom for a three-month period. Upon recovery, species composition, biomass and community dominance will be determined. Benthic flora will be sampled using glass microscope slides incubated at the same sites as the rock-filled baskets and sampled at the same frequency. Qualitative species analysis, chlorophyll-a and biomass measurements will be made. Replicate benthic flora and fauna samples will be taken to allow for statistical analysis of community changes. Representatives of all taxa present will be preserved in a species reference collection, complete with voucher specimens. 4

Special benthic programs may occur on an intermittent basis in response to regional concerns. A survey of asiatic clam (*Corbicula* sp.) distribution in the vicinity of the Plant intake and the upriver shoreline and backwater slough areas will be initiated in accordance with guidance provided in Reference 28.

Fish: Identification of fish species in the Hanford Reach is essentially complete. The Supply System's preliminary program (Refs 16-22) has examined the spatial and temporal distribution, relative species abundance, age structure and feeding habits of fish found near the WNP-1/4 and 2 intake and discharge locations. In the preoperational program, emphasis will be placed on fish found in the immediate vicinity of the S/HNP intake and discharge structures.

Species and numbers of fish residing seasonally near the structures will be examined with particular attention given to anadromous outmigrants and juvenile smallmouth bass. Samples will be obtained using one or more of the following sampling methods: hoop-nets, electroshocking or beach seining. Sampling locations for each of these methods are shown in Figure 6.1-2. A tag and release program will be used in an attempt to determine population size and residence time within the study area.

Fish sampling will be conducted on at least a monthly basis. The planned sampling frequency by method is provided in Table 6.1-6. The program will be statistically designed to estimate the standard error of all calculations.

Special fish sampling programs may occur on an intermittent basis in response to regional concerns. The Columbia River upstream of the intake and discharge location is presently receiving considerable attention from Federal and State fisheries agencies and the mid-Columbia PUD's to determine the impacts of hydroelectric development on fisheries resources. Studies regarding fish passage and migrations; spawning and rearing success; and turbine and system mortality are either in progress or have been planned (see Section 6.3). Periodic studies in the vicinity of the S/HNP intake are planned to capture marked fish released at upstream locations. Such studies will provide improved information on distribution and residence time of anadromous species near the intake and discharge location. Other short-term studies may be initiated as the need arises. 4

Plankton: Some fraction of the river's plankton will be drawn into the Plant with cooling water and another fraction will be exposed to the effects of entrainment in the discharge plume. The numbers affected represent an extremely small fraction of the population passing the Plant. Studies conducted by the Supply System on the Columbia River indicate that planktonic algae and microcrustaceans in the aquatic system near WNP-1/4 and 2 do not have a major role in energy transfer pathways (Ref 16-22). The small volume of water to be withdrawn by the S/HNP and the small volume to be discharged is inconsequential in comparison to the total river flow. No significant impact on the plankton community is expected. Therefore, no plankton sampling is proposed during the preoperational monitoring program.

6.1.2 GROUNDWATER

Reference 34 is the most complete catalog of monitoring wells located on the Hanford Reservation. There are over 2200 wells on the Hanford Reservation, more than 45 of which are located within 5 miles of the S/HNP Site (Section 2.4.2). Extensive environmental monitoring programs concerning the physical, chemical and radiological characteristics of groundwater on the Hanford Reservation have been conducted for the Department of Energy (DOE) (Ref 35). These programs and investigations continue to accumulate comprehensive information on groundwater characteristics and are expected to be continued routinely as part of the DOE program. The results of these groundwater investigations are presented in Section 2.4.2.
Eight additional monitoring wells were recently installed in the immediate vicinity of the S/HNP Site (Figure 2P-1 of the S/HNP PSAR Appendix 2P).

There are no plans to monitor non-radiological groundwater quality parameters during the preoperational phase.

There will be no release of radioactive liquid to the ground during normal operations. There are no realistic accidental releases of radioactive liquids to the ground. S/HNP PSAR Section 2.4.13.3 describes the models used for transport of radionuclides to groundwater. 4

6.1.3 AIR

6.1.3.1 Meteorology

Meteorological data reported in Section 2.3 were collected at the WNP-2 site from April 1, 1974 through March 30, 1976. The data collection system is described in the WNP-2 Environmental Report - Operating Licensing Stage, Amendments No. 1 through 5, Section 6.1.3.1. A copy of this section is included in Appendix D.

Two options exist for the preoperational and operational meteorological monitoring programs. The first option is to initiate an on-Site monitoring program after issuance of the construction permit. This program will satisfy requirements of regulatory guidelines regarding operational meteorological monitoring programs. The second option recognizes the unique characteristics of the Hanford Reservation in terms of existing meteorological monitoring programs and that there may be some form of joint

monitoring program in the near or medium-range future. Under this option, on-site meteorological measurements and routine and accidental dose assessments would be performed for the entire Hanford Reservation through a common headquarters. The selection of the specific option will depend on regulatory requirements in effect following issuance of the Construction Permit (CP) and on the administrative feasibility of conducting cooperative meteorological monitoring programs for the Hanford Reservation and vicinity (see Section 6.3.3).

6.1.3.2 Models

6.1.3.2.1 Short-Term Atmospheric Dispersion Model

The dispersion factors (χ/Q) for ground-level releases were determined using the methodology presented in Regulatory Guide 1.145 (Ref 36).

The χ/Q values applicable for releases of less than or equal to two hours duration were calculated at the distances of interest, using the joint frequency distributions of wind speed and wind direction by atmospheric stability class. 4

During neutral (D) or stable (E, F, or G) atmospheric stability conditions when the 10 meter windspeed is less than 6 m/s, the 2-hour χ/Q value was calculated from the following set of equations:

$$\chi/Q = \frac{1}{\bar{u}(\pi \sigma_y \sigma_z + A/2)} \qquad (6.1\text{-}1)$$

$$\chi/Q = \frac{1}{\bar{u}(3\pi \sigma_y \sigma_z)} \qquad (6.1\text{-}2)$$

$$\chi/Q = \frac{1}{\bar{u} \Sigma_y \sigma_z} \qquad (6.1\text{-}3)$$

where

χ/Q = the relative concentration at ground level (sec/m^3)

π = 3.14159

$\bar{u}$ = the mean wind speed at 10 meters (m/s)

σ_y = the Pasquill-Gifford lateral plume spread, a function of atmospheric stability and distance (m)

σ_z = the Pasquill-Gifford vertical plume spread, a function of atmospheric stability and distance (m)

A = 2200 m^2, the smallest vertical plane cross-sectional area of the building from which the effluent is released

Σ_y = the lateral plume spread with meander and building wake effects (m). Σ_y is a function of atmospheric stability, windspeed, and distance. For distances of 800 meters or less, $\Sigma_y = M\,\sigma_y$ where M is based on Figure 3 of Reference 1. For distances greater than 800 meters, $\Sigma_y = (M-1)\ \sigma_{y800m} + \sigma_y$.

χ/Q values were calculated using Equations 6.1-1, 6.1-2, and 6.1-3. The higher value calculated from Equations 6.1-1 and 6.1-2 was compared to the value computed from Equation 6.1-3 and the lower was chosen as the appropriate χ/Q value. 4

For all other meteorological conditions (ie, unstable - A, B, or C atmospheric stability and/or 10 m wind speeds of 6 m/s or greater), plume meander was not considered. The appropriate χ/Q value was chosen as the higher value calculated from Equation 6.1-1 or 6.1-2.

The realistic χ/Q values for the standard population distances were calculated using a direction-dependent (sector-dependent) methodology. Cumulative probability distributions of χ/Q values were determined for each of the 16 wind direction sectors relative to the total hours in all sectors. For realistic estimates at the population distances, χ/Q values at the 3.125 percentile (relative to all sectors or approximately 50 percent for a given sector) were selected from these probability distributions. These selected values represented periods of two hours or less. The annual-average value was calculated in accordance with the methodology described in Regulatory Guide 1.111, Rev. 1 (Ref 37). Values for periods of 8, 16, 72, and 624 hours were obtained by logarithmic interpolation between the 2-hour value and the annual-average value in the same sector.

To select representative atmospheric dispersion value at the Exclusion Area Boundary and Low Population Zone (LPZ) Boundary, χ/Q values were determined using direction independent methodology per Regulatory Guide 1.111. This methodology, although sector independent, gives realistic estimates for the Site as a whole. The 2-hour χ/Q values were ranked without regard to sector and an overall cumulative probability distribution determined. From this distribution, the value which was exceeded no more than 50 percent of the total time, was selected for the realistic estimate. Values for longer time periods (ie, 8 and 16 hours, and 3 and 26 days) were determined by a logarithmic interpolation between the overall 50th percentile 2-hour value and the maximum annual average χ/Q value over the 16 sectors. 4 5

Input meteorological data consisted of joint frequency distributions (JFD's) of hourly averages of wind speed and wind direction by stability class. For computer modeling purposes, twelve wind speed groups were used to give good resolution at lower wind speeds (Ref 38). The annual JFD with the standard 7 wind speed groups is shown in Table 6.1-7. The JFD's were based on two years of data collected at WNP-2 as described in Section 6.1.3. Occurrences of calms and variable wind directions were distributed by direction and stability class to the lowest wind speed group of the JFD's. Calms were assigned a speed one-half of the threshold speed of the wind vane. Winds were based on observations at 33 ft and stability class on observations of delta T (245-33 ft) in accordance with Regulatory Guide 1.23 (Ref 39). 4

6.1.3.2.2 Short-Term Dispersion Estimates

The realistic χ/Q estimates at the Exclusion Area Boundary and LPZ Boundary for a hypothetical accident are presented in Table 6.1-8. The maximum 0 to 2-hr value at the Exclusion Area Boundary is 1.2×10^{-5} sec/m^3, and at the LPZ is 4.7×10^{-6} sec/m^3. 5

The realistic χ/Q estimates as a function of distance are presented in Table 6.1-9. These are sector-dependent values. The higher values are to the SSE of the S/HNP and the lower values are to the W. 4

6.1.3.2.3 Long-Term Atmospheric Dispersion Model

This section describes the model for atmospheric dispersion estimates applicable for long-term dose assessment. Dispersion factors (χ/Q) were determined using the methodology presented in Regulatory Guide 1.111, Rev. 1 (Ref 37) and the NRC computer code XOQDOQ (Ref 40).

The calculations were made for the Site boundary and at the standard distances out to 50 miles. All releases were assumed to be at ground level.

χ/Q values were determined by:

$$(\chi/Q)_D = \frac{2.032}{x} \sum_{ij} \frac{n_{ij}}{N\Sigma_{zj}\bar{u}_{ij}} \qquad (6.1\text{-}4)$$

where

$(\chi/Q)_D$ = the average effluent concentration, χ, normalized by source strength, Q, at a downwind distance, x, for a given direction, D (sec/m^3) 4

x = downwind distance (m)

n_{ij} = length of time in hours of valid data for a given wind direction, D, wind speed class, i, and atmospheric stability, j

N = total number of hours of valid data

Σ_{zj} = effective vertical dispersion parameter (m) for stability class j

$\bar{u}_{ij}$ = average wind speed (m/s) for wind speed class, i, and stability class, j, for sector D.

An effective vertical stability parameter, Σ_{zj}, is calculated to account for building wake effects as follows (Ref 37):

$$\Sigma_{zj} = \left[\sigma_{zj}^2 + \frac{H^2}{2\pi}\right]^{1/2} \qquad (6.1\text{-}5)$$

with the constraint

$$\Sigma_{zj} \leq \sigma_{zj}\sqrt{3} \qquad (6.1\text{-}6)$$

where

σ_{zj} = Pasquill-Gifford vertical plume spread (m), a function of atmospheric stability, j, and distance, x

H = maximum adjacent building height (m).

The value used for the term H was 34m. This approximates the average height of the buildings adjacent to which routine releases are expected: Containment, Turbine, Auxiliary, Fuel, and Radwaste Buildings. Open terrain correction factors were used as described in Regulatory Guide 1.111, Rev. 1 (Ref 37).

6.1.3.2.4 Long-Term Dispersion Estimates

The annual average relative concentrations (χ/Q's) at the Site boundary are presented in Table 6.1-10 for S/HNP Units 1 and 2 separately. The same information is presented in graphical form in Figure 6.1-3. The highest estimate for releases from Unit 1 is 1.5 x 10^{-5} sec/m^3 in the ESE sector and from Unit 2 is 2.6 x 10^{-5} sec/m^3, in the ESE sector. 4

The annual average relative concentrations at the Hanford Reservation and at selected locations are given in Tables 6.1-11 and 6.1-12. The annual average relative concentrations as a function of distance are presented in Table 6.1-13. From this table, the relative concentrations at a distance of 2 miles are plotted in Figure 6.1-4. The higher values at each distance are to the SSE. Values of 2.26 day decay and undepleted χ/Q, 8-day depleted and decayed relative concentration (χ/Q) and for deposition (D/Q) are also presented in this table as provided by Computer Code XOQDOQ.

6.1.3.3 Cooling Tower Effects Models

The environmental impacts of the operation of an evaporation cooling system include the formation of fog, ice and elevated visible plumes, as well as the airborne

concentration and ground deposition of dissolved solids contained in drift droplets released from the cooling system.

The occurrence of icing, ground-level fog, elevated visible plumes, and the airborne concentration and ground deposition rates of dissolved solids in drift, were calculated using the computer model FOG (Ref 41, 42). The FOG model provides predictions of these environmental impacts over the area surrounding the Site. This model uses the entire set of hourly meteorological measurements collected at the meteorological tower at WNP-2.

A second limited dispersion modeling analysis was conducted with the LVPM model (Ref 43). This model was used to represent expected plume rise and plume moisture content during typical summer morning and winter morning periods. Input to the LVPM model are average morning meteorological conditions as obtained from the WNP-2 meteorological data base.

6.1.3.3.1 FOG Model

The FOG model simulates the dispersion of the plume from evaporative cooling systems using sequential hourly meteorological data. A bent-over plume treatment is used by incorporating Briggs plume rise equations (Ref 44) to the downwind distance where the plume rise stops. Gaussian dispersion equations are then used for calculations beyond this distance. The plume buoyancy employed in the plume rise calculations is computed from the effluent temperature and air flow rate at the exit of the cooling tower and from the ambient dry bulb temperature and relative humidity. For the round mechanical-draft multifan cooling towers, plume merging is considered using equations developed by Briggs (Ref 45) for a "cluster" of cells. No enhanced plume rise due to the merging of plumes from neighboring towers is considered; this conservative assumption leads to lower plume rises and greater ground-level effects. 4

The FOG model makes calculations over a polar grid centered on the cooling system. This grid consists of up to 20 downwind distances. After all calculations have been made, the results are further processed and summarized on a Cartesian grid. The plume is assumed to propagate rectilinearly, and any meandering effects due to wind shifts are neglected. Required Pasquill stability classes are determined from the measured difference between the dry bulb temperatures at the two levels of the on-Site meteorological tower. The dispersion parameters used (sigma y and

sigma z) were those of Pasquill-Gifford (Ref 46). Formulations for critical wind speed relative to the aerodynamic downwash of the exhaust plumes are also included in the FOG model.

6.1.3.3.1.1 Induced ground level fogging. Induced ground-level fog is defined as a reduction in ground-level visibility to 1000 m (5/8 mile) ~~or less~~ as a result of the operation of the cooling systems. According to the international definition, 1000 m is the limit on visibility above which fog is not considered to occur (Ref 47). The fogging calculations were based on a criterion that 1.2 x 10^{-3} lbs of liquid water per lb of dry air (0.015 g of water/m^3) would result in a visibility of 1000 m (5/8 mile) or less (Ref 48). The water content of the plumes at ground level is calculated by means of the dispersion analysis (Section 6.1.3.3.1). All moisture in excess of that required to saturate the ambient air is assumed to form condensed water droplets. An empirical equation presented by Petterssen (Ref 48) is then used to relate the atmospheric water content to horizontal visibility.

6.1.3.3.1.2 Induced ground level icing. The frequencies of occurrence of various ice thicknesses resulting from the operation of ~~the cooling towers were calculated~~ by the FOG model, which includes subroutines to simulate the formation and accumulation of ice and to calculate the frequencies of ice occurrence. 4

The ice-formation routines predict accumulations of ice around a cooling system from the impingement of condensed water and drift droplets. Calculations of ice buildup are made for both vertical and horizontal flat surfaces. The rate of ice buildup can be limited either by the liquid water delivery rate to the collecting surface or by the heat balance necessary to sustain freezing conditions.

In the case of ice formation on elevated flat vertical surfaces, ice buildup can result from the impingement of both condensed water and drift droplets. The liquid water delivery rate is computed as the liquid mass flux times the intercepted surface area. This value is then multiplied by a collection efficiency of 0.8 for the condensed water droplets. The dispersion of the relatively small condensed water droplets is treated the same as that of the vapor plume, while the transport of the drift droplets is the same as that employed for the salt deposition calculations. The FOG model performs an energy balance on the surface or volume of interest. Ice formation is assumed to occur only when the ambient temperature is less than 0°C. Under

certain conditions, the ice buildup rate can be limited by heat transfer considerations. This occurs when the latent heat of fusion released during freezing results in a surface temperature equal to 0°C, even though ambient temperature is less than 0°C. Since any additional ice buildup would increase the surface temperature above 0°C, such ice formation would not be possible.

In the case of ice formation on horizontal ground-level surfaces, ice buildup is assumed to result only from the fallout of the drift droplets. Since the much smaller condensed water droplets have negligibly small settling velocities, the condensed water droplets are assumed not to impinge on flat horizontal surfaces. The heat transfer limitations on ice formation on flat horizontal surfaces are basically the same as those discussed above for flat vertical surfaces, with the exception of melting due to solar radiation, which is not included because unshielded flat horizontal surfaces are always exposed to solar radiation, whereas vertical surfaces are not.

6.1.3.3.1.3 Elevated visible plumes. The FOG model was used to calculate the frequencies of occurrence of elevated visible plumes over each grid point. The total flux of air through a cross-section of the plume normal to the plume axis is calculated at successive downwind distances. This calculation is made whether the plume is in the rising stage or has reached its maximum height and leveled off. The amount of entrained air is computed as the difference between the total air flow and the air flow leaving the cooling system. The entrained air and the effluent air from the cooling system are assumed to be thoroughly mixed isobarically, and the thermodynamic properties of the resulting mixture are calculated. A visible plume is predicted to occur if calculations show that the mixed plume is supersaturated. 4

6.1.3.3.1.4 Drift analysis. The FOG model was used to calculate the transport and ground deposition rate of dissolved solids contained in the entrained drift droplets released from the cooling systems.

Drift deposition analysis by the FOG model involves the following three calculations: (a) the sequential release of the entrained drift droplets from the effluent plume, (b) the subsequent horizontal transport of the drift droplets, and (c) the airborne concentrations and deposition rates at prespecified downwind distances for each wind direction.

It is assumed in the FOG model that the excess water vapor, the temperature excess, the vertical velocity, and the initial concentration of drift droplets follow a Gaussian distribution normal to the plume axis. The plume is assumed to extend two standard deviations (ie, two sigma y and two sigma z) away from the plume axis. The release of the entrained droplets at any point within the plume depends on the relative magnitudes of the terminal fall velocity of the droplets and the vertical velocity of the air in the plume. At each downwind distance under consideration, these two velocities are compared for the various size categories of plume droplets, and a fraction of the droplets is released. This process is repeated until all droplets are released from the plume. When the plume reaches its maximum height, the vertical velocity throughout the plume is zero. Droplets released from the plume fall first through the plume air, and then through the ambient air beneath the plume. This drift is carried downstream by the ambient wind until it is deposited on the ground. The rate of fall of the drift droplets is proportional to their terminal velocity, which in turn is dependent on the droplet size. The droplet size can change by evaporative processes, which depend on the physical and transport properties of both the liquid droplets and the surrounding air. For relative humidities below 50 percent, complete evaporation of the drift droplets to dry particles is possible. A stepwise procedure is employed in the FOG model to compute the trajectory of the droplets by considering the above effects. 4

Drift deposition rates and airborne concentrations of dry drift particles are calculated for each of the sequential meteorological records included in the 2-year meteorological data set. These are then summarized to obtain the deposition (lb/acre-yr) and airborne concentrations of dry particles (micrograms/m^3) over the entire grid. The calculation of airborne concentration is made at a height of 2 m above the ground surface.

6.1.3.3.2 LVPM Model

Cooling tower plume rise and moisture content were calculated with the LVPM (Ref 3), a one-dimensional numerical model capable of predicting the detailed behavior of plumes for a given meteorological condition. The numerical technique utilized in the LVPM model is described by equations for the motion of a quasi-incompressible fluid. Based on the assumption of steady-state plume, the model simulates a continuous efflux into a horizontally homogeneous atmosphere. This assumption simplifies the numerical

computation and leads to practical and economical application.

The LVPM model was used to calculate plume rise and plume moisture content, ie, vertical profiles of temperature, vertical velocity, and moisture through the plume at selected downwind distances for average summer and winter conditions. In addition, variations of plume rise as a function of ambient atmospheric stability are calculated.

6.1.3.4 Air Quality

Nonradiological air quality measurements in Benton County, where the S/HNP Site is located, are the responsibility of the Tri-County Air Pollution Control Authority (TCAPCA). As a result of the small quantities of nonradiological air pollutants to be released to the atmosphere, the Applicant will not conduct a preoperational air quality monitoring program.

The primary air quality nuisance in the Hanford area is dust. Thus, only total suspended particulates (TSP) are monitored by the TCAPCA at Hanford. During the 1980's, the annual mean average of TSP at Hanford was below the Federal standard of 60 micrograms/m^3. The highest 24-hour measurement at the Hanford Reservation was 279 micrograms/m^3 on July 9, 1980 (Ref 49). The sample mainly consisted of volcanic ash from the Mt. St. Helens eruption that was being resuspended as windblown dust into the atmosphere. During the day of the eruption (May 18, 1980), however, Sehmel (Ref 50) reported an average concentration for respirable particles (less than 5.5 micrograms diameter) of 1430 micrograms/m^3. 4

6.1.4 LAND

6.1.4.1 Geology and Soils

No geological or soil studies have been made specifically to determine the environmental impact on these factors of construction and operation of the facility. Detailed analyses of soil engineering properties at the Site have been carried out for the purpose of determining safety-related design parameters. These analyses and the results are reported in Section 2.5.4 of the S/HNP PSAR. Detailed geological studies have also been carried out in the Site Area and are reported in Section 2.5.1 of the S/HNP PSAR.

There are no indications from any of the geological or soils studies that construction or operation of the Plant would have an adverse environmental impact on these factors.

6.1.4.2 Land Use and Demographic Surveys

Land use information and data presented in Section 2.1 were obtained by such means as on-Site visits, personal communications with cognizant persons and organizations (eg, agricultural, extension agents and relevant county and state agencies), publications, maps, and aerial photographs. The list of numbered references in Section 2.1 indicates the specific sources of information and data contained in the text, tables, and figures.

Demographic analyses were conducted using traditional scientific demographic methods. The list of numbered references for Section 2.1 indicates specific sources of demographic information and data.

Population estimates are based on the latest available data. All population estimates and projections were calculated with the centroid of S/HNP Units 1 and 2 as the geographic reference. For the analysis of the population within 10 miles, a house count was conducted in October, 1981. For the estimate of the population between 10 and 50 miles, data from the 1980 U.S. Census were analyzed for blocks, tracts and enumeration districts. 4

Population projections from 1990 through 2030 were based on county forecasts for the states of Washington and Oregon. For the census years 1990 and 2000, existing projections were directly employed. For the years 2010, 2020 and 2030, projections were made following a logic similar to that of the U.S. Census projections through 2030 for the nation as a whole. It was assumed that after the year 2000, stabilization of population growth will gradually occur within a 50-mile radius of the Site. For each of the census years, from 2010 through 2030, it was estimated that the rate of population increase in each county would decline by one-half of the rate prevalent in the previous decade. For each county within 50 miles, this procedure results in a stabilized population by the year 2030.

Distribution of population growth was assumed to be equal throughout each county, with the major exceptions of the Benton and Franklin metropolitan counties, which are nearest to the Site. Based on (a) interviews with local planners and city officials and (b) review of land use and

annexation plans, a number of areas within the Tri-Cities were identified as having high growth potential. Those areas include the Horn Rapids Triangle in Richland, the Horn-Williamette area in West Richland and northwest Pasco near the new I-182 bridge. Accordingly, for the period 1980-2000 appropriate enumeration districts and census blocks were projected to grow at approximately twice the rate of the remainder of the metropolitan area. Several of these areas were projected to sustain growth from 2000-2010, but after 2010 all areas were projected to stabilize and generally parallel the overall metropolitan area growth rates.

6.1.4.3 Preoperational Ecological Programs

This section describes the preoperational program designed to assess the terrestrial ecological characteristics of the Site, with primary reference to important terrestrial species. A species was considered important as defined in Regulatory Guide 4.2, Rev. 2. Species listed as Endangered, Threatened or Sensitive, and species of special interest as defined by the Washington Natural Heritage Program, were considered important species.

The monitoring program was designed to identify preoperational ecological conditions so that specific environmental changes induced by the S/HNP could be recognized and assessed. The program was divided into three stages: preapplication, Site preparation and construction, and preoperational. Preapplication studies were designed with these specific objectives: 4

a. Describe the terrestrial biota from a regional and Site specific perspective

b. Determine which important species might occur within the study area and verify occurrence whenever possible

c. Identify important species or areas of special concern that may be affected by the S/HNP.

Site preparation and construction monitoring will expand upon the important conclusions of preapplication monitoring, and will continue until Plant construction is completed. The objectives of this monitoring effort are:

a. Determine the actual distribution of important species within the Site and Associated Areas

b. Monitor abundance and/or habitat usage of species indicated in c. above

c. Estimate the impact of Site preparation and construction upon plant or wildlife species and/or habitats

d. Describe potential mitigation measures, if necessary, to ameliorate and/or compensate for adverse terrestrial impacts.

Preoperational monitoring is the final stage before operation and is designed to provide the data necessary for evaluating any changes to the terrestrial environment arising from S/HNP operation. In many instances, the previous monitoring programs will provide the necessary data base.

6.1.4.3.1 Preapplication Monitoring

The vegetation and wildlife of the Hanford Reservation has been thoroughly studied in connection with the activities of the U.S. Department of Energy (and its predecessors), the Supply System and the U.S. Army Corps of Engineers (riparian zone only). The preapplication monitoring program was designed to confirm that the area likely to be affected by the S/HNP is similar to areas already described in the literature, and therefore, impacts will be predictable based primarily on data from previous studies. Field surveys also were conducted to check for the occurrence of important species, as defined in NRC Regulatory Guide 4.2. 4

Relevant literature is listed in Section 2.2. The area studied was the Site and Associated Areas, which encompassed the Site and the railroad, transmission line, pipeline, and access road corridors (see Section 2.2.1.3). To assure proper coverage, the corridor width was assumed to be 300 m.

Qualitative field surveys of vegetation were conducted in April-October, 1981. Each area was searched on foot by a plant taxonomist/ecologist to identify any threatened, endangered, or other sensitive plant species or habitats and to document their presence, local and regional abundance, sensitivity, and relationships to the S/HNP.

A qualitative field investigation of wildlife was conducted to: (a) assure applicability of existing information to the Site and Associated Areas, (b) locate specific areas used by important wildlife species, and (c) search for

unique wildlife features within the area to be directly impacted by Site preparation and station construction. This field investigation was conducted in May, June and July, 1981.

The Site and Associated Areas were traversed in a systematic manner to record all wildlife sign and observations.

The S/HNP intake/discharge location and the old Hanford townsite were studied in detail. The townsite is unique within the Hanford Reservation because of the trees planted decades ago by early settlers for shade and fruit production. Since the pipeline corridor transects the townsite, a reconnaissance of the entire area was conducted.

Most of the trees within the townsite were checked for wildlife use signs. Trees with significant wildlife sign (eg, raptor nests) were mapped for future identification. An attempt was made to ascertain if nests were active and which species was using them. If possible, nest success was determined. In addition to trees, all other remaining features of the townsite (ie, the old schoolhouse, pumphouse, and miscellaneous remnants from the town) were checked for signs of wildlife use.

The remaining important feature of the townsite was the riparian habitat along the Columbia River. This area was checked for wildlife use sign, especially breeding and feeding activity of hydrophilic species. The extent and quality of riparian habitat available to wildlife was noted on aerial photographs. 4

6.1.4.3.2 Site Preparation and Construction Monitoring

As previously mentioned, this monitoring effort will determine the distribution of important species within the Site and Associated Areas and monitor the abundance of these important species or areas of special concern (as indicated from preapplication studies): bald eagles, long-billed curlews, and the old Hanford townsite. This monitoring effort will begin sufficiently in advance of the start of construction activities to provide the preconstruction data base necessary for assessing the extent of construction impacts. Studies will continue until construction effects have subsided or the extent of impact has been satisfactorily appraised. The following describes the methodologies for each facet of the monitoring program.

Important Plant Species. The listing status of persistant sepal yellow cress, *Rorippa calycina*, var. *Columbiae*, will

be monitored in case of a change from its present status as a candidate for listing as threatened or endangered on the Federal list, and threatened on the Washington State list. The area occupied by the population along the riparian zone will be determined during the time of low water levels in the spring. The percentage of the population which will be disturbed by construction will be estimated. An additional check of the population during the low water period in late summer or fall will be conducted to help determine the ability of the species to resist disturbance.

Important Wildlife Species. A reconnaissance of the Site and associated areas will occur twice each spring and winter to map the distribution of important species. Occurrence data will be recorded and no effort will be made to estimate population levels. The objective of this investigation is to determine if the distribution of important species changes during construction activities.

Bald Eagles. Bald eagles primarily are found during the winter at the old Hanford townsite. This area will be surveyed monthly during the winter to determine the number of eagles present. An attempt will be made to determine habitat usage within the Site and associated areas. Observation regarding prey selection, preferred roosting sites and sensitivity to disturbance will be recorded.

Long-billed Curlews. Curlews are found during the breeding period (March-June) and at least two pairs have been found within the Site and associated areas. Potential nesting habitat within or adjacent to the Site and associated areas will be surveyed monthly (during the breeding period) for signs of breeding activity. Territories actively defended will be mapped and nesting success will be determined whenever possible. In addition, the breeding chronology will be monitored to assist in scheduling construction activities. 4

Old Hanford Townsite. The townsite is an area of special concern for wildlife. The objective of this portion of the monitoring program is to develop a data base on wildlife occurrence and monitor the impacts of construction activities upon wildlife at the townsite. Raptors, landbirds, and deer will be monitored.

Wildlife abundance will be monitored in the spring and fall/winter to sample breeding adults and winter residents, respectively. Spring sampling will occur in April and May; fall/winter sampling will occur from November through January. The procedures for this monitoring effort are outlined in Table 6.1-14.

6.1.4.3.3 Preoperational Monitoring

Site preparation and construction monitoring will supply an adequate data base for monitoring the effects of Plant operation on Rorippa calycina, var. Columbiae, bald eagles, long-billed curlews and wildlife at the old Hanford townsite. Monitoring other wildlife species or wildlife use areas is not deemed necessary at this time.

Data regarding the land area altered or rendered unsuitable for biological productivity will be measured near the end of construction. A map showing all areas of disturbance will be developed.

The Supply System is studying the effects of drift on vegetation and wildlife. The drift effects associated with the S/HNP do not require monitoring and will be less than those found at the Supply System units because of a much reduced particulate ratio. Therefore, the Supply System study will serve as a conservative estimate of the drift effects which might result from the S/HNP.

6.1.5 RADIOLOGICAL MONITORING

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The S/HNP preoperational radiological environmental monitoring program (REMP) is designed to provide measurements of radiation and radioactive materials in those exposure pathways, and for those radionuclides which are expected to lead to the highest radiation exposures of individuals from the operation of the S/HNP. The preoperational program objectives are to measure background levels and their variations in exposure pathways surrounding the Site; to train personnel; and to evaluate procedures, equipment, and techniques.

The S/HNP preoperation REMP is based on a combination of airborne, terrestrial and aquatic monitoring stations. Airborne sample stations have been chosen based on the projected population distribution around the Site, adjacent land use, and meteorological data presented in Chapter 2. The area within a ten-mile radius of the Site is of primary interest in the terrestrial monitoring part of the program. Attention is given to the area of Franklin County which uses Columbia River water for irrigation and is in the prevailing downwind direction. Aquatic sampling locations have been chosen based on the need to determine the S/HNP impact on the aquatic environs separately from other facilities on the Hanford Reservation.

Table 6.1-15 describes the sample type, approximate location, sample collection, and analyses to be performed on each sample. Analytical techniques will be used such that the detection capabilities in Table 6.1-16 are achieved. Figure 6.1-5 and 6.1-6 show the approximate location of the stations.

A more detailed discussion of the S/HNP REMP is discussed below:

Radioiodine and Particulates

The air sampling network will consist of seven stations. Three of the stations will be located in the vicinity of the Site boundary in three different downwind directions. One additional Site boundary station will be situated in an upwind direction to monitor potential impact from the Hanford Reservation 200 Area. Three stations from the Supply System program will be used to complete the air monitoring network. The Supply System Station 6, located approximately 9 miles SSE from the S/HNP, is situated in the vicinity of a proposed residential community. Supply System Station 8 is in the general vicinity of the nearest farm, approximately 11 miles ESE from the S/HNP. The control station for this monitoring program will be Supply System Station 9 located about 25 miles WSW from S/HNP. 4

Airborne iodine and particulates will be sampled by continuous low volume air samplers with a flow rate of approximately 1 ft^3/min. Radioiodine will be collected via charcoal canisters fitted in-line with the glass fiber filter for particulate collection.

The particulate filters will be changed weekly and analyzed for gross beta (beta analysis will occur no sooner than 24 hrs from time of collection to allow for radon and thoron daughter decay). Quarterly composited filters, by location, will be analyzed for gamma-emmitting nuclides. Individual weekly filters will have gamma isotopic analysis performed only if gross beta results are ten times the mean of the control location. Charcoal canisters will be analyzed weekly for iodine-131.

Direct Radiation

Direct radiation levels will be measured by a TLD (thermoluminescent dosimeter) System consisting tentatively of thirty-four stations. The exact number and location of stations will depend upon data on

prevailing wind directions, station accessibility and the existing TLD stations maintained by the Supply System and Battelle PNL for the Department of Energy.

A TLD station will be located in each sector on an inner ring in the general area of the Site boundary (inclusive of airborne locations) and an outer emergency assessment ring in the four to five mile range. Data from the Supply System Stations 6 (community) and 9 (control) will be used to complete the sampling network.

Duplicate TLD sets will be placed at each location. One set will be exchanged on a quarterly basis, the other set of dosimeters will be collected annually.

Groundwater

Groundwater will not be used for drinking or construction activities at the S/HNP. Groundwater on the Hanford Reservation is extensively monitored by Battelle PNL; during 1980, 317 wells were sampled at various times for radionuclide and chemical contaminants (Ref 51). As a result of continual groundwater monitoring in the Hanford area, and the fact that the S/HNP will not utilize groundwater, the S/HNP preoperational REMP will not include this media as part of its program. 4

Columbia River Water

River water will be sampled at the S/HNP intake and discharge facilities. The intake water will be sampled to identify the isotopes and concentrations present prior to use by the S/HNP. The water from the discharge line will be sampled prior to dilution by the Columbia River, and analysis will identify the isotopes and their concentrations which may be due to the S/HNP operation. Similar samples will be taken immediately downstream from the S/HNP discharge. The Columbia River will be sampled at the first downstream user. The water will be sampled, prior to any treatment or mixing, in the vicinity of the river water intake.

Drinking Water

Drinking water will be monitored utilizing the data from the Supply System's stations at the DOE 300 Area and at the Municipal Water Treatment Plant for the City of Richland.

Sediment

Sediment samples will be collected above and below the S/ENP discharge structure. Due to the velocity of the Columbia River in the vicinity of the discharge, sedimentary deposits are minimal. Data from the Supply System Sediment Station 35 will be used to evaluate potential radionuclide adsorption to sediments below the S/ENP discharge.

Indicator Organisms

Periphyton, moss or rooted macrophytes will be sampled where available near the sediment station location. These indicator organisms will be analyzed to determine if radioactive effluents released from up-stream users and potentially from the S/ENP discharge are accumulated by the biota.

Fish

Fish will be collected from locations near the S/ENP discharge utilizing, in part, available data from the Supply System. The species selected will include resident fish and/or those fish which are seasonally available. A station at the lower Granite Dam on the Snake River, utilized by the Supply System REMP, will be used as a control station. 4

Milk

Milk samples will be obtained from farms or individual milk animals which are located in sectors with the higher calculated annual average atmospheric dilution factors. The S/ENP REMP will utilize data from the Supply System Stations 8, 9, 37 and 38. Milk Station 9 is the control location.

Food Products

Data from the Supply System food product sampling network (Supply System Stations 8 and 9) will be used by the S/ENP REMP.

The type of analysis to be performed for the various media was chosen to provide measurements of radionuclides from which the population doses may be estimated or verified to be below that specified in Appendix I of 10 CFR 50. In some cases, the analysis provides a trend indicator and will signal the need to perform additional specific analyses of individual samples. The frequencies selected are those expected

to minimize the effect of day-to-day variations and provide an adequate quantity of samples to meet minimum sensitivity requirements of Table 6.1-16. The samples will provide statistically valid data which will be compared to subsequent results in order to detect variation from expected values.

The S/HNP REMP will employ quality control procedures to ensure that samples are collected and prepared for measurement in a thorough, concise manner. Instrumentation to measure radioactivity will be state-of-the-art technology at the time the program begins. The analytical laboratory will be required to meet internal quality control standards and to participate in an inter-laboratory quality control program. The internal quality control analyses will include spikes (samples to which known acitivity is added), duplicate samples and blanks (samples free of activity). The results of all quality control analyses will be included in each progress and/or semi-annual report. 4

The S/HNP preoperational REMP will be instituted two years prior to Plant operation. The duration of the S/HNP preoperational REMP for specific media will be as follows:

Two Years	One Year	Six Months
Direct Radiation	Airborne Particulate	Airborne Iodine
Fish	Milk (except iodine)	Milk (iodine)
Vegetation	River Water	
Sediment	Drinking Water	

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TABLE 6.1-1

DESCRIPTION OF WATER QUALITY SAMPLING STATIONS
FOR SITE PREPARATION AND
CONSTRUCTION MONITORING PROGRAM

Station	Location	Description
WQ-1	RM 361.5 + 300 ft.	Control Station; 0.06 miles upstream of the S/HNP intake
WQ-2	RM 361.4	0.1 miles downstream of the S/HNP discharge
WQ-3	RM 361.3	0.2 miles downstream of the S/HNP Discharge
WQ-4	RM 359.5	2.0 miles downstream of the S/HNP discharge
WQ-5	RM 351.9	WNP 1 & 4 Intake; 9.6 miles downstream of the S/HNP discharge

NOTE: See Figure 6.1-1 for station locations.

4

TABLE 6.1-2

ANALYTICAL METHODS AND LEVELS OF DETECTION FOR WATER CHARACTERISTICS TO BE MEASURED DURING THE CONSTRUCTION MONITORING PROGRAM

Characteristic	Method	Detection Limit
1. Temperature	In situ Probe (Ref 29) W/ERTCO, ASTM mercury thermometers for calibration and verification	1.0°C
2. Dissolved Oxygen	In situ Probe (Ref 29) W/Azid modification of Winkler Iodometric (Ref 12) for calibration and verification	0.10 mg/liter
3. pH	In situ Probe (Refs 12, 29) W/Potentiometric (Corning 610A) for calibration and verification	0.1 pH units 4
4. Turbidity	In situ Turbidimeter (Ref 30) W/Nephelometric (Ref 11) formazin standards for calibraiton	0.01 NTU
5. Suspended Solids	Glass Fiber filatration and (Ref 12) gravimetric at 105°C (mettler balance) Preservation: cool to 4°C; 2 days max	1.0 mg/liter
6. Light Penetration	20cm Black & White Secchi Disk	
7. Oil and Grease	Solvent Extration, Partition	1.0 mg/liter

TABLE 5.1-1

ANALYTICAL METHODS, DETECTION LIMITS AND PRESERVATION TECHNIQUES PROPOSED FOR THE WATER QUALITY PARAMETERS TO BE MONITORED IN THE PRECONSTRUCTION MONITORING PROGRAM

Parameter	Detection Units	Limit	Analytical Method	Calibration Method	Preservation Technique	Reference
WEEKLY SAMPLES						
Temperature	°C	-0.5	In situ Electrode	NBS/CO ASTM Hg Thermometer	—	20
Dissolved Oxygen	mg O_2/l	0.1	In situ Electrode	(Iodometric Winkler Modification)	Fix 2ml each $MnSO_4$, NaOH-KI, H_2SO_4	20
pH	pH units	0.1	In situ Electrode	Potentiometric	Anal to (°C; 16 hours) maximum	20, 20
Specific Conductivity	umhos/cm	0.50	In situ Electrode	0.01 N Potassium Chloride KCl Solution	25°C	20
Turbidity	NTU	0.05	In situ Electrode	Nephelometric Turbidity Standards	Anal to (°C; 12 days)	11, 20
Total Alkalinity	mg $CaCO_3$/l	1.0	Potentiometric Titrimetric		Anal to (°C; 24 hrs)	11
Total Hardness	mg $CaCO_3$/l	1.0	EDTA Titrimetric		Anal to (°C; 7 days)	11
Cadmium (Total + Dissolved)	mg Cd/l	0.1	Graphite Furnace		24 [illegible]	11
Chromium (Total + Dissolved)	mg Cr/l	0.1	Graphite Furnace		24 [illegible]	11
Copper (Total + Dissolved)	mg Cu/l	1.0	Graphite Furnace		24 [illegible]	11
Iron (Total + Dissolved)	mg Fe/l	1.0	Graphite Furnace		24 [illegible]	11
Lead (Total + Dissolved)	mg Pb/l	1.0	Graphite Furnace		24 [illegible]	11
Mercury (Total + Dissolved)	mg Hg/l	0.1	Cold Vapor (Flameless)		24 [illegible]	11
Zinc (Total + Dissolved)	mg Zn/l	0.0	AA Direct			
MONTHLY SAMPLES						
Total Suspended Solids (Non-Filterable Residue)	mg TSS/l	1.0	Gravimetric @ 105°C		Anal to (°C; 2 days)	11
Total Dissolved Solids (Filterable Residue)	mg TDS/l	1.0	Gravimetric @ 105°C		Anal to (°C; 2 days)	11
Ammonia-Nitrogen	mg NH_3-N/l	0.005	Phenate		Anal to (°C; 24 hrs) 2ml H_2SO_4/l	11
Nitrate-Nitrogen	mg NO_3-N/l	0.01	Cadmium Reduction		Anal to (°C; 7 days) 2ml H_2SO_4/l	11
Nitrite-Nitrogen	mg NO_2-N/l	0.01	Diazotization		Anal to (°C; 24 hrs)	11
Organic-Nitrogen	mg TKN/l	0.50	Titrimetric		Anal to (°C; 24 hrs)	11
Orthophosphorus	mg PO_4-P/l	0.005	Colorimetric (Vanadomolybdophosphoric)		Anal to (°C; filter 24 hrs)	11
Total Phosphorus	mg PO_4-P/l	0.005	Colorimetric (Vanadomolybdophosphoric)		Anal to (°C; 7 days)	11
Calcium	mg Ca/l	0.02	AA, Direct		24 [illegible]	11
Magnesium	mg Mg/l	0.01	AA, Direct		24 [illegible]	11
Sodium	mg Na/l	0.002	AA, Direct		Polyethylene	11
Potassium	mg K/l	0.01	AA, Direct		Polyethylene	11
Bicarbonate	mg HCO_3/l	1.0	Potentiometric + Titrimetric		Anal to (°C; 24 hrs)	11
Sulfate	mg SO_4/l	1.0	Turbidimetric		Anal to (°C; 7 days)	11
Chloride	mg Cl/l	1.0	Titrimetric		Anal [illegible] (7 days)	11
Fluoride	mg Fl/l	0.10	Specific Ion Electrode	Colorimetric-Spano Method	Anal to (°C; 7 days)	11, 12
Silica	mg Si/l		Colorimetric (Molybdosilicate)		Anal to (°C; 7 days)	11
Arsenic (Total + Dissolved)	mg As/l	0.1	Graphite Furnace		24 [illegible]	20
Barium (Total + Dissolved)	mg Ba/l	0.10	AA, Direct		24 [illegible]	11
Boron (Total + Dissolved)	mg Bo/l	10.0	Plasma Emission Spectroscopy		24 [illegible]; (6 mos)	
Cobalt (Total + Dissolved)	mg Co/l	1.0	Graphite Furnace		24 [illegible]	11
Manganese (Total + Dissolved)	mg Mn/l	1.0	AA, Direct		24 [illegible]	11
Selenium (Total + Dissolved)	mg Se/l	1.0	Graphite Furnace		24 [illegible]	11
Total Residual Chlorine			In situ Electrode	Colorimetric	[illegible] or [illegible]	11, 12
Oil and Grease	mg/l	1.0	Solvent Extraction; Partition	Gravimetric	2ml Conc. H_2SO_4; Anal to (°C	11
Color, Apparent	Color Units	0.0	Colorimetric (Platinum-Cobalt)		Anal to (°C; 24 hrs max	11
Fecal Coliform	organisms/100ml	1	Multiple Tube Fermentation		Sample [illegible]; anal to (°C	11
QUARTERLY SAMPLES						
PCBs	µg/l	1.0	Mass Spectroscopy/Gas Chromatography		Anal to (°C	11
Chlorinated Hydrocarbons	µg/l	1.0	Mass Spectroscopy/Gas Chromatography		Anal to (°C	11
Hydrogen Sulphide	mg H_2S/l	0.02	Colorimetric (Methylene Blue)		2ml [illegible]; 24 hrs	

TABLE 6.1-4

DESCRIPTION OF WATER QUALITY SAMPLING STATIONS FOR THE PREOPERATIONAL MONITORING PROGRAM

Station	Location	Description
WQ-0	RM 388.1	Control station Vernita Bridge (Hwy 024) (26.5 miles upstream of S/HNP Intake)
WQ-1	RM 361.5	S/HNP Intake
WQ-2	RM 361.4	Downstream boundary of mixing zone (0.1 miles downstream of S/HNP Discharge)
WQ-4	RM 359.5	2.0 miles downstream of S/HNP Discharge 4
WQ-5	RM 351.9	WNP 1 & 4 Intake (9.6 miles downstream of S/HNP Intake)
WQ-6	RM 345.0	300 Area Intake (16.5 miles downstream of S/HNP Discharge)
WQ-7	RM 338.0	City of Richland Municipal Intake (23.5 miles downstream of S/HNP Discharge)

NOTE: See Figure 6.1-1 for station locations.

TABLE 6.1-5

DESCRIPTION OF BENTHIC INVERTEBRATE SAMPLING STATIONS FOR THE PREOPERATIONAL MONITORING PROGRAM

Station	Location	Description
BI-1	RM 361.5+300 ft	Control station (0.06 miles upstream of S/ENP Intake)
BI-2	RM 361.4	Downstream boundary of mixing zone (0.1 miles downstream of S/ENP Discharge)
BI-3	RM 359.5	2.0 miles downstream of S/ENP Discharge

4

TABLE 6.1-6

PROPOSED FISH SAMPLING FREQUENCY, LISTED BY STATION AND METHOD, FOR THE PREOPERATIONAL MONITORING PROGRAM

Month	Beach Seine (6 stations)	Hoop Net (4 stations)	Electro-Fishing (5 stations)
January	1	0	0
February	1	0	0
March	2	1	2
April	4	2	4
May	4	2	4
June	4	2	4
July	2	1	2
August	2	1	2
September	2	1	2
October	1	0	0
November	1	0	0
December	1	0	0

NOTE: See Figure 6.1-2 for station locations.

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TABLE 9.1-7

Sheet 1 of 4

S/EMP ANNUAL JOINT FREQUENCY DISTRIBUTIONS*

Stability Class A

Speed (mph)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	0
0.75- 3.49	2	1	0	0	0	0	1	0	0	0	0	0	0	1	1	2	8
3.50- 7.49	22	17	8	7	7	3	16	15	9	11	12	4	12	9	15	26	193
7.50-12.49	20	20	12	8	1	3	7	13	52	8	6	5	10	9	20	19	213
12.50-18.49	7	5	1	0	0	0	2	4	21	21	8	9	9	7	13	6	113
18.50-23.99	0	0	0	0	0	0	0	0	6	0	6	6	12	8	20	1	59
>23.99	1	0	0	0	0	0	0	0	0	0	1	5	6	5	9	1	28
Total	52	43	21	15	8	6	26	32	88	40	33	29	49	39	78	55	614

Stability Class B

Speed (mph)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	0
0.75- 3.49	2	3	0	2	1	0	1	0	2	3	1	1	3	0	2	0	21
3.50- 7.49	41	25	17	7	6	21	20	30	21	22	25	15	29	21	21	30	359
7.50-12.49	17	15	6	2	4	11	9	12	60	19	12	13	10	3	8	14	223
12.50-18.49	11	0	0	0	0	0	0	1	14	17	12	11	11	12	9	6	100
18.50-23.99	0	0	0	0	0	0	0	0	1	4	0	7	6	3	10	2	41
>23.99	0	0	0	0	0	0	0	0	0	0	2	1	2	2	6	0	13
Total	71	43	23	11	11	32	30	43	106	65	60	48	61	41	56	60	765

Stability Class C

Speed (mph)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	0
0.75- 3.49	5	5	3	1	2	3	1	1	5	1	3	4	1	5	10	10	60
3.50- 7.49	58	36	15	13	6	12	11	53	49	31	22	22	21	18	29	43	459
7.50-12.49	36	27	12	14	6	6	11	26	60	49	16	14	22	12	12	16	347
12.50-18.49	13	7	2	0	0	0	1	2	8	25	26	16	14	6	13	9	142
18.50-23.99	1	0	0	0	0	0	0	0	1	5	7	8	7	3	7	1	42
>23.99	0	0	0	0	0	0	0	0	0	1	5	3	4	2	6	0	21
Total	113	75	32	28	14	21	44	82	111	112	79	67	69	46	77	79	1071

TABLE 8.1-3

Stability Class D

Speed (mph) / Cols	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.75- 3.49	62	37	32	29	32	52	53	50	39	55	50	41	43	60	60	70	4
3.50- 7.49	99	93	46	65	50	59	122	169	140	119	71	50	62	91	161	159	803
7.50-12.49	70	68	19	22	15	0	37	75	165	183	74	56	53	70	106	82	1576
12.50-18.49	23	12	4	0	0	0	0	15	70	154	103	50	40	75	81	26	1005
18.50-23.99	0	1	2	0	0	0	1	0	6	39	47	25	13	50	47	4	687
>23.99	0	0	0	0	0	0	0	0	0	10	30	9	0	11	25	0	235
Total	250	203	101	116	97	119	211	317	620	560	383	239	227	371	480	347	109
																	4479

Stability Class E

Speed (mph) / Cols	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.75- 3.49	67	45	35	20	37	68	56	53	66	50	50	55	47	90	80	70	12
3.50- 7.49	68	32	53	52	37	36	83	156	161	100	100	90	100	169	238	156	893
7.50-12.49	25	13	9	10	4	0	45	147	160	102	66	65	77	216	220	86	1627
12.50-18.49	1	6	1	1	0	0	11	33	91	127	82	26	26	126	86	13	1237
18.50-23.99	0	7	0	0	0	0	1	3	7	52	20	11	8	25	12	0	600
>23.99	0	13	0	0	0	0	0	0	1	26	14	6	2	2	0	0	154
Total	161	114	98	91	78	92	196	392	626	665	380	265	260	620	644	333	64
																	6595

Stability Class F

Speed (mph) / Cols	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
0.75- 3.49	60	56	35	17	32	31	32	30	41	56	39	53	34	66	62	72	5
3.50- 7.49	65	60	55	31	16	20	71	157	144	113	64	54	54	86	136	127	742
7.50-12.49	7	0	1	10	1	0	17	90	96	64	20	16	41	80	64	16	1250
12.50-18.49	0	0	1	0	0	0	0	7	14	19	6	0	2	1	2	0	545
18.50-23.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54
>23.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	140	120	96	78	67	55	120	292	295	250	129	123	133	233	264	215	0
																	2605

TABLE 6.1-7

Stability Class G

Speed (mph)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	11
0.75- 3.49	100	97	100	67	71	56	41	62	44	15	44	19	36	52	81	100	1017
3.50- 7.49	87	65	67	37	8	13	47	122	125	56	11	22	25	44	119	119	987
7.50-12.49	2	1	3	3	0	0	2	62	71	16	4	0	4	9	27	9	201
12.50-18.49	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	11
18.50-23.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>23.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	197	161	170	107	79	67	90	206	240	110	79	67	65	105	227	236	2227

Stability Class All

Speed (mph)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm																	32
0.75- 3.49	314	244	205	164	175	100	105	184	197	190	195	191	164	200	312	348	3544
3.50- 7.49	440	336	261	212	120	160	190	702	617	460	325	273	303	410	719	668	6460
7.50-12.49	101	132	66	69	11	16	110	413	660	401	190	101	219	407	659	242	3851
12.50-18.49	55	32	11	1	0	0	22	62	206	366	237	112	110	227	204	50	1703
18.50-23.99	1	8	2	0	0	0	2	1	21	100	96	57	46	89	96	8	531
>23.99	1	21	0	0	0	0	0	0	1	65	52	24	22	22	46	1	235
Total	992	773	543	446	330	192	717	1364	1724	1610	1103	818	864	1463	1836	1325	16356

Annual
Percentage Occurrence by Stability Classes

A	B	C	D	E	F	G
1.75	6.68	6.55	27.10	20.09	15.93	13.62

Annual
Distribution of Wind Direction Vs Stability

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM
A	52	41	21	15	0	6	26	12	88	40	11	29	49	19	78	55	0
B	71	47	21	11	11	32	30	43	106	65	60	40	61	41	56	60	0
C	113	75	32	28	14	21	44	82	133	112	79	67	69	46	77	79	0
D	258	203	103	116	97	119	211	313	428	560	301	239	227	171	488	347	0
E	161	116	90	91	70	92	196	192	424	465	340	265	260	620	644	333	12
F	140	120	96	70	67	55	120	292	295	250	129	121	111	211	266	215	9
G	197	161	170	107	79	67	90	206	240	110	79	67	65	105	227	236	11
Total	992	773	543	446	330	192	717	1364	1724	1610	1103	818	864	1463	1836	1325	32

TABLE 6.1-7

Annual
Distribution of Variable Winds
(These Values Are Not Included in the Previous JFD's)

Speed (mph)	A	B	C	D	E	F	G	TOTAL
Calm	0	0	0	0	0	0	0	0
0.75-3.49	1	5	15	48	30	41	43	183
3.50- 7.49	22	31	32	42	19	11	8	165
7.50-12.49	3	1	3	3	3	0	0	13
12.50-18.49	0	0	0	0	1	0	0	1
18.50-23.99	0	0	0	0	0	0	0	0
>23.99	0	0	0	0	0	0	0	0
Total	26	37	50	93	53	52	51	362

*Based on WNP-2 data with the 33-ft wind and delta T (245-33 ft) stability.
Total Number of Observations: 17544
Total Number of Valid Observations: 16356
Total Number of Missing Observations: 1188
Percent Data Recovery for this Period: 93.2 %
Mean Wind Speed for this Period: 7.5 mph
Total Number of Observations with Backup Data: 0
Wind Measured At: 33.0 Feet
Wind Threshold at: 0.75 mph

TABLE 6.1-8

REALISTIC SHORT-TERM CHI/Qs BY SECTOR FOR S/HNP AT THE EXCLUSION AREA BOUNDARY AND THE LOW POPULATION ZONE

Accident Period	Location: Exclusion Area Boundary	Location: Low Population Zone (4 miles)	
2 hours	1.2E-5	4.7E-6	
8 hours	8.8E-6	3.0E-6	5
16 hours	7.3E-6	2.4E-6	
72 hours (3 days)	5.0E-6	1.5E-6	
624 hours (26 days)	2.9E-6	7.8E-7	

Notes:

1. These realistic Chi/Q values (sec/m^3) are applicable for a ground-level release to a ground-level receptor, based on delta T stability class category and include plume meander and building wake effects. The values are sector-independent 50th percentile Chi/Q values. 4

2. Based on WNP-2 meteorological data for the period April 1, 1974, to March 31, 1976: 33-ft wind and delta T (245-33 ft).

TABLE 6.1-9 Sheet 1 of 10

REALISTIC SHORT-TERM ACCIDENT CHI/Qs BY SECTOR FOR S/ENP AT STANDARD DISTANCES

Distance: 805 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	7.4E-5	6.5E-5	4.8E-5	3.1E-5
NNE	5.3E-5	4.7E-5	3.6E-5	2.5E-5
NE	4.0E-5	3.5E-5	2.7E-5	1.9E-5
ENE	3.8E-5	3.4E-5	2.6E-5	1.8E-5
E	3.5E-5	3.1E-5	2.4E-5	1.7E-5
ESE	6.2E-5	5.5E-5	4.2E-5	2.9E-5
SE	7.8E-5	6.9E-5	5.3E-5	3.7E-5
SSE	7.8E-5	6.9E-5	5.2E-5	3.6E-5
S	5.8E-5	5.1E-5	4.0E-5	2.8E-5
SSW	3.7E-5	3.4E-5	2.7E-5	2.0E-5
SW	1.2E-5	1.2E-5	1.2E-5	1.2E-5
WSW	9.4E-6	9.4E-6	9.4E-6	9.4E-6
W	7.6E-6	7.6E-6	7.6E-6	7.6E-6
WNW	8.7E-6	8.7E-6	8.7E-6	8.7E-6
NW	3.6E-5	3.2E-5	2.5E-5	1.8E-5
NNW	7.1E-5	6.2E-5	4.5E-5	2.9E-5

Notes:

1. These realistic Chi/Q values (sec/m^3) are for a ground-level release to a ground-level receptor, based on delta T stability class category and include plume meander and building wake effects. The values are sector-dependent 50th percentile values.

2. Based on WNP-2 meteorological data for the period April 1, 1974, to March 31, 1976: 33-ft wind and delta T (245-33 ft).

3. Standard distances based on Regulatory Guide 1.111.

TABLE 6.1-9

Distance: 2414 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	1.8E-5	1.5E-5	9.1E-6	4.6E-6
NNE	1.3E-5	1.0E-5	6.7E-6	3.6E-6
NE	8.3E-6	6.9E-6	4.6E-6	2.6E-6
ENE	7.7E-6	6.5E-6	4.4E-6	2.5E-6
E	7.0E-6	5.8E-6	3.9E-6	2.2E-6
ESE	1.4E-5	1.2E-5	7.7E-6	4.2E-6
SE	2.0E-5	1.7E-5	1.1E-5	5.5E-6
SSE	2.0E-5	1.6E-5	1.0E-5	5.4E-6
S	1.3E-5	1.1E-5	7.1E-6	4.0E-6
SSW	7.2E-6	6.2E-6	4.5E-6	2.8E-6
SW	1.4E-6	1.4E-6	1.4E-6	1.4E-6
WSW	1.1E-6	1.1E-6	1.1E-6	1.1E-6
W	8.7E-7	8.7E-7	8.7E-7	8.6E-7
WNW	9.9E-7	9.9E-7	9.8E-7	9.6E-7
NW	7.7E-6	6.4E-6	4.3E-6	2.5E-6
NNW	1.7E-5	1.4E-5	8.6E-6	4.3E-6

4

TABLE 6.1-9

Distance: 4023 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	9.5E-6	7.3E-6	4.2E-6	1.9E-6
NNE	6.2E-6	4.9E-6	2.9E-6	1.4E-6
NE	3.8E-6	3.1E-6	2.0E-6	1.0E-6
ENE	3.8E-6	3.1E-6	2.0E-6	1.0E-6
E	3.4E-6	2.8E-6	1.7E-6	8.9E-7
ESE	7.5E-6	5.9E-6	3.5E-6	1.7E-6
SE	1.0E-5	8.1E-6	4.8E-6	2.2E-6
SSE	1.0E-5	8.1E-6	4.7E-6	2.2E-6
S	6.3E-6	5.0E-6	3.1E-6	1.6E-6
SSW	3.4E-6	2.8E-6	1.9E-6	1.1E-6
SW	5.0E-7	4.9E-7	4.9E-7	4.8E-7
WSW	3.9E-7	3.8E-7	3.8E-7	3.7E-7
W	3.2E-7	3.1E-7	3.1E-7	3.0E-7
WNW	3.5E-7	3.5E-7	3.5E-7	3.4E-7
NW	3.7E-6	3.0E-6	1.9E-6	9.6E-7
NNW	8.9E-6	6.8E-6	3.9E-6	1.7E-6

4

TABLE 6.1-9

Distance: 5633 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	6.3E-6	4.7E-6	2.6E-6	1.1E-6
NNE	3.9E-6	3.0E-6	1.7E-6	7.8E-7
NE	2.4E-6	1.9E-6	1.1E-6	5.6E-7
ENE	2.4E-6	1.9E-6	1.1E-6	5.6E-7
E	2.1E-6	1.7E-6	1.0E-6	4.9E-7
ESE	4.6E-6	3.6E-6	2.1E-6	9.4E-7
SE	7.0E-6	5.3E-6	3.0E-6	1.3E-6
SSE	7.0E-6	5.3E-6	2.9E-6	1.3E-6
S	4.0E-6	3.1E-6	1.9E-6	8.8E-7
SSW	2.0E-6	1.6E-6	1.1E-6	6.0E-7
SW	2.5E-7	2.5E-7	2.5E-7	2.5E-7
WSW	2.0E-7	2.0E-7	2.0E-7	2.0E-7
W	1.6E-7	1.6E-7	1.6E-7	1.6E-7
WNW	1.8E-7	1.8E-7	1.8E-7	1.7E-7
NW	2.3E-6	1.8E-6	1.1E-6	5.3E-7
NNW	5.7E-6	4.3E-6	2.3E-6	9.7E-7

4

TABLE 6.1-9

Distance: 7242 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	4.4E-6	3.3E-6	1.8E-6	7.0E-7
NNE	2.8E-6	2.1E-6	1.2E-6	5.2E-7
NE	1.7E-6	1.3E-6	7.8E-7	3.7E-7
ENE	1.7E-6	1.3E-6	7.8E-7	3.7E-7
E	1.5E-6	1.2E-6	6.9E-7	3.2E-7
ESE	3.4E-6	2.6E-6	1.4E-6	6.3E-7
SE	5.2E-6	3.9E-6	2.1E-6	8.5E-7
SSE	5.1E-6	3.8E-6	2.1E-6	8.4E-7
S	2.8E-6	2.2E-6	1.3E-6	5.9E-7
SSW	1.4E-6	1.1E-6	7.4E-7	4.0E-7
SW	1.6E-7	1.6E-7	1.6E-7	1.6E-7
WSW	1.2E-7	1.2E-7	1.2E-7	1.2E-7
W	1.0E-7	1.0E-7	1.0E-7	1.0E-7
WNW	1.1E-7	1.1E-7	1.1E-7	1.1E-7
NW	1.7E-6	1.3E-6	7.6E-7	3.6E-7
NNW	4.1E-6	3.1E-6	1.6E-6	6.5E-7

4

TABLE 6.1-9

Distance: 12070 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	2.6E-6	1.9E-6	9.4E-7	3.4E-7
NNE	1.6E-6	1.2E-6	6.4E-7	2.5E-7
NE	9.9E-7	7.5E-7	4.2E-7	1.8E-7
ENE	9.9E-7	7.5E-7	4.2E-7	1.8E-7
E	9.2E-7	7.0E-7	3.8E-7	1.6E-7
ESE	2.0E-6	1.5E-6	7.8E-7	3.1E-7
SE	3.0E-6	2.2E-6	1.1E-6	4.1E-7
SSE	3.0E-6	2.2E-6	1.1E-6	4.1E-7
S	1.8E-6	1.3E-6	7.1E-7	3.0E-7
SSW	8.8E-7	6.9E-7	4.2E-7	2.0E-7
SW	1.2E-7	1.1E-7	1.0E-7	8.7E-8
WSW	5.9E-8	5.9E-8	5.8E-8	5.7E-8
W	4.8E-8	4.8E-8	4.7E-8	4.6E-8
WNW	5.4E-8	5.3E-8	5.2E-8	5.0E-8
NW	9.8E-7	7.4E-7	4.1E-7	1.7E-7
NNW	2.4E-6	1.7E-6	8.5E-7	3.1E-7

4

TABLE 6.1-9

Distance: 24140 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	1.3E-6	9.2E-7	4.3E-7	1.5E-7
NNE	8.3E-7	6.0E-7	2.9E-7	1.1E-7
NE	5.0E-7	3.7E-7	1.9E-7	7.6E-8
ENE	4.8E-7	3.6E-7	1.9E-7	7.5E-8
E	4.9E-7	3.6E-7	1.8E-7	7.0E-8
ESE	1.1E-6	7.7E-7	3.8E-7	1.3E-7
SE	1.5E-6	1.1E-6	5.1E-7	1.8E-7
SSE	1.5E-6	1.1E-6	5.2E-7	1.8E-7
S	9.1E-7	6.7E-7	3.4E-7	1.3E-7
SSW	5.1E-7	3.9E-7	2.1E-7	9.2E-8
SW	8.0E-8	7.2E-8	5.8E-8	4.2E-8
WSW	2.4E-8	2.3E-8	2.3E-8	2.2E-8
W	1.9E-8	1.9E-8	1.8E-8	1.8E-8
WNW	2.1E-8	2.0E-8	2.0E-8	1.9E-8
NW	5.1E-7	3.7E-7	1.9E-7	7.5E-8
NNW	1.2E-6	8.4E-7	4.0E-7	1.3E-7

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TABLE 6.1-9

Distance: 40234 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	8.1E-7	5.6E-7	2.5E-7	8.1E-8
NNE	5.0E-7	3.6E-7	1.7E-7	5.8E-8
NE	3.1E-7	2.2E-7	1.1E-7	4.2E-8
ENE	2.9E-7	2.1E-7	1.1E-7	4.1E-8
E	3.1E-7	2.2E-7	1.1E-7	3.9E-8
ESE	6.5E-7	4.6E-7	2.1E-7	7.2E-8
SE	9.3E-7	6.5E-7	3.0E-7	9.7E-8
SSE	9.3E-7	6.5E-7	3.0E-7	9.9E-8
S	6.1E-7	4.4E-7	2.1E-7	7.4E-8
SSW	3.3E-7	2.5E-7	1.3E-7	5.3E-8
SW	6.1E-8	5.3E-8	3.9E-8	2.6E-8
WSW	1.2E-8	1.2E-8	1.2E-8	1.2E-8
W	9.5E-9	9.5E-9	9.4E-9	9.4E-9
WNW	9.9E-9	9.9E-9	9.9E-9	9.8E-9
NW	3.1E-7	2.3E-7	1.1E-7	4.1E-8
NNW	7.2E-7	5.0E-7	2.3E-7	7.3E-8

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TABLE 6.1-9

Distance: 56327 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	5.7E-7	3.9E-7	1.7E-7	5.4E-8
NNE	3.8E-7	2.6E-7	1.2E-7	3.9E-8
NE	2.2E-7	1.6E-7	7.9E-8	2.8E-8
ENE	2.1E-7	1.5E-7	7.4E-8	2.7E-8
E	2.3E-7	1.6E-7	7.6E-8	2.6E-8
ESE	4.8E-7	3.4E-7	1.5E-7	4.9E-8
SE	6.7E-7	4.6E-7	2.1E-7	6.6E-8
SSE	6.7E-7	4.7E-7	2.1E-7	6.7E-8
S	4.4E-7	3.1E-7	1.5E-7	5.0E-8
SSW	2.6E-7	1.9E-7	9.6E-8	3.7E-8
SW	5.1E-8	4.3E-8	3.0E-8	1.8E-8
WSW	7.6E-9	7.6E-9	7.6E-9	7.5E-9
W	6.1E-9	6.1E-9	6.1E-9	6.1E-9
WNW	6.6E-9	6.5E-9	6.5E-9	6.4E-9
NW	2.3E-7	1.6E-7	7.9E-8	2.8E-8
NNW	5.2E-7	3.6E-7	1.6E-7	4.9E-8

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TABLE 6.1-9

Distance: 72420 meters

Receptor Direction	Accident Period 8 hours	16 hours	72 hours	624 hours
N	4.6E-7	3.1E-7	1.4E-7	4.1E-8
NNE	3.0E-7	2.1E-7	9.3E-8	3.0E-8
NE	1.7E-7	1.2E-7	6.0E-8	2.1E-8
ENE	1.7E-7	1.2E-7	5.8E-8	2.1E-8
E	1.8E-7	1.3E-7	5.9E-8	2.0E-8
ESE	3.9E-7	2.7E-7	1.2E-7	3.7E-8
SE	5.2E-7	3.6E-7	1.6E-7	4.9E-8
SSE	5.2E-7	3.6E-7	1.6E-7	5.0E-8
S	3.6E-7	2.5E-7	1.2E-7	3.8E-8
SSW	2.1E-7	1.5E-7	7.6E-8	2.8E-8
SW	4.5E-8	3.7E-8	2.5E-8	1.4E-8
WSW	5.5E-9	5.5E-9	5.5E-9	5.5E-9
W	4.4E-9	4.4E-9	4.4E-9	4.4E-9
WNW	4.6E-9	4.6E-9	4.6E-9	4.6E-9
NW	1.8E-7	1.3E-7	6.0E-8	2.1E-8
NNW	4.0E-7	2.7E-7	1.2E-7	3.7E-8

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TABLE 6.1-10 Sheet 1 of 2

ANNUAL AVERAGE ATMOSPHERIC DISPERSION AND DEPOSITION PARAMETERS FOR S/HNP

Site Boundary: Unit 1

Dir	Distance (meters)	Chi/Q (sec/m3)	Chi/Q Decayed (sec/m3)	Chi/Q Decayed, Depleted (sec/m3)	D/Q (m^{-2})
N	1150.	1.043E-05	1.040E-05	9.308E-06	4.571E-08
NNE	1175.	8.661E-06	8.632E-06	7.722E-06	4.112E-08
NE	1095.	7.276E-06	7.252E-06	6.513E-06	3.177E-08
ENE	930.	9.820E-06	9.780E-06	8.876E-06	3.185E-08
[illegible]	910.	8.727E-06	8.699E-06	7.900E-06	3.383E-08
SE	930.	1.504E-05	1.499E-05	1.360E-05	5.545E-08
SE	1095.	1.400E-05	1.396E-05	1.253E-05	5.311E-08
SSE	1290.	1.012E-05	1.007E-05	8.970E-06	2.780E-08
S	1265.	8.321E-06	8.281E-06	7.385E-06	2.202E-08
SSW	1290.	6.341E-06	6.310E-06	5.621E-06	1.626E-08
SW	1325.	4.941E-06	4.918E-06	4.373E-06	1.061E-08
WSW	1125.	5.499E-06	5.474E-06	4.913E-06	1.242E-08
W	1100.	4.439E-06	4.423E-06	3.972E-06	9.598E-09
WNW	1120.	5.175E-06	5.148E-06	4.624E-06	1.106E-08
NW	1325.	4.921E-06	4.896E-06	4.355E-06	1.397E-08
NNW	1175.	9.362E-06	9.334E-06	8.348E-06	3.502E-08

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NOTES:

1. Relative concentrations are for a ground-level release are undepleted and undecayed, and incorporate Pasquill-Gifford dispersion coefficients, building height wake, and open terrain correction factors.

2. Based on WNP-2 meteorological data for the period April 1, 1974 to March 31, 1976: 33-ft wind and delta T (245-33 ft).

3. Distances are from the center of each Containment.

TABLE 6.1-10 Sheet 2 of 2

Site Boundary: Unit 2

Dir	Distance (meters)	Chi/Q (sec/m3)	Chi/Q Decayed (sec/m3)	Chi/Q Decayed, Depleted (sec/m3)	D/Q (m^{-2})
N	1150.	1.043E-05	1.040E-05	9.308E-06	4.571E-08
NNE	1145.	9.001E-06	8.972E-06	8.037E-06	4.295E-08
NE	765.	1.288E-05	1.286E-05	1.179E-05	5.699E-08
ENE	650.	1.707E-05	1.702E-05	1.577E-05	5.677E-08
E	635.	1.528E-05	1.524E-05	1.413E-05	6.037E-08
ESE	650.	2.616E-05	2.610E-05	2.417E-05	9.884E-08
SE	765.	2.473E-05	2.468E-05	2.264E-05	9.528E-08
SSE	1145.	1.270E-05	1.264E-05	1.134E-05	3.594E-08
S	1265.	8.321E-06	8.281E-06	7.385E-06	2.202E-08
SSW	1290.	6.341E-06	6.310E-06	5.621E-06	1.626E-08
SW	1520.	3.601E-06	3.582E-06	3.160E-06	7.416E-09
WSW	1400.	3.542E-06	3.522E-06	3.123E-06	7.525E-09
W	1375.	2.887E-06	2.873E-06	2.550E-06	5.871E-09
WSW	1400.	3.282E-06	3.261E-06	2.894E-06	6.653E-09
NW	1385.	4.428E-06	4.404E-06	3.908E-06	1.244E-08
NNW	1175.	9.362E-06	9.334E-06	8.348E-06	3.502E-08

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TABLE 6.1-11

ANNUAL AVERAGE ATMOSPHERIC DISPERSION AND DEPOSITION PARAMETERS FOR S/HNP

Hanford Reservation Boundary

Dir	Distance (meters)	Chi/Q (sec/m3)	Chi/Q Decayed (sec/m3)	Chi/Q Decayed, Depleted (sec/m3)	D/Q (m^{-2})
N	30000.	2.899E-08	2.687E-08	1.683E-08	4.094E-11
NNE	15100.	5.747E-08	5.501E-08	3.855E-08	1.233E-10
NE	13000.	5.610E-08	5.379E-08	3.861E-08	1.099E-10
ENE	12600.	6.184E-08	5.831E-08	4.257E-08	8.905E-11
E	12600.	5.243E-08	5.009E-08	3.623E-08	9.127E-11
ESE	13100.	8.867E-08	8.434E-08	6.080E-08	1.450E-10
SE	15000.	8.996E-08	8.609E-08	6.041E-08	1.431E-10
SSE	13200.	1.100E-07	1.047E-07	7.536E-08	1.305E-10
S	11800.	1.026E-07	9.808E-08	7.163E-08	1.191E-10
SSW	13700	6.822E-08	6.471E-08	4.640E-08	7.155E-11
SW	15600.	4.899E-08	4.639E-08	3.258E-08	3.990E-11
WSW	16900.	3.463E-08	3.230E-08	2.261E-08	2.854E-11
W	26600.	1.508E-08	1.369E-08	8.936E-09	9.842E-12
WNW	27800.	1.554E-08	1.375E-08	9.052E-09	1.083E-11
NW	30700.	1.758E-08	1.557E-08	1.001E-08	1.654E-11
NNW	31200.	2.515E-08	2.332E-08	1.447E-08	3.035E-11

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TABLE 6.1-12

ANNUAL AVERAGE ATMOSPHERIC DISPERSION PARAMETERS AND DEPOSITION ESTIMATES AT SELECTED LOCATIONS

Item	Direction	Distance (meters)	Chi/Q (sec/m3)	Chi/Q Decayed (sec/m3)	Chi/Q Decayed Depleted (sec/m3)	D/Q (m^{-2})
Residence	S	12125	9.862E-08	9.420E-08	6.856E-08	1.137E-10
Residence	NE	13485	5.317E-08	5.089E-08	3.636E-08	1.031E-10
Residence	ENE	13765	5.433E-08	5.095E-08	3.680E-08	7.640E-11
Residence	E	13750	4.612E-08	4.388E-08	3.138E-08	7.845E-11
Residence	ESE	14840	7.385E-08	6.978E-08	4.949E-08	1.166E-10
Residence	SSE	15640	8.621E-08	8.128E-08	5.723E-08	9.701E-11
WYZ Barricade	E	3500	5.180E-07	5.116E-07	4.240E-07	1.471E-09

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TABLE 6.1-11

ANNUAL AVERAGE DISPERSION PARAMETERS AND DEPOSITION ESTIMATES AT STANDARD DISTANCES FOR S/NMP*

No Decay, Undepleted
Corrected for Open Terrain Recirculation

Annual Average X/Q (sec/m³)

Distance in Miles

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	9.521E-05	1.756E-05	9.230E-06	4.739E-06	1.921E-06	1.040E-06	6.705E-07	4.715E-07	3.534E-07	2.773E-07	2.252E-07
SSW	6.458E-05	1.401E-05	7.367E-06	3.797E-06	1.540E-06	8.496E-07	5.446E-07	3.838E-07	2.883E-07	2.266E-07	1.843E-07
SW	3.727E-05	1.163E-05	6.101E-06	3.165E-06	1.301E-06	7.176E-07	4.617E-07	3.264E-07	2.457E-07	1.935E-07	1.576E-07
WSW	2.900E-05	9.452E-06	4.941E-06	2.571E-06	1.050E-06	5.767E-07	3.699E-07	2.608E-07	1.964E-07	1.541E-07	1.253E-07
W	2.336E-05	7.409E-06	3.895E-06	2.009E-06	0.201E-07	4.501E-07	2.886E-07	2.034E-07	1.528E-07	1.201E-07	0.764E-08
WNW	2.707E-05	8.799E-06	4.644E-06	2.378E-06	0.543E-07	5.190E-07	3.305E-07	2.318E-07	1.733E-07	1.357E-07	1.100E-07
NW	3.525E-05	1.155E-05	6.115E-06	3.113E-06	1.249E-06	6.779E-07	4.310E-07	3.010E-07	2.255E-07	1.764E-07	1.429E-07
NNW	5.136E-05	1.693E-05	9.003E-06	4.580E-06	1.836E-06	9.957E-07	6.327E-07	4.420E-07	3.300E-07	2.584E-07	2.095E-07
N	5.611E-05	1.833E-05	9.716E-06	6.944E-06	1.906E-06	1.078E-06	6.855E-07	4.002E-07	3.589E-07	2.809E-07	2.275E-07
NNE	4.662E-05	1.558E-05	8.324E-06	4.285E-06	1.670E-06	8.996E-07	5.688E-07	3.966E-07	2.952E-07	2.302E-07	1.859E-07
NE	3.688E-05	1.190E-05	6.384E-06	3.197E-06	1.274E-06	6.984E-07	4.378E-07	3.060E-07	2.283E-07	1.783E-07	1.442E-07
ENE	3.702E-05	1.231E-05	6.581E-06	3.342E-06	1.337E-06	7.238E-07	4.594E-07	3.213E-07	2.398E-07	1.874E-07	1.517E-07
E	3.192E-05	1.059E-05	5.635E-06	2.854E-06	1.140E-06	6.163E-07	3.908E-07	2.731E-07	2.037E-07	1.592E-07	1.287E-07
ESE	5.612E-05	1.806E-05	1.000E-05	5.111E-06	2.041E-06	1.104E-06	7.005E-07	4.897E-07	3.653E-07	2.854E-07	2.308E-07
SE	8.916E-05	2.285E-05	1.215E-05	6.181E-06	2.480E-06	1.346E-06	8.556E-07	5.991E-07	4.476E-07	3.502E-07	2.836E-07
SSE	6.912E-05	2.226E-05	1.177E-05	6.031E-06	2.441E-06	1.332E-06	8.502E-07	5.974E-07	4.475E-07	3.510E-07	2.848E-07

Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	1.077E-07	9.930E-08	6.574E-08	3.091E-08	2.696E-08	2.033E-08	1.617E-08	1.333E-08	1.129E-08	9.751E-09	8.559E-09
SSW	1.538E-07	8.175E-08	5.630E-08	3.226E-08	2.243E-08	1.695E-08	1.350E-08	1.115E-08	9.449E-09	8.172E-09	7.179E-09
SW	1.118E-07	7.038E-08	4.691E-08	2.800E-08	1.950E-08	1.477E-08	1.178E-08	9.734E-09	8.262E-09	7.151E-09	6.287E-09
WSW	1.044E-07	5.557E-08	3.694E-08	2.192E-08	1.522E-08	1.149E-08	9.147E-09	7.549E-09	6.307E-09	5.534E-09	4.854E-09
W	8.151E-08	4.329E-08	2.874E-08	1.787E-08	1.104E-08	8.941E-09	7.116E-09	5.872E-09	4.875E-09	4.301E-09	3.777E-09
WNW	9.157E-08	4.814E-08	3.174E-08	1.867E-08	1.287E-08	9.669E-09	7.665E-09	6.304E-09	5.326E-09	4.593E-09	4.024E-09
NW	1.188E-07	6.236E-08	4.096E-08	2.404E-08	1.654E-08	1.241E-08	9.827E-09	8.075E-09	6.816E-09	5.873E-09	5.142E-09
NNW	1.742E-07	9.122E-08	5.997E-08	3.514E-08	2.417E-08	1.812E-08	1.434E-08	1.178E-08	9.919E-09	8.561E-09	7.494E-09
N	1.893E-07	9.934E-08	6.541E-08	3.842E-08	2.640E-08	1.980E-08	1.574E-08	1.296E-08	1.094E-08	9.414E-09	8.264E-09
NNE	1.542E-07	8.088E-08	5.234E-08	3.081E-08	2.088E-08	1.553E-08	1.224E-08	1.063E-08	8.439E-09	7.252E-09	6.334E-09
NE	1.198E-07	6.259E-08	4.107E-08	2.401E-08	1.649E-08	1.235E-08	9.764E-09	8.014E-09	6.758E-09	5.819E-09	5.091E-09
ENE	1.261E-07	6.589E-08	4.326E-08	2.538E-08	1.738E-08	1.301E-08	1.029E-08	8.444E-09	7.120E-09	6.129E-09	5.361E-09
E	1.070E-07	5.586E-08	3.666E-08	2.142E-08	1.471E-08	1.101E-08	8.707E-09	7.145E-09	6.026E-09	5.185E-09	4.534E-09
ESE	1.918E-07	1.001E-07	6.541E-08	3.829E-08	2.625E-08	1.963E-08	1.550E-08	1.271E-08	1.071E-08	9.211E-09	8.053E-09
SE	2.358E-07	1.236E-07	8.126E-08	4.762E-08	3.276E-08	2.454E-08	1.944E-08	1.597E-08	1.347E-08	1.164E-08	1.016E-08
SSE	2.373E-07	1.252E-07	8.278E-08	4.887E-08	3.378E-08	2.543E-08	2.020E-08	1.663E-08	1.407E-08	1.214E-08	1.065E-08

TABLE 4.1-13

2.260 Day Decay, Undepleted
Corrected for Open Terrain Recirculation

Distance in Miles

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	5.512E-05	1.750E-05	9.196E-06	4.710E-06	1.903E-06	1.037E-06	0.003E-07	4.629E-07	3.459E-07	2.706E-07	2.191E-07
SSW	4.051E-05	1.397E-05	7.334E-06	3.774E-06	1.535E-06	0.392E-07	5.362E-07	3.760E-07	2.821E-07	2.211E-07	1.792E-07
SW	3.722E-05	1.168E-05	6.075E-06	3.147E-06	1.290E-06	7.095E-07	4.552E-07	3.209E-07	2.409E-07	1.892E-07	1.537E-07
WSW	2.903E-05	9.421E-06	4.957E-06	2.554E-06	1.040E-06	5.091E-07	3.637E-07	2.596E-07	1.914E-07	1.500E-07	1.216E-07
W	2.133E-05	7.308E-06	3.879E-06	1.998E-06	0.131E-07	4.450E-07	3.044E-07	1.999E-07	1.497E-07	1.174E-07	9.514E-08
WNW	2.702E-05	0.767E-06	4.610E-06	2.351E-06	9.430E-07	5.114E-07	3.245E-07	2.267E-07	1.409E-07	1.318E-07	1.064E-07
NW	3.519E-05	1.152E-05	0.007E-06	3.093E-06	1.237E-06	0.094E-07	4.242E-07	2.961E-07	2.205E-07	1.720E-07	1.388E-07
NNW	5.121E-05	1.609E-05	8.976E-06	4.561E-06	1.825E-06	9.076E-07	0.263E-07	4.375E-07	3.201E-07	2.544E-07	2.057E-07
N	5.604E-05	1.829E-05	0.407E-06	4.926E-06	1.973E-06	1.040E-06	6.705E-07	4.743E-07	3.537E-07	2.762E-07	2.233E-07
NNE	4.657E-05	1.554E-05	8.296E-06	4.104E-06	1.650E-06	0.914E-07	9.623E-07	3.911E-07	2.904E-07	2.260E-07	1.821E-07
NE	3.603E-05	1.107E-05	6.201E-06	3.101E-06	1.267E-06	6.035E-07	6.324E-07	3.014E-07	2.202E-07	1.707E-07	1.410E-07
ENE	3.695E-05	1.226E-05	6.544E-06	3.310E-06	1.322E-06	7.131E-07	4.509E-07	3.142E-07	2.336E-07	1.819E-07	1.464E-07
E	3.107E-05	1.054E-05	5.612E-06	2.840E-06	1.130E-06	6.003E-07	3.052E-07	2.684E-07	1.896E-07	1.555E-07	1.254E-07
ESE	5.604E-05	1.800E-05	1.003E-05	5.000E-06	2.023E-06	1.091E-06	0.099E-07	4.007E-07	3.575E-07	2.705E-07	2.265E-07
SE	6.910E-05	2.304E-05	1.210E-05	6.153E-06	2.463E-06	1.333E-06	0.456E-07	5.907E-07	4.403E-07	3.436E-07	2.776E-07
SSE	0.961E-05	2.219E-05	1.172E-05	5.995E-06	2.419E-06	1.316E-06	0.374E-07	5.044E-07	4.301E-07	3.425E-07	2.771E-07

Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	1.021E-07	9.404E-08	6.108E-08	3.556E-08	2.395E-08	1.755E-08	1.358E-08	1.009E-08	0.979E-09	7.554E-09	6.459E-09
SSW	1.491E-07	7.003E-08	5.104E-08	2.944E-08	1.904E-08	1.457E-08	1.126E-08	9.056E-09	7.408E-08	6.202E-09	5.372E-09
SW	1.201E-07	0.747E-08	4.435E-08	2.576E-08	1.744E-08	1.207E-08	9.990E-09	0.053E-09	6.660E-09	5.619E-09	4.817E-08
WSW	1.011E-07	5.204E-08	3.453E-08	1.944E-08	1.336E-08	9.703E-09	7.555E-09	0.053E-09	4.962E-09	4.105E-09	3.572E-09
W	7.910E-08	6.144E-08	2.711E-08	1.544E-08	1.054E-08	7.734E-09	5.903E-09	4.046E-09	3.955E-09	3.325E-09	2.841E-09
WNW	0.020E-08	4.559E-08	2.953E-08	1.678E-08	1.110E-08	0.127E-09	6.236E-09	4.968E-09	4.067E-09	3.404E-08	2.894E-09
NW	1.151E-07	5.935E-08	3.042E-08	2.163E-08	1.457E-08	1.061E-08	0.159E-09	6.516E-09	5.350E-09	4.404E-09	3.825E-09
NNW	1.707E-07	8.850E-08	5.762E-08	3.311E-08	2.235E-08	1.645E-08	1.270E-08	1.031E-08	0.556E-09	7.236E-09	6.226E-09
N	1.054E-07	9.630E-08	0.277E-08	3.613E-08	2.441E-08	1.790E-08	1.397E-08	1.128E-08	9.347E-09	7.911E-09	6.805E-09
NNE	1.507E-07	7.734E-08	6.994E-08	2.837E-08	1.090E-08	1.300E-08	1.069E-08	0.974E-08	7.067E-09	5.050E-09	5.094E-09
NE	1.168E-07	0.026E-08	3.098E-08	2.219E-08	1.404E-08	1.003E-08	0.340E-09	6.001E-08	5.095E-09	4.415E-08	3.848E-09
ENE	1.216E-07	6.228E-08	4.014E-08	2.263E-08	1.500E-08	1.004E-08	0.302E-09	0.595E-08	5.308E-09	4.496E-09	3.816E-09
E	1.039E-07	5.340E-08	3.459E-08	1.965E-08	1.313E-08	9.550E-09	7.357E-09	5.001E-08	4.032E-09	4.055E-09	3.061E-09
ESE	1.040E-07	9.555E-08	6.171E-08	3.495E-08	2.328E-08	1.092E-08	1.300E-08	1.038E-08	0.514E-09	7.137E-09	6.005E-09
SE	2.303E-07	1.193E-07	7.791E-08	4.430E-08	2.904E-08	2.107E-08	1.693E-08	1.361E-08	1.124E-08	0.076E-09	0.123E-09
SSE	2.302E-07	1.197E-07	7.702E-08	4.667E-08	3.001E-08	2.197E-08	1.697E-08	1.361E-08	1.121E-08	9.427E-09	8.064E-09

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TABLE 6.1-11

0.000 Day Decay, Depleted
Corrected for Open Terrain Recirculation

Distance in Miles

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	5.223E-05	1.602E-05	8.222E-06	4.141E-06	1.627E-06	8.658E-07	5.408E-07	3.725E-07	2.741E-07	2.114E-07	1.689E-07
SSW	6.217E-05	1.278E-05	6.557E-06	3.310E-06	1.312E-06	7.011E-07	4.382E-07	3.033E-07	2.236E-07	1.727E-07	1.382E-07
SW	3.526E-05	1.062E-05	5.430E-06	2.766E-06	1.103E-06	5.922E-07	3.725E-07	2.580E-07	1.907E-07	1.676E-07	1.103E-07
WSW	2.826E-05	8.623E-06	4.433E-06	2.267E-06	8.895E-07	4.758E-07	2.982E-07	2.066E-07	1.519E-07	1.174E-07	9.391E-08
W	2.218E-05	6.768E-06	3.467E-06	1.756E-06	6.948E-07	3.715E-07	2.328E-07	1.888E-07	1.186E-07	8.168E-08	7.329E-08
WNW	2.561E-05	8.027E-06	4.132E-06	2.078E-06	8.079E-07	4.280E-07	2.663E-07	1.829E-07	1.343E-07	1.033E-07	8.240E-08
NW	3.335E-05	1.054E-05	5.442E-06	2.720E-06	1.058E-06	5.593E-07	3.476E-07	2.385E-07	1.746E-07	1.345E-07	1.071E-07
NNW	4.859E-05	1.545E-05	8.016E-06	4.004E-06	1.557E-06	8.224E-07	5.111E-07	3.506E-07	2.571E-07	1.977E-07	1.576E-07
N	5.309E-05	1.673E-05	8.651E-06	4.325E-06	1.683E-06	8.904E-07	5.537E-07	3.801E-07	2.789E-07	2.148E-07	1.711E-07
NNE	4.611E-05	1.422E-05	7.410E-06	3.676E-06	1.415E-06	7.438E-07	4.593E-07	3.138E-07	2.293E-07	1.758E-07	1.387E-07
NE	3.412E-05	1.086E-05	5.612E-06	2.794E-06	1.082E-06	5.701E-07	3.534E-07	2.420E-07	1.772E-07	1.361E-07	1.083E-07
ENE	3.582E-05	1.123E-05	5.856E-06	2.919E-06	1.132E-06	5.968E-07	3.702E-07	2.536E-07	1.857E-07	1.427E-07	1.136E-07
E	3.020E-05	9.664E-06	5.016E-06	2.496E-06	9.656E-07	5.087E-07	3.153E-07	2.159E-07	1.580E-07	1.214E-07	0.664E-08
ESE	5.309E-05	1.721E-05	8.968E-06	4.466E-06	1.729E-06	9.113E-07	5.650E-07	3.869E-07	2.833E-07	2.175E-07	1.721E-07
SE	6.545E-05	2.006E-05	1.081E-05	5.404E-06	2.102E-06	1.111E-06	6.907E-07	4.740E-07	3.476E-07	2.674E-07	2.131E-07
SSE	6.539E-05	2.031E-05	1.040E-05	5.271E-06	2.067E-06	1.099E-06	6.857E-07	4.720E-07	3.471E-07	2.675E-07	2.136E-07

Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	1.387E-07	6.909E-08	4.361E-08	2.357E-08	1.521E-08	1.078E-08	8.098E-09	6.339E-09	5.112E-09	4.218E-09	3.543E-09
SSW	1.136E-07	5.087E-08	3.584E-08	1.954E-08	1.264E-08	8.972E-09	6.752E-09	5.291E-09	4.271E-09	3.526E-09	2.964E-09
SW	8.743E-08	4.902E-08	3.101E-08	1.700E-08	1.103E-08	7.838E-09	5.921E-09	4.649E-09	3.748E-09	3.109E-09	2.618E-09
WSW	7.721E-08	3.062E-08	2.432E-08	1.325E-08	8.555E-09	6.063E-09	4.557E-09	3.567E-09	2.876E-09	2.372E-09	1.992E-09
W	6.026E-08	3.014E-08	1.899E-08	1.035E-08	6.689E-09	4.744E-09	3.569E-09	2.796E-09	2.256E-09	1.862E-09	1.565E-09
WNW	6.755E-08	3.341E-08	2.088E-08	1.125E-08	7.214E-09	5.083E-09	3.803E-09	2.965E-09	2.382E-09	1.959E-09	1.640E-09
NW	8.777E-08	4.331E-08	2.702E-08	1.453E-08	9.306E-09	6.551E-09	4.898E-09	3.817E-09	3.066E-09	2.521E-09	2.111E-09
NNW	1.291E-07	6.375E-08	3.983E-08	2.148E-08	1.388E-08	9.747E-09	7.312E-09	5.718E-09	4.689E-09	3.882E-09	2.193E-09
N	1.403E-07	6.941E-08	4.343E-08	2.347E-08	1.518E-08	1.068E-08	8.022E-09	6.278E-09	5.063E-09	4.179E-09	3.513E-09
NNE	1.142E-07	5.596E-08	3.469E-08	1.853E-08	1.183E-08	8.308E-09	6.203E-09	4.831E-09	3.879E-09	3.189E-09	2.671E-09
NE	8.868E-08	4.363E-08	2.718E-08	1.459E-08	9.339E-09	6.576E-09	4.918E-09	3.834E-09	3.082E-09	2.535E-09	2.124E-09
ENE	9.296E-08	4.578E-08	2.844E-08	1.522E-08	9.714E-09	6.818E-09	5.083E-09	3.951E-09	3.166E-09	2.597E-09	2.169E-09
E	7.964E-08	3.889E-08	2.422E-08	1.299E-08	8.306E-09	5.843E-09	4.364E-09	3.401E-09	2.732E-09	2.246E-09	1.880E-09
ESE	1.417E-07	6.961E-08	4.338E-08	2.318E-08	1.479E-08	1.039E-08	7.758E-09	6.029E-09	4.836E-09	3.971E-09	3.322E-09
SE	1.746E-07	8.623E-08	5.385E-08	2.902E-08	1.862E-08	1.314E-08	9.843E-09	7.687E-09	6.189E-09	5.099E-09	4.279E-09
SSE	1.751E-07	8.714E-08	5.465E-08	2.960E-08	1.906E-08	1.347E-08	1.011E-08	7.864E-09	6.367E-09	5.268E-09	4.405E-09

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TABLE 6.1-11

Corrected for Open Terrain Recirculation

Distance in Miles

Sector	0.250	0.500	0.750	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500
S	1.025E-07	4.019E-08	2.478E-08	1.176E-08	4.226E-09	2.096E-09	1.234E-09	8.079E-10	5.605E-10	4.213E-10	3.247E-10
SSW	1.100E-07	3.747E-08	1.924E-08	9.146E-09	3.285E-09	1.629E-09	9.594E-10	6.283E-10	4.420E-10	3.276E-10	2.524E-10
SW	3.756E-08	2.623E-08	1.347E-08	6.403E-09	2.300E-09	1.141E-09	6.716E-10	4.397E-10	3.094E-10	2.293E-10	1.767E-10
WSW	6.354E-08	2.149E-08	1.103E-08	5.245E-09	1.884E-09	9.341E-10	5.502E-10	3.602E-10	2.535E-10	1.879E-10	1.448E-10
W	4.730E-08	1.599E-08	0.212E-09	1.904E-09	1.402E-09	6.955E-10	4.095E-10	2.681E-10	1.887E-10	1.398E-10	1.078E-10
WNW	5.610E-08	1.000E-08	9.754E-09	4.633E-09	1.664E-09	8.260E-10	4.864E-10	3.185E-10	2.241E-10	1.661E-10	1.280E-10
NW	1.021E-07	3.453E-08	1.771E-08	8.430E-09	3.028E-09	1.502E-09	8.842E-10	5.790E-10	4.074E-10	3.019E-10	2.327E-10
NNW	1.920E-07	6.520E-08	3.340E-08	1.592E-08	5.717E-09	2.835E-09	1.669E-09	1.093E-09	7.692E-10	5.700E-10	4.393E-10
N	2.420E-07	8.209E-08	4.215E-08	2.004E-08	7.198E-09	3.570E-09	2.102E-09	1.376E-09	9.684E-10	7.177E-10	5.531E-10
NNE	2.264E-07	7.657E-08	3.931E-08	1.869E-08	6.714E-09	3.329E-09	1.960E-09	1.284E-09	9.031E-10	6.694E-10	5.159E-10
NE	1.554E-07	5.254E-08	2.698E-08	1.282E-08	4.607E-09	2.285E-09	1.345E-09	0.880E-10	6.194E-10	4.593E-10	3.540E-10
ENE	1.193E-07	4.034E-08	2.071E-08	9.840E-09	3.533E-09	1.754E-09	1.033E-09	6.744E-10	4.759E-10	3.527E-10	2.718E-10
E	1.223E-07	4.135E-08	2.123E-08	1.009E-08	3.625E-09	1.798E-09	1.059E-09	6.932E-10	4.877E-10	3.615E-10	2.786E-10
ESE	2.077E-07	7.023E-08	3.606E-08	1.714E-08	6.150E-09	3.054E-09	1.798E-09	1.177E-09	0.285E-10	6.140E-10	0.732E-10
SE	2.597E-07	0.784E-08	4.510E-08	2.144E-08	7.702E-09	3.819E-09	2.249E-09	1.473E-09	1.036E-09	7.679E-10	5.918E-10
SSE	1.095E-07	6.407E-08	3.289E-08	1.564E-08	5.617E-09	2.786E-09	1.640E-09	1.074E-09	7.550E-10	5.601E-10	4.316E-10

Sector	5.000	7.500	10.000	15.000	20.000	25.000	30.000	35.000	40.000	45.000	50.000
S	2.579E-10	1.146E-10	6.941E-11	3.500E-11	2.123E-11	1.424E-11	1.020E-11	7.660E-12	5.956E-12	4.758E-12	3.883E-12
SSW	2.005E-10	0.909E-11	5.397E-11	2.720E-11	1.651E-11	1.107E-11	7.932E-12	5.956E-12	4.631E-12	3.699E-12	3.019E-12
SW	1.404E-10	6.236E-11	3.778E-11	1.909E-11	1.156E-11	7.749E-12	5.552E-12	4.169E-12	3.242E-12	2.589E-12	2.114E-12
WSW	1.150E-10	5.109E-11	3.095E-11	1.564E-11	9.468E-12	6.348E-12	4.549E-12	3.415E-12	2.656E-12	2.121E-12	1.731E-12
W	0.560E-11	3.803E-11	2.304E-11	1.164E-11	7.047E-12	4.725E-12	3.386E-12	2.542E-12	1.977E-12	1.579E-12	1.289E-12
WNW	1.017E-10	4.517E-11	2.736E-11	1.383E-11	0.370E-12	5.612E-12	4.021E-12	3.020E-12	2.348E-12	1.875E-12	1.531E-12
NW	1.848E-10	0.211E-11	4.974E-11	2.514E-11	1.522E-11	1.020E-11	7.310E-12	5.489E-12	4.268E-12	3.409E-12	2.783E-12
NNW	3.490E-10	1.550E-10	9.391E-11	4.747E-11	2.873E-11	1.926E-11	1.380E-11	1.036E-11	0.059E-12	6.437E-12	5.254E-12
N	4.194E-10	1.952E-10	1.182E-10	5.976E-11	3.617E-11	2.425E-11	1.738E-11	1.305E-11	1.015E-11	0.105E-12	6.615E-12
NNE	4.090E-10	1.821E-10	1.103E-10	5.574E-11	3.374E-11	2.262E-11	1.621E-11	1.217E-11	9.463E-12	7.559E-12	6.170E-12
NE	2.812E-10	1.249E-10	7.567E-11	3.825E-11	2.315E-11	1.552E-11	1.112E-11	0.351E-12	6.493E-12	5.187E-12	4.234E-12
ENE	2.159E-10	9.592E-11	5.811E-11	2.937E-11	1.778E-11	1.192E-11	0.540E-12	6.413E-12	4.986E-12	3.983E-12	3.251E-12
E	2.213E-10	9.811E-11	5.955E-11	3.010E-11	1.822E-11	1.221E-11	0.752E-12	6.572E-12	5.110E-12	4.082E-12	3.332E-12
ESE	1.759E-10	1.670E-10	1.012E-10	5.113E-11	3.095E-11	2.075E-11	1.487E-11	1.116E-11	0.680E-12	6.934E-12	5.660E-12
SE	0.701E-10	2.888E-10	1.265E-10	6.394E-11	3.870E-11	2.595E-11	1.859E-11	1.396E-11	1.086E-11	0.672E-12	7.070E-12
SSE	3.429E-10	1.523E-10	9.227E-11	4.664E-11	2.823E-11	1.893E-11	1.356E-11	1.018E-11	7.918E-12	6.325E-12	5.162E-12

*33 ft winds, delta T (254°-33°). Data Period 4/74-3/76.

TABLE 6.1-14

SUMMARY OF PROCEDURES FOR MONITORING WILDLIFE OCCURRENCE AT THE OLD HANFORD TOWNSITE

	Sampling Period	
Species/Group	Spring	Fall/Winter
Raptors	Method: Biweekly counts of nesting raptors. Data: Breeding population, breeding chronology, nest location, clutch size and number fledged.	Method: Monthly direct counts of winter residents. Data: Occurrence.
Landbirds	Method: Biweekly direct counts along predetermined strip transects. Data: Relative abundance and species diversity.	Method: Monthly reconnaissance. Data: Species diversity of winter population.
Deer	Method: Biweekly spotlight surveys and dawn counts. Data: Number of deer using townsite for breeding and fawn production (if possible).	No surveys planned, but deer observations incidental to other surveys will be recorded.

TABLE 6.1-13

Sheet 1 of 2

S/HMP RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Sample Media	Location	Sampling Frequency[1]	Analysis Type	Analysis Frequency	
Airborne Radioiodine[2] Particulates[3]	3 locations at Site Boundary (in different sectors) with highest calculated annual average groundlevel concentrations 1 location at Site Boundary in an upwind direction Supply System Station 8 (residence having highest X/Q) Supply System Station Number 6 (Community) Supply System Station Number 9 (control) approximately 30 miles from the Site Boundary	Continuous sampling, weekly collection	Radioiodine I-131 Particulates Gross Beta[4]	Weekly Weekly	4
			Gamma isotopic[5]	Composite, by location quarterly	
Direct Radiation[6]	A station will be located in each sector of: (1) an inner ring in the general area of the Site Boundary (inclusive of airborne locations), and (2) an outer ring in the four to five mile range Supply System Station Number 6 (Community) Supply System Station Number 9 (Control)	Quarterly set (2 TLDs) Annual set (2 TLDs)	Gamma Dose Gamma Dose	Quarterly Annually	
Waterborne Drinking Water[3]	Supply System Station Numbers 29 and 30 (Richland Water Treatment Plant and DOE 300 Areas)	Composite[7] for month	H-3 Radioiodine Gamma isotopic	Quarterly composite Semi-monthly Monthly	5
River Water[3]	S/HMP Intake S/HMP Discharge	Composite[7] for month	H-3 Gamma isotopic	Quarterly composite Monthly	4

TABLE 8.1-13

Sample Media	Location	Sampling Frequency[1]	Analysis: Type	Analysis: Frequency
Aquatic				
Indicator Organisms[6]	Above and below S/HMP discharge	Semi-annually	Gamma Isotopic	Semi-annually
Sediment[6]	Supply System Station Number 35 and above S/HMP discharge	Semi-annually	Gamma Isotopic	Semi-annually
Ingestion				
Milk[3,8]	Closest milk animal	Semi-monthly during grazing season; monthly at other times	Gamma Isotopic	Semi-monthly; monthly
	Supply System Station 8		I-131	
	Supply System Station Number 9 (Control)			Semi-monthly when animals are in pasture
	Supply System Station Number 37			
	Supply System Station Number 38 S/HMP discharge			
Fish[6]	Supply System Station 37 (in vicinity of HMP-3 discharge)	Semi-annually	Gamma Isotopic (Edible portion)	Semi-annually
	Snake River (1 control)			
Fruit and Vegetables[9]	Supply System Station Number 8	Monthly during growing season	Gamma Isotopic	Monthly
	Supply System Station Number 9 (Control)			

(1) Deviation may be required if samples are unobtainable due to hazardous conditions, seasonal availability, malfunction of automatic sampling equipment, or other legitimate reasons. All deviations will be documented in the annual report.
(2) Minimum six month preoperational sampling.
(3) Minimum one year preoperational sampling.
(4) Particulate sample filters will be analyzed for gross Beta after at least 24 hours decay. If gross Beta activity is greater than 10 times the mean of the control sample, gamma isotopic analysis should be performed on the individual sample.
(5) Gamma isotopic means identification and quantification of gamma emitting radionuclides that may be attributable to the effluents of the facility.
(6) Minimum two years preoperational monitoring.
(7) Composite samples will be collected with equipment which is capable of collecting an aliquot at time intervals which are short relative to the compositing period.
(8) Milk samples will be obtained from farms or individual milk animals which are located in sectors with the higher calculated annual average ground-level D/Q's. If Cesium-134 or Cesium-137 is measured in an individual milk sample in excess of 30 pCi/l, then Strontium 90 analysis should be performed.
(9) Fruit and vegetables will be obtained from farms or gardens which use Columbia River water, if possible, for irrigation, and different varieties will be obtained as they are in season. One sample each of root food, leafy vegetables, and fruit should be collected each period.

TABLE 4.1-16

MAXIMUM VALUE FOR THE LOWER LIMIT OF DETECTION (LLD)[a]

Analysis	Water (pCi/l)	Airborne Particulate or Gas (pCi/m³)	Fish (pCi/kg, wet)	Milk (pCi/l)	Vegetation (pCi/kg, wet)	Sediment (pCi/kg, dry)
gross beta	4	1×10^{-2}				
^{3}H	2,000					
^{54}Mn	15		130			
^{59}Fe	30		260			
$^{58,60}Co$	15		130			
^{65}Zn	30		260			
^{95}Zr	30					
^{95}Nb	15					
^{131}I	10	7×10^{-3}		1	60	
^{134}Cs	15	5×10^{-2}	130	15	60	150
^{137}Cs	18	6×10^{-2}	150	18	80	180
^{140}Ba	60			60		
^{140}La	15			15		

Note: This list does not mean that these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported.

[a]These detection capabilities are tabulated in terms of the lower limits of detection (LLDs). The LLD is defined, for purposes of this guide, as the smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal. 4

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66\, s_b}{E \cdot V \cdot 2.22 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

where

LLD is the lower limit of detection as defined above (as pCi per unit mass or volume)

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute).

E is the counting efficiency (as counts per disintegration).

V is the sample size (in units of mass or volume)

2.22 is the number of disintegrations per minute per picocurie.

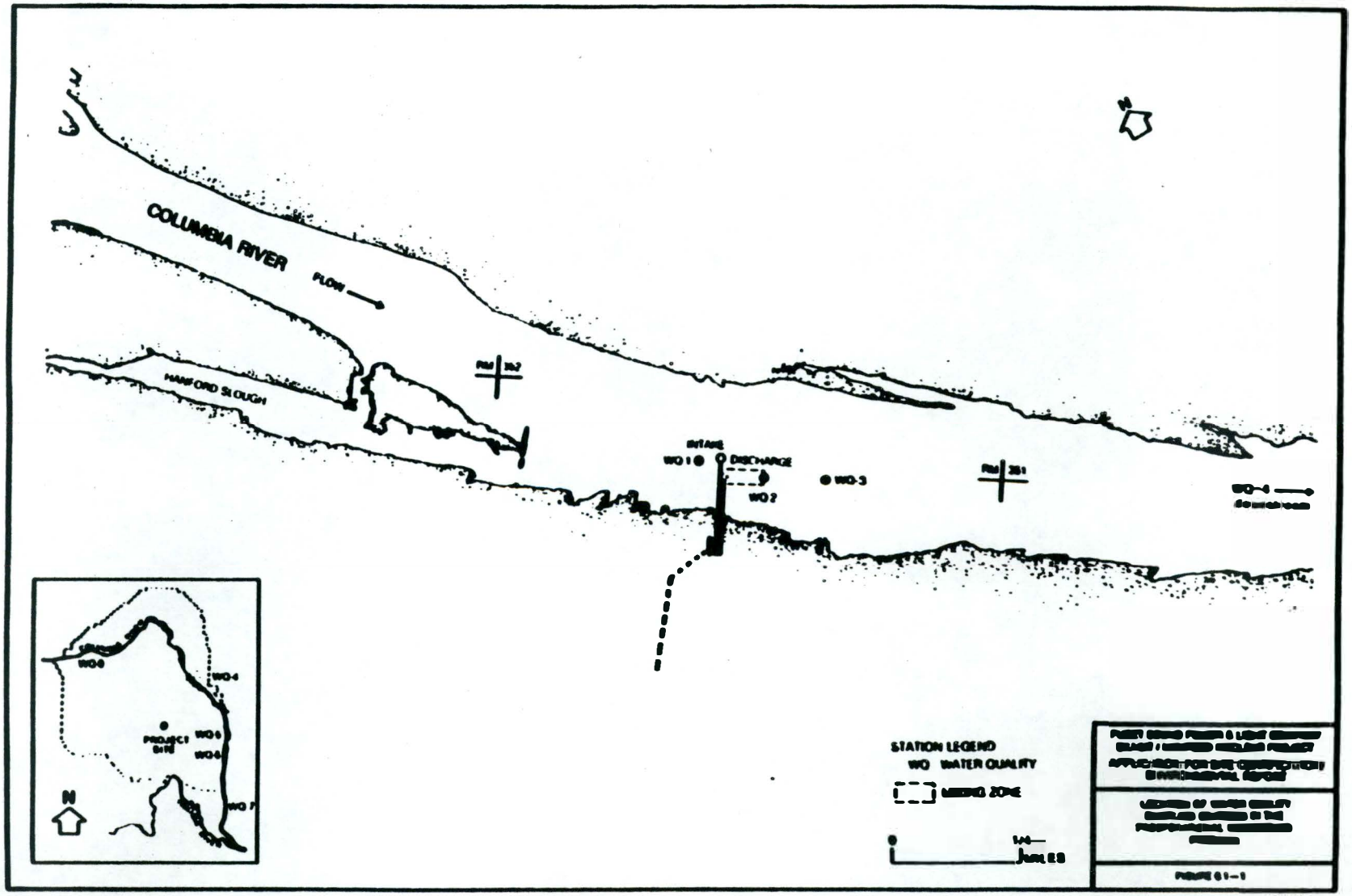
Y is the fractional radiochemical yield (when applicable).

λ is the radioactive decay constant for the particular radionuclide.

Δt is the elapsed time between sample collection and counting.

The value of s_b used in the calculation of the LLD for a particular measurement system should be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicted variance. In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background should include the typical contributions of other radionuclides normally present in the samples (e.g. potassium-40 milk samples).

[b]LLD for drinking water.


COLUMBIA RIVER
FLOW
HANFORD SLOUGH
RM 362
RM 351
INTAKE
DISCHARGE
WO 1
WO 2
WO 3
WO 4
WO 5
WO 6
WO 7
PROJECT SITE
N
STATION LEGEND
WO WATER QUALITY
MIXING ZONE
1/4
MILES

Amendment 4

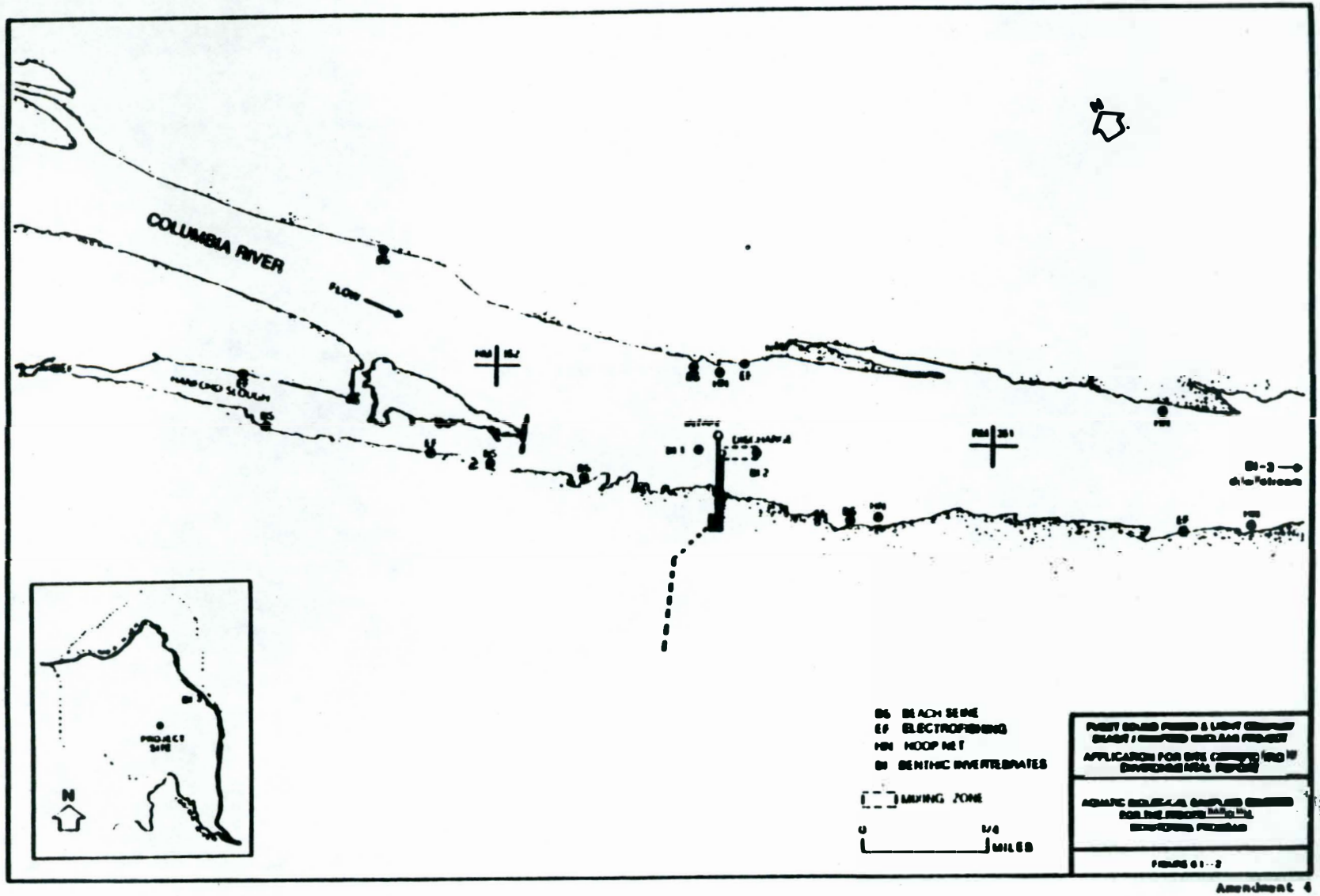
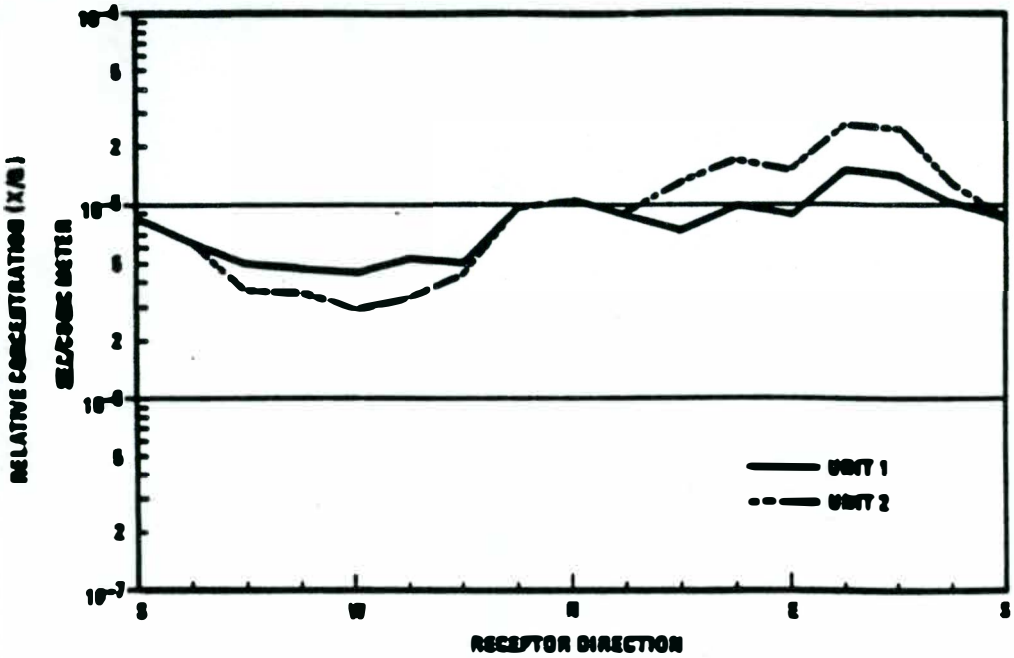

COLUMBIA RIVER
FLOW
HANFORD SLOUGH
BS-3
downstream
PROJECT SITE
N
BS BEACH SEINE
EF ELECTROFISHING
HN HOOP NET
BI BENTHIC INVERTEBRATES
MIXING ZONE
0
1/4
MILES

FIGURE 6.1-2



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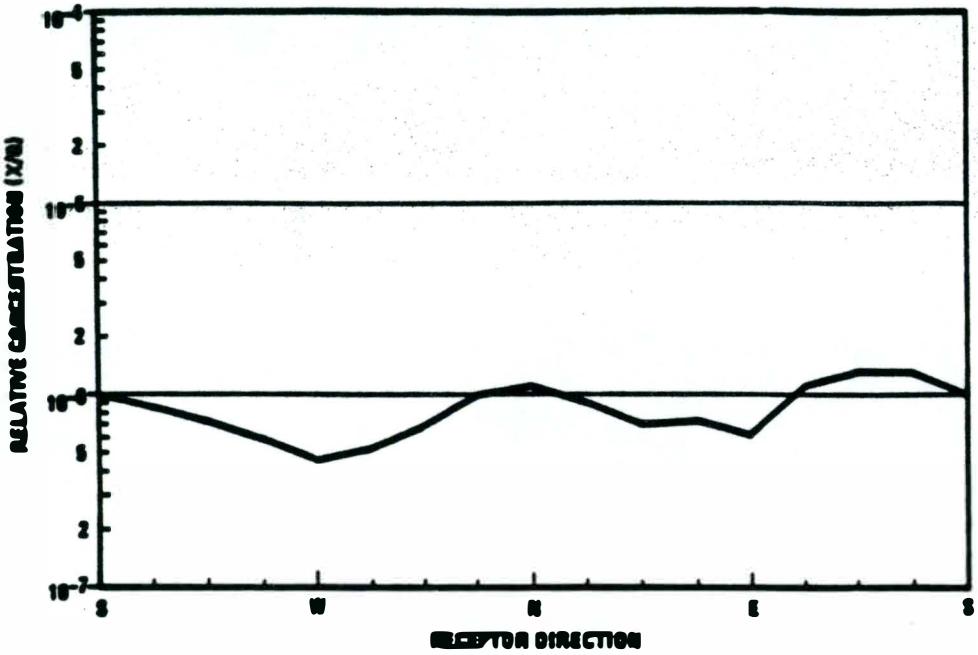
ANNUAL CHI/Q
AT S/HNP SITE BOUNDARY

FIGURE 6.1-3



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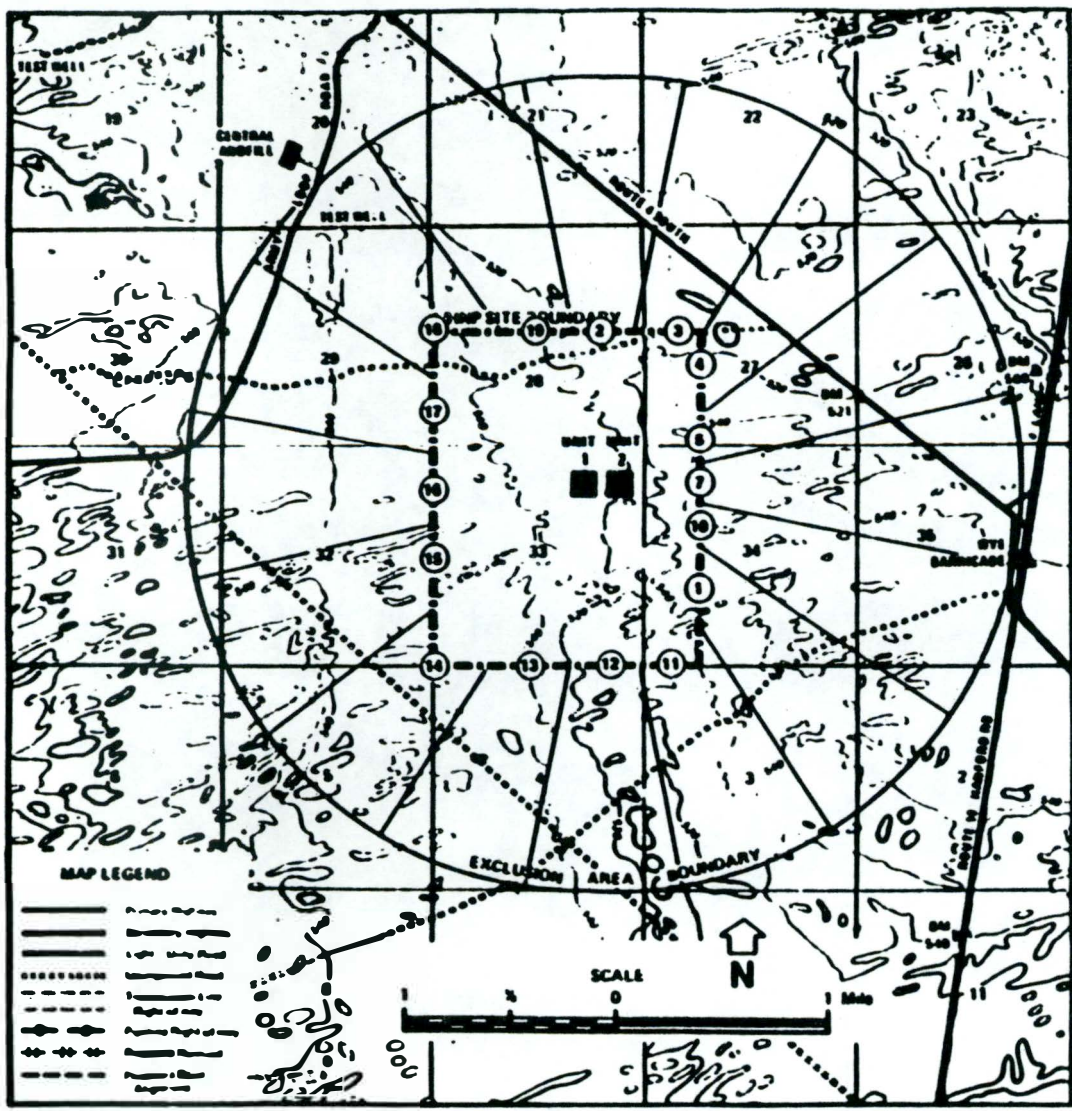
SKAGIT/HANFORD
NUCLEAR PROJECT
ANNUAL CHI/Q AT TWO MILES

FIGURE 6.1-4



LEGEND:

STATION NO.	MEDIA
1 THROUGH 3	PARTICULATES RADIOIODINE DIRECT RADIATION
4 & 7 10 THROUGH 15	DIRECT RADIATION
16	PARTICULATES RADIOIODINE DIRECT RADIATION
17 THROUGH 19	DIRECT RADIATION

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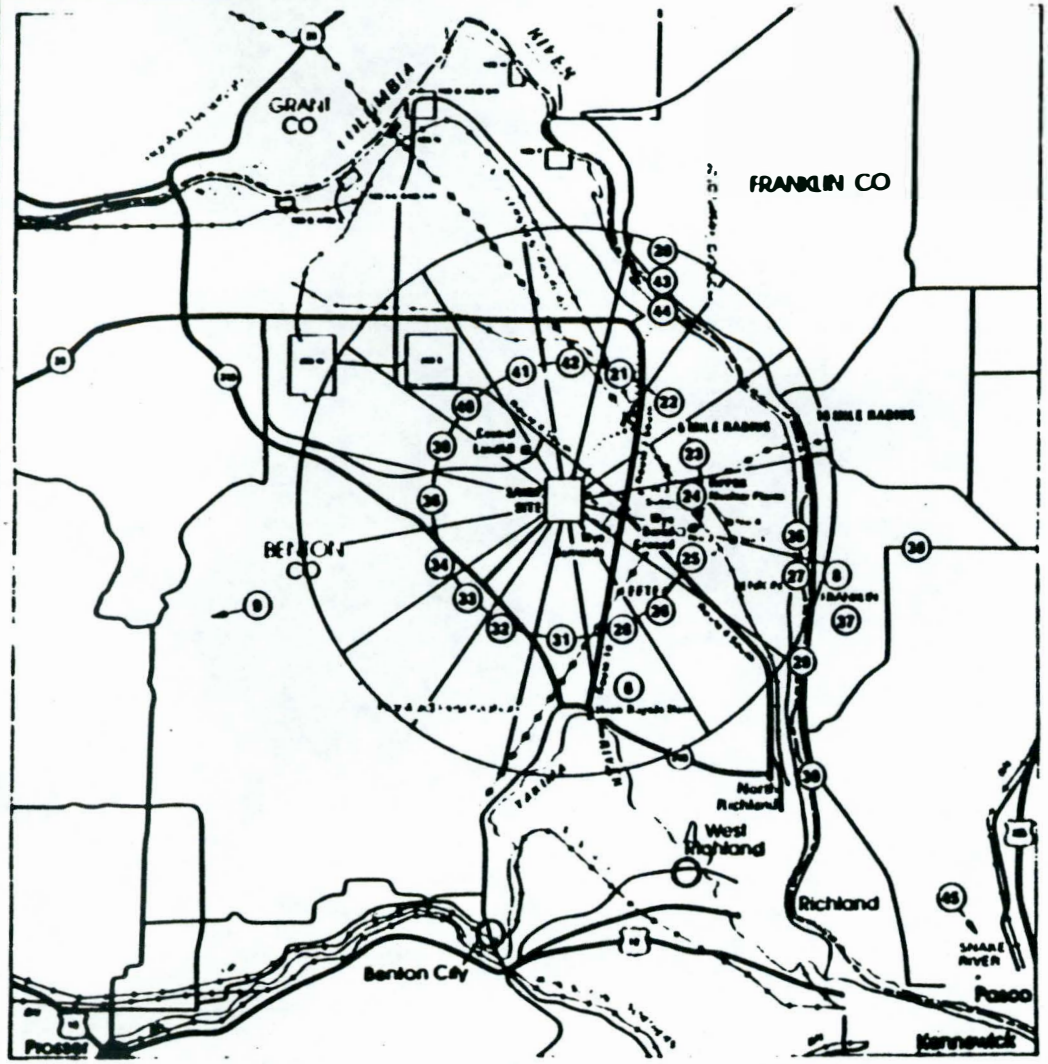
ENVIRONMENTAL REPORT

PLANT BOUNDARY MONITORING LOCATIONS — REMP

FIGURE 6.1-5



LEGEND:

STATION NO.	MEDIA
6 (WPPSS-6)	PARTICULATES RADIOIODINE DIRECT RADIATION
8 (WPPSS-8)	PARTICULATES RADIOIODINE MILK FRUITS AND/OR VEGETABLES
9 (WPPSS-9)	PARTICULATES RADIOIODINE DIRECT RADIATION MILK FRUITS AND/OR VEGETABLES
20	SEDIMENT AND INDICATOR ORGANISMS
21 THROUGH 26	DIRECT RADIATION
27 (WPPSS-27)	FISH
28	DIRECT RADIATION
29 and 30 (WPPSS 29 and 30)	DRINKING WATER
31 THROUGH 34	DIRECT RADIATION
35 (WPPSS-35)	SEDIMENT AND INDICATOR ORGANISMS
36	DIRECT RADIATION
37 and 38 (WPPSS 37 and 38)	MILK
39 THROUGH 42	DIRECT RADIATION
43 and 44	RIVER WATER
46	FISH

N

0 1 2 3 4 5

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APPLICATION FOR SITE CERTIFICATION
ENVIRONMENTAL REPORT

MONITORING LOCATIONS BEYOND THE SITE BOUNDARY — REMP

FIGURE 6.1-6

6.2 OPERATIONAL MONITORING PROGRAMS

6.2.1 RADIOLOGICAL MONITORING

The radiological environmental monitoring program (REMP) is designed to meet Federal and State requirements.

The S/HNP operational REMP will be an extension of the preoperational REMP described in Section 6.1.5. A comprehensive radiological monitoring program will be conducted for the first three years of commercial power production (or the period corresponding to the maximum fuel burnup in the initial core cycle). The scope of monitoring in subsequent years will be determined based upon the results of the two year preoperational program and the initial three years of S/HNP operation. If it can be demonstrated that the concentrations of radionuclides and doses to organisms associated with a particular pathway are sufficiently small, the number of samples and sample types may be reduced. An adequate program for measuring radiation levels and radioactivity in the S/HNP environs will be maintained on a continuing basis to assist in verifying anticipated radioactivity concentrations and related public exposure.

To the extent possible, the S/HNP REMP will be interfaced with the monitoring program established for the Washington Public Power Supply System (Supply System) Nuclear Projects 1, 2 and 4. The operational monitoring program will also utilize data from the U.S. Department of Energy (DOE) and Washington State Radiological Surveillance programs. Battelle Northwest Laboratories has conducted a comprehensive annual radiological monitoring program of the Hanford Generating Plant and surrounding environs for more than 20 yrs. The Washington State Division of Social and Health Services collects and analyzes samples of Columbia River water, air, milk, and shellfish at a number of locations relevant to the S/HNP (Section 6.3.4). 4

Together with the S/HNP monitoring program, this extensive data base will be used to monitor:

a. Important pathways for the anticipated types and quantities of radionuclides released from the Plant

b. Potential buildup of long-lived radionuclides in the environment, and the physical and biological sites of accumulation that may contribute to human exposure

c. Potential radiation exposure to important plants and animals

d. Correlations between levels of radiation and radioactivity releases from Plant operation

6.2.2 CHEMICAL EFFLUENT MONITORING

The water quality monitoring program will ensure that the quality of the receiving waters, the Columbia River, is maintained at the level specified by State and Federal standards during construction and operation. Sampling will be done on effluents from the various waste streams entering the S/HNP discharge line. The effluent plume will also be sampled. The operational monitoring program frequency and methods of analysis will be basically those of the preoperational monitoring program described in Section 6.1. Detailed descriptions of sampling locations, frequencies and analytical techniques are included in that section. At a minimum, the sampling stations and frequencies listed in Table 6.2-1 will be utilized.

Additional sampling locations in the S/HNP discharge and in the major axis of the discharge plume will be established as part of the operational sampling program as necessary. 4
Effluent in the discharge pipeline will be sampled weekly during the first few months of operation until a satisfactory balance of chemical additions is established. It is expected that during the initial year of operation, sufficient data will be gathered to characterize the effluent so that the sampling frequency may be adjusted appropriately. The sampling frequency then will be reduced to bi-weekly or monthly for a period of one year. Each sample taken for analysis will consist of a 24-hour composite to ensure a representative sample. Expected chemical waste characteristics of the discharge are given in Table 3.6-5. Analysis will be for parameters which:

a. the preoperational program has shown to exist in the intake water;

b. are expected to be part of the discharge (Section 3.6), and;

c. are required by current State or Federal regulations.

A tentative listing of the chemical parameters to be measured is given in Table 6.2-2; not all parameters will be measured at each station. Parameters may be added to or

deleted from this list based on the results of the pre-operational studies and modifications in local, State or Federal regulations.

A detailed chemical study to define the extent and nature of the effluent plume will be performed during the first few months of operation. The sampling scheme will be a three-dimensional grid blanketing the region of the plume, with control locations sampled directly upstream from the S/HNP discharge. The samples collected will be analyzed for the parameters identified in a., b., and c. above. This study will monitor changes in plume structure and water quality. From the results, positions for monthly and bi-weekly sampling locations in the major axis of the plume will be determined as part of the overall operational water quality monitoring program. Knowledge and experience gained during the first year's sampling program will be the basis for the ongoing water quality and chemical discharge monitoring studies.

The operational program will be coordinated with the existing water quality monitoring conducted upstream at Vernita Bridge (RM 388.1) by the USGS, and similar discharge monitoring conducted for WNP 1, 2 and 4 downstream of the S/HNP, as well as with the USGS program at Richland (RM 338.9).

4

6.2.3 THERMAL EFFLUENT MONITORING

The operational program for thermal effluent monitoring is part of an integrated chemical and hydrological study of the discharge and receiving waters. Many of the sampling locations are the same as have been identified in the pre-operational program in Section 6.1 and the additional three-dimensional plume monitoring stations required for water quality monitoring in Section 6.2.2. The thermal monitoring program consists of instantaneous and continuous monitoring studies. The instantaneous temperature monitoring program functions in conjunction with the operational water quality program to provide bi-weekly to monthly measurements. Seasonal studies of the temperature profiles in the Columbia River near the S/HNP discharge will monitor the extent of the thermal plume.

6.2.3.1 Continuous Thermal Monitoring

Continuous thermographs will be placed in the S/HNP intake and discharge. Temperature measurements will be made at

seven locations with the frequencies noted in Table 6.2-1. This monitoring grid will tie into two existing continuous thermographs maintained by USGS at Vernita Bridge and the City of Richland water supply intake as well as with proposed continuous thermograph at the intake of WNP 1/4.

6.2.3.2 Instantaneous Thermal Monitoring

The thermal and water quality monitoring programs undertaken during S/HNP operations will be integrated. Instantaneous temperature measurements will be routinely made at all water quality sampling locations (Table 6.2-1). During initial S/HNP operation, thermal plume definition will be made in conjunction with the chemical water quality studies outlined in Section 6.2.2 over a three-dimensional grid.

6.2.4 METEOROLOGICAL MONITORING

The operational meteorological monitoring program will be a continuation of the preoperational program discussed in Section 6.1.3.1. 4

6.2.5 ECOLOGICAL MONITORING

The ecology of the Hanford Reservation has been under continuous study since 1943 by State and Federal agencies (Section 6.3). The operational and preoperational program will supplement the accumulation of scientific data by acquiring additional biological information.

The operational monitoring program for the S/HNP will be a continuation of the preoperational program (discussed in Sections 6.1.1.2 (Aquatic) and 6.1.4.3 (Terrestrial)). The operational program will be conducted for one year, after which an evaluation will determine the necessity of continuation or alteration.

Additional monitoring programs will be conducted during the first year of operation to evaluate the incidence of impingement and entrainment in the Plant intake and cooling water supply system.

TABLE 6.2-1

WATER QUALITY MONITORING STATIONS OPERATIONAL PROGRAM

		RM	S/HNP Sampling Frequency
Vernita Bridge	WQ-0 (USGS)	388.1	Monthly
S/HNP Intake	WQ-1	361.6	Continuous
S/HNP Discharge	WQ-1A	361.5	Continuous
Downstream Boundary of Legal Mixing Zone	WQ-2	361.4	Monthly*
2 Miles Downstream Along Major Axis of Discharge	WQ-4	359.5	Monthly
WNP 1 & 4 Intake	WQ-5	351.9	Monthly
City of Richland Municipal Intake (USGS)	WQ-7	338.9	Monthly

*Scheduled frequency after first year. During the first year this station will be sampled more frequently.

4

TABLE 6.2-2

CHEMICAL PARAMETERS MEASURED IN OPERATIONAL MONITORING PROGRAM(1)

Calcium	Solids, Total Suspended	4
Magnesium	Solids, Total Dissolved	
Iron, Total	Alkalinity, Total	
Silica	Hardness, Total	
Chromium, Total	Oil and Grease	5
Chromium, Hexavalent	Oxygen, Dissolved	4
Copper		5
Lead	Chlorine, Residual	4
Manganese	Chlorine, Demand	
Phosphorus, Total	Coliform, Fecal	5
Sodium	Conductivity	
Tin	Turbidity	
Zinc		
Borates	Temperature	4
Chloride	pH	
Nitrate		
Sulfate		

(1) This list of parameters will be modified to incorporate all chemical parameters that will be required by the S/WNP NPDES Permit with the State of Washington and any applicable Federal requirements in force at the time of operation.

6.3 RELATED ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

Puget is aware of environmental measurement and monitoring programs listed in the following sections which may be related to such programs that Puget plans to conduct. These programs will be followed to determine the relevance of the information obtained, and information will be exchanged as appropriate.

6.3.1 HYDROLOGICAL AND WATER QUALITY STUDIES IN PROGRESS

Agency	Program
U.S. Geological Survey, Tacoma District Office	Continuous water stage and discharge measurements of the Columbia River below Priest Rapids Dam (RM 394.5) (Ref 1).
U.S. Geological Survey, Tacoma District Office	Continuous water temperature measurements of the Columbia River at the City of Richland water supply treatment plant (RM 338) and at Vernita Bridge (RM 388.1) (Refs 2,3). 4
U.S. Geological Survey, Tacoma Disrict Office	Monthly to quarterly monitoring of National Stream Quality Accounting Network Stations at Vernita Bridge and City of Richland pumping plant intake. Parameters measured are: conductance, pH, turbidity, dissolved oxygen, fecal coliform, hardness, major cations and anions, alkalinity, dissolved and suspended solids, dissolved silica, total and dissolved nutrients, metals (total recoverable, suspended recoverable, and dissolved). In addition, at the Vernita Bridge Station, periphyton biomass, chlorophyll a and b and phytoplankton cell counts are conducted.

U.S. Department of Energy, Richland Operations Office	Weekly pH, turbidity, dissolved oxygen, biochemical oxygen demand, and coliform sampling of the Columbia River at the City of Richland water supply treatment plant (RM 338), 300 Area (RM 345), and Vernita Bridge (RM 388.1), by Battelle-Northwest (Ref 4).
U.S. Department of Energy, Richland Operations Office	Weekly coliform, fluoride and nitrate sampling of Columbia River at the City of Richland water supply treatment plant (RM 338), 300 Area (RM 345), and 100 Areas (to RM 384), by Hanford Environmental Health Foundation (Ref 5).
U.S. Department of Energy, Richland Operations Office	Monthly to annual groundwater depth and water quality measurements for observation wells on Hanford Reservation, by Battelle-Northwest and Rockwell Hanford Company (Refs 4,6).
U.S. Department of Energy, Division of Biomedical and Environmental Research	Studies by Battelle-Northwest on sediment and radionuclide transport in the Columbia River below Priest Rapids (Ref 3).
U.S. Department of Energy, Richland Operations Office	Environmental surveillance of the levels of radionuclide concentrations in Columbia River water, foodstuffs, wildlife, soils and vegetation, and direct radiation on the Hanford Reservation, by Battelle-Northwest (Ref 7).
U.S. Army Corps of Engineers, North Pacific Division	Review of Columbia River and tributaries water resources (Ref 8).
Washington State Department of Ecology	Water temperature, dissolved oxygen, conductivity, color, pH, turbidity, total coliform bacteria and fecal coliform bacteria sampling in the

4

	Columbia River at Highway 24 Bridge near Vernita (RM 388.1) (semimonthly during water year 1972, quarterly during water year 1975, semimonthly since October 1975), and at the Port of Pasco public dock (RM 328.4 (semimonthly December 1971 - September 1972), and occasional biochemical oxygen demand and streamflow determinations at both sites. Sampling of additional 21 parameters at Vernita bridge during water year 1972 (Ref 9). Data also available through STORET (Ref 10).
U.S. Environmental Protection Agency	Miscellaneous water quality measurements in STORET data system for period 1957 to present at following Columbia River locations between McNary and Priest Rapids Dams: RM 292.0 (McNary Dam), 292.4, 292.5, 293.0, 324.9 (above mouth of Snake River), 326.3, 328.0 (Kennewick-Pasco railroad bridge), 328.3, 329.0, 330.0 (Kennewick-Pasco State Highway 12 bridge), 334.7 (below mouth of Yakima River), 388.1 (Vernita Bridge, State Highway 24), 388.5, 395.6, 397.1 (Priest Rapids Dam) (Ref 10).

4

6.3.2 ECOLOGICAL PARAMETERS

6.3.2.1 Aquatic Studies in Progress

Agency	Program
U.S. Department of Energy, Division of Biomedical and Environmental Research	Annual (since 1947) census of the fall chinook salmon spawning population in the Columbia River between Richland and Priest Rapids Dam, by Battelle-Northwest. Weekly

	aerial observations have provided data to evaluate the fluctuations in spawning populations in this section of the river and to examine the relationships between numbers of fish and perturbations in the river (Ref 11).
U.S. Department of Energy, Division of Biomedical and Environmental Research	Studies on fish behavior in waters whose quality has been altered by various perturbations. Emphasis in this work is on the effects of water level fluctuation on the use of shoreline and shallow water habitats by resident and anadromous fish (Ref 12).
U.S. Department of Energy, Division of Biomedical and Environmental Research	Studies by Battelle Northwest on the impact of flow manipulation due to hydroelectric power generation on important fish species.
U.S. Army Corps of Engineers, Grant County PUD, Chelan County PUD	Studies of upstream adult migrant fish passage over Columbia River dams. These fish counts are generally made from April to October each year.
Mid-Columbia Studies Committee	Studies on Priest Rapids Dam and the Hanford Reach to increase salmon production by assessing mortalities accurately, assessing fish condition and improving survivability past Priest Rapids Dam (Ref 13).
Grant County PUD Ephrata, Washington	On-going survey of fall chinook salmon spawning areas on Vernita Bar, downstream of Priest Rapids dam, from 1978 - 1980 (Refs 14, 15).

4

Grant County PUD Ephrata, Washington	Studies of the contribution of Priest Rapids Hatchery fall chinook to the artificial and natural spawning populations near Priest Rapids Dam during 1979 (Ref 16).
Grant County PUD Ephrata, Washington	Studies at Priest Rapids Dam in 1981 to assess fry movements downstream through the forebay and dam (Ref 17).
Grant, Douglas and Chelan Counties PUD's	An assessment of the downstream migration of juvenile salmonids in the mid-Columbia River (Ref 18).
Grant, Douglas and Chelan Counties PUD's	Evaluation of the effectiveness of water spilling at Wanapum Dam for the passage of juvenile salmon (Ref 19).
Washington State Department of Fisheries	Aerial spawning surveys in the Hanford Reach and vicinity. Surveys to determine chinook spawning are conducted from October through November. Carcass recovery of spawning fall chinook salmon occurs on an irregular basis. 4
Washington State Department of Game	Year-round creel census of anglers in the Ringold area, and in the upper Hanford Reach from July - October. Periodic fish sampling and slough surveys are conducted to determine relative abundance of fish species and production of resident fish spawning area.
U. S. Fish and Wildlife	Studies to determine impact of resident fish populations on salmonid smolt rearing in McNary pool.
National Marine Fisheries Service	Research on timing and abundance of juvenile downstream migrant salmonids at Priest Rapids Dam.

National Marine Fisheries Service	Research on the enhancement of downstream passage of juvenile salmonids at Priest Rapids Dam and other PUD dams on the Columbia River.

6.3.2.2 Related Terrestrial Ecology Monitoring Programs

Agency	Program
Grant County P.U.D.	Grant County PUD is conducting a short-term study of the effects of fluctuating water levels on island habitats in the Hanford Reach of the Columbia River. This study will supply little relevant information for the S/HNP; nonetheless, the final report will be reviewed (Ref 20).
Washington Public Power Supply System	Vegetation. Studies in the vicinity of WNP 1, 2, and 4 have been conducted under contract to Battelle, Pacific Northwest Laboratories, and Beak Consultants, Inc. These studies are continuing and include vegetation transects and soil and plant chemistry. These studies will provide baseline data for monitoring the effects of drift on the soil and vegetation. These data will be used to determine if drift impacts might potentially occur at the S/HNP (Refs 21, 22, 23). 4 Wildlife. Studies in the vicinity of WNP 1, 2, and 4 have been conducted by Supply System personnel and Battelle, Pacific Northwest Laboratories. These studies documented relative abundance of pocket mice, deer, rabbits and landbirds. These data will assess the impact of drift on resident wildlife. Studies of deer, rabbits and landbirds are continuing. These data also will be used to determine if drift impacts might

	potentially occur at the S/HNP (Refs 21, 22, 24).
U.S. Army Corps of Engineers	Studies of the riparian biota were conducted in 1980 under contract to Battelle, Pacific Northwest Laboratories. The issued report is titled "Wildlife Usage, Threatened and Endangered Species and Habitat Studies of the Hanford Reach, Columbia River, Washington". This study evaluated potential impacts of the potential Ben Franklin Dam. Data presented in this report is directly related to S/HNP and is cited frequently in Section 2.2.1 (Ref 25).
U.S. Department of Energy	ALE Reserve. The objective of the Arid Lands Ecology (ALE) Reserve is to quantitatively assess the role of environmental stresses on the structure and function of shrub steppe ecosystems in the northwestern United States. Natural and man-induced stresses have been evaluated for a 10-year period on the ALE Reserve. Widespread stresses studied include drought, fire, cattle grazing and plowing. Data regarding habitat stress is relevant to the S/HNP (Section 2.2.1.6). Data regarding vegetation and wildlife provides valuable regional data on the shrub steppe that is summarized in Section 2.2.1 (Ref 26). 4
	Vegetation. Battelle has conducted vegetation studies on the Hanford Reservation for several years, including ecological characterization and studies of productivity, succession, fire effects, revegetation, drought response, and uptake of transuranic elements by plants. Some of these were close enough to the S/HNP to provide valuable background information (Section 2.2.1 and Ref 26).

Rockwell International is conducting radionuclide accumulation studies of plant samples, but not ecological vegetation studies. These data are not particularly relevant to the S/HNP (Ref 20).

Wildlife. Battelle has conducted many studies on the wildlife of the Hanford Reservation including habitat requirements, food habits, population ecology, breeding ecology and radionuclide transport. In general, these studies provide relevant data on the S/HNP area and often will help monitor wildlife impacts which may result from the S/HNP (Ref 26).

In addition to the continuing studies at the ALE Reserve, long-term monitoring of certain wildlife populations are being conducted throughout the Hanford Reservation:

a. Canada Goose Nesting Surveys.

Since 1953, routine yearly surveys of goose nesting on Hanford islands have been conducted. Productivity of individual nests on each of 20 islands has been documented and related to natural and man-caused environmental changes (Ref 26). 4

b. Great Blue Heron Studies

Radionuclide and heavy metal analyses of excreta collected under a colony at Hanford have been compared to several other colonies in the Northwest. This study enables researchers to examine the trends in chemical composition of excreta as they relate to known contamination in the environment (Ref 26).

c. Bald Eagle Wintering Surveys

Yearly wintering surveys of bald eagles are conducted on the Hanford Reach of the Columbia River. A careful watch is being made to determine if Hanford operations are having any impact on this threatened species activities (Ref 26).

d. Gulls and Terns

Two colonies of ring-billed and California gulls, and three colonies of Forster's terns nest on islands in the Hanford Reach. Periodic nesting surveys relate nesting success to various environmental perturbations (Ref 26).

e. Deer

Over 20 mule deer are presently being radiotracked to determine movement patterns in relation to Hanford operations (Ref 26). 4

6.3.3 METEOROLOGICAL MONITORING PROGRAMS IN PROGRESS

Agency	Program
Washington Public Power Supply System	The meteorological data collection program at the WNP-2 site (about 5 miles from the S/WNP Site) was operational from April 1974 to June 1976 and was resumed in the fall of 1979. System measurements include wind speed and wind direction at the 33- and 245-ft levels. Temperature difference measurements are made between the two levels. Dewpoint temperature is measured at the 33-ft level;

	precipitation is measured at ground level.
U.S. Department of Energy Richland Operations Office	The Hanford Meteorological Station (11 miles west/northwest of the S/HNP Site) is operated for the Department of Energy (DOE) by Battelle. This station is manned by an observer-forecaster 24 hrs/day. Complete surface weather observations are made hourly. Wind and temperature profiles from the surface to 400 ft are monitored continuously (Ref 27). In addition, a network of eighteen telemetered wind and temperature stations, including those near the WNP-2 site and S/HNP Sites, is operated on the Hanford Reservation to assist in defining airflow patterns. Micrometeorological and climatological records dating from 1944 to 1970 are available from the Hanford Meteorological Station (Ref 28). 4
U.S. Department of Energy Richland Operations Office	Climatological measurements of maximum and minimum temperature, humidity, and precipitation are currently being made on DOE'S Arid Lands Ecology (ALE) Reserve by Battelle (Ref 29). The ALE Reserve lies to the west of the S/HNP Site.

6.3.4 RADIOLOGICAL STUDIES IN PROGRESS

Agency	Program
U.S. Department of Energy	A comprehensive radiological monitoring program for the Hanford Plant and surrounding environs is carried out by Battelle-Northwest Laboratories to evaluate the

	disposition and translocation of Hanford plant-released radionuclides (continuous since before 1960). Table 6.3-1 provides a summary of the program, taken from Reference 30, and Figures 6.3-1 and 6.3-2 show sampling locations. Annual reports provide surveillance program details (Ref 30) and results (Refs 31, 32).
Washington State, Division of Social and Health Services	A state-wide radiological program is carried out by the Radiological Control Units (Ref 33). Samples of Columbia River water, air, milk and shellfish are obtained at a number of locations relevant to WNP-2 and WNP-1/4 which are shown in Table 6.3-2 and Figure 6.3-3. Results are reported to the Environmental Protection Agency and published annually.
Washington Public Power Supply System	Preoperational radiological environmental program prior to the start-up of WNP-2. Table 6.3-3 provides a summary of the program taken from Reference 34. Figure 6.3-4 and its key, Table 6.3-5, show the sampling locations. Table 6.3-4 lists representation results of samples collected between March 1978 through June 1980. 4
	The results of the US DOE and Washington State programs are published annually and are available publicly. Their procedures and methodologies are discussed in their annual reports (Refs 30, 31, 32, 33, and later reports).
	The Supply System program is discussed in Reference 34. The S/HNP is interfacing with

the Supply System program to the extent possible (Section 6.1.5).

The results of all three programs are readily available to the S/[redacted]. 4

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TABLE 6.3-1

ROUTINE ENVIRONMENTAL RADIATION SURVEILLANCE SCHEDULE - 1979
U. S. DEPARTMENT OF ENERGY

Type of Sample	Type of Analysis	W	BW	M	BM	Q	SA	A
WATER:								
Columbia River Water	Radioactivity		2	2				
	Dose Rate			2				
	Chemical	2						
	Biological			2				
Sanitary Water	Radioactivity	1		3		9		
	Chemical	2(a)						
Groundwater Wells	Radioactivity					340	36	
	Chemical					255	40	35
AIR:								
Filters	Radioactive Particulates		44					
Molecular Sieves	Tritium		6					
Charcoal Cartridge	Radioiodines		10	34				
OTHER:								
Radiation Level	Dose Rate			61				
Shoreline Survey	Dose Rate			11				
Waste Site Survey	Radioactivity					3	66	3
Road Survey	Radioactivity			6		3		
Aerial Survey	Radioactivity							1
Railroad Survey	Radioactivity					3		2
Milk	Radioactivity		9					
Fish (Columbia River)	Radioactivity			1	1		4	
Wild Fowl	Radioactivity			2		5		9
Mammals	Radioactivity				10			

4

TABLE 6.3-1 Sheet 2 of 2

Type of Sample		Type of Analysis	W	BW	M	BM	Q	SA	A
Soil		Radioactivity							21
Vegetation		Radioactivity							21
Foodstuffs:	Meat	Radioactivity					1	1	1
	Produce	Radioactivity			5	1			6

(a) Samples routinely analyzed and reported by the Hanford Environmental Health Foundation.

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TABLE 6.3-2

ENVIRONMENTAL RADIATION SURVEILLANCE NETWORK
WASHINGTON STATE DEPARTMENT OF SOCIAL AND HEALTH SERVICES
HEALTH SERVICES DIVISION
July 1977 to June 1978

Station Code	Location	Sample Type
Puget Sound		
PS 0101	Seattle - Smith Tower	Air
0102	Seattle - Boeing Field	TLD*
0201	Cedar River - Landsberg	Surface Water
1302	Puyallup River - Puyallup	Surface Water
1702	Puget Sound - Bangor	Oyster, Sediment
1704	Puget Sound Naval Shipyard - Bremerton	Sediment
3201	Olympia	TLD
3301	Edmonds	TLD
3401	Bremerton	TLD
3501	Bangor	TLD
3601	Pack Forest - Lt. Br. of Spring	Ground Water
3602	Pack Forest - Rt. Br. of Spring	Ground Water
3603	Pack Forest - Ditch below Spring	Ground Water
3604	Pack Forest - Ditch 200' Uphill	Ground Water
Coastal Peninsula		
CP 1801	Elma	TLD
2401	Port Angeles	TLD
Southwest		
SW 0301	Kalama River - Kalama	Surface Water
0904	Columbia River - Longview	Surface Water
0905	Cottonwood Island - Columbia River	Sediment

4

TABLE 6.3-2

Station Code	Location	Sample Type
0906	Columbia River - East Shore, Trojan	Sediment
1100	Kalama - Sewage Treatment Plant	TLD, Soil
2002	Woodland	Milk
2100	Kelso - Vision Acres	TLD, Soil
3100	Longview, Ocean Beach Substation	TLD, Soil
4100	Trojan Plant - Meteorology Tower	TLD
Northwest		
NW 0204	Skagit River - Concrete	Surface Water
0501	Skagit County - General Area	Milk
1501	Bellingham	TLD
1601	Lyman	TLD
Southcentral		
SC 0202	Yakima River - Yakima (Parker)	Surface Water
Northcentral		
NC 0103	Okanogan River - Malott	Surface Water
0701	Wenatchee - Sewage Treatment Plant	TLD
Southeast		
SE 0011	Hanford - Well 699-17-5	Ground Water
0012	Hanford - Well 699-9-E2	Ground Water
0013	Hanford - Well 699-2-3	Ground Water
0104	Columbia River - Richland Water Treatment	Surface Water
0601	Benton County - General Area	Milk
0701	Franklin County - General Area	Milk

TABLE 6.3-2

Station Code	Location	Sample Type
1101	Richland	TLD
1201	Hanford - NECO Burial Site - NE Corner	TLD, Soil
1202	Hanford - NECO Burial Site - NW Corner	TLD, Soil
1203	Hanford - NECO Burial Site - SW Corner	TLD, Soil
1204	Hanford - NECO Burial Site - SE Corner	TLD, Soil
3201	WPPSS - 2 - Station 1	TLD, Soil
3202	WPPSS - 2 - Station 2	TLD, Soil
3203	WPPSS - 2 - Station 3	TLD, Soil
3204	WPPSS - 2 - Station 4	TLD, Soil
3208	WPPSS - 2 - Station 8	TLD, Soil
3235	WPPSS - 2 - Station 35	Sediment
3236	WPPSS - 2 - Station 36	Sediment
Northeast		
NE 0101	Spokane - City Hall	Air
0102	Charraroy - 20 miles north of Spokane	TLD
0103	Spokane	TLD
1101	Deer Park - General Area	Milk
2101	Sherwood U. Mill - Station A	Soil, Air
2103	Sherwood U. Mill - Station C	Soil Air, TLD
2105	Sherwood U. Mill - Station E	Air, TLD
2106	Sherwood U. Mill - Station F	Air
2107	Sherwood U. Mill - Station G	Air, Soil, TLD
2109	Sherwood U. Mill - Station Rajewski Ranch	Air, Soil, TLD
2121	Sherwood U. Mill - Station L1	Sediment
2122	Sherwood U. Mill - Station L2	Sediment
2123	Sherwood U. Mill - Station L3	S. Water, Sediment
2124	Sherwood U. Mill - Blue Creek	S. Water

4

TABLE 6.3-2

Station Code	Location	Sample Type
2131	Sherwood U. Mill - Station S1	Ground Water
2123	Sherwood U. Mill - Station S2	Ground Water
2133	Sherwood U. Mill - Station S3	Ground Water
2134	Sherwood U. Mill - Station MW1	Ground Water
2135	Sherwood U. Mill - Station MW2	Ground Water
2136	Sherwood U. Mill - Station MW3	Ground Water
2138	Sherwood U. Mill - Station MW5	Ground Water
2139	Sherwood U. Mill - Station MW6	Ground Water

*Thermoluminescent Dosimeter

4

TABLE 6.3-3

SUPPLY SYSTEM RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Sample Type	Location[1]	Sampling and[1] Collection Frequency	Type and Frequency[11] of Analysis
Airborne Particulate and Radioiodine	1.2 miles S of WNP-2 1.5 miles NNE of WNP-2 2.0 miles SE of WNP-2 9 miles SSE of WNP-2 7 miles SSE of WNP-2 8 miles S of WNP-2 3 miles WNW of WNP-2 4.2 miles ESE of WNP-2 30 miles WSW of WNP-2	Continuous Sampling Weekly Collection	Particulate: Gross Beta[2] Gamma isotopic[3] on quarterly composite (by location) 4 Radioiodine: Gamma for I-131 weekly
Direct Radiation[4]	1.2 miles S of WNP-2 1.5 miles NNE of WNP-2 2.0 miles SE of WNP-2 9 miles SSE of WNP-2 7 miles SE of WNP-2 8 miles S of WNP-2 3 miles WNW of WNP-2 4.2 miles ESE of WNP-2 30 miles WSW of WNP-2 3 miles E of WNP-2 3 miles ENE of WNP-2 7 miles NNW of WNP-2 13 stations at 22½° sectors	Quarterly, Annually	Gamma Dose

TABLE 6.3-3

Sample Type	Location[1]	Sampling and[1] Collection Frequency	Type and Frequency[11] of Analysis
River Water	Intake WNP-1/4[5] Discharge WNP-1/4[5] Intake WNP-2 Discharge WNP-2	Composite aliquots[6] for month	Gamma isotopic[3] Tritium[7]
Drinking Water	7 miles ERDA 300 Area 11 miles Richland Water Treatment Plant	Composite aliquots[6] for month	Gamma isotopic[3] Tritium[7]
Ground Water[8]	#1 well WNP-2 #2 well WNP-2 well WNP-1 well WNP-4	Quarterly	Gamma isotopic[3] Tritium
Sediment	apx 1 mile upstream apx 2 miles downstream	Semi-annually	Gamma isotopic[3]
Milk[9]	Closest milk animal Farm SE apx 7 miles SE Farm SE apx 8 miles ESE Control, 30 miles WSW	Semi-monthly grazing season Monthly at other times	Gamma isotopic[3] Iodine - 131
Fish	4 in vicinity of discharge 1 control Snake River	Semi-annually	Gamma isotopic[3]

TABLE 6.3-3

Sample Type	Location[1]	Sampling and[1] Collection Frequency	Type and Frequency[11] of Analysis
Fruit and Vegetables[10]	Within 10-mile radius	Monthly during growing season	Gamma isotopic[3]

1 Deviation may be required if samples are unobtainable due to hazardous conditions, seasonal availability, malfunction of automatic sampling equipment, or other legitimate reasons. All deviations will be documented in the annual report.

2 Particulate sample filters will be analyzed for gross beta after at least 24 hours decay. If gross beta activity is greater than 10 times the mean of the control sample, gamma isotopic analysis should be performed on the individual sample.

3 Gamma isotopic means identification and quantification of gamma emitting radionuclides that may be attributable to the effluents of the facility.

4 Thermoluminescent Dosimeter (TLD) badges which contain 3-5 chips will be used. Each station will have two badges; one will be changed each quarter and one will be changed annually. The badges in each 22½° sector will be placed at the exclusion areas of the Plants.

5 Sampling of the river water from the intake and discharge of WNP-1/4 will begin at least 60 days prior to the fuel loading for WNP-1.

6 Composite samples will be collected with equipment which is capable of collecting an aliquot at time intervals which are short relative to compositing period.

7 Tritium analysis will be performed on a quarterly composited sample.

8 Wells sampled will be those which are being used to provide drinking water for construction personnel at each of the Plants.

9 Milk samples will be obtained from farms or individual milk animals which are located in sectors with the higher calculated annual average ground-level D/Q's. If Cesium-134 or Cesium-137 is measured in an individual milk sample in excess of 30 pCi/l, then Strontium 90 analysis should be performed.

10 Fruit and vegetables will be obtained from farms or gardens which use Columbia River water for irrigation, if possible, and different varieties will be obtained as they are in season. One sample each of root food, leafy vegetables, and fruit should be collected each period. 4

11 Frequency of analysis will be as collected or as stated in these footnotes for special cases.

Note
In addition to above guidance for operational monitoring, the following material is supplied for the preoperational programs.

The monitoring program defined will be instituted 2 years prior to the fuel loading of WNP-2. The preoperational program should follow the duration specified in the schedule below.

TABLE 6.3-3 Sheet 5 of 5

Two Years	One Year	Six Months
direct radiation	airborne particulate	airborne iodine
fish	milk (except iodine)	milk (iodine)
vegetation	river water	
sediment and soil	drinking water	
	ground water	

The Preoperational Radiological Monitoring Program objectives are to measure background levels and their variations along anticipated critical pathways surrounding the Supply System site, to train personnel, and to evaluate procedures, equipment and techniques.

4

TABLE 6.3-4

PREOPERATIONAL ENVIRONMENTAL RADIOLOGICAL MONITORING DATA

The data below represents results of samples taken from March, 1978 through June 1980.

Sample Date	Station Number	Sediment Isotope (pCi/g) Co-60	Cs-137	Other Gamma
05-17-78	35	0.59±0.21	0.36±0.13	0.15*
05-17-78	36	0.32±0.11	0.38±0.09	0.15*
11-27-78	36	0.38±0.11	0.49±0.09	0.15*
12-21-78	35	0.15*	0.22±0.05	0.15*, Zn-65 = 0.37±0.11
07-10-79	35	0.13±0.06	0.31±0.07	0.15*
11-19-79	35	0.13±0.06	0.31±0.06	0.15*
11-19-79	36	0.61±0.11	0.48±0.07	0.15*
05-08-80	35	0.15*	0.20±0.03	0.15*

*Indicates value is a maximum.

TABLE 6.3-4

Sample Date	Station Number	Soil Isotope (pCi/g)* Cs-137	Zn-65	Fe-59	Other Gamma
05-08-78	1	0.5±0.1	0.15	0.26	0.15
05-08-78	2	0.15*	0.15	0.26	0.15
05-08-78	3	0.7±0.1	0.15	0.26	0.15
05-08-78	7	0.50±0.70	0.15	0.26	0.15
05-08-78	9	0.14±0.04	0.15	0.26	0.15
05-10-79	1	0.15*	-	-	0.15
05-10-79	2	0.55±0.70	-	-	0.15
05-10-79	3	0.14±0.03	-	-	0.15
05-10-79	7	0.15*	-	-	0.15
05-10-79	9	0.15*	-	-	0.15
05-08-80	1	1.65±0.14	-	-	0.15
05-08-80	2	0.15*	-	-	0.15
05-08-80	3	1.12±0.12	-	-	0.15
05-08-80	7	1.88±0.14	-	-	0.15
05-08-80	9	0.15*			

Natural K-40 in the soil ranged from 7-14 pCi/g with an average of 10 pCi/g for the ten (10) samples.

*Indicates value is a maximum.

TABLE 6.3-4

Garden Produce

Sample Type	Collection Site	Collection Date	Gamma Emitters* pCi/g Wet
Chard	Pasco	06-20-78	0.08
Chard	Pasco	06-20-78	0.08
Carrots	Grandview	06-20-78	0.08
Apricots	Pasco	07-24-78	0.08
Onions	Pasco	07-24-78	0.08
Cabbage	Pasco	07-24-78	0.08
Apricots	Grandview	07-24-78	0.08
Onions	Grandview	07-24-78	0.08
Beans	Grandview	07-24-78	0.08
Chard	Pasco	08-21-78	0.08
Carrots	Pasco	08-21-78	0.08
Apples	Pasco	08-21-78	0.08
Onions	Grandview	08-21-78	0.08
Apples	Grandview	08-21-78	0.08
Chard	Pasco	09-25-78	0.08
Carrots	Pasco	09-25-78	0.08
Grapes	Pasco	09-25-78	0.08
Chard	Grandview	09-25-78	0.08
Carrots	Grandview	09-25-78	0.08
Tomatoes	Grandview	09-25-78	0.08

*Indicates value is a maximum.

TABLE 6.3-4

Garden Produce

Sample Type	Collection Site	Collection Date	Gamma Emitters* pCi/g Wet
Chard	Pasco	10-23-78	0.08
Carrots	Pasco	10-23-78	0.08
Tomatoes	Pasco	10-23-78	0.08
Comfrey	Grandview	10-23-78	0.08
Carrots	Grandview	10-23-78	0.08
Tomatoes	Grandview	10-23-78	0.08
Comfrey	Grandview	05-22-79	0.08
Lettuce	Pasco	05-22-79	0.08
Onion	Pasco	05-22-79	0.13
Strawberry	Pasco	05-22-79	0.08
Carrots	Grandview	06-25-79	0.08
Comfrey	Grandview	06-25-79	0.08
Cherries	Grandview	06-25-79	0.08
Chard	Pasco	06-25-79	0.08
Carrots	Pasco	06-25-79	0.08
Cherries	Pasco	06-25-79	0.08
Apples	Pasco	07-29-79	0.08
Carrots	Pasco	07-29-79	0.08
Peppers	Pasco	07-29-79	0.08
Chard	Grandview	07-29-79	0.08
Carrots	Grandview	07-29-79	0.08
Apples	Grandview	07-29-79	0.08

*Indicates value is a maximum.

TABLE 6.3-4

Garden Produce

Sample Type	Collection Site	Collection Date	Gamma Emitters[a] pCi/g Wet
Carrots	Pasco	08-21-79	0.08
Cabbage	Pasco	08-21-79	0.08
Apples	Pasco	08-21-79	0.08
Tomatoes	Grandview	08-21-79	0.08
Comfrey	Grandview	08-21-79	0.08
Apples	Pasco	09-18-79	0.08
Cabbage	Pasco	09-18-79	0.08
Carrots	Pasco	09-18-79	0.08
Tomatoes	Grandview	09-18-79	0.08
Chard	Grandview	09-18-79	0.08
Carrots	Grandview	09-18-79	0.08
Turnip Tops	Pasco	05-08-80	0.08
Onion	Pasco	05-08-80	0.08
Comfrey	Grandview	05-08-80	0.08
Onion	Grandview	05-08-80	0.08
Swiss Chard	Pasco	06-23-80	0.08
Beets	Pasco	06-23-80	0.08
Comfrey	Grandview	06-23-80	0.08
Beets	Grandview	06-23-80	0.08

[a]Indicates value is a maximum.

TABLE 6.3-4

			Fish				
			pCi/g (wet)*				
Station	Sample Date	Species	Co-60	Cs-137	Fe-59	Zn-65	Other Gamma
Columbia	04-26-78	Sucker	0.13	0.13	0.26	0.26	0.13
Snake	04-26-78	Trout	0.13	0.13	0.26	0.26	0.13
Columbia	04-26-78	Squawfish	0.13	0.13	0.26	0.26	0.13
Columbia	04-26-78	Salmon	0.13	0.13	0.26	0.26	0.13
Columbia	04-26-78	Carp	0.13	0.13	0.26	0.26	0.13
Snake	10-24-78	Trout	0.13	0.13	0.26	0.26	0.13
Columbia	10-20-78	Salmon	0.13	0.13	0.26	0.26	0.13
Columbia	10-20-78	Salmon	0.13	0.13	0.26	0.26	0.13
Columbia	10-20-78	Salmon	0.13	0.13	0.26	0.26	0.13
Columbia	10-20-78	Catfish	0.13	0.13	0.26	0.26	0.13
Columbia	04-25-79	Salmon	0.13	0.13	-	0.13	0.13
Columbia	04-25-79	Salmon	0.13	0.13	-	0.13	0.13
Columbia	04-25-79	Trout	0.13	0.13	-	0.13	0.13
Columbia	04-25-79	Trout	0.13	0.13	-	0.13	0.13
Snake	04-25-79	Trout	0.13	0.13	-	0.13	0.13
Columbia	10-29-79	Whitefish	0.13	0.13	-	0.13	0.13
Snake	10-30-79	Steelhead	0.13	0.13	-	0.13	0.13
Columbia	04-23-80	Whitefish	0.13	0.13	-	0.13	0.13

*Indicates value is a maximum.

TABLE 6.3-4

Fish

Station	Sample Date	Species	pCi/g (wet)* Co-60	Cs-137	Fe-59	Zn-65	Other Gamma
Columbia	04-23-80	Whitefish	0.13	0.13	-	0.13	0.13
Columbia	04-23-80	Whitefish	0.13	0.13	-	0.13	0.13
Columbia	04-23-80	Whitefish	0.13	0.13	-	0.13	0.13
Snake	04-21-80	Steelehead	0.13	0.13	-	0.13	0.13

Well Water

Station	Sample Date	pCi/l Tritium
WNP-2 Well #3	11-19-78	380±340

Direct Radiation

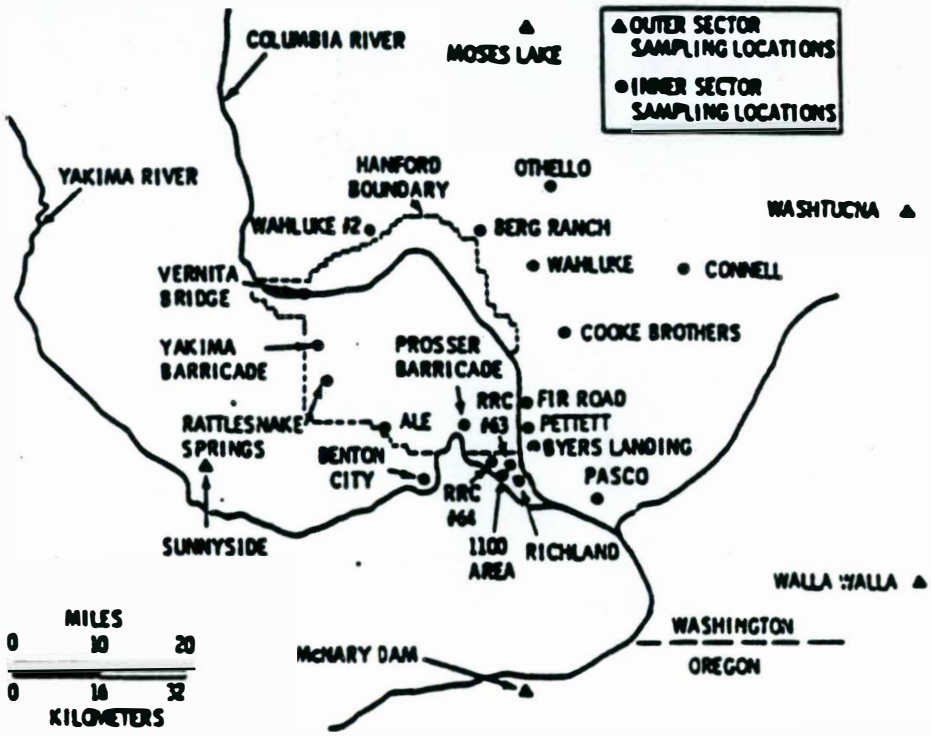
Direct radiation measurements were made during this period using thermoluminescent dosimeters (TLDs) at twenty-five (25) stations around the Site. The results of these measurements were 0.25±0.03 mrem/day.

*Indicates value is a maximum.

TABLE 6.3-5

STATION SAMPLE DESCRIPTION FOR FIGURE 6.3-4

Station Number	Sample Type
1 through 7	Particulate Radioiodine Direct Radiation
8	Particulate Radioiodine Direct Radiation Milk Fruit and/or Vegetables
9	Particulate Radioiodine Direct Radiation Milk Fruit and/or Vegetables 4
10 through 25	Direct Radiation
26	River Water
27 and 28	River Water Fish
29 and 30	Drinking Water
31 through 34	Ground Water
35 and 36	Sediment
37 and 38	Milk



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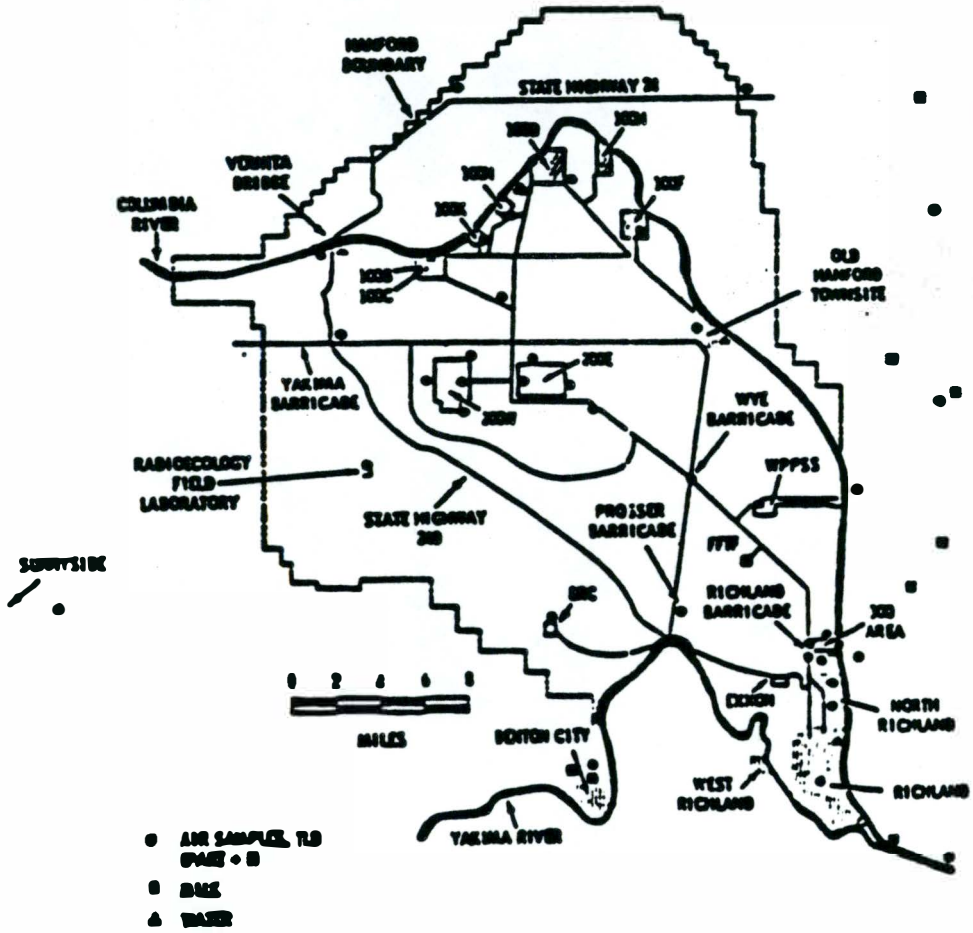
HANFORD ENVIRONMENTAL AIR SAMPLING LOCATIONS USDOE

FIGURE 6.3-1



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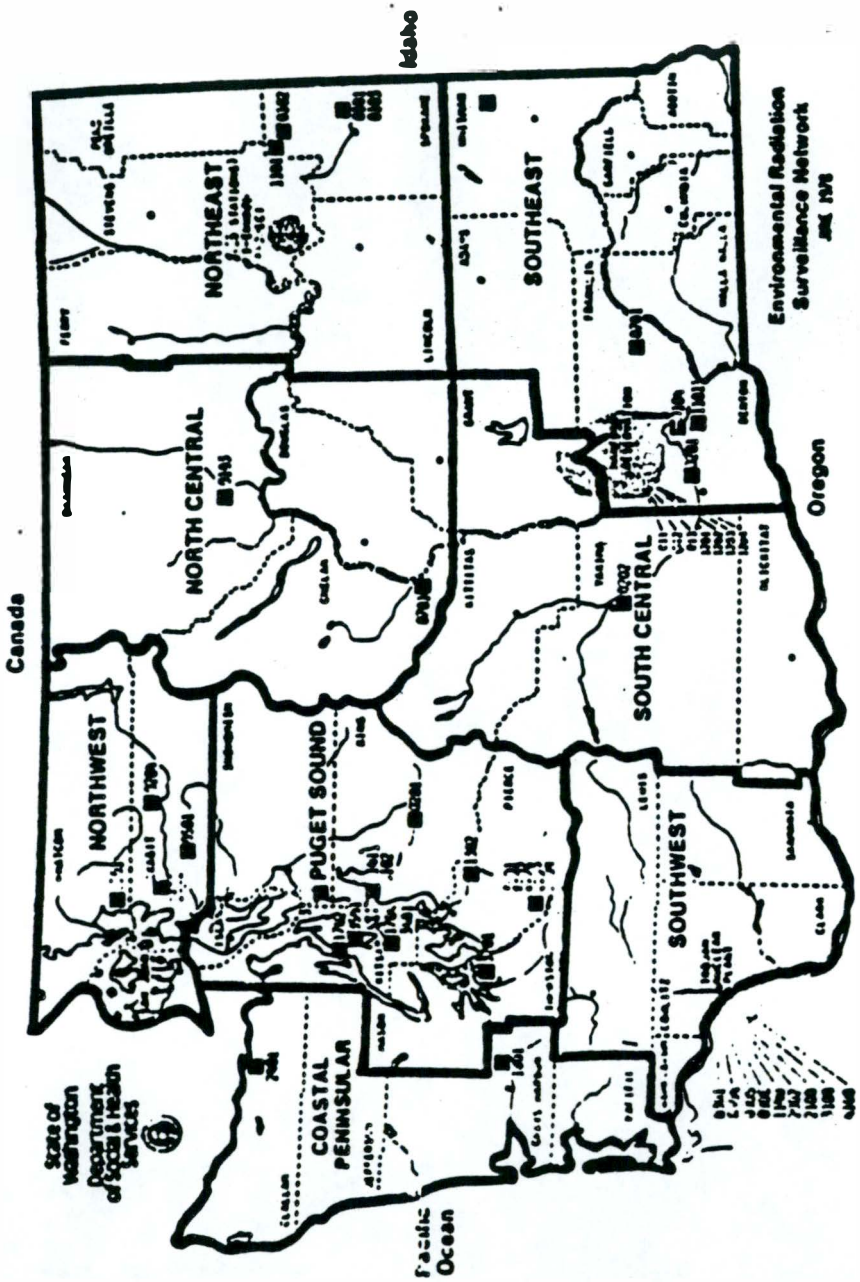
RADIOLOGICAL MONITORING
STATIONS HANFORD
OPERATED BY DOE

FIGURE 6.3-2



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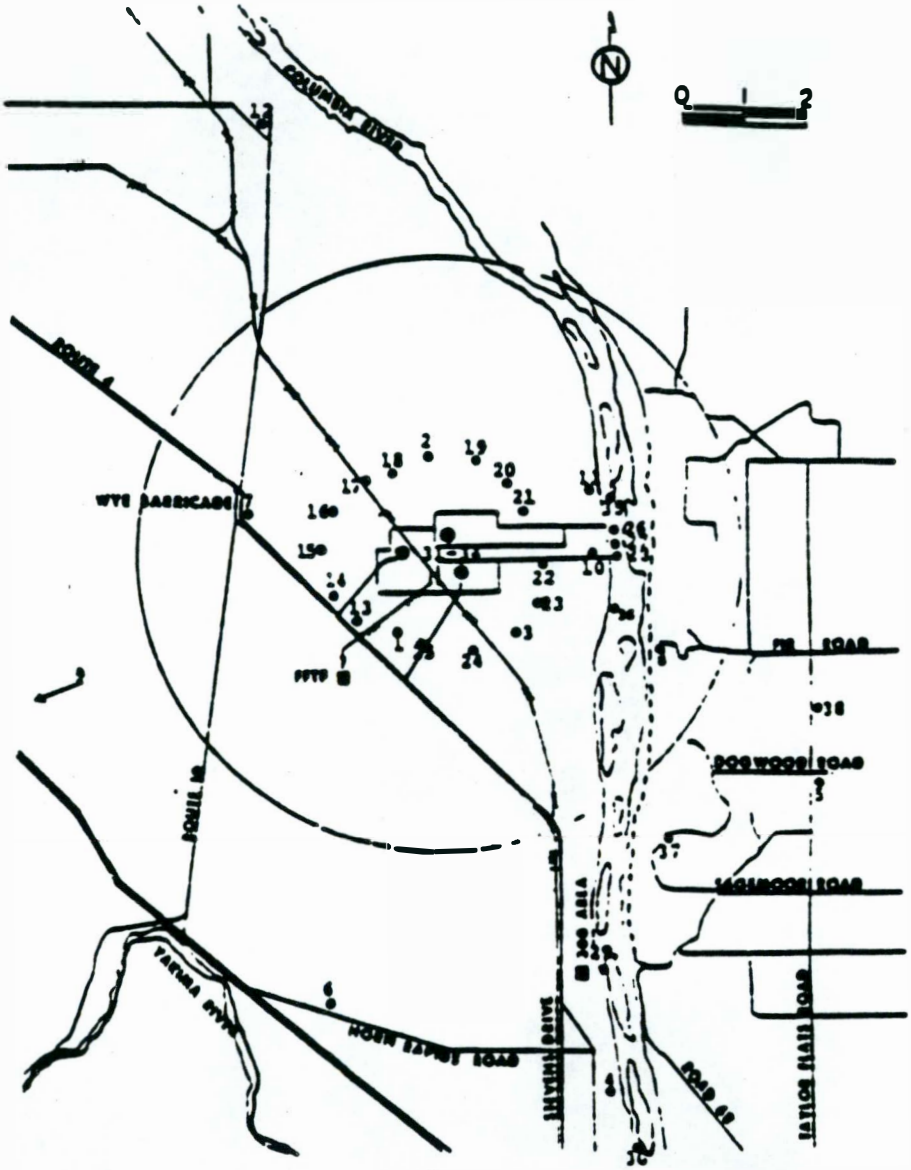
STATEWIDE SAMPLING LOCATIONS WASHINGTON DSHS

FIGURE 6.3-3



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RADIOLOGICAL SAMPLE
STATION LOCATIONS WPPSS

FIGURE 6.3-4

CHAPTER 7.0

ENVIRONMENTAL EFFECTS OF ACCIDENTS

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ENVIRONMENTAL EFFECTS OF ACCIDENTS

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SECTION 7.0

ENVIRONMENTAL EFFECTS OF ACCIDENTS

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7.0 ENVIRONMENTAL EFFECTS OF ACCIDENTS

This section discusses the environmental effects of possible accidents that may occur within the Plant.

7.1 PLANT ACCIDENTS INVOLVING RADIOACTIVITY

From the beginning of the nuclear power industry, a detailed accident and safety analysis has been a normal part of the design and licensing of each power plant. The results of this analysis are presented to the NRC in the form of Safety Analysis Reports. These reports contain detailed descriptions of the facility and Plant Site, as well as a highly conservative analysis of the effects of normal and abnormal plant conditions. In addition to the analysis presented in the Safety Analysis Report, further examination of the environmental effects of normal and abnormal Plant conditions, based on realistic parameters, is presented in this report. The analysis presented in the following section is based on the assumption that only one of the two units will have an accident at any given time.

The purpose of this section is to consider the potential radiological effects on the environment of accidental events which might occur during the lifetime of the Plant, and to compare these potential effects with those of normal Plant operation and natural background radiation. 4

Radiological effects which result from normal Plant operation are discussed in Section 5.2.

There are two main aspects of Plant safety: prevention of Plant accidents, and containment of radioactivity in the event of an accident. Prevention of Plant accidents begins with conservative design of the reactor and its control system and with conservative engineering of the reactor installation. Starting with this base, the designer seeks to anticipate the possible sources of malfunction and to make provisions for mitigating their effects in the design. A strict quality assurance program ensures high component and system reliability.

As a result of the normal operation of any nuclear plant, radioactive materials are produced in the core of the reactor. These materials are contained within the Plant by a number of successive barriers which are incorporated in the Plant design. These barriers are the fuel material,

the zircaloy fuel cladding, the steel wall of the reactor vessel, and the containment system.

Containment of the radioactivity in the event of an accident also involves the incorporation of Engineered Safety Features (ESF) in the Plant design, such as radiation shields, emergency cooling systems, and filters.

In considering the environmental effect of Plant accidents, several important distinctions must be made from other Plant environmental effects.

The estimated effects are potential, rather than certain. The environmental effects of these potential events must be considered in conjunction with their probability of occurrence. As a result of measures taken for accident prevention through design, manufacture, and operation, occurrences of accidental events in actual operating nuclear power plants have been extremely rare. The probability of accidental events in operating nuclear plants has been maintained at this low level through design review, use of conservative operating limits, and quality assurance.

The actual exposures from normal Plant operation and the potential exposures from accidents are small compared to the background radiation present in our natural environment. For example, the natural background gamma radiation is approximately 100 mrem per year (Section 2.8). 4

The estimated radiation exposures from potential Plant accidents, when calculated on a realistic basis, are generally lower than the radiation exposures resulting from long-term normal operation. This is the case even for major accidents such as the rupture of a main coolant pipe, and results from the action of the ESF in reducing the consequences of these accidents.

In the following sections, a number of possible Plant accidents are identified and analyzed, and their radiological consequences are estimated. Most of the accidents postulated in these analyses have never happened. On the few occasions when malfunctions have occurred in operating nuclear power plants, ESF have performed adequately and no injuries to the public have resulted.

7.1.1 APPROACH TO THE ANALYSIS OF ACCIDENTS

The occurrence of abnormal Plant conditions and accidental events must be considered in design, licensing, and operation of nuclear power plants. In technical terms, an

accident is an unexpected chain of events (ie, a process rather than a single event). In Safety Analysis Reports, the basic events involved in various possible Plant accidents are identified and studied with regard to the adequacy of the performance of the ESF. In addition, the potential radiological effects of Plant accidents are analyzed by the evaluation of physical factors involved in each chain of events which might result in radiation exposures to humans. These factors include the meteorological conditions existing at the time of the accident, the radionuclide uptake rates, and exposure times and distances, as well as the many factors which depend on the Plant design and mode of operation. In these analyses, the factors affecting the consequences of each accident are identified and evaluated, and uncertainties in their values are discussed.

Because some degree of uncertainty always exists in the prediction of these factors, it has become general practice in Safety Analysis Reports to assume conservative values in making calculated estimates of radiation doses. For example, it is customarily assumed that the accident occurs at a time when unfavorable weather conditions exist, and that the performance of the ESF is degraded by unexpected failures. The use of these unfavorable values or the various factors involved in the analysis provides assurance that each safety system has been adequately designed, that is, with sufficient capacity to cover the full range of effects to which each system could be subjected. For this reason, these conservative values for each factor have been called "design basis values". 4

The specific chain of events in which all unfavorable factors are assumed to occur accidentally and concurrently is called a Design Basis Accident (DBA). In the process of safety review and licensing, the radiation exposure levels calculated for the DBA are compared to the guideline values established in NRC Regulation 10 CFR 100, and if these calculated exposures fall below the guideline levels, the Plant safety systems are judged to be adequate.

As a result of this highly conservative analysis, the radiation exposure levels calculated for a DBA in Safety Analysis Reports are not actually expected to occur, even if the event initiating the accident occurs. In fact, the calculated exposures resulting from a DBA are generally far in excess of what would be expected and do not provide a realistic means of assessing the radiological effects of real Plant accidents. In the analyses presented here, the radiation exposures associated with Plant accidents have been analyzed on a realistic basis, as specified in NRC Regulatory Guide 4.2, Rev. 2 (Ref 1).

The analysis of Plant accidents is a technically complex subject, involving the full range of scientific disciplines which contribute to the design and operation of a nuclear power plant. Those technical terms used which are important in understanding the effects of potential accidents are defined. The individual accident and the actions of the appropriate ESF will be described in a general manner, but no attempt will be made to provide detailed information on the systems, or to establish definitely the adequacy of the performance of these systems. It is the purpose of the Safety Analysis Report to cover these areas.

The two main aspects of Plant safety are prevention of accidents, and containment of radioactivity in the event that an accident occurs. The effectiveness of the measures which have been taken for accident prevention is judged on the basis of the resulting accident probability, ie, the calculated frequency at which the accident occurs with prevention measures in place. The effectiveness of the measures taken in containment of radioactivity can be judged by the calculated values of the radiological exposures associated with each accident. As discussed in Federal Register 36 FR 22851 in the proposed annex to Appendix D of 10 CFR 50, the determination of the environmental impact of potential accidents requires the consideration of both the potential exposures and the probabilities of receiving these exposures. 4

Postulated accidents and occurrences are divided into nine accident classes (Table 7.1-1) identified in the NRC Regulatory Guide 4.2. The environmental impact of the postulated incidents is evaluated using the assumptions set forth in this Guide. The NRC has indicated that Class 1 events (trivial incidents) and Class 2 events (small releases outside containment) need not be considered in an accident discussion. However, these events are included and evaluated under routine radioactive releases presented in Section 5.2.

The occurrence of Class 9 accidents involves hypothetical sequences of failures of reactor protection systems and ESF more severe than those postulated in the design basis. Their consequences would be severe, but the probability of their occurrence is so slight that the environmental risk is extremely small. In the design, manufacture, and operation of a nuclear power reactor, quality assurance and continued surveillance and testing, plus the application of conservatism in design, provide and maintain the required degree of assurance that the probability of accidents in this class is remote enough to consider the environmental risk extremely low. Nevertheless, in response to the recent NRC Statement of Interim Policy (Ref. 2), the

effects of a Postulated Class 9 accident at the plant have been assessed and are presented in Section 7.4.

7.1.2 METHODS AND PARAMETERS USED TO DETERMINE POTENTIAL RADIATION EXPOSURES

7.1.2.1 Radiation Dose Models and Physical Data

In the field of radiation technology, there are several units of measure in common use, and an understanding of their meaning is essential to an understanding of the environmental impact of radiation. The first unit of interest is the curie. The number of curies is an indicator of the amount of radioactive material present. It does not indicate the amount of radiation received by anyone, nor the relative importance of one isotope compared to another, nor does it consider any biological factors. Perhaps the most important thing about curies is that the number of curies released, as such, has no bearing on public safety.

There are two reasons why the number of curies alone cannot be used to determine health effect. First, a curie of one isotope is not as harmful as a curie of another. For example, one curie of Krypton-87 causes 80 times as much dose as one curie of Krypton-83m. This is because the beta and gamma radiation emitted by Kr-87 are much more energetic than that emitted by Kr-83m. The other major reason is that a curie released is not a curie received. The important consideration is the radiation dose which could be received; this is measured in rem. The rem is a measure of the body tissue dose of any ionizing radiation or x-radiation in terms of its estimated biological effect relative to a dose of one roentgen (r). Often a more practical unit is millirem (mrem), which is 0.001 rem. The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. Therefore, the rem is the absorbed dose (expressed in rads) weighted by the biological response of human tissue to the radiation in question (expressed as rbe, relative biological effectiveness), in short, rem = rads x rbe. 4

In determining the environmental effect of radiation on humans, a knowledge of the level of potential dose, in rems, at a particular location is not sufficient. In order to assess somatic and genetic effects, it is necessary to know the number of people present at that location who receive the dose. Thus, another unit of population dose

has been used, the man-rem. The number of man-rems (the radiation dose levels, rems, at a particular place times the population receiving the dose) can be used as a general indicator of the relative environmental impact of a particular source of radiation. For example, if 360,000 people received 0.1 rem, the corresponding population dose would be 36,000 man-rem.

The calculation of thyroid inhalation, whole-body, and population doses for the accidents were carried out with formulas in Section 7.1.5. The formulas assume that the release is continuous and that cloud depletion due to ground deposition is insignificant.

The values of half-lives and fission yields were taken from the Meek and Rider Report (Ref 3), and are in general agreement with those in TID-14844 (Ref 4) and ORNL-2127 (Ref 5). The values for the gamma energies are those given in the Table of Isotopes (Ref 6). The thyroid dose conversion factors are taken from the ICRP Committee II Report (Ref 7). The breathing rates used in the calculations of inhalation doses are based on the average daily breathing rates assumed in the ICRP Report (Ref 7), which are also used in the NRC Regulatory Guides (Ref 8). The dose equations, isotope energies, and other parameters used to calculate doses are presented in Section 7.1.5. 4

7.1.2.2 Atmospheric Dilution Effects

Because of the natural action of the atmosphere, any gaseous material released from a point on the earth's surface will be greatly diluted in traveling to another point some distance away. As the distance from the source increases, the concentration of the gas in the air decreases, and thus the dose rate decreases. The basic meteorological conditions which determine the degree of atmospheric dilution around the Plant Site are being studied in a detailed monitoring program (Secton 2.3).

For the analysis of accident situations, the atmospheric dilution factors depend upon the nature of the release. In the loss-of-coolant accident, for example, the activity might be released at a constant rate, with the leakage distributed uniformly over the surface of the containment. In the steam line break accident, the activity is released from the ruptured steam pipe. The form and rate of release become less important at distances outside the Exclusion Area Boundary, however, and the expected radiation doses beyond the Exclusion Area Boundary can be calculated with

adequate accuracy by using dilution factors derived by the method suggested in Section 7.1.5.

In order to determine the doses resulting from various occurrences and accidents at the Plant Site, a 50th percentile criterion, as specified in NRC Regulatory Guide 4.2, is used to calculate realistic atmospheric dilution conditions. The methods used to determine the 50-percent probability level X/Q, and their corresponding values for various sectors and time periods are discussed in Section 6.1.3.

The 50 percent level X/Q values as well as the gamma whole-body dose conversion factors take into consideration the effect of building wake and sector wind frequency distribution. Values of the resulting average atmospheric dilution factors for the time periods 0-2 hours, 2-8 hours, 8-24 hours, 1-4 days, and 4-30 days are presented in Tables 6.1-8 and 6.1-9.

Concentrations of radioactive gases used in the calculation of whole-body doses are based on the equivalent Pasquill stability class and wind speed which yield the 50-percent level X/Q. The semi-infinite cloud model is used for whole body dose calculations. Whole-body gamma dose conversion factors at the Exclusion Area Boundary are given in Table 7.1-2. 4

7.1.2.3 Population Distribution

Man-rem dose estimates were conservatively based on the year 2030 population projections. The population distributions as a function of distance and sector for the years 1980 through 2030 have been estimated as presented in Section 2.1.

All short-term releases (less than 8 hours) were assumed to occur under conditions of invariant wind (i.e., the wind direction was steady for the duration of the release). The population doses were based on the assumption that for 0 to 50 miles, wind direction was invariant. Thus, doses as a result of any given short-term release (less than 8 hours) are delivered only in one 22.5 degree sector. The value of X/Q for a particular distance is used to determine the dose to the population living at that distance, and the total population dose was determined by taking the product of the dose times the number of people receiving that dose for each segment of a 22.5 degree sector and summing this product for the entire 22.5 degree sector for a distance out to 50 miles from the reactors. For those accidents that result in a release over a longer period of time

(greater than 8 hours to less than 30 days), credit is taken for the directional variability of the wind; over such a longer period of time, it is reasonable to assume that direction does change. Therefore, the distribution of wind directions at the Site was used, and the population doses delivered in any 22.5 degree sector were determined by using the X/Q value weighted by the frequecy of wind in that sector. Population dose was then determined by summing the results for all sectors around the Site.

7.1.2.4 Reactor Core Operating History Prior to Assumed Accidents

The inventories of radioactive materials in the fuel pellets and fuel rod gap spaces in the reactor core depend upon:

a. Core power

b. Plant capacity factor

c. Temperature distribution in the pellets

d. Length of operating time prior to the accident or shutdown 4

e. Diffusion rates of radioisotopes through the fuel pellet material.

7.1.3 ANALYSIS OF ACCIDENTS

A summary of the doses resulting from the postulated accidents and from normal operation is presented in Table 7.1-3.

7.1.3.1 Class 1 - Trivial Incidents Inside Containment

Class 1 accidents are postulated as the release of small quantities of radioactive material inside the containment. The various mechanisms by which this may occur include small spills, leaks, and pipe breaks. Because these releases occur within the containment and uncontrolled release of radioactivity is prevented, the environmental consequences of these incidents are trivial. An evaluation of this class of accident is included under routine radioactive discharges in Section 5.2.

7.1.3.2 Class 2 - Small Releases Outside Containment

Class 2 events include small spills and leaks from equipment outside the containment. A low level of continuous leakage from components such as valve packing and stems, pump seals, flanges, etc., is anticipated. Radioactivity release events of this class are considered to be minor perturbations of normal operating conditions, and are analyzed as anticipated operational occurrences along with radioactivity releases due to normal operation in Section 3.5 and 5.2.

The events in Classes 1 and 2 represent occurrences which are anticipated during Plant operation, and their consequences, which are small, are considered within the framework of routine effluents from the Plant.

7.1.3.3 Class 3 - Radwaste System Failure

Class 3 accidents are postulated to involve the release of radioactivity to the environment through a failure or malfunction in the radwaste system.

Because liquids released by an accident would be retained on the Site during the accident, and because the liquids would not contribute significantly to an off-Site exposure, only the inventory of radioactive gases in the various radwaste tanks is of importance. The possibility of an equipment failure or serious malfunction is remote due to the general design of the system and the in-service inspection performed on the systems. A number of combinations of inadvertent operator errors and equipment malfunctions or failures could be identified which might result in a release of some or all of the radioactivity stored in the various radwaste tanks. In general, the amounts of radioactivity which could be released by any such combination of events are limited in the following ways: 4

Plant Feature	Function
Limits on reactor coolant activity	Restricts total curies present in radwaste system tanks
Radiation monitors	Allows early detection of release, allowing operator action to terminate release

Limits on tank size	Restricts total curies present in any one tank
Isolation valves	Allows operator to terminate release
Interlock procedures	Reduces probability of inadvertent releases

Three releases of different types have been analyzed in order to cover the range of postulated events.

7.1.3.3.1 Equipment Leakage or Malfunction

The accident postulated is a failure of equipment in the Liquid Radwaste System that would cause the sudden release of 25 percent of the maximum volume contained in the waste collector tank. This tank is considered because its failure would result in the largest amount of radioactivity released from the building by the failure of any one tank. The radioactivity of the liquid released is based on the normal accumulation of radwaste over a 24-hour period.

The accident might occur as a result of operator error in conjunction with a connecting pipe failure. This possibility is considered extremely remote. The parameters and assumptions used in this analysis are that: 4

a. Twenty-five percent of the maximum volume of accumulated liquid waste will be spilled.

b. Iodine partition factor is 100.

c. Noble gas release as a result of the accident is negligible.

d. Meteorology for less than 8 hours is used because the release from this accident is expected to last for less than 8 hours.

The radioactivity released to the environment is given in Table 7.1-4. The thyroid inhalation dose to an individual located at the Exclusion Area boundary as a result of this accident is given in Table 7.1-3.

7.1.3.3.2 Low Temperature Off-Gas Adsorption Tank Rupture

The off-gas low temperature adsorption system has been incorporated in the Plant design to reduce the gaseous radwaste releases from the Plant. It is assumed that within this system, the first low temperature charcoal bed failure would result in the most significant whole-body dose. The analysis of this event is based on the following assumptions:

a. Source term 50,000 microcuries/sec release rate after 30-minutes decay, and maximum accumulated activity in the first charcoal bed is based on 181 days buildup time for xenon and 4.2 days for krypton.

b. Ten percent of the activity contained in the charcoal bed is released.

c. Meteorology for less than 8 hours is used because the release from this accident is expected to last for less than 8 hours.

The radioactivity released to the environment is given in Table 7.1-5. The resultant whole-body gamma and beta skin doses to an individual located at the Exclusion Area Boundary are given in Table 7.1-3. The whole-body population dose to individuals living within 50 miles of the reactors is given in Table 7.1-6. 4

7.1.3.3.3 Release of Liquid Waste Collector Tank Contents

This accident is defined to be the sudden release of 100 percent of the maximum volume contained in the radwaste collector tank. Other assumptions used in evaluating the consequences of this accident are identical to those used in the Class 3.1 accident. The radioactivity released to the environment is given in Table 7.1-7. The thyroid inhalation dose to an individual located at the Exclusion Area Boundary as a result of this accident is given in Table 7.1-3. In making an assessment of the probability of releases of this type, it is not possible to establish precise numerical values. Events in Class 3 are not anticipated during Plant operation, but an event of this type could occur sometime during the 40-years of Plant life.

7.1.3.4 Class 4 - Fission Products in Primary System (BWR)

Class 4 accidents are postulated as those events that release radioactivity from the fuel into the primary system. Examples given include assumptions of fuel failures during normal operation and off-design transients that induce fuel failures above those expected.

In order to demonstrate the potential environmental consequences of this type of accident, two accidents are postulated and evaluated:

a. Fuel cladding defects

b. Off-design transients that induce fuel failures above those expected (such as flow blockage and flux maldistributions).

7.1.3.4.1 Fuel Cladding Defects

Releases from these events are included and evaluated under routine releases in accordance with proposed Appendix I of 10 CFR 50 and are included in the routine radioactive discharge in Section 5.2. 4

7.1.3.4.2 Off-Design Transients that Induce Fuel Failures Above Those Expected (Such as Flow Blockage and Flux Maldistributions)

This accident is assumed to induce fuel failures in the core above those expected. The following assumptions are postulated for an off-design transient:

a. A release of 0.02 percent of the core inventory of noble gases and 0.02 percent of the core inventory of halogens occurs into the reactor coolant.

b. One percent of the halogens and 100 percent of the noble gases in the reactor coolant are released into the steam.

c. The air ejector is automatically isolated by a high radiation signal in the steam line.

d. Radioactivity carries over to the condenser, where 10 percent of the halogens and 100 percent of the noble gases are available for leakage from the

condenser to the environment at 0.5 percent per day for the course of the accident (24 hours).

e. Meteorology for short term (less than 8 hrs) releases was used for this accident.

The radioactivity released to the environs for the duration of the accident is given in Table 7.1-8.

The resultant whole-body gamma, thyroid inhalation, and beta skin doses to an individual located at the minimum Exclusion Area Boundary are given in Table 7.1-3. The whole-body population dose to individuals living within 50 miles of the reactors is given in Table 7.1-6.

7.1.3.5 Class 5 - Fission Products to Primary and Secondary Systems (PWR)

Analysis of a Class 5 accident is not applicable because the S/HNP uses a BWR.

7.1.3.6 Class 6 - Refueling Accidents Inside Containment

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Class 6 accidents are postulated to include refueling accidents inside the containment. Because refueling requires that the drywell head and reactor vessel head be removed, the drywell is open and radioactive material released as a result of fuel failure from this class of accidents is available for transport directly to the containment. These contaminants are released to the environs via the containment purge exhaust system after being treated by a series of roughing, HEPA, and charcoal filters. Following a refueling accident, operators will initiate evacuation of personnel from the the containment and initiate emergency procedures as appropriate for the amount of radioactivity released to the environs. It should be noted that the containment system will automatically isolate on detection of high radiation levels in the containment purge system.

To demonstrate the potential environmental consequences of this type of accident, two refueling accidents are postulated and evaluated:

a. Fuel bundle drop

b. Heavy object drop onto fuel in core.

7.1.3.6.1 Fuel Bundle Drop

A fuel bundle drop is postulated to occur as a result of the mishandling of a spent fuel assembly. The accident is assumed to result in damage to one row of fuel rods in the assembly. The subsequent release of radioactivity from the damaged fuel assembly will bubble through the water covering the assembly, where most of the radioactive iodine will be entrained. The following assumptions are postulated for a fuel bundle drop accident:

a. The gap activity (noble gases and halogens) in one row of fuel rods is released into the water. (Gap activity is one percent of total activity in a rod.)

b. One-week decay time occurs before the accident.

c. Iodine decontamination factor in water is 500. Noble gases are not retained by water.

d. Charcoal filter efficiency for iodines is 99 percent.

e. All fission products released to the containment atmosphere were conservatively assumed to be available for release to the environment over the duration of the incident, although containment isolation can be achieved before all of the activity is released directly to the environment. 4

f. Meteorology for less than 8 hours is used because the release from this accident is expected to last for less than 8 hours.

The activity contained in the fuel rod gap and that released from the Reactor Building as a result of this accident is given in Table 7.1-9. The resultant whole-body gamma, thyroid inhalation, and beta skin doses to an individual located at the Exclusion Area Boundary are given in Table 7.1-3. The total population dose to individuals living within 50 miles of the reactors is given in Table 7.1-6.

7.1.3.6.2 Heavy Object Drop Onto Fuel in Core

This accident is assumed to result in damage to an average fuel assembly. The same assumptions as used in the fuel

bundle drop accident apply, except that 100 hours of decay time is assumed before the object drop occurs.

The radioactivity released to the pool water and that from the Reactor Building as a result of this accident is given in Table 7.1-10. The resultant whole-body gamma, thyroid inhalation, and beta skin doses to individuals located at the Exclusion Area Boundary are given in Table 7.1-3. The total population dose to individuals living within 50 miles of the reactors is given in Table 7.1-6.

7.1.3.7 Class 7 - Spent Fuel Handling Accidents

Class 7 accidents are postulated to include spent fuel handling accidents outside the Reactor Building. This class of accident can occur inside the Fuel Building or on the Site. In the case of the latter, this would result in the release of radioactive material directly into the environs. For accidents occurring inside the Fuel Building, the following conditions exist. The Fuel Building exhaust system, which is designed to capture contaminants that may escape through the spent fuel pool and fuel transfer pool surface during fuel handling, is in operation. Contaminants captured by this system will be treated by a series of roughing, HEPA, and charcoal filters 4
before discharge to the environs. Following a fuel-handling accident inside the Fuel Building, evacuation and isolation of the building will be initiated. Following isolation of the building HVAC system, the Fuel Building atmosphere will be treated by the Standby Gas Treatment System.

In order to demonstrate the potential environmental consequences of this type of accident, three spent fuel-handling accidents are postulated and evaluated:

a. Fuel assembly drop in fuel storage pool

b. Heavy object drop onto fuel rack

c. Fuel cask drop.

7.1.3.7.1 Fuel Assembly Drop in Fuel Storage Pool

This accident is defined as the mishandling of a spent fuel assembly. This accident assumes the same radioactivity release as postulated for a Class 6.1 accident. The

assumptions used in evaluating this accident, as well as the resultant off-site doses, are identical to Class 6.1.

7.1.3.7.2 Heavy Object Drop Onto Fuel Racks

This accident assumes a release of radioactivity from a damaged fuel assembly similar to that postulated for the Class 6.2 accident, except that a 30-day decay period before the accident occurs is assumed. Other assumptions used are identical to those in Class 6.2. Table 7.1-11 lists the activity release from the fuel assembly to the spent fuel pool and the activity released to the environment.

The whole-body gamma, thyroid inhalation, and beta skin doses to an individual at the Exclusion Area Boundary as a result of the accident are given in Table 7.1-3. The total population dose to persons living within 50 miles of the reactors is given in Table 7.1-6.

7.1.3.7.3 Fuel Cask Drop

A fuel cask drop is postulated to occur as a result of the mishandling of a fuel cask. The accident is assumed to result in damage to all fuel assemblies contained in one fully loaded cask. The following assumptions are postulated for a fuel cask drop accident: 4

a. Noble gas gap activity from one fully loaded fuel cask (120-day cooling and decay) is released. Gap activity is 1 percent of total activity in the pins.

b. A fully loaded cask contains 32 fuel assemblies. This assumption is based upon transportation by rail and the General Electric IF 400 size cask.

c. The accident occurs outside of the Fuel Building, resulting in the release of 100 percent of the gap activity from one fully loaded cask directly to the environs.

d. Meteorology for less than 8 hours is used because the release from this accident is expected to last for less than 8 hours.

Table 7.1-12 lists the activity released from a fully loaded cask. The whole-body gamma and beta skin doses to

an individual at the Exclusion Area boundary as a result of this accident is given in Table 7.1-3. The total population dose to persons living within 50 miles of the reactors is given in Table 7.1-6.

During fuel handling operations in the Reactor and Fuel Buildings, there exists the remote possibility that one or more fuel assemblies will sustain some mechanical damage by being dropped, having something dropped on them, or through rough handling while being moved in and out of storage racks, the conveyor car, etc. There exists an even more remote possibility that this damage will be severe enough to breach the cladding and release some of the radioactive fission products contained therein. Accidents in Classes 6 and 7 are of similar or lower probability compared to accidents in Class 3 and 4, but are still possible.

7.1.3.8 Class 8 - Accident Initiation Events Considered Design Basis Evaluation in the Safety Analysis Report

Class 8 accidents include the inside containment loss-of-coolant accident (small and large pipe breaks), and the reactivity excursion accident (control rod drop). The break in an instrument line that penetrates the containment and that contains primary coolant is not applicable because there are no such lines. 4

7.1.3.8.1 Loss-of-Coolant-Accidents (LOCA)

A LOCA is defined as a loss of reactor coolant due to a sudden circumferential rupture of a reactor coolant system pipe or any line connected to that system.

To demonstrate the potential environmental consequences of this type of accident, two LOCAs are postulated and evaluated:

a. Small pipe break (6 inch diameter or less)

b. Large pipe break.

7.1.3.8.1.1 Small Pipe Break (6 inch or less). The following assumptions and parameters are postulated for evaluating the environmental consequences of LOCA for a small pipe break (6 inch or less):

a. Source Term: The average radioactivity inventory in the primary coolant given in Table 7.1-13 is released to the containment. This inventory is based on the off-gas release rate of 50,000 microcuries/sec after 30 minutes delay.

b. The effects of plateout and decontamination factor in the pool reduce the source term 20%.

c. The effects of radiological decay during holdup in the containment are taken into account.

d. The free iodine and the noble gases available for release from the containment leak from the containment to the environment at a rate of 0.1 percent of the contained volume per day for the first 24 hours, and at 0.05 percent of the contained volume per day for the remainder of the accident.

e. No mixing occurs in the annulus region between the Containment and the Enclosure Building,

f. Negative pressure in the annulus is maintained for the duration of the accident and whatever is leaked from the containment is released through the Standby Gas Treatment System.

g. Charcoal adsorber efficiency for the Standby Gas Treatment System is 99 percent for iodines.

h. The breathing rate for persons off-Site is 3.47×10^{-4} meters^3/sec for the first 8 hours. From 8 to 24 hours following the accident, the breathing rate is assumed to be 1.75×10^{-4} meters^3/sec. Thereafter, the rate is assumed to be 2.32×10^{-4} meters^3/sec.

i. Short-lived isotopes for short-term release contribute a significant amount of radioactivity; therefore, credit is taken for the radiological decay in transit for a period less than 8 hours, thereafter, no credit is taken for decay.

j. Meteorology for both short time (less than 8 hours) and longer time (8 hours to 30 days) releases is used.

The release and resulting doses as a function of time from accident onset are given in Tables 7.1-14 and 7.1-15. The total population dose to persons living within 50 miles of the reactors is given in Table 7.1-6.

7.1.3.8.1.2 Large Pipe Break. The LOCA large pipe break is assumed to be a sudden circumferential break in a recirculation line, permitting the discharge of coolant into the primary containment from both sides of the break. The assumptions and parameters postulated for evaluating the environmental consequences of this accident are identical to those assumed for the LOCA small pipe break with the following exceptions:

a. Source Term: The average radioactivity inventory in the reactor coolant given in Tables 7.1-3 is assumed to be released to the containment (this inventory is based on an off-gas release rate of 50,000 microcuries/sec after 30 minutes delay), plus a release into the coolant of 0.2 percent of the core inventory of halogens and noble gases given in Table 7.1-16.

b. The individual fission product inventories in the core are calculated for the end of core life (1000 days) assuming full power operation of 4100 MWt.

The release and resulting doses as a function of time are given in Tables 7.1-17 and 7.1-15. The total population dose to persons living within 50 miles of the reactors is given in Table 7.1-6.

4

7.1.3.8.1.3 Class 8.1 (a), Break in Instrument Line From Primary System That Penetrates the Containment. This accident is postulated to involve lines not provided with isolation capacity inside containment. This type of accident is not appropriate for the Skagit BWR containment system.

7.1.3.8.2 Control Rod Accidents

7.1.3.8.2.1 Class 8.2 (a), Rod Ejection Accident (Pressurized Water Reactor). This class of accident is not applicable for this analysis.

7.1.3.8.2.2 Class 8.2 (b), Rod Drop Accident (Boiling Water Reactor). A rod drop accident is defined as the complete (but not necessarily sudden) rupture, breakage, or disconnection of a random fully-inserted control rod drive from its cruciform control blade, at or near the coupling, in such a way that the blade becomes stuck at its location (fully inserted). This assumption sets up a condition whereby, if the drive were withdrawn, the stuck blade could

later fall from the core causing a reactivity insertion accident. The following assumptions are postulated for a rod drop accident:

a. A release occurs into the coolant of 0.025 percent of the core inventory of noble gases and 0.025 percent of the core inventory of halogens.

b. One percent of the halogens and 100 percent of the noble gases in the reactor coolant are released into the condenser.

c. The air ejector is automatically isolated by a high radiation signal on the steam line.

d. Radioactivity carries over to the condenser, where 10 percent of the halogens and 100 percent of the noble gases are available for leakage from the condenser to the environment at 0.5 percent per day for the course of the accident (24 hours).

e. Meteorology for short term (less than 8 hrs) and longer term (8 hrs to 24 hrs) releases was used for this accident.

The activity released to the environs as a function of time for the duration of the rod drop accident is given in Table 7.1-18. The resultant whole-body gamma, thyroid inhalation, and beta skin doses to an individual located at the Exclusion Area boundary are given in Table 7.1-3. The whole-body population dose to individuals living within 50 miles of the reactors is given in Table 7.1-6. 4

7.1.3.8.3 Steamline Break Accidents

7.1.3.8.3.1 Class 8.3 (a), Steamline Breaks (Pressurized Water Reactor). This class of accident is not applicable for this analysis.

7.1.3.8.3.2 Class 8.3 (b), Steamline Breaks (Boiling Water Reactor). A steamline break accident is a circumferential break of a main steamline outside the containment.

In order to demonstrate the potential environmental consequences of this type of accident, two steamline break accidents are postulated and evaluated:

a. Small pipe break (of 0.25 ft^2)

b. Large pipe break.

For these postulated breaks, considering the most probable operating conditions prior to the break and using realistic assumptions, the calculated two-phase mixture level in the reactor pressure vessel does not reach the steamline before isolation is complete. Therefore, only steam will issue from these breaks for the entire transient.

Small Pipe Break (of 0.25 ft^2): The following assumptions and parameters are postulated for evaluating the environmental consequences of a main steamline break accident for a small pipe break:

a. The primary coolant activity based on an off-gas release rate of 50,000 microcuries/sec after 30 minutes delay is given in Table 7.1-13.

b. The main steamline will release coolant for 5 seconds after the isolation signal is received.

c. The total amount of steam escaping from the break is 62,500 lb. This quantity is the sum of a steam loss of 2-minute duration prior to reactor trip and a steam loss during 5.0 seconds complete closure of the main steamline isolation valve. 4

d. Iodine in the fluid released to the atmosphere is at one-tenth the primary system liquid concentration.

e. Fifty percent of the iodines and 100 percent of the noble gases in the fluid exiting through the break are released to the atmosphere.

f. Meteorology for less than 8 hours is used, as the release from this accident is expected to last for less than 8 hours.

The total activity released to the environs is given in Table 7.1-19. The resultant whole-body gamma, thyroid, and beta skin doses to an individual located at the Exclusion Area Boundary are given in Table 7.1-3. The whole-body population dose to individuals living within 50 miles of the reactors is given in Table 7.1-6.

Large Pipe Breaks: The assumptions and parameters postulated for evaluating the evironmental consequences of a main steamline break accident for a large pipe break are identical to those given for a small pipe break, with the

exception that the total amount of steam escaping from the break is 34,000 lb. This quantity is the sum of a steam loss of 0.5 seconds duration prior to reactor trip and a steam loss during complete closure of the main steamline isolation valve. It is assumed that the main steamline will release coolant for 5 seconds after the isolation signal is received.

The total activity released to the environs is given in Table 7.1-20. The resultant whole-body gamma, thyroid inhalation, and beta skin doses to an individual located at the Exclusion Area Boundary are given in Table 7.1-3. The whole-body population dose to individuals living within 50 miles of the reactors is given in Table 7.1-6.

In making an assessment of the probability of the occurrence of typical events considered as design basis accidents in the Safety Analysis Report, a firm numerical estimate is not possible because of the extreme rarity of such events. Quality assurance for design, manufacture, and operation and highly conservative design considerations combine to produce piping and vessels with an extremely low probability of failure. Therefore, when the consequences as indicated in Table 7.1-3 are weighted by probabilities, the environmental risk is low.

7.1.3.9 Class 9: Hypothetical Failures More Severe Than Class 8 Failures 4

The postulated occurrences in Class 9 are discussed in Section 7.4.

7.1.4 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

In the preceding discussion, a number of possible Plant accidents and abnormal operating conditions have been identified and analyzed. These selected events cover the full range of accident analyses required in the NRC guidelines (Ref 1). The resulting estimates of potential Exclusion Area Boundary doses, along with an assessment of the likelihood of each event, are listed in Table 7.1-3. Table 7.1-6 summarizes the various accidents for the whole-body population dose within 50 miles of the reactors.

In the column giving the general assessment of the likelihood of these events and conditions, several categories have been used. Those conditions classified as "Certain" are continuous (i.e., the condition is normal, or present at all times). The radiation exposures given for natural

background and normal operation are annual values. Those events which could be expected to occur at frequencies of from once per Plant lifetime to as often as once per year are classified "Occasional". Those events or conditions which would be expected to occur at frequencies less than once per Plant lifetime are classified "Rare". Finally, there are a number of events which are considered very unlikely, with projected probabilities much less than once per Plant lifetime. These events have been classified "Extremely Rare".

From the results in the table, several specific conclusions can be reached concerning off-Site dose:

a. As discussed in the introduction, the radiation exposures which would result from the occurrence of accidents are generally lower than those expected from normal operation, and much lower than that from natural background radiation.

b. When these potential exposures are considered in conjunction with their probabilities of occurrence, the resulting environmental impact is negligible.

c. Because the radiation exposure received from natural background continually varies 5 to 20 percent because of natural events, the population exposures possible from Plant accidents are negligible when compared to these natural variations. For example, a 5-percent increase in the natural background for a year would result in an additional 2163 man-rem within 50 miles of the reactors. This amount far overshadows any potential population exposure from any accident considered. 4

d. Most of the radiation dose levels are so low as to be undetectable, even with the most sensitive, modern radiation detection instruments.

The information given in Table 7.1-3 indicates that the realistically estimated radiological consequences of the postulated accidents would result in exposures of an assumed individual at the Exclusion Area Boundary well within the maximum permissible doses of 10 CFR 20. The tabulated information also shows that the estimated integrated exposure of the population within 50 miles of the reactors from each postulated accident would be orders of magnitude smaller than that from the naturally-occurring radioactivity which corresponds to approximately 43,262 man-rem/yr, based on a natural background level of 0.10 rem/yr

and a predicted population within 50 miles of the reactors for the year 2030. When considered with the probability of occurrence, the annual potential radiation exposure of the population from all the postulated accidents is an even smaller fraction of the exposure from natural background radiation and, in fact, is well within naturally-occurring variations in the natural background. It is concluded form the results of the realistic analysis that the environmental risks due to postulated radiological accidents at the Plant Site are exceedingly small and need not be considered further.

7.1.5 DOSE MODELS USED TO EVALUATE THE ENVIRONMETAL CONSEQUENCES OF ACCIDENTS

This discussion identifies the models used to calculate off-Site radiological doses that would result from releases of radioactivity due to various postulated accidents. The postulated accidents are listed in Table 7.1-1.

7.1.5.1 Assumptions

The following assumptions are basic to both the model for the whole-body dose due to immersion in a cloud of radioactivity and the model for the thyroid dose due to inhalation of radioactivity: 4

a. Direct radiation from the source point is negligible compared to whole-body radiation due to submersion in the radioactivity leakage cloud.

b. All radioactivity releases are treated as ground level releases regardless of the point of discharge.

c. The dose receptor is a standard man, as defined by the International Commission on Radiological Protection (ICRP) (Ref 9).

d. Isotopic data, such as decay constants and decay energy emissions, are taken from Table of Isotopes (Ref 6). Table 7.1-21 lists those values.

e. Dose conversion factors are taken from TID-14844 (Ref 4) and from Regulatory Guide 1.109 (Ref 10). Gamma and Beta dose conversion factors are obtained by using the method of Meteorology and

Atomic Energy (Ref 11). Tables 7.1-21 and 7.1-2 lists these values.

7.1.5.2 Whole-Body Dose

Calculation of the gamma dose from an extended source, such as a cloud, starts with the consideration that the radiation received by the receptor from a differential area or volume is the same as if it came from a point source. If the dimensions of a homogeneous cloud of gamma-emitting material are large compared with the distance that the gamma rays travel, an equilibrium condition occurs, provided the receptor volume is small. A cloud with these dimensions acts as though the plume were an infinite source of gamma-emitting material. For a receptor at ground level, only half the passing cloud contributes to the gamma dose of the receptor.

The semi-infinite whole-body gamma dose is given by the following equation:

$$ {}_{\gamma}D_{\infty} = 0.25 \ (X/Q) \sum_{i=1}^{N} Q_i \ \bar{E}_i \qquad (7.1\text{-}1) $$

4

where:

${}_{\gamma}D_{\infty}$ = gamma dose from semi-infinite cloud (rad)

$\bar{E}_i$ = average gamma energy for isotope i (MEV/dis) (values given in Table 7.1-21)

Q_i = source strength (curie).

X/Q = atmospheric dilution factor (sec/meter^3)

7.1.5.3 Thyroid Inhalation Dose

Assuming the atmospheric dilution factors given in Tables 6.1-8 and 6.1-9, the thyroid dose for a given time period is obtained from the following equation:

$$D = \chi/Q \; \beta \sum_{i=1}^{N} Q_i \; DCF_i \qquad (7.1\text{-}2)$$

where:

D = thyroid inhalation dose (rem)

χ/Q = atmospheric dilution factor (sec/meter^3)

N = Number of isotopes

β = breathing rate (meter^3/sec)

Q_i = total activity of iodine isotope i released, (curies)

DCF_i = dose conversion factor given in Table 7.1-21 for iodine isotope i (rem/curies inhaled)

The isotopic data and breathing rates are given in Table 7.1-21.

7.1.5.4 Beta Skin Dose (Ref 12)

4

Assuming the atmospheric dilution factors given in Tables 6.1-8 and 6.1-9 for a semi-infinite cloud of beta radiation, the dose in air is given by:

$$_{\beta}D_{\infty} = \chi/Q \sum_{i=1}^{N} Q_i \; DCF_i \qquad (7.1\text{-}3)$$

where:

$_{\beta}D$ = beta dose from a semi-infinite cloud (rem)

DCF_i = dose conversion factor given in Table 7.1-21

χ/Q = atmospheric dilution factor (sec/meter^3)

Q_i = activity of radioactive material released as a result of equipment failures (C_i)

N = number of isotopes

7.1.6 MODELS AND DATA FOR EVALUATING RADIOLOGICAL SOURCE TERMS

The evaluation of the radiological impact of accidents involves assumptions and application of data. Many of the assumptions are stated in NRC Regulatory Guide 4.2. Other assumptions are specified in the discussions of the individual accidents. Although the accidents are dissimilar, many of the models and much of the data are commonly used in the evaluations. It is the purpose of this section to provide the general information used for accident evaluations.

Fission product inventories for the core and gap are based on operation at 4100 MWt for 1000 days full power operation. The reactor thermal power is based on the maximum design condition. Activity inventories for the total core, total gap, and gap of one fuel rod (848 assemblies, 63 rods per assembly) are given in Table 7.1-16.

Reactor coolant concentrations of iodines based on an off-gas release rate of 50,000 microcuries/sec at 30 minutes decay are given in Table 7.1-13.

References for Section 7.1

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2. Statement of Interim Policy, "Nuclear Power Plant Accident Considerations Under the National Environmental Policy Act of 1969," 45 FR 40101-40104, June 13, 1980.

3. J. E. Meek and B. F. Rider, Summary of Fission Product Yields for U-235, Pu-239, and Pu-241, at Thermal, Fission Spectrum and 14 Mev Neutron Energies, Report Number APEC-3398 (March 1, 1964).

4. J. J. DiNunno et al, Calculation of Distance Factors for Power and Test Reactor Sites, AEC Report Number TID-14844 (March 1, 1962)

5. J. O. Blomeke and M. F. Todd, Uranium-235 Fission - Product Production as a Function of Thermal Neutron Flux, Irradiation Time, and Decay Time, AEC Report Number ORNL-2127 (August 19, 1957)

6. C. M. Lederer et al, Table of Isotopes, 6th edition (1968).

7. ICRP Publication 2, Report of Committee II Permissible Dose for Internal Radiation (1959).

8. AEC Regulatory Guide 1.3, Rev 2, Assumptions Used for Evaluating the Potential Radiological Cosnequences of a Loss of Coolant Accident for Boiling Water Reactors (June 1974)

9. "Report of ICRP Committee II Permissible Dose for Internal Radiation (1959)", Health Physics, 3:30, pp 146-153 (1960).

10. Regulatory Guide 1.109, Rev 1, Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I (October 1977).

11. D. H. Slade, Meteorology and Atomic Energy, TID-24190 (July 1968).

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12. M. J. Berger, "Beta-Ray Dose in Tissue-Equivalent Material Immersed in a Radioactive Cloud", Health Physics, Vol 26 No. 1 (1974). 4

TABLE 7.1-1

CLASSIFICATION OF POSTULATED ACCIDENTS AND OCCURRENCES

No. of Class	Description	Example(s)
1	Trivial incidents	Small spills; small leaks inside containment
2	Misc. small releases outside containment	Spills; leaks and pipe breaks
3	Radwaste system failures	Equipment failure; serious malfunction or human error
4	Events that release radioactivity into the primary system (BWR)	Fuel failures during normal operation; transients outside expected range of variables
5	Events that release radioactivity into the primary and secondary system (PWR)	Class 4 and steam generator leak
6	Refueling accidents inside containment	Drop fuel element; drop heavy object onto fuel; mechanical malfunction or loss of cooling in transfer tube
7	Accidents to spent fuel outside containment	Drop fuel element; drop heavy object onto fuel; drop shielding cask - loss of cooling to cask; transportation incident on-Site
8	Accident initiation events considered in design-basis evaluation in the Safety Analysis Report	Reactivity transient; rupture of primary piping; flow decrease - steam break
9	Hypothetical sequence failures more severe than Class 8	Successive failure of multiple barriers normally provided and maintained

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TABLES 7.1-2

GAMMA DOSE CONVERSION FACTOR

Isotope	Conversion Factor rem-m^3/curies/sec
Kr-83m	2.40E-06
Kr-85m	3.71E-02
Kr-85	5.11E-04
Kr-87	1.88E-01
Kr-88	4.66E-01
Xe-131m	2.90E-03
Xe-133m	7.96E-03
Xe-133	9.32E-03
Xe-135m	9.89E-02
Xe-135	5.74E-02
Xe-137	4.50E-02
Xe-138	2.80E-01

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TABLE 7.1-3

Sheet 1 of 2

SUMMARY OF DOSES RESULTING FROM ACCIDENTS AT EXCLUSION AREA BOUNDARY
(3050 meters)

Accident Class	Description	Thyroid (rem)	Whole-Body Gamma Dose (rem)	Beta Skin Dose (rem)	General Assessment of Likelihood
Natural (Annual)	Background Radiation	1.0E-01	1.0E-01	---	certain
Expected Release from Normal Operation (Annual)		Negligible	(Section 5.2)	(Section 5.2)	certain
1.0(a)	TRIVIAL ACCIDENTS	---	---	---	occasional
2.0(a)	SMALL RELEASES OUTSIDE CONTAINMENT	---	---	---	occasional
3.0	RADWASTE SYSTEM FAILURES				
3.1	Equipment Leakage or Malfunction	6.6E-03	---	---	rare
3.2	Release from Low Temperature Charcoal Adsorption Tank Rupture	---	1.3E-04	0.4E-05	rare
3.3	Release of Liquid Waste Collector Tank Contents	5.3E+00	---	---	rare
4.0	FISSION PRODUCTS TO PRIMARY SYSTEM (BWR)				
4.1(a)	Fuel Cladding Defects	---	---	---	occasional
4.2	Off-Design Transients that Induce Fuel Failures Above Those Expected	4.1E-04	9.1E-05	9.3E-05	rare
5.0	FISSION PRODUCTS TO PRIMARY AND SECONDARY SYSTEM (PWR)	----------Not Applicable----------			
6.0	REFUELING ACCIDENT				
6.1	Fuel Bundle Drop	1.0E-05	1.6E-05	1.5E-05	rare
6.2	Heavy Object Drop Over Fuel in Core	9.0E-05	1.5E-04	1.6E-04	rare
7.0	SPENT FUEL HANDLING ACCIDENTS				
7.1	Fuel Assembly Drop in Fuel Storage Pool	1.0E-05	1.6E-05	1.5E-05	rare
7.2	Heavy Object Drop onto Fuel Rack	9.7E-06	1.3E-05	1.1E-05	rare

TABLE 7.1-2

Accident Class	Description	Thyroid (rem)	Whole-Body Gamma Dose (rem)	Beta Skin Dose (rem)	General Assessment of Likelihood
7.3	Fuel Cask Drop	---	2.7E-06	1.7E-04	rare
8.0	ACCIDENT INITIATION EVENTS CONSIDERED IN DAR				
8.1	Loss-of-Coolant Accidents				
	Small Pipe Break	3.5E-08	1.7E-10	7.7E-11	Extremely rare
	Large Pipe Break	6.4E-03	2.4E-04	1.7E-04	Extremely rare
8.1(a)	Break in Instrument Line from Primary System that Penetrates the Containment	Not Applicable			
8.2(a)	Rod Ejection Accident (PWR)	Not Applicable			
8.2	Rod Drop Accident (BWR)	5.1E-04	1.1E-04	6.6E-05	Extremely rare
8.3(a)	Steamline Breaks (PWR)	Not Applicable			
8.3	Steamline Breaks (BWR)				
	Small Break	8.5E-05	3.9E-06	4.7E-06	Extremely rare
	Large Break	5.0E-05	2.5E-06	2.0E-06	Extremely rare

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TABLE 7.1-4

CLASS 3.1 ACCIDENT

RADIOACTIVITY RELEASED AS A RESULT
OF EQUIPMENT LEAKAGE OR MALFUNCTION
(Liquid Waste Collector Tank)

Isotope	Radioactivity Released to the Environment (curies)
I-131	1.42E-04
I-132	3.20E-04
I-133	6.84E-04
I-134	1.60E-04
I-135	5.44E-04

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TABLE 7.1-5

CLASS 3.2 ACCIDENT

RADIOACTIVITY RELEASED AS A RESULT OF THE FIRST CHARCOAL BED FAILURE IN THE LOW-TEMP RECHAR SYSTEM

Isotope	Charcoal Bed Radioactivity (curies)	Radioactivity Released to Environment (curies)
Kr-83m	1.14E+01	1.14E+00
Kr-85m	6.94E+01	6.94E+00
Kr-85	1.84E+00	1.84E-01
Kr-87	6.46E+01	6.46E+00
Kr-88	1.44E+02	1.44E+01
Xe-131m	1.10E+01	1.10E+00
Xe-133m	4.06E+01	4.06E+00
Xe-133	2.72E+03	2.72E+02
Xe-135m	4.62E+00	4.62E-01
Xe-135	5.20E+02	5.20E+01
Xe-137	1.22E-01	1.22E-02
Xe-138	2.06E+01	2.06E+00

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TABLE 7.1-6 Sheet 1 of 2

SUMMARY OF POPULATION DOSES RESULTING FROM ACCIDENTS

Accident Class	Description	Year 2030 Man-rem
1.0(1)	TRIVIAL ACCIDENTS	---
2.0(1)	SMALL RELEASES OUTSIDE CONTAINMENT	---
3.0	RADWASTE SYSTEM FAILURES	
3.1	Equipment Leakage or Malfunction	---
3.2	Release From Low-Temp Charcoal Adsorbtion Tank Rupture Tank Contents	3.6E+00
3.3	Release of Liquid Waste Collector Tank Contents	---
4.0	FISSION PRODUCTS TO PRIMARY SYSTEM (BWR)	
4.1(1)	Fuel Cladding Defects	---
4.2	Off-Design Transients that Induce Fuel Failures Above Those Expected	2.4E+00
5.0	FISSION PRODUCTS TO PRIMARY AND SECONDARY SYSTEM (PWR)	-Not Applicable-

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TABLE 7.1-6 Sheet 2 of 2

Accident Class	Description	Year 2030 Man-rem
6.0	REFUELING ACCIDENTS	
6.1	Fuel Bundle Drop	4.4E-01
6.2	Heavy Object Drop Over Fuel in Core	4.1E+00
7.0	SPENT FUEL HANDLING ACCIDENTS	
7.1	Fuel Storage Pool	4.4E-01
7.2	Heavy Object Drop onto Fuel Rack	3.7E-01
7.3	Fuel Cask Drop	7.4E-02
8.0	ACCIDENT INITIATION EVENTS CONSIDERED IN SAR	
8.1	Loss-of-Coolant Accidents	
	Small Pipe Break	4.3E-06
	Large Pipe Break	5.7E+00
8.1(a)	Break in Instrument Line from Primary System that Penetrates the Containment	--Not Applicable--
8.2(a)	Rod Ejection Accident (PWR)	--Not Applicable--
8.2(b)	Rod Drop Accident (BWR)	3.1E+00
8.3(a)	Steamline Breaks (PWR)	--Not Applicable--
8.3(b)	Steamline Breaks (BWR)	
	Small Break	1.1E-01
	Large Break	6.9E-02

(1) Incidents included and evaluated under routine releases contained in Section 5.2.

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TABLE 7.1-7

CLASS 3.3 ACCIDENT

RADIOACTIVITY RELEASED AS A RESULT
OF GROSS EQUIPMENT FAILURE
(Liquid Waste Collector Tank)

Isotope	Radioactivity Released to the Environment (curies)
I-131	5.68E-04
I-132	1.27E-03
I-133	2.74E-03
I-134	6.40E-04
I-135	2.18E-03

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TABLE 7.1-8

CLASS 4.2 ACCIDENT

RADIOACTIVITY RELEASED AS THE RESULT OF AN OFF-DESIGN TRANSIENT ACCIDENT

Isotope	Radioactivity Released to Environment (curies) Time Period (hours)		
	0 - 2	2 - 8	8 - 24
I-131	9.88E-03	2.92E-02	7.47E-02
I-132	1.07E-02	1.06E-02	1.99E-03
I-133	1.59E-02	4.15E-02	7.68E-02
I-134	1.06E-02	2.65E-03	2.20E-05
I-135	1.51E-02	2.99E-02	2.70E-02
Kr-83m	7.22E-01	5.83E-01	6.95E-02
Kr-85m	1.91E+00	3.15E+00	1.84E+00
Kr-85	1.02E-01	3.07E-01	8.17E-01
Kr-87	2.49E+00	1.21E+00	4.70E-02
Kr-88	4.57E+00	5.51E+00	1.58E+00
Xe-131m	6.15E-02	1.83E-01	4.73E-01
Xe-133m	6.74E-02	1.92E-01	4.45E-01
Xe-133	1.91E+01	5.59E+01	1.40E+02
Xe-135m	1.08E+00	5.26E-03	5.95E-10
Xe-135	3.11E+00	6.93E+00	8.44E+00
Xe-137	7.54E-01	4.15E-10	0
Xe-138	3.13E+00	2.72E-02	1.75E-08

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TABLE 7.1-9

CLASS 6.1 ACCIDENT

RADIOACTIVITY RELEASED AS A RESULT OF A FUEL BUNDLE DROP ACCIDENT

Isotope	Gap Radioactivity Released to Pool Water (curies)	Radioactivity Released to Environment (curies)
I-131	1.12E+02	2.25E-03
I-133	9.52E-01	1.91E-05
Kr-85	1.84E+00	1.84E+00
Xe-131m	9.98E-01	9.98E-01
Xe-133m	6.24E-01	6.24E-01
Xe-133	1.60E+02	1.60E+02
Xe-135	2.59E-03	2.59E-03

4

TABLE 7.1-10

CLASS 6.2 ACCIDENT

RADIOACTIVITY RELEASED AS A RESULT OF A HEAVY OBJECT DROP ONTO FUEL IN CORE

Isotope	Gap Radioactivity Released to Water (curies)	Radioactivity Released to Environment (curies)
I-131	9.80E+02	1.96E-02
I-133	7.65E+01	1.53E-03
I-135	7.41E-02	1.48E-06
Kr-85m	4.55E-05	4.55E-05
Kr-85	1.45E+01	1.45E+01
Xe-131m	6.81E+00	6.81E+00
Xe-133m	2.70E+00	2.70E+00
Xe-133	1.57E+03	1.57E+03
Xe-135m	0	0
Xe-135	2.42E-01	2.42E-01

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TABLE 7.1-11

CLASS 7.2 ACCIDENT

RADIOACTIVITY RELEASED AS A RESULT
OF A HEAVY OBJECT DROP ONTO FUEL RACK

Isotope	Gap Radioactivity Released to Spent Fuel Pool (curies)	Radioactivity Released to Envriomment (curies)
I-131	1.06E+02	2.13E-03
Kr-85	1.44E+01	1.44E+01
Xe-131m	3.24E+00	3.24E+00
Xe-133m	3.35E-03	3.35E-03
Xe-133	6.15E+01	6.15E+01

4

TABLE 7.1-12

CLASS 7.3 ACCIDENT

RADIOACTIVITY RELEASED AS A RESULT OF FUEL CASK DROP

Isotope	Radioactivity Released to the Environment (curies)
Kr-85	4.53E+02
Xe-131m	2.42E-01
Xe-133	1.22E-02

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TABLE 7.1-13

EQUILIBRIUM PRIMARY[1] COOLANT RADIOACTIVITY

Isotope	Halogen Concentration[2] microcuries/gm	Noble Gas Release Rate microcuries/sec (t=0)
I-131	5.50E-03	-
I-132	5.50E-02	-
I-133	3.70E-02	-
I-134	1.15E-01	-
I-135	5.50E-02	-
Kr-83m	-	1.70E+03
Kr-85m	-	3.06E+03
Kr-85	-	5.00E+00
Kr-87	-	1.00E+04
Kr-88	-	1.00E+04
Kr-89	-	6.50E+04
Xe-131m	-	7.50E+00
Xe-133m	-	1.45E+02
Xe-133	-	4.10E+03
Xe-135m	-	1.30E+04
Xe-135	-	1.10E+04
Xe-137	-	7.50E+04
Xe-138	-	4.46E+04

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(1) Based on an average off-gas release rate of 50,000 microcuries/sec after 30 minutes delay.

(2) Based on reactor coolant water mass of 2.64×10^8 gm.

TABLE 7.1-14

CLASS 8.1 ACCIDENTS

RADIOACTIVITY RELEASED AS A RESULT OF
LOSS-OF-COOLANT ACCIDENT - SMALL PIPE BREAK

Isotope	Radioactivity Released to Environment (curies) Time Period (hours)				
	0 - 2	2 - 8	8 - 24	24 - 96	96 - 720
I-131	2.40E-07	7.12E-07	1.82E-06	3.52E-06	1.06E-05
I-132	1.82E-06	1.81E-06	3.38E-07	1.26E-09	3.24E-19
I-133	1.57E-06	4.12E-06	7.64E-06	4.80E-06	4.48E-07
I-134	2.52E-06	6.34E-09	5.28E-09	7.32E-15	0
I-135	2.18E-06	4.32E-06	3.92E-06	4.28E-07	1.88E-10
Kr-83m	5.32E-07	4.30E-07	5.12E-08	6.62E-11	1.48E-22
Kr-85m	1.16E-06	1.92E-06	1.12E-06	4.90E-09	5.82E-13
Kr-85	2.22E-09	6.64E-09	1.77E-08	3.98E-08	3.42E-07
Kr-87	2.70E-06	1.31E-06	5.08E-08	4.02E-12	0
Kr-88	3.50E-06	4.22E-06	1.21E-06	1.18E-08	2.14E-16
Xe-131m	3.32E-09	9.88E-09	2.56E-08	5.18E-08	2.10E-07
Xe-133m	6.36E-08	1.81E-07	4.2E-07	5.56E-07	8.68E-07
Xe-133	1.81E-06	5.30E-06	1.33E-05	2.36E-05	4.72E-05
Xe-135	4.54E-06	1.01E-05	1.23E-05	2.6E-06	1.11E-08
Xe-135m	1.08E-06	5.24E-09	5.94E-16	0	0
Xe-137	1.56E-06	8.60E-16	0	0	0
Xe-138	4.14E-06	3.60E-08	2.82E-14	0	0

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TABLE 7.1-15

CLASS 8.1 ACCIDENTS

DOSES RESULTING FROM LOSS-OF-COOLANT ACCIDENTS AT EXCLUSION AREA BOUNDARY

Time Periods in hours	Dose in rem		
	Thyroid	Whole Body	Beta Skin
Class 8.1 Accident			
Small Pipe Break			
Total	3.5E-08	1.7E-10	7.7E-11
0 - 2 hrs	2.9E-09	6.4E-11	3.1E-11
2 - 8 hrs	7.4E-09	5.6E-11	2.3E-11
8 - 24 hrs	6.4E-09	3.4E-11	1.6E-11
24 - 96 hrs	7.6E-09	8.1E-12	4.6E-12
96 - 720 hrs	1.1E-08	4.3E-12	2.5E-12
Large Pipe Break			
Total	4.4E-03	2.4E-04	1.7E-04
0 - 2 hrs	2.5E-04	7.2E-05	4.1E-05
2 - 8 hrs	6.9E-04	7.0E-05	3.4E-05
8 - 24 hrs	6.8E-04	4.1E-05	3.2E-05
24 - 96 hrs	1.1E-03	2.8E-05	2.7E-05
96 - 720 hrs	1.8E-03	3.4E-05	3.2E-05

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TABLE 7.1-16

FISSION PRODUCT INVENTORIES
(curies)

Isotope	Core(1)	Gap(2)	Gap Radioactivity(3) Per Rod
I-131	1.19E+08	1.19E+06	2.23E+01
I-132	1.72E+08	1.72E+06	3.22E+01
I-133	1.97E+08	1.97E+06	3.69E+01
I-134	2.54E+08	2.54E+06	4.75E+01
I-135	2.01E+08	2.01E+06	3.76E+01
Kr-83m	1.23E+07	1.23E+05	2.30E+00
Kr-85m	2.67E+07	2.67E+05	5.00E+00
Kr-85	1.23E+06	1.23E+04	2.30E-01
Kr-87	4.92E+07	4.92E+05	9.21E+00
Kr-88	6.97E+07	6.97E+05	1.30E+01
Kr-89	8.20E+07	8.20E+05	1.53E+01
Xe-131m	7.38E+05	7.38E+03	1.38E-01
Xe-133m	8.20E+05	8.20E+03	1.53E-01
Xe-133	2.30E+08	2.30E+06	4.31E+01
Xe-135m	6.97E+07	6.97E+05	1.30E+01
Xe-135	4.02E+07	4.02E+05	7.52E+00
Xe-137	1.93E+08	1.93E+06	3.61E+01
Xe-138	1.80E+08	1.80E+06	3.37E+01

(1) Based on operating power of 4100 MWt

(2) Equal to 1 percent of the total core inventory (Regulatory Guide 4.2)

(3) Based on 848 fuel assemblies in the core and 63 rods per assembly

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TABLE 7.1-17

CLASS 8.1 ACCIDENTS

RADIOACTIVITY RELEASED AS A RESULT OF LOSS-OF-COOLANT ACCIDENT - LARGE PIPE BREAK

Isotope	Radioactivity Released to Environment (curies) Time period (hours)				
	0 - 2	2 - 8	8 - 24	24 - 96	96 - 720
I-131	3.95E-02	1.17E-01	2.99E-01	5.76E-01	1.74E+00
I-132	4.29E-02	4.26E-02	7.98E-03	2.97E-05	7.66E-15
I-133	6.35E-02	1.66E-01	3.08E-01	1.93E-01	1.81E-02
I-134	4.20E-02	1.05E-02	8.77E-05	1.22E-10	0
I-135	6.04E-02	1.20E-01	1.09E-01	1.19E-02	5.22E-06
Kr-83m	1.45E+00	1.17E+00	1.39E-01	1.80E-04	4.02E-16
Kr-85m	3.82E+00	6.30E+00	3.68E+00	1.61E-01	1.91E-06
Kr-85	2.05E-01	6.15E-01	1.64E+00	3.68E+00	3.16E+01
Kr-87	4.99E+00	2.42E+00	9.41E-02	7.43E-06	0
Kr-88	9.14E+00	1.10E+01	3.17E+00	3.08E-02	5.60E-10
Xe-131m	1.23E-01	3.65E-01	9.48E-01	1.92E+00	7.74E+00
Xe-133m	1.35E-01	3.85E-01	8.92E-01	1.18E+00	7.81E-01
Xe-133	3.81E+01	1.12E+02	2.81E+02	5.00E+02	9.94E+02
Xe-135	6.22E+00	1.39E+01	1.69E+01	3.56E+00	1.52E-02
Xe-135m	2.16E+00	1.05E-02	1.19E-09	0	0
Xe-137	1.51E+00	8.31E-10	0	0	0
Xe-138	6.26E+00	5.45E-02	3.51E-08	0	0

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TABLE 7.1-18

CLASS 8.2(b) ACCIDENT

RADIOACTIVITY RELEASED AS THE RESULT OF A ROD DROP ACCIDENT

Isotope	Radioactivity Released to Environment (curies) Time Period (hours)		
	0 - 2	2 - 8	8 - 24
I-131	1.24E-02	3.65E-02	9.35E-02
I-132	1.34E-02	1.33E-02	2.49E-03
I-133	1.98E-02	5.20E-02	9.60E-02
I-134	1.32E-02	3.31E-03	2.75E-05
I-135	1.89E-02	3.74E-02	3.38E-02
Kr-83m	9.04E-01	7.29E-01	8.70E-02
Kr-85m	2.39E+00	3.94E+00	2.30E+00
Kr-85	1.26E-01	3.77E-01	1.00E+00
Kr-87	3.11E+00	1.51E+00	5.87E-02
Kr-88	5.72E+00	6.90E+00	1.98E+00
Xe-131m	7.69E-02	2.28E-01	5.91E-01
Xe-133m	8.43E-02	2.40E-01	5.56E-01
Xe-133	2.38E+01	6.99E+01	1.75E+02
Xe-135m	1.35E+00	6.58E-03	7.45E-10
Xe-135	3.90E+00	8.71E+00	1.06E+01
Xe-137	9.44E-01	5.19E-10	0
Xe-138	3.91E+00	3.40E-02	2.19E-08

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TABLE 7.1-19

CLASS 8.3(b) ACCIDENT

RADIOACTIVITY RELEASED AS THE RESULT OF A STEAM LINE BREAK ACCIDENT - SMALL PIPE BREAK

Isotope	Radioactivity Released to the Environment (curies)
I-131	7.80E-03
I-132	7.80E-02
I-133	5.24E-02
I-134	1.63E-01
I-135	7.80E-03
Kr-83m	2.12E-02
Kr-85m	3.82E-02
Kr-85	6.26E-05
Kr-87	1.25E-01
Kr-88	1.25E-01
Xe-131m	9.38E-05
Xe-133m	1.81E-03
Xe-133	5.12E-02
Xe-135m	1.63E-01
Xe-135	1.38E-01
Xe-137	9.38E-01
Xe-138	5.56E-01

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TABLE 7.1-20

CLASS 8.3(b) ACCIDENT

RADIOACTIVITY RELEASED AS THE RESULT OF A STEAM LINE BREAK ACCIDENT - LARGE PIPE BREAK

Isotope	Radioactivity Released to the Environment (curies)
I-131	4.62E-03
I-132	4.62E-02
I-133	3.12E-02
I-134	9.68E-02
I-135	4.62E-02
Kr-83m	1.27E-02
Kr-85m	2.28E-02
Kr-85	3.76E-05
Kr-87	7.48E-02
Kr-88	7.48E-02
Xe-131m	5.60E-05
Xe-133m	1.09E-03
Xe-133	3.08E-02
Xe-135m	9.74E-02
Xe-135	8.24E-02
Xe-137	5.60E-01
Xe-138	3.32E-01

4

TABLE 7.1-21

PHYSICAL DATA FOR ISOTOPES

Isotope	Decay Constant (hr^{-1})	Gamma Energy (MeV/disint.)	Beta Dose Conversion Factor (rem/sec/curies/m^3)	Thyroid Dose Conversion Factor (rem/curie)
I-131	3.59E-03	3.71E-01	3.06E-02	1.48E+06
I-132	3.07E-01	2.40E+00	-	5.25E+04
I-133	3.41E-02	4.77E-01	-	4.00E+05
I-134	8.00E-01	1.94E+00	-	2.50E+04
I-135	1.07E-01	1.77E+00	-	1.24E+05
Xe-131m	2.45E-03	3.30E-03	1.41E-02	-
Xe-133	5.48E-03	3.00E-02	9.75E-03	-
Xe-133m	1.28E-02	3.26E-02	2.88E-02	-
Xe-135	7.58E-02	2.46E-01	5.98E-02	-
Xe-135m	2.66E+00	4.22E-01	2.00E-02	-
Xe-137	1.07E+01	1.50E-01	2.96E-01	-
Xe-138	2.38E+00	2.87E+00	7.60E-02	-
Kr-83m	3.73E-01	8.00E-04	-	-
Kr-85	7.35E-06	2.10E-03	4.32E-02	-
Kr-85m	1.58E-01	1.51E-01	4.94E-02	-
Kr-87	5.47E-01	1.37E+00	2.27E-01	-
Kr-88	2.48E-01	1.75E+00	3.85E-02	-

4

BREATHING RATES

Time Period (hours)	Breathing Rates ($meter^3$/sec)
0 to 8	3.47E-04
8 to 24	1.75E-04
24 to 720	2.32E-04

7.2 TRANSPORTATION ACCIDENTS INVOLVING RADIOACTIVITY

The transportation of new fuel to the reactor and irradiated fuel from the reactor to a fuel reprocessing plant and the transportation of solid radioactive wastes from the reactor to waste burial grounds is within the scope of paragraph (g) of 10 CFR 51.20. The contribution of the environmental effects of such transportation to the environmental costs of licensing the nuclear power reactors are as set forth in Summary Table S-4 of 10 CFR 51. 4

7.3 OTHER ACCIDENTS

In addition to accidents that can release radioactivity to the environs, there may be accidents involving nonradioactive materials which do have consequences that affect the environment. Accidents such as chemical explosions, fires, ~~and leakage~~ or ruptures of vessels containing oil or toxic materials can have significant environmental impacts. Provisions to minimize these impacts have been included in the S/HNP design.

7.3.1 CHEMICAL

The following chemicals are maintained in storage tanks of various capacities:

a. 66° Baume sulfuric acid

b. 50-percent sodium hydroxide solution

c. 1-percent sodium hypochlorite solution

d. Glycol

e. Sodium pentaborate 4

Each tank will be equipped with level indicators. Periodic visual inspection will be performed of storage tanks and piping systems to detect leakage. Each tank will be diked or curbed to form a controlled drainage area that will be sufficient to hold the entire contents of the tank. The controlled area will be surfaced to prevent leaching. A tank failure would allow the contents to drain into the controlled area, where it would be maintained for transfer to alternate storage by portable pumps. Because the controlled area will not be provided with drain connections, these chemicals cannot be drained to storm sewers or otherwise released to the environment. The sodium pentaborate tanks will be located in the containment and any leakage will be controlled in a curbed area. Chemicals used in Plant operation do not form explosive mixtures.

In the unlikely event of a fire occurring simultaneously with an indoor chemical tank failure, where the liquid would evaporate to gas, normal ventilation facilities would evacuate the vapors outside at elevations where atmospheric dispersion would result in a negligible effect on the environment.

7.3.2. STEAM BOILER

The electric auxiliary boiler has no fuel storage or fuel lines. It is flameless and essentially without fire hazard. The failure of the boiler would release steam and chemically treated water. Chemical treatment of the water consists of the injection of an electrolyte such as sodium-phosphate, sodium-sulfate, etc, into the boiler to maintain the proper conductivity range of 1000 to 3000 micromho/cm. Because the chemical content of the water is low and nontoxic, the off-Site impact on the environment would be negligible.

7.3.3 DIESEL OIL AND TURBINE LUBE OIL TANKS

All underground diesel oil tanks will be either coated or constructed from noncorrosive materials. These tanks will be vented through individual flame arrestors and a low tank level will be alarmed in the control room. In case of leak or spillage, early detection and corrective action will prevent any significant contamination of the environment. The Oily Waste System used to clean up minor oil leaks is described in Secton 3.7.

Lube oil reservoirs and oil coolers will be housed in a 3-hour fire enclosure in the Turbine Building. In the lube oil cooler, the cooling water normally will be maintained at a higher pressure than the lube oil so that leakage would be from the water to the oil system. 4

Lube oil reservoir levels will be indicated locally and alarmed in the control room. Oil mixed with water entering the Plant facility floor drainage system will be processed for oil removal as described Section 3.7.

Lube oil will be supplied to the turbine generator bearings by guarded oil piping to minimize fire hazard. Fire protection will be provided for the fuel oil and lube oil systems. If a fire should occur in or near the diesel fuel day tanks or lube oil tanks, the fire would be extinguished automatically by the Plant Fire Protection System which will be designed to extinguish this type of fire within 15 minutes. The environmental impact would be similar to that from any small oil fire.

Because of the low density of people, crops, and wildlife in the vicinity of the Plant, smoke would have no measurable effects on the environment. Since no readily combustible material will exist between the fenceline and

the fire location, the fire itself could not spread to the surrounding vegetation beyond the Site fence.

Fire prevention measures which will be taken include instruction of Plant personnel on the possible sources of fire, on the various aspects of fire prevention and on the proper actions to be taken if a fire does occur. In addition, the Plant is designed to reduce both the probability of a fire starting and the extent and effects of a fire if one occurs.

Oil delivered to the Site by truck is transferred to the diesel oil storage tanks through a hose. An operator is present during this transfer operation, and if any leaks are observed, the transfer can be stopped by closing the isolation valves and stopping the pump. Since the unloading area is treated with a bituminous material, any small spills can be cleaned up with an oil absorbent material.

The prevention of oil leaks is carried out by routine inspection of oil storage and transfer facilities, by the monitoring of oil flow lines, and by accurate inventory of all oil on hand. Should a loss of oil be detected, action will be taken immediately to isolate and repair the faulty equipment and to take the appropriate steps to remove excess oil and to effect cleanup. 4

7.3.4 GAS SUPPLY SYSTEMS

The following gases are maintained in storage tanks:

a. Hydrogen

b. Carbon dioxide

c. Nitrogen

The storage tanks and the distribution system piping will be tested after installation for leakage, and pressure and flow indicators will be provided to detect any leakage of the system.

Hydrogen gas will be stored at a pressure of approximately 2400 psig. The gas will be supplied from the storage tanks to the main generator through the distribution piping. Safety relief valves will be provided to protect the storage tanks from over-pressure. The storage tanks will be outdoors to preclude any hazard due to leakage of hydrogen gas.

If any leakage should occur from the distribution piping, the Turbine Building ventilation system will exhaust the leakage before reaching an explosive level. The atmospheric dispersion of the leakage exhausted through the vent will result in a negligible effect on the environment.

Carbon dioxide will be stored in insulated tanks in liquid state at approximately 300 psig and 0°F. The tanks will be outdoors and will be provided with safety valves for protection against over-pressure. 4

Occurrence of leakage in the carbon dioxide piping or storage tanks would result in negligible effect on the environment.

Nitrogen gas will be stored at a pressure of approximately 2400 psig. The nitrogen gas will be supplied through piping to individual components. Safety relief valves will be provided to protect the storage tanks from over-pressure.

If any leakage should occur from the piping, the Plant ventilation system will exhaust nitrogen gas without any significant environmental impact.

7.4 ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.4.1 INTRODUCTION

In this section, the potential environmental effects of a postulated Class 9 accident at the plant are assessed. The assessment is done in a risk analysis format; that is, the probabilities of realizing various levels of consequences from a wide spectrum of possible accidents and associated environmental conditions are considered. The intent of such an analysis is to produce an assessment which reflects the environmental risk from postulated accidents and is responsive to the recent interim policy statement issued by the U.S. NRC regarding nuclear power plant accident assessments under NEPA (Ref 1). For this reason the data utilized in carrying out this analysis follows the practice of previous assessments that addressed the interim policy statement rather than the requirements of Reg. Guide 4.2. In a similar manner the assumptions used in this analysis are based primarily on risk assessment practice rather than rigorous extensions of the design practice utilized in the development of the Plant as reflected in the PSAR.

The approach to be taken in considering accident sequences is to apply the Reactor Safety Study (RSS) rebaselined analysis, based on a BWR/4-Mark I containment plant of the RSS to the S/HNP which is a BWR/6-Mark III containment plant. This approach directly follows the precedent set by the NRC staff in preparing environmental statements for various types of BWR plants (eg, BWR/4 in Ref 18, BWR/5 in Ref 13 and BWR/6 in Ref 19). This approach specifically follows the guidance set forth in the NRC's Statement of Interim Policy: "In-plant accident sequences that can lead to a spectrum of releases shall be discussed and shall include sequences that can result in inadequate core cooling. Detailed quantitative consideracions that form the basis of probabilistic estimates of releases ... shall be referenced therein" (Ref 1). It should be noted, however, that a preliminary BWR/6 study (Ref 8) reports that a design evaluation of BWR/6 plant protection results in significant reduction in the probability of core damage and societal risks. Therefore, it is felt that the conservative approach presented herein of following the RSS rebaselined analysis, with augmentation for some of the improved S/HNP design features, provides a basis for meeting the intent of NRC's Statement of Interim Policy. 4

The next section of the chapter, Section 7.4.2, discusses the general approach and defines the scope of the analysis which has been performed. This is followed by Section

7.4.3 which describes the methods used and presents the results obtained in determining the frequencies of certain radioactivity releases from postulated accidents. In Section 7.4.4, the method for determining the amounts of airborne radionuclides released is discussed leading to the consequences which are estimated and discussed in Sections 7.4.5, 7.4.6 and 7.4.7. The potential consequences of releases to groundwater are addressed in Section 7.4.8.

7.4.2 GENERAL APPROACH AND SCOPE OF ANALYSIS

7.4.2.1 Background Discussion

The most complete and systematic study of light water reactor accident consequences has been presented in the Reactor Safety Study (RSS) (Ref 2), completed in late 1975. In this study, extensive use was made of probabilistic analysis methods to identify potential accident sequences, to evaluate their expected frequencies, and to estimate their public impacts in a statistical manner. The methodology involved a heavy use of logic diagrams (event trees and fault trees) to trace or lay out a host of possible accident sequences which were then subjected to various levels of quantitative analysis to define a collection of potentially significant risk contributors. The expected frequencies of these accident sequences were evaluated on the basis of available data, and representative sequences from the collection were analyzed to estimate the radioactivity releases that would result. This allowed a grouping of the accident sequences into a system of radioactivity release categories which, in turn, identified those sequences that were the dominant probabilistic contributors to each category. 4

The radiological consequences of the releases for each category were assessed using a system of composite population distributions and a statistical sampling of weather data derived from actual nuclear power plant sites throughout the United States. These results were then combined probabilistically to produce a generic risk envelope for U.S. commercial light water reactors. Very similar risk envelopes were obtained for both PWR and BWR class plants. One of the more significant observations resulting from this study (Ref 2) was that the assessed risk envelope was dominated by severe accidents, that is, accidents involving core melt. These accidents would result from the possible degradation or failure of one or more redundant emergency safety systems, and hence are beyond the design basis limits for nuclear power plants.

The dominant contributors to the BWR analyzed in the RSS recently have been updated ("Rebaselined") (Ref 3). The rebaselining was done largely to incorporate peer group comments (Ref 4) and better data and analytical techniques resulting from research and development since the publication of the RSS. Entailed in the rebaselining effort was the evaluation of the individual dominant accident sequences as they are understood to evolve. The earlier technique of grouping a number of accident sequences into the encompassing release categories, as was done in the RSS, was largely eliminated.

7.4.2.2 Procedure for S/HNP

The S/HNP nuclear steam supply system is a General Electric design, with design and operating characteristics similar to the RSS prototype BWR. Therefore, the present assessment for the S/HNP has used as its starting point the rebaselined accident sequences and sequence groups. Sequences initiated by natural phenomena such as tornadoes, floods, or seismic events, as well as those that could be initiated by deliberate acts of sabotage, have not been included in these event sequences. The radiological consequences of such events would not be different in kind from those which have been treated. Moreover, it has been concluded, based upon the design requirements of 10 CFR 50 (Appendix A) relating to the effects of natural phenomena, as well as the security requirements of 10 CFR 73, that these events should not contribute significantly to risk. 4

The rebaselined accident sequences and sequence groups were reviewed and modified as appropriate to reflect important dissimilarities between the BWR analyzed in the RSS and the S/HNP design. In summary, these reviews indicated significant differences in both: the frequencies of initiating events, due to recent compilations of actual operating experience; and in the failure modes of the containment, due to different equipment capabilities and containment designs. The offsite consequences of the releases were evaluated using methods similar to those used in the RSS. Specifically, the CRAC2 computer code (Ref 16), an improved version of the original CRAC code developed in support of the RSS, was employed. However, weather data, population distribution and other data specific to the S/HNP Site were used. The treatment of evacuation also took into account population characteristics unique to the Site.

The particular methodologies employed in both the accident frequency reviews and in the offsite consequence assessments are discussed in more detail in the following

sections. The combined risk assessment results for all accident release categories have been displayed in probabilistic format in Table 7.4-7 and Figures 7.4-4 to 7.4-9. These figures and the table display measures of risk as customarily found in probabilistic risk assessments of nuclear facilities.

Finally, the potential risk from releases to groundwater are addressed in Section 7.4.8. The capability of the Site's hydrologic system to provide a significant pathway to the environment is treated therein.

7.4.3 DETERMINATION OF RELEASE PROBABILITIES

7.4.3.1 Dominant Accident Sequence Descriptions

The RSS rebaselined analysis of BWR's reduced the number of accident sequences to three basic groups by considering only those accidents with large releases that make a significant contribution to the plant risk. In the nomenclature of the RSS (Ref 2), these three groups are TW, TC, and TQUV+AE+S_1E+S_2E.

The TW accidents cover those event sequences which contain a failure to remove decay heat from the containment system. Typical of these sequences are situations in which the core is shut down, the primary system (core) is isolated from the power conversion system (main turbine and condenser), and primary system inventory is maintained by at least one of the multiple standby makeup systems. Under these conditions, core decay heat is rejected by the primary system through relief valves to a suppression pool within the containment. If overpressure failure of the containment (resulting from overheating of the suppression pool) is to be avoided, heat removal systems provided for this purpose must operate. It is the failure of these systems to function that characterizes TW. As has been shown in the RSS (Ref 2), containment failure resulting from overpressure may be the precursor of a core meltdown accident. That is, the containment system failure may cause malfunctioning of the system(s) which had been providing makeup to the primary system and, hence, dryout of the primary system, thereby overheating the core. 4

The TC accidents denote those event sequences which include a failure to achieve subcriticality. Typical of these sequences are situations in which the primary system (core) is isolated from the power conversion system (main turbine and condenser), primary system inventory is maintained by

at least one of the multiple standby makeup systems, and the suppression pool heat removal system functions. If, as is postulated, subcriticality is not achieved because of failure to insert sufficient control rods and failure of the standby liquid control system, then the core power, which is rejected to the suppression pool, may exceed the capability of the suppression pool heat removal system, resulting in pool overheating and containment failure owing to overpressure. As in the TW accidents, containment failure may lead to a degraded core by causing failure of the functioning core makeup system(s).

The TQUV+AE+S_1E+S_2E accident group is characterized by failure to provide makeup water to the core. That is, a degraded core results from failure of the many systems which can provide coolant to the core or failure of all emergency cooling systems in the event of postulated leaks or breaks in the primary system. As contrasted with the TW and TC accidents, degradation of the core precedes possible containment failure. 4

7.4.3.2 Review of RSS Accident Probabilistic Assessment Applicability to the S/HNP

Expected transients such as turbine trips and load rejects are the initiators of most of the dominant accidents. All of the TC and TW accidents and a portion of the TQUV+AE+S_1E+S_2E accidents are started by such transients. In the RSS it was estimated that 10 such initiating events per year might be expected. More recent work (see Appendix A of Reference 5) has refined this estimate by detailed analysis of the operating experience of BWR's. The frequencies associated with TC were found to be 6.2 per year and with TW 9.4 per year. These values were used in the S/HNP study. Although a downward adjustment of TQUV+AE+S_1E+S_2E initiators can be rationalized, they were not changed from the RSS as a conservative simplification. 5 4

The sequences and conditional probabilities found in the RSS rebaselined assessment were deemed appropriate to the S/HNP, with the exception of the events anticipated to follow containment failure in the TC and TW scenarios. The RSS found that containment failure in the TC and TW cases would lead directly to loss of makeup to the core and subsequent core melt because suction pressure to the makeup pumps would be insufficient at the elevated pool temperature. The pumps in the S/HNP, however, have been designed to operate under these conditions of low suction pressure. Hence, it was necessary to continue the TC and TW accident sequences to assess the accident outcomes leading to

containment failure and atmospheric releases. These continuations are presented in the following section.

This degree of adoption of the RSS rebaselined assessment is believed to be conservative in that the accident probabilities for the S/HNP are expected to be lower because of evolutionary plant design improvements which have been made since the design of the BWR, circa 1975, assessed in the RSS. A description of these improvements can be found in Reference 6.

7.4.3.3 Continuation of TW Accidents

Because sufficient suction pressure would be available to the makeup pumps in the event of the containment failure in the TW accidents, it is necessary to continue the accident sequence to determine the probable outcomes leading to possible atmospheric releases. Figure 7.4-1 presents, diagramatically, such an assessment for the S/HNP using the sequence representation methods of the RSS.

The probability of entering this continuation of TW was found by adjusting the RSS rebaselined probability for all TW (1.3×10^{-5}/year) for the fewer initiating transients now expected. This slight adjustment yielded a probability of 1.22×10^{-5}/year ($9.4/10 \times 1.3 \times 10^{-5}$/year).

The containment leakage or failure which reduces containment pressure is a consequence of prior events in the TW sequence. The location of the failure or leakage path is important in assessing the accident outcome. Containment Failure or Leakage Above Pool (Figure 7.4-1) assures that a source of makeup water to the core makeup pumps is retained. Failure or leakage below the pool drains the pool and leads directly to core melt because because core makeup is lost. As indicated, the probability of draining the pool is judged to be small (0.1). Local dynamic loads on the structure containing the pool can be postulated due to the quenching of steam discharged from the reactor through discharge lines to the pool. The quenchers provided on these discharge lines, however, have been shown to limit dynamic loads to small values. Therefore, a failure below the pool large enough to limit containment pressure rise is unlikely.

The manner in which containment pressure is relieved affects the expectation that pumps and equipment which have been providing core makeup water prior to pressure relief will continue to do so. If an abrupt and violent overpressure failure were to occur, mechanical interaction

disrupting the operating makeup systems would be more likely than if the containment progressively cracked and leaked sufficiently to relieve pressure. In this assessment, it is judged that the likelihood that Containment Leakage Prevents Failure (Figure 7.4-1) is 0.5. The containment is concrete extensively reinforced with steel. Such composite structures can be expected to undergo extensive cracking and yielding of reinforcing steel at exceedingly high pressures. Abrupt rupture is not expected; however, local leakage from seals and gaskets on the equipment hatch, personnel hatch, CRD removal hatch, penetrations, etc, can be expected to occur. Hence, the establishment of leakage great enough to arrest further pressure rise is likely.

The TW accident postulates that at least one makeup pump survives until the containment leaks or fails. Thus, it is likely that at least One Makeup Pump Survives after the containment leaks or fails, particularly in the case of containment leakage. A probability of 0.9 was assigned to this situation on the basis that containment leakage can have little impact on an operating system (temperature, pressure, humidity, etc.). The environment to which the necessary equipment would be exposed may lead to equipment deterioration as water vapor and energy enter and eventually exit the secondary containment. Hence, the safety grade control systems which are provided may become inoperable depending on the adverse effect of localized environmental factors as governed by the location of leaks and energy flow paths relative to this equipment. Note that this concern is counterbalanced by the number of independent equipment trains (HPCS, LPCS and RCIC) provided to supply makeup water. 4

In the case of containment failure, the abrupt and violent nature of the failure reduces the chances that One Makeup Pump Survives. The possibility of structural collapse or distortion interacting with equipment vital to the makeup function suggests that the success probability be reduced. A probability of 0.75 was assigned. Note that, during depressurization of the containment, adequate suction conditions for the makeup pumps would be lost on account of vapor formation in the bulk of the pool. The result would be a temporary loss of pump(s) output flow but not mechanical failure of the pump(s). Output would be recovered shortly after equilibrium conditions have returned to the pool.

If the makeup to the core is continued after containment leakage or failure occurs, the threat remains that in time the suppression pool level will decline because of evaporation caused by core decay energy rejected to the pool. In

time, this decline would reduce suction pressure to the makeup pumps resulting in loss of output flow, dryout of the core, and core melt. A 4 foot loss in the 19 feet of pool would yield this result. The suction piping to the pumps is designed to give a detectable (5%) loss of output pressure at rated flow with a 2 foot loss in pool level. With continued loss of level, output pressure would decline rapidly. This loss in ouput pressure as the level declines from 2 feet below initial level to 4 feet below initial level results in a corresponding reduction in pump output flow which is counterbalanced by the reduced flow requirements needed to replace core decay heat boil off. Approximately 21 hours, subsequent to containment leakage or failure, would be required to reach this low pool level.

This 21-hour period allows an opportunity to provide makeup water to the suppression pool so that adequate pool level is not lost. A 300 GPM flow would be needed. Considering the nominal flow needed and the time available, it is judged that the chances of Suppression Pool Makeup being established by a temporary means are good. Therefore, a success probability of 0.9 has been assigned. (See Figure 7.4-1).

If the Drywell and Safety/Relief Valves (S/RV) Discharge Lines are Intact during a core meltdown, then steam and non-condensibles would be forced through the suppression pool thereby scrubbing radioisotopes and markedly reducing the accident release to the atmosphere. There is little reason to expect that the drywell and S/RV discharge lines will not remain intact. The wetwell portion of the containment system completely encloses the drywell and, hence, it will not be subjected to a significant pressure differential during the containment pressurization phase of the accident. Furthermore, the drywell has a design pressure (30 psig) twice that of the wetwell (15 psig); therefore, the failure pressure of the wetwell would be substantially below that of the drywell. Hence, even abrupt failure of the wetwell would not be expected to cause a pressure difference large enough to fail the drywell. In light of this, a success probability of 0.95 was assigned under the conditions that the containment (wetwell) leaks. A probability of 0.8 was used for the case in which the containment fails abruptly in recognition of the rapid depressurization and the possibility of mechanical interaction of the failure with the drywell and S/RV discharge lines. 4

When the aforementioned events proceed as indicated in Figure 7.4-1, the probabilities of each of the 11 TW sequence terminations become quantified as shown. For the purpose of subseqent release and release consequence analysis, these 11 sequences have been grouped according to

their significant characteristics. Neither sequence 1 nor 6 would result in a core melt. Sequences 2, 4, 7, and 9 would result in a core melt with releases from the drywell being forced through the suppression pool; these four sequences will be collectively referred to as TWK. Sequences 3, 5, 8, 10, and 11, as a group dubbed TWL, would result in a core melt with releases from the drywell bypassing the suppression pool.

7.4.3.4 Continuation of TC Accidents

Continuation of the TC accidents (see Figure 7.4-2) proceeds in a similar manner as the TW continuation with many of the same considerations.

The probability of entering this continuation of TC was found by adjusting the RSS rebaselined probabilility for all TC (1.0×10^{-5}/year) for fewer initiating transients now expected. This yielded a probability of 0.62×10^{-5}/year ($6.2/10 \times 1.0 \times 10^{-5}$/year).

The probability of Containment Failure or Leakage Above Pool (0.9) was not changed because, although the higher power level of the core (20% vs 1%) implies a more rapid containment pressurization rate; both pressurization rates represent a relatively slowly applied load to the containment. 4

The probability that Containment Leakage Prevents Failure was decreased from 0.5 to 0.25 because the leakage path must conduct considerably more flow (factor of approximately 20) and be correspondingly larger.

The Drywell and S/RV Discharge Lines Intact success probability was not changed from those used in the TW continuation because the effects of relieving pressure in the TC case would not be significantly different.

The possibility of providing makeup to the pool, as was included in the TW sequences, does exist for the TC case but has been omitted as it is an improbable response. The reason is that, at the 20% power level of the core, 4 feet of pool depth would be lost in approximately 45 minutes as compared with 21 hours for the TW case. This minimal time makes the chances of establishing successful temporary means to provide makeup are considerably less likely.

When the operations indicated in Figure 7.4-2 have been performed, the probabilities of each of the five TC sequence terminations become quantified as shown. As with

the TW sequences, these five sequences have been grouped according to their significant characteristics. Sequences 1 and 3 would result in a core melt with releases from the drywell being forced through the suppression pool; these sequences will be collectively referred to as TCK. Sequences 2, 4, and 5, as a group dubbed TCL, would result in a core melt with releases from the drywell bypassing the suppression pool.

7.4.4 DETERMINATION OF RELEASE FRACTIONS

The rebaselined BWR releases (Ref 3), which were calculated after the RSS (Ref 2) was published, apply specifically to a plant equipped with a Mark I containment. No equally detailed calculations have been done for the S/HNP which will be equipped with a Mark III containment. However, a general inspection of similarities and differences in plant design and plant response to severe accident sequences, coupled with identification of pertinent radioactivity retention mechanisms for each case, indicate that use of the rebaselined values would generally tend to overestimate releases for corresponding accident sequences at the S/HNP. That is, if a detailed analysis of physical processes and radioactivity behavior were performed, it is estimated that the releases would be equivalent to or lower than the corresponding rebaselined values for BWR (Mark I). The rationale leading to this conclusion is summarized below. 4

The major accident sequences for each plant type are very similar. Based on the similarity between nuclear steam supply systems in each plant, the rates of steam and gas generation and of radionuclide liberation from core material should be quite similar. Therefore, the significant factors to examine relate to differences in leakage paths from containment and to differences in the calculated or expected effectiveness of important radionuclide retention processes.

One group of accident sequences, postulated to result in primary containment rupture in the wetwell, is characterized by either loss of the pressure suppression pool or bypassing of the pool resulting in direct venting to the atmosphere. For the rebaselined BWR, these sequences are $TC\gamma'$, $TW\gamma'$ and the set $(TQUV\gamma' + AE\gamma' + S_1E\gamma' + S_2E\gamma')$. For the S/HNP, these sequences are TCL, TWL, and the set $(TQUV\gamma' + AE\gamma' + S_1E\gamma' + S_2E\gamma')$. Note that the latter set has been adopted directly from the rebaselined RSS as explained in Section 7.4.3.2.

Since the leakage paths from containment would be essentially the same for either Mark I or Mark III designs, it is expected that use of the BWR rebaselined methodology to evaluate atmospheric releases for the S/HNP would yield equivalent results. In addition, if recent estimates of primary coolant system radionuclide retention in transient accidents (Ref 7) were applied, then an updated analysis for the S/HNP should produce somewhat lower atmospheric releases than those obtained for the BWR rebaselined case.

The group of accident sequences postulated to result in primary containment rupture without loss of the pressure suppression pool includes TCγ, TWγ, and the set (TWUVγ + AEγ + $S_1E\gamma$ + $S_2E\gamma$) for the rebaselined BWR and TCK, TWK and the set (TQUγ + AEγ + $S_1E\gamma$ + $S_2E\gamma$) for the S/HNP. The leakage paths from containment for these sequences would be somewhat different in the Mark I and Mark III designs. In each case the radionuclides should pass through the pressure suppression pool and into the vapor space above the pool. The BWR rebaselined analysis (Mark I) assumes that the leakage then passes through the annular space outside of the steel drywell before release to the atmosphere. In a Mark III design, the postulated rupture location is high on the wetwell wall so that the flow path from the vapor space above the pool would be into the wetwell volume, which would be leaking through the concrete wall to the outside. The BWR rebaselined calculations predict significant radionuclide deposition on the annular surfaces during leakage; source decontamination factors for the process range from about 2 to 5 for particulate forms and from about 5 to 30 for radioiodine, depending on the accident sequence. Although the identical process would be absent in a Mark III design, radionuclide deposition on surfaces in the main containment should be partially and, perhaps, fully as effective in depleting the source. In addition, recent developments indicate that significant source attenuation (a factor of 10 for radioiodine and particulates) should be considered during flow through suppression pools, even for pools at saturation temperatures (Ref 5). This was not considered in the BWR rebaseline work. Therefore, this S/HNP analysis did not take any additional credit for the pool scrubbing and deposition removal mechanisms. Furthermore, it is therefore expected that an analysis of the above sequences for the S/HNP using updated methodology accounting for pool scrubbing and deposition would produce lower atmospheric releases than the values used in this S/HNP analysis for corresponding sequences in the BWR rebaselined analysis. 4

Table 7.4-1 shows the core release fractions associated with the S/HNP accident sequences, as taken from the RSS

rebaseline. The core release fractions represent the significant isotope groups as identified in the RSS.

Other data needed by CRAC2 to calculate the offsite consequences of releases have been indicated in Table 7.4-1. These data are extensions of the rebaselined RSS to the S/HNP and have been adjusted as required. Specifically, the time of release is significantly shorter for the TW sequences because of the lower design pressure of the containment. Similarly, the warning time prior to a release has been significantly reduced because of the higher decay power at the time of containment failure.

The release elevation has been taken as 10 meters in all cases, which is a relatively low level release. The energy release rates are those of the RSS rebaselined except that no differentiation has been made between releases through the pool and those releases which bypass the pool; the higher value found in the RSS rebaselined was used.

7.4.5 EVALUATION OF SEVERE ACCIDENT CONSEQUENCES

7.4.5.1 Outline of Basic Methodology

The societal risk from the six severe accidents postulated at the S/HNP has been estimated using the Calculation of Reactor Accident Consequences (CRAC2) computer code. CRAC2 (Ref 16) is a revised version of the code that was developed in support of the RSS. A brief description of the general calulative scheme of the CRAC2 code follows. A more detailed discussion may be found in Appendix VI of the RSS. 4

7.4.5.2 General Calculative Scheme of CRAC2

The overall methodology employed by CRAC2 has been summarized in Figure 7.4-3. Site-specific data include not only accident release parameters but also meteorological, demographic and economic data, as well as emergency protective measures.

The calculation of reactor accident consequences starts with a postulated breach of containment and release of radioactivity. Following this hypothetical event, the dispersion of the radioactive material, cloud depletion, and ground contamination are computed by means of atmospheric dispersion models. This information is then used by

dosimetric models to estimate the early and chronic doses received by individuals. Early doses result from exposure to the passing cloud (direct radiation and inhalation) and also from early exposure to the contaminated ground. Chronic doses are accrued via ingestion of contaminated food and dairy products, inhalation of resuspended ground contamination, and long-term exposure to contaminated ground.

Next, the health effects are estimated, based on the doses calculated previously and the distribution of people surrounding the plant out to a distance of 500 miles. Several mitigation measures, including evacuation and relocation of people, as well as the possibility of food and land interdiction, are considered in the computation of the population exposure and the acute and latent health effects. Acute effects refer to those injuries and fatalities occurring within a year of the accident. Latent effects refer to those somatic effects which later are manifested in the form of cancer; a plateau period is not assumed.

Lastly, economic impacts are calculated in terms of interdicted ~~areas of~~ land, crops, and milk, the estimated costs of such interdiction and associated ground decontamination, as well as any evacuation and relocation expenses.

CRAC2 results are displayed as a set of complementary cumulative distribution functions for specific consequences. These distributions are determined from the calculated magnitude of each consequence for each combination of postulated accident release, meteorological conditions following the release, and number of people exposed to the contamination, as well as the probability of each such combination. 4

7.4.5.3 Accident Release Parameters

As discussed previously in Section 7.4.3, six severe accident sequences have been postulated at the S/~~HNP~~. The six release categories, including the calculated probabilities per reactor-year (ry) and other parameters pertinent to the off-site consequences, have been listed in Table 7.4-1. The release magnitudes for each accident sequence can be obtained by multipying the release fractions given in Table 7.4-1 by the amounts of radioactivity that would be present in the core at the time of containment failure. The inventory of radionuclides in the S/~~HNP~~ core was represented by the values shown in Table 7.4-2 and is based on a core thermal power of 3971 MW. This inventory was derived

by multiplying the standard CRAC2 inventory data by 3971/3412, where 3971 is 104.5% of the licensed S/HNP core thermal power in megawatts and 3412 is the thermal power upon which the CRAC2 data has been based. The CRAC2 standard inventory was developed by the designers of the code using methods similar to those reported in Appendix VI, Section 3, of the RSS but taking into account more recent data, such as a trend to 25% higher core exposures.

7.4.5.4 Meteorological Data and Sampling Strategy

To trace the movement of the radioactive cloud downwind, CRAC2 requires weather data defined in terms of wind direction, wind speed, atmospheric stability class, and rainfall intensity. Input weather data consisted of a full year of consecutive hourly measurements collected nearby at the 240 foot WNP-2 meteorological tower between October 1, 1979 and September 30, 1980. Winds were based on observations at 33 feet; stability classes were based on the ambient temperature differences between 33 and 240 feet, per Regulatory Guide 1.23. These hourly observations permitted a time-varying, though not a spatially-varying, treatment of the atmospheric conditions (excluding wind direction) following a hypothetical accident.

A means of efficiently sampling start times (the time at which an accident release is assumed to occur) was sought so that all of the significant weather sequences occurring throughout the year could be sampled without having to choose 8,760 different start times. To accomplish this task, CRAC2 processed the hourly data into 29 mutually exclusive meteorological "bins". 4

- RAINFALL EXISTENCE VS. CLOUD LOCATION (7 bins)
- WIND SPEED SLOWDOWNS VS. CLOUD LOCATION (5 bins)
- STABILITY CLASSES VS. WINDSPEED INTERVALS (17 bins)

All 29 bins were randomly sampled four times apiece to reduce the sampling uncertainty. The calculated magnitudes of the reactor consequences for each of the 116 start times were weighted according to the probability of the prevailing weather condition.

7.4.5.5 Resident and Transient Population

The resident and transient populations within a 500 mile radius of the plant were represented by estimated numbers of individuals within 544 spatial regions. These regions were defined by 16 equally spaced radials from the Site, beginning at 11-1/4 degrees west of due north, and by 34 concentric circles centered at the Site. The spacing of these circles resulted in the intervals shown in Table 7.4-3; the 16 standard compass directions listed in the same table were defined by the radials.

The resident population (Table 7.4-3) within each region has been derived using 1980 census data and anticipated population trends through the year 2010. The transient population within 10 miles of the Site (Table 7.4-4) has been based on estimates of the numbers of individuals expected to work at facilities within the 10-mile zone as well as migrant workers, fishermen and hunters expected to frequent this zone. To simulate the transient nature of this population, their numbers were reduced by multiplying by the fraction of a year they are expected to be in the zone.

7.4.5.6 Agricultural Land Use and Economic Data 4

Eight western states and two Canadian provinces lie within a 500 mile radius of the S/HNP. Each spatial region (Section 7.4.5.5) was assigned to that political unit which constitutes most of its area. The habitable land fraction of each region was determined using a planimeter.

Agricultural profiles of these states and provinces appear in Table 7.4-5. For the eight states, agricultural land as a percent of total land, dairy sales as a percent of agricultural sales, and annual agricultural sales per farm-acre were all taken from 1979 agricultural statistics (Ref 8). The value of agricultural land per acre was taken from the 1978 Census of Agriculture (Ref 9). Both of these last two statistics were inflated to March 1980 dollar values using ratios of the appropriate consumer price indices (CPI-W) published by the U.S. Bureau of Labor Statistics (Ref 10).

For British Columbia and Alberta, the farmland fraction, dairy fraction of farm sales, and annual farm sales per acre were extracted from 1977 Canadian statistics (Ref 11). This last statistic was adjusted to March 1980 U.S. dollar values by means of the Canadian CPI for food (Ref 12) and

the Canada-U.S. currency exchange rate. Lastly, the value of a Canadian farm-acre was assigned the conservatively high value corresponding to the State of Washington.

In addition to the agricultural economic data described above, CRAC2 employs other economic factors in its assessment of accident impacts. These values, shown in Table 7.4-6, were obtained from the standard CRAC2 input file.

7.4.5.7 Emergency Protective Measures

A properly planned and expeditiously carried out public evacuation would greatly reduce the risk of acute health effects associated with early exposure to a passing radioactive cloud and the contaminated ground in the cloud's wake. Accordingly, CRAC2 considers the risk-reduction benefits of evacuation. The evacuation scheme described below is a conservative representation of the preliminary evacuation study described in Section 13.3 of the S/HNP PSAR.

Significant atmospheric releases of radioactivity would in general be preceded by one or more hours of warning time (postulated as the time interval between the awareness of impending core melt and the beginning of the release of radioactivity from the containment building). For the purpose of calculating radiation exposure, CRAC2 assumes that all people who are within 5 miles of the plant in addition to those who are in a 45 degree fan-shaped area between 5 and 10 miles from the site; with the downwind direction as its centerline, would evacuate after a delay of one hour. This delay time is defined as the elapsed time between notification of the proper authorities and the actual commencement of evacuation. The CRAC2 model further assumes that each evacuee would leave the area by moving radially outward at a constant effective speed of 10 mph until he completed his evacuation to a distance of 10 miles from the site. 4

The people outside of the evacuation radius are assumed to remain at their locations for 7 days. If the 7-day whole body dose were to approach lethal levels (200 rems), then CRAC2 assumes that immediate detection would be made and that relocation would occur at 24 hours after the accident.

7.4.6 RESULTS OF CRAC2 ACCIDENT ASSESSMENT

7.4.6.1 Dose and Health Impacts

The dose and health impacts calculated have been presented in the form of complementary cumulative distribution functions (see Figures 7.4-4, 7.4-5, 7.4-7 and 7.4-8), which have been summarized in Table 7.4-7. All six of the accident sequence groups in Table 7.4-1 contributed to the results, the consequences of each having been weighted by its associated probability.

Figure 7.4-4 shows the probability distributions for the number of people who might receive, from early exposure, whole body doses greater than or equal to 200 rem and 25 rem, and thyroid doses greater than or equal to 300 rem, all on a per-reactor-year basis. Early exposure includes external doses from the radioactive cloud and the contaminated ground, and the dose from internally deposited radionuclides from inhalation of contaminated air during the cloud passage. Other pathways of exposure are excluded. The 200-rem whole body dose figure corresponds approximately to a threshold value for which hospitalization would be indicated for the treatment of radiation injury. The 25-rem whole body (which has been identified as the lower limit for a clinically observable physiological effect in nearly all people) and 300-rem thyroid figures correspond to the Commission's guideline values for reactor siting in 10 CFR Part 100. 4

The figure shows in the left-hand portion that there are less than 2 chances in 100,000 per reactor year that one or more persons may receive doses equal to or greater than any of the doses specified. The fact that each of the three curves approaches a horizontal line shows that if one person were to receive such doses the chances are about the same that several tens to hundreds would be so exposed. The chances of larger numbers of persons being exposed at these level are seen to be considerably smaller. For example, the chances are less than 2 in 100,000,000 per reactor year that 10,000 or more people might receive whole body doses of 200 rem or greater. A majority of the people reflected in this figure would be expected to reside within a 17.5-mile radius of the plant; virtually all would reside within a 55-mile radius.

Figure 7.4-5 shows the probability distribution for the total population exposure in person-rem, ie, the probability per year that the total population exposure will equal or exceed the values represented by the curve.

Figure 7.4-6 shows the early whole body dose to individuals as a function of initial distance from the plant. These individuals' doses are "average" values which consider the probability of each of the accidents shown in Table 7.4-1.

Figure 7.4-7 shows the probability distributions for acute fatalities, representing radiation injuries that would produce fatalities within about one year after exposure. All of the acute fatalities would be expected to occur within a 20-mile radius and the majority within a 15-mile radius. The results of the calculations shown in this figure and all of the other results reflect the effect of evacuation within the 10-mile plume exposure pathway. For the very low probability accidents having the potential for causing radiation exposures above the threshold for acute fatality at distances beyond 10 miles, it would be realistic to expect that authorities would evacuate persons at all distances at which such exposures might occur. Acute fatality consequences would therefore reasonably be expected to be very much less than the numbers shown.

Figure 7.4-8 represents the statistical relationship between population exposure and the induction of fatal cancers that might appear over a period of many years following exposure. The impacts on the total population within 50 miles are shown separately. Further, the fatal latent cancers have been subdivided into those attributable to exposures of the thyroid and all other organs. Consistent with Appendix VI (Section 9.3.5) of the RSS, it was assumed that 10% of all malignant thyroid nodules would result in fatalities; the RSS, however, had recognized that this mortality rate is somewhat conservative. Hence, an incidence of 13.4 deaths per million man-rem was predicted for thyroid doses below 3000 rems; for doses in excess of 3000 rems, the thyroid was to be ablated with no subsequent risk of nodules. 4

7.4.6.2 Economic Impact

Various measures for avoidance of adverse health effects, including those due to residual radioactive contamination in the environment are possible consequential impacts of severe accidents. Calculations of the probabilities and magnitudes of such impacts have also been made. Unlike the radiation exposure and adverse health effect impacts presented above, impacts associated with adverse health effects avoidance are more readily transformed into economic impacts.

The results are shown as the probability distribution for costs of offsite mitigating actions in Figure 7.4-9 and are included in the impact summary: Table 7.4-7. The factors contributing to these estimated costs include the following:

- Evacuation costs;
- Value of crops contaminated and condemned;
- Value of milk contaminated and condemned;
- Costs of decontamination of property where practical;
- Indirect costs due to loss of use of property and incomes derived therefrom.

The latter costs would arise from the necessity for interdiction to prevent the use of property until it is either free of contamination or can be economically decontaminated.

Figure 7.4-9 shows that at the extreme end of the accident spectrum these costs could approach five billion dollars but that the probability that this would occur is exceedingly small, less than one chance in 100 million per reactor-year. 4

7.4.6.3 Average Risks

The foregoing presentation has dealt with both the frequency (or likelihood of occurrence) of accidents and their impacts (or consequences). Since the ranges of both factors are quite broad, it is useful to combine them to obtain average measures of environmental risk. A common way in which this combination of factors is used ~~to estimate~~ risk is to multiply the probabilities by the consequences. The resultant risk is then expressed as a number of consequences expected per unit of time.

In Table 7.4-8 are shown average values of risk associated with population dose acute fatalities, latent fatalities, and costs for early evacuation and other protective actions. These average values have been obtained by summing the probabilities multiplied by the consequences over the entire range of the distributions. Since the probabilities are on a per-reactor-year basis, the averages shown are also on a per-reactor-year basis.

7.4.7 UNCERTAINTIES

Throughout this assessment, the methodology of and some of the data used in the RSS have been employed. Where readily available and applicable, more recent data have been employed. Significantly, this assessment uses site-specific data such as weather and demographics which has not been done in the RSS. In instances, where detailed analysis or data were not available, conservative assumptions were used. On balance, it is believed that this assessment carries with it nearly the same uncertainties as the RSS.

It should also be noted that the Three Mile Island accident has resulted in a very comprehensive evaluation of reactor accidents by a significant number of investigative groups both within the NRC and outside of it. Actions to improve the safety of nuclear power plants have come out of these investigations, including those from the President's Commission on the Accident at Three Mile Island, and NRC staff investigations and task forces. A comprehensive "NRC Action Plan Developed as a Result of the TMI-2 Accident," NUREG-0660, Vol. I, May 1980, collects the various recommendations of these groups and describes them under the subject areas of: Operational Safety; Siting and Design; Emergency Preparedness and Radiation Effects; Practices and Procedures; and NRC Policy, Organization and Management. The action plan presents a sequence of actions that will result in improvements in safety. The S/HNP is receiving and will receive the benefit of these actions. The improvement in safety from these actions has not been quantified, however, and the radiological risk of accidents discussed in this chapter does not reflect these improvements. 4

7.4.8 RELEASES TO GROUNDWATER

A potential pathway for public radiation exposure and environmental contamination to be considered for severe reactor accidents results from temperatures inside the reactor core sufficiently high to cause melting and subsequent penetration of the containment building basemat. This would create the potential for the release of radioactive material into the hydrosphere through contact with groundwater. The penetration of the basemat could release molten core debris to the geologic strata beneath the Plant. The soluble radionuclides in the debris could be leached and transported with groundwater to down gradient domestic wells used for drinking water or to surface water bodies used for drinking water, aquatic food and

recreation. Releases of radioactivity to the groundwater underlying the Site could also occur via depressurization of the containment atmosphere or radioactive ECCS and suppression pool water through the failed containment.

A pathway of concern at the S/HNP Site is to the Columbia River and hence to the biosphere. The Site is located on the Hanford Reservation about eight miles west of the Columbia River. Groundwater at the Site exists in both a water table aquifer and confined, artesian aquifers largely in unconsolidated alluvial and glacial sediments. The water table aquifer at the Site is about 125 feet below the surface. Flow in the unconfined aquifer is toward the Columbia River, which is its sink. There is no recharge of the water table at the Site.

The Plant buildings are located on highly permeable glacio-fluvial outwash sands and gravels. Contaminated water released from the Plant would travel vertically downward until it r ached the water table, and would then move down gradient toward the Columbia River. Although there are many wells on the Hanford Reservation, they are closely monitored. In the event of a core melt accident, use of water from effected wells could be halted. Therefore, the analysis focused on potential contamination of the Columbia River by way of contaminated groundwater from the Site.

An analysis of this potential was prepared (Ref 13) for a large BWR located between the S/HNP and the Columbia River and within three miles of the river. Because of the direct applicability of this work, it is quoted directly. 4

"Large releases to the ground of radioactive water resulting from chemical reprocessing of reactor fuel have occurred at the Hanford Reservation. From 1944 to 1972, over 490 billion liters (130 billion gallons) of waste water and millions of curies of fission products have been discharged from seepage pits to the ground. There have been extensive measurements of the groundwater plumes of several radioactive isotopes and other chemicals released from the seepage pits. Because of this large body of information obtained over the years, the movement of radionuclides in groundwater at the site is relatively well understood. Several constituents of leached waste have migrated up to about 24 kilometers (15 miles) in the direction of the Columbia River in the timespan 1944 to 1975. On the basis of the observed plume migration we have estimated the groundwater velocity in the unconfined aquifer under the site to be about 2 meters (7 feet) per day toward the Columbia River. Contaminated water released from the plant in the event of a core melt accident could migrate to the river in a minimum of about 6 years. This compares to a

minimum groundwater travel time of about 0.6 years used for the LPGS site." LPGS refers to "Liquid Pathway Generic Study" (Ref 14).

"For holdup times on the order of years the LPGS showed that the only significant contributors to population dose to surface water users would be the isotopes Cs-137 and Sr-90. Actual observation of the movement of Cs-137 and Sr-90 in site soil columns and in-situ measurements at the seepage pits indicate that these two isotopes are strongly bound to the soil (Ref 15). While the plumes of substances not easily sorbed, such as tritium and nitrate, can be seen to extend tens of miles, most of the cesium and strontium has remained within a few tens of feet from the points of release. Based upon these data, the staff has estimated retardation factors, which reflect the effects of sorption of the radionuclides within the aquifer, to be about 8400 for Cs and 1400 for Sr. Using these values of the retardation factors, we estimate that it would take a minimum of 50,400 years for Cs-137 and 8400 years for Sr-90 to reach the Columbia River. These travel times compare to 51 years for Cs-137 and 5.7 years for Sr-90 employed in the LPGS. Because their half-lives are approximately 30 years, virtually all the Cs-137 and Sr-90 would decay in the groundwater before it could reach the Columbia River. Since nearly all of the population dose for liquid pathway release can be shown to be due to these two isotopes, the staff concludes that the liquid pathway consequences at the Hanford Reservation, resulting from a postulated Class 9 accident, would be significantly less than that calculated for the LPGS large river site and would present no unique contribution to risk." 4

Finally, there are measures which could be taken, if necessary, to isolate liquid contaminants such as tritium before they could contaminate the river. The staff's estimate of a 6 year minimum travel time would allow ample time or engineering measures such as slurry walls and dewatering to isolate the radioactive contamination near the source."

Because the pathway to the Columbia River from the S/HNP is at least twice as long as that for the plant evaluated by the NRC staff, their conclusions are applicable to the S/HNP.

7.4.9 RISK CONSIDERATIONS

The health risks to the surrounding population cannot be readily monetized to permit quantitative comparison with

other risks and alternatives. They may, however, be placed in perspective by comparison with risks presented by normal operations at the plant and those risks arising from a variety of activities unrelated to the plant.

The radiological dose to the population within 50 miles from normal operation may result in about 0.51 whole body person-rem per reactor-year and 1.5 thyroid person-rem per reactor-year which may result in about 0.000069 total latent cancer deaths in the exposed population. The comparison of deaths for normal operation with about 0.007 latent cancer deaths from Table 7.4-8 shows that the accident risks are approximately comparable to those for normal operation.

There are no acute fatality nor economic risks associated with normal releases; therefore, these risks are unique to accidents. For perspective and understanding of the meaning of the acute fatality risk of about 0.000068 per reactor-year, however, it is noted that to a good approximation, the population at risk will be that within about 15 miles of the Plant or about 45,000 persons in the year 2010. Accidental fatalities per year for a population of this size, based upon overall averages for the United States, are approximately 10 for motor vehicle accidents, 3 from falls, 1 from drowning, and 1 from burns (Ref 17). 4

Similarly, the latent fatality risk of 0.007 per year will be shared by the population within 500 miles, that is, approximately 18,000,000 people in the year 2010. The accidental fatalites per year for a population of this size are approximately 4000 from motor vehicle accidents, 1400 from falls, 560 from drowning, 520 from burns, and 220 from firearms.

By these comparisons, it is apparent that health risks presented by the Plant are very much smaller than those to which the population is exposed and, therefore, on a relative basis, the Plant's risk contribution is negligible.

References for Section 7.4

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19. Final Environmental Statement Related to the Operation of Grand Gulf Nuclear Station, Units 1 and 2, U.S. Nuclear Regulatory Commission, Docket Nos. 50-416 and 50-417 (NUREG-0777), September 1981.

TABLE 7.0-1

ACCIDENT RELEASE PARAMETERS

Accident Frequency	Probability	Time of Release	Duration of Release	Warning Time	Elevation of Release	Containment Energy Release	Sr-Pu	I	Cs	Te	Ba	Ru	La	
	/reactor year	hrs.	hrs.	hrs.	meters	10^6 cal/sec		-Fraction of Core Inventory-(1)						
TCE	0.67×10^{-6}	1.5	2.0	1.0	10	1	1	0.07	0.14	0.12	0.015	0.01	0.002	4
TME	2.42×10^{-6}	16	2.0	6	10	1	1	0.001	0.11	0.003	0.011	0.007	0.001	
TQUV7+AE7+ S_1E7+S_2E7	1×10^{-6}	1.5	0.5	1.0	10	15	1	0.02	0.055	0.11	0.006	0.007	0.0013	5
TCL	1.53×10^{-6}	1.5	2.0	1.0	10	1	1	0.45	0.67	0.64	0.073	0.052	0.0003	4
TML	1.61×10^{-6}	16	2.0	6	10	1	1	0.090	0.27	0.41	0.025	0.020	0.005	
TQUV7'+AE7' + $S_1E7'+S_2E7'$	3.0×10^{-7}	1.5	0.5	1.0	10	15	1	0.095	0.3	0.36	0.034	0.027	0.005	5

(1) These radionuclide groups are defined in Table 7.0-2. 4

TABLE 7.4-2

CORE RADIONUCLIDE INVENTORY

Group/Radionuclide	Radioactive Inventory in Millions of Curies	Half-Life (days)
A. Noble Gases		
Krypton-85	0.7727	3919.
Krypton-85m	36.38	0.1867
Krypton-87	66.38	0.3528
Krypton-88	89.91	0.1167
Xenon-133	214.2	5.290
Xenon-135	44.23	0.3811
B. Iodines		
Iodine-131	101.7	8.040
Iodine-132	149.7	0.3992
Iodine-133	214.1	0.8667
Iodine-134	234.7	0.0365
Iodine-135	201.8	0.2744
C. Alkali Metals		
Rubidium-86	0.0960	18.65
Cesium-134	14.67	752.4
Cesium-136	4.991	13.00
Cesium-137	7.608	10990.
D. Tellurium-Antimony		
Tellurium-127	0.072	0.3896
Tellurium-127m	1.145	109.3
Tellurium-129	29.64	0.5466
Tellurium-129m	7.795	33.60
Tellurium-131m	16.91	1.250
Tellurium-132	147.5	3.250
Antimony-127	0.085	3.000
Antimony-129	31.59	0.1800
E. Alkaline Earths		
Strontium-89	111.6	52.00
Strontium-90	5.018	10260.
Strontium-91	144.0	0.3950
Barium-140	199.7	12.79
F. Cobalt and Noble Metals		
Cobalt-58	0.0082	71.30
Cobalt-60	0.0052	1921.
Molybdenum-99	192.6	2.751
Technetium-99m	186.2	0.2500
Ruthenium-103	144.0	39.59
Ruthenium-105	95.57	0.1850
Ruthenium-106	33.66	369.0
Rhodium-105	64.87	1.479
G. Rare Earths, Refractory Oxides and Transuranics		
Yttrium-90	6.456	2.670
Yttrium-91	136.1	58.80
Zirconium-95	173.2	65.50
Zirconium-97	181.6	0.7000
Niobium-95	163.7	35.10
Lanthanum-140	199.8	1.676
Cerium-141	177.8	32.53
Cerium-143	172.8	1.379
Cerium-144	106.5	284.4
Praseodymium-143	169.4	13.58
Neodymium-147	75.99	10.99
Neptunium-239	2194.	2.350
Plutonium-238	0.1360	32510.
Plutonium-239	0.0300	8912000.
Plutonium-240	0.0337	2600000.
Plutonium-241	6.309	5333.
Americium-241	0.0042	158100.
Curium-242	1.903	163.0
Curium-244	0.0070	6611.

TABLE 3.6-3

RESIDENT POPULATION
YEAR 2010

DIRECTION

Miles	E	ENE	NE	NNE	N	NNW	NW	WNW	W	WSW	SW	SSW	S	SSE	SE	ESE
0-.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.5-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.-2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4-4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6-7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7-8.5	0	0	5	5	22	0	0	0	55	0	0	0	0	0	0	0
8.5-10	0	0	56	77	83	11	0	13	126	0	0	0	0	0	0	0
10-12.5	0	20	94	112	207	253	4	2,279	455	463	299	114	0	0	0	0
12.5-15	17	94	116	136	260	260	2,149	33,570	2,229	769	412	96	0	0	0	0
15-17.5	62	155	155	202	295	129	1,039	13,044	6,093	291	291	182	12	0	31	31
17.5-20	160	267	155	100	260	29	2,590	29,944	206	676	340	139	139	166	61	61
20-25	983	1,675	563	862	477	141	59,720	22,314	704	704	6,484	893	983	203	82	161
25-30	897	6,555	664	3,447	305	177	22,906	5,290	121	299	13,621	10,274	665	64	621	299
30-35	600	957	196	753	209	291	3,237	63	111	77	3,100	12,641	806	23	321	1,622
35-40	504	2,964	261	323	175	97	507	254	1,496	98	663	3,931	6,675	20	309	504
40-45	14,634	2,156	141	475	166	179	652	2,445	6,622	100	240	3,426	11,441	819	432	534
45-50	16,189	1,042	162	90	120	159	777	2,427	13,661	1,379	100	1,935	25,999	2,083	436	1,257
50-55	1,116	230	812	201	209	1,527	601	1,315	505	506	42	302	99,731	17,671	3,832	776
55-60	12,274	230	201	621	260	23,160	1,130	726	251	663	179	291	16,570	10,910	2,317	6,616
60-65	6,557	366	352	630	601	29,770	11,575	10,750	210	602	559	102	1,326	5,762	12,162	1,665
65-70	250	2,215	2,610	639	1,626	1,262	2,150	1,874	187	639	219	189	796	2,653	3,829	6,594
70-85	1,751	531	267	1,110	1,622	656	860	2,741	1,799	269	2,877	3,570	132	699	3,009	44,065
85-100	1,630	3,274	2,226	1,956	2,152	263	5,760	1,710	93	929	5,630	2,760	60	771	12,591	15,264
100-150	22,011	19,236	545,193	47,100	126,290	2,941	44,799	10,341	8,747	6,516	27,250	52,504	23,668	716,827	30,220	9,207
150-200	29,096	31,647	71,573	35,679	10,943	10,076	17,633	2,545	6,790	95,347	33,183	1,017,605	220,725	2,651,759	706,946	8,704
200-250	457,127	71,937	95,046	122,727	205,000	24,501	520,319	33,793	15,235	271,206	260,859	344,233	116,294	109,872	2,607,726	166,350
250-500	53,949	190,919	1,462,612	163,820	254,621	292,040	207,977	53,248	490,437	812,744	54,185	0	0	0	32,722	71,053

TABLE 7.5-1

TRANSIENT POPULATION
YEAR 2010

	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Miles																
0-.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.5-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.-2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4-4.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.5-5	0	0	0	0	0	90	203	0	0	0	0	0	0	0	0	0
5-6	0	0	0	0	90	90	0	0	0	0	0	0	0	0	114	0
6-7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	228	0
7-8.5	0	1	1	1	4	2	0	0	1	0	0	0	0	0	114	0
8.5-10	0	15	15	17	16	17	1	0	1	0	18	0	0	920	0	0

TABLE 7.4-3

AGRICULTURAL LAND USE AND ECONOMIC DATA

Political Entity	Seeding Month	Harvesting Month	Farm Land Fraction	Dairy Product Fraction	Annual Sales $/Acre	Value of Farm $/Acre
Washington	May	September	0.378	0.130	162.0	860.0
Oregon	May	September	0.303	0.065	91.0	633.0
California	April	October	0.323	0.115	413.0	1600.0
Nevada	April	October	0.128	0.187	25.0	260.0
Idaho	May	September	0.293	0.162	130.0	725.0
Montana	May	September	0.665	0.026	26.0	266.0
Utah	April	October	0.244	0.236	39.0	502.0
Wyoming	May	September	0.564	0.010	23.0	101.0
British Columbia	May	September	0.006	0.239	316.0	869.0
Alberta	May	September	0.103	0.051	79.0	860.0

4

TABLE 7.4-6

UPDATED ECONOMIC FACTORS

Economic Factor and Unit of Measure	Value 1980 Dollar
Decontamination Cost of Farm Fields ($/Acre)	$ 499.0
Decontamination Cost of Residential, Business, and Public Area ($/Person)	3349.0
Value of Residential, Business, and Public Area ($/Person)	31580
Relocation Cost ($/Person)	4,344.0
Cost of Milk Consumption ($/Person)	135
Cost of Non-Dairy Products Consumed ($/Person)	685
Evacuation Direct Costs ($/Evacuee)	95

4

TABLE 2.9-7

Sheet 1 of 1

SUMMARY OF ENVIRONMENTAL HEALTH AND PROBABILITIES

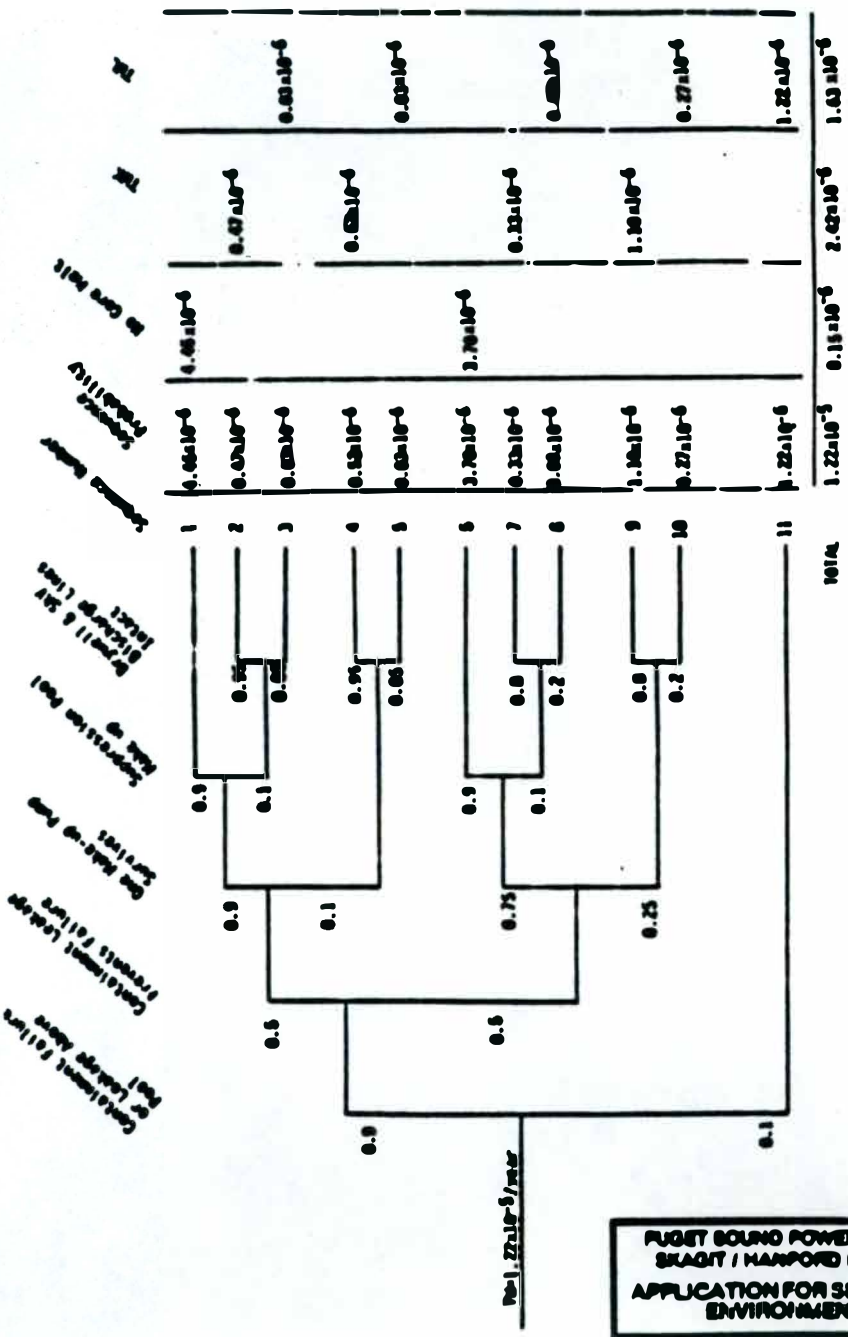
Probability/ Of Impact Per Reactor-Year	Persons Exposed over 200 rem	Persons Exposed over 25 rem	Acute Fatalities	Population Exposure Millions of person-Rem 50 Mi/Total	Latent Cancer Excl. Thyroid 50 Mi/Total	Cost of Offsite Mitigating Actions Millions of Dollars	
10^{-6}	0	0	0	0/0	0/0	0	4
10^{-5}	0	250	0	0.3/2.2	20/140	62	5
5×10^{-6}	0	1,500	0	1.7/8	97/400	320	
10^{-6}	0	11,000	0	8/19	500/1100	1,200	
10^{-7}	100	90,000	2	11/32	1400/2400	3,000	4
10^{-8}	22,000	100,000	1,000	20/100	2500/8000	6,000	
Deleted Figure	7.6-6	7.6-6	7.6-7	7.6-5	7.6-8	7.6-9	

TABLE 7.4-8

AVERAGE VALUES OF ENVIRONMENTAL RISK PER REACTOR-YEAR

Population exposure	
Person-Rem within 50 miles	31.3
Person-Rem Total	103.
Acute Fatalities	6.84×10^{-5}
Latent Cancer Fatalities	
All Organs Excluding Thyroid	5.86×10^{-3}
Thyroid Only	1.22×10^{-3}
Total	7.08×10^{-3}
Cost of Mitigation Measures	$ 5,470

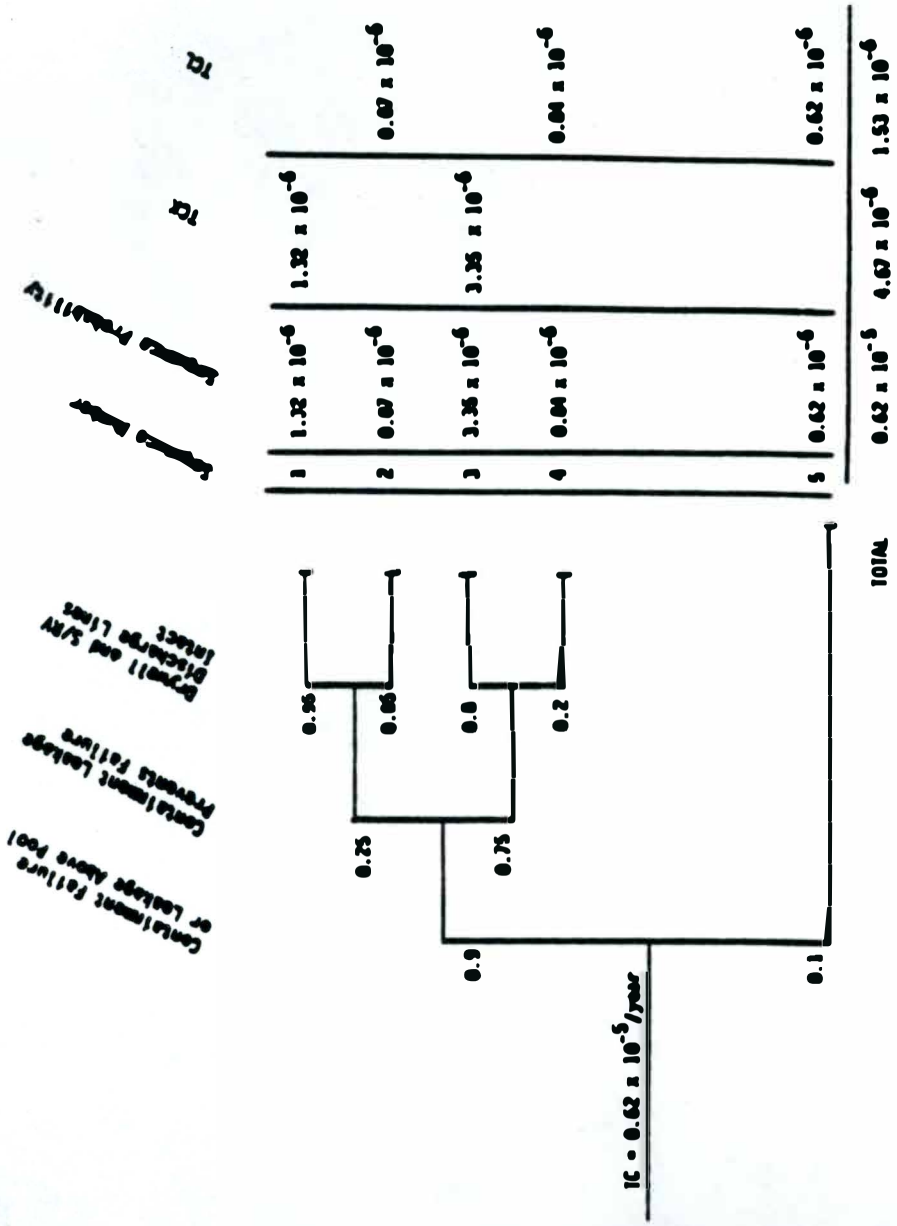
4



PUGET SOUND POWER & LIGHT COMPANY
SKAGIT / HANFORD NUCLEAR PROJECT
APPLICATION FOR SITE CERTIFICATION/
ENVIRONMENTAL REPORT

CONTINUATION OF TW

FIGURE 7.4-1



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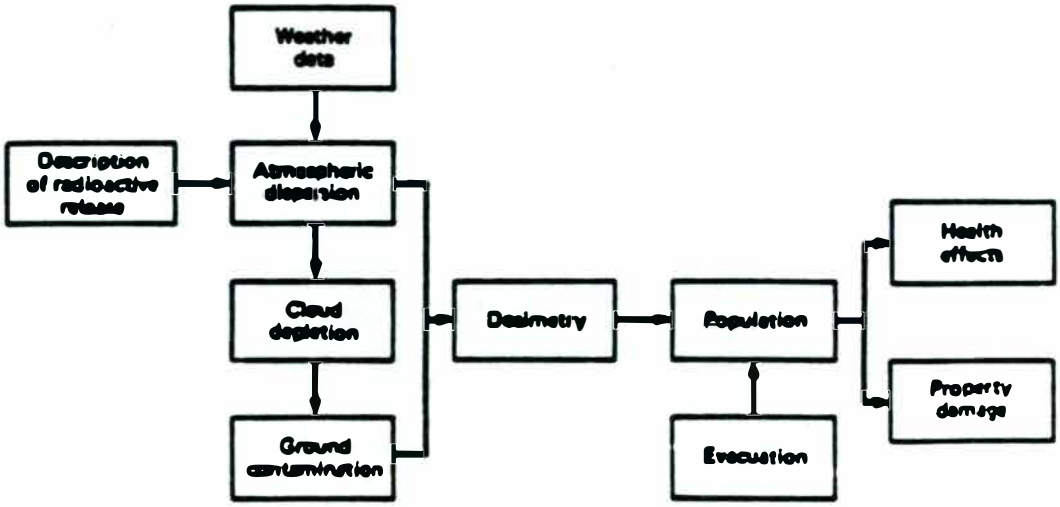
CONTINUATION OF TC

FIGURE 7.4-2



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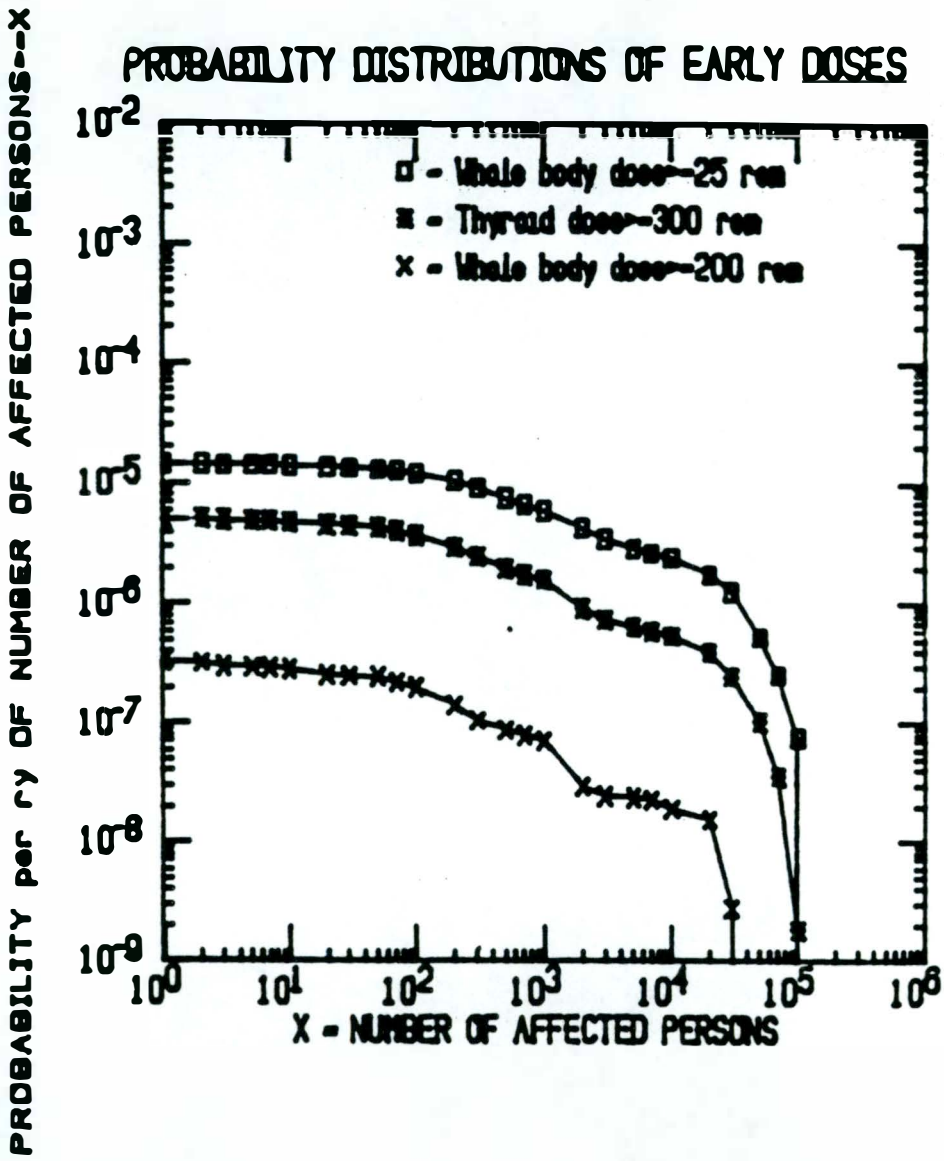
SCHEMATIC OUTLINE OF CONSEQUENCE MODEL (CRAC2)

FIGURE 7.4-3



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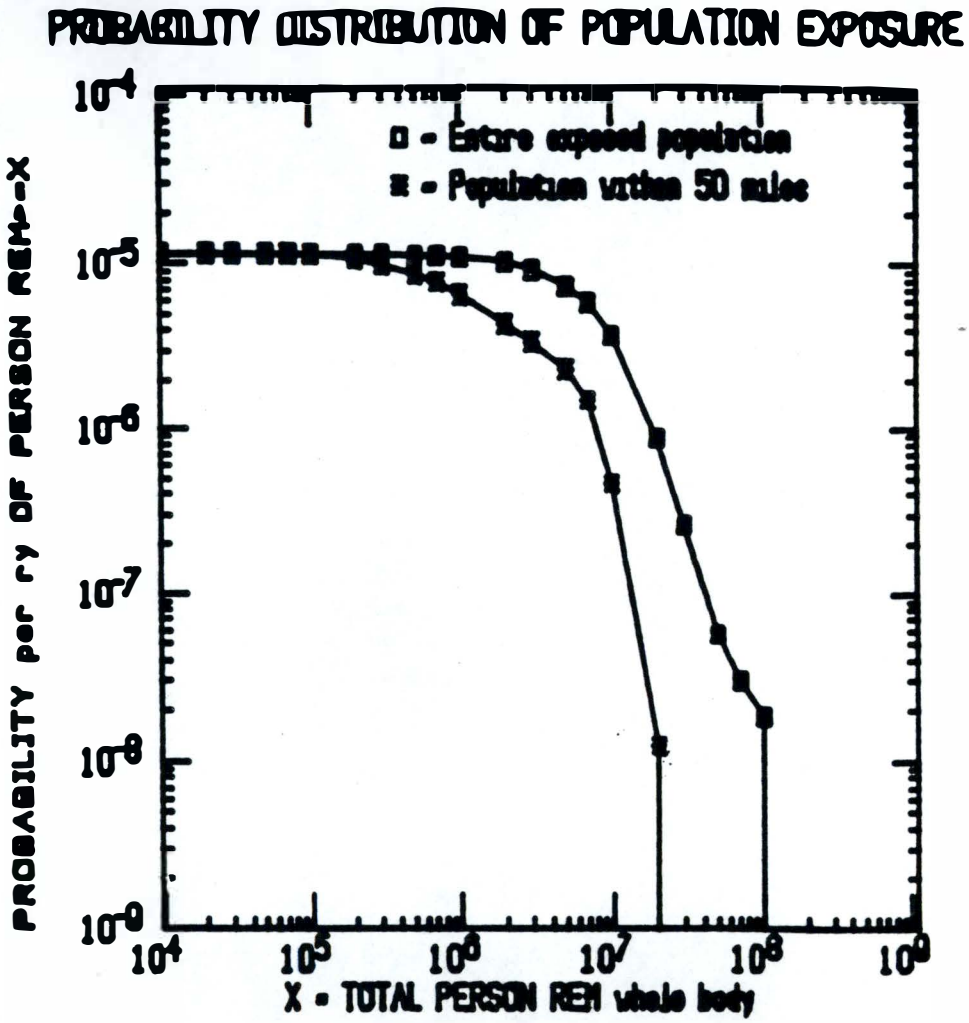
INDIVIDUAL EARLY
DOSE IMPACTS

FIGURE 7.4-4



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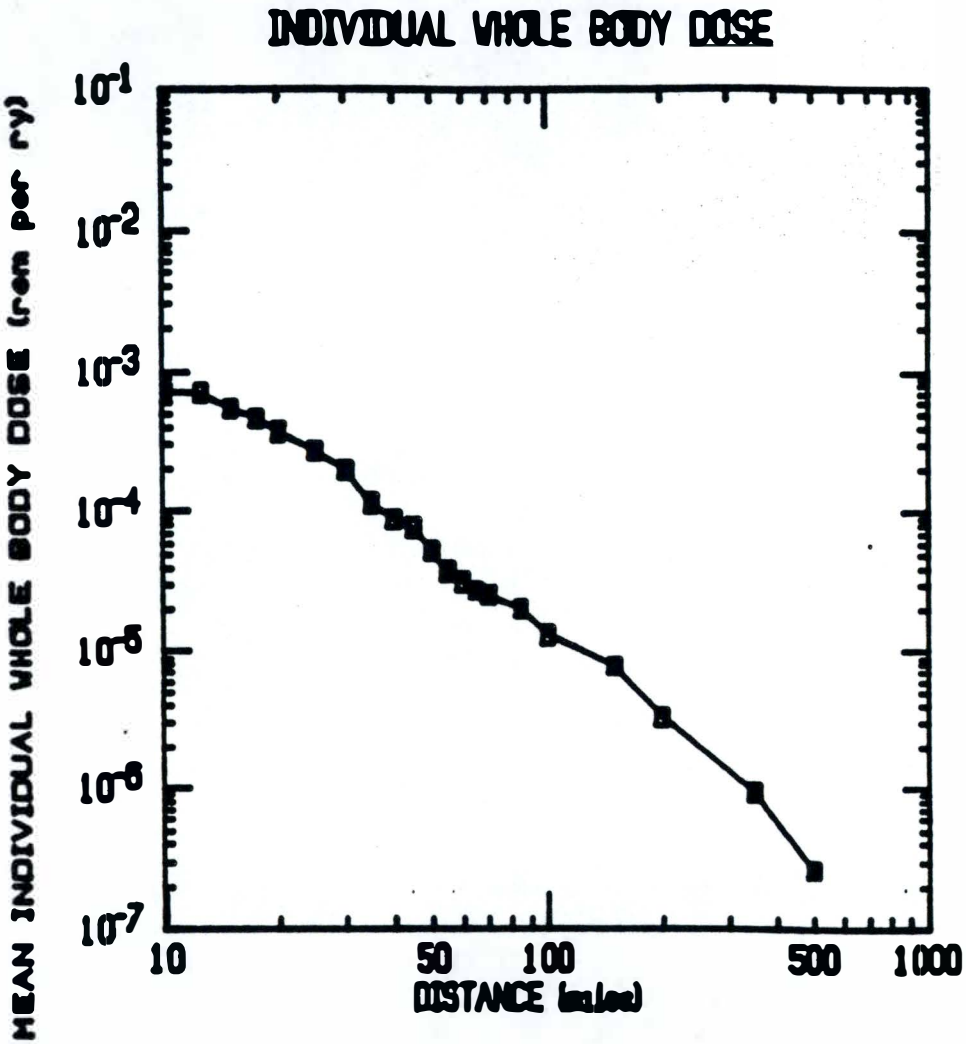
POPULATION EXPOSURE

FIGURE 7.4-5



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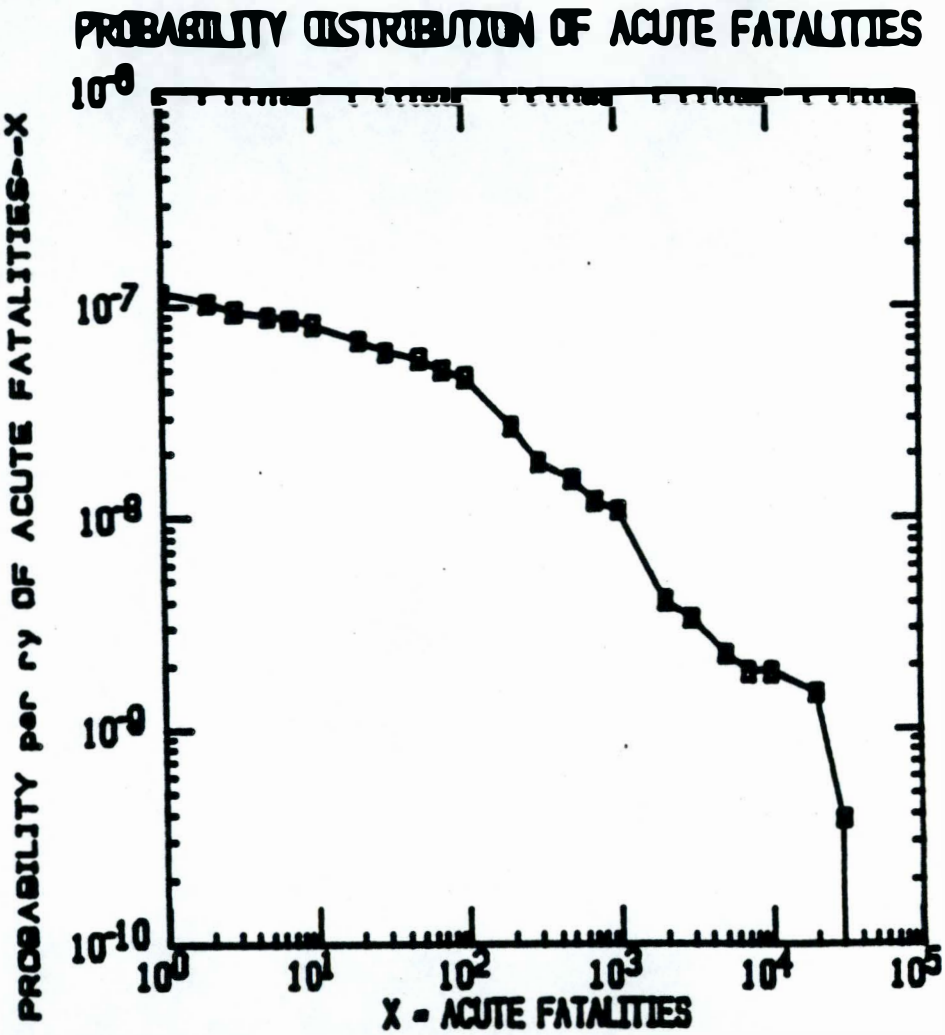
INDIVIDUAL WHOLE
BODY DOSE DOWNWIND

FIGURE 7.4-6



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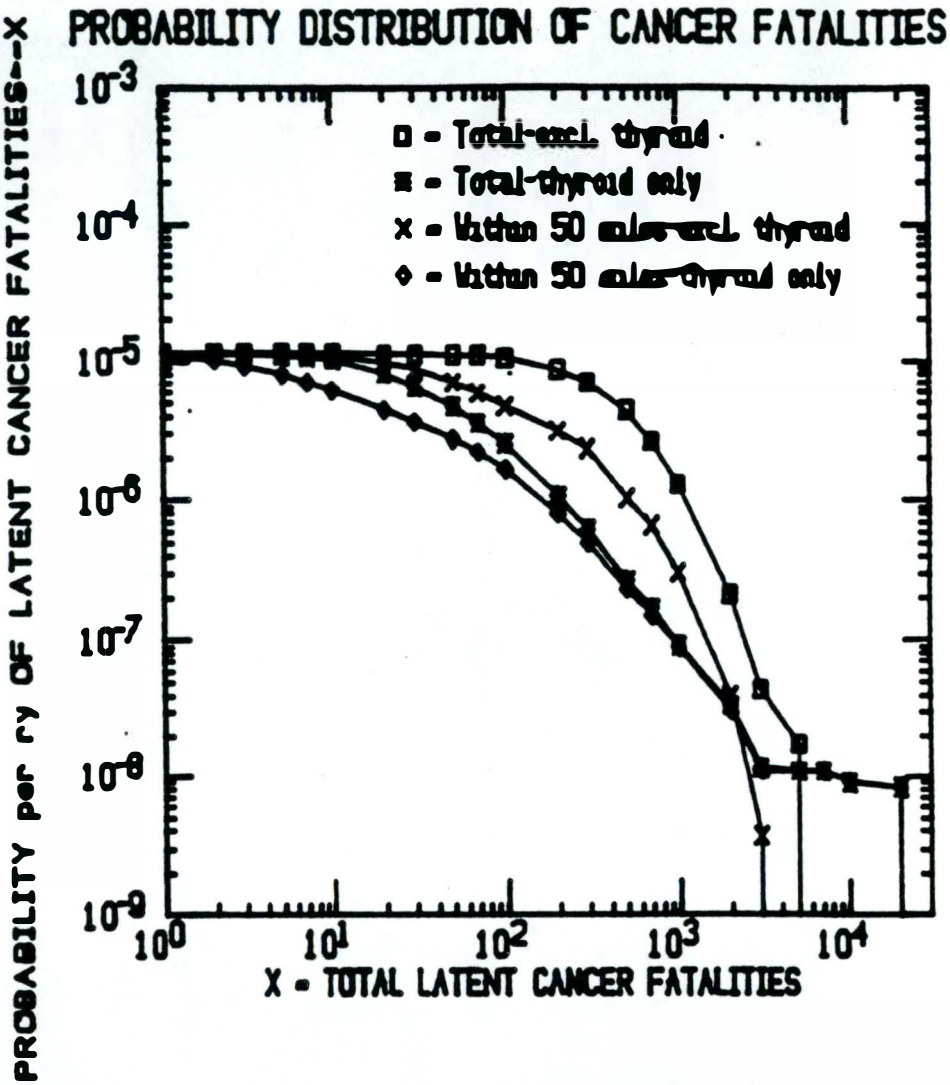
ACUTE FATALITIES

FIGURE 7.4-7



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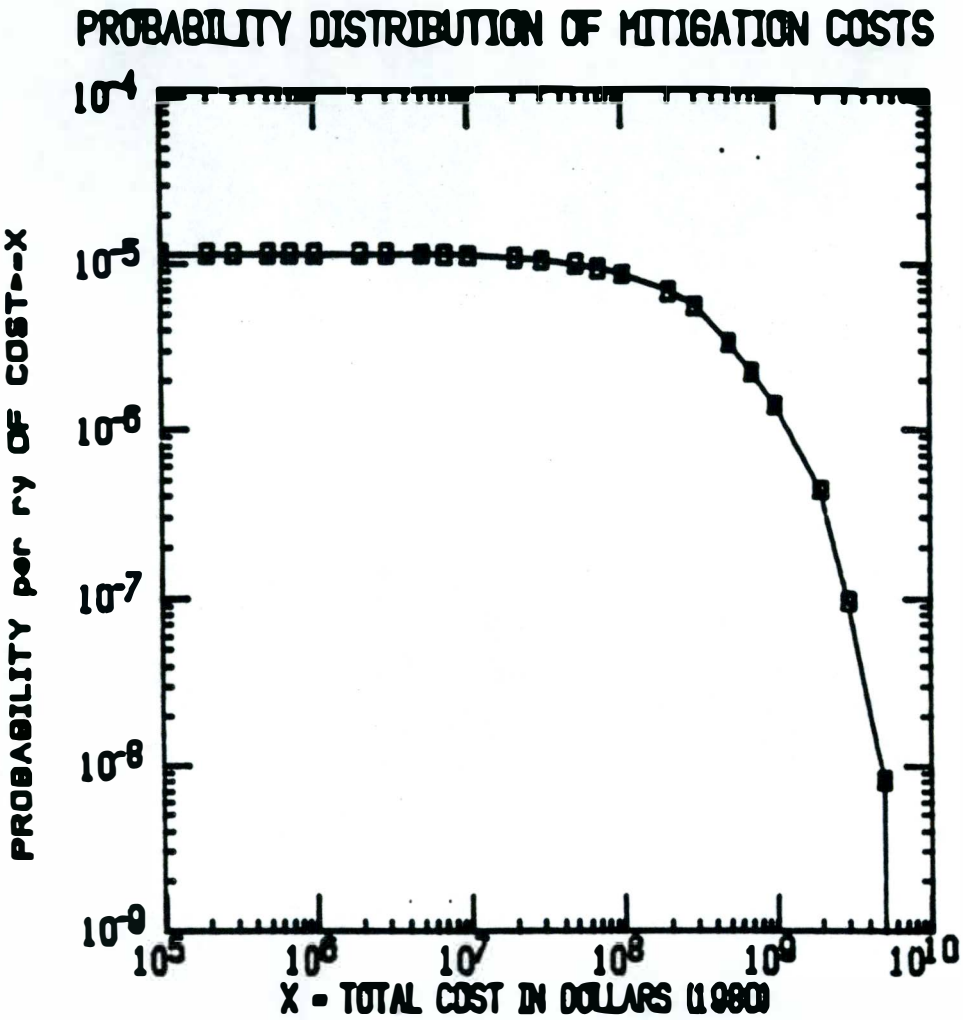
LATENT CANCER FATALITIES

FIGURE 7.4-6



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COST OF MITIGATION MEASURES

FIGURE 7.4-9

CHAPTER 8.0

ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

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CHAPTER 8.0

ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

TABLES

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8.0 ECONOMIC AND SOCIAL EFFECTS OF PLANT CONSTRUCTION AND OPERATION

The two unit Skagit/Hanford Nuclear Project will consist of two light water boiling reactors and two turbine generators. The net electrical generation for distribution outside of the S/HNP will be approximately 1,275 megawatts per unit.

The Site of the facility is 1200 acres located 2 miles west of the WYE barricade in the central portion of the Hanford Reservation. The Site is in Benton County and is approximately 15-20 miles northwest of the cities of Richland, Pasco, and Kennewick, which comprise the core of the Tri-Cities Standard Metropolitan Statistical Area (SMSA). In 1980, the population of the Tri-Cities SMSA was 144,469.

Site preparation is expected to commence in 1983 with commercial operation of Unit 1 beginning in January, 1991 and Unit 2 in January, 1993. The annual average on-Site labor force will range from 571 in 1983 to 4,617 in 1988 to 1677 in 1991. The operations force (e.g. 1994) for the two units will be comprised of approximately 295 permanent employees. An additional refueling contingent of 200 workers will be required at periodic intervals. 4

8.1 RELIABILITY BENEFITS

8.1.1 GENERATION OF ELECTRICITY

The primary benefits of the Skagit/Hanford Nuclear Project are those inherent in the value of the generated electricity which will be delivered by the Applicants to their customers.

Forecasts of electrical supply and demand for the Applicants and the Northwest region are set out in Chapter 1, Tables 1.1-6 and 1.1-7, respectively. These forecasts assume that each unit of the Project will supply 765 MW (average) of energy (6.7 billion kW-hr) in its first full year of commercial operation. The following year, and each year thereafter, each unit is scheduled to supply 937 MW (average) of energy (8.2 billion kW-hr).

The disposition of electric energy from the Project is expected to be similar to that experienced in the West Group Area in 1980. The relative consumption by each class

of consumer in the West Group Area in 1980 is as follows (Ref 1):

	1980
Residential -	34.8 %
Commercial -	18.7 %
Industrial -	42.6 %
Irrigation -	3.9 %
Total	100.0 %

The forecast consumption by customer class for the Northwest Region as of the 1991 Unit 1 commercial operation date is as follows (Ref 2):

	1991
Residential -	31.7 %
Commercial -	20.2 %
Industrial -	43.0 %
Irrigation -	5.1 %
Total	100.0 %

Actual and estimated electric power requirements in the West Group Area are shown on Table 1.1-5. A lower annual average growth rate is expected for the period from 1981-82 to 1998-99 than was experienced in the period from 1965-66 to 1980-81. This change is the result of consumer and producer efforts to conserve energy, higher nonpromotional electric rates, more efficient electrical appliances and electrical appliance saturation.

8.1.2 RELIABILITY

In the Northwest Regional Forecast of Power Loads and Resources, date June 1981, the expected date of commercial operation for the Skagit/Hanford Nuclear Project is January 1991. Based on that date the forecast states that the cumulative probability of not meeting total energy load through June 1992, with the Project on schedule is 99 percent and of not meeting firm load is 88 percent (Ref 3). With all projects including S/[redacted] on schedule, the probability of not meeting total energy loads in any year through 1992 ranges from 34 percent to 52 percent. Similarly, the probability of not meeting firm energy loads ranges from 11 percent to 28 percent.

The various Northwest states are developing emergency curtailment plans, which would be implemented in the event of an electrical energy shortage. These plans typically

begin with increasingly stringent voluntary curtailment measures, before moving ahead with mandatory actions.

As the probability for meeting total and firm energy loads in all periods of 1981 to 1992 decreases, the need for projects, such as S/NNP, being available as scheduled becomes greater with the hope that, if a deficit occurs, only the voluntary portions of the emergency plan will need to be utilized.

8.1.3 ECONOMIC AND SOCIAL BENEFITS OF MEETING LOAD GROWTH REQUIREMENTS

In order to provide regulatory agencies with empirical information regarding the socioeconomic benefits of meeting load growth requirements, Puget Sound Power and Light Company commissioned a study in 1980 entitled The Socio-economic Value of Reliable Electric Power (Ref 4).

This study undertook a review of the impact of extended power outages upon the social and economic well-being of the people in a given service area. The basic findings were as follows:

1. Health risks to the population are varied and significant. Power interruptions typically result in: (a) overburdened medical facilities; (b) reduced mobility of emergency vehicles; (c) spoilage of blood and drugs; (d) contamination of laboratory experiments; and (e) disrupted sewage and water treatment. In addition, back-up generation has completely or partially failed at a number of hospitals. 4

2. Safety problems have also been closely associated with power outages: (a) fires increase because of accidents and increased use of candles and wood-stoves; (b) falls increase because of lack of adequate lighting; (c) traffic accidents increase due to inoperative signals; (d) air-traffic accidents increase in probability because of the lack of obstruction lighting on highrise buildings and towers; (e) injuries to police and firemen increase; and (f) industrial accidents and injuries may increase because of sudden stoppage of equipment and machines.

3. Economic costs of an outage relate to several kinds of losses. Short-term dollar costs, for example, have been found to be significant. The

1977 New York City outage, for example, is estimated by the Department of Energy to have cost over $345 million. Several short outages in California in 1978 were estimated to have cost over $11 million (Ref 4).

Long-term economic losses of power interruptions, however, may be even more significant than the short-term effects. Research on industrial location has documented the importance of reliable electric power to companies seeking new plant locations. Further, an inadequate supply of electric power may prevent electric utilities from accepting new customers. Such a situation could lead to unemployment and out-migration from a service area.

4. Inequities - Power interruptions affect various segments of the population differently. Minority groups which are vulnerable include the elderly, the handicapped and infirm and the poor.

   Businesses which are most negatively affected include: (a) sawmills; (b) rubber and plastics firms; (c) banks; (d) aluminum, metal and glass manufacturers; and (e) such agricultural activities as dairy and poultry.

5. Social disorganization is associated with power interruptions due to disruption of the social order. Outages frequently result in increases in: (a) crime; (b) psychological stress--anxiety, tension and fear; (c) breakdowns in communications and transportation; and (d) adverse effects on social institutions. Although the 1977 New York City blackout is the most dramatic example of a breakdown in social order, outages in Memphis, San Antonio and Providence also resulted in increased criminal behavior.

6. Quality of life. Impacts of previous outages suggest that of fourteen quality of life indicators on an Urban Institute scale (Ref 4); six decline, four are questionable, and four remain unchanged. None improves.

In summary, the socioeconomic consequences associated with previous power outages have often been profound. Such outages have resulted in loss of life, health and safety risks to the population, both short-term and long-term economic costs, inequitable impacts on vulnerable segments of the population and increased social disorganization.

8.1.3.1 Survey of Puget Customers Regarding the Socioeconomic Costs of Electric Energy Shortages

In order to obtain the consumers' perspective on the potential socioeconomic consequences of an inability to meet the load, direct input was obtained from 1,625 Puget Power customers via a mailed survey (Ref 4). Samples were drawn from the business, institutional, agricultural and residential sectors. In order to give respondents a common perspective, each questionnaire included a scenario of an inability to meet the load. One scenario dealt with daily three hour rotating outages over an eight week period. A second scenario posed a 25 percent curtailment over a sixteen week period. Half of the sample was asked to respond to the first scenario and half to the second.

While responses from the 1,625 consumers provide a vast amount of data and information, the findings support four primary conclusions:

1. Virtually all consumers regard reliable electric power as extremely important to themselves, their businesses and their community. Substantial majorities of all groups of respondents stressed the importance of reliable electricity to their socioeconomic well-being.

2. Consumers perceive significant socioeconomic costs to be associated with power shortages. For example, in responding to the curtailment scenario, 141 local businesses estimated their dollar loss to exceed $28.9 million (See Table 8.1-1). Further identified costs included not merely dollars lost in the short-term, but also health and safety risks, impacts on the elderly, declines in agricultural production, negative implications for the long-term economic stability of the area and decreases in the quality of life. Finally, responses regarding "back-up" generation reveal that few businesses and institutions have such alternatives available.

3. A majority of all consumer groups see an adverse effect upon their communities if inadequate electric power supplies make Puget Power unable to connect new homes and businesses. Most respondents saw such a situation as leading inevitably to "no growth", stagnation and a general decline in socioeconomic prosperity.

4. From the consumer survey, it is apparent that the potential energy shortages in the Northwest possess adverse implications for the social system. The socioeconomic costs, as defined by hundreds of consumers making input into the study, go far beyond the costs previously identified in the research literature on the impact of power shortages. 4

Construction of S/[redacted] will reduce the probability of an inability to meet the load and thereby contribute to the avoidance of the socioeconomic costs of power shortages.

References for Section 8.1

1. John McConnaughey, Bonneville Power Administration, Power Requirements Branch (December 9, 1981).

2. "Econometric Model - Electricity Sales Forecast" PNUCC (July 1981), p. 32.

3. "Northwest Regional Forecast of Power Loads and Resources" PNUCC (June 1981), p. 2-15.

4. The Socioeconomic Value of Reliable Electric Power, Puget Sound Power and Light Company (1980).

TABLE 8.1-1

ESTIMATED DOLLAR LOSS BY CONSUMER GROUP

Customer Group	Scenario: Rotating Outage — Number of Respondents	Rotating Outage — Estimated Dollar Loss (In Millions)	Curtailment — Number of Respondents	Curtailment — Estimated Dollar Loss (In Millions)
Business	172	$14.2	141	$28.9
Institutional	121	4.2	99	2.7
Agricultural	49	1.8	56	4.3
Total	342	$20.2	296	$35.9

NOTE: Ninety-seven respondents stated they would have a dollar loss but did not estimate the exact number.

Source: The Socioeconomic Value of Reliable Electric Power, Puget Sound Power and Light, Bellevue, Washington, 1981.

8.2 COSTS

The costs of the Skagit Hanford Nuclear Project can be separated into two categories: (a) the capital costs incurred prior to operation and; (b) the annual costs of operation.

8.2.1 CAPITAL COSTS

The total estimated capital cost for the Project at commercial operation is $7.808 billion (see Table 8.2-1). This estimate is based on a detailed earlier estimate which was re-examined and adjusted in 1980 to reflect recent changes in economic parameters and industry trends, and the relocation of the Project to the Hanford Reservation.

The start of Unit 1 construction is scheduled for January 1983. Unit 2 will start two years after Unit 1. Commercial operation for Units 1 and 2 is scheduled for January 1991 and January 1993 respectively.

8.2.2 ANNUAL COSTS OF OPERATION

The annual costs of operation include fuel, operation and maintenance and insurance. These costs (see Table 8.2-2) are reported in mills per kilowatt-hour for comparison with alternate energy sources (Section 9.5).

The reported costs are bus bar costs levelized over the 30-year life of the Plant. Table 8.2-3 provides a summary of statistical data that was used in estimating the costs.

The reference source of data used in determining fuel costs is S.M. Stoller Corporation. Costs were developed in 1991 dollars using estimated "real escalation" costs levelized over the plant lifetime and adjusted for anticipated inflation. The operation and maintenance costs were derived using a one-unit currently operating nuclear plant as a base adjusted to reflect two units. All costs were levelized in accordance with EPRI Study PS-1201 SR dated July, 1979.

TABLE 8.2-1

COST INFORMATION FOR NUCLEAR ($000)

1.	Interest During Construction	%/Year	9%	
		Compound Rate	N/A	
2.	Length of Construction Workweek	Hours/Wk	40	4
3.	Estimated Site Labor Requirement	Manhours/KWe	17.02	
4.	Average Site Labor Pay Rate (Incl. Fringe Benefits) Effective at Month and Year of NSSS Order	$/Hour	11.53(*)	5
5.	Escalation Rates: Site Labor	%/Year	N/A	
	Materials	%/year	N/A	
	Composite Esc Rate	%/year	10% 1980 and 1981 8% 1982 and beyond	4
6.	Power Plant Costs (Nuclear Units 1 & 2)			

		Unit 1	Unit 2	
Direct Costs				
a.	Land and Land Rights	$ 3,000	$ 0	
b.	Structures and Site Facilities	464,962	294,584	5
c.	Reactor Plant Equipment	331,413	330,446	
d.	Turbine Plant Equipment	226,375	241,431	
e.	Heat Rejection System	-------	-------	
f.	Electric Plant Equipment	114,093	86,582	
g.	Miscellaneous Equipment	21,732	13,820	
h.	Spare Parts Allowance	6,882	3,304	
i.	Contingency Allowance	Incl Above	Incl Above	
	Subtotal	1,168,457	970,167	
Indirect Costs				4
a.	Construction Facilities, Equipment, and Services	201,564	154,977	
b.	Engineering and Construction Management Services	298,815	101,183	
c.	Other Costs	142,164	54,473	
d.	Interest During Construction (@ 9%/year)	925,833	489,588	
Escalation				
	Escalation During Construction (@ 8%/year)	1,512,067	1,789,212	
Total Cost				
	Total Plant Cost @ Start of Commercial Operation	4,248,900	3,559,600	

(*) May 1973 dollars. 5

TABLE 8.2-2

ESTIMATED COSTS OF ELECTRICAL ENERGY GENERATION NUCLEAR UNITS 1 & 2

	Mills/Kilowatt-Hour (Levelized over 30 yr operating period)
Fixed Charges(1)	
Operating Income	31.4
Depreciation	16.6
Interim Replacements	----
Taxes	21.3
Total Fixed Charges (FCR at 13.88%)	69.3
Fuel Cycle Costs(2)	
Cost of U_3O_8 (Yellowcake)	12.9
Cost of Conversion and Enrichment	6.6
Cost of Conversion and Fabrication of Fuel Elements	4.3
Cost of Processing Spent Fuel	----
Carrying Charge on Fuel Inventory	8.6
Cost of Waste Disposal	5.5
Credit for Plutonium or U-233	0
Total Fuel Cycle Costs	37.9
Costs of Operation and Maintenance	
Fixed Component	23.1
Variable Component	8.5
Total O & M Costs	31.6
Costs of Insurance	
Property Insurance	1.9
Liability Insurance	.2
Total Insurance Costs	2.1
Total Bus Bar Costs	140.9

(1) Assumed capacity factor is 70%. Assumed cost of money is 10.67%.

(2) Shipping charges included. Assumed heat rate of 10,215 BTU/kwh.

4

TABLE 8.2-3

FACT SHEET FOR POWER GENERATION COSTS

ITEMS	NUCLEAR	FOSSIL
Plant Net MWe		
Each	1275	508
Total	2550	2540
Commercial Operation	1/91; 1/93	(3) 1/91; (2) 1/93
Total Project Costs ($ x 10^6) @ Commercial Operation	7,808	6,131
Total Project Costs ($/KW) @ Commercial Operation	3062	2414
Levelized Fixed Charge Rate (%)	13.880	14.580
Fuel Costs 1/1/91 ($/$10^6$ BTU)	1.88	3.38
Heat Rate BTU/KWH	10,215	10,600
Escalation Rates		
O & M %/Yr	8	8
Fuel %/Yr	8	8
Levelizing Factors		
O & M	2.3567	2.3567
Fuel	2.3567	2.3567
Capacity Factor (%)	70	70

8.3 SOCIAL AND ECONOMIC IMPACTS

8.3.1 DESCRIPTION OF THE PROJECT IN THE CONTEXT OF THE TRI-CITIES AREA

The location of the Site in relation to the Tri-Cities and surrounding communities and counties is shown in Figure 8.3-1.

The early development of Richland, Kennewick and Pasco was tied to the agriculture and transportation industries. Until World War II, for example, Richland (founded in 1910) was a small farming community of several hundred people. At the same time, Pasco and Kennewick developed economies integrally related to the railroad industry. By 1940 the populations of Pasco and Kennewick had grown to 3,913 and 1,918, respectively. The combined population of the three cities in 1940 was 6,078 (Ref 1). 4

In 1942, the town of Richland was taken over by the United States Government through condemnation proceedings as part of a 600 square mile reservation for the Hanford Engineering Works. From 1943-1945 the city of Richland was built to house the personnel and administrative offices associated with the plutonium production facilities on the Reservation. While the character of Pasco and Kennewick was less dramatically affected during this period, they too, grew and changed due to war-time activities and operation of the Hanford Works (Ref 2).

By 1950 the population of the Tri-Cities was over 50,000 and the economy of the area had become closely linked to nuclear technology. By the 1960's corporations such as Westinghouse, Battelle, North American Rockwell, United Nuclear Corporation, Boeing and Exxon located nuclear operations in the Tri-Cities area. The Tri-Cities Nuclear Industrial Council has been an active force in promoting the development of nuclear industries. 5

By the 1970's construction of the Fast Flux Test Facility (USDOE) and WPPSS Nuclear Plants (WNPs) 1, 2, and 4 by Washington Public Power Supply System (Supply System) provided a dramatic stimulus to the local economy. Over the 1978-1979 period, for example, the Tri-Cities SMSA had the ninth largest increase in personal income of the 273 SMSAs in the United States (Ref 3). 4

From 1970-1980 the population of the Tri-Cities Standard Metropolitan Statistical Area (SMSA) grew 54 percent, from 93,356 to 144,469 (Ref 1).

Much of this increase in economic and demographic activity was related to nuclear facility construction on the Hanford Reservation. For example, in 1970 there were approximately 1,756 construction workers in the Tri-Cities SMSA but by 1979 this figure had grown to 11,110 on an average annual basis, of which 7,630 were employed by the Supply System. By June of 1981, monthly employment in the Tri-Cities SMSA reached 13,880 construction workers. 4

8.3.2 DELINEATION OF IMPACT AREA

Nuclear related construction over the past generation has changed the socioeconomic character of the Tri-Cities Area. The great bulk of the new activity generated by this construction - from population growth to traffic congestion - has occurred in the SMSA and particularly within Richland, Pasco, Kennewick, West Richland and Benton City.

School enrollment data presented in Table 8.3-1 illustrate the localized nature of construction related in-migration. 5
In May of each year school districts in the area conduct a survey to identify "construction pupils," i.e., students whose parents are employed at WNP-2 or 1/4 and whose date of residence in the school district was subsequent to May 1, 1972 (for WNP-2) and May 1975 (for WNP-1/4).

Table 8.3-1 depicts the results of the May 1980 survey. As these data demonstrate, construction pupils, both in terms of absolute and relative impact, are concentrated in the school districts closest to the Site and the core of the SMSA. For example, the Richland, Kennewick and Kiona-Benton districts accounted for approximately 83 percent of all construction pupils identified by the Supply System audit. 4

Such data as the school enrollment figures in Table 8.3-1 strongly suggest that the impacts of S/HNP - both positive and adverse - will be centered within Benton and Franklin Counties in general and particularly in the following five communities: (1) Benton City, (2) Kennewick, (3) Pasco, (4) Richland, and (5) West Richland. Other communities in Benton and Franklin Counties (e.g., Prosser) will only be modestly affected by S/HNP construction and operation.

According to the Supply System surveys undertaken between 1975 and 1978, daily commuters residing in Yakima County

accounted for 8.5-12.5 percent of the construction work force at WNP-1/4. Estimates based on the survey for the 1979-1980 period of daily commuters residing in Yakima County were 10 percent of the construction workforce on WNP-1/4. This percentage may be lower for the total Supply System construction workers since WNP-2 began construction earlier and could draw more heavily on locally available labor.

During the 1980 labor-management dispute, it was estimated that about 18 percent of the 6,600 job loss belonged to Yakima County. This may over estimate commuters in the total workforce since the possibility exists that local hires may be protected at the expense of commuters and the fact that commuters become a proportionately larger share of the workforce as the peak year approaches. Therefore, estimates of commuters residing in Yakima County are probably in the range of 10-15 percent of the total construction workforce. If this pattern continues through the S/HNP construction period, several hundred residents of such communities as Grandview, Sunnyside and Mabton would obtain jobs on the Project. The economies of the outlying communities can be expected to be enhanced through the S/HNP employment and income effects. The fact that these community work forces have extensive nuclear construction experience suggests that these workers will benefit from the S/HNP job opportunities, although such communities as Grandview, Sunnyside and Mabton are not considered part of the impact area. 4

8.3.3 ALTERNATIVE SCENARIOS

Over the past decade the Tri-Cities SMSA has been one of the most dynamic socioeconomic settings in the United States (Ref 4). During the period 1970-1980, for example, the population increased by 54.8 percent compared to an 11.4 percent rate for the nation.

Dependence upon energy related construction, operation and research makes the area vulnerable to marked changes in business conditions and particularly subject to the impacts of external decisions regarding energy development.

The range of alternative futures does not appear to be decreasing in the 1980's. For example, the following external decisions will each have a major role in determining the short-term (1982-1990) future of the Tri-Cities area:

1. Decisions of if and when construction of WNP-4 will re-commence.

2. Decisions permitting construction of S/HNP.

3. Decisions of courts on the constitutionality of Initiative 394. This Initiative could have an effect upon WNP 1, 2 and 4, as well as a proposed powerhouse at Priest Rapids Dam.

4. Decisions by USDOE to (a) decrease, (b) maintain or (c) increase activities on the Hanford Reservation. At the present time approximately 12,000 jobs are accounted for by USDOE and its contractors.

Given the uncertainty associated with these decisions as well as the magnitude of their potential impact upon the future of the Tri-Cities, a "scenario" approach is appropriate for the present analysis. Four scenarios are utilized:

Scenario 1 - Construction of WNP-4 resuming as scheduled in 1983 and peaking in 1985 with S/HNP not constructed.

Scenario 2 - Construction of WNP-4 resuming in 1983 and peaking in 1985 coupled with construction of S/HNP commencing in 1983 and peaking in 1988.

Scenario 3 - Construction of S/HNP commencing in 1983, peaking in 1988 and WNP-4 cancelled.

Scenario 4 - No major construction projects after the completion of WNP-1 and WNP-2 for the period 1980-2000.

Scenarios 1 and 4 are presented as alternative baseline scenarios to indicate the socioeconomic character of the area without construction of the Project. In this study "impacts" are conceptualized as the difference between the projected socioeconomic condition of the Tri-Cities without as compared to with S/HNP.

8.3.4 ROLE OF THE SOCIO-ECONOMIC MONITORING PROGRAM

Previous research has demonstrated that nuclear power stations may have a range of socio-economic impacts upon local communities.

Accordingly, Puget will develop and implement a two-phase program: (1) where adverse socio-economic impacts can be identified on an a priori basis, appropriate mitigation measures will be taken; and (2) a socio-economic monitoring program will be utilized to identify actual as opposed to projected impacts and impact areas. The results of this ongoing monitoring will enable Puget to develop effective mitigation measures as necessary.

8.3.5 TAX REVENUES ASSOCIATED WITH CONSTRUCTION AND OPERATION

8.3.5.1 Tax Revenues

Significant tax revenues would be generated by the construction and operation of S/HNP for local jurisdictions and the State of Washington. These revenues would emerge from the following:

1. Property taxes on the facility. According to Washington Tax Law, private electric utilities are subject to a property tax imposed by the county (Ref 5). In the case of the S/HNP, Benton County would collect the property tax and disburse part to the State for inclusion in the General Fund for public education. The remaining portion would accrue to Benton County for disbursement within the County. 4

   The exact amount of tax revenues generated depends on the assessments, levies and laws in effect at the time the Project goes on the tax rolls. The average levy rate will probably decrease because of the Project. The following data, therefore, are presented as examples only and are subject to change. They do, however, place the magnitude of the potential tax revenues in perspective.

   Table 8.3-2 presents projected costs of construction by year, estimates of cumulative assessed value and estimates of potential property taxes accruing to the State and Benton County during the construction period. As these data indicate, substantial property tax revenuer could be paid to both Benton County (total $139 million) and the State (total $106 million) during the construction period from 1983-1992.

   Potential property tax revenues during operation of the facility will be of even greater magnitude and

will have dramatic effects upon the tax base of local taxing jurisdictions (Table 8.3-3). These tax base increases could be translated into major revenues for each jurisdiction. In the first year of operation of both units, for example, the following situation would exist if (a) 1981 tax rates were in effect and (b) the facility was assessed at 80 percent of its value. 4

Example:

Year	Assessed Value (1981$)	Property Tax (1981$) State	Benton County	Total
1994	$2.4 billion	$8,250,000	$11,250,000	$19,500,000

5

Over the lifetime of the Plant, therefore, several hundred million dollars in taxes could be paid to Benton County for distribution within the county as well as to the State. To put the impact of the S/HNP in perspective, the total valuation of all property in Benton County in 1981 was just over $2.7 billion and taxes collected for the State, county, roads and schools were $25.9 million. The assessed value of S/HNP (in 1981 dollars) alone would be almost double the valuation of all assessable county property at the current time. If the present tax base remained constant until 1994, this would mean that the S/HNP would account for about 47 percent of the property tax base when assessed at 80 percent of full value (see Table 8.3-3). 4 5 4 5

2. Sales and use taxes of 5.3 percent are collected by the State and disbursed as follows: 4.5 percent to the State, 0.3 percent for the local transit district and .5 percent to local jurisdiction. 4

Recent fiscal conditions in the State of Washington have resulted in increased sales taxes at the state level. At the time of this analysis, such proposals were being considered and the following discussion is based on taxes in effect as of October, 1981. 5

The sales and use tax effects are applied to an assumed construction cost of about $5.3 billion. This amount is about $2.5 billion less than the estimated final value of the facility ($7.8 billion) because it excludes a number of costs, such as the value of the 4

property, the allowance for funds during construction, transmission costs, fuel costs, and various tax payments. The example shown here assumes that one-half of the purchases were liable for Benton County sales/use taxes. The year 1987 is displayed to demonstrate an annual year effect of these revenues. 4 5

Recipient	Annual Revenue (1987 as Example Year)	Total Revenue over 1983-1992
State	$ 39,480,000	$238,500,000
Benton County	2,190,000	13,250,000
Other Counties	2,190,000	13,250,000
Benton Franklin Transit District	1,300,000	$ 7,950,000
Total	$ 45,160,000	$272,950,000

4

During operation, the sales and use tax is particularly important because of the cost of nuclear fuel. It is estimated, for example, that the costs of the initial cores of the two units will be $322.1 million in 1981 dollars. Purchase of these cores could provide $14,494,000 in revenues to the State; $1,610,000 to Benton County and $966,000 to the Benton-Franklin Transit Authority.

The following revenues would be generated if annual fuel costs were $132.4 million in 1981 dollars:

Entity	Annual Revenues due to Nuclear Fuel Costs Only
State	$5,958,000
Benton County	662,000
Benton-Franklin Transit District	397,000
Total	$7,017,000

5

In addition to these fuel costs, the tax on local purchases will produce revenues each year during the operation phase. It is estimated that approximately $5,000,000 in local purchases of materials and services will be made each year resulting in increased annual revenues for both Benton County and the Transit District.

3. Business and occupational taxes are collected by the State during construction. On 5.3 billion dollars of tax base, taxes would be over $23,000,000. 4

4. Business taxes imposed by local communities will generate revenues from the Project. Purchases of local materials, supplies and engineering services, for example, will result in increased business activity during both construction and operation.

5. Other revenues will accrue to the local taxing jurisdictions and the State through the business activity ~~generated by~~ expenditures of persons employed at the Project. The relatively high incomes of such employees will mean that they will stimulate more business activity than the average worker and that they will pay more than average taxes. Estimated annual income per worker at S/HNP during construction is $37,289 (1980 dollars). Estimated annual salary per employee during the operations phase is $23,600 (1980 dollars). In 1979, the average annual wages in the Tri-Cities SMSA were $15,962.

8.3.5.2 Projected Conditions Under Alternative Scenarios

Under Scenarios 2 and 3, if 1981 levies were in effect, the Project would generate the following estimated revenues during construction:

	Estimated Revenues During Construction
State	$380 million
Benton County	$150 million
Benton-Franklin Transit District	$ 8 million
	$538 million

During S/HNP operation Benton County would annually receive $29.3 million in property taxes and over $700,000 in sales tax. The State would receive $21.5 million and $5.9 million respectively. The Benton-Franklin Transit District would receive nearly $400,000 per year from sales tax on nuclear fuel alone.

The magnitude of these additional revenues over those that would be collected under Scenario 1 would allow Benton County to consider such options as significantly improving services, disbursing funds to local communities and/or lowering tax levies.

Under the baseline scenarios, neither these revenues nor these options would exist.

8.3.6 POPULATION

8.3.6.1 Existing and Developing Conditions

Table 8.3-4 presents population changes for the area over the period 1940 to 1980. As these data indicate, the SMSA has had significant and sustained growth in recent decades with an increase of 54.8 percent in the 1970-80 period.

With regard to age structure, the population of the SMSA is composed of a disproportionately large number of younger persons as projected for 1982 (Ref 4):

Age Category	1982 (Ref 7) N	%
0-19	50,120	33.7
20-34	41,860	28.1
35-44	17,140	11.5
45-64	28,970	19.5
65+	10,810	7.2
Total	148,900	100.0%

In terms of projections of future population growth, Yandon (Ref 6) has pointed out that population projections for the Tri-Cities have been notoriously inaccurate to the extent that some projections have been out of date even before they were published. Thus, in evaluating projections, the impact of external decisions must be fully recognized.

The 1982-1990 population of the Tri-Cities will be influenced by the level of construction activity on the Hanford Reservation. Table 8.3-5 presents projected nuclear related construction workforce by year for the Project as well as WNP 1, 2, and 4. As these data indicate, in no case will the workforce between 1982-1990 exceed the 1981 workforce. These data demonstrate a declining construction workforce in the area related to nuclear construction even with S/HNP. This situation may lead to either

absolute population losses or declines in the expected rate of growth.

As Schau (Ref 7) has shown, the bulk of population growth in the Tri-Cities area during the latter 1970's was due to high rates of in-migration. Much of this in-migration was associated with increased USDOE and Supply System employment in the area. From 1975-1980, employment by USDOE and its contractors increased from 9,800 to 12,100. From 1975-1980, Supply System average annual employment increased from 1,585 to 6,549. During the latter half of the decade, these two agencies accounted for 35 percent of all average annual non-agricultural jobs added to the economy during 1975-1980. The combined effect of primary and secondary jobs created by these two agencies was over 63 percent of new jobs created in the Tri-Cities area.

The State of Washington population projections for the Tri-Cities SMSA over the next two decades are reflective of dramatic population increases in the 1970's and project large increases continuing through the 1982-1992 period. These projections overstate the potential for population growth for four reasons: (1) a decline of Supply System construction employment is planned, (2) there is a high degree of uncertainty relating to the future level of USDOE funding, projected growth rates range from being slightly negative to 1 percent per year, (3) even if WNP-4 and S/HNP are constructed the workforce is already in place (see Table 8.3-5) and (4) no other new large construction projects are definite for the area.

On the basis of this line of reasoning, it is assumed that actual population growth rates during 1982-1993 will reflect the population growth rates that would have applied during 1970-1981 had the Supply System not existed and DOE employment remained constant at its 1970 level. It is assumed that the intrinsic growth rate for population is approximately 1 percent per year, or similar to the national growth rate projections. However, these intrinsic growth rates will not compensate for the fact that population will be lost as nuclear construction is completed and workers and families migrate to other sites. Therefore, population under every scenario is expected to decline at some point during 1981-1993.

For Scenarios 1, 2, 3 and 4, it was assumed that when total construction jobs on the Reservation declined, 70 percent of all resident construction workers who lost jobs would leave the area within the year, that the secondary jobs associated with the lost construction jobs (secondary jobs = 0.8 times construction jobs) would also disappear

and that 40 percent of the resident secondary workers would leave the area within one year. For other sectors of the population, it is projected that in-migration rates will equal out-migration rates. It was assumed that 15 percent of the construction work force and secondary jobholders were daily commuters residing outside the SMSA. It was assumed that the average family size of construction and secondary workers is 3.2 and 2.5, respectively, and that there are 1.3 jobs per household. In-migration rates for the operations work force are assumed to be 25 percent. Finally, it is assumed that the population associated with DOE activity increases at one percent per year and that no other major construction projects will occur in the area before 1990.

Table 8.3-6 depicts the projected population by the State over the 1982-1993 period as well as the potential population based on the four scenarios. Some anomalies in the projections are present in the table. Scenario 4 has the largest population in 1993, which is not what would be expected. The reason for this is two-fold: the fact that the intrinsic growth rates of 1 percent per year operate on a larger base in Scenario 4, as compared to the other scenarios, and that out-migration is assumed to be the same for all scenarios. Scenario 4 actually might be expected to have higher out-migration rates and lower in-migration rates and therefore, even a lower population than that projected here.

8.3.6.2 Projected Population Conditions Under Alternative Scenarios

No population growth is projected due to construction of S/HNP. As the following data indicate, loss of construction and secondary workers is projected in all four scenarios:

Number of Persons Leaving SMSA

Year	Scenario 1 (WNP1,2,4)	Scenario 2 (WNP1,2,4 and S/HNP)	Scenario 3 (WNP1,2 and S/HNP	Scenario 4 (WNP1,2)
1982	-	-	-	-
1983	2268	1141	4719	5839
1984	928	-	3729	5095
1985	-	-	-	1236
1986	1306	-	-	26
1987	1375	-	-	-
1988	2349	1706	-	-
1989	900	2013	49	-
1990	-	2166	1775	-
1991	-	693	696	-
1992	-	735	739	-
1993	-	-	-	-
Total	9126	8454	11,707	12,196

In both of the baseline scenarios a decline in population and the rate of growth is projected in the Tri-Cities SMSA. In Scenario 1, for example, it is projected that almost 4,402 construction workers and secondary workers will leave the area over the period 1982-1990. Taking into account other departing family members, Scenario 1 projects a loss of over 9,000 people during the nine year period even with construction of WNP-4.

Scenario 4 projects even greater population out-migration with over 12,000 persons leaving the area between 1982-1986.

Given the projections of out-migration in the baseline scenarios, construction of S/HNP will not be a stimulant for further population increases.

In both Scenarios 1 and 2 out-migration of construction and secondary workers will be reduced in the short-term (1983-1987) but is still projected to occur in the 1988-1992 period.

By 1994, it is estimated that slightly more than 600 people will be added to the population under Scenario 2, as a result of operation, amounting to about 0.4 percent of the projected population of the SMSA. Under Scenario 1, about 400 people will be added to the population by 1994 as a result of operation of nuclear plants.

8.3.7 AVAILABILITY OF QUALIFIED WORKFORCE

Projections regarding the size of the construction and operations force are presented in Table 8.3-7.

Construction

As of June 1981, there were 13,880 individuals engaged in contract construction in the SMSA (Ref 8). More than two-thirds of these workers were employed on WNP 1/4 and 2. Tri-Cities is the locus of most major craft unions required for nuclear power station construction including Electricians #112 with 1720 members, Laborers #348 with 2,100 members, and Plumbers and Fitters #498 with 550 members. All craft unions have established apprentice programs and Puget will implement a program to qualify craftspersons as necessary.

Despite projected out-migration of construction workers none of the construction scenarios indicates the lack of availability of qualified construction workers. Further, in recent years the Supply System has had minimal difficulty in obtaining sufficient craftsmen for nuclear facility construction. Individuals who remain residents of the area but commute to regional construction projects will generally curtail such long distance commuting as employment opportunities become available at S/HNP.

Competition for local construction workers could conceivably arise from several projects or conditions:

1. Change in the construction schedules of WNP 1 and 2 could produce conflicts with S/HNP. Even if S/HNP and WNP 4 were to peak simultaneously in 1988, the construction force would be less than that of the WNP units of mid-1981.

2. Increases in the USDOE construction program could occur. For example, discussions with USDOE officials revealed potential construction of a Replacement Production Reactor and a Basalt Waste Isolation Facility in the mid-1980's.

3. Smaller local construction projects may emerge but most such projects which are known at the present time will have been completed by 1986: I-82 Bridge; Finley Alcohol Plant; Alumax Plant in Umatilla; Kanegafuchi chemical plant in Richland; U & I Potato Processing Plant in Plymouth; and the North Richland Toll Bridge.

4. A currently unannounced major project could emerge in the local area. Given the time necessary to plan and finance large projects, however, such an event is unlikely.

In general, construction projects outside the local area (e.g., Creston, Satsop and Mt. Tolman) would not be competitive with S/HNP because, as research on commuting has demonstrated, workers will tend to minimize commuting distances (Ref 9).

Operations

S/HNP will require an operations force of approximately 295 individuals. The major categories of employment will be operations, maintenance, security and both technical and non-technical support. It is estimated that at least 75 percent of the operations force will be composed of residents already living in the local area as of 1985.

Operations force requirements of 220 persons from the local labor pool will be available due to the high technology orientation of the area and the fact that several local schools have established programs with Battelle Institute for technical training. Further, the long lead time allows local residents to make individual career planning decisions which will improve their chance of being selected for the operations force. 4

8.3.8 ECONOMY

8.3.8.1 Existing and Developing Conditions

In FY 1981, the major non-agricultural employment categories in the Tri-Cities were:

Industry	Percent of Non-Agricultural Wage and Salary Employment
Construction	17.5
Trade	19.3
Services	25.2
Government	16.9
Manufacturing	14.4
Other	6.7
	100.0

As of June, 1981, the Tri-Cities SMSA had a resident labor force of 79,360 of whom 73,510 (92.6%) were employed and 5,850 (7.4%) were unemployed. The labor force participation rate for the total population was 48.7 percent (Ref 8).

Data on income indicate that approximately 81 percent of the income in the area is directly earned, 10 percent comes from dividends, rent and interest and 9 percent from transfer payments. Average monthly payroll data for the first quarter of 1981 were:

	Average Monthly Payroll Per Employee	
Industry	Tri-Cities SMSA	Washington State
Manufacturing	$1,557	$1,650
Mining	1,916	1,662
Construction	1,928	1,678
Transportation, Communications, Utilitie	1,379	1,627
Wholesale, Retail Trade	775	970
Finance, Insurance, Real Estate	999	1,219
Services	1,397	989
Government	1,310	1,306

The convergence of construction and high technology workers in the area made the Tri-Cities the ninth fastest growing SMSA in the United States in terms of personal income (Ref 3).

The two largest contributors to these increases in employment and income are USDOE and the Supply System. In 1980, approximately 12,100 jobs were accounted for by USDOE and its contractors (Ref 4). An additional 12,174 persons were employed by the Supply System in 1981.

Efforts are being made locally to diversify the economy. Three independent municipal corporations, the Port of Pasco, the Port of Kennewick, and the Port of Benton, each manage shipping facilities and commercial and industrial

properties, including industrial parks for the siting of new heavy and light industries. For example, the Port of Pasco manages Big Pasco Industrial Park, composed of 600 acres and 1.5 million square feet of buildings which are leased to firms, and also operates the Tri-Cities Airport. All of the ports engage in industrial promotional activities, including the provision of financing and construction assistance to encourage new firms to locate in the area. Chambers of commerce in each of the three cities, as well as the Tri-City Nuclear Industrial Council in Richland, are actively engaged in attempting to attract new industries to the area.

Finally, the Washington Department of Commerce and Industrial Development maintains a Development Services Division office in Kennewick, providing a source of information and research data to assist local organizations and to encourage new firms to locate in Tri-Cities.

To at least some degree such efforts have been successful and in 1981 Kanegafuchi Chemicals and American Steel announced plans to build plants within the SMSA.

Future economic conditions in the Tri-Cities are particularly difficult to predict because of the major external decisions regarding USDOE funding, Initiative 394 and the situation of the Supply System, particularly WNP-4.

The Bureau of Economic Analyses projects increases in employment over the next several decades (Ref 10). These projections are generally based on recent trends and overestimate increases in such areas as contract construction by a considerable degree. For example, all four scenarios project varying degrees of outmigration of construction workers rather than an influx.

8.3.8.2 Projected Economic Conditions Under Alternative Scenarios

Construction of S/HNP will have a beneficial impact upon the economy by providing employment for construction and secondary workers who would otherwise migrate from the area during 1983-1992.

Both Scenarios 1 and 4 reveal a declining economy in the Tri-Cities area without the construction of S/HNP. In Scenario 4, the loss of jobs and income would be most severe amounting to a loss of over 8,000 construction and operations workers between 1982-1985.

Based on potential payroll data, lost income opportunities in both baseline scenarios would run into the hundreds of millions of dollars. Construction workers are among the most highly paid employees in the Tri-Cities area and their local expenditures are a significant driving variable in the local economy.

As compared to the two potential baseline conditions, the impacts of S/HNP can be delineated:

(1) Employment - Construction will provide employment ranging from 563 in 1983 to 4,446 in 1988 to 1386 in 1991. Over the 1983-1991 period S/HNP will provide almost 24,000 person years of employment.

Secondary employment will also be maintained during the construction period. Previous research has indicated a multiplier of 1.8 for nuclear construction in the Tri-Cities (Ref 11). After taking commuters into account, it is projected that construction will support over 16,000 person years of employment in other sectors of the local economy. 4

Operations will provide employment for 295 individuals over the 40 year life of the facility - 11,800 person years of work. Assuming each operation job maintains 0.8 secondary jobs, S/HNP will mean employment for approximately 236 persons in other sectors of the economy. In addition, 200 workers will be employed during periodic refueling operations.

None of this employment would take place in either of the baseline scenarios.

(2) Income - During construction, it is projected that annual income per worker will average approximately $37,000 in 1980 dollars for a total of $949 million over the construction period (See Table 8.3-8). During operation, the total payroll on an annual basis will be $8,141,000 in 1980 dollars or an average of $23,600 per worker (see Table 8.3-20). 5

These relatively high income levels will stimulate other sectors of the economy and produce expanded business activity throughout the SMSA.

None of this income would be generated in the baseline scenarios. 4

(3) Purchase of local materials and services - During construction Puget expects to purchase local supplies and services when they are readily available and

competitively priced. Given the extent to which the local economy has developed in tandem with nuclear power, it is expected that a number of local firms will be available to provide materials and services at a reasonable cost.

During operation, it is assumed that purchases of materials and services will be approximately $5 million per year in 1981 dollars. Over the 40 year operating life of the facility, this totals to $200 million spent in the local area.

None of these purchases would occur under the baseline scenarios.

8.3.9 GOVERNMENT AND FISCAL

8.3.9.1 Existing and Developing Conditions

Both Benton and Franklin Counties have an elected county commission governmental structure, with each county maintaining its own independent planning department. Benton County employs four professional planners and one planner/draftsman, while Franklin County employs two professional planners. In addition, both counties have such customary departments as county assessor, auditor, clerk, prosecutor, engineer, extension agent, and court facilities. Coordination and cooperation between the two county structures is facilitated by the Benton-Franklin Governmental Conference in Richland.

Each of the Tri-Cities municipalities is governed by a council-manager system, with the mayor elected by council in each city. Other municipalities in the counties also maintain city council governments. Municipal planning staffs include 5 positions in Kennewick, 3 in Pasco, 10 in Richland, and 2 in West Richland.

Budgetary data for selected municipalities and the two county units in the Tri-Cities SMSA are summarized in Tables 8.3-9 through 8.3-11. Locally-collected taxes combine with intergovernmental revenues transfers to represent the primary sources of operating revenues for both the counties and the impact area municipalities (Tables 8.3-9 and 8.3-10). The two county governments concentrate their operating expenditures on general-governmental services and transportation programs. Municipal expenditures as displayed in Table 8.3-11 tend to be concentrated in the areas of (a) general government

services, (b) security of persons and property, and (c) transportation.

As is true of many areas, particularly those which have experienced the added demands of rapid population and economic expansion, governments in the Tri-Cities area have experienced increased expenditure demands and restricted revenues in recent years. These pressures have resulted in proposals for increased local tax rates to provide additional revenues (Refs 12-1, 12-2). Local voters, however, have been hesitant to approve additional or increased taxation, forcing a reduction in some program areas and a general emphasis on fiscal austerity - a trend which is likely to continue into the near-term future. Municipal revenues in 1981 are estimated to have declined in Richland, Kennewick, and Pasco from 1980. Among the consequences of budget restrictions have been program reductions and employee cut-backs. Additional cut-backs may be expected. For example, the city of Richland has projected a decline in manpower in the fire and emergency services department from 39 to 35 persons as a result of anticipated 1982 budget levels.

8.3.9.2 Projected Fiscal Conditions Under Alternative Scenarios

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Scenarios 1 and 4 show that there would be outmigration from the study area as the employment and income from the construction sector declines (Table 8.3-6). This would lead to declines in revenues to local communities. The additions of employment and income due to S/HNP, as shown in Scenarios 2 and 3, would significantly increase local revenues over what would be the case under Scenario 1 at similar points in time without these economic variables. Additional revenues to the State and local areas would come from such sources as property taxes, sales taxes, and B&O taxes, etc.

As indicated in Section 8.3.5, construction and operation of S/HNP would generate significant tax revenues in Benton County, if tax rates are not lowered. It is estimated, for example, that Benton County could potentially receive $150 million in revenues from the facility during the construction period alone for use by the County and for disbursement to local jurisdictions. Additional revenues of $30 million would potentially be available during each year of operation, if tax rates remain at 1981 levels. 5

These revenues would have a sustained and significantly positive impact on the fiscal condition of Benton County 4

and, depending upon the manner in which the revenues are disbursed, upon communities within Benton County.

It has been suggested by some (Ref 13) that these property tax revenues collected by Benton County should be shared proportionately with cities, school districts and other jurisdictions where the bulk of the S/HNP work force will reside. Based on past trends of the WPPSS labor force, this would include Richland, West Richland, Kennewick and Benton City. Under the existing tax system those cities would receive property-tax revenues at the discretion of Benton County Commissioners. Neither Franklin County nor the City of Pasco (also within the immediate impact area) would receive any property-tax revenues emanating from the Project under the existing tax system.

Under the baseline scenarios none of these revenues would be available to improve the fiscal condition of Benton County and its local jurisdiction.

8.3.10 TRANSPORTATION

8.3.10.1 Existing and Developing Conditions

Regional

Three airports are available, with the Tri-Cities Airport in Pasco being the primary commercial airport. Republic Airlines provides flights to major airports throughout the Western states. Cascade Airlines utilizes both the Tri-Cities and Richland Airports to provide regional commuter service. Horizon Air has recently initiated additional commuter service to Tri-Cities (Ref 12-3). Charter service is available at the Tri-Cities Airport as well as at the airports in Richland and Kennewick. Pacific Southwest Airlines has applied to provide additional regional jet-liner service to the Tri-Cities Airport beginning in 1982.

Regional highway access to and from the area is possible via U.S. Route 12, connecting the Tri-Cities to Yakima and the Seattle area to the west and Lewiston, Idaho, to the east; U.S. 395 north to Spokane, and State Route 14 west to Vancouver, Washington. Interstate 84 connects the area to Salt Lake City and Portland. Projected highway developments include the planned completion of Interstate 82 and the Interstate 182 spur into the Tri-Cities.

Local

Local roads have been overburdened by the rapid growth experienced in the Tri-Cities area, resulting in traffic congestion and high accident rates in several places (Ref 12-4) The area surrounding the Hanford Reservation has experienced traffic overload as a consequence of Supply System construction and USDOE activity with staggered work hours only partially alleviating problems (Refs 12-4, 12-5).

Future developments include the I-182 Bridge connecting northwest Pasco and Richland, to be completed in 1983, and the North Richland Bridge across the Columbia proposed for completion in 1986. In addition, the Benton-Franklin Transit Authority was created in the Spring of 1981.

8.3.10.2 Projected Transportation Conditions Under Alternative Scenarios

The following data indicate the projected number of commuter vehicles associated with construction workers under each scenario, assuming 1.6 persons per vehicle (see Ref 14):

Year	Scenario 1 (WNP1,2,4)	Scenario 2 (WNP1,2,4 and S/HNP)	Scenario 3 (WNP1,2 and S/HNP	Scenario 4 (WNP1,2)
1984	3,766	4,533	2,092	1,325
1986	2,899	4,960	2,061	0
1988	931	3,710	2,779	0
1990	0	1,521	1,521	0

These data indicate that during the period 1984-1990 the difference between traffic on the Reservation with construction of S/HNP as opposed to without construction will average approximately 2,100 vehicles per day per year. In addition, trucks and heavy equipment associated with construction will add to traffic on and near the Reservation.

The greatest amount of commuter traffic will occur under Scenario 2 when 4,960 vehicles are projected. Even this peak, however, will only be 81 percent of the estimated average of 6,118 construction worker commuter vehicles associated with WNP 1, 2 and 4 in 1981.

Under Scenario 3, in no year would the number of vehicles exceed 45 percent of the estimated commuter vehicles in 1981.

Although the construction scenarios indicate commuter traffic well below that which existed in 1981, several improvements are being considered by Puget:

1. A new roadway, connecting the SR240 Highway to the Plant Site, will operate each work day as two lanes in the peak direction between the hours of 6:00 A.M. and 8:30 A.M. northbound, and 3:00 P.M. to 5:30 P.M. southbound. At all other times one lane in each direction will service all other traffic. This improvement includes 2 lanes of 14 feet with 8 foot shoulders, pavement markings, signing, control by flagmen at each end and a connecting roadway on the east side of the Plant Site to Route 10.

2. SR240 Highway from the intersection of the new roadway to the By-Pass Highway intersection will operate each working day as a four-lane facility by utilizing shoulder driving for HOV, high occupancy vehicles, in the peak hours of 6:00 A.M. to 9:00 A.M. towards the Plant Site and 3:30 P.M. to 6:00 P.M. away from the Plant Site. All other hours the highway will be one lane in each direction. This roadway section, normally one 12-foot lane in each direction, will include the peak hour additional 12-foot wide shoulder lanes, with new pavement, pavement markings, signing. The additional lanes will operate for high occupancy vehicles of at least two persons per vehicle. The HOV lane will encourage car pooling and may reduce traffic volumes on all the routes to the Site. Improvements will include modifications of the railroad grade crossing near the By-Pass Highway as well as additional embankment to provide for the 12-foot shoulder lanes.

3. Intersection improvements at the SR240 Highway intersection with the By-Pass Highway and the intersection of the By-Pass Highway with Van Giesen Street will require two-lane turning for the major movements to and from the Plant Site. This will shorten the green time required for the turning and therefore assist in improving the through-lane capacity at each of these intersections. Acceleration lanes, for free right turning, as well as optional turning considerations on a fast-flashing yellow, in lieu of a

green left-turn arrow, will be considered to improve intersection capacity.

These basic improvements will carry the traffic for the S/HNP site through its entire construction schedule. In addition, measures such as car pooling and shift staggering will reduce traffic throughout the construction phase. 4

It should be noted that construction and operation of S/HNP will generate substantial revenues for the Benton-Franklin Transit Authority. For example, S/HNP may generate as much as $8 million for the Transit Authority during the construction period 1983-1992. During operation revenues of nearly $400,000 would be generated each year. 5

Finally, substantial revenues will accrue to the Road District in Benton County through property taxes paid on the facility. These funds could be utilized to improve roads in the county.

Under the baseline scenarios these property tax revenues would not be available to either the Benton-Franklin Transit Authority or the Benton County Road District.

8.3.11 HOUSING

8.3.11.1 Existing and Projected Housing Infrastructure 4

The recent population growth trends in the Tri-Cities have been accompanied by a corresponding expansion of the housing stock. The total number of housing units in Benton County rose from 21,826 in 1970 to 42,651 in 1980, a 95 percent increase. In Franklin County, the number of housing units rose by 58 percent, from 8,425 in 1970 to 13,316 in 1980 (Ref 1).

This trend is evident by referring to the data in Table 8.3-12. Between 1976 and 1980, the total number of housing units in the combined Richland-Kennewick-Pasco urban area increased by 39 percent. Apartments comprise over one-half of all new units. The greatest increases in housing stock occurred in Kennewick, where total units increased by 52 percent in four years.

Vacancy rates for recent years are reported in Table 8.3-13. As these data indicate, there is a general trend toward an increased number of vacancies.

Total residential building permits dropped from 1,813 in 1979 to 553 in 1980. Only 178 residential building permits were issued during the first quarter of 1981 (Ref 15). If that level of activity were maintained throughout the remainder of the year, total 1981 building permits would amount to about 10 percent of the 1979 total. Given prior rapid housing construction, the local residential construction industry is presently operating far below capacity, a situation which is unlikely to be reversed while interest rates remain high (Ref 15).

8.3.11.2 Projected Housing Conditions Under Alternative Scenarios

All four scenarios posit out-migration of construction and secondary workers over the 1982-1991 period. Coupled with decreased growth rates and diminished in-migration, increased housing vacancies are projected in each case with the highest vacancies occurring in Scenario 4. For example, it is projected that approximately 4,255 households would leave the area between 1982-1986 under Scenario 4. 4

The scenarios projecting construction of S/HNP suggest that over the next decade a number of individuals who would have otherwise migrated from the area during 1982-1992 will remain and provide support for the housing market. For example, in the case of Scenario 3 as compared to Scenario 4, it is projected that construction of S/HNP will enable approximately 3,000 construction and secondary workers to remain in the Tri-Cities area over the period 1983-1986. This diminished outmigration of 4,615 households would have ~~a significant~~ positive impact upon the housing market.

During operation, it is estimated that less than 100 new families would move into the area and, consequently, the impact on housing due to project related in-migration will be quite small. 5

8.3.12 EDUCATION

8.3.12.1 Existing and Developing Conditions

Public Elementary and Secondary Education

Table 8.3-14 reports 1979-80 and 1980-81 enrollments of local school districts, capacity and change over the past two years.

Given that the vast majority of student enrollments associated with worker influx to Hanford-area projects have been in the Richland and Kennewick school systems, it is instructive to review current enrollment trends in those systems. As indicated in Table 8.3-14, both Richland and Kennewick schools lost students over the two year period. Preliminary data on 1981 enrollments indicate that as of September 1981, Kennewick enrollments had increased to slightly over 11,000, while Richland remained stable at 8,439 (Ref 12-6).

Although the area appears to have reached a stabilization in enrollment, educational facility expansion is continuing:

(1) The Pasco school district is scheduled to complete a new junior high school in 1983.

(2) Kennewick currently has two new elementary schools under construction increasing capacity by 1,050 to be complete in 1982 and 1983 respectively. A third elementary school is planned for completion in 1984. A middle school is planned for completion in 1984 with a capacity of 800 students.

(3) Finley plans remodeling which will increase capacity by 200 students. This construction will begin in 1982.

Table 8.3-15 presents data on the staff and expenditures of the school districts on a per pupil basis. As these data indicate, local districts do not deviate significantly from the state averages on either measure. Kiona-Benton and Kennewick have the lowest expenditures per pupil.

Private Elementary and Secondary Schools

In addition to public school systems, there are a number of private schools available in the area. Eight parochial

schools have a combined enrollment of 1,400 in their elementary and high school programs.

Other private schools include a Montessori school in Kennewick, the Tri-City Junior Academy in Pasco and several pre-school and day care centers.

Post-Secondary Educational Facilities and Programs

Columbia Basin College in Pasco, offers two-year associate degrees in 37 Arts and Science fields and in 22 vocational/technical programs, including a complete night school program.

The Joint Center for Graduate Study, in Richland is organized cooperatively by the University of Washington, Washington State University and Oregon State University, and offers upper-division undergraduate degree programs in four engineering fields. The Graduate Center also offers graduate programs in fourteen fields, focusing on engineering, the technical sciences and education.

Other post-secondary programs include noncredit continuing education programs offered by both Columbia Basin College and the Joint Center for Graduate Study, one private business college and three beauty schools.

8.3.12.2 Projected Educational Conditions Under Alternative Scenarios

No increase in school population is projected due to Project-related in-migration. The construction and secondary workers who will be employed as a result of the S/HMP are assumed to result in diminished outmigration. Therefore, the Project-related students would be expected to be prior residents of the Tri-Cities area. It should be noted, however, that the total enrollment would be greater with the S/HMP than without it.

Under the baseline scenarios out-migration of construction and secondary workers would result in reduced enrollments and increases in nonutilized capacity in the educational system. Scenario 4, for example, would result in the out-migration of over 4,000 students from the area over the period 1982-1986. Since none of the local school districts is at capacity, this substantial enrollment decline would result in loss of jobs for teachers, reduced revenues from the State and perhaps even the closing of individual schools.

Construction of S/ENP, however, differs from the baseline scenarios in that it would:

(a) Diminish out-migration of households and students over the 1983-1988 period. For instance, the difference between Scenarios 3 and 4 is approximately 1,000 students remaining in the area due to construction of S/ENP.

(b) Maintain State funding for these students and reduce the need for staff reductions in the school systems.

(c) Reduce the need for special levies in the local area to finance non-basic educational activities of local school systems.

(d) Increase the tax base of the Richland School District by such a magnitude that the special levy for residents of Richland would be virtually nil.

Under the baseline scenarios none of these beneficial impacts would occur.

During operation, it is projected that less than 100 students would be added to enrollments of schools within the SMSA.

8.3.13 UTILITIES

8.3.13.1 Existing and Developing Conditions

Water Supply Systems

Although there are small non-profit and private water systems serving limited numbers of customers in peripheral areas of the counties, the systems supplying Richland, Kennewick, Benton City and West Richland serve over 90 percent of the total water system customers in Benton County, while the majority of Franklin County water customers are served by the Pasco supply system.

In the City of Richland, the water supply system is currently operating near capacity. In 1980, peak demand was approximately 37,000,000 GPD and pumping capacity was 47,200,000 GPD (Ref 15).

In Kennewick, 1980 demand on the water supply system was 94 percent of the 22,000,000 GPD pumping capacity (Ref 16).

Substantial upgrading of the system capacity is scheduled for completion in 1984-85.

The Pasco water system currently has the capacity to pump 18,500,000 GPD, exceeding peak daily demands of about 14,600,000 GPD. A new $650,000 water line project was recently approved to permit major industrial expansion in the southwest section of the municipality.

In West Richland, data reported by the Benton County Planning Department in 1980 indicated average daily demand levels of 640,000 GPD, just 32 percent of the 2,000,000 GPD pumping capacity (Ref 17). Similarly, the Benton City water system has substantial excess capacity, with data reported in 1980 indicating that average daily demand levels were 7 percent of pumping capacity.

Waste Water Treatment

The Kennewick system is operating at 72 percent of the 90,000 population capacity. The Pasco wastewater treatment facility is operating at about 26 percent of capacity.

The Richland wastewater system is near capacity, with data reported by the Benton County Planning Department indicating that system demands were approaching 90 percent of capacity by 1980 (Ref 17). Both Benton City and West Richland have experienced treatment demands which exceed current system capacities. Improvements are planned in both communities (Ref 17).

Solid Waste

Solid waste disposal in the area surrounding the Tri-Cities is accomplished by a combination of public/private systems. Wastes collected in Richland are disposed in a sanitary landfill operated by the city in the Horn Rapids area. Wastes from Kennewick, Benton City, West Richland and Pasco are disposed in the sanitary landfill operated by the city of Pasco.

Although at present solid waste disposal in the area is by conventional landfill procedures, there have been several recent proposals to develop energy extraction facilities which would burn solid waste materials (Refs 12-7, 12-8).

Other Utilities

The Tri-Cities and the surrounding area are provided electrical service by several public utility agencies. In Benton County, about 66 percent of the electric utility customers are served by the Benton City PUD. The cities of

Richland and West Richland are provided with electrical supplies by Richland Energy Services, which is currently operating at about 80 percent of capacity but is being expanded. About 9 percent of the electric utility customers in outlying areas of Benton County are services by the Benton REA. In Franklin County, most localities, including Pasco, are supplied by the Franklin Public Utility District.

The primary supplier of telephone services in the Tri-Cities vicinity is the General Telephone Company of the Northwest, which supplied service to over 90 percent of all Benton County customers, including those in Richland, Kennewick, West Richland and Benton City. The remaining Benton County telephone customers are served by United Telephone Company of the Northwest. In Franklin County, Pasco is provided telephone services by the Pacific Northwest Bell Telephone Company.

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8.3.13.2 Projected Utility Service Conditions Under Alternative Scenarios

Under the baseline scenarios, out-migration and decreased growth rates are projected. Further, declines in employment, income and the local economy are anticipated. This economic slowdown would result in decreased revenues and force local jurisdictions to forego planned utility expansions and improvements in service. There would be less demand on the current capacities of utility services. Finally, with the lower population in the baseline scenarios, special levy rates may increase.

The construction scenarios depict a more dynamic economy with higher tax revenues at present tax rates. Local jurisdictions would be able to improve services when compared to the no-project scenarios. In all cases except Scenario 2, a decline in population is estimated and, therefore, a decline in demand for services. For Scenario 2, a slight increasing trend (0.6 percent average annual growth rate) is shown to the year 1987, declining thereafter.

8.3.14 PUBLIC SAFETY

8.3.14.1 Existing and Developing Conditions

Police protection is provided by sheriff's departments in Benton and Franklin Counties, local municipal police departments and the Washington State Patrol division headquartered in Kennewick. Table 8.3-16 provides descriptive data on the staff size and number of patrol cars available to each of the counties and the municipal police departments in the immediate Tri-Cities vicinity.

Jail facilities in the impact area include county jails in both Benton and Franklin counties, as well as separate city jails in Richland, Kennewick and Pasco.

Both property and violent crime rates are below those experienced in other parts of Washington. During 1979, for example, the rate of violent crime per 100,000 residents was 370.2 in the Tri-Cities, compared with 659.5 in Yakima, 39[illegible].5 in Spokane, and 434.6 for the state (Ref 18).

Current jail facilities are inadequate and state-mandated improvements in Benton County jail facilities have resulted in the recently-initiated construction of a new 109-bed county jail, scheduled to replace the existing 33-bed jail in 1983. The new facility will also house an expanded county justice center comprised of courtrooms and the county sheriff offices. With completion of this facility, prisoner overloads currently experienced at the Benton County, Franklin County, and Richland and Kennewick jails will be eliminated. In addition, a new juvenile detention and court facility operated jointly by Benton and Franklin counties in Kennewick opened in 1980.

Fire protection in the Tri-Cities area is provided by municipal fire departments, and by fire protection units for specific service areas in Benton and Franklin counties. The various departments serving the impact area are listed in Table 8.3-17 along with data on staff size, number of volunteer fire fighters, and the service area covered. Only Pasco and Richland maintain exclusively full-time non-volunteer fire departments. These independent departments are engaged in mutual aid programs to insure cooperation in emergency situations.

8.3.14.2 Projected Public Safety Conditions Under Alternative Scenarios

Both baseline scenarios depict a declining economy and in each case layoffs, cutbacks and delays of improvements in the police and fire systems would be expected. Reduced revenues would have a negative impact upon the range of public safety services.

The population effects of the S/HNP will not increase demands on the public safety infrastructure beyond the current levels. The Project-related tax revenues will provide needed support for the public safety services of local jurisdictions.

Operation of the facility will have a very small impact on public safety services. The operations population effects will represent only about 0.4 percent of the projected population of the SMSA.

8.3.15 HEALTH CARE

8.3.15.1 Existing and Developing Conditions

The Tri-Cities is served by a variety of public and private health care facilities and services. These are three comprehensive care hospitals: Kadlec Hospital in Richland, Kennewick General Hospital, and Our Lady of Lourdes Hospital in Pasco, with a combined total of 276 beds (Ref 16).

Kadlec Hospital established an emergency medical center in Kennewick in June 1981 and ambulatory surgery services are provided by the Mid-Columbia Surgical Suite in Richland. A paramedic program affiliated with Kennewick General Hospital supplements ambulance services in the area provided by municipalities and two private ambulance companies. A Poison Control Center is affiliated with Kadlec Hospital in Richland. Prosser Memorial operates an out-patient clinic in Benton City which treats an average of 400 people per month. Convalescence centers with 24 hour nursing care are located in Richland, Kennewick and Pasco.

Finally, the Hanford Environmental Health Foundation (HEHF) performs a broad spectrum of testing, medical and psychological services for USDOE contractors at Hanford as well as the surrounding industrial community.

The HEHF operates the Emergency Decontamination Center. The Center is equipped for the monitoring, control and treatment of radiation over-exposure patients.

The Tri-Cities is served by approximately 125 physicians and surgeons, over 50 dentists, and other specialists covering the spectrum of the health care, including psychiatry, ophthalmology, private nursing and nutritional counseling.

Public health programs are provided by the Benton-Franklin District Health Department, which has administrative offices in Richland (Ref 19). Among the programs in place are:

1. A Women's, Infant and Children (WIC) Clinic to provide nutritional assessments and counseling for pregnant and lactating women, infants and young children.

2. A Well Child Clinic to provide physical examinations and assessments for children.

3. Home visit programs to provide prenatal, postpartum and newborn care.

4. Various home health care programs involving nursing, physical therapy, speech therapy, occupational therapy and home health aides.

5. An environmental health service program inspection of public institutions, recreation places and sanitation regulation.

6. LaClinca, a clinic in Pasco providing health care for migrant farm workers and low-income families.

The primary source of mental health care is the Mid-Columbia Mental Health Center in Richland. This facility provides emergency stress management service on a 24-hour basis, crisis-intervention programs, outpatient therapy and counseling, a rape relief/sexual assault program, drug and alcohol abuse programs and an in-patient acute care facility, as well as consultation and educational programs (Ref 20). In addition, the Tri-Cities area has nine private mental health or psychological counselors and sixteen marriage and family counselors.

Projected additions to the health care infrastructure include a large medical professions building scheduled to start construction in October of 1981 and a blood bank planned by the Red Cross. There are plans to establish one

of the Tri-City hospitals as a trauma center to facilitate emergency care of critical injuries and illnesses (Ref 12-9). A proposal to expand Our Lady of Lourdes Hospital would include new medical surgical and patient care beds, improved emergency facilities, pediatrics, radiology, radiation therapy and special care departments, as well as an intensive alcohol-abuse treatment center.

8.3.15.2 Projected Health Care Conditions Under Alternative Scenarios

Both baseline scenarios depict out-migration of construction and secondary workers. For example, in Scenario 4 over 12,000 persons are projected to leave the area between 1982 and 1986. This out-migration will result in excess capacity in the health care system and potentially lead to lower levels of care as finances are strained. Further, in either of the baseline scenarios out-migration of secondary workers is projected. Some of these individuals will be in the health care field - physicians, technicians and nurses.

In the construction scenarios, out-migration is expected to be reduced through the 1980's. In Scenario 3, for example, it is estimated that over 8,000 persons would leave the SMSA between 1982 and 1986 and that the excess capacity in the mid-1980's under Scenario 4 would be minimized. The population effects of the S/HNP will help utilize the health care facilities and services that will already be in place. 4

8.3.16 HUMAN SERVICES

8.3.16.1 Existing and Developing Conditions

The Tri-Cities area exhibits a range of public human services agencies. Both Benton and Franklin counties provide cooperative extension programs, health services programs through their district health departments, and separate emergency service departments. Each of the Tri-Cities has a senior citizens center.

State human service offices in the Tri-Cities include the job services offices of the Employment Security Department, Food Stamp offices, the Division of Developmental Disabilities, Financial and Medical Assistance, the Child Protective Service, Emergency Medical Service, a Senior Companion Program, Vocational Rehabilitation and various

Farm Workers Programs. The Federal Government maintains local Social Security offices.

In addition to these public human service programs, the area is also served by a large number of private agencies and voluntary human service organizations ranging from special interest clubs to civic groups to service-oriented organizations such as the Salvation Army.

Focusing specifically on organizations providing for the service needs of specific disadvantaged or distressed population groups, Table 8.3-18 gives examples of the human service facilities and organizations available to local residents ranging from the Retarded Citizens Association to legal services for relief for victims of rape and abuse. Various organizations provide counseling programs on family problems, family planning, alcohol abuse, legal aid, behavioral difficulties and child placement. Services exist to aid persons affected by various physical, emotional, and learning disabilities. Assistance and counseling programs are available not only for the distressed and disadvantaged, but also for persons wishing to start a new business.

8.3.16.2 Projected Human Service Conditions Under Alternative Scenarios

Baseline scenarios project a declining economy and population out-migration. Human services may be adversely affected due to (a) fewer financial contributions and (b) out-migration of volunteer staff. At the same time, economic conditions in the area may lead to increased need for both personal and vocational counseling.

Under the construction scenarios, out-migration will be reduced, employment and income opportunities will be enhanced. Fewer persons, e.g. volunteers, will leave the area and the economy will permit more individuals to contribute to service and charitable organizations.

The operation period effects of the facility will contribute to the economy and thereby have a positive impact upon the level and quality of human services.

8.3.17 PRIVATE SECTOR

8.3.17.1 Existing and Developing Conditions

The Tri-Cities is characterized by a well developed private business sector:

Type of Business	Number of Establishments
Building Supplies and Garden Supplies	44
General Merchandise Stores	19
Food Stores	88
New and Used Car Dealers	20
Gasoline Service Stations	60
Apparel and Accessory Stores	68
Eating Places	135
Drinking Places	36
Drug Stores and Proprietary Stores	30
Banking Establishments	24
Real Estate Establishments	137
Business Services	94
Automobile Repair Shops	46
Amusement and Recreation Establishments	19
Health Services	181
Personal Services	95

There are over 2,300 hotel and motel rooms in the immediate Tri-Cities vicinity with an average occupancy rate of 65 percent (Ref 21).

There are over 4,000 service establishments and 32 shopping centers and malls in the Tri-Cities area.

Expansion of the private sector continues to occur, as evidenced by a recent proposal to construct a $40 million shopping mall in Richland (Ref 12-10).

8.3.17.2 Projected Private Sector Conditions Under Alternative Scenarios

Under the baseline scenarios a declining economy is projected. Out-migration of workers, declines in per capita income and less business activity would result in lost sales, layoffs, business closings and in some cases, bankruptcy.

The construction scenarios would result in jobs and income for both construction and secondary workers. This contribution to the economy would stimulate local purchases and maintain business activity. Further, the tax revenues provided by the facility would enable local jurisdictions to maintain their budgets, avoid lay-offs and purchase goods and services from the private sector.

None of these economic contributions to the private sector would occur under the baseline scenarios.

During operation, it is anticipated that over $5 million per year in purchases from local businesses would be made.

8.3.18 RECREATION AND LEISURE

8.3.18.1 Existing and Developing Conditions

Recreational and leisure facilities and opportunities covering a broad spectrum of participant and spectator activities are available in the Tri-Cities area under the administration of municipalities, county governments, the State of Washington, federal entities, and private firms and organizations. There are 36 city parks located in the Tri-Cities, operated under the supervision of the three municipal Parks and Recreation departments (Ref 16). 4

Benton County Parks and Recreation Department manages Columbia Park, providing a four-mile waterfront area, camping areas, boating facilities, picnic areas, hiking, swimming, golf, an archery range, and access to swimming, fishing, and picnicing facilities at Two Rivers, Hover, Horn Rapids and Plymouth Parks. There are approximately 1,400 acres of developed public park lands and 3,650 undeveloped acres in Benton County (Ref 17).

The State of Washingon maintains facilities for swimming, fishing, boating, picnic areas and other uses at Sacajawea State Park, located near the juncture of the Snake and Columbia rivers in Franklin County. Other state parks, including the 3,710 acre Sun Lakes State Park, are also accessible from the Tri-Cities. Similar activities and facilities plus overnight camping facilities are locally available in Levy Park and Fishhook Park, both administered by the U.S. Army Corps of Engineers and the Corps maintains recreation and tourist facilities at Ice Harbor Lock and Dam.

Table 8.3-19 provides an overview of physical and participant recreation opportunities for Tri-City residents.

Spectator sports and leisure activities available in the area include movie theatres, a full range of television and radio stations, several forms of racing and amateur sports teams. Cultural attractions include the Benton County Historical Museum, several art galleries, and performing arts productions.

Expansion of recreational and leisure opportunities include a new city park in Kennewick, a proposal to re-open a swimming park under the management of Benton County, a baseball field developed by the Kennewick American Legion, and a water amusement park to be developed by a private firm in Kennewick. The availability of such activities will expand with the development of a planned multi-use arts and entertainment center in Kennewick (Ref 12-11), and a proposed $16 million arts center in Richland (Ref 12-12). Several innovative park facilities have been proposed, including an off-road vehicle (ORV) park under construction by the city of Richland (Ref 12-13).

8.3.18.2 Projected Conditions Under Alternative Scenarios

The baseline scenarios project decreased population levels and thus suggest decreased use of recreational facilities in the area. This lower usage may result in decreased hours of operation and/or the closing of some recreational facilities.

Under the construction scenarios, a more dynamic economy and reduced out-migration are projected. Both of these conditions would provide support for recreational facilities in the area.

8.3.19 LIBRARIES

8.3.19.1 Existing and Developing Conditions

The Tri-Cities area contains several library facilities, the most extensive of which are operated by the Mid-Columbia Library. Richland and Prosser have their own public libraries. The Mid-Columbia Library is centered in Kennewick and maintains branches and services throughout the SMSA. At the end of 1980, Mid-Columbia had a total of 218,086 volumes.

8.3.19.2 Projected Conditions Under Alternative Scenarios

The major impact of the Project on the Mid-Columbia Library will be to provide a significant source of new revenue. Mid-Columbia depends upon property tax revenues to develop and maintain its services. For example, in 1980, $386,715 in revenues were obtained via Real and Personal Property Taxes. This figure represented over 43 percent of all revenues for the year. Given the fact that the S/HNP is within the taxing purview of the Library (through Benton County), it can be expected that the proposed facility will generate significant tax revenues and enable the Library to improve and expand services. For example, if the Project was to be valued at $6.24 billion and taxed at 1981 rates, an annual total of $1.8 million would potentially be received by Mid-Columbia Library.

Under the baseline scenarios none of these funds would be available to the Library.

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3. 1979 Personal Income Data for Counties and SMSAs Available, BEA 81-27, U.S. Department of Commerce, Bureau of Economic Analysis, Washington, D.C. (May 20, 1981).

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6) "Kennewick enrollment tops 11,000 students," 9/9/81.
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8) "Plant near prosser turns waste into power for PUD," 6/9/81.
9) "Cooperation marks trauma center meet," 4/22/81.
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TABLE 8.3-1

CONSTRUCTION PUPILS FOR WNP 1/4 AND 2, IDENTIFIED BY SCHOOL DISTRICT SURVEYS AND CONFIRMED BY WASHINGTON PUBLIC POWER SUPPLY SYSTEM AUDIT, 1980

School District	Total Number Of Pupils	Number of Construction Pupils	Percent of Construction Pupils	Percent Construction Pupils Comprise of Total Enrollmant
Columbia[a]	886	38	1.6	4.2
Finley[b]	902	33	1.4	3.6
Grandview	2,175	49	2.2	2.2
Kennewick	10,604	971	42.9	9.1
Kiona-Benton[c]	1,163	168	7.5	14.4
Pasco	5,535	152	6.8	2.7
Prosser	2,007	93	4.2	4.6
Richland	8,308	736	32.5	8.8
Sunnyside	3,412	22	.9	.6
Mabton	591	0	--	--
Total	33,992	2,262	100.0	--

[a]Burbank (Pasco) area

[b]Kennewick Area

[c]Benton City - West Richland Area

Source: Construction Pupil Survey, 1980, Washington Public Power Supply System, Richland, WA

TABLE 8.3-2

ESTIMATED CONSTRUCTION COST AND POTENTIAL PROPERTY TAX REVENUES DURING CONSTRUCTION[1]

Year	Cost of Construction[2] ($000)	Cumulative Cost ($000)	Potential Revenue to:[3] State ($000)	Benton County ($000)	Total ($000)
1979-1982	332,754	--	--	--	--
1983	178,729	511,483	--	--	--
1984	273,672	785,155	2,806	3,677	6,483
1985	426,993	1,212,148	4,333	5,676	10,009
1986	693,550	1,905,698	6,812	8,924	15,736
1987	877,469	2,783,167	9,948	13,033	22,981
1988	912,100	3,695,267	13,208	17,305	30,513
1989	580,811	4,276,078	15,284	20,024	35,308
1990	494,648	4,770,726	17,052	22,341	39,393
1991	301,756	5,072,482	18,131	23,754	41,885
1992	228,739	5,301,221	18,948	24,825	43,773
Total	5,301,221	5,301,221	106,522	139,559	246,081

(1) All values for demonstration only are subject to change.

(2) The total value of the Plant includes the cost of construction plus the value of the property and allowance for Funds during Construction (AFDC), Sales Tax, Property Tax and Fuel, and Transmission Costs which total the $8 billion plant valuation.

(3) Based on 1980 levies (1981 taxes):

(a) State = $3.5743 per M
(b) Benton County: $4.6829 per M
  (1) County: $.98 per M
  (2) Library: $.2955 per M
  (3) Port Benton: $.3238 per M
  (4) Road District: $1.3619 per M
  (5) Richland School District: $1.7217 per M

TABLE 8.3-3

TAX BASE INCREASES FROM S/HNP
(ASSESSED VALUATION INCREASES IN 1981 DOLLARS)

Taxing Jurisdiction	1981 Assessed Valuation ($000)	Total Assessed Valuation with S/HNP (1981 dollars)	Increase in Valuation	S/HNP as as Percent of Total
Benton County	$2,720,630	$5,120,630	88 %	46.9 %
Library	853,018	3,253,018	281 %	73.8 %
Port of Benton	1,303,086	3,703,086	153 %	64.8 %
Road District	853,018	3,253,018	281 %	73.8 %
Richland School District	1,186,743	3,586,743	202 %	66.9 %

NOTE: Data presented as illustrations only and subject to change. The "Increased in Valuation due to S/HNP" column is based on 1981 valuation levels and an assumed plant value of 2.4 billion (80 percent of three billion).

TABLE 8.3-4

LOCAL POPULATION, 1940-1980

	1940	1960	1970	1980	1970-1980 Percent Growth
Benton County	12,053	62,070	67,540	109,444	62.0
Unincorporated Areas	7,529	18,958	20,907	32,655	56.2
Incorporated Areas	4,524	43,112	46,633	76,789	64.7
Benton City	640	1,210	1,070	1,980	85.0
Kennewick	1,918	14,244	15,212	34,397	126.1
Prosser	1,719	2,763	2,954	3,896	31.9
Richland	247	23,548	26,290	33,578	27.7
West Richland	--	1,347	1,107	2,938	165.4
Franklin County	6,207	23,342	25,816	35,025	35.7
Unincorporated Areas	1,650	7,520	10,153	14,619	44.0
Incorporated Areas	4,557	15,822	15,663	20,406	30.3
Pasco	3,913	14,522	13,920	17,944	28.9
Tri-Cities SMSA	--	--	93,356	144,469	54.8

Sources: Bureau of the Census. 1980 Census of Population and Housing, Advance Reports. Final Population and Housing Unit Costs: U.S. Department of Commerce. U.S. Government Printing Office: Washington, D.C.

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TABLE 8.3-5

PROJECTED NUCLEAR RELATED CONSTRUCTION WORKFORCE ON THE HANFORD RESERVATION BY YEAR

Year	S/[redacted]	WNP 2	WNP 1/4	WNP 4	Total	Percent of 1981 Workforce
1981	—	3,280	6,510	—	9,790	100
1982	—	3,370	5,630	—	9,000	91.9
1983	563	1,940	3,520	1,800	7,823	79.9
1984	1,227	—	2,120	3,906	7,253	74.1
1985	2,202	—	840	5,243	8,285	84.6
1986	3,298	—	—	4,638	7,936	81.1
1987	4,168	—	—	3,293	7,461	76.2
1988	4,446	—	—	1,490	5,936	60.6
1989	3,888	—	—	351	4,239	43.3
1990	2,433	—	—	—	2,433	24.9
1991	1,386	—	—	—	1,386	14.2

TABLE 8.3-6

POPULATION PROJECTIONS BY SCENARIO

Year	State Projection of Tri-Cities SMSA Population	Scenario 1 (WNP,1,2,4)	Scenario 2 (WNP 1,2, 4, SHNP)	Scenario 3 (WNP 1,2, and S/HNP)	Scenario 4 (WNP 1,2 only)
1981	148,251	148,251	148,251	148,251	148,251
1982	152,104	149,402	149,402	149,402	149,402
1983	155,956	147,134	148,261	144,683	143,563
1984	159,809	146,206	148,693	140,954	138,468
1985	163,662	147,573	151,993	141,653	137,232
1986	168,508	146,267	152,850	143,782	137,206
1987	174,354	144,892	153,200	146,874	138,572
1988	178,201	142,543	151,494	148,798	139,952
1989	183,047	141,643	149,481	148,749	141,345
1990	187,895	142,366	147,315	146,974	142,752
1991	191,653	143,783	146,622	146,278	144,173
1992	195,411	145,215	145,887	145,539	145,609
1993	199,241	146,661	146,719	146,368	147,059

TABLE 8.3-7

SKAGIT/HANFORD NUCLEAR PROJECT
ESTIMATED ON-SITE PERSONNEL (1)

Year	Manual	Bechtel Non-Manual	WESCO Non-Manual	Security	Puget (2) O & M	Total
1983 (3)	500	50	13	6	2	571
1984	1,085	125	17	26	4	1,257
1985	2,005	175	22	34	6	2,242
1986	3,020	250	28	66	9	3,373
1987	3,810	330	28	90	29	4,287
1988	4,035	380	31	116	55	4,617
1989	3,450	405	33	116	104	4,108
1990	2,075	330	28	116	168	2,717
1991 (4)	1,155	212	19	116	175	1,677
1992	200	87	19	116	179	601
1993 (5)	--	--	--	116	179	295

NOTES:
(1) All entries are annual averages.
(2) Additional personnel to support refueling outages is estimated to be 200 people.
(3) Start of Construction - 1/83.
(4) Commercial Operation Unit 1 - 1/91.
(5) Commercial Operation Unit 1 - 1/93.

TABLE 8.3-8

CONSTRUCTION PERIOD PAYROLL BY YEAR ($000)

	Manual	Bechtel Non-Manual	NESCO Non-Manual	Security	Puget O & M	Total
1983	$ 19,760	$ 1,400	$ 382	$ 101	$ 54	$ 21,697
1984	42,879	3,499	500	437	108	47,423
1985	79,238	4,898	647	571	162	85,516
1986	119,350	6,998	823	1,108	244	128,523
1987	150,571	9,237	823	1,511	785	162,927
1988	159,463	10,636	911	1,948	1,488	174,446
1989	136,344	11,336	970	1,948	2,814	153,412
1990	82,000	9,237	823	1,948	4,546	98,554
1991	45,646	5,934	558	1,948	4,735	58,821
1992	7,904	2,435	558	1,948	4,843	17,688
Total	$843,155	$65,610	$ 6,995	$13,468	$19,779	$949,007

NOTE: Data in 1980 dollars.

TABLE 8.3-9

Sheet 1 of 2

SUMMARY OF 1979 OPERATING REVENUES AND SELECTED EXPENDITURES IN BENTON AND FRANKLIN COUNTIES

	Benton County Amount	%	Franklin County Amount	%
REVENUES				
Total Taxes	$ 6,704,449	55	$ 2,340,749	42
General Property Taxes	(2,813,577)	(23)	(1,835,182)	(33)
Retail Sales and Use Taxes	(3,762,410)	(31)	(376,224)	(7)
Business Taxes	(--)	(--)	(--)	(--)
Licenses and Permits	113,684	1	67,266	1
Intergovernmental Revenues	2,849,377	23	2,376,951	42
Charges for Services	582,545	5	318,980	6
Fines and Forfeits	350,548	3	120,727	2
Miscellaneous	1,630,800	13	376,092	7
TOTAL	$ 12,231,403	100	$ 5,600,765	100

4

TABLE 8.3-9

	Benton County		Franklin County	
	Amount	%	Amount	%
SELECTED EXPENDITURES				
General Government Services	$ 3,216,657	32	$ 2,196,403	40
Security of Persons and Property	1,715,513	17	794,586	15
Physical Environment	343,304	4	107,586	2
Transportation	3,160,173	32	2,075,883	38
Economic Environment	10,771	*	9,448	*
Mental and Physical Health	1,197,734	12	165,590	3
Intellectual Environment	311,051	3	85,222	2
TOTAL	$ 9,955,203	100	$ 5,434,718	100

*Less than 1 percent

Source: Local Government Comparative Statistics, Washington State Auditor, Olympia, 1980.

TABLE 8.2-10

SUMMARY OF 1979 OPERATING REVENUES, LOCAL MUNICIPALITIES

	Richland		Pasco		Kennewick		Benton City	
	Amount	%	Amount	%	Amount	%	Amount	%
Total Taxes	$ 3,766,011	66	$ 2,303,516	45	$ 3,923,358	49	$ 90,272	14
General Property Taxes	(1,273,026)	(16)	(836,260)	(16)	(1,312,753)	(16)	(20,112)	(4)
Retail Sales and Use Taxes	(812,298)	(10)	(958,676)	(18)	(1,626,273)	(18)	(43,756)	(7)
Business Taxes	(1,511,556)	(19)	(521,031)	(10)	(911,709)	(11)	(18,004)	(3)
Licenses and Permits	215,916	3	176,334	3	296,647	4	16,167	3
Intergovernmental Revenue	2,571,055	32	2,141,725	41	2,903,706	36	480,278	76
Charges for Services	377,114	5	174,199	3	387,009	5	3,915	1
Fines and Forfeits	124,934	2	116,360	2	172,155	2	6,034	1
Miscellaneous	1,081,288	13	292,789	6	225,588	4	30,121	5
TOTAL REVENUES	$ 8,130,426	101*	$ 5,282,843	100	$ 8,016,275	100	$ 636,301	100
Per Capita Taxes	$ 112		$ 164		$ 114		$ 66	
Per Capita Revenues	$ 242		294		$ 233		$ 321	

NOTE: The city of West Richland did not submit a report to the State Auditor's Office.

Source: Local Government Comparative Statistics, Washington State Auditor, Olympia, 1980.

* Over 100 due to rounding

TABLE 8.2-11

SUMMARY OF 1979 SELECTED EXPENDITURES, LOCAL MUNICIPALITIES

	Richland		Pasco		Kennewick		Benton City	
	Amount	%	Amount	%	Amount	%	Amount	%
General Government Services	$ 2,510,876	28	$ 873,068	16	$ 1,290,667	16	$ 183,679	21
Security of Persons and Property	2,735,309	30	1,816,338	34	2,772,635	33	87,773	10
Physical Environment	1,679,238	19	699,533	13	1,450,946	17	10,831	2
Transportation	1,170,969	13	1,811,069	34	2,542,659	31	217,034	44
Economic Environment	50,209	1	--	--	--	--	63,704	13
Mental and Physical Health	373,091	4	36,565	1	60,710	1	3,603	1
Intellectual Environment	481,044	5	94,999	2	202,233	2	--	--
TOTAL	$ 9,010,936	100	$ 5,331,372	100	$ 8,320,640	100	$ 605,624	100
Per Capita Expenditures	$ 260		$ 297		$ 242		$ 245	

NOTE: The city of West Richland did not submit a report to the State Auditor's Office

Source: Local Government Comparative Statistics, Washington State Auditor, Olympia, 1980.

TABLE 8.3-12

TRI-CITIES HOUSING STOCK, 1976, 1978, 1980

Area	Total Units(n)	Single-Family Residences		Mobile Homes		Apartment Units*	
		N	%	N	%	N	%
Total							
1976	34,253	26,347	77	2,685	8	5,221	15
1978	43,386	27,781	64	4,893	11	10,712	25
1980	47,598	29,660	62	5,729	12	12,209	26
Kennewick							
1976	13,663	9,812	72	1,398	10	2,453	18
1778	18,642	11,567	62	2,405	13	4,670	25
1980	21,059	12,699	60	2,736	13	5,624	27
Richland							
1976	11,835	10,370	88	96	1	1,369	11
1978	14,636	9,523	65	883	6	4,230	29
1980	15,458	10,156	66	933	6	4,369	28
Pasco							
1976	8,755	6,165	70	1,191	14	1,399	16
1978	10,108	6,691	66	1,605	16	1,812	18
1980	11,081	6,805	61	2,060	19	2,216	20

*Includes Condominium Units

Source: Tri-Cities Real Estate Research Report, Spring 1981, College of Business and Economics, Washington State University.

TABLE 8.3-13

RECENT HISTORY OF TRI-CITIES HOUSING VACANCIES
1976-1980

Year	Total Units Vacant		Residences Vacant		Apartments Vacant		Mobile Homes Vacant	
	Number	%	Number	%	Number	%	Number	%
1976	282	0.8	171	0.6	96	1.8	15	0.6
1978	573	1.3	256	0.9	286	2.7	31	0.6
1980	1,316	2.8	367	1.2	855	7.0	94	1.6

Source: Tri-Cities Real Estate Research Report, Spring, 1981, College of Business and Economics, Washington State University.

TABLE 8.3-14

ENROLLMENTS AND CAPACITY OF SCHOOL DISTRICTS

School District	1979-80	1980-81	Current Capacity	Nonutilized Capacity
Columbia (0400)	885	886	1,129	243
Finley (0503)	903	902	1,163	261
Grandview (0116-200)	2,217	2,175	2,783	608
Kennewick (0017)	10,767	10,604	11,290	686
Kiona-Benton (0052)	1,164	1,163	1,165	462
Othello (0147-163-55)	2,413	2,315	2,603	288
Pasco (0001)	5,490	5,535	7,016	1,481
Prosser (0116)	2,012	2,007	2,312	305
Richland (0400)	8,559	8,308	10,103	1,795
Sunnyside (0207)	3,548	3,412	3,770	358
TOTAL	37,958	37,307	43,794	6,487

Sources: Office of Superintendent of Public Instruction, Olympia, September, 1981.

TABLE 8.3-15

AVERAGE ANNUAL FTE PUPILS PER TOTAL CERTIFICATED STAFF, AND EXPENDITURES PER PUPIL, 1979-80

School District	Total Certificated Staff	Pupils Per FTE Certificated Staff	Expenditures Per Pupil
Columbia	51.7	16.5	$2,110.91
Finley	48.5	18.2	2,192.08
Grandview	119.6	17.7	2,178.28
Kennewick	594.7	17.2	2,069.60
Kiona-Benton	55.4	19.8	1,991.85
Othello	134.1	16.8	2,381.61
Pasco	293.2	17.6	2,386.47
Prosser	110.8	17.3	2,125.18
Richland	479.3	17.3	2,221.25
Sunnyside	183.8	18.4	2,386.66
State of Washington	42,441.7	17.2	2,344.32

Source: Office of Superintendent of Public Institution, Olympia, May, 1981.

TABLE 8.3-16

POLICE PERSONNEL IN TRI-CITIES AREA

Type	Staff	Patrol Cars
Benton City Municipal	5	2
Kennewick Municipal	56	17
Pasco Municipal	37	10
Richland Municipal	55	9
West Richland Municipal	9	3
County Sheriff (Benton) County	25	16
County Sheriff (Franklin) County	32	N/A

4

TABLE 8.3-17

FIRE PROTECTION PERSONNEL WITHIN TRI-CITIES AREA

Fire Protection Unit	Staff			Service Area
	Full-Time	Volunteers	Total	
Kennewick	33	15	48	City
Pasco	26	0	26	City
Richland	42	0	42	City
BCRFD#1	1	126	127	Kennewick Area
BCRFD#2	1	17	18	Benton City
BCRFD#3	1	11	12	Prosser Area
BCRFD#4	1	17	18	West Richland
BCRFD#5	1	68	69	Southeast of Prosser
FCRFD#3	3	65	68	Surrounds City of Pasco

NOTE: There are "Mutual Aid Agreements" between all fire districts in the area. The "Tri-Cities Mutual Aid Agreement" (September 15, 1980) includes the cities of Pasco, Kennewick, Richland, BCRFDs #1, #2, #3, FCRFD#3, Walla Walla County and the Rockwell Hanford Fire Protection Department.

TABLE 8.3-18 Sheet 1 of 2

EXAMPLES OF HUMAN SERVICES FACILITIES AND ORGANIZATIONS IN THE TRI-CITY SMSA

Facility or Organization	Descriptive Comments
911 Emergency Dispatch Cntr	Provides immediate referral to emergency information and dispatch of ambulance, fire, police, etc., services.
Benton-Franklin Association for Retarded Citizens	Counseling, recreation, transportation and referral services for learning-disabled individuals.
Benton-Franklin Developmental Center	Provides services and programs for developmentally disadvantaged children.
Catholic Family Services	Provides foster care programs, family and individual counseling programs and adoptive services.
Children's Home Society of Washington	Residential treatment facilities and programs for emotionally disturbed children.
Benton-Franklin Council on Aging	Programs to provide meals, household assistance, health care and information and transportation services.
Evergreen Legal Services	Free legal aid program for civil cases involving low-income persons.
Good Shepherd Home	A residential treatment program for adolescent girls with behavior problems.
Women's Resource Center	Broad range of information, education, support and referral services for women.

TABLE 8.3-18 Sheet 2 of 2

Facility or Organization	Descriptive Comments
Planned Parenthood of Benton-Franklin Counties	Family planning education, information and assistance programs.
Tri-Cities Chaplaincy	Chaplaincy service to those with life-threatening illnesses and their families, including a hospice program.
Women's Resource Center	Broad range of information, education, support and referral services for women.

TABLE 8.3-19

EXAMPLES OF PHYSICAL RECREATIONAL FACILITIES AVAILABLE IN THE TRI-CITIES AREA

Physical Activity	Descriptive Comments
Tennis	62 outdoor courts (e.g., Sylvester Park, Amon Park, Pasco High School). Indoor courts at Tri-City Court Club.
Golf	Six courses including Tri-City Country Club, Canyon Lakes and West Richland Municipal Golf Course. Several driving ranges and pro shops are also available.
Bowling	Lanes in each city including Atomic Bowling Center, Clover Leaf Lanes and Columbia Lanes.
Swimming	Private (e.g., Ranchette Estates) and public (e.g., Kennewick) swimming pools in the area. Boating, waterskiing and swimming on the Columbia River in the Tri-Cities area.
Ball	Baseball fields and basketball courts are located throughout the Tri-Cities including such places as Badger Canyon, Craighill Playgrounds, Stevens Playground and Lewis and Clark School. Soccer and football fields are also located in various areas.
Skating	Rollerskating, ice-skating and skateboard facilities.
Camping	Several hundred campsites within driving distance from the Tri-Cities area including Levy Park, Fishook Park and Sun Lakes.
Fishing	Steelhead, sturgeon, trout, and crappie fishing in the lakes and rivers near the Tri-Cities area.
Hunting	Duck, geese, pheasant and quail hunting. Deer and elk hunters in the Blue Mountains and the Cascade Range.

TABLE 8.3-20

OPERATIONS PAYROLL BY YEAR ($000)

	Example Year 1994	Total Payroll (1991-2020)	
Puget O & M	$ 4,843	$145,295	4
Puget O & M Refueling	1,350	40,500	
Security	1,948	58,443	5
Total	$ 8,141	$244,238	

NOTE: Data in 1980 dollars. 4

8.4 IMPACTS ON INDIAN NATIONS

8.4.1 EXISTING AND DEVELOPING CONDITIONS

The Columbia River Basin contains several Indian tribes which in 1855 signed treaties with the United States reserving to the tribes "the right of taking fish at all usual and accustomed places in common with citizens of the territory". These tribes are the Yakima Indian Nation, the Warm Springs Tribes, the Umatilla Tribes and the Nez Perce Tribe.

The courts have interpreted the treaty fishing right as entitling the tribes to take up to 50% of the harvestable fish run. In a recent decision, now on appeal, the court found that treaty tribes have an implied right under the treaties not to have the fishery habitat environmentally degraded to the point where the treaty fishing right would be impaired. The tribes believe that this decision plus reserved water right decisions preserves for them the right to a sufficient quantity and quality of water to protect the fishery habitat.

The interest of Indian tribes in the Columbia River fishery was also recognized in the federal Regional Power Act, P.L. 96-501. Under that legislation, a program is to be developed to protect, mitigate and enhance fish and wildlife on the Columbia River and its tributaries. The Indian tribes must be consulted in the development of this program. 4

This section addresses whether the proposed project will impact the Columbia River treaty tribes and their treaty fishing right. Of these tribes, the Yakima Indian Nation is located closest to the Hanford Reservation. They are situated on the 1,387,505 acre Yakima Reservation in Yakima and Klickitat Counties. At its closest approach, the Yakima Reservation is approximately 13 miles from the Hanford Reservation.

Much of the Reservation is forested; the remainder is primarily agricultural. The Yakima River flows along the northeastern boundary of the Yakima Reservation.

The population centers on the Yakima Reservation are Toppenish with a population of 6,100; Wapato (3,000), Harrah (350) and White Swan (300). Tribal headquarters are in Toppenish.

As of May, 1980 there were 6,508 enrolled tribal members. Of these, 4,072 (63 percent) lived on the Yakima Reservation and 2,436 (37 percent) lived off-reservation. The county Indian population increased approximately 62 percent from 1970-1979 compared to 12 percent for the total population (Ref 1).

Indian employment patterns in the Yakima SMSA in 1980 were as follows (Ref 1):

Employment Category	Indian Employment	Total Employees in Yakima SMSA
Government	1,136	10,080
Manufacturing Total	60	6,570
lumber & wood	50	1,290
printing & publishing	10	1,870
Non-Manufacturing Total	367	63,460
agriculture, forestry fishing	250	18,430
construction	20	2,880
transportation, communication & utilities	10	2,730
wholesale & retail trade	25	16,050
finance, insurance & real estate	22	2,110
service	40	11,180
Total	1,563	70,030

The unemployment rate of Indians in the area is estimated to be 30 percent.

The Division of Planning and Development of the Yakima Tribe has set forth the following goals (Ref 1):

1. To preserve the heritage, culture and way of life of the Indian people.

2. Full development of the Tribe's renewable resources for the economic benefit of the people within limits that will insure protection of these resources.

3. Continued economic development to establish diversity of employment opportunities up to the limits of full employment for tribal members.

4. To provide those services necessary for increasing the social well-being of tribal members.

5. Full jurisdiction and control within the boundaries of the Yakima Reservation.

These goals have been proposed to guide Yakima development strategy over the 1980 decade.

8.4.2 PROJECTED CONDITIONS UNDER ALTERNATIVE SCENARIOS

No section of the Yakima Reservation lies within the designated impact area. Under the construction scenarios the Project would neither affect the Yakima Reservation, interfere with the Tribe's fishery rights, nor impede the Tribe's development goals. The Project would also not impact the Treaty fishing rights of other treaty tribes in the Columbia River Basin.

In June of 1979 the Yakima Tribal Council passed a resolution banning the transportation of nuclear wastes, residues, fuels, products and by-products within the borders of the Yakima Reservation (Ref 2). Neither the construction nor the operation of S/UNP will cause any such materials to be transported through the Yakima Reservation.

References for Section 8.4

1. Economic Development Program, Yakima Indian Nation, Toppenish, WA (1980-1981). 4

2. Resolution #T-27-79, Yakima Indian Nation, Toppenish, WA (1980-1981).

8.5 SUMMARY OF SOCIAL AND ECONOMIC BENEFITS AND COSTS

8.5.1 BENEFITS

The primary benefit of the Project will be the employment, income and population effects on the socioeconomic infrastructure of the local area. Each of the four scenarios projects out-migration of construction and secondary workers over the period 1983-1992 resulting in absolute population losses and/or declines in the rate of growth. Construction of the Project, however, diminishes the out-migration for the area and thus helps support the socioeconomic infrastructure of the area. This support may provide a useful time period for the Tri-Cities to diversify its economic base.

One example of the S/HNP effects on the socioeconomic infrastructure can be drawn from the difference between the projected conditions of local schools without, e.g. Scenario 4, and with, e.g. Scenario 3, the Project.

Scenario 4 (baseline) - Schools would experience declines in enrollment of over 4,000 during the 1982-1986 period. This loss of students would mean reduced funding from the State and could result in reductions in the teaching and administrative staff. Special levies to support non-basic educational activities would be needed.

Scenario 3 (Construction of S/HNP) - Declines in enrollment would occur but would be less than in Scenario 4 due to the population effects of the S/HNP construction and secondary workers in the area over the 1983-1988 period. This maintenance of enrollment would provide for continuation of State funding and reduce the need for special levies and staff reductions. Finally, the major addition of the S/HNP to the tax base of the Richland School District would virtually eliminate the District's special levy for residents.

While projected school conditions are one example of the manner in which S/HNP will support the socioeconomic infrastructure of the Tri-Cities, other illustrations could be drawn from such dimensions of the community as housing, health care, fiscal condition and the impact on local businesses. In each of these areas, the S/HNP effects on the infrastructure would be of major benefit as compared to the declining economy and stagnant population depicted by the baseline scenarios.

In addition to supporting of the socioeconomic infrastructure the Project will provide:

1. Adequate Generation

The Project will contribute to ensuring sufficient generating capacity for the region and decrease the probability of an inability to meet the load in the future. The potential socioeconomic costs of power shortages and curtailments have been shown to be significant in the State of Washington (Ref 1).

2. Tax Benefits

The Project will have a significant positive impact upon Benton County as well as the State. Based on 1981 tax rates, it is estimated the Project would generate the following revenues during construction over and above those revenues generated under Scenarios 1 and 4 at the same points in time. 4

	Estimated Revenues During Construction
State	$ 380 million
Benton County	$ 150 million
Benton-Franklin Transit District	$ 8 million
	$ 538 million

Under 1981 tax rates, during operation, the S/HNP would annually provide Benton County with $30 million in property taxes and in sales tax. The State would receive $21.5 million and $5.9 million respectively. The Benton-Franklin Transit District would receive nearly $400,000 per year. 5

The significant increase in the tax base would allow Benton County to consider such options as (a) significantly improving services, (b) disbursing funds to local communities, and (c) lowering tax rates by as much as 70 percent. 4

Increased revenues for local jurisdiction will allow them to maintain and improve services and potentially reduce the property tax levy in the County. Further, local governments will be able

to avoid lay-offs which would be associated with the baseline scenarios.

3. Employment Benefits

There will be a reduced loss of jobs due to construction of the facility. Employment will range from 571 in 1983 to 4617 in 1988 to 1677 in 1991. Over the period 1983-1991 S/HNP will provide almost 24,000 person years of employment.

Secondary employment will also result during the construction and operations periods. Previous research indicated a multiplier of 1.8 for nuclear construction in the Tri-Cities (Ref 2). Thus, apart from commuters, it is projected that construction will generate over 16,000 person years of employment in other sectors of the economy.

Operation of the facility will provide employment for 295 individuals over the 40 year life of the facility - 11,800 person years of work. This emplc ment and income will support about 531 jobs in the local economy.

An additional 200 workers will be employed during periodic refueling operations, and their expenditures will support the local economy.

4. Income Benefits

During construction, it is projected that annual income per worker will average $37,000 in 1980 dollars for a total of $949 million over the construction period.

During operation, it is projected that annual income per worker will average $23,600 in 1980 dollars for a total of $244 million over the 40 year operating life.

These relatively high income levels will stimulate other sectors of economy and produce expanded business activity throughout the SMSA.

5. Purchase of Local Materials and Services

During construction Puget intends to purchase local supplies and services when they are readily available and competitively priced. Given the extent to which the local economy has developed in

tandem with nuclear-related construction, it is expected that a number of local firms will provide materials and services.

During operation, it is estimated that local purchases of materials and services will be approximately $5 million per year in 1981 dollars. Over the 40 year operating life of the facility, this figure totals to $200 million spent in the local area.

6. Benefits to Communities Outside the SMSA

It is estimated that at any given time, 15 percent of the nuclear construction force on the Reservation resides outside the SMSA and commutes on a daily basis. Thus, towns such as Sunnyside, Grandview and Mabton will also benefit from the employment and income effects of the S/HNP.

Under Scenarios 1 and 4 a number of these residents will be unable to find employment in the area and will migrate from these communities. Scenarios 2 and 3 would each enhance the local employment opportunities for such individuals and thereby diminish out-migration.

7. Maintain Character of Tri-Cities

Perhaps the most commonly voiced socioeconomic concern regarding energy development relates to its incompatibility with the character of the local area. Since more recent energy projects have been nonmetropolitan communities, concern is often expressed that large scale construction would disrupt the rural lifestyle.

The S/HNP, however, will operate to support the existing quality of life in the Tri-Cities SMSA. The social, economic, demographic, institutional and psychological profile of the Tri-Cities area has developed in tandem with nuclear power since 1943.

The construction and operation of the S/HNP will be in harmony with socioeconomic trends which have characterized the local area for nearly two generations.

8.5.2 TRAFFIC COSTS

Local roads have been overburdened by the rapid growth experienced in the Tri-Cities area, resulting in traffic congestion and high accident rates in several places. In 1981, for example, it is estimated that approximately 6,100 commuter vehicles were associated with the construction force of WNP 1, 2 and 4 on the average for the year.

The difference between commuter vehicle traffic on the Reservation with S/HNP as opposed to without is projected to average approximately 2,100 additional vehicles per day between 1984-1990.

The greatest amount of commuter traffic will occur under Scenario 2 when 4,960 total vehicles are projected. Even this peak, however, will only be 81 percent of the estimated average of 6,118 construction union vehicles associated with WNP 1, 2 and 4 in 1981.

Under Scenario 3, in no year would the number of commuter vehicles exceed 45 percent of the estimated commuter vehicles in 1981.

Although the construction scenarios indicate commuter traffic well below that which existed in 1981, several improvements are being considered by Puget:

1. A new roadway connecting the SR240 Highway to the Plant Site.

2. SR240 Highway from the intersection of the new roadway to the By-Pass Highway intersection will operate as a four-lane facility by utilizing shoulder driving for HOV (high occupancy vehicles) in the peak hours of 6 A.M. to 9 A.M. towards the Plant Site and 3:30 P.M. to 6 P.M. away from the Plant Site.

3. Improvements at the SR240 Highway intersection with the By-Pass Highway and the intersection of the By-Pass Highway with Van Giesen Street.

These basic improvements will carry the traffic for the S/HNP through its entire construction sequence and schedules. In addition, such measures as car pooling and shift staggering will reduce traffic throughout the construction phase.

It should be noted that construction and operation of S/HNP will generate substantial revenues for the Benton-Franklin

Transit Authority. During construction, for example, S/HNP may generate as much as $8 million for the Transit Authority between 1983-1992 over the revenues received under Scenarios 1 and 4 for the same time period. During operation nearly $400,000 more would be available annually under Scenarios 2 and 3 versus Scenarios 1 and 4. 4 5

Finally, substantial revenues will accrue to the Road District in Benton County through property taxes paid on the facility. These funds could be utilized to improve roads in the county. 4

Under the baseline scenarios these revenues would not be available to either the Benton-Franklin Transit Authority or the Benton County Road District.

References for Section 8.5

1. John McConnaughey, Bonneville Power Administration, Power Requirements Branch (December 9, 1981).

2. Socioeconomic Impact Study WNP 1 & 4, Volume 4: Final Report, prepared by Community Development Services, Inc. for Washington Public Power Supply System, Seattle, Washington (May 1979).