PALO VERDE NUCLEAR GENERATING STATION

ENVIRONMENTAL REPORT OPERATING LICENSE STAGE

VOLUME IV

ARIZONA PUBLIC SERVICE COMPANY
PROJECT MANAGER AND OPERATING AGENT

8006230 705

CHAPTER 4

ENVIRONMENTAL EFFECTS OF SITE PREPARATION, STATION CONSTRUCTION, AND TRANSMISSION FACILITIES CONSTRUCTION

CONTENTS

CONTENTS (cont)

TABLES

FIGURES

4. ENVIRONMENTAL EFFECTS OF SITE PREPARATION, STATION CONSTRUCTION, AND TRANSMISSION FACILITIES CONSTRUCTION

The PVNGS site occupies approximately 4050 acres. Of this, about 2450 acres are being modified for the plant and associated facilities. Environmental effects noted during construction, so far, have not differed greatly from the estimates presented in the ER-CP and FES. The following sections summarize observed effects and expected environmental impacts of further construction.

4.1 SITE PREPARATION AND STATION CONSTRUCTION

The discussion of the effects of site preparation and plant construction considers both land and water use and reflects current construction plans as well as environmental impacts observed during construction.

4.1.1 EFFECTS ON LAND USE

4.1.1.1 Site Preparation

4.1.1.1.1 Clearing and Grubbing

Approximately 2450 acres will eventually be cleared for construction of the units and supporting facilities. One thousand acres currently used for construction facilities will be allowed to revegetate.

Not all acreage is being disturbed at the same time since construction activities progress sequentially from unit to unit. Additionally, areas reserved for potential future evaporation ponds (see figure 3.1-4) will not be disturbed for evaporation pond construction until additional capacity is required.

4.1.1.1.2 Excavation and Use of Fill

4.1.1.1.2.1 Archaeological Preservation. Thirteen archaeological sites located within or near the boundaries of the plant site were preserved by the following means:

- Excavation of known archaeological sites
- Investigation for other potential sites
- Mapping and analyses of trail networks

Where artifacts and evidence of archaeological significance were found, they were preserved and analyzed. Hence, the archaeological heritage of the site has been established and preserved.

4.1.1.1.2.2 Major Construction Excavations. Removed topsoil is stockpiled in spoil areas during construction. Excess subsoil removed during excavation and site grading is used to build reservoir berms or as construction fill wherever possible. It is estimated that approximately 15 million cubic yards of soil will have been excavated before the end of the construction of all power blocks and supporting facilities. No explosives are required for site excavation.

4.1.1.1.3 Grading

Onsite grading is being confined to areas requiring excavation, placement of embankments, and backfill. These areas are:

- Reservoir
- Power blocks
- Cooling tower basins
- Evaporation pond
- Water reclamation area
- Administration building

- Warehouse and shop buildings
- Switchyards
- Material laydown yards
- Roads, railroads

Offsite grading has been confined to the following:

- Access roads
- Railroad access

4.1.1.2 Site Construction

4.1.1.2.1 Permanent Site Access

4.1.1.2.1.1 Roads. Permanent offsite roadway access is as shown in figure 3.1-3. Permanent onsite access roads are shown in figure 3.1-4.

4.1.1.2.1.2 Railroads. A railroad spur approximately 2 miles long has been constructed north from the Southern Pacific Railroad line (see figure 3.1-3) to the southern boundary of the site. Onsite railway spurs are as shown in figure 3.1-4.

4.1.1.2.2 Site Drainage

With the exception of some site access roads and the meteorological tower, all construction and operation activities take place east of the railroads. All site drainage east of the railroad is retained onsite. As a result of this design, construction materials remain onsite.

4.1.1.2.3 Temporary Site Facilities

4.1.1.2.3.1 Roads and Railroads. Temporary construction roads are built for access to the power blocks, spoil and borrow areas, reservoir, evaporation ponds, landfill switchyard area,

warehouses, shop buildings, administration building, and to the water reclamation area.

Construction roads used during plant construction are of a permanent nature since they will be used for up to 10 years. They are surfaced with materials such as asphaltic concrete paving or gravel.

Dust is controlled on roads by the use of water trucks.

4.1.1.2.3.2 Temporary Facilities. The following temporary construction buildings have been erected.

- General construction office
- Main warehouse
- Auxiliary warehouse
- General shop
- Carpenter shop
- Lofting deck
- Change house
- Timekeeping building
- Concrete testing laboratory
- First aid
- Firehouse
- Miscellaneous buildings and shops
- Batch plant

These facilities have been located by considering the following criteria:

- Accessibility
- Interference with future construction
- Convenience to offsite and onsite access

4.1.1.2.3.3 Batch Plant. The batch plant and ice facilities are south of Unit 3 and located adjacent to a railroad spur (see figure 3.1-4).

This location provides:

- Convenient servicing and access of powerblock requirements
- Elimination of mix truck congestion
- Drainage of water and daily waste to the designated collection area

4.1.1.2.3.4 Bridges and Culverts. Water run-off during construction is diverted by drainage canals into on-site retention basins. Culverts are used to avoid erosion of temporary roads.

4.1.1.2.3.5 Removal of Temporary Facilities. After construction is completed, selected construction facilities will be removed, topsoil will be replaced and the land will be allowed to revegetate naturally. Construction roads that do not become part of the permanent road system will be removed. Construction roadside slopes and spoil area slopes will be graded to meet existing contours to prevent water accumulation or erosion.

4.1.1.2.4 Pipelines

Buried onsite pipelines are provided for pumping makeup water, blowdown, circulating water, and diesel fuel.

4.1.1.3 Minimizing Undesirable Effects of Projected Related Activities

4.1.1.3.1 Dust Control

Dust-control methods are used during all phases of site preparation and construction. During clearing, grubbing, and earthmoving operations, dust is controlled by using water trucks.

4.1.1.3.2 Rubbish and Waste Control

Combustible construction trash is burned at a designated burning area to reduce volume, and the residue covered with earth. Noncombustible construction trash is disposed of in the spoil area by landfill methods.

The concrete batch plant discharges waste from material wash into a settling pond. Waste from truck wash is also discharged into a settling pond.

4.1.1.3.3 Sanitation

Sanitary facilities capable of handling the needs of the maximum construction work force are provided as described in section 3.7.

Industrial interceptors are used to intercept floor-drain wastes at the vehicle maintenance and paint shop facilities. After interception, the non-petroleum floor-drain effluents are discharged into the storm-drain system. Petroleum products from vehicle and equipment operation are collected and removed from the site. They are not discharged into streams or drainage areas.

4.1.1.3.4 Fire Protection System

The plant fire protection and prevention system is designed in accordance with the requirements of the American Nuclear

Insurers (ANI), the requirements of Nuclear Mutual Ltd. (NML), applicable codes and regulations of the State of Arizona, the National Fire Codes and the National Fire Protection Association (NFPA), and Occupational Safety and Health Standards.

During construction, two 431,000-gallon water tanks are used as a temporary source for fire protection water. After plant construction, the tanks will provide storage for domestic water makeup as well as a minimum of 600,000 gallons of fire protection water. During the final stages of construction, the fire protection water supply yard main for each generating unit will be arranged so that each branch line from the yard main to the various areas in the generating unit facilities may be supplied with water by alternate flow paths. Two-way fire hydrants with hose houses are being installed at approximately 250-foot intervals along the yard main for each unit.

4.1.1.4 Existing Terrain Protection

4.1.1.4.1 Erosion Control

Significant erosion from rainfall runoff has not been experienced on construction areas where the slope is less than or equal to 2% (level areas). Steeper slopes are protected by peripheral interception ditches along the top edge of all cut-and-fill slopes.

4.1.1.4.2 Access to Historical and Cultural Landmarks

Historical, cultural, and archeological sites, and natural landmarks in the region are described in section 2.6. Appropriate precautions have been taken with regards to any significant archeological and historical findings prior to construction.

4.1.1.5 Work Force Regulations

4.1.1.5.1 Construction Traffic

A peak work force of approximately 6200 persons was experienced during the second quarter of 1979. Table 8.1-3 lists the estimated labor force requirements during construction by quarterly reporting period. Table 4.1-1 lists the estimated amount of traffic generated as a result of construction at PVNGS. Table 4.1-1 assumes that (1) all traffic counted on Wintersburg Road south of Buckeye-Salome Road during a June 1978 Maricopa County Highway Department traffic survey was construction related, (2) the proportion of construction workers per vehicle in and out of the plant site will remain constant at the June 1978 ratio of 1.86 persons per car, and (3) the number of common carrier trucks in and out of the plant site will remain constant at the rate of one truck per 100 vehicles. Most major station components, excluding the reactor vessels and steam generators, are being delivered to the PVNGS plant site via railroad. The reactor vessels and steam generators are transported from Puerto Penasco, Mexico, via Mexican Highway 8 and Arizona Highway 85. Sand and aggregate is delivered to the PVNGS plant site via road or rail, depending on its source.

4.1.1.5.2 Construction Noise

The impact of construction noise was determined by measuring the sound levels in the vicinity of PVNGS during construction. The methodology of the construction noise survey is presented in section 6.1.

The nearest residence to PVNGS is approximately 1 mile from any construction activity. The sound level measured at this residence on a typical work day was 34 dBa, a level essentially unchanged since the original preconstruction survey described in section 2.7. This level corresponds to an ambient L_{dn} of

Table 4.1-1
1979 TO 1986 ESTIMATED PVNGS CONSTRUCTION-RELATED DAILY TRAFFIC COUNT

Year[a]	Cars	Common Carrier Trucks	Total Vehicles
1979	3,340	33	3,373
1980	2,860	29	2,889
1981	2,500	25	2,525
1982	1,820	18	1,838
1983	1,710	17	1,727
1984	1,050	11	1,061
1985	560	6	566
1986	150	2	152

a. Data presented for the second calendar quarter of each year.

41 dBa, and is considered acceptable for a rural environment under EPA and HUD criteria.

4.1.1.5.3 Social Implications

Effects of the presence of a construction work force on social and institutional processes are discussed in chapter 8.

4.1.2 ECOLOGICAL IMPACT

4.1.2.1 Vegetation

The site preparation and construction of PVNGS and associated facilities will result in the removal of vegetation from about 2450 acres of the site. About 1600 acres of the 4050-acre site will remain undisturbed. Approximately 1500 acres of the total 2450 acres which are cleared had been disturbed and abandoned as cropland prior to construction.

Construction impact on onsite vegetation has not been significant for the following reasons:

- Plant communities at the site are common throughout the region.
- No federally listed endangered or threatened species are known to occur at the site.
- Permission has been obtained from the Arizona Commission of Agriculture and Horticulture for clearance of any State-protected species.
- Natural revegetation of disturbed areas is being allowed to take place.

Perennial plant succession in the area of the PVNGS site has been described as being very slow with species such as burrobush and creosotebush being invader species. Observations at the PVNGS site have documented early successional patterns following various degrees of disturbance. Plant species observed establishing on various disturbed areas are listed in table 4.1-2.

Refer to figure 4.1-1 for the PVNGS site vegetation map that shows the effect of construction on vegetation.

Additional vegetation removal has taken place due to construction of the 36.5-mile wastewater conveyance route. Most of the route traverses developed land. No significant damage to vegetation has occurred.

4.1.2.2 Wildlife

The primary adverse impact to wildlife during construction has been the loss of onsite habitat. Individuals of resident species have been displaced during initial land clearing onsite and along the wastewater conveyance route. Some species such as waterfowl have already benefited from the creation of new

Table 4.1-2

LIST OF PLANT SPECIES ESTABLISHING ON DISTURBED AREAS AT THE PVNGS SITE (Sheet 1 of 4)

Scientific Name	Common Name	Seeded Topsoil	Unseeded Topsoil	East Wash Diversions	Other Areas
AIZOACEAE					
Trianthema portulacastrum	Horse Purslane		X		
AMARANTHACEAE					
Amaranthus sp.	Pigweed		X		
Tidestromia lanuginosa	Wooly Tidestromia		X		X
BORAGINECEAE					
Amsincki intermedia	Intermediate fiddleneck	X	X		
Amsincki tessellata	Bristly fiddleneck	X	X		
Cryptantha angustifolia	Cryptantha	X	X		
Cryptantha muricata	Cryptantha	X			
Cryptantha petrocarya	Cryptantha	X			
Pectocarya heterocarpa	Combseed	X	X		
Pectocarya platycarpa	Combseed		X		
CHENOPODIACEAE					
Artiplex canescens	Four-wing saltbush	X	X		
Artiplex fasiculata	Saltbush	X			
Artiplex polycarpa	Desert saltbush	X	X		X
Artiplex semibaccata	Australian saltbush	X			
Chenopodium album	Lambsquarters	X	X		
Chenopodium noralea	Goosefoot		X		
Chenopodium sp.	Goosefoot		X		
Monolepis nuttalliana	Patata	X			
Salsola kali	Russian thistle		X		X
Salsola ibericus	Russian thistle	X	X		
COMPOSITAE					
Ambrosia acanthicarpa	Burweed	X			
Ambrosia confertifolia	Slimleaf brusage	X	X		
Ambrosia dumosa	Burrobush		X		
Aploppapus heterophyllus	Jimmyweed				X

Table 4.1-2

LIST OF PLANT SPECIES ESTABLISHING ON DISTURBED AREAS AT THE PVNGS SITE (Sheet 2 of 4)

Scientific Name	Common Name	Seeded Topsoil	Unseeded Topsoil	East Wash Diversions	Other Areas
COMPOSITAE					
Baccharis sarothroides	Desert Broom	X	X		X
Isocoma cf. heterophylla	Isocoma		X		
Machaeranthera arida	Aster	X	X		
Matricaria matricarioides	False camomile	X	X		
Monoptilon bellicoides	Monoptilon		X		
Pectis papposa	Chinchweed (Fetic Marigold)		X		
Rafinesquia neomexicana	Chicory		X		
Sonchus oleraceous	Sow thistle	X	X		
CRUCIFEREA					
Descurainia obtusa	Tansy mustard		X		
Lepidium lasiocarpa	Peppergrass	X	X		
Sisymbrium irio	Tumble mustard	X	X		
EUPHORBIACEAE					
Euphorbia micromera	Littleleaf Spurge		X		
GERANIACEAE					
Erodium cicutarium	Redstem filaree	X	X		
Erodium texana	Tufted storksbill	X	X		
GRAMINEA					
Avena sativa	Wild oat		X		
Bouteloua aristidoides	Sixweeks Needle Grama		X		
Bromus arizonicus	Bromegrass	X	X		
Bromus rubens	Foxtail chess	X	X		
Cynodon dactylon	Bermudagrass				X
Eragrostis cilianensis	Stinkweed		X		
Muhlenbergia microsperma	Muhley	X	X		
Panicum sp.	Panicum		X		
Poa bigelovii	Bigelow bluegrass	X	X		

Table 4.1-2

LIST OF PLANT SPECIES ESTABLISHING ON DISTURBED AREAS AT THE PVNGS SITE (Sheet 3 of 4)

Scientific Name	Common Name	Seeded Topsoil	Unseeded Topsoil	East Wash Diversions	Other Areas
GRAMINEA (cont.)					
Polypogon sp.	Rabbitsfoot	X	X		
Schismus arabicus	Arabian schismus	X	X		
Schismus barbatus	Mediteranian schismus	X	X		
Vulpia octoflora	Sixweeks fescue	X	X		
HYDROPHYLLACEAE					
Phacelia distans	Scorpion weed	X	X		
Nama sp.	Nama		X		
LABIACEAE					
Teucrium cubense	Gremander	X	X		
LEGUMINOSAE					
Hoffmanseggia densiflora	Hog Potato				X
Melilotus indicus	Sweetclover	X			
Prosopis juliflora	Mesquite				
LOASACEAE					
Mentzelia affinis	Blazing star		X		
MALVACEAE					
Malva parviflora	Little mallow		X		
Sphaeralcea coultari	Coulter Globe mallow	X	X		
Sphaeralcea emoryi	Emory Globe mallow	X	X		
NYCTAGINACEAE					
Abronia angustifolia	Sand Verbena		X		
Boerhaavia torreyana	Spiderling		X		
PLANTAGINACEAE					
Plantago sp.	Plantain		X		

Table 4.1-2

LIST OF PLANT SPECIES ESTABLISHING ON DISTURBED AREAS AT THE PVNGS SITE (Sheet 4 of 4)

Scientific Name	Common Name	Seeded Topsoil	Unseeded Topsoil	East Wash Diversions	Other Areas
POLYGONACEAE					
Eriogonum trichopes	Wild buckwheat		X		
Eriogonum sp.	Wild buckwheat		X		
Polygonum aviculare	Knotweed		X		
PORTULACACEAE					
Portulaca oleracea	Purslane		X		
RESEDACEAE					
Oligomeris linifolia	Oligomeris	X	X		
SOLANACEAE					
Lycium sp.	Wolfberry	X			
Physalis lobata	Ground Cherry	X	X		
Solanum elaeagnifolium	Silverleaf Nightshade				X
TAMARICACEAE					
Tamarix pentandra	Tamarisk	X	X	X	X
UMBELLIFERAE					
Bowlesia incina	Bowlesia	X			
Spermolepis echinata	Spermolepis		X		
ZYGOPHYLACEAE					
Larrea divaricatus	Creosotebush		X		
Kallstroemia Californica	California Caltrop				X

1. Other areas include abandoned cropland, temporary retention basins, and small areas of surface soil disturbance.

habitats (e.g., water storage reservoir, retention basins, and east wash diversion canal). Actual and further anticipated impacts are not expected to affect wildlife significantly in the Palo Verde Hills region, Maricopa County, or the State of Arizona.

Actual and predicted further wildlife impacts due to construction are as follows:

A. Croplands which were abandoned during initial construction activities presently support increased populations of rodents, cottontails, and jackrabbits. Raptors and mammalian predators have increased their foraging activities in these areas. Clearing additional areas of indigenous habitat and abandoned cropland for evaporation ponds will result in the short term loss or displacement of some individuals. There will be a long term reduction in regional populations proportionate to the size of the area cleared during the life of the facility.

B. Mammalian predators such as the coyote and raptorial birds may be adversely affected by the reduction in prey populations resulting from clearing activities. Construction noise and other manmade disturbances may further limit carnivore use of habitats adjacent to plant structures. Berms created along East Wash during initial construction at PVNGS have and should continue to benefit burrowing owls by providing suitable burrow locations.

C. Breeding habitat for several bird species (e.g., Gambel's quail and mourning dove) has been reduced by construction on site and additional clearing for the evaporation ponds will occur. Some of this loss will be mitigated by the growth of suitable breeding habitat (e.g., desert riparian woodland) which is presently developing along the East Wash diversion system.

D. The construction reservoir and retention basins now present in the area are used as wintering habitat and limited breeding habitat by some waterfowl and shorebird species.

E. No federally threatened or endangered species are likely to inhabit the site. The peregrine falcon and bald eagle which are federally endangered could potentially visit the site, but suitable breeding and foraging habitat is absent from the site and surrounding region. The brown pelican, also federally endangered, is an erratic visitor in the region. A single brown pelican was observed on site during construction. The Gila monster, listed as threatened by the State of Arizona, inhabits the site. Individuals encountered during construction are removed and released in nearby undisturbed habitat.

F. Several of the 14 bat species potentially inhabiting the region can benefit from site development. The storage reservoir and on site structures will provide additional watering and roosting areas which are limited in the site region. Additional lighting may attract and concentrate flying insects, thus facilitating bat foraging. Bats have been observed roosting in construction facilities at the site.

G. Impacts to and from invertebrates are small. Mosquito populations have been maintained on site because of the existence of standing water in construction areas. Mosquitoes have not reached and are not expected to reach nuisance levels as a result of site development. Some crop pests (e.g., noctuid moths) may be attracted to lights at PVNGS, but it is unlikely that these will adversely affect croplands near the site. Some of the invertebrates on the site will be destroyed or displaced during remaining site development activities.

In cooperation with the U.S. Department of Agriculture (USDA) Biological Control of Weeds Laboratory of Albany, California, and the Maricopa County Extension Service, PVNGS environmental personnel are releasing a moth, Coleophora parthenica, for onsite biological control of the noxious Russian thistle weed. Populations of this insect may establish themselves at PVNGS over the next few years. If the moth is as effective in controlling Russian thistle here as it has been in other areas, the Russian thistle habitat will be reduced on the site. The moth is very specific in choosing host plants. There appears to be little possibility that impacts will result to any crop plant due to the release of this moth on the PVNGS site.

4.1.2.3 Aquatic Resources

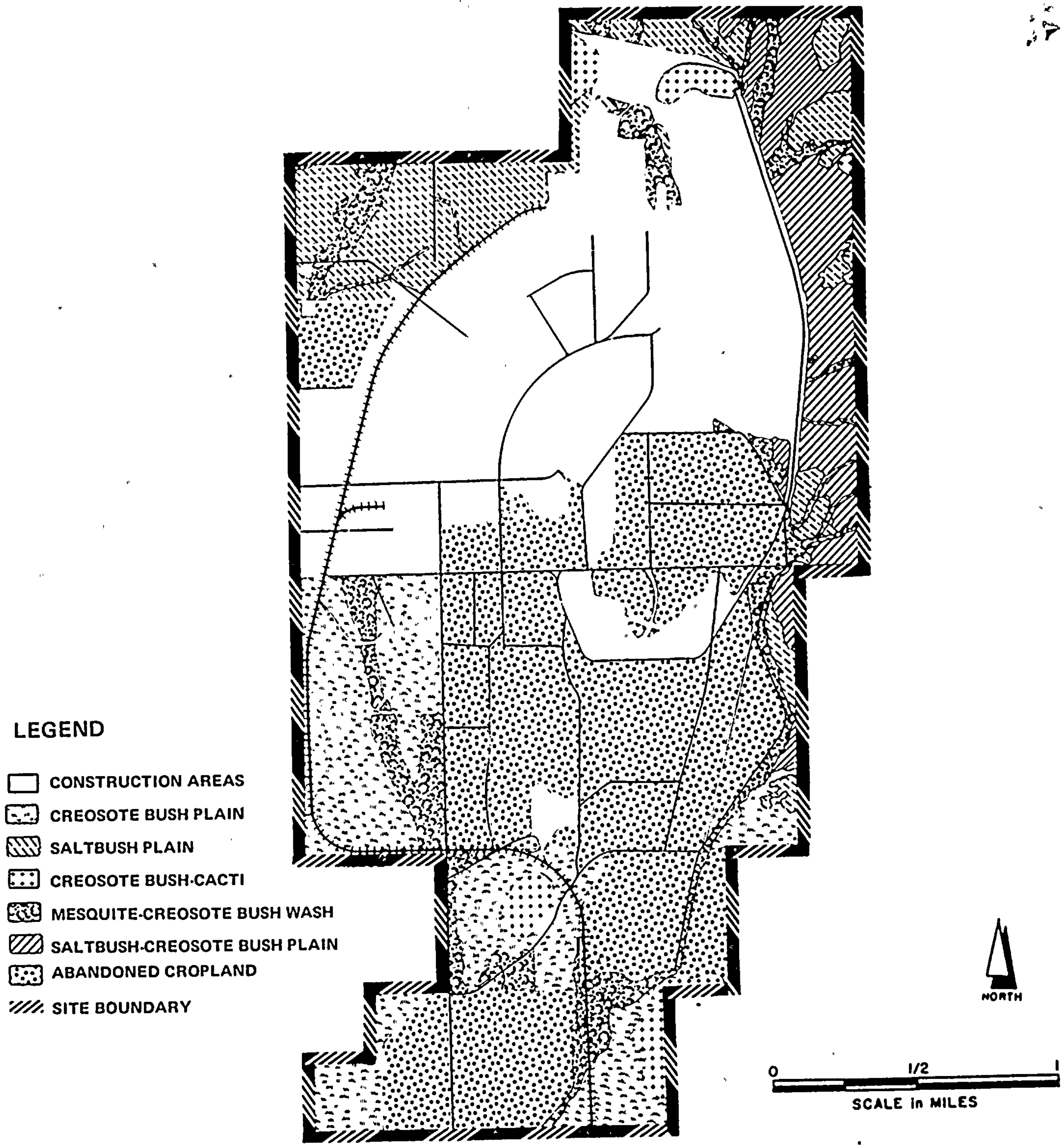
No natural aquatic habitats occur on the PVNGS site. The removal of groundwater for construction use is not likely to affect phreatophytes in the area.

4.1.2.4 Ecological Impact Conclusions

No significant adverse ecological impacts are anticipated to result from the construction of PVNGS. The modification of various habitats on the site is insignificant compared to the amount of similar habitats remaining in the region, county, and state. The potential for impact on any endangered or otherwise protected species is anticipated to be low. No natural body of surface water exists at the site. The storage of water on the site during construction may be beneficial to certain species in the area.

4.1.3 WATER USE

Site preparation and ongoing plant construction has not adversely affected natural water bodies, groundwater, or groundwater use within the vicinity of PVNGS. Future site preparation and plant construction practices are not anticipated to adversely affect water use within the vicinity of the site.



Palo Verde Nuclear Generating Station
ER-OL

PVNGS SITE VEGETATION MAP

Figure 4.1-1

4.2 TRANSMISSION FACILITIES CONSTRUCTION

4.2.1 ELECTRIC TRANSMISSION FACILITIES

The transmission systems associated with PVNGS are described in section 3.9.1. Information presented in ER-CP Section 4.2.1 and the FES has been updated to reflect final line routings and the addition of a transmission line from PVNGS to Devers Substation in California. The impacts expected due to construction of Project 1 and 3 transmission facilities are summarized in this section.

Information concerning the PVNGS to Devers line is contained in the U.S. Department of Interior Bureau of Land Management and U.S. Nuclear Regulatory Commission Final Environmental Statement, Palo Verde-Devers 500 kV Transmission Line, February, 1979. Descriptions are presented for preferred and alternate routes.

4.2.1.1 Project 1

Construction of access roads and transmission tower footing excavations in connection with the Project 1 transmission system will slightly modify the existing topography through a local increase in erosion potential. The Project 1 lines are generally routed through areas of flat to gently rolling terrain, thus the need for extensive excavation or cut and fill operations are not anticipated.

A potential environmental impact of Project 1 transmission corridor preparation and construction is the removal of vegetation and its associated faunal communities, as well as the disruption of terrestrial wildlife habitats and some aquatic habitats. It is expected that the Project 1 transmission corridor will require approximately three acres of land per mile. Where new roads will be required, the construction of 14-foot-wide access roads will necessitate the alteration of about four acres per mile. Additional land will be required

for concrete batch plants, pulling stations and storage areas. Clearing of natural vegetation will be kept to a minimum by limiting clearing activities to plants which pose a barrier to vehicle access or a hazard to electrical transmission. The impact of construction on vegetation and associated fauna is anticipated to be generally small.

4.2.1.2 Project 3

The transmission line will share a corridor and roads with a proposed 345 kV line for most of its length. In the area where the line will not parallel the 345 kV line, the topography is generally flat and soil impact is expected to be slight.

The route segment opened by Project 3 construction accounts for approximately 15 miles of the 195 mile length and is routed entirely over flat or gently rolling terrain. Because foundation work and the use of very heavy equipment are not required in wood structure line construction, no significant impact is expected on ground cover.

Construction activity will, however, cause some displacement of fauna due to the loss of habitat. Such displacement may result in the loss of some individuals directly or indirectly due to increased competitive pressures in the surrounding populations.

A previous study of the effect of power lines on avian populations in southern New Mexico reported that golden eagles (Aguila chrysactos), cactus wrens (Campylorhynchus brunneicapillum), white-necked ravens, and some hawks will select transmission towers for nesting as an alternative to natural sites.(2) These species require high sites which are limited in desert communities. Raptor species frequently will use the crossarms of the towers as observation posts.

4.2.2 WASTEWATER CONVEYANCE FACILITIES

The impacts experienced in construction of the wastewater conveyance system and the mitigation measures practiced are summarized in this section. These impacts are not significantly different from those described in ER-CP Section 4.2.2 and the FES.

Pipeline construction has not generated any adverse or unanticipated environmental impacts. The line crosses underneath streams eliminating changes in drainage or surface hydrology. The generally level topography of the route is restored once the excavations are backfilled. Topsoil is stockpiled during construction and is replaced after the trench is backfilled. Native grass and plant seeds are retained within the topsoil and will germinate naturally during normal growing seasons, after the soil is replaced. Temporary disturbance of wildlife has occurred in the few areas where brush was removed, although this was windrowed to maintain some degree of cover for wildlife. APS has proposed to use an EPA approved herbicide in places to control the growth of Russian thistle weed. Agricultural activity temporarily lost, is returning as those portions of the pipeline are completed. The effectiveness of mitigation measures is continually monitored both by construction and environmental personnel.

Archaeological excavations were completed as scheduled. Much valuable data was obtained from the artifacts uncovered in the excavation. Cultural remains were abundant in several of the sites. A thorough description of this project is found in the final report published by the Museum of Northern Arizona.[2]

4.2.3 REFERENCES

1. Environmental Impact Study of Proposed 345-kV Power Transmission Line Corridors from Dona Ana County, New Mexico to Greenlee County, Arizona, prepared for the El Paso Electric Company, prepared by the New Mexico Environmental Institute, Las Cruces, New Mexico, January 1974.

2. Hohokam Settlement on the Middle Gila: Excavations along the Palo Verde Pipeline, Museum of Northern Arizona, December 1979.

4.3 RESOURCES COMMITTED

The information presented in ER-CP Section 4.3 and the FES has not changed significantly since submittal of the ER-CP. Estimates of resources committed are summarized in this section.

4.3.1 COMMITMENTS CONSIDERED

Irreversible commitments generally concern changes set in motion by the proposed action which, at some later time, could not be altered so as to restore the present order of environmental resources. Irretrievable commitments are generally the use or consumption of resources that are neither renewable nor recoverable for subsequent use.

The types of resources of concern can be identified as (1) material resources, including materials of construction, renewable resource materials consumed in operation, and nonrenewable resources consumed, and (2) nonmaterial resources, including a range of beneficial uses of the environment.

Resources considered which may be irreversibly committed by the operation are: (1) biological species destroyed in the vicinity, (2) construction materials that cannot be recovered and recycled with present technology, (3) materials that are rendered radioactive and cannot be decontaminated, (4) materials consumed or reduced to unrecoverable forms of waste, (5) the atmosphere and water bodies used for disposal of heat and certain waste effluents, to the extent that other beneficial uses are curtailed, and (6) land areas rendered unfit for other uses. Those of importance to construction of this project are discussed in the following sections. Commitments made as a result of operation are described in section 5.7.

4.3.1.1 Biotic Resources

Construction has some adverse effects on the onsite biota of undisturbed areas, and disturbance of some of the biota adjacent to the site.

The construction of the station has resulted in the direct disturbance of several identified vegetation communities and associated fauna. It is also likely that transmission system construction will cause some disturbances.

The reproductive potential of most species in the PVNGS area or along the transmission line and pipeline corridors is sufficiently high that losses of individuals as a result of station construction will not have a long-term effect on population stability and structure of the local ecosystems. For a few species, principally the top mammalian and avian carnivores (species which are not particularly abundant in some of the areas), losses of individuals could have a long-term effect on the numbers of individuals in the local population. Those individuals lost through station construction, or by increased hunting pressure along transmission corridors, can be considered an irretrievable commitment.

4.3.1.2 Material Resources

Materials of construction are almost entirely of the depletable category of resources. Concrete and steel constitute the bulk of these materials; numerous other mineral resources are incorporated in the physical plant.

Some materials are of such value that economics clearly promote recycling. Facility operation will contaminate only a portion of the plant to such a degree that radioactive decontamination would be needed to reclaim and recycle the constituents. Some parts of the facility will become radioactive by neutron activation. Radiation shielding around the reactor and around other components inside the primary neutron shield constitutes the major material in this category, for which it is not feasible to separate the activation products from the base materials. Components that come in contact with reactor coolant or with radioactive wastes will sustain variable degrees of surface contamination, some of which would be removed if recycling is desired. The quantities of materials that could not be contaminated for unlimited recycling probably represent very small fractions of the resources available in kind and in broad use in industry.

Many materials on the "List of Strategic and Critical Materials"[(1)] (e.g., aluminum, asbestos, beryllium, cadmium, lead, nickel, platinum, silver, tin, tungsten, and zinc) are used in nuclear facilities. Construction materials are generally expected to remain in use for the full life of the facility, in contrast to fuel and other replaceable components discussed later. There will be a long period of time before terminal disposition of construction materials must be decided. At that time, quantities of materials in the categories of precious metals, strategic and critical materials, or resources having small natural reserves must be considered individually, and plans to recover and recycle as much of these valuable depletable resources as is practicable will depend on need.

4.3.1.3 Mineral Resources

There are known mineral resources in the vicinity of the plant site consisting of sand, gravel and clays. Withdrawal of land for site development from all mineral extraction should not significantly alter the availability of sand, gravel, or clays in the area.[2]

4.3.1.4 Land Resources

Land commitment is potentially reversible with the amount of commitment being a function of the level of decommissioning chosen.

4.3.2 REFERENCES

1. G. A. Lincoln, "List of Strategic and Critical Materials," Fed. Regist. 37(39): 4123(1972).

2. Letter dated July 23, 1975, from S. Doremus, Deputy Asst. Secretary of Interior, to W. H. Regan, USNRC, Washington, D.C.

4.4 RADIOACTIVITY

Information presented in ER-CP Section 4.1 and the FES has been revised to reflect updated construction manpower estimates. Radiation doses to the construction workforce are presented in this section.

4.4.1 CONSTRUCTION DOSES

Since PVNGS is a multiple-unit site, and Unit 3 will be under construction while the other two units are operating, construction workers on Unit 3 will be occupationally exposed to radiation. The exposure will be greater for Unit 3 workers than for workers at any other PVNGS unit because they will see the greatest radiation source. Table 4.4-1 shows annual total body doses at various locations at Unit 3.

The total man-rem doses to construction personnel during the construction of Units 2 and 3 are shown in table 4.4-2. Refer to PVNGS FSAR Section 12.4 for models, assumptions, and input data.

4.4.2 REFERENCES

1. PVNGS FSAR Section 12.4.

Table 4.4-1
ANNUAL INDIVIDUAL BODY DOSES AT UNIT 3
FROM UNITS 1 AND 2

Location	Total Body Doses (mrem/yr)		
	Immersion	Direct	Total
Unit 3 Turbine Bldg	0.27	3.88	4.15
Unit 3 Containment	0.23	0.64	0.87
Unit 3 Auxiliary Bldg	0.23	0.64	0.87
Unit 3 Cooling Tower	0.11	0.02	0.13

Table 4.4-2
MAN-REM DOSES TO CONSTRUCTION PERSONNEL

Year	Doses
1983	4.1
1984	5.5
1985	4.0
1986	0.5
Total	14.1

4.5 CONSTRUCTION IMPACT CONTROL PROGRAM

Estimates of the overall environmental impact of site preparation and construction were made in Chapter 4 of the ER-CP. Control measures designed to minimize these impacts were also described. Baseline programs, against which enivronmental impacts could be measured, were implemented in 1973. These included groundwater level and quality measurements in the perched and regional aquifiers (refer to section 2.4) and ecological studies (section 2.2). Certain recommendations and requirements for the continuing conduct of these programs were made by the NRC staff in the FES in September, 1975. In response to these requirements, a Construction Phase Groundwater Monitoring Program and Ecological Monitoring Program were submitted to the Commission on April 5, 1976. The programs were reviewed and approved by the NRC on June 17, 1976. These programs were incorporated into the Construction Phase Environmental Control Program.

The requirements of the FES were incorporated into the written program. In addition, the recommendations stated in the FES, with the exception of anthropod sampling, were also incorporated.

4.5.1 GENERAL DESCRIPTION

The Construction Phase Environmental Control Program is under the direction of Arizona Public Service Company (APS). Bechtel Power Corporation, as Engineer-Constructor, is given certain responsibilities for implementing the program. In addition, outside consultants are used for certain monitoring and sampling requirements. The program consists of:

- Site Environmental Protection
- Groundwater Monitoring
- Ecological Monitoring
- Archaeological Investigation and Mitigation

- Procedures for Limiting Adverse Effects During and from Construction
- Procedures for Evaluating and Reporting Adverse Environmental Impacts
- Procedures for Auditing and Inspecting Environmental Activities

The program is designed to ensure that environmental control requirements found in the following documents are met:

- Environmental Report (ER)
- Final Environmental Statement (FES)
- Preliminary Safety Analysis Report (PSAR)
- Atomic Safety and Licensing Board (ASLB) Initial Decision
- Construction Permit (CP)
- State Certificate of Environmental Compatibility (CEC)

4.5.2 RESPONSIBILITY AND AUTHORITY

The program is directed by a Responsible Engineer, APS Nuclear Services Department, designated by the Vice President, Nuclear Projects.

The Manager, Nuclear Services, and the Vice President, Nuclear Projects, have the responsibility to notify the Nuclear Regulatory Commission (NRC) of any construction activity, not previously evaluated by the NRC, that may result in a significant adverse environmental impact, or having significantly greater impact than that previously evaluated. This responsibility includes authority to stop work until approval of the NRC is obtained. Authority to stop work is also delegated to the APS Site Construction Manager.

The APS Quality Assurance Department, Nuclear Services, conducts audits and surveillances of the Environmental Control Program to assure that the program is appropriately implemented. Audits are conducted in accordance with the APS Quality Assurance Program Manual.

4.5.3 PROGRAM DESCRIPTIONS

4.5.3.1 Site Environmental Protection Design

1. Makeup, blowdown and circulating water lines are designed, where practicable, to be placed underground and backfilled.

2. Peripheral interception ditches, when necessary, are placed along deep cut and high fill slopes to reduce erosion. Energy dissipators are installed at the bottoms if drop pipes are used.

3. Facilities or embankments have been designed so that the on-site tributary to Winters Wash is isolated in a manner to prevent construction materials from entering the Winters Wash system.

4. Runoff retention facilities have been placed to provide retention of construction runoff resulting from a 10-year, 24-hour rainfall event specified by 40CFR43.425.

5. Appropriate environmental protection features are included in technical sections of subcontract specifications.

6. Major and minor water crossings of the wastewater conveyance line are underground.

7. The wastewater conveyance line was installed to avoid existing riparian areas so that the environmental impact on all stream beds was minimized.

8. Diking, channeling or planting were incorporated into the pipeline design and specifications in areas where erosion could occur due to pipeline installation.

9. Environmental briefing sessions are conducted for construction personnel.

10. Land used for temporary construction facilities will be returned to its general original condition by replacing topsoil and allowing revegetation, as necessary.

11. Organic materials from the plant site, not used for erosion control, are buried in on-site disposal areas.

12. Subsoil removed during excavation and grading of the site, as well as materials excavated elsewhere, is used wherever possible as construction fill.

13. On-site grading is confined to areas requiring excavation, placement of embankments and backfill. Off-site grading is confined to access roads, rail-road access and the wastewater conveyance pipeline.

14. Dust is controlled by the use of water trucks.

15. Temporary constructions roads are removed if they do not become part of the permanent road system, and the land is returned to its general original condition. Permanent roads are used wherever possible.

16. Construction roadside slopes and spoil area slopes are graded to conform with existing contours to prevent water accumulation and erosion.

17. Combustible construction trash is burned at designated areas to reduce volume and residue buried. Permits are obtained.

18. Concrete batch plant and truck wash waste are discharged to a retention basin.

19. Human wastes not processed in the site sewage treatment plant are transported off-site by a closed tank truck for proper disposal.

20. Petroleum product wastes from construction activities are collected in oily waste sumps and removed from the site.

21. Standard noise control devices that meet OSHA requirements are installed on trucks and other equipment.

22. Cleared brush and vegetation (unplanted) are used for erosion control to the greatest practicable extent.

23. Wastewater from dewatering operations is directed to on-site retention basins.

24. Known cases of coccidioidomycosis (Valley Fever) among the construction workers or pipeline sub-contractors are reported to the State and County Health Departments.

25. Heavily compacted soils are loosened as practicable to facilitate natural revegetation growth.

26. Subcontract specifications are reviewed to assure that appropriate environmental protection commitments are incorporated in subcontracts. Subcontracts are administered in the field to assure that the commitments are met. Preconstruction environmental briefing sessions are conducted with contract construction crews to identify and explain environmental policy.

4.5.3.2 Additional Commitments Applicable to the Off-Site Pipeline and Related Facilities

1. Clearing activities are minimized in pipeline corridors by careful planning and supervision, including considerations of soil stability, protection of adjacent vegetation, selectivity in the choice of access and construction road routes and the protection of stream banks.

2. Use of growth retardants, chemicals and biocides during construction of the wastewater pipeline or access roads is prohibited.

3. Metal and other solid waste attributed to construction is removed upon completion of construction.

4. Rubber-tired vehicles are used to transport structures, equipment and supplies. Travel of rubber-tired vehicles is restricted to established construction roads and other established roads required for access. Usage of tracked vehicles is limited to areas where such machinery is absolutely necessary.

5. Soil that has been excavated during pipeline construction is evenly backfilled into the area, or removed from the area.

6. With respect to access road construction:

   a. Wherever practicable, only single-lane roads of 14-foot maximum width have been constructed.

   b. Slopes, have been cut so that the depth of cut is as shallow as possible without endangering safety, the cut of the slopes does not exceed 1:1 in ordinary material and 0.5:1 in hardpan, the depth of excavation generally is as shallow as conditions permit, and the cut and fill operations are minimized by following natural contours wherever possible.

   c. Linear road construction is avoided in areas that require sustained grades of greater than 6%.

   d. Road rights-of-way are clearly marked to prevent tractor operators from making unnecessarily wide roadbeds.

   e. Roads were laid out to minimize the loss of vegetation.

f. Access roads will be closed in a manner that will effectively bar access to unauthorized vehicles. Signs warning against unauthorized access (trespass) will be posted at suitable locations when permission can be obtained from landowners.

g. Vegetation intercepted by access roads is driven over wherever possible in lieu of physical removal.

h. Roads are constructed in accordance with sufficiently high standards to allow movement of heavy equipment.

7. Adequate drainage, water bars and other safeguards are provided for the collection, transport and distribution of runoff to prevent localized erosion.

8. Filling in or breaking down of stream banks is avoided wherever possible.

9. Impacts due to rubbish resulting from pipeline construction have been minimized.

10. The land is being restored to its original contour to maintain natural drainage and esthetic values. In construction areas where erosion potential exists, and upon consultation with the property owner, consideration will be given to revegetation with appropriate flora that can stabilize the soil as rapidly as possible. All state-of-the-art erosion control measures not specifically required or recommended are followed wherever applicable, particularly in the vicinity of watercourses and stream crossings that are located in the Gila River Basin.

11. After pipeline installation, topsoil is replaced, most notably in disturbed agricultural areas.

12. Spoils produced during construction within 100 feet of the Gila River or its tributaries are removed to minimize possible transport that could result in siltation.

13. Damage to the stream banks of the Gila River and its tributaries is repaired immediately following construction.

14. Natural drainage is restored immediately following construction.

15. Use of chemical substances for dust and vegetation control is prohibited.

16. An ecological consultant is available to advise the construction foreman on the protection of ecologically sensitive features on, or adjacent to riparian habitat and construction within 100 feet of the bank of the Gila River or its tributaries.

4.5.3.3 Construction Phase Groundwater Monitoring Program

4.5.3.3.1 Monitoring Program for Perched Mound

Because potential construction contaminants would be observed first in the perched mound, the density of monitoring points is greater in this aquifer than for the regional aquifer.

Water Levels

Existing boreholes, shown in figure 4.5-1, are used to monitor perched water elevation. These data are plotted graphically and trends followed to discover anomalous changes.

Water Quality

Water quality sampling analyses are shown in table 4.5-1. This list was developed after careful consideration of the major chemical constituents related to perched and regional groundwater, construction materials, construction activities likely

TABLE 4.5-1

WATER QUALITY ANALYSIS PARAMETERS

Parameter
Arsenic
Boron
Cadmium
Chloride
Total Cyanide
Fluoride
Phenol
Specific Conductance
T D S
Lead
Zinc
Sodium
Chromium (Hexavalent)
Nitrate (NO_3)
pH
Radioactivity
Sulfates

to affect the water, the U.S. Public Health Service Drinking Water Standards and the EPA National Interim Primary Drinking Water Standards. The analyses are done for those parameters listed in the table; however, if the TDS value varies by 20% or more from one measurement to the next at any well, a more complete analysis is conducted to identify the source of the variation.

4.5.3.3.2 Monitoring Program for Regional Aquifer

While chemical and water level changes are expected to appear first in the perched mound, in order to maintain continuity of measured data, the regional aquifer is monitored as well. The monitoring program surveys the regional aquifer water levels and water quality at the locations shown in figure 4.5-2.

A testing program for the wells which are sampled on-site was established in June, 1975. Samples were analyzed in September, 1975, to establish the water quality baseline. Additional samples were analyzed prior to construction. Table 4.5-1 lists the parameters measured. This list was developed after careful consideration of the major chemical content of the existing perched and regional aquifers. The analyses are done for those parameters listed; however, if the TDS concentration changes by more than 20% from one measurement to the next at any well, a more complete analysis is performed to identify the source of the change.

4.5.3.4 Ecological Monitoring Program

Construction activities are highly visible and can potentially cause environmental impacts. The predicted ecological impacts from the construction of PVNGS have been addressed in sections 4.1 and 4.3 and several mitigation measures, or controls, to lessen the potential construction impacts have been listed in this section and the FES. These environmental controls directly relate to the major causal links between construction

activities and potential ecological degration including habitat alteration, noise, dust and chemical pollution of the air, land, drainage areas and water. Since the likelihood of any substantial adverse damage to the stability and structure of the biotic communities in the region of the PVNGS site due to construction activities, other than direct habitat alteration is low, this program has been directed towards an overall field and aerial reconnaissance of habitat alteration and environmental education of construction personnel. It has been designed with the intent of:

- Increasing environmental awareness among construction personnel.
- Providing the opportunity of early detection of previously unforeseen adverse environmental impacts.
- Allowing for mitigation measures to be considered promptly once an adverse impact is noted.
- Documenting environmental changes which actually occur during plant construction and the mitigation measures taken to lessen these impacts.

4.5.3.4.1 Environmental Awareness Presentations

The cumulative effect of minor and major decisions made by construction personnel is the most important factor determining the ecological condition of the site after construction. Consequently, an integral part of the preconstruction conference held with contractor and subcontractor employees is a session on environmental awareness. The objectives of these conferences are to (1) indicate to construction personnel how their work affects the environment, and (2) provide guidelines to

minimize the adverse environmental impacts, where practical. The presentations include:

- A 12-minute videotape describing the ecologically sensitive habitats and other areas of specific ecological concern at the PVNGS site.
- An explanation and distribution of an illustrated Environmental Construction Handbook prepared for construction personnel.

The Handbook was prepared for distribution to field supervisors and foremen and presents suggestions about environmental practices that can be applied by individuals during construction at PVNGS. The Handbook provides a mechanism to aid in explaining the "how" and "why" of the environmental controls found in the contract specifications. Pertinent ecological information is presented in terms of the kinds of construction activity at PVNGS which significantly impact the environment. Information concerning the natural history of important plants and animals at and near the site is discussed in the context of practical suggestions as to how to reduce to a minimum the adverse impact of the construction activities. The Handbook is written using unsophisticated terminology and is amply illustrated.

4.5.3.4.2 Field Surveys

Ecological field surveys are conducted in order to (1) provide ground verification of photointerpretation studies, (2) identify ecological impacts which are imminent or which have occurred and can be mitigated, and (3) document the actual ecological impacts of construction activity. Table 4.5-2 lists the major characteristics analyzed, the frequency of observation and explains the rationale for including the specific characteristics.

Table 4.5-2

MAJOR ECOLOGICAL OBSERVATIONS TO BE ANALYZED AT AND IN THE GENERAL REGION OF THE PVNGS SITE

Observation	Rationale
1. Habitat Alteration, for example:	Habitat alteration will be the major detectable impact.
a. Status of existing drainage courses, particularly East and Winters Wash and location of new drainage courses.	Aleration of East Wash course represents a major habitat modification.
b. Amount and kind of habitat disturbed, including accumulative amount of habitat lost and any habitat lost due to construction equipment and vehicles outside of designated work areas.	An upper limit of 3700 acres can be cleared at PVNGS.
c. Apparent amount of soil erosion.	Soil conservation practices can result in preventing the loss of valuable seed reserves and growth media and can prevent soil sedimentation.
d. New species habitat formation.	Creation of new habitat, including shallow pools of water could result in the use of the site by new species. In certain cases, control measures are practical.
2. Revegetation Practices - How and where they are being carried out.	Properly carried out revegetation efforts can be an important mitigative action for the original vegetation lost.
3. Presence of any rare, endangered, threatened or state-protected fauna[a].	In certain instances, for example with Gila monsters and desert tortoises, special mitigative measures can be developed to protect these species to insure that they are disturbed as little as possible.

[a] All state-protected plants on the PVNGS site have been transplanted or otherwise protected prior to construction.

Due to implementation of environmental protection controls, including construction sediment basins to trap sediment from worksite runoff and implementing a comprehensive environmental control program, no major ecological problems were anticipated or have been encountered to date. The surveys are made by trained plant and animal ecologists who are familiar with the desert ecosystem at PVNGS and with the construction plans.

4.5.3.4.3 Aerial Reconnaissance Surveys

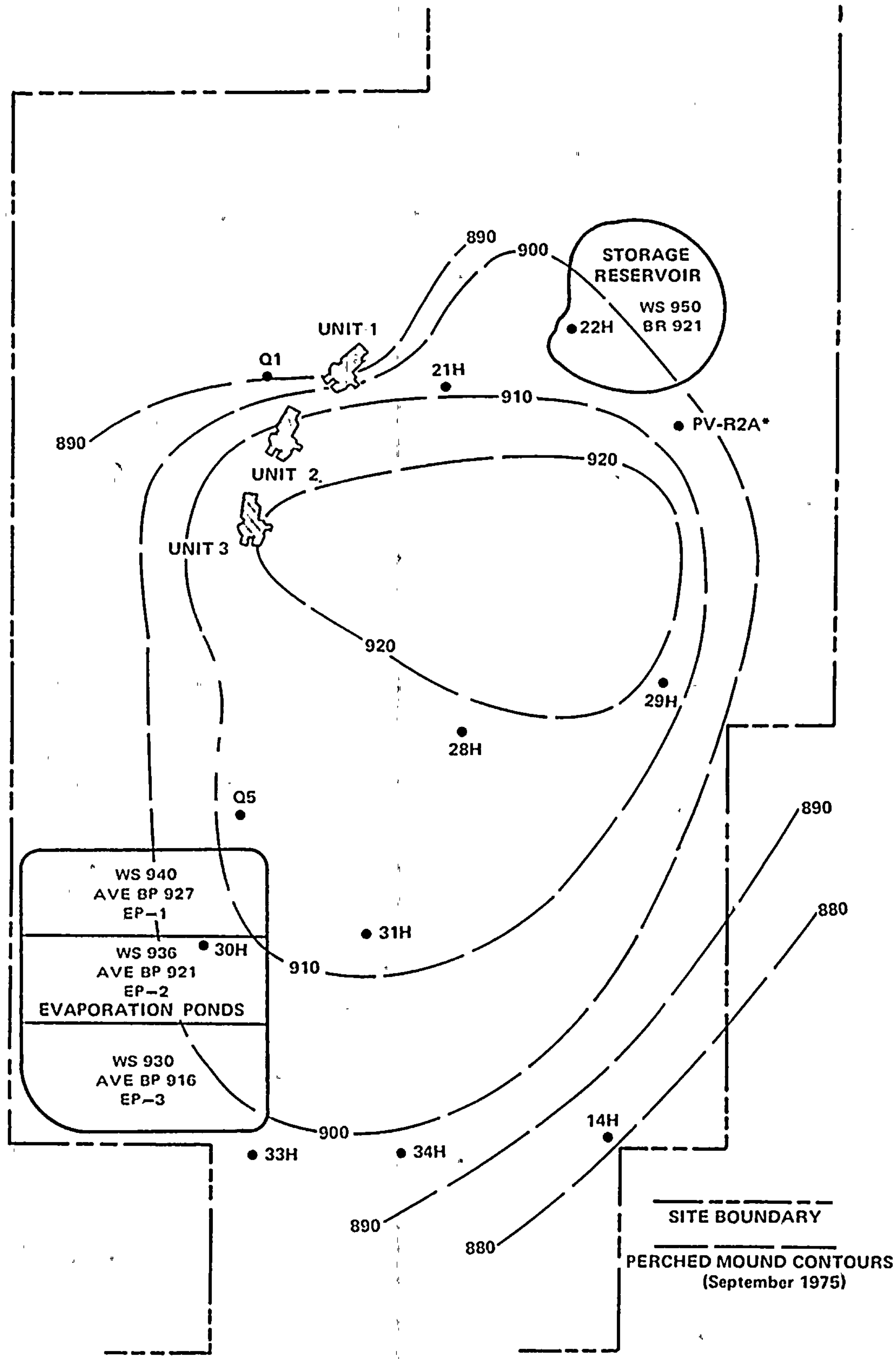
In order to help document ecological impacts of construction and to obtain information useful in making mitigation suggestions, aerial photography (1 inch = 2,000 feet) is performed and interpreted at least once per year. The aerial reconnaissance surveys provide a regional overview of the impacts of construction activities on and near the PVNGS site.

The photography is interpreted immediately after it is developed and printed in order to aid in developing mitigation plans which will be responsive to actual environmental conditions at the site. Both the number of acres disturbed and levels of disturbance are identified and evaluated.

4.5.3.5 Archaeological Monitoring

A study of the archaeological remains which may be directly endangered by the construction of the Palo Verde Nuclear Generating Station has been conducted and steps to mitigate the effects of construction have been taken. Field investigations of the directly affected archaeological resources consisted of excavation by professionally accepted methods, controlled surface collection of artifacts, and extensive documentation with methods including detailed mapping, photography and field notes. This research was directed toward two goals: (1) answering questions and investigating problems of current archaeological importance relative to the immediate

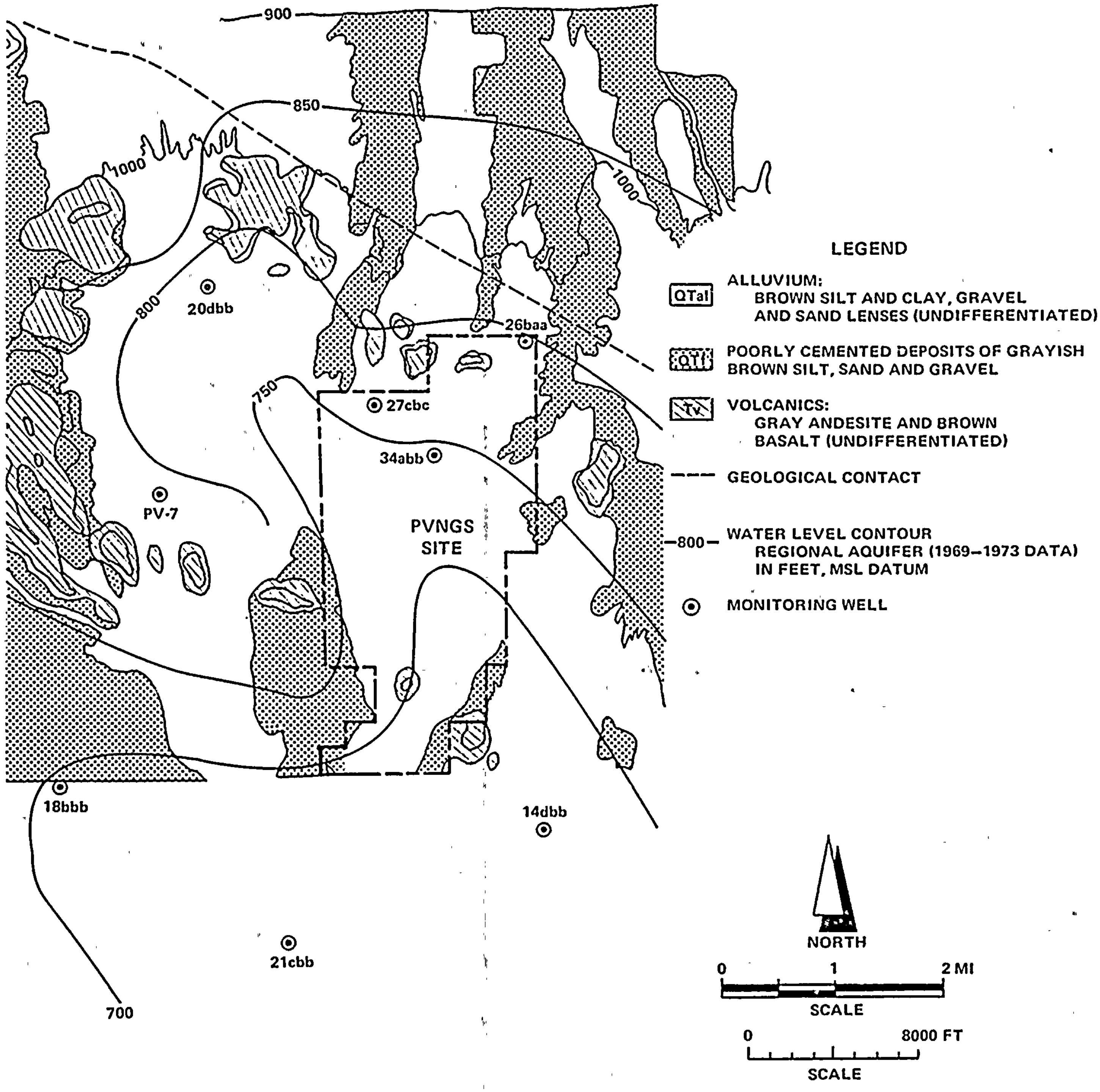
situation of the plant site; and (2) preserving for future study selected sites or segments of sites which are representative of certain archeological remains found in the plant site. The mitigation program includes intensive field study of nine archaeological sites, a comprehensive laboratory analysis of recovered artifactual and non-artifactual materials, completion of all curatorial requirements of the field records and recovered collections and a descriptive and interpretive report of publishable quality. Investigations of a modern labor camp have been restricted to limited field observations and records. Two prehistoric sites not directly impacted by the proposed plant construction were subjected to thorough field documentation of their surficial expressions but subsurface explorations were not attempted to preserve this aspect of the sites. Notification of archaeological finds discovered during construction activities is made to the Museum of Northern Arizona before work proceeds. Mitigation is then based upon the recommendations of the Museum.



*FORMERLY PV-R2

Palo Verde Nuclear Generating Station
ER-OL

LOCATION OF MONITORING WELLS-
PERCHED MOUND
Figure 4.5-1



NOTE:

WELLS PV-7 AND 20dbb PROVIDE
LEVEL MONITORING ONLY

Palo Verde Nuclear Generating Station
ER-OL

LOCATION OF MONITORING WELLS-
REGIONAL AQUIFER
Figure 4.5-2

APPENDIX 4A

RESPONSES TO NRC QUESTIONS

CHAPTER 5

ENVIRONMENTAL EFFECTS OF STATION OPERATION

CONTENTS

CONTENTS (cont)

CONTENTS (cont)

TABLES

FIGURES

5. ENVIRONMENTAL EFFECTS OF STATION OPERATION

5.1 EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM

This section provides a summary of the effects of station operation updated to reflect 5 years of meteorological monitoring. There have not been changes to PVNGS systems or structures since the Atomic Safety and Licensing Board (ASLB) construction permit hearings, February 23 through 27, 1976, that would significantly increase the environmental effects of station operation above those forecast by ER-CP Section 5.1 or the FES.

Because PVNGS is a dry site, there are no intake or discharge structures in the context of Section 5.1 of Regulatory Guide 4.2, Rev. 2 to interact with the biota of the water source or receiving waters. Wastewater effluent is transported to the site by a pipeline and is treated and then stored in the onsite reservoir. Water is lost from the site mainly via evaporation from the cooling towers. Other losses of water may include evaporation and seepage from the onsite reservoir, the cooling tower drift, and a very small amount from the evaporation ponds.

The only other system that dissipates heat to the environment is the essential spray pond system (ESPS). Heat is rejected to the ESPS from the safety-related auxiliary systems, which reject it to the atmosphere via sprays. The ESPS operates during reactor shutdown and provides cooling water for the diesel generators. It is anticipated that the ESPS will be used approximately three times a year for periods greater than 1 day, during reactor shutdown.

The round mechanical draft cooling tower system is discussed in detail in section 3.4. Reference design parameters for the cooling towers are presented in table 3.4-1. The curve of

expected exit-air temperature is shown in figure 3.4-8. Figure 3.1-4 illustrates the round mechanical draft cooling tower site arrangement used in these analyses.

5.1.1 EFFLUENT LIMITATIONS AND WATER QUALITY STANDARDS

Effluent limitations and water quality standards are not applicable to PVNGS as there will be no water discharges offsite.

5.1.2 PHYSICAL EFFECTS

Heated effluent from the heat dissipation system will not be discharged to natural surface water bodies, but will be processed onsite for reuse as described in sections 3.3 and 3.4. Thus, operation of the heat dissipation system will not affect the temperature of natural surface water bodies.

Waste from the circulating-water systems consists of blowdown corresponding to 15 cycles of concentration of the makeup water and drift from the cooling towers. Blowdown is continuously discharged to the lined evaporation ponds, as required to maintain water quality. No significant adverse effect on the groundwater system is expected to result from the lined evaporation ponds. The composition of the blowdown is given in table 3.6-1.

Makeup water for the circulating-water system consists of treated wastewater effluent from the City of Phoenix 91st Avenue Sewage Treatment Plant, which will be stored onsite in an 80-acre reservoir. The water will receive additional treatment before storage, with a resulting total dissolved solids (TDS) concentration of approximately 1000 mg/l. Seepage from the reservoir could reach the mound of perched groundwater under the site. However, the TDS concentration of perched groundwater is as great or greater than the stored makeup water and, therefore, no adverse effect on groundwater quality is expected.

5.1.3 BIOLOGICAL EFFECTS

The cooling-water reservoir will contain water suitable for wildlife use. Waterfowl and shorebirds will probably be attracted to this expanse of open water. Birds of up to 80 species may visit the reservoir.[1] Table 5.1-1 lists the 80 species of birds and their present occurrence in Maricopa county. The reservoir may provide a resting place for migratory waterfowl. Other wildlife species may use the reservoir for drinking water, and some amphibians may breed there.

Bird mortality from collisions with cooling towers is not expected to occur since the towers are lower than other major site structures. Further, the site is not located on a major migratory flyway, and adverse meteorological conditions that could interfere with bird navigation rarely occur in the site region.

5.1.4 OTHER EFFECTS

Operation of the round mechanical draft cooling towers may cause ground-level fog, elevated visible plumes, ground deposition and airborne concentrations of dissolved solids from drift droplets, noise, and consumptive water use.

5.1.4.1 Computer Models

Computer models used to evaluate the effects of cooling tower operation are described in section 6.1.3.3.3.

5.1.4.2 Fogging and Icing

The effect of an evaporative heat dissipation system on the formation of fogging and icing conditions is determined by the quantity and location of added moisture and on the existing ambient air conditions. The major factors of significance in determining the enhancement of fogging and icing occurrences

Table 5.1-1

BIRD SPECIES THAT MAY VISIT THE PVNGS RESERVOIR[1] (Sheet 1 of 7)

Common Name	Scientific Name	Breeding[a]	Present Abundance and Status in Maricopa County
Common loon	Gavia immer		Casual transient
Horned grebe	Podiceps auritus		Casual transient
Eared grebe[b]	Podiceps nigricollis		Abundant winter visitor
Western grebe	Aechmophorus occidentalis		Casual winter visitor, transient
Pied-billed grebe[b]	Podilymbus podiceps	B	Rare summer resident, fairly common winter visitor
Double-crested cormorant	Phalacrocorax auritus	B	Uncommon transient
Great blue heron[b]	Ardea herodias	B	Common resident
Green heron	Butorides virescens	B	Fairly common resident
Little blue heron	Florida caerulea		Causal visitor
Cattle egret	Bubulcus ibis		Casual visitor
Great egret	Casmerodius albus		Uncommon transient
Snowy egret	Egretta thula		Fairly common transient

a. B indicates species that presently breed in Maricopa County.
b. Likely to use the reservoir.

Table 5.1-1
BIRD SPECIES THAT MAY VISIT THE PVNGS RESERVOIR[1] (Sheet 2 of 7)

Common Name	Scientific Name	Breeding[a]	Present Abundance and Status in Maricopa County
Black-crowned night heron	*Nycticorax nycticorax*		Uncommon transient
Least bittern	*Ixobrychus exilis*	B	Rare local summer resident
American bittern	*Botaurus lentiginosus*		Rare transient
Wood stork	*Mycteria Americana*		Casual summer visitor
White-faced ibis[b]	*Plegadis Chihi*		Common transient
Whistling swan	*Olor columbianus*		Casual winter visitor
Canada goose	*Branta canadensis*		Fairly common winter visitor
White-fronted goose	*Anser albifrons*		Rare fall transient, winter visitor
Snow goose	*Chen caerulescens*		Uncommon winter visitor
Black-bellied tree duck	*Dendrocygra autumnalis*	B	Uncommon summer resident
Mallard[b]	*Anas platyrhynchos*		Fairly common winter visitor
Gadwall[b]	*Anas strepera*		Fairly common winter visitor

Table 5.1-1
BIRD SPECIES THAT MAY VISIT THE PVNGS RESERVOIR[1] (Sheet 3 of 7)

Common Name	Scientific Name	Breeding[a]	Present Abundance and Status in Maricopa County
Pintail[b]	*Anas acuta*		Abundant winter visitor
Green-winged teal[b]	*Anas crecca*		Abundant winter visitor
Cinnamon teal[b]	*Anas cyanoptera*	B	Fairly common winter and summer visitor
American wigeon[b]	*Anas americana*		Abundant winter visitor
Shoveler[b]	*Anas clypeata*		Common winter visitor
Wood duck[b]	*Aix sponsa*		Uncommon winter visitor
Redhead[b]	*Aythya americana*		Fairly common winter visitor, transient
Ring-necked duck[b]	*Aythya collaris*		Common winter visitor
Canvasback[b]	*Aythya valisineria*		Fairly common winter visitor
Lesser scaup	*Aythya affinis*		Fairly common winter visitor
Common goldeneye	*Buecphala albeola*		Irregular winter visitor
Ruddy duck[b]	*Oxyura jamaicensis*	B	Fairly common winter visitor, uncommon summer resident

Table 5.1-1
BIRD SPECIES THAT MAY VISIT THE PVNGS RESERVOIR[1] (Sheet 4 of 7)

Common Name	Scientific Name	Breeding[a]	Present Abundance and Status in Maricopa County
Hooded merganser	Lophodytes cucullatus		Casual winter visitor
Common merganser	Mergus merganser		Fairly common winter visitor
Red-breasted merganser	Mergus serrator		Casual winter visitor, transient
Virginia rail	Rallus limicola	B	Fairly common winter visitor
Sora	Porzana carolina	B	Fairly common winter visitor
Common gallinule	Gallinula chloropus	B	Common resident
American coot[b]	Fulica americana	B	Abundant resident
Semipalmated plover	Charadrius semipalmatus		Uncommon transient
Snowy plover	Charadrius alexandrinus		Rare transient
Killdeer[b]	Charadrius vociferus	B	Common resident
American golden plover	Pluvialis dominico		Casual transient
Black-bellied plover	Pluvialis saquatarola		Uncommon fall transient
Common snipe	Capella gallinago		Common winter visitor

Table 5.1-1

BIRD SPECIES THAT MAY VISIT THE PVNGS RESERVOIR[1] (Sheet 5 of 7)

Common Name	Scientific Name	Breeding[a]	Present Abundance and Status in Maricopa County
Long-billed curlew	*Numenius americanus*		Rare transient
Whimbrel	*Numenius phaeopus*		Casual transient
Spotted sandpiper[b]	*Actitis macularia*		Common fall transient, winter visitor
Solitary sandpiper	*Tringa solitaria*		Uncommon transient
Willet	*Catoptrophorus semipalmatus*		Rare transient
Greater yellowlegs[b]	*Tringa melanoleuca*		Fairly common transient, winter visitor
Lesser yellowlegs[b]	*Tringa flavipes*		Fairly common transient, winter visitor
Pectoral sandpiper	*Calidris melanotos*		Uncommon fall transient, casual winter visitor
Baird's sandpiper	*Calidris bairdii*		Fairly common fall transient
Short-billed dowitcher	*Limnodromus griseus*		Casual transient
Long-billed dowitcher[b]	*Limnodromus scolopaceus*		Fairly common transient, winter visitor

Table 5.1-1

BIRD SPECIES THAT MAY VISIT THE PVNGS RESERVOIR.[1] (Sheet 6 of 7)

Common Name	Scientific Name	Breeding[a]	Present Abundance and Status in Maricopa County
Stilt sandpiper[b]	Micropalama himantopus		Common transient
Western sandpiper[b]	Calidris mauri		Common transient, fairly common winter visitor
Marbled godwit	Limosa fedoo		Casual transient
Sanderling	Calidris alba		Casual fall transient
American avocet[b]	Recurvirostra americano	B	Common fall transient, fairly common spring transient
Black-necked stilt[b]	Himantopus mexicanus	B	Fairly common local resident, common migrant
Red phalarope	Phalaropus fulicarius		Casual fall transient
Wilson's phalarope[b]	Steganopus tricolor		Abundant transient
Northern phalarope	Lobipes lobatus		Fairly common fall transient
Herring gull	Larus argentatus		Casual transient
Ring-billed gull	Larus delawarensis		Uncommon visitor
Franklin's gull	Larus pipixcan		Casual transient
Bonaparte's gull	Larus philadelphia		Casual visitor

Table 5.1-1

BIRD SPECIES THAT MAY VISIT THE PVNGS RESERVOIR[1] (Sheet 7 of 7)

Common Name	Scientific Name	Breeding[a]	Present Abundance and Status in Maricopa County
Forster's tern	*Sterna forsteri*		Casual transient
Black tern	*Chlidonias niger*		Uncommon transient
Vermilion flycatcher[b]	*Pyrocephalus rubinus*	B	Fairly common resident
Long-billed marsh wren	*Telmatogytes palustris*	B	Uncommon summer resident
Water pipit	*Antus spinoletta*		Abundant winter visitor
Yellowthroat	*Geothlypis trichas*	B	Fairly common local summer resident
Song sparrow	*Melospiza melodia*	B	Locally common resident

are the characteristics and quantity of effluent air, the height of the effluent plume rise, and the downwind dispersion of the effluent plume.

Potential horizontal and vertical icing conditions were not considered in the analysis. A day or more of subfreezing temperatures is necessary for any ice to accumulate to significant thickness. Therefore, because the maximum daily temperature in the site vicinity has never been reported below 32F,[(2-5)] no quantitative estimates were made of potential icing conditions.

The fogging results were calculated based on the visibility criterion that a liquid water content of 1.2 x 10^{-5} pound liquid water per pound of dry air (0.015 g H_2O/m^3 of dry air) would result in a visibility of 1000 meters or less.[(6)]

5.1.4.2.1 Effects on Ground Transportation

Generally, driving conditions can be affected by visibility reductions caused by fogging over roadways resulting from moisture emissions from the operation of cooling systems. The surrounding roadways within 10 miles of PVNGS include Wintersburg Road, Buckeye-Salome Road, 339th Avenue, Ward Road, and Interstate 10. The location and orientation of each of these roadways relative to the site are listed in table 5.1-2. The predicted annual mean frequencies of occurrence of reduced ground-level visibility to less than 1000 meters (5/8 mile) were less than 1 h/yr for all roads except Ward Road which is predicted not to have any reduced ground-level visibility.

These predictions of insignificant fogging occurrences produced by the operation of the cooling towers for PVNGS are consistent with the experience of the Arizona Public Service Company (APS) with operating cooling towers in the Phoenix area.

Due to the very low relative humidity in the Phoenix area, cooling tower plumes are relatively bouyant during cold temperatures, when fogging would normally be a problem. In checking 2

Table 5.1-2
MAJOR ROADWAYS WITHIN 10 MILES OF PVNGS

Major Roadways and Orientation	Classification	Distance and Direction from PVNGS (miles)[a]
Wintersburg Road (N-S)	Asphalt	0.8 W
Ward Road (E-W)	Dirt	1.4 S
Buckeye-Salome Road (NW-SE)	Asphalt	2.0 NE
339th Avenue (N-S)	Asphalt/ Dirt	4.5 SE
I-10 (NW-SE)	Interstate highway	5.8 NE

a. 8-point compass used.

2 the past history of the Saguaro, Ocotillo, Aqua Fria, and Kyrene Power Plants, no record or memory was found of any fogging that restricted traffic in any way. This history is significant in that some of the cooling towers listed are within a few hundred feet of a road.

5.1.4.2.2 Effects on Air Transportation

The closest air carrier airport to the plant site is the Phoenix Sky Harbor International Airport, approximately 50 miles east of the site. At this distance, the cooling systems would not affect airport operations.

5.1.4.2.3 Effects on Water Transportation

There are no major waterways in the vicinity of the site; therefore, the cooling tower system would not affect water transportation.

5.1.4.3 Elevated Visible Plumes

The predicted occurrences of elevated visible plumes from the cooling towers, and their environmental impact on surrounding area airports and population centers, are discussed in this section.

5.1.4.3.1 Maximum Occurrence of Elevated Visible Plumes

Isopleths of the predicted annual frequency of occurrence of elevated visible plumes are presented in figure 5.1-1. The isopleth is based upon a 100% capacity factor for Units 1, 2 and 3, and corresponds to data presented in table 3.4-1 and figure 3.4-3. The maximum predicted occurrences are approximately 530 h/yr in the immediate vicinity of the cooling towers. 2

5.1.4.3.2 Occurrence of Elevated Visible Plumes at Airports

Sky Harbor International Airport is located at too great a distance to be affected by elevated visible plumes generated by the operation of the cooling towers.

5.1.4.3.3 Occurrence of Elevated Visible Plumes at Surrounding Population Centers

The surrounding population centers within 10 miles include Wintersburg, Arlington, Dixie, Hassayampa, and Tonopah, Arizona. The location of these population centers relative to the site are listed in table 5.1-3. The predicted annual mean frequencies of occurrences of elevated visible plumes are approximately 1 h/yr for Wintersburg, less than 1 h/yr for Arlington and 0 h/yr for Dixie, Hassayampa, and Tonopah, Arizona.

5.1.4.3.4 Occurrence of Elevated Visible Plumes by Month

Table 5.1-4 presents the maximum frequencies of occurrence of elevated visible plumes greater than 0.50 mile in length for

Table 5.1-3

POPULATION CENTERS WITHIN 10 MILES OF PVNGS

Population Center	Distance and Direction from PVNGS (miles)
Wintersburg	3.5 N
Arlington	7.5 SE
Dixie	6.5 ESE
Hassayampa	8.8 ESE
Tonopah	9.0 NNW

each month of the year and for each of the 16 compass directions. The tabulated values are of plumes from the nine round mechanical draft cooling towers. The results show a maximum frequency of approximately 15 h/mo during March in a northeast direction from the round mechanical draft cooling towers. Table 5.1-5 presents the predicted maximum monthly visible plume lengths for the cooling towers.

5.1.4.4 Solids Discharge from the Cooling System

5.1.4.4.1 Dissolved Solids Deposition

To evaluate the environmental impacts associated with dissolved solids in the cooling tower drift, the predicted deposition was separated into deposition as dry drift particles, as droplets, and as total. Deposition is based upon a 100% capacity factor
2
for Units 1, 2, and 3 and corresponds to data presented in table 3.4-1 and figure 3.4-3. Figure 5.1-2 displays isopleths of the predicted annual solids deposition for dry particles that remain after the water completely evaporates from the drift droplets. Predictions of the annual solids deposited in droplet form are presented in figure 5.1-3. The predicted total annual solids deposition patterns--solid materials deposited as dry particles and in droplet form--are shown in figure 5.1-4.

Table 5.1-4

MAXIMUM MONTHLY FREQUENCIES OF VISIBLE PLUMES GREATER THAN 1/2 MILE IN LENGTH (h/mo)

Month	Direction from the Mechanical Draft Towers															
	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
January	3.1	5.7	2.2	1.1	1.1	0.7	0.9	1.8	8.8	12.9	6.6	7.9	3.9	0.9	0.9	1.1
February	5.0	3.9	1.7	0.6	0.0	0.0	0.4	0.6	2.9	5.0	4.4	2.1	0.8	1.7	0.2	1.9
March	6.1	15.3	2.5	1.3	1.1	1.3	0.2	1.3	3.4	7.6	4.4	4.8	1.9	1.9	1.7	4.2
April	4.7	10.4	2.2	0.4	0.0	0.6	0.2	0.6	3.2	3.2	1.5	0.6	0.6	1.7	0.2	1.9
May	0.0	1.5	0.4	0.2	0.2	0.2	0.2	0.0	0.2	1.5	0.0	0.2	0.0	0.2	0.0	0.0
June	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
July	0.0	12.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0
August	0.0	6.1	0.7	0.0	0.0	0.0	0.0	0.2	0.0	1.3	0.4	0.0	0.0	0.0	0.0	0.0
September	0.0	3.8	0.0	0.0	0.0	0.0	0.0	0.2	0.4	1.3	0.2	0.0	0.0	0.0	0.0	0.0
October	0.7	3.3	0.7	0.2	0.2	0.2	0.2	0.2	3.6	4.5	2.9	3.1	1.1	0.0	0.2	0.2
November	1.6	2.5	3.6	1.6	0.0	0.4	0.2	0.2	2.0	4.2	6.7	1.8	0.4	0.2	0.4	0.4
December	3.8	3.1	2.4	0.9	0.2	0.0	0.0	2.1	6.6	8.3	3.1	3.1	1.7	1.4	0.7	1.9

Table 5.1-5

MAXIMUM MONTHLY VISIBLE PLUME LENGTHS

(miles)

Month	Direction from the Mechanical Draft Towers															
	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
January	1.5	2.5	1.5	2.0	0.8	2.5	0.8	1.5	3.0	3.0	4.0	2.5	1.5	2.0	2.0	1.5
February	3.0	1.5	5.0	1.0	---	0.5	4.0	2.0	3.0	3.0	2.0	1.5	0.8	2.0	0.8	2.5
March	20.0	5.0	1.5	1.0	1.5	0.8	0.8	2.0	3.0	7.5	10.0	3.0	2.0	1.5	4.0	5.0
April	1.0	20.0	1.5	0.8	0.5	20.0	0.8	10.0	>20.0	10.0	10.0	0.8	1.0	20.0	0.8	7.5
May	0.5	0.8	1.5	0.8	2.5	---	0.8	---	1.5	2.5	0.5	1.0	---	0.8	---	---
June	0.5	0.8	0.5	---	---	---	---	---	---	0.5	0.5	---	---	---	---	---
July	0.5	0.8	0.5	---	---	---	---	---	0.5	0.8	0.5	---	---	---	---	---
August	0.5	1.5	1.5	0.3	---	---	---	0.8	---	0.8	0.8	---	---	---	---	---
September	0.5	0.8	0.5	---	---	---	---	0.8	0.8	1.5	0.8	---	---	---	---	---
October	2.5	2.0	2.0	3.0	0.8	2.0	1.5	2.0	3.0	>20.0	2.0	1.5	0.8	---	0.8	0.8
November	5.0	1.5	0.8	1.5	0.5	0.8	0.8	0.8	2.0	5.0	3.0	0.8	0.8	2.0	0.8	1.5
December	3.0	2.5	2.5	1.5	1.5	---	---	2.0	3.0	4.0	4.0	3.0	1.5	2.5	1.0	5.0

--- Less than 0.25 mile.

5.1.4.4.2 Airborne Concentration of Dry Drift Particles

Figure 5.1-5 presents isopleths of the predicted annual mean airborne concentrations of dry drift particles. The maximum calculated values at the site boundary were 51 $\mu g/m^3$ and approximately 1 $\mu g/m^3$ for 24-hour and annual time periods, respectively.

The maximum 24-hour airborne dry drift concentration of 51 $\mu g/m^3$ was calculated at the site boundary northeast of the towers. This concentration decreased with downwind distance. For example, at 1 mile beyond the site boundary, the estimated concentrations are reduced to approximately 47 percent of the maximum value, at 2 miles they are approximately 22 percent, and at 3 miles they are approximately 20 percent.

5.1.4.5 <u>Increased Ground-Level Temperature</u>

The round mechanical draft cooling towers for PVNGS are predicted to have a negligible effect on ground-level temperature. The maximum predicted increased ground-level temperature was less than 0.1F.

5.1.4.6 <u>Increased Ground-Level Relative Humidity</u>

The mean annual increases of ground-level relative humidity beneath the plume from the cooling system were calculated on a polar grid centered on the cooling system. These values represent represent the mean predicted increases of ground-level relative humidity above ambient when the cooling system plume is overhead. Figure 5.1-6 presents isopleths of the annual predicted increase of ground-level relative humidity caused by the operation of the round mechanical draft cooling towers. As can be seen, these annual ground-level relative humidity increases are less than 1% and would be difficult to detect.

5.1.4.7 Cooling Tower Plume Behavior

Upper-air soundings taken at the Sky Harbor International Airport were used by the NUS LVPM computer code as basic states of meteorological conditions to investigate the general cooling tower plume behavior. (Refer to section 6.1). The reference or basic state at PVNGS is generally similar to that at Phoenix. Soundings were averaged by month and hour of observation during the period July 1952 through May 1957. This period represents the latest 5 years of data on magnetic tape. Subsequent to this period, the Sky Harbor station no longer took soundings. Behavior of the cooling tower plume predicted by the model represents the mean for a given month.

Average January and July soundings were used as representative winter and summer conditions, respectively. For an average winter morning (0800 Mountain Standard Time), a strong ground-based inversion (12.1F per 1000 feet) with surface temperature at 42F existed to the first 850-foot level. Surface windspeed was 4.0 mi/h from the east, increasing to 11.5 mi/h at a height of about 2300 feet. Relative humidity was 75 percent at the surface, decreasing to 40 percent at the 2300-foot level.

The average summer morning sounding (0800 Mountain Standard Time) reveals a constant temperature lapse rate of approximately 4.2F per 1000 feet for the first 6560 feet. In the evening (2000 Mountain Standard Time), the atmosphere is in neutral condition because of daytime surface heating. Average surface temperature is 88F in the summer morning, and 100.4F in the summer evening. Relative humidity during an average summer morning is about 49 percent near the ground, decreasing to 45 percent at 2170 feet. A nearly constant relative humidity was observed in the average summer evening sounding with a value near 32 percent in the lower 2170 feet.

The initial momentum and buoyancy of the effluent from the cooling towers are expected to raise the vapor plume to a height of approximately 920 feet during the average winter

morning. Neutral buoyancy height is about 630 feet. No major difference in plume rise was predicted between winter mornings and evenings. For all wind directions, a saturated plume extending through the maximum height of penetration was predicted.

During the average summer morning, a plume can penetrate through a height of approximately 1900 feet. Plume buoyancy becomes neutral at a height of 1210 feet. No saturated plume was predicted for the average summertime condition for any hour of the day.

Figures 5.1-7 and 5.1-8 show some of the plume parameters as a function of height for winter and summer mornings, respectively. The height of maximum penetration is determined by taking the height where the vertical velocity of the plume becomes zero. Neutral buoyancy height (equilibrium level of buoyancy) is defined as the level where the plume and ambient temperatures are identical. Cloud water is defined as condensed water droplets that have a negligible terminal velocity and are carried by the updraft in the plume.

Figures 5.1-7 and 5.1-8 display these plume parameter variations to the maximum penetration heights which correspond to downwind distances of 3.59 and 7.64 kilometers, respectively, from the tower locations. These calculated values represent the operation of one cooling tower. No reinforcement of the plumes generated from the towers is associated with the simultaneous operation of all 3 units. 2

The average visible plume length is estimated to be 870 feet during the average winter morning and 780 feet during the average winter evening. Ground-level moisture excess over ambient in the vicinity of the cooling towers is estimated to be insignificant under normal weather conditions in the area, as listed in table 5.1-6. Figures 5.1-9 and 5.1-10 show the excess relative humidity profile at the plume centerline at

Table 5.1-6

RELATIVE HUMIDITY EXCESS, AT GROUND LEVEL, CAUSED BY OPERATION OF COOLING TOWER SYSTEM

Ambient Condition	Ambient Relative Humidity	Excess Relative Humidity at Ground Level (%)			
		1 km Downwind	3 km Downwind	5 km Downwind	10 km Downwind
Mean winter morning (0800 MST)	72	0.01	0.03	0.06	0.11
Mean winter afternoon (2000 MST)	55	0.07	0.17	0.23	0.22
Mean summer morning (0800 MST)	49	0.00	0.00	0.00	0.00
Mean summer afternoon (2000 MST)	34	0.00	0.00	0.00	0.00

various distances downwind from the cooling towers under average winter and summer morning conditions. Significant weather modification from the operation of the cooling tower system is not expected.

5.1.4.8 Parametric Study of Plume Rise

To examine expected plume rise in the site area, a parametric analysis was performed for the average winter and summer morning conditions. The LVPM computer code was used (see section 6.1). Two major parameters influence the plume rise: the ambient temperature lapse rate and the ambient windspeed. Using these parameters, the following analyses were performed:

- Plume rise was examined as a function of vertical temperature gradient, assuming the gradient is constant with height. (See figure 5.1-11.)
- Examination of plume rise as a function of ambient windspeed at the tower top. (See figure 5.1-12.)

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

$$U_2 = U_H \left(\frac{z}{H}\right)^P$$

where

U_z = windspeed at height z

U_H = windspeed at tower height H

P = empirical constant, which is 0.25 for the winter morning and 0.12 for the summer morning from Phoenix upper-air soundings

The average January and July morning soundings were used as representative winter and summer morning reference states,

respectively, when not defined in the above analysis. The plume height from the cooling tower system can be expected to exceed 410 feet for all seasons, as shown in figure 5.1-12. Lowest plume rise is found under strong ground-based inversions in the summer morning.

The effect of windspeed on plume rise is pronounced. Very strong winds (on the order of 30 to 40 mi/h) could limit the plume rise to less than 310 feet from the tower top as illustrated in figure 5.1-12.

5.1.4.9 Noise

The noise sources associated with the round mechanical draft cooling towers are described in section 5.6.

5.1.4.10 Consumptive Water Loss

For the round mechanical draft cooling towers, the major consumptive water loss will be through the evaporative cooling process. The entrainment of droplets as drift in the effluent plume will cause additional water losses. Table 5.1-7 presents a summary of the average consumptive water losses by month. The values in this table are based upon a 95-percent load factor for each month and were calculated from monthly averages of meteorological data obtained from 5 years of hourly onsite data. Each of the generating units will be shut down for refueling during 1 month in each year. Correcting the annual average consumptive water loss for refueling shutdowns leads to an annual average consumptive water loss for the three units of approximately 64,000 acre-ft per year. The effects of this water use is discussed in section 5.6.

Blowdown from the cooling towers will be directed to the evaporation ponds.

Table 5.1-7

AVERAGE CONSUMPTIVE WATER LOSSES FROM COOLING TOWER SYSTEM[(a)(b)]

Month	Evaporation	Blowdown and Drift	Total Consumptive Loss
January	53	4	57
February	55	4	59
March	56	4	60
April	59	4	63
May	62	4	66
June	67	5	72
July	66	5	71
August	66	5	71
September	64	5	69
October	60	4	64
November	56	4	60
December	53	4	57

a. All values in acre feet per day per unit.

b. Annual average water loss per unit is 21,350 acre feet.

5.1.5 REFERENCES

1. Demaree, S. R., Radke, E. L., and Witzeman, J. L., Birds of Maricopa County, Arizona. Annotated Field List Maricopa Audubon Society, 1972.

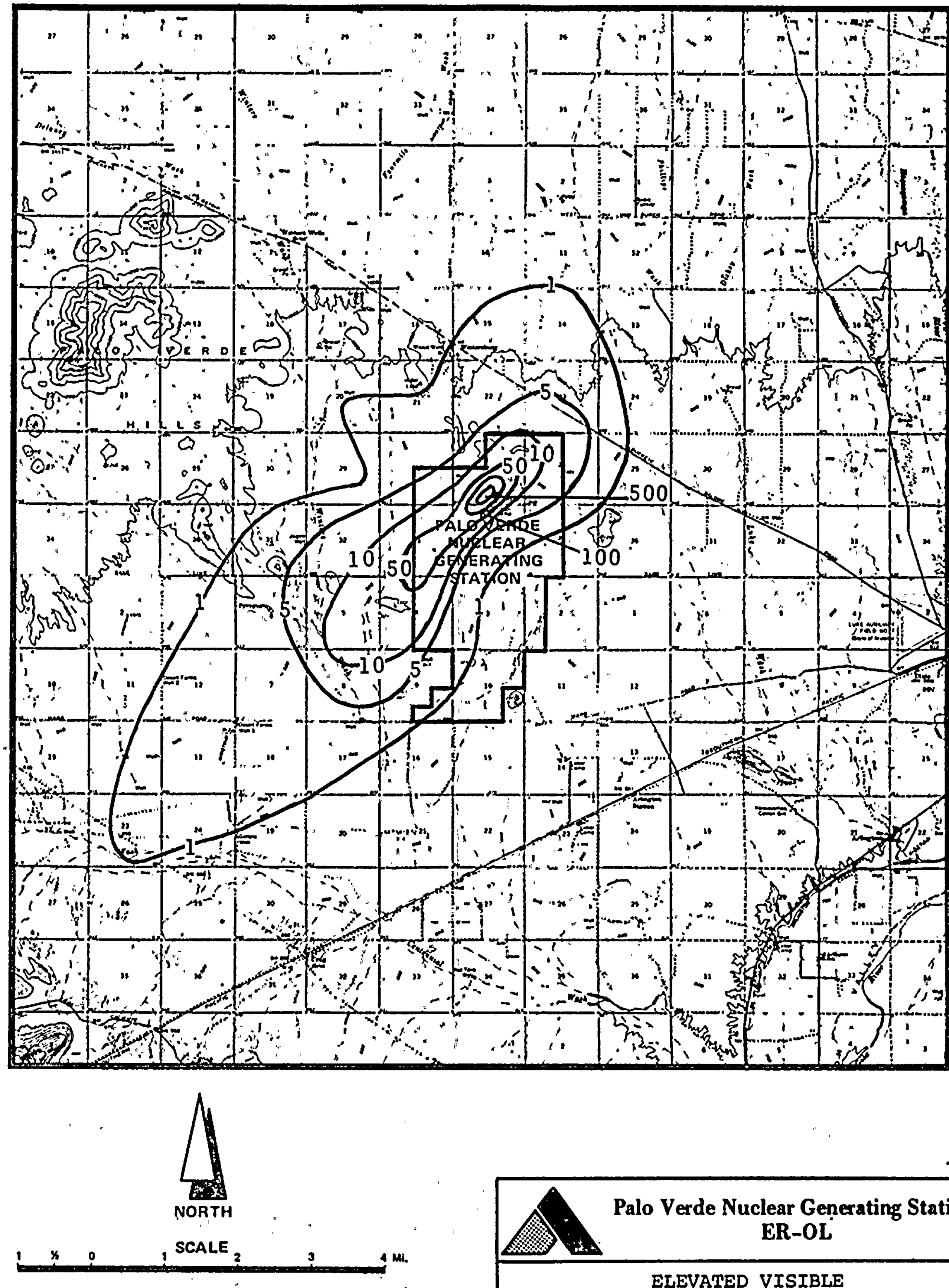
2. Environmental Data Service, Phoenix Arizona, 1972. Local Climatological Data, Annual Summary With Comtive Data, National Oceanic and Atmospheric Administration, Asheville, North Carolina, 1972.

3. Environmental Science Services Administration, "Buckeye, Arizona, 1893-1957, Climatological, Summary," Climatography of the United States, No. 20-2, 1975.

4. Environmental Science Services Administration, "Gila Bend, Arizona, 1893-1957, Climatological Summary," Climatography of the United States, No. 20-2, 1975.

5. Environmental Science Services Administration, "Litchfield Park, Arizona, 1918-1957, Climatological Summary," Climatography of the United States, No. 20-2, 1975.

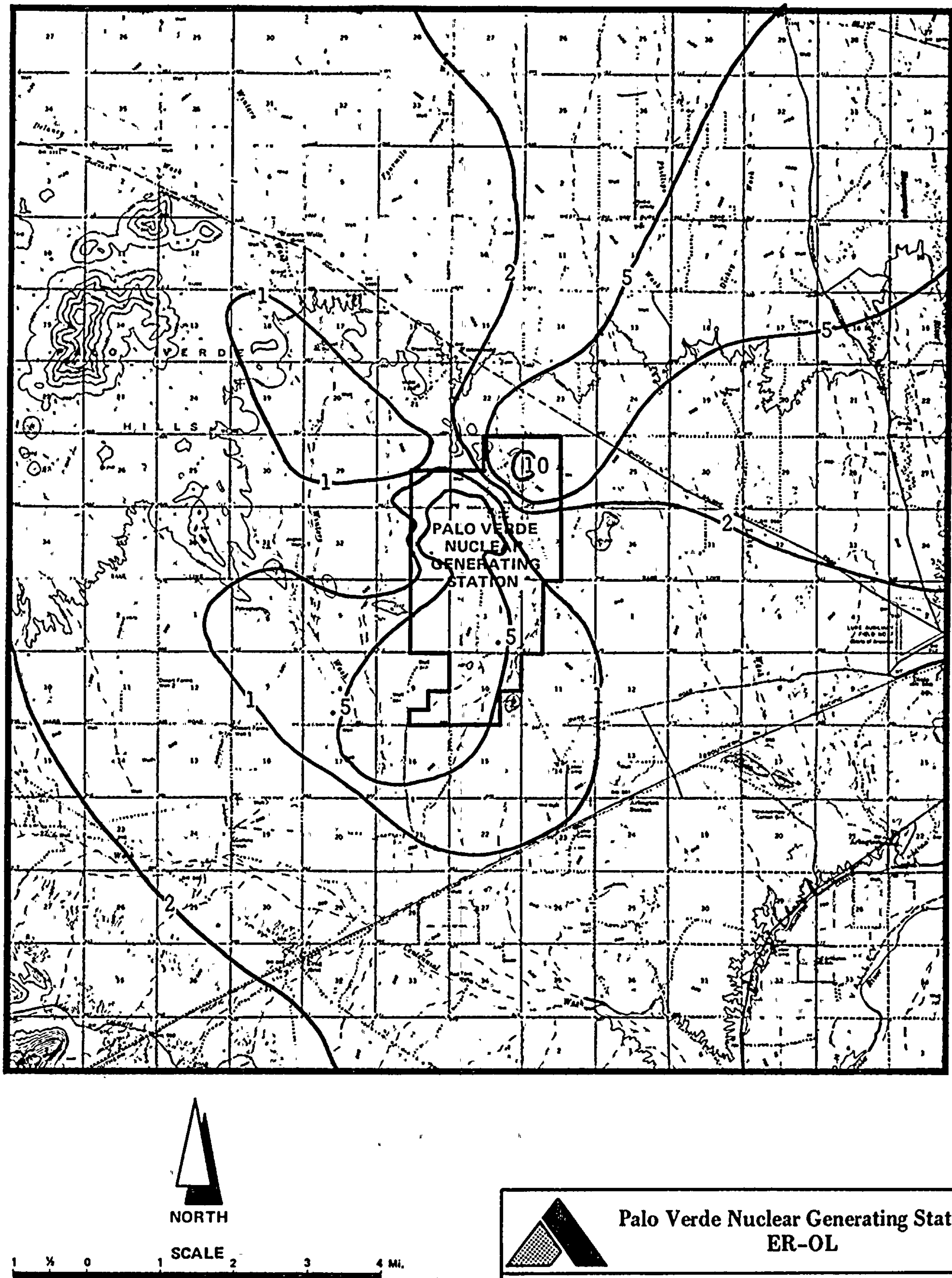
6. Petterssen, S., Weather Analysis and Forecasting, Vol. II, Weather and Weather Systems, 2nd ed., McGraw-Hill Book Co., Inc., New York, 1956.



Palo Verde Nuclear Generating Station
ER-OL

ELEVATED VISIBLE
PLUMES
(HOURS/YEAR)

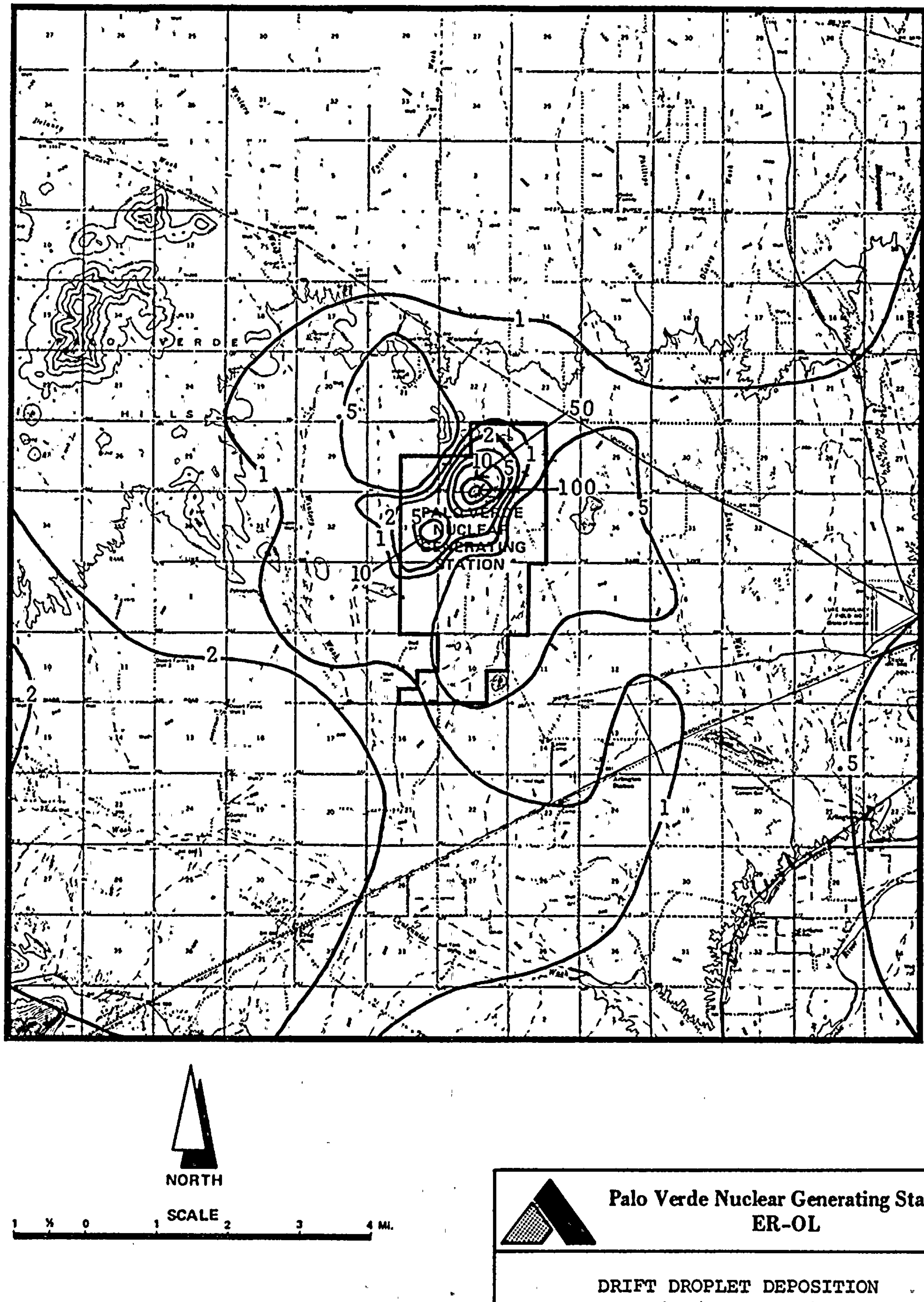
Figure 5.1-1



Palo Verde Nuclear Generating Station
ER-OL

DRY DRIFT PARTICLE DEPOSITION (LB/ACRE-YEAR)

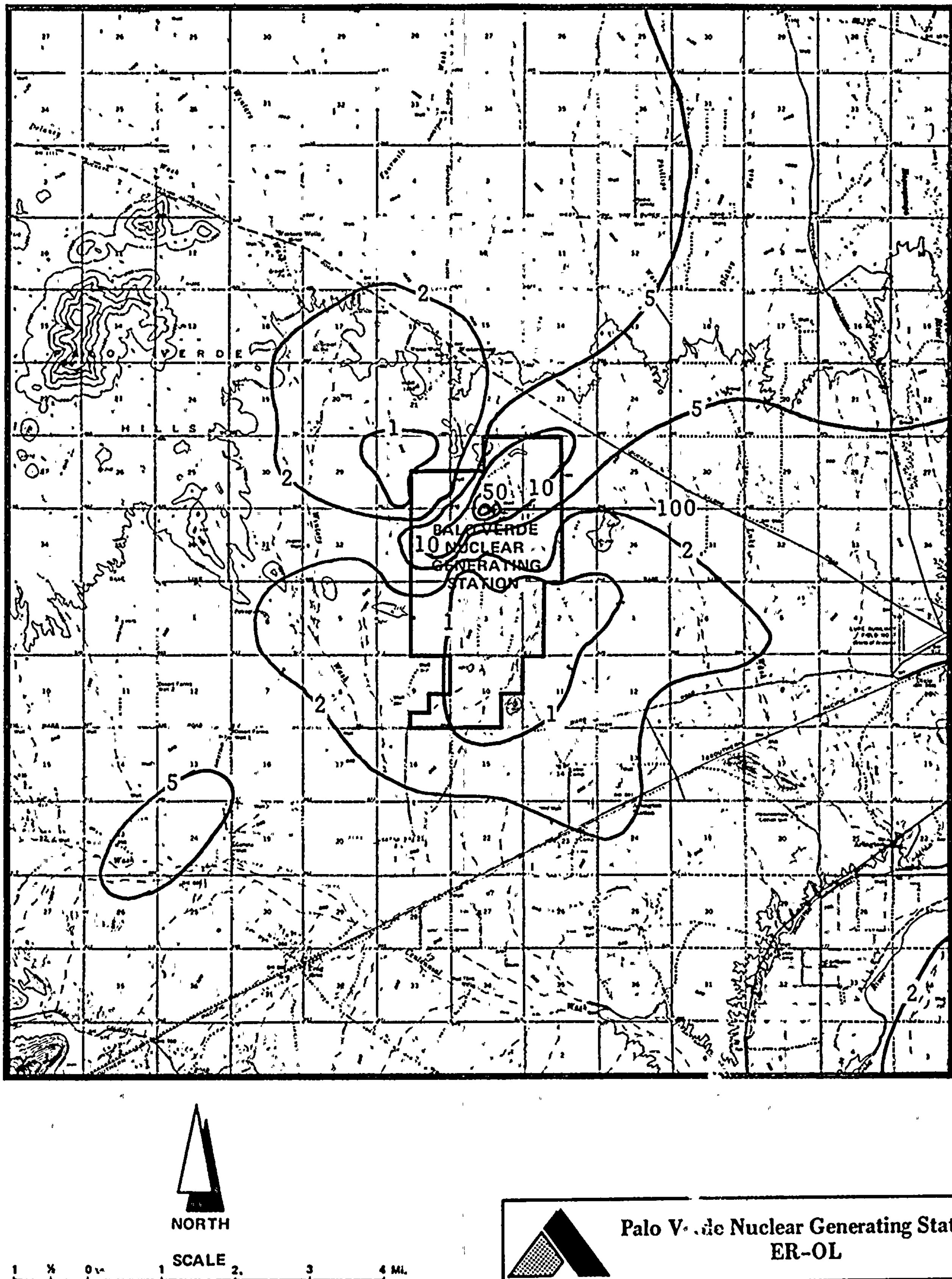
Figure 5.1-2



Palo Verde Nuclear Generating Station
ER-OL

DRIFT DROPLET DEPOSITION
(LB/ACRE-YEAR)

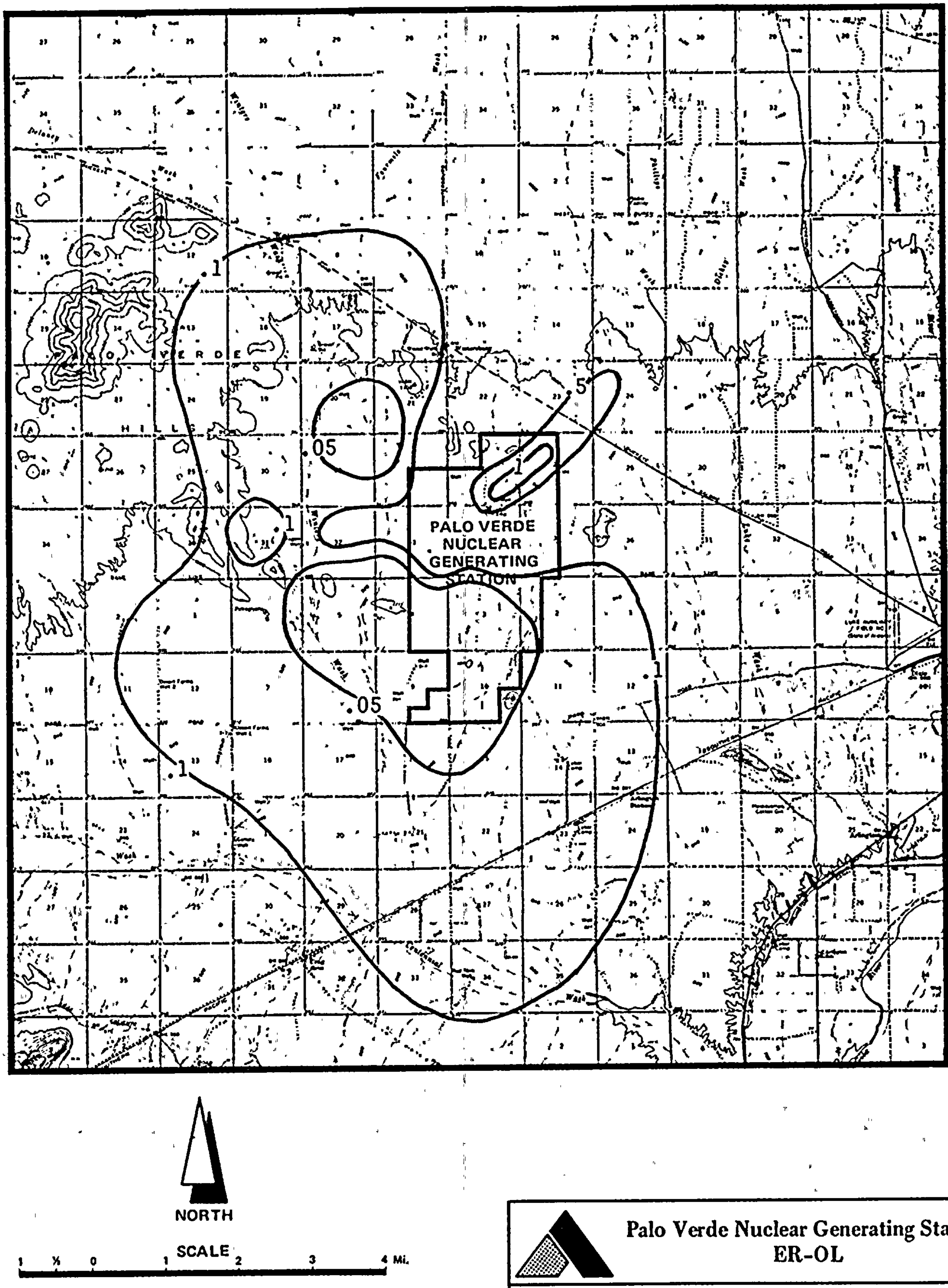
Figure 5.1-3



Palo V. .de Nuclear Generating Station
ER-OL

TOT. . SOLIDS DEPOSITION
(LB/ACRE-YEAR)

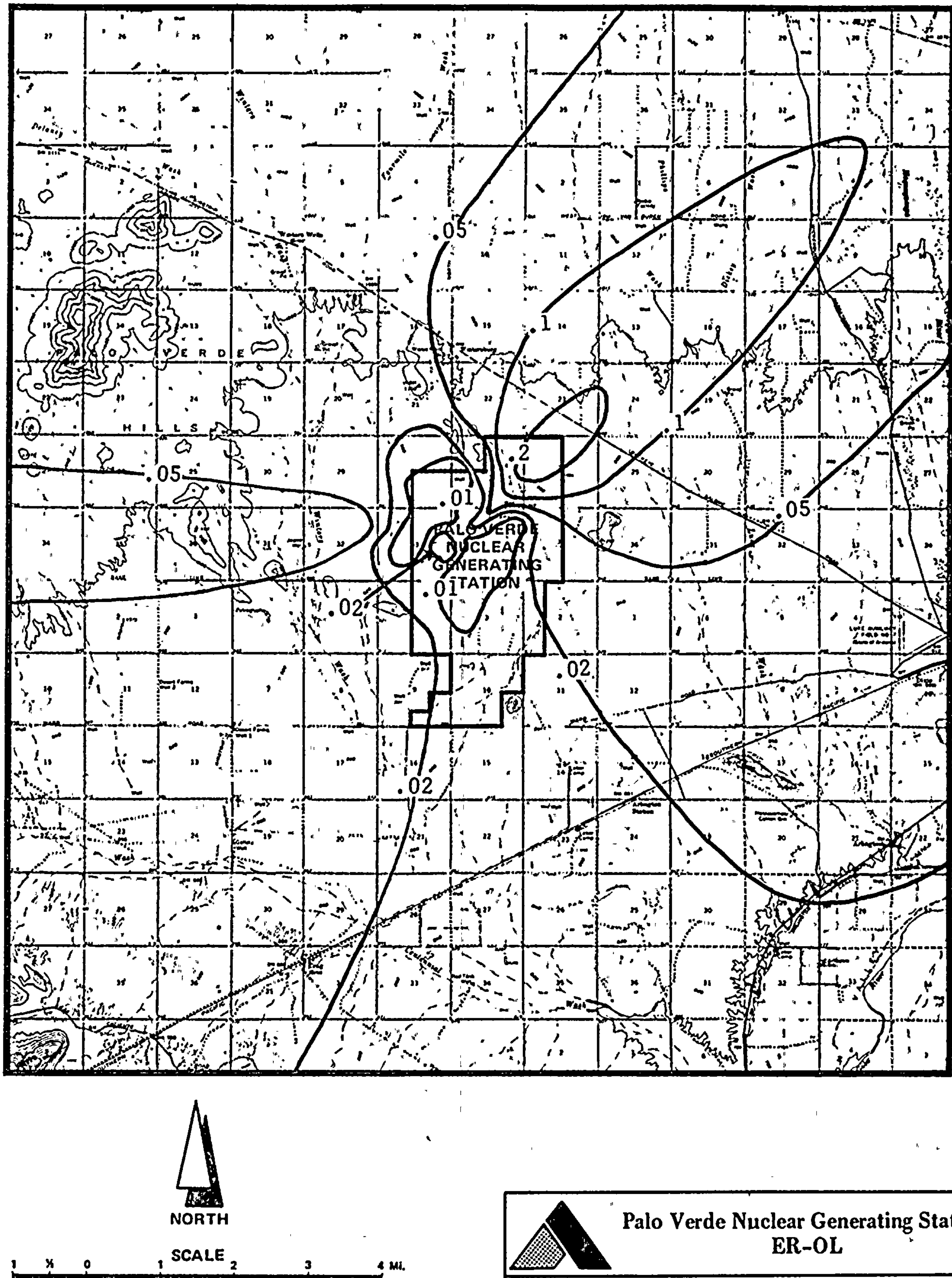
Figure 5.1-4



Palo Verde Nuclear Generating Station
ER-OL

MEAN ANNUAL AIRBORNE CONCENTRATIONS OF DRY DRIFT PARTICLES ($\mu g/m^3$)

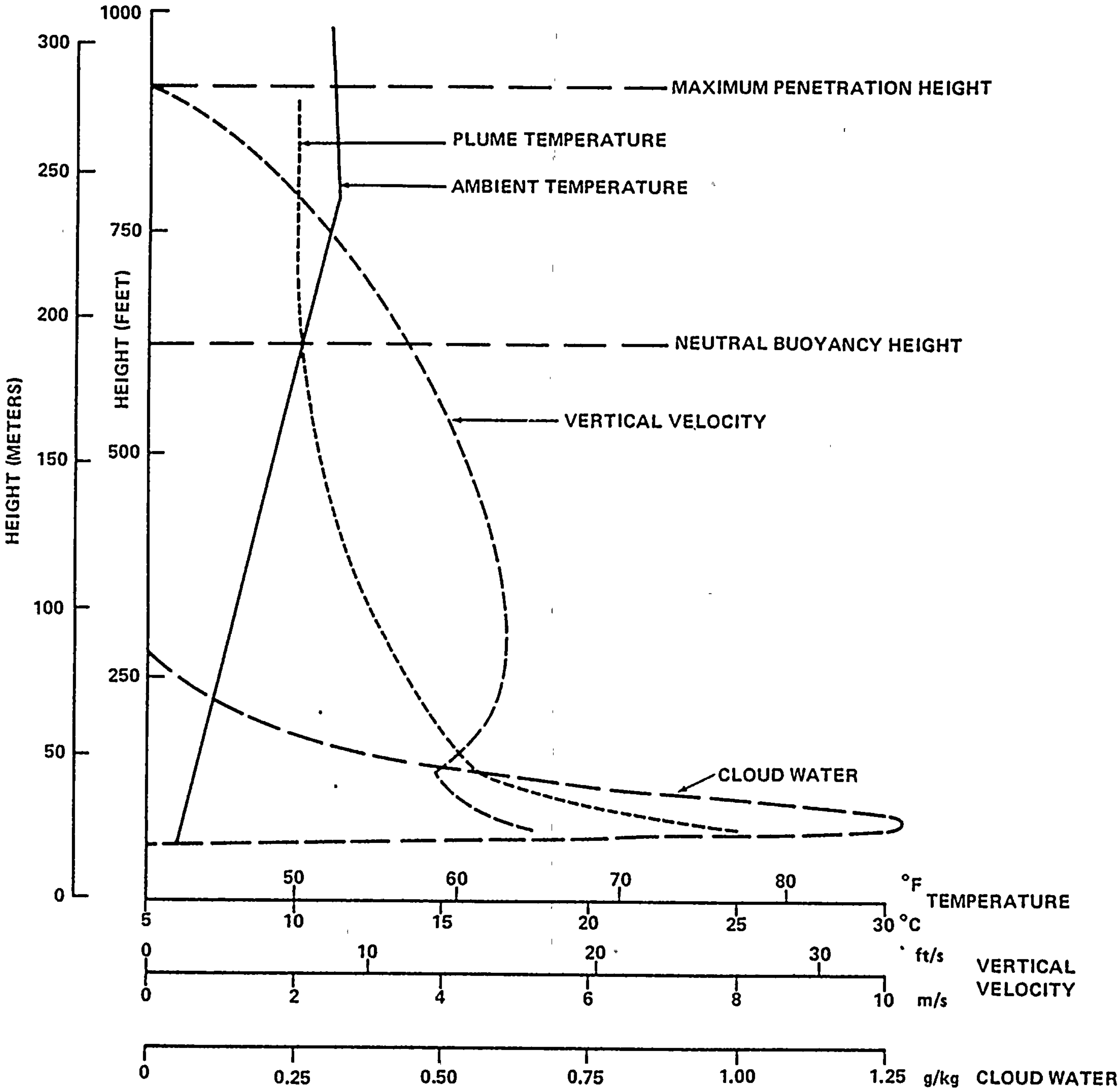
Figure 5.1-5



Palo Verde Nuclear Generating Station
ER-OL

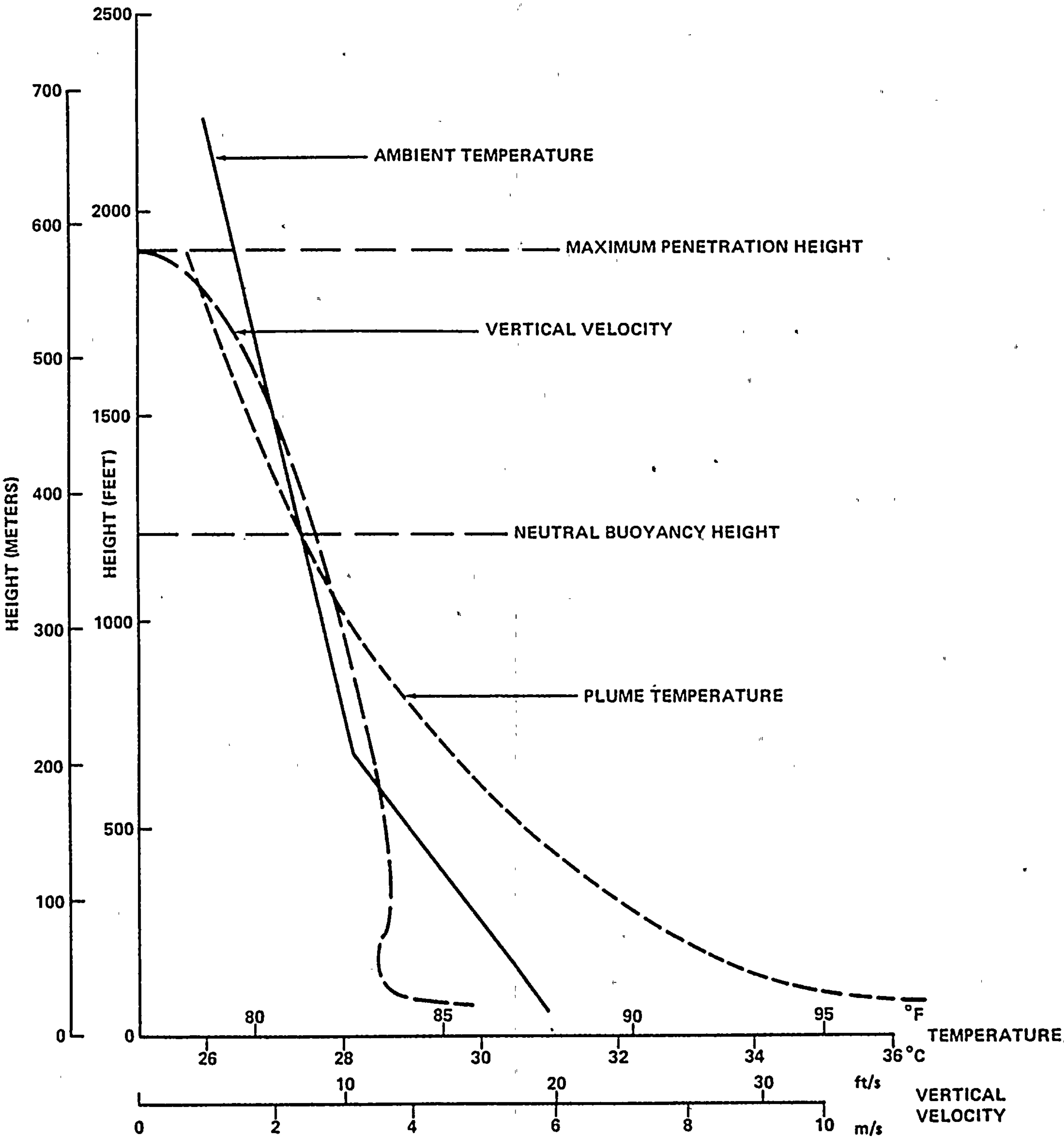
ANNUAL INCREASE OF RELATIVE HUMIDITY (PERCENT)

Figure 5.1-6



Palo Verde Nuclear Generating Station
ER-OL

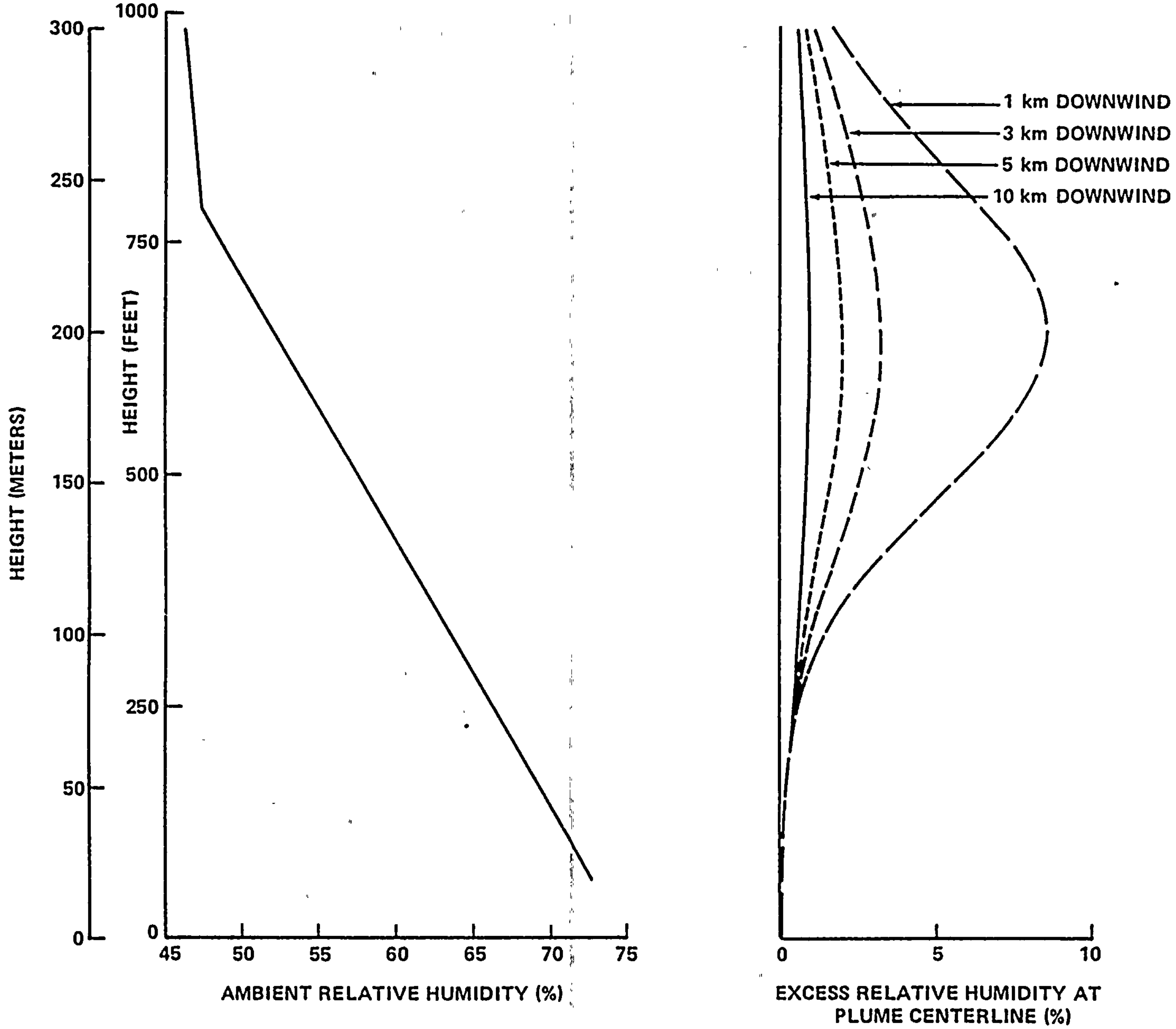
PLUME PARAMETER VARIATIONS,
AVERAGE WINTER MORNING
CONDITIONS
Figure 5.1-7



Palo Verde Nuclear Generating Station
ER-OL

PLUME PARAMETER VARIATIONS, AVERAGE SUMMER MORNING CONDITIONS

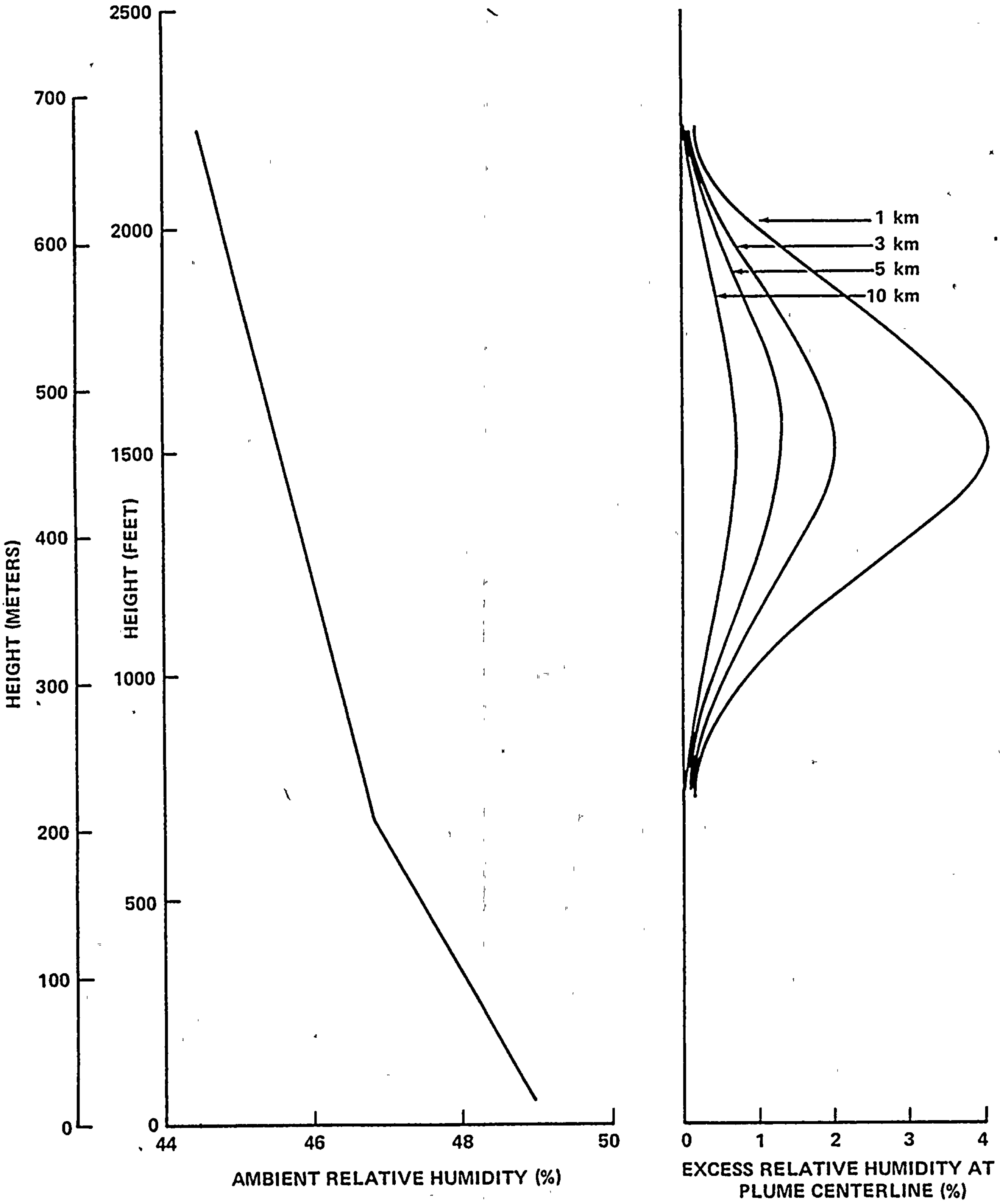
Figure 5.1-8



Palo Verde Nuclear Generating Station
ER-OL

EXCESS RELATIVE HUNIDITY,
AVERAGE WINTER MORNING
CONDITIONS

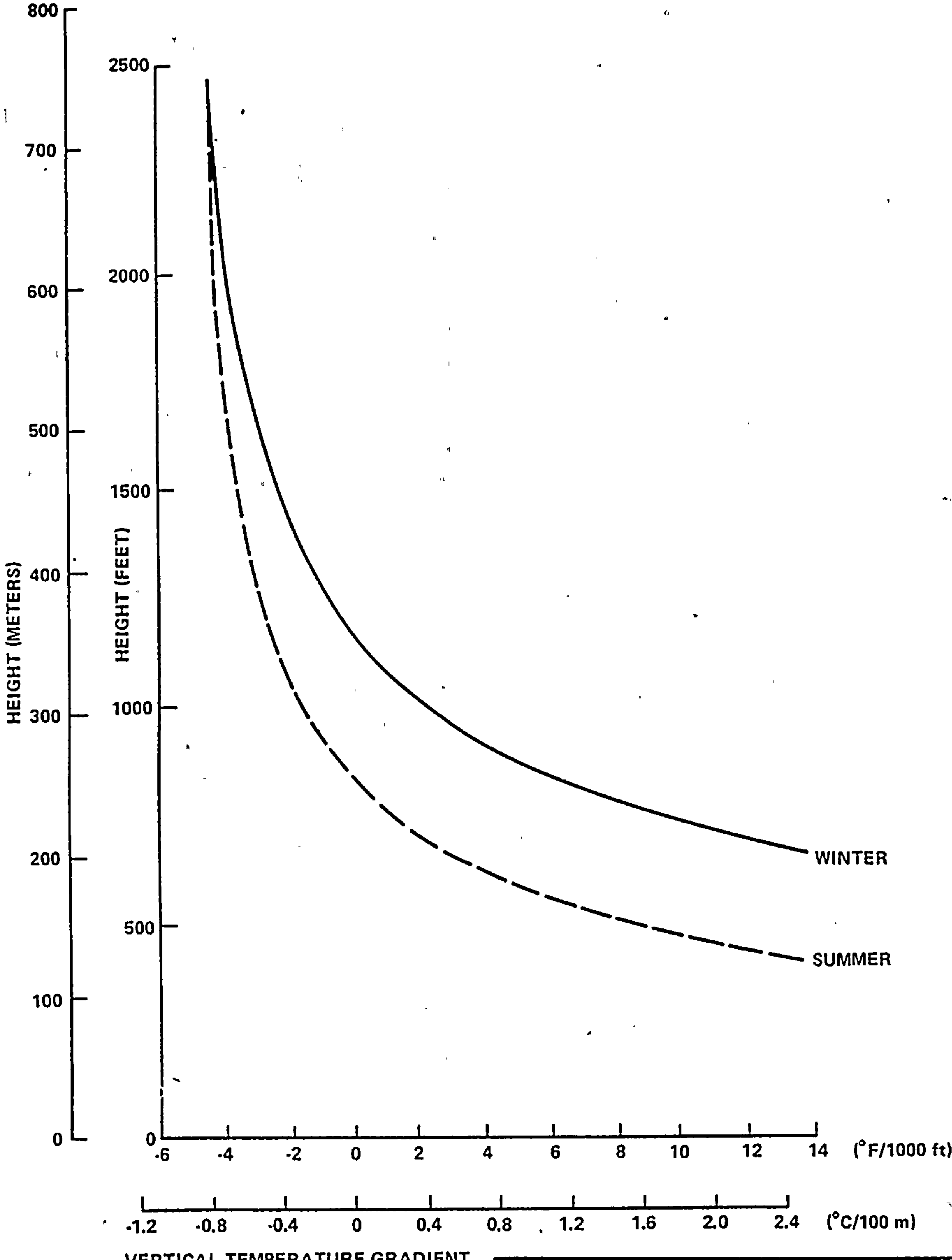
Figure 5.1-9



Palo Verde Nuclear Generating Station
ER-OL

EXCESS RELATIVE HUMIDITY,
AVERAGE SUMMER MORNING
CONDITIONS

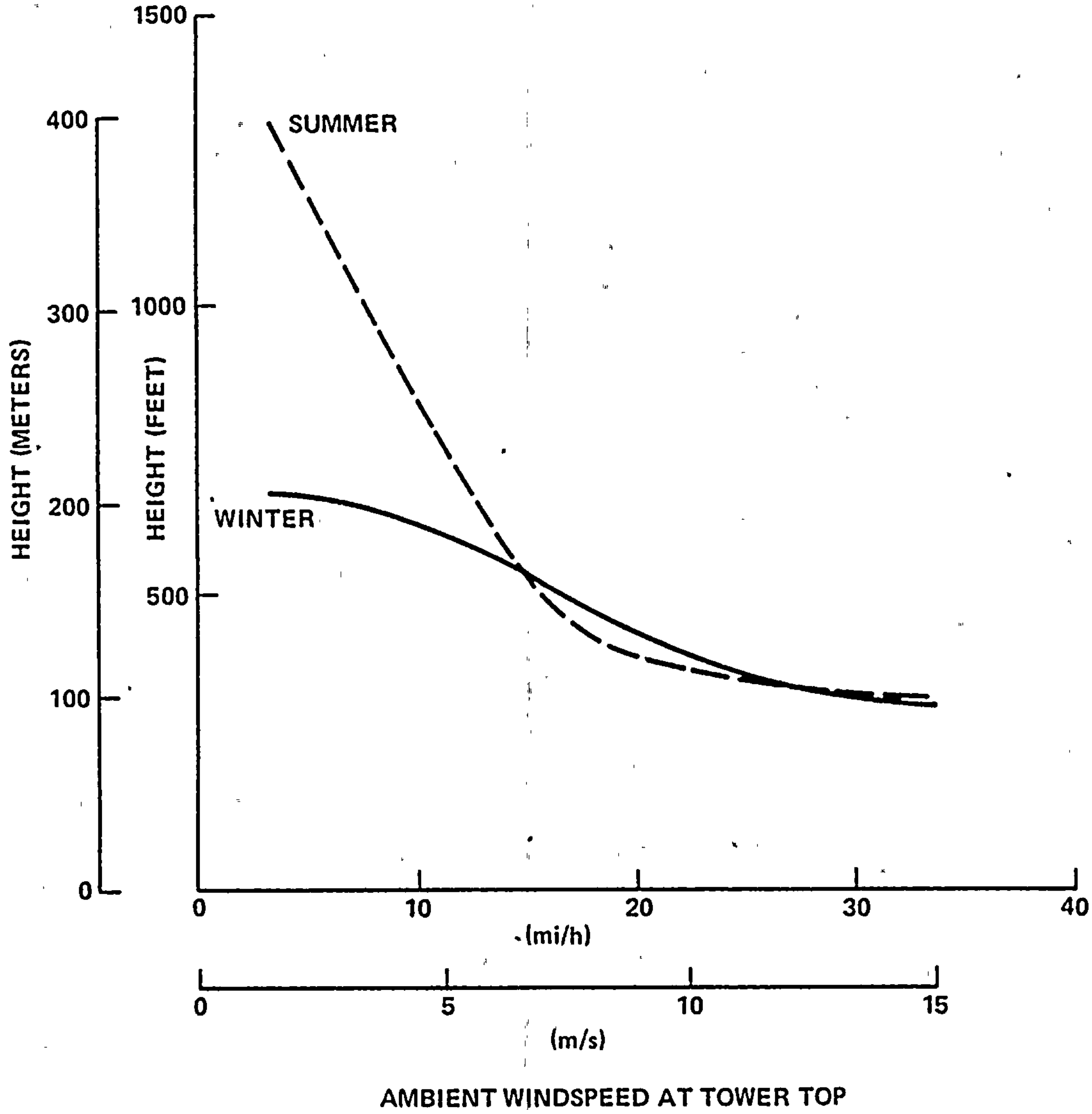
Figure 5.1-10



Palo Verde Nuclear Generating Station
ER-OL

VARIATION OF PLUME HEIGHT AS
A FUNCTION OF AMBIENT
STABILITY CONDITION

Figure 5.1-11



Palo Verde Nuclear Generating Station
ER-OL

VARIATION OF PLUME HEIGHT AS
A FUNCTION OF WINDSPEED

Figure 5.1-12

5.2 RADIOLOGICAL IMPACT FROM ROUTINE OPERATION

Information presented in ER-CP Sections 5.2 and 5.3 and the FES has been updated to reflect revised source terms and evolution of radwaste systems, to utilize 5 years of meteorological data and revised land use information, and to conform with regulatory guides issued for implementation of 10CFR50, Appendix I. The conclusions of the ER-CP are generally unchanged, and the new analysis is presented below.

The PVNGS site is in a rural setting characterized mostly by desert scrub growth. Because the plant is located on a dry site (i.e., no nearby bodies of water), the liquid radwaste system is designed so that during normal operation no offsite releases of radioactive liquids originate from the plant. Thus, exposure to man and biota due only to radioactive gaseous effluents is analyzed.

About 10% of the land within 10 miles of the site is used for agricultural purposes; cotton is the major crop. Sugar beets are raised as a cash crop and alfalfa, barley, and wheat are grown as fodder for dairy herds. A more detailed description of the local population distribution and land use patterns is presented in section 2.1 while section 2.2 contains a description of the local biota.

5.2.1 EXPOSURE PATHWAYS

Figure 5.2-1 shows a simplified food chain at the site, including examples of the four basic trophic levels (producer, primary consumer, secondary consumer, and tertiary consumer). The decomposers, parasites, and transformers (e.g., nitrogen-fixing bacteria) have not been included in the figure.

Most animal species actually feed at more than one trophic level depending on the availability of food and the season, as well as several other environmental stresses. Examples in figure 2.2-1 have been chosen because they typically have a

more restricted diet than omnivores, and because most are fairly common at the site. Feeders at one trophic level would be expected to accumulate greater amounts of radioactivity than those feeding at more than one trophic level.

The gaseous activity releases are expected to be comprised of noble gases, tritium, iodines, and particulates.

Gaseous effluent transport to flora and fauna and to humans is shown schematically in figure 5.2-1. For flora, a dose resulting from direct radiation from ground deposition of radioiodines and particulates and external cloud exposure from all emissions is calculated. Little uptake of iodines is expected through roots since rainfall is sparse. For fauna, the calculated dose results from external cloud immersion, direct radiation from ground deposition of iodines, and ingestion of other biota containing iodines.

Exposure through ingestion requires the physical transport of radioactive materials through a food chain. In this regard, only iodines are expected to be of concern. Since noble gases do not react chemically with other substances under normal conditions, there is no physical basis for their transport through food chains or for their reconcentration.

For the individual receiving the maximum dose, external exposure due to gaseous cloud immersion, contaminated ground surface exposure, and direct radiation from PVNGS are considered. Internal exposures are considered due to the inhalation of gaseous iodine and ingestion of vegetables, cow milk, and meat onto which iodines and particulates have been deposited. Population exposures are also calculated.

5.2.2 RADIOACTIVITY IN ENVIRONMENT

The distribution of radioactivity in the environment due to gaseous releases from nuclear units can be described in terms of atmospheric concentrations and ground concentrations.

Atmospheric concentrations are calculated using the release estimates of section 3.5 and the atmospheric dispersion parameters of section 2.3. For the continuous release model, used to estimate long term effects, the annual average χ/Q is used. The atmospheric concentrations (C_a) are estimated simply as

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

Where

$C_{ai}(\bar{r})$ = picocuries/m^3 at position $\bar{r}$ of isotope i

Q_i = curies of isotope i released per year

3.17×10^4 = number of pCi/Ci divided by number of sec per yr

$\chi/Q(\bar{r})$ = annual average atmosphere dispersion parameter at position of interest ($\bar{r}$), s/m^3.

This model predicts highest concentrations nearest the emission source because of the ground level release model used for determination of χ/Q's. In reality, the maximum ground level concentrations may be at some more distant point because of elevated release points and possibility of plume rise. In this event, the maximum value from elevated releases would be smaller than the maximum value predicted by the ground level release model. The maximum site boundary concentrations due to emissions predicted from a unit are shown in table 5.2-1.

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

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

Table 5.2-1

MAXIMUM SITE BOUNDARY CONCENTRATIONS (Sheet 1 of 2)

	Radio-nuclide	Maximum Site Boundary Ground Level Air Concentration (pCi/m^3)$^{(a)}$	Maximum Site Boundary Ground Surface Concentration (pCi/m^2)$^{(b)}$
	H-3	2.5×10^{2}	--$^{(c)}$
	C-14	2.0	--
	Ar-41	6.4	--
3	Kr-83m	2.8×10^{-1}	--
	Kr-85m	1.7	--
	Kr-85	$5.1 \times 10^{+3}$	--
	Kr-87	6.9×10^{-1}	--
	Kr-88	2.8	--
	Kr-89	2.5×10^{-2}	--
	Xe-131m	$1.0 \times 10^{+2}$	--
3	Xe-133m	$1.4 \times 10^{+1}$	--
	Xe-133	$2.2 \times 10^{+3}$	--
	Xe-135m	1.0×10^{-1}	--
	Xe-135	7.6	--
	Xe-137	4.8×10^{-2}	--
	Xe-138	3.6×10^{-1}	--
	Mn-54	1.1×10^{-4}	8.6
	Fe-59	4.1×10^{-5}	4.6×10^{-1}
	Co-58	4.1×10^{-4}	7.2
	Co-60	1.8×10^{-4}	$7.3 \times 10^{+1}$
	Br-83	8.6×10^{-5}	2.1×10^{-3}
3	Br-84	3.1×10^{-5}	1.7×10^{-4}
	Br-85	9.7×10^{-7}	5.0×10^{-7}

a. Maximum site boundary annual average $\chi/Q = 8.02 \times 10^{-6}$ s/m^3

3 b. Maximum site boundary annual average $D/Q = 1.6 \times 10^{-8}$ m^{-2}

c. Negligible

Table 5.2-1
MAXIMUM SITE BOUNDARY CONCENTRATIONS (Sheet 2 of 2)

Radio-nuclide	Maximum Site Boundary Ground Level Air Concentration (pCi/m^3)(a)	Maximum Site Boundary Ground Surface Concentration (pCi/m^2)(b)
Sr-89	9.2×10^{-6}	1.2×10^{-1}
Sr-90	1.4×10^{-6}	1.1
I-130	6.3×10^{-5}	8.2×10^{-3}
I-131	2.1×10^{-2}	$4.1 \times 10^{+1}$
I-132	1.8×10^{-3}	4.4×10^{-2}
I-133	1.3×10^{-2}	2.9
I-134	6.4×10^{-4}	5.8×10^{-3}
I-135	4.8×10^{-3}	3.4×10^{-1}
Cs-134	1.3×10^{-4}	$2.4 \times 10^{+1}$
Cs-137	2.0×10^{-4}	$1.6 \times 10^{+2}$

3

Where

$Cg_i(\bar{r}) = \frac{\text{picocuries at position r of isotope i}}{m^2}$

Q_i = curies of isotope i released per year

$D/Q\ (\bar{r})$ = annual average atmospheric deposition parameter at position of interest $(\bar{r})$, m^{-2}

λ_i = radiological decay constant of isotope i, s^{-1}

3.17×10^4 = number of pCi/Ci divided by number of seconds per yr

$t = 4.73 \times 10^8$ s(15 yr)

The maximum site boundary ground concentrations resulting from ground level releases for a unit are shown in table 5.2-1.

5.2.3 DOSE RATE ESTIMATES FOR BIOTA OTHER THAN MAN

Calculations have been performed to determine maximum dose rates to biota due to operation of PVNGS. Results are based on a per unit operation. Calculations are performed for unspecified flora due to ground deposition and cloud immersion, and for two species of fauna, the blacktailed jackrabbit and the kit fox.

5.2.3.1 Flora Dose Rate Estimates

Using the maximum site boundary ground level air concentrations and surface concentrations, maximum dose rates for each unit to flora are presented in table 5.2-2.

The dose estimates were based on values calculated by an NUS version of GASPAR for the air dose and ground plane dose.

5.2.3.2 Fauna Dose Rate Estimates

Doses are calculated for the kit fox and for the blacktailed jackrabbit, which makes up most of the diet of the kit fox and which consumes vegetation (100 g/d) upon which radioiodines may be deposited. It is assumed that the jackrabbits are living at the location of maximum site boundary ground deposition and that the kit fox obtains 100% of his diet (175 g/d) from these jackrabbits. External doses are also considered due to ground deposition and cloud immersion at those same locations.

The jackrabbit dose model assumes that the ingestion dose is proportional to vegetable ingestion dose for a child. The dose was based on GASPAR results, corrected for the ratio of the vegetable ingestion rates and total body weights between a jackrabbit and a child. The kit fox ingestion dose model assumes that the ingestion dose is proportional to the child meat ingestion dose from GASPAR, corrected for the ratio of

Table 5.2-2

MAXIMUM SITE BOUNDARY FLORA DOSES

Pathway	Doses (mrad/yr/unit)					
	Unit 1		Unit 2		Unit 3	
	Flora Surface	Total Body	Flora Surface	Total Body	Flora Surface	Total Body
Cloud immersion[(a)]	10.1	0.50	11.0	0.54	12.5	0.61
Deposited Radionuclides[(b)]	0.013	0.011	0.014	0.012	0.017	0.015

3

a. Maximum site boundary cloud immersion doses occur at

- 1037m N of Unit 1 for Unit 1 releases
- 1836m SSW of Unit 2 for Unit 2 releases
- 1607m SSW of Unit 3 for Unit 3 releases

b. Maximum site boundary deposited radionuclide surface doses occur at

- 1057m NNE of Unit 1 for Unit 1 releases
- 993m W of Unit 2 for Unit 2 releases
- 871 W of Unit 3 for Unit 3 releases

grass and meat ingestion rates and total body weights between a kit fox and a child. The jackrabbit was assumed to obtain 100% of its diet from grasses.

Table 5.2-3 presents the doses to both the jackrabbit and kit fox. No observable effects are expected at these dose rates.

5.2.4 DOSE RATE ESTIMATES FOR MAN

The evaluation of compliance with Appendix I of 10CFR50 and 40CFR190 is presented in appendix 5B.

5.2.4.1 Liquid Pathways

The liquid radwaste system is designed so that during normal operation no offsite releases of radioactive liquids originate from the plant.

5.2.4.2 Gaseous Pathways

Appendix 5B presents detailed individual and population dose estimates to man from the gaseous pathways. Table 5.2-4 summarizes the maximum individual dose estimates; the child dose is the limiting case. The location of the highest dose is the residence 2300 meters north of Unit 1.

5.2.4.3 Direct Radiation from Facility

Appendix 5B presents the methodology used in the calculation of direct radiation doses. Dose rates at the nearest school and hospital, both of which are more than 5 miles from PVNGS, are negligible.

5.2.4.4 Annual Population Doses

Table 5.2-5 presents the annual population doses evaluated at mid-plant life as represented by the projected year 2000 population. The methodology is described in appendix 5B.

Table 5.2-3
MAXIMUM SITE BOUNDARY FAUNA DOSES (MRAD/YR/UNIT) (Sheet 1 of 2)

Organ	Unit 1					
	Jack Rabbit			Kit Fox		
	Plume	Ground Plane	Ingestion	Plume	Ground Plane	Ingestion
Total body[(a)]	0.50	0.011	26.	0.50	0.011	0.61
Bone[(a)]	0.50	0.011	67.	0.50	0.011	2.25
Thyroid[(b)]	0.50	0.011	28.	0.50	0.011	0.66
Skin[(a)]	10.1	0.013	26.	10.1	0.013	0.61

a. All plume doses and total body, bone, and skin doses from ingestion occur at:

- 1037m N of Unit 1 for Unit 1 releases
- 1836m SSW of Unit 2 for Unit 2 releases
- 1607m SSW of Unit 3 for Unit 3 releases

b. All ground plane and thyroid ingestion doses occur at:

- 1057m NNE of Unit 1 for Unit 1 releases
- 993m W of Unit 2 for Unit 2 releases
- 871m W of Unit 3 for Unit 3 releases

3

Table 5.2-3

MAXIMUM SITE BOUNDARY FAUNA DOSES (MRAD/YR/UNIT) (Sheet 2 of 2)

Organ	Unit 2					
	Jack Rabbit			Kit Fox		
	Plume	Ground Plane	Ingestion	Plume	Ground Plane	Ingestion
Total body	0.54	0.012	29.	0.54	0.012	0.67
Bone	0.54	0.012	73.	0.54	0.012	2.46
Thyroid	0.54	0.012	36.	0.54	0.012	0.86
Skin	11.0	0.014	29.	11.0	0.014	0.67
Organ	**Unit 3**					
	Jack Rabbit			Kit Fox		
	Plume	Ground Plane	Ingestion	Plume	Ground Plane	Ingestion
Total body	0.61	0.015	32.	0.61	0.015	0.76
Bone	0.61	0.015	83.	0.61	0.015	2.78
Thyroid	0.61	0.015	42.	0.61	0.015	1.00
Skin	12.5	0.017	32.	12.5	0.017	0.76

3

3

Table 5.2-4
MAXIMUM INDIVIDUAL DOSE[a]

	Child Dose (mrem/yr/unit)			
	Total Body	Bone	Thyroid	Skin
Plume	0.30	0.30	0.30	4.1
Ground plane	0.0033	0.0033	0.0033	--
Vegetable ingestion	1.9	4.6	2.2	1.9
Inhalation	0.14	0.00073	0.316	0.14
Direct radiation	0.00093	0.00093	0.00093	0.00093
Total	2.3	4.9	2.8	6.1

a. Refer to table 5B-1 for a complete listing of individual doses.

3

Table 5.2-5
POPULATION DOSES
(man-rem/year/unit)

Pathway	Total Body	Thyroid
Plume	3.5	3.5
Ground plane	0.00795	0.00795
Inhalation	2.43	4.15
Vegetation ingestion	17.6	19.5
Meat ingestion	0.53	0.53
Milk ingestion	1.7	2.0
Total	25.8	27.9

3

3

5.2.5 SUMMARY OF ANNUAL RADIATION DOSES

Table 5.2-6 presents a table of individual doses compared with the design objectives of Appendix I of 10CFR50. Table 5.2-7 presents a comparison of doses to the individual and the limits of 40CFR190. The details of the calculations are described in appendix 5B.

Table 5.2-6
MAXIMUM INDIVIDUAL DOSES COMPARED TO APPENDIX I OF 10CFR50

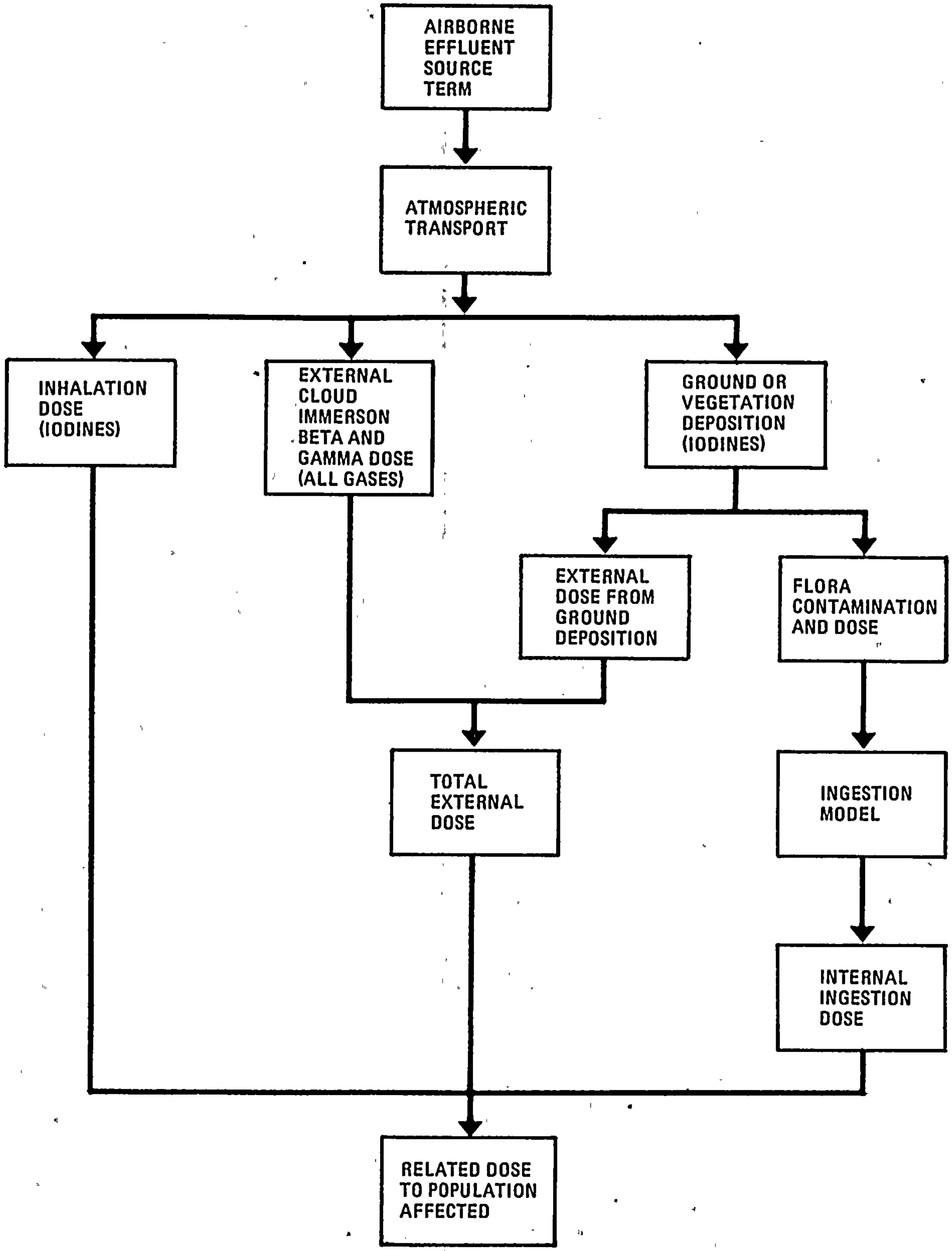
	Dose (mrem/yr/unit)	Appendix I Limit (mrem/yr/unit)
Noble gases		
Total body	0.30	5
Skin	4.1	15
Radioactive iodine and particulates		
Maximum organ	4.6 (child bone)	15

3

Table 5.2-7
MAXIMUM INDIVIDUAL DOSES COMPARED TO 40CFR190

	Dose (mrem/yr)	40CFR190 Limit (mrem/yr)
Total body	5.7	25
Thyroid	6.7	75
Maximum organ (child bone)	12.5	25

3



Palo Verde Nuclear Generating Station
ER-OL

PVNGS EXPOSURE
PATHWAY MODEL

Figure 5.2-1

5.3 EFFECTS OF CHEMICAL AND BIOCIDE DISCHARGES

The information formerly presented in ER-CP Section 5.4 and the FES has not been significantly altered. This section summarizes updated studies of environmental effects due to operation of the plant.

5.3.1 BLOWDOWN EFFECTS

Blowdown will be directed to a series of lined evaporation ponds as described in section 3.6. Chemical wastes from the plant will not be discharged to natural surface waters.

No detectable offsite ecological effects are anticipated from the slight increase in humidity caused by the evaporation ponds. Because of the extreme aridity of the area, any detectable increase in humidity would be quite local.

The steep sides of the ponds will reduce the area for potential growth of botulism. The area for potential botulism growth will also be reduced by individually controlling water levels in each pond. It is anticipated that the total area of ponds developed at any time will be covered with water continuously. Thus it appears unlikely that material in the evaporation ponds could become airborne.

The evaporation ponds may be used by waterfowl and other birds. Essentially any species of waterfowl that is attracted to the reservoir at PVNGS also could be expected to use the evaporation ponds. Pintail, American Wigeon, and Green-winged Teal probably will be present at the ponds more often than other species. Other important recreational species or rare species which might be seen on occasion include the Brown Pelican (listed by the federal government as endangered), White-faced Ibis (Audubon Blue-listed), Common Gallinule, and American Coot (game species). Maximum usage probably will occur in the fall migration period and in early winter when

rain is relatively frequent and many bird species are present in the Southwest.

Evaporation ponds at the Mojave Generating Station in southern Nevada are used by waterfowl without any obvious ecological problems.(1) There, more than 200 acres of evaporation ponds usually have water in them; some of the ponds are very saline, while others contain reclaimable water. The depth of the water in these ponds varies from zero to 12 feet; the size of the individual ponds varies from 3 to 55 acres. Some of the evaporation ponds have vegetation. Several hundred birds have been sighted in the ponds, particularly in late fall. The most heavily used ponds apparently are the oldest and largest, which are very saline.

In the Phoenix area, waterfowl are known to have used evaporation ponds associated with the sewage treatment plants on the Salt River. Use of these ponds has generally been considered to be beneficial to birds except when botulism outbreaks occur.(2)

Predictions about the possible deleterious effects to wildlife from toxic concentrations of chemicals in the evaporation ponds are problematic. The ultimate form (ionic, double salts, etc), pH, and concentrations in the evaporation ponds are variable; however it appears unlikely that toxic chemicals could develop.

Significant contamination is not expected to occur in the water table because the evaporation pond will be lined with a material that limits seepage.

Refer to section 6.2 for operational environmental monitoring programs.

5.3.2 EFFECTS OF COOLING TOWER DRIFT

The predicted distribution of drift from the cooling towers has been reevaluated using 5 years of meteorological data. This evaluation is presented in section 5.1.

After approximately 15 cycles of concentration, the salt content of the circulating water will be approximately one-third the salt content of sea water. The salt will be primarily sodium chloride with substantial amounts of magnesium and calcium chlorides and sulfates. Less than 0.1 percent by weight of the solids will be heavy metals or biocides. Drift from cooling towers is designed to be controlled to 0.0044 percent loss of the circulating water flow (refer to section 5.1).

As discussed in section 5.1, the highest predicted total (wet and dry) offsite deposition caused by operation is less than 12 lb/acre/yr. Those species of plants found in the region are adapted to growing under highly saline conditions,[3,4,5] therefore, the small amount of salt from PVNGS added to that already present in the soil of the region is not expected to affect biota in any measurable way. As discussed in Regulatory Guide 4.11, salt deposition rates of less than 17 lb/acre/yr are not considered measurable. Any heavy metal and biocide discharges are anticipated to be at a level so low as not to be distinguishable from normal background levels.

5.3.3 REFERENCES

1. Fontane, T., Mojave Generating Station, Personal Communication, November 22, 1977.

2. Arizona Game and Fish Department News Releases of November 11 and 8, 1977.

3. Al-Jibury, L. K., Salt Tolerance of Some Desert Shrubs in Relation to Their Distribution in the Southwestern Deserts of North America, Ph.D. Thesis, Arizona State University, Phoenix, 1972.

4. Wallace, A. and Romey, E. M., "Salt Tolerance of Some Desert Shrub Species," In Radioecology and Ecophysiology of Desert Plants at the Nevada Test Site, USAEC Office of Information Services, TID-25954, pp 358-362, 1972.

5. Wint, F. W., "The Ecology of Desert Plants," Scientific American, Vol. 192, 68-75.

5.4 EFFECTS OF SANITARY AND OTHER WASTE DISCHARGES

This section has been revised to reflect updated meteorological data and current PVNGS system design.

5.4.1 SANITARY WASTES

During plant operation, treated effluent from the package sewage treatment plant will be delivered to the water reclamation plant. The treated onsite sewage effluent will be available as additional water for cooling system makeup during normal operations. When the water reclamation plants are temporarily not operating, chlorinated effluent from the package sewage treatment plant will be delivered to the onsite evaporation pond. No major adverse environmental impact is anticipated from this operation, because there will be no direct discharges from the evaporation pond. Lining the evaporation pond limits seepage of the impounded effluent into local groundwater aquifers. Therefore, the evaporation pond is not expected to significantly affect recharge to the aquifers.

5.4.2 GASEOUS EFFLUENTS

There are three groups of facilities on the PVNGS site that are stationary sources of pollutants; the diesel generators, auxiliary boilers and recalciners. Source operational modes and emission parameters are described in section 3.7 and listed in table 5.4-1. Mobile source emissions will result from the operational workforce. Estimated annual averages of traffic volume in and out of PVNGS during operation are provided in table 5.6-2. 4

The diesel generators and auxiliary boilers are operated only on a limited basis:

A. The diesel generators are each tested for about 1 hour per month. This testing is not concurrent and the

Table 5.4-1

EMISSION PARAMETERS FOR FOSSIL FUEL-FIRED FACILITIES

Parameter	Diesel Generator	Auxiliary Boilers		Recalciner
		Large	Small	
Stack diameter (in)	32	84	44	36
Stack height (above grade) (ft)	93	50	50	80
Exhaust temperature (°F)	910	622	579	165
Exhaust flow rate (ACFM)	48,950	100,000	24,000	-
Exhaust velocity (ft/min)	-	-	-	1,800
Fuel type	No. 2 diesel[d]	No. 2 diesel[d]	No. 2 diesel[d]	No. 2 diesel[d]
Operational mode	1 h/mo	8 d/yr/unit	8 d/yr/unit	Continuous
Emissions:				
Nitrogen oxides	2,300[a]	2,300[b]	-	456
Sulfur Oxides	675[a]	7,583[b]	-	180
Hydrocarbons	35[a]	682[b]	-	17
Particulates	164[a,c]	209[b,c]	-	84
Carbon monoxide	766[a]	522[b,c]	-	23

ACFM = Actual cubic feet per minute.

a. Per diesel generator. Two generators per PVNGS unit. Emissions in units of pounds per year.

b. Based on both boilers. Ratio by ACFM to separate between boilers. Emissions in units of pounds per day.

c. Emission ratioed from those for NO_x by means of emission factors for diesel-powered industrial equipment and distillate oil-burning industrial boilers in reference 5.

d. Normalized to 1% sulfur fuel with no SO_2 removal from flue gases.

2

2

2

2

generators are not otherwise operated except under abnormal conditions.

B. The auxiliary boilers are operated for approximately 8 days per year for each unit served during the initial startup of the nuclear generating units.

The diesel generators and auxiliary boilers are operated only
a small fraction of the year and are not expected to be 2
operated simultaneously. Therefore, the offsite concentrations are predicted only for the operation of each of the facilities separately. No nitrogen oxides (NO_x) concentrations are predicted, as there is only an annual NAAQS for NO_x.

The offsite concentration values for SO_2 and other pollutants presented in table 5.4-2 were determined for the diesel generators using the EPA dispersion model RAM[(1)] and for the auxiliary boilers using the EPA dispersion model ISC[(2)]. Since both sources are close enough to the unit structures to be within the "region of building influence," the RAM model was modified to account for the effects of aerodynamic downwash by a methodology described by Briggs[(3)] to determine conditions of downwash and concentrations during downwash. The existing ISC model includes the effects of aerodynamic
downwash and was therefore not modified. 2

The comprehensive ISC model was used with four years of onsite meteorological data (1974 through 1977) to predict the short-term concentrations presented in table 5.4-2 for SO_2 and other criteria pollutants due to operation of the auxiliary boilers. A recent summary of the ISC Model obtained from the EPA "Guideline on Air Quality Models" is provided in Appendix 5A. The use of four years of meteorological data as input to this model allows the use of the highest second-highest calculated concentration for any given year to be compared to NAAQS for SO_2 due to the operation of the two auxiliary boilers.

Table 5.4-2

MAXIMUM EXPECTED OFFSITE CONCENTRATIONS AND COMPARISON WITH STANDARDS

Pollutant	Averaging Period	Standard (ug/m3)	Pollutant Source: Auxiliary Boilers for Units 1, 2 & 3	Diesel Generators for Unit 1	Unit 2	Unit 3	Recalciner	Operational Traffic
Sulfur oxides	Annual	80	-	-	-	-	.45	.10
Sulfur oxides	24-h	365	45	36	30	38	8.3	.10
Sulfur oxides	3-h	1300	185	68	56	70	15.4	.40
Particulates	Annual	60	-	-	-	-	.21	.38
Particulates	24-h	150	1.2	9	7	9	3.8	.38
Carbon monoxide	8-h	10,000	21	83	67	86	2.1	50
Carbon monoxide	1-h	40,000	-	-	-	-	-	401
Nitrogen oxides	Annual	100	-	-	-	-	1.1	3.3
Hydrocarbons	3-h	160	-	-	-	-	-	2.5

The diesel generators do not have the potential to produce high air pollution concentrations; therefore, the conservative NUS modified RAM model was used with one year of meteorological data (1975) to predict the highest short-term concentrations presented in table 5.4-2. The use of one year of meteorological data requires the use of the highest calculated concentrations for comparison to NAAQS. The normal variations in yearly meteorological data could not radically increase the calculated impact concentrations to approach the NAAQS.

In regard to predicted concentration of pollutants presented in table 5.4-2 due to operation of the diesel generators, it was assumed that only two generators which serve one of the three generating units would be in operation at any given time. Thus, a set of two generators were assumed to be operating 24 hours per day for 365 days a year. This mode of operation is considered conservative since the diesel generators are anticipated to be tested separately for about one (1) hour per month. This testing is not concurrent and the generators are not otherwise operated except under abnormal conditions. 2

In regard to predicted concentration of pollutants presented in table 5.4-2, due to operation of the auxiliary boilers, it was conservatively assumed that both the large and the small boilers were in operation continuously at maximum load (i.e., 24 hours per day for 365 days per year). However, it should be noted that these two boilers which serve all three nuclear operating units are anticipated to be operated for approximately 8 days per year for each nuclear generating unit during the initial start-up of each unit.

The recalciners are operated continuously throughout the year. The highest predicted offsite concentrations for the operation of these facilities are also compared with the annual and short-term NAAQS for SO_2, and other pollutants in table 5.4-2. The concentrations were calculated using the EPA dispersion

model CRSTER[4] modified to accept terrain elevations higher
than the lowest stack height. One year of onsite meteoro-
logical data (1975) was used to predict the annual and short-
term concentrations. The recalciners are not affected by
downwash and do not have the potential to produce air quality
impact concentrations close to the NAAQS. Therefore, the use
of one year of meteorological data is sufficient to determine
2 maximum air quality impacts. An assumed constant mixing
height of 500 meters was used for all modeling since no mixing
height information is currently available in a format accept-
able to CRSTER or RAM for the surface data examined. This
mixing depth was selected based on the tabulated mixing height
information of Holzworth[5]. The low effective plume heights
(less than 100 meters) under all stability conditions means
that plume reflection from the top of the mixing layer is
insignificant for these emissions.

The maximum expected short-term offsite concentrations caused
by the operation of auxiliary boilers and the diesel generators
located closest to the PVNGS site boundary are presented in
table 5.4-2. These predicted concentrations are less than the
short-term NAAQS for the respective pollutants. The primary
24-hour average NAAQS for SO_2 and PM are 365 and 260 μg/m^3,
respectively. The secondary 24-hour average NAAQS for total
suspended particulates (TSP) is 150 μg/m^3. The highest 24-hour
average concentrations of SO_2 and PM predicted at the PVNGS
site boundary due to the emissions from the auxiliary boilers
2 are 45 and 1.2 μg/m^3. The highest 24-hour average SO_2 and PM
concentrations predicted at the site boundary due to the diesel
2 generators at Unit 1 are 36 and 9 μg/m^3, while those predicted
at the site boundary due to the diesel generators at Unit 3 are
2 38 and 9 μg/m^3. Because the Units 1 and 2 generators are
located further from the site boundary than the Unit 3 gener-
ator, offsite concentrations due to their operation are lower.
The primary 8-hour average NAAQS for carbon monoxide standard

is 10,000 μg/m^3 and the concentrations predicted at the site
boundary due to the auxiliary boiler emissions is 21 μg/m^3. 2
The highest 8-hour average carbon monoxide concentrations
predicted at the site boundary due to the diesel generators at
Units 1 and 3 are 83 and 86 μg/m^3, respectively.

The short-term NAAQS for SO_2 is 365 μg/m^3 for 24 hours and
1300 μg/m^3 for three hours, which is not to be exceeded more
than once per year. The short-term SO_2 concentrations pre-
sented in table 5.4-2 due to the operation of the auxiliary
boilers is the second highest value predicted for any given 2
year (this is sometimes referred to by the EPA as the highest
second-highest concentration). The short-term SO_2 concentra-
tions presented in table 5.4-2 due to the operation of the
diesel generators and recalciner represent the highest value
predicted for any given year.

Estimates were made of ambient pollutant concentrations along
access roadways due to the operational workforce for the three
units. The traffic volume data presented in table 5.6-2 for the
year 1986 were used in these calculations. A total of 23 buses,
67 cars, and 3 trucks were assumed to enter and leave the site
each day. As a conservative assumption, these vehicles were
assumed to enter and leave the site during two one-hour periods.
EPA emission factors(6,7) for 1980 model vehicles were used.
Other assumptions used include an average vehicular speed of 4
45 mph, ambient temperature of 70F, and buses and trucks are
gasoline powered. Calculations were made for hydrocarbon, carbon
monoxide, nitrogen oxides, particulate and sulfer dioxide emis-
sions. Concentration estimates were obtained from these vehicular
emissions assuming wind blowing normal to a continuously emitting
infinite line source using the appropriate dispersion equation.(8)
Concentration calculations were made at a distance of 10 miles
from the roadway assuming conservative 1 m/sec wind speed and F
stability class conditions. The value of the vertical dispersion

4 coefficient used in these calculations of 1.6 m was obtained from the formulation of the EPA dispersion model HIWAY.[9] The estimated pollutant concentrations are listed in table 5.4-2. The only significant concentrations for carbon monoxide.

The calculated pollutant concentrations from stationary and mobile sources as listed in table 5.4-2 are well below the standards.

4 Therefore, in summary, no offsite violations of the NAAQS are
2 predicted for SO_2 or any other criteria pollutants due to the operation of the diesel generators, auxiliary boilers or recalciners; nor from the vehicular exhaust emissions from the operational workforce traffic.

5.4.3 REFERENCES

1. User's Guide for RAM Volume 1 & II, Environmental Sciences Research Laboratory, Research Triangle Park, North Carolina EPA-600/8-78-106, November, 1978

2. Bowers, J. F., J. R. Bjorklund and C. S. Cheney. "Industrial Source Complex (ISC) Dispersion Model User's Guide, Volumes 1 and 2." Publication Nos. EPA-450/4-79-0, 1 (NTIS PB-80-133044, 133051, Magnetic tape PB-80-133036), Office of Air Quality
2 Planning and Standards, U. S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, December 1979

3. Briggs, Gary, "Diffusion Estimation for Small Emissions," Air Resources Atmospheric Turbulence and Diffusion Laboratory, National Oceanic and Atmospheric Administration, ATDL Contribution File No. 769 (Draft), Oak Ridge, Tennessee, May 1973.

4. "User's Manual for Single-Source (CRSTER) Model," Office of Air and Waste Management, Office of Air Quality Planning and Standards, U.S. Environmental

Protection Agency, Report No. EPA-450/2-77-013, Research Triangle Park, North Carolina, July 1977.

5. Holzworth, George C., "Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States", Environmental Protection Agency, Office Of Air Programs, Research Triangle Park, North Carolina, January 1972. 2

6. "Mobile Source Emission Factors", Office of Air and Waste Management", U.S. Environmental Protection Agency, Report No. EPA-400/3-78-005, Washington D.C., March 1978.

7. "Compilation of Air Pollutant Emission Factors", Office of Air and Waste Management, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Report No. AP-42, Research Triangle Park, North Carolina, August 1977, w. suppl.

8. Turner, D. Bruce, "Workbook of Atmospheric Dispersion Estimates", Air Resources Field Research Office, Environmental Science Services Administration, Office of Air Programs, Research Triangle Park, North Carolina 1970 4

9. Zimmerman, John R., and R.S. Thompson, "User's Guide for HIWAY, A Highway Air Pollution Model", Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA-650/4-74-008, Research Triangle Park, North Carolina, February 1975

5.5 EFFECTS OF OPERATION AND MAINTENANCE OF THE TRANSMISSION AND CONVEYANCE SYSTEMS

5.5.1 TRANSMISSION SYSTEM

The transmission systems associated with PVNGS are described in section 3.9.1. Information presented in ER-CP Section 5.6.1 and the FES has been updated to reflect final line routing and the addition of a transmission line from PVNGS to Devers Substation in California. The impacts expected due to operation and maintenance of the Projects 1 and 3 transmission systems are updated and summarized in this section. Information concerning the expected impacts of the PVNGS to Devers line is presented in the U.S. Department of Interior Bureau of Land Management and U.S. Nuclear Regulatory Commission Final Environmental Statement, Palo Verde-Devers 500 kV Transmission Line, February 1979. Descriptions are presented for preferred and alternate routes.

5.5.1.1 Transmission System Impacts

5.5.1.1.1 Maintenance Program

Maintenance programs are not expected to have significant environmental effects; however, those environmental effects that do occur from maintenance will be short term. Transmission-system construction practices will result in stable open-field associations and therefore minimal right-of-way maintenance. Where maintenance clearing is required the biotic association as a whole will not be adversely affected.

Maintenance will be conducted on an as-required basis. Frequent ground access to the transmission lines for maintenance will not be required. Transmission line access points are indicated on figures 3.9-1 and 3.9-2. The same environmental precautions that were taken during construction will be taken for non-emergency maintenance and repairs. Noise and dust created by maintenance-vehicle traffic is not expected to be bothersome due to the low frequencies of ground patrol. 2

It is expected that maintenance/surveillance for Project 1 lines will be as follows:

- Air patrol - three times per year
- Ground Patrol - once per year
- Walk and climb - once every five years
- Repair and maintenance items identified in surveillance on an as-required basis.

2 It is expected that maintenance/surveillance for Project 3 lines will be as follows:

- Ground patrol - three times per year
- Repair and maintenance items identified in surveillance on an as-required basis.

The PVNGS - Devers line will be maintained according to a plan to be developed by Southern California Edison and approved by the Bureau of Land Management, as required by the Final Environmental Statement, Palo Verde - Devers 500 kV Transmission Line.

Access roads built during the construction phase of the transmission systems ordinarily will not be maintained.

Herbicides and pesticides will not be used for maintenance of transmission-system corridors. Soil sterilants may be used within the confines of substations to control weed growth.

5.5.1.1.2 Electrical Effects

5.5.1.1.2.1 Line Clearances. No adverse effects resulting
2 from corona or electrical field effects are expected. Vertical height guidelines of Section 232 of the National Electric Safety Code will be followed to eliminate the interference with communication or railroad systems.

5.5.1.1.2.1 Grounding Systems. Grounding systems will be installed to handle currents that occur under fault conditions. 2

5.5.1.1.2.1.1 Project 1 Grounding Systems. Counterpoise shall be installed in accordance with figure 5.5-1. Foundation resistance tests shall be conducted and counterpoise installed in accordance with the following:

- Footing resistance at each tower/pole shall be tested while it is completely isolated from any ground connection, excluding the foundations.
- The testing shall be during periods of relatively dry soil conditions, if possible.
- Tower/pole foundation resistance tests shall be measured with a Vibroground Model #263A meter manufactured by Associated Research, Inc. of Chicago, Illinois, or equivalent. Foundation resistance shall be measured using the three-probe method.
- Where tower/pole foundation resistance measures 20 ohms or less, no corrective measures are required. For tower and poles with foundation resistance in excess of 20 ohms, the foundation resistance shall be corrected to 20 ohms, if possible, with the installation of ground rods as needed, but not to exceed 20 ground rods per tower/pole. The method of installation for ground rods is shown on figure 5.5-1. 2

5.5.1.1.2.1.2 Project 3 Grounding Systems. Grounding will be by copper butt raps on each wooden pole leg as indicated in figure 5.5-2.

5.5.1.1.2.1.2 PVNGS-Devers Grounding Systems.

The ground resistance of the towers shall be measured after towers are assembled and prior to installation of conductor

and shield wire. Measurements of tower to ground resistance shall be made by utilizing the three-point method and a self-contained instrument reading ohms directly, such as the Vibroground Model No. 263a meter, manufactured by Associated Research, Inc. of Chicago, Illinois; the Megger Earth Tester Model 63220, by James G. Biddle Co. of Plymouth Meeting, Pennsylvania; or approved equal. All measurements shall be made at a distance of not less than 100 feet from base of tower. The three-point method is described in IEEE Std. 80.

Soil conditions, at time of measurement, shall be evaluated.

Where the ground resistance is less than specified for the tower no supplemental ground connections will be required. Where measurements show that the tower to ground resistance is more than specified, supplemental grounding shall be installed to lower the ground resistance as shown on figure 5.5-3. After each separate installation of any counterpoise and/or ground
2 rods, additional ground resistance measurements shall be made. Ground rods shall be as shown on figure 5.5-3. The tops of ground rods shall be set a minimum of one foot below normal ground surface.

Counterpoise installations shall be installed within the right of way. All counterpoise installations shall be made as shown on figure 5.5-3. In the area of the El Paso Natural Gas pipeline, the counterpoise installed on the pipeline side of the tower shall be installed along the direction of the line and not at an angle. Included therein shall be the excavation and backfill of the trench for the counterpoise, anchoring the counterpoise to the surface of the ledge as required, and the connection of the counterpoise to the towers. Connecting cables for ground rods and counterpoise shall be 3/8 inch in diameter, 7-strand galvanized cable Utility Grade guy strand ASTM class "C" galvanizing or equal. No splices below ground in ground cables shall be permitted except in ground rod clamps.

5.5.1.1.3 Ecological Resources

The effects of transmission-line operation and maintenance relate primarily to the access roads that create increased access to areas that were previously difficult to reach. The operation and maintenance activities will have very little, if any, adverse effects on terrestrial and aquatic systems once construction activities have been completed.

In sensitive areas with species such as Gila monster, desert tortoise and bighorn sheep, and in areas vegetated with endangered and threatened plant species, fences and gates will be placed appropriately to inhibit unauthorized off-highway vehicle use of access roads. It is expected that no changes of long-term significance to the area's fauna will result from operation and maintenance activities.

5.5.1.1.4 Cultural and Paleontological Resources

Cultural and paleontological resources are likely to be impacted the greatest during the construction phase of the project. Access and spur roads will be closed as required (and contingent on the consent of the land owner) after construction to minimize relic hunting. 1

5.5.1.1.5 Land Use

Land use can be affected in two ways by a transmission line. The presence of the transmission line can change current practices and/or alter future flexibility in land use. These effects will vary depending on existing land use.

Land used for grazing will not be significantly impaired by the transmission line systems. Normal grazing practices will be maintained because cattle will be able to graze under the lines. Cultivation practices on agricultural lands may be slightly modified due to the presence of the proposed transmission system. The aerial application of seed, herbicides,

and other materials to the crops may be altered by the transmission lines.

5.5.2 WASTEWATER CONVEYANCE PIPELINE

Information presented in ER-CP Section 5.6.2 and the FES remain valid. The impacts expected due to the operation and maintenance of the wastewater conveyance pipeline as well as mitigation measures are summarized in this section.

5.5.2.1 General Maintenance

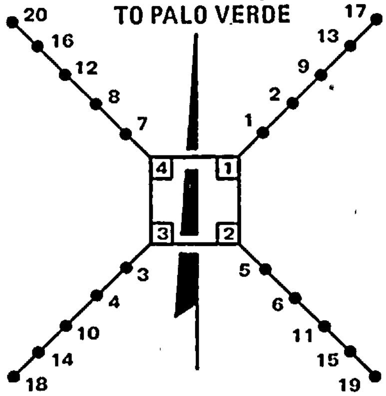
Pipeline maintenance will be minimal. The pipeline will be underground and the land in the right-of-way will revert to its original state, which is either agricultural or natural desert. The existing service roads and highways will be used for the minimal maintenance access that may be required.

5.5.2.2 Effects of Operation Maintenance

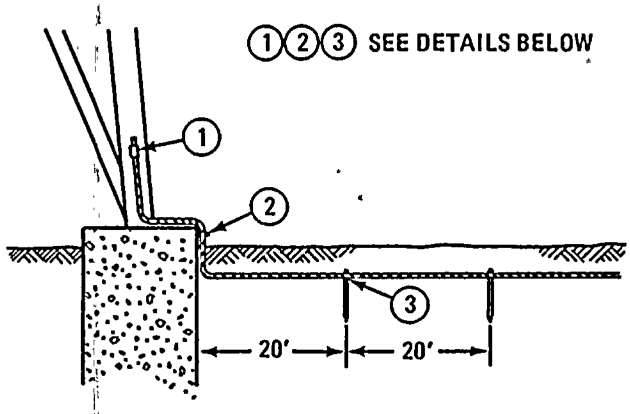
No significant environmental effects are expected as a result of the operation and maintenance programs. Ecological impact of maintenance of the pipeline will be minimal. Since portions of the right-of-way will not be returned to agricultural use, certain noxious weeds will rapidly emerge. APS has proposed to mitigate this ecological detriment by judicious application of a suitable weed control chemical in the affected areas.[1] Adverse archaeological and ecological effects of the maintenance of the wastewater pipeline, once installed, should be minimal because additional maintenance roads are not required.

5.5.3 REFERENCES

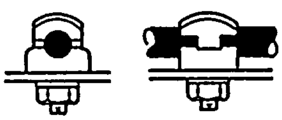
1. Letter to the Nuclear Regulatory Commission, from E. E. Van Brunt Jr., October 2, 1979.



INSTALLATION OF RODS
SHALL BE IN ORDER SHOWN.

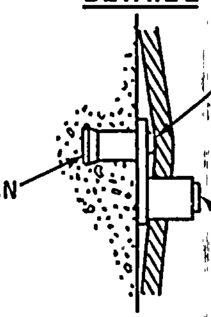


DETAIL 1

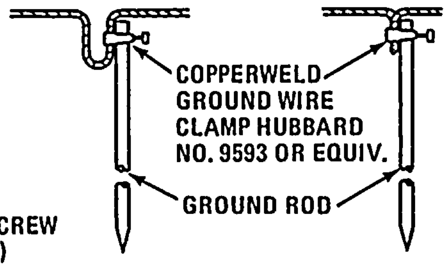


CABLE TO FLAT TERMINATING
CLAMP. PENN-UNION LSN025NE
OR EQUIV.

DETAIL 2



DETAIL 3



EITHER METHOD
ACCEPTABLE

2

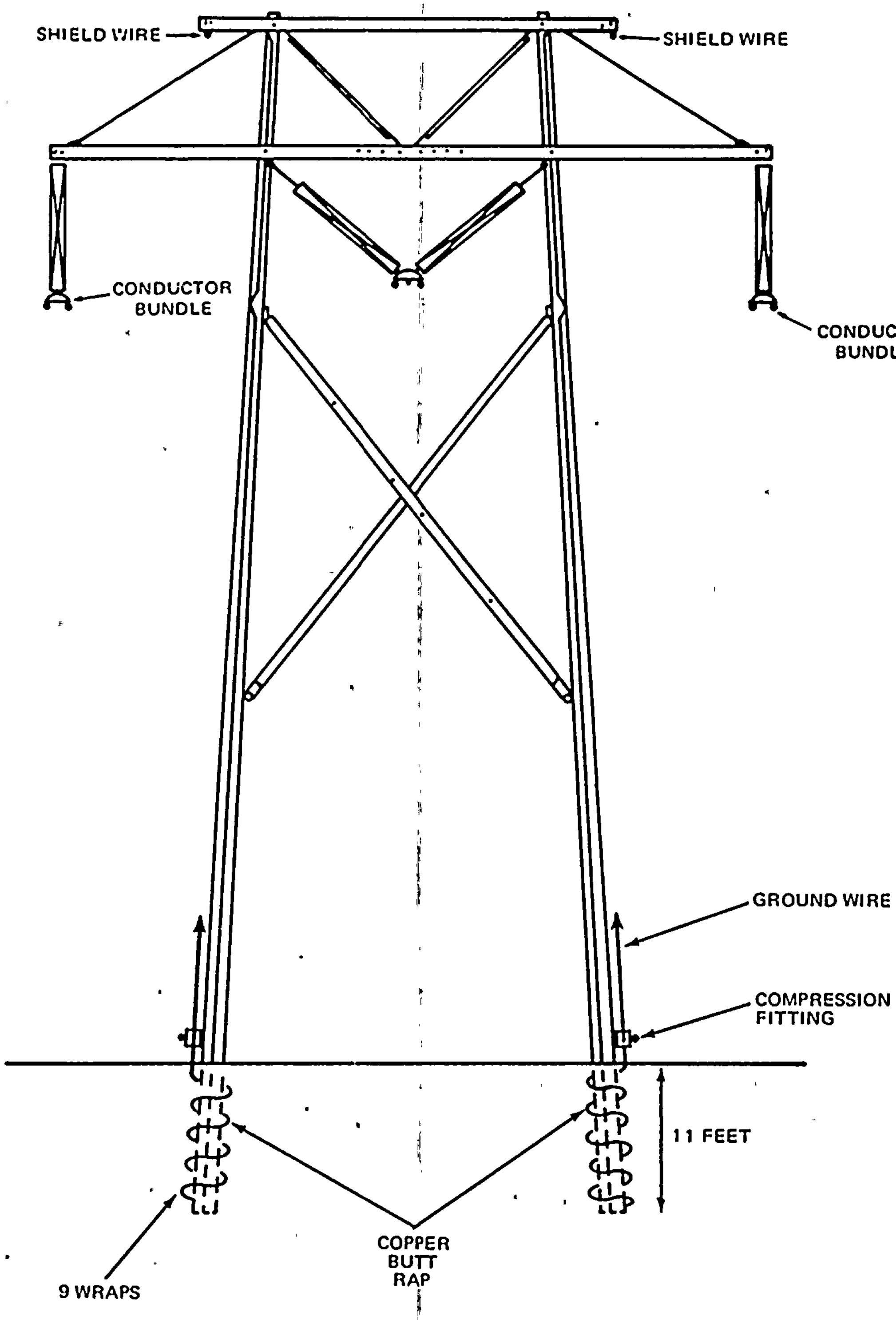
NOTES:

1. GROUND WIRE MAY BE EITHER 5/16" OR 3 NO. 8 COPPERWELD ATTACHED TO CONCRETE FOOTING PER DETAIL 2 IF PROJECTION IS 18-INCHES OR OVER.
2. WIRE TO BE BURIED 12-INCHES DEEP IN UNCULTIVATED AREA WHERE SOIL IS AVAILABLE AND COVERED WITH ROCK WHERE NO SOIL IS AVAILABLE. IN CULTIVATED AREA, WIRE DEPTH IS TO BE 2-FEET OR AS SPECIFIED.
3. ONE 3/4-INCH x 10-FOOT COPPERWELD ROD FOR EACH 20-FOOT LENGTH OF COUNTERPOISE IS TO BE USED WHERE REQUIRED WITH CONCRETE OR GROUTED FOOTING.
4. GROUND RODS ARE TO BE DRIVEN OR A HOLE DRILLED AND THE ROD GROUTED SO THE TOP OF THE ROD MATCHES THE COUNTERPOISE IN DEPTH BELOW THE SURFACE OF THE GROUND.
5. ALL COUNTERPOISE MUST BE CONTAINED WITHIN THE LIMITS OF THE RIGHT-OF-WAY. THE DIRECTION OF THE COUNTERPOISE MAY BE ALTERED UP TO 15° OR DOUBLED BACK TO AVOID OBSTRUCTIONS PROVIDED IT DOES NOT HAVE A TURNING RADIUS OF LESS THAN 10-FEET OR COME WITHIN 20-FEET OF ITSELF OR ANY PART OF THE TOWER.
6. GROUT FOR RODS IN ROCK HOLES TO CONSIST OF ONE PART PORTLAND CEMENT AND THREE PARTS CLEAN SAND WITH SUFFICIENT WATER FOR EASY PLACEMENT.

Palo Verde Nuclear Generating Station
ER-OL

COUNTERPOISE INSTALLATION DETAILS
PROJECT 1

Figure 5.5-1

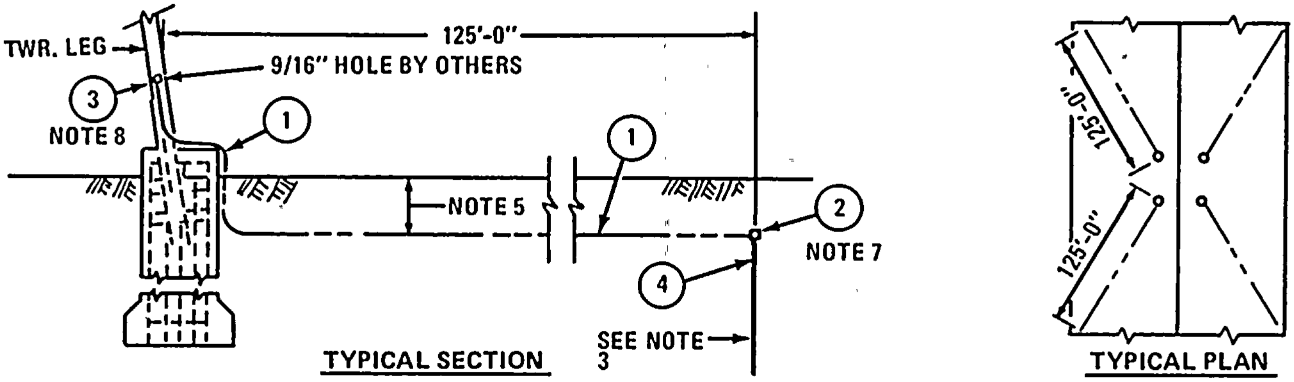


2

Palo Verde Nuclear Generating Station
ER-OL

PROJECT 3
GROUNDING DETAILS

Figure 5.5-2



NOTES:

1. FOLLOWING TOWER ERECTION BUT BEFORE GROUND WIRE INSTALLATION, THE RESISTANCE BETWEEN THE TOWER STEEL AND GROUND SHALL BE MEASURED. IN ADDITION, A MEASUREMENT SHALL BE TAKEN AFTER COUNTERPOISE IS INSTALLED.
2. ALL COUNTERPOISE MUST BE CONTAINED WITHIN THE LIMITS OF THE RIGHT-OF-WAY. THE DIRECTION OF THE COUNTERPOISE MAY BE ALTERED OR DOUBLED BACK TO AVOID OBSTRUCTIONS PROVIDED IT DOWS NOT HAVE A TURNING RADIUS OF LESS THAN 10 FT. OR COME WITHIN 20 FT. OF ITSELF OR ANY PART OF THE TOWER.
3. GROUND RODS ARE TO BE DIRVEN OR A HOLE DRILLED AND THE ROD GROUTED SO THE TOP OF THE ROD MATCHES THE COUNTERPOISE IN DEPTH BELOW THE SURFACE OF THE GROUND. 2
4. IF ONLY TWO ARMS ARE REQUIRED, ANY TWO DIAGONALLY OPPOSITE TWR LEGS MAY BE USED.
5. CABLE TO BE BURIED 12" DEEP IN UNCULTIVATED AREAS WHERE SOIL DEPTH IS AVAILABLE AND COVERED WITH ROCK OR ANCHORED TO LEDGE WHERE NO SOIL IS AVAILABLE. IN CULTIVATED AREAS, CABLE DEPTH IS TO BE 18".
6. GROUND CONNECTION BETWEEN FOOTING AND TOWER LEG SHALL BE MADE IN ALL CASES.
7. TWO CROSBY TYPE CONNECTORS TO BE USED.
8. ATTACH COUNTERPOISE TO TOWER LEG AT THE BACKSIDE OF FOOTING GROUND CONNECTION OR IN A VACANT STEPBOLT HOLE.
9. THE CONTRACTOR SHALL PROVIDE THE EDISON APPROVED COUNTERPOISE MATERIAL.

COUNTERPOISE TABLE

FOOTING RESISTANCE (OHMS)	COUNTERPOISE REQUIRED (PER TOWER)
0 – 30	NONE
31 – 100	TWO
OVER 100	FOUR

Palo Verde Nuclear Generating Station
ER-OL

COUNTERPOISE DETAILS
PVNGS-DEVERS

Figure 5.5-3

5.6 OTHER EFFECTS

5.6.1 ENVIRONMENTAL EFFECTS OF WATER DIVERSION

5.6.1.1 Wastewater Effluent Use

Information presented in ER-CP Section 5.7 and the FES has been updated by the following changes:

A. Condenser cooling water requirements for PVNGS have been revised to 21,350 acre-ft/yr/unit.

B. Estimates of sewage effluent availability have been prepared by the City of Phoenix Water and Sewer Department and by the Maricopa Association of Governments (MAG) Regional Council.

C. A number of reports have been prepared on the water use, reuse, and associated habitats along the Salt and Gila Rivers from 23rd Avenue in Phoenix to Gillespie Dam.

5.6.1.1.1 PVNGS Condenser Cooling Water Requirements

As discussed in section 3.3.1, the per-unit condenser cooling water requirement at the Palo Verde site is estimated to be 21,350 acre-ft/yr. This requirement is based on the following assumptions:

A. City of Phoenix wastewater effluent is to be utilized as the source of condenser cooling water in combination with that provided by the smaller City of Tolleson Wastewater Treatment Plant.

B. Wastewater effluent is to be obtained from the 91st Avenue Sewage Treatment Plant and the Tolleson Wastewater Treatment Plant. 4

C. The planned unit capacity factor is 95%.

D. Annual average ambient meteorological conditions.

E. There will be no blowdown treatment.

F. Losses will be as defined in figure 3.3-1.

G. One month per year allowed for refueling.

PVNGS water requirements vary by month. The sum of the requirements for each month gives the per-unit requirement of
2 21,350 acre-ft/yr.

5.6.1.1.2 Effluent Availability Projections

Projections of effluent availability from the 91st Avenue
2 Sewage Treatment Plant have been made by the Corps of Engineers and U.S. Environmental Protection Agency for the
4 Maricopa Association of Governments (MAG) in 1979 and by the
2 City of Phoenix Water and Sewer Department.

The Corps of Engineers and the U.S. Environmental Protection Agency have estimated[18] the quantity of effluent discharges from the 91st Avenue Plant as follows:

1980	1983	1985	1990	1995	2000
84.5 MGD	98.0 MGD	102.9 MGD	113.7 MGD	124.3 MGD	137.0 MGD

2 In comparison to the foregoing estimates, in September, 1979, the City of Phoenix estimated[1] effluent discharges from the 91st Avenue Plant for the same years as follows:

1980	1983	1985	1990	1995	2000
100,200 a-f[a]	116,000 a-f	126,600 a-f	153,060 a-f	179,500 a-f	205,900 a-f
(89.5 MGD)	(104 MGD)	(113 MGD)	(137 MGD)	(160 MGD)	(184 MGD)

4 In 1981, MAG revised their projections of the quantities of effluent to be discharged from the 91st Avenue Plant as a result of improved effluent flow data, the development of actual sewer service connection figures for the Multi-City system and increased

2 a. acre-feet

population projections by the MAG Transportation Planning
Office[20]. These new projections are as follows:

1985	1990	1995	2000
103.6 MGD	119.0 MGD	133.4 MGD	151.5 MGD

In comparison to the MAG 1981 estimates, in August 1981, the
City of Phoenix estimated effluent discharges from the 91st 4
Avenue Plant for the same years as follows[21]:

1985	1990	1995	2000
143,469	177,807	211,799	247,739
a-f	a-f	a-f	a-f
(128.1 MGD)	(158.8 MGD)	(189.1 MGD)	(221.2 MGD)

On the basis of these two independent estimates (extrapolating
the increase in flows from 1985 to 1986 from the differential 2
between the estimates for 1983 and 1985), the effluent dis-
charges in 1986 are expected to fall within the range of
105.4 MGD to 134.2 MGD, or 118,000 to 150,300 acre-feet. The 4
validity of estimates is confirmed at least partially by
comparison of estimates for 1980 with the actual flows from the
91st Avenue Plant, as follows:

COE/EPA 1980 Estimate	84.5 MGD
Phoenix 1980 Estimate	89.5 MGD
Actual 1980 Effluent Discharges[19]	88.46 MGD

2

Assuming that the total effluent produced at the 91st Avenue
Plant in 1986 will be in the range of 118,000 to 150,300 4
acre-feet, the amount available for use at Palo Verde will be 2
in the range of 79,500 to 111,800 acre-feet. The basis used 4
to determine the amount available for use at Palo Verde 2
assumes that 38,500 acre-feet will be delivered or discharged

to users having prior rights to use at Palo Verde pursuant to Agreement No. 13904, as follows:

Buckeye Irrigation District	30,000 acre-feet
2 Arizona Game & Fish Department	7,300 acre-feet
U.S. Water Conservation Lab	1,200 acre-feet

This deduction is conservative insofar as predicting the
amounts available to Palo Verde, because the U.S. Water Con-
4 servation Laboratory ceases to exist and hence, is no longer
using its reserved effluent and the Arizona Game & Fish
Department has abandoned its wildlife project for which 7,300
acre-feet were reserved. There are no other users of effluent
with rights prior to Palo Verde.

The only other user of effluent from the 91st Avenue Plant is
the Buckeye Irrigation District, which, in the five-year
period from 1972 to 1977, diverted on the average 82,000
acre-feet per year from the Gila River at the Buckeye Heading.
2 Of this average amount, the source of 14,500 acre-feet was
the Salt River Project feeder ditch. The balance, or 67,500
acre-feet, is assumed to be effluent from the 91st Avenue and
the 23rd Avenue Plants (Reference 18, page 3-42). Of such
67,500 acre-feet of effluent, 30,000 acre-feet was discharged
into the river pursuant to the agreement between BID and the
City of Phoenix. Assuming that in 1987 (the first year in
which all three Palo Verde units will be in operation for a
full year) the total effluent discharges from the 91st Avenue
4 Plant are extrapolated to 107.16 MGD, the amount of effluent

available to BID for agricultural irrigation would be 55,966 to 86,250 acre-feet, determined as follows: 4

	MAG 1981 Estimate (acre-feet)	Phoenix 1981 Estimate (acre-feet)	
			2
Total Effluent Available	120,016	150,300	4
BID/Phoenix Contract	30,000	30,000	2
PVNGS Use	64,050	64,050	4
Total	94,050	94,050	
Balance discharged to River and available to BID	25,966	56,250	2 4
Total Effluent Available to BID	55,966	86,250	2 4

If the Phoenix 1981 estimates prove to be accurate, there will be sufficient effluent available to meet BID's 1972-77 average uses. If the MAG 1981 estimates are assumed, then the difference between the total amount available to BID (55,966 acre-feet) and its average 1972-77 usage (67,500 acre-feet) will have to be made up from one or more of the following sources: 4 2 4 2

(1) Annual increases in effluent discharges from 91st Avenue Plant - (MAG Est. 1985-1990) ..... 3,450 acre-feet/year 4

(2) Effluent discharges from 23rd Avenue Plant .... 41,000 acre-feet/year[(b)] 2

---

b. Roosevelt Irrigation District has a prior right (which has not yet been exercised) to purchase up to 20,000 acre-feet of effluent from the 23rd Avenue Plant.

2 (3) Pumped Water .... Difference between
4 11,534 acre-feet and
the sum of sources
(1) and (2)

2 On the basis of the foregoing assumptions, there will be no apportionment of effluent (except pursuant to contract) and none will be required.

Another source of effluent which contributes to the previous discussion is the Tolleson Wastewater Treatment Plant which heretofore has not been worthy of note because of its minimal contribution of flows in the area. However, because of recent changes in the wastewater planning process, the Tolleson WWTP is in the process of being expanded from a present capacity of 4.0 MGD to 8.3 MGD which will be completed by early in 1982. Flows from the existing and future plant additions are designed to be discharged into the Salt River channel similar to that from the Phoenix facilities.

However, on June 12, 1981 APS, the Salt River Project and Tolleson
4 entered into an agreement for the delivery and purchase of effluent for the benefit of the Palo Verde units.

The contract calls for the maximum delivery of 8.3 MGD of secondary treated effluent to the Palo Verde pipeline, recognizing Tolleson's previous commitments to a local turf grass farmer (2.0 MGD) and their own potential reuses (.6 MGD) both of which fluctuate during the year. As a resource, the Tolleson effluent will be used first before other effluent supplies, therefore, potentially increasing the flows to the Salt River from the 91st Avenue Plant as discussed above. The primary purpose for this effluent purchase is to ensure effluent availability for peak summer month operation of all three Palo Verde units.

Assuming each of the three Palo Verde units is shut down for
2 one month each year for refueling and maintenance, and operates at a 95% capacity factor during the balance of the year,

and assuming average ambient conditions, the effluent usage is estimated to be (refer to figure 3.3-1).

	Each Unit	3 Units	
			2
Miscellaneous Pipeline and Reclamation Plant Losses	--	0.10 MGD	
Reservoir Evaporation and Seepage	--	0.39 MGD	4
Cooling Tower Evaporation, Drift and Blowdown	19	57 MGD	2
			4
	Total	57 MGD	

The criteria used in evaluating losses included specification requirements for pipe leakage, solar evaporation rates appropriate for the site, design permeability of the reservoir liner, and specification details of the cooling towers and other plant systems. 2

2

5.6.1.1.3 Environmental Effects of Water Diversion

A number of reports have been prepared on the water use, reuse, and associated habitats along the Salt and Gila Rivers from 23rd Avenue in Phoenix to Gillespie Dam.[3-8] These reports point out that the total water balance of the beds of the Salt and Gila Rivers from the City of Phoenix 23rd Avenue Sewage Plant, downstream to Gillespie Dam (hereinafter described as the River Study Area), must be considered in order to accurately predict the ecological effects of wastewater use.

Although the surface water and groundwater regimes are interdependent, the major potential ecological impacts from use of the wastewater effluent can be classified as those resulting from alterations of habitats which are primarily dependent on groundwater (e.g., the areas supporting phreatophytes) and habitats primarily dependent on surface water.

5.6.1.1.3.1 Groundwater Dependent Habitat. Based on historical rates of groundwater recharge, it does not appear that piping the wastewater effluent required to meet the cooling requirements will substantially alter the groundwater-dependent habitats of the River Study Area. The important phreatophyte habitats in the River Study Area are largely recharged from other sources. For example, the winter flood of 1965-1966 contributed to substantial replenishment of the underground water supply in the greenbelt region between 91st Avenue and Buckeye Heading, and this stretch of the river currently receives underflows from the Gila River (estimated to be 3500 acre-feet per year).[3,4]

Considering the next reach of river between Buckeye Heading and the South Extension Canal, it is anticipated that Buckeye Irrigation District (BID) will continue to exercise its appropriative rights and divert almost all the water in the Gila River at Buckeye Heading during much of the year. Therefore, this region is expected to change little in phreatophyte habitat quality. The BID has under contract 30,000 acre-ft/yr of wastewater effluent from the 91st Avenue Sewage Treatment Plant. When the PVNGS pipeline becomes operational, this wastewater effluent will be delivered via the pipeline and may result in BID having to pump less groundwater to supplement its irrigation needs. Therefore, the nearby adjacent section of the River Study Area could have a faster groundwater recharge rate.

The last region of the River Study Area, extending from the South Extension Canal to Gillespie Dam, presently supports an extensive phreatophyte habitat which is heavily used by white-winged doves. This stretch of the River Study Area has historically had a shallow water table, resulting in water-logged conditions in lands adjacent to the river. Sewage effluent has never had a very important role in the continual maintenance of this portion of the River Study Area,[3] and it is not anticipated to have a significant role in the future.

5.6.1.1.3.2 Surface Water Dependent Habitats. Use of wastewater effluent for PVNGS would result in a gradual reduction of the surface water-dependent habitats during the 1983-1986 period. The resulting impact on the surface water habitat is expected to be minimal. It is known that decreasing the amount of surface water will result in altering wildlife habitat, making it less favorable to some species and more favorable to others.[8] Although it is speculative to determine what the everchanging river channel will be like in the future, it has been documented that one endangered species, the Yuma Clapper Rail, inhabited the 107th Avenue Flushing Meadows Marsh as early as 1970.[9]

The seasonal and daily fluctuations in water levels in the river channel can affect various biological phenomena ranging from plant germination to mosquito breeding. The upper reaches of the River Study Area (whose surface water habitats are comprised primarily of wastewater effluent) presently have a wide fluctuation of water level over a 24-hour period, since maximum effluent discharges can be up to four times the minimum discharges into the river. The River Study Area also undergoes irregular seasonal fluctuations as a result of runoff from rains, rain interception, and periodic flooding. Use of wastewater effluent at PVNGS will result in wider seasonal (although not daily) fluctuations of the surface water levels in the upper reaches of the River Study Area compared to those existing presently. Effluent used by the Buckeye Irrigation Company is diverted as shown in figure 3.9-5. 2

Although reducing the wastewater flow will cause a temporary loss of open water aquatic habitat, this loss would not substantially reduce the number of any wildlife species which may be using the area. For example, the Yuma Clapper Rail is most prevalent in the Colorado River Delta in Mexico and along the southern portions of the Colorado River in the United States.[10] The status of Yuma Clapper Rail populations remains uncertain; however, its numbers are apparently greater than originally thought when this species was classified as endangered.[11]

5.6.1.1.4 Conclusions

The ultimate effect of using wastewater effluent at PVNGS is dependent upon the actual quantities of effluent available. Using the MAG estimates, the effects are expected to be more severe than with the City of Phoenix estimates. However, even using the MAG estimates, which are considered to be a lower bound of effluent availability, it is anticipated that transporting water to PVNGS would have no substantial long-term negative impacts on the Sonoran desert riparian or aquatic ecosystems. PVNGS water use would have negligible ecological

impacts on groundwater-dependent habitats, and short term ecological effects on surface water-dependent habitats.

Decisions concerning dams, impoundments and river channelization will also greatly affect the quality of wildlife habitat in the River Study Area. Currently, 7500 acre-ft/yr of wastewater effluent is committed to the Airzona Fish and Game Commission for wildlife enhancement downstream of 91st Avenue. This amount will be unaffected by PVNGS wastewater use. The Maricopa County Flood Control District is presently considering a project that will clear vegetation from a 1000 ft wide strip in the channels of the Salt and Gila Rivers between 91st Avenue and Gillespie Dam for the purposes of flood control. The Corps of Engineers and the Bureau of Reclamation are performing a study (Central Arizona Water Control Study) to be completed in May 1982, which considers flood control measures such as levies and channelization for the Salt and Gila Rivers.

5.6.1.2 Groundwater Use

During plant operation, groundwater from the regional aquifer will be used only for the domestic water supply. The domestic water requirement for three units is estimated to be about 1000 gal/min (1600 acre-ft/yr). This rate of groundwater withdrawal is about one-third the withdrawal rate during the last few years of irrigation. The effects of onsite pumping for the domestic water supply on regional aquifer water levels has been analyzed based on values of transmissivity (100,000 (gal/d)/ft) and storage coefficient (0.005), as determined by an aquifer pumping test conducted on the production well (B-1-6) 34 abb. For the projected pumping rate of 1600 acre-ft/yr, the predicted drawdown in the production well after 35 years of operation is 30 feet. By the same analysis, the predicted drawdown at distances of 0.5, 1, 2, 5, and 10 miles is 10.6, 9.1, 7.5, 5.3 and 3.7 feet, respectively. These predictions overestimate the

drawdown because they do not incorporate the compensating effects of cessation of irrigation in the site area. As noted previously, a significant rise in water levels has been observed since 1975 because of the reduction of onsite pumping rates from about 6000 acre-ft/yr (the result of agricultural activity) to 350 acre-ft/yr during construction. Because of this reduced pumping rate, regional aquifer water levels are expected to continue to rise during construction. When all three units are in operation and the pumping rate is increased to 1600 acre-ft/yr, water levels can be expected to decline, but at a rate slower than that observed during irrigation (prior to 1975).

5.6.2 PLANT OPERATION NOISE

The information formerly presented in ER-CP Section 5.7 and the FES has been revised to reflect new HUD noise criteria. The operational noise projections were reanalyzed.

The principal sources of plant operation noise include the cooling towers, transformers and related electrical equipment in the switchyard, turbines, motors and pumps of each unit, and reclamation plant motors and pumps.

The round, wet mechanical-draft cooling towers will be the dominant noise source. The rotating fans, vortex shedding, turbulence, airflow over fins, bearing rumble, and resonance in the plenum are the noise sources in the cooling towers. Noise from circulating water pumps and motors will be minor compared to noise from these sources. The vortex shedding and turbulence from the fan blades are the principal noise sources of the towers. This noise will be proportional to fan tip speed and the pressure rise across the fan. Water falling onto the packing of the tower and into the pond, which covers the area of the base, will cause additional noise. The sound power level assumed here for each cooling tower is based on the manufacturer's operational noise data.[12] The assumed sound

power level of the turbines, transformers, and pumps and motors is based on published source-term data that has been appropriately scaled to the size of the PVNGS equipment[13,14,15]

Operational sound levels were predicted using the computer code SOCON. SOCON calculates resultant sound levels, including background sound, on a grid basis from an arbitrary number of noise sources at different locations, assuming uniform hemispherical sound propagation and frequency-dependent atmospheric absorption. Inputs include the sound-power frequency spectrum and grid coordinates of each source. These are provided in table 5.6-1. Outputs include coordinates of A-weighted sound-level isopleths, which are then plotted on a site map. 2

The attenuation factors used to account for atmospheric absorption in the analysis are based on information presented by Beranek.[16] The basic model is conservative in that no credit is given for excess attenuation by vegetation, ground effects, topographical effects, or meteorological effects such as shadow zones induced by wind or thermal gradients.

Point sources were considered in this analysis, including the three cooling towers for each unit, the equipment within each unit, the switchyards, and the reclamation plant. Predicted sound levels from the operation of PVNGS are presented in figure 5.6-2. Because the sound power level of each source is assumed to be constant, the predicted sound levels are approximately equal to the L_{eq} sound levels (refer to section 6.1.1.2). Actual sound levels will vary depending on the operation of auxiliary equipment, the use of equipment producing intermittent noise, and atmospheric conditions.

The maximum predicted sound level at the site boundary will occur along the west boundary near the cooling towers of Unit 3 where the maximum predicted L_{dn} sound level is 64 dBa. Sound levels due to plant operation are conservatively predicted not to exceed the HUD acceptable noise criteria of 65 dBa for L_{dn} in any offsite areas.

Table 5.6-1

SOUND POWER SPECTRA AND LOCATION FOR NOISE SOURCES

Source	Location[(a)(b)] (feet)	Overall Sound Power Level (dB, re: 10^{-12} Watts)	Frequency Spectrum (dB, re: 10^{-12} Watts) 63 Hz	125	250	500	1000	2000	4000	8000
Unit 1	E211400 N870510	105.9	-	-	-	-	-	-	-	-
Unit 2	E210650 N869760	105.9	-	-	-	-	-	-	-	-
Unit 3	E210350 N868710	105.9	-	-	-	-	-	-	-	-
Transformers	E212450 N868860	119.9	-	-	-	-	-	-	-	-
Reclamation Pumps	E212600 N872910	108.7	-	-	-	-	-	-	-	-
Cooling Towers:										
Unit 1 A	E211250 N871710	-	123.5	120.5	116.6	111.7	107.9	110.3	112.2	112.9
B	E210600 N871860	-	123.5	120.5	116.6	111.7	107.9	110.3	112.3	112.9
C	E210950 N871360	-	123.5	120.5	116.6	111.7	107.9	110.3	112.2	112.9
Unit 2 A	E210200 N870660	-	125.5	120.5	116.6	111.7	107.9	110.3	112.2	112.9
B	E209750 N870660	-	123.5	120.5	116.6	111.7	107.9	110.3	112.2	112.9
C	E209900 N870210	-	123.5	120.5	116.6	111.7	107.9	110.3	112.2	112.9
Unit 3 A	E209450 N869310	-	123.5	120.5	116.6	111.7	107.9	110.3	112.2	112.9
B	E209000 N869160	-	123.5	120.5	116.6	111.7	107.9	110.3	112.2	112.9
C	E209300 N868860	-	123.5	120.5	116.6	111.7	107.9	110.3	112.2	112.9

(a) Grid coordinates are for the site grid as shown in Figure 3.1-4 which corresponds to a 20.000 foot grid based on the Arizona coordinate system, central zone.

(b) All sources assumed at ground level.

2

Along the Buckeye-Salome Road the noise levels, due primarily to traffic, exceed the HUD acceptable noise criterion of $L_{dn} \leq 65$ dBA for residential areas and fall within the HUD normally unacceptable range of 65 dBa < L_{dn} < 75 dBa. Information on the background sound levels is presented in section 2.7. Traffic noise levels will tend to mask the noise of plant operation along and to the north of the Buckeye-Salome Road. Plant operation noise will not significantly increase the noise levels at the residences along Buckeye-Salome Road. However, because of the low ambient noise levels in areas other than along the Buckeye-Salome Road, the plant operation noise may be audible approximately 4 miles from the plant cooling towers.

5.6.2.1 Documentation of SOCON

SOCON was written by B. Bartram and R. Werth based on references 16 and 17 in FORTRAN-IV on the NUS Prime 500 system. SOCON produces A-weighted sound pressure level contours on a 27x27 grid using sound power level spectrums from a number of sources (up to 50) and background sound levels. The contributions from each source to the sound pressure level at a grid point is calculated on the basis of the following equations: 2

$$SPL_s = 10 \log \sum_f 10^{(SPL_{f/10})}$$

$$SPL_f = PWL_f + AA_f - 1.7x10^{-6} fr - 20 \log r + 2.5$$

where:

SPL_s = sound pressure level contribution for the source (re: $2x10^{-5}$ N/m^2)

SPL_f = sound pressure level contributions for each center band frequency, i. (re: $2x10^5$ N/m^2)

PWL_f = sound power level for the source for frequency f (re: 10^{-12} Watts)

f = frequency, H_2 (SOCON considers eight octave bands - 63, 125, 250, 500, 1000, 2000, 4000, and 8000 H_2)

AA_f = A-weighting factor for the frequency band. SOCON uses the following A-weighting factors for the eight octave bands above: -26.1, -16.2, -8.6, -3.3, 0.0, 1.2, 1.0 and -1.1 (dB).

r = distance from the source to the grid point (feet)

2 SOCON produces tables of 1) the sound pressure level of each grid point, 2) the background sound pressure level, 3) the increase over the background, and 4) the contribution of the sources to the sound levels. Further, for each dBA value selected, SOCON produces a map with the coordinates of that sound pressure level contour.

SOCON calculates atmospheric attenuation with the factor $1.7x10^{-6}$ f r (dB) which is based on curves of excess attenuation due to molecular absorption (Reference 17). SOCON assumes hemispherical sound propagation in the terms -20 log r + 2.5. The SOCON predictions are conservative in that no credit is given for excess attenuation by vegetation, ground effects, topographical effects, or meteorological effects such as shadow zones induced by wind or thermal gradients.

5.6.3 OPERATIONAL WORKFORCE IMPACTS

The projected number of operational workers at PVNGS is provided in table 8.1-3A. The table provides a quarterly accounting of the workforce increase as Units 1, 2, and 3 are completed. It

Table 5.6-2

ESTIMATE OF STARTUP PERIOD OPERATIONAL TRAFFIC VOLUME
IN AND OUT OF PLANT

Year	Projected Average # of Cars & Buses In and Out Per Day		Projected Average Number of Common Carrier Trucks In and Out Per Day	Projected Total Average of Vehicles In and Out Per Day
	Buses	Cars		
1981	12	28	3	43
1982	17	33	3	53
1983	19	51	3	73
1984	20	50	3	73
1985	22	58	3	83
1986	23	67	3	93

2

is expected that 75% of the operational workforce will be hired from outside the area. It is also expected that they will reside in west Phoenix.

Estimated annual averages of traffic volume in and out of PVNGS during operation is provided in table 5.6-2.

5.6.4 REFERENCES

1. Letter from Robert B. Steytler, Assistant Director, City of Phoenix Wastewater Operations, to Mr. Terry Hudgins, Arizona Public Service Company, September 20, 1979.

2. Maricopa Association of Governments, 208 Water Quality Management Program, Final Plan, July, 1979.

3. Halpenny, L. C. and Greene, D. K., Water Balance Investigation of River Bed, Salt and Gila Rivers, 23rd Avenue to Gillespie Dam, Arizona Water Development Corp., Tucson, Arizona, 1975.

4. Halpenny, L. C. and Clark, S. D., 1977 Supplement to Water Balance Investigation of River Bed, Salt and Gila Rivers, 23rd Avenue to Gillespie Dam, Arizona Water Development Corp., Tucson, Arizona, 1977.

5. Water Resources Associates, Inc., Report on Water Balance, Salt and Gila Rivers, 23rd Avenue to Gillespie Dam, Scottsdale, Arizona, 1975.

6. Water Resources Associates, Inc., Explanatory Notes on Mapping of Vegetation Types, Salt and Gila Rivers, 23rd Avenue, Phoenix, to Gillespie Dam, Scottsdale, Arizona, 1976.

7. Potential Reuse Options for Wastewater Effluent and Residual Solids, U.S. Army Corps of Engineers, Los Angeles District, Phoenix urban study, 1977.

8. Haase, E. F., 1973. Draft Environmental Study. Gila River from the Confluence of the Salt River Downstream to Gillespie Dam. Submitted to the U.S. Army Engineer District, Los Angeles, California.

9. Personal communications. B. Pinkowski, NUS Corp. with Richard Todd, Arizona Game and Fish Dept., November 4, 1977.

10. Tomlinson, R. E. and Todd, R. L., "Distribution of Two Western Clapper Rail Races as Determined by Responses to Taped Calls", The Condor, Vol. 75, No. 2, 1973, pp. 177-183.

11. American Ornithologists Union, Report of the American Ornithologists Union Committee on Conservation, 1976-1977, supplement to AUK, Vol. 94, No. 4, 1977.

12. Personal communication, R. Andes, NUS Corp., with J. S. Gosmano, Marley Cooling Tower Company, September 23, 1977.

13. Heitner, I., "How to Estimate Plant Noise," Hydrocarbon Processing, December 1968.

14. Harris, C. M., Handbook of Noise Control, McGraw-Hill Book Company, Inc., New York, 1957.

15. Berger, B., et al., "Transformer Noise," Philosophical Transactions of the Royal Society, Series A, Vol. 263, pp 381-411, 1968.

16. Beranek, L. L., Noise and Vibration Control, McGraw-Hill Book Co., Inc., New York, 1971.

17. Beranek, L. L., Noise Reduction, McGraw-Hill Book Co., Inc., New York, 1960.

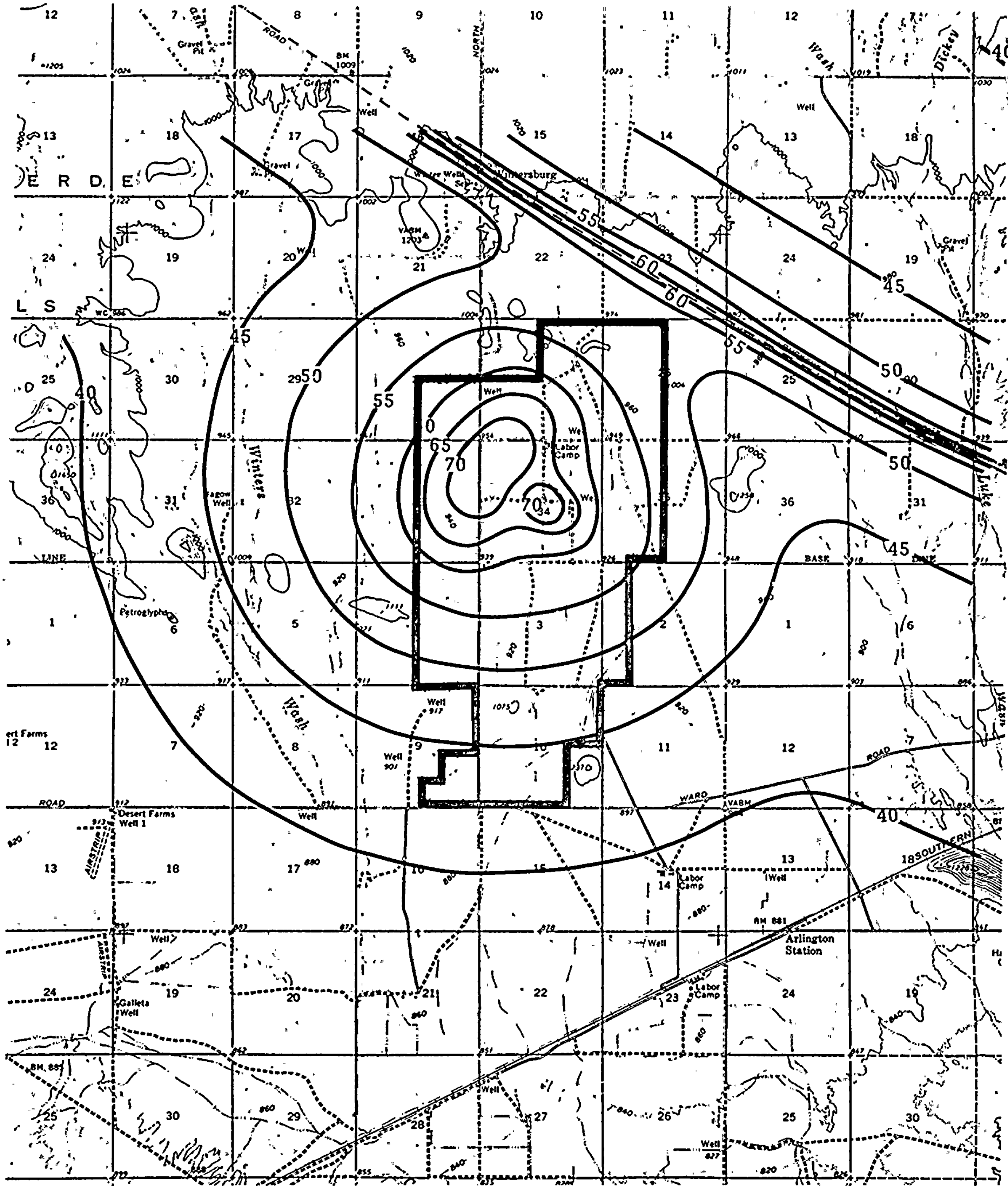
18. Final Environmental Impact Statement on the Maricopa Association of Governments Point Source Metro Phoenix 208 Waste Water Management Plan, U.S. Environmental Protection Agency, July 1979. 2

19. Memo from K. E. Spiker to R. B. Stextler, Phoenix Water & Sewer Department, January 23, 1981

20. MAG 208 Point Source Plan Revision, Eastside Area Analysis, Local vs. Regional, September 1981. James Fulton, Consultant; John Carrolo Engineers; Dibble & Associates. 4

21. Flow Projection Comparison. MAG 208 Study vs Phoenix Wastewater Division Projection in MGD. Dated August 26, 1981. Prepared by Robert Steytler, Assistant Director, Wastewater Operations, City of Phoenix.

Figure 5.6-1 DELETED 2



NOTE: VALUES IN dBA

Palo Verde Nuclear Generating Station
ER - OL

DAY-NIGHT
AVERAGE SOUND LEVEL CONTOURS
FOR PLANT OPERATIONS
Figure 5.6-2

5.7 RESOURCES COMMITTED

Resources committed due to plant operation were estimated in ER-CP Section 5.8 and the FES and have not changed significantly. What follows is a summary of information previously presented.

5.7.1 REPLACEABLE COMPONENTS AND CONSUMABLE MATERIALS

Uranium is the principal natural resource material irretrievably consumed as a result of plant operation. Other materials include fuel-cladding materials, reactor core component materials, fuels and various chemicals such as sodium hypochlorite, nitrogen, sulfuric acid, and sodium hydroxide.

In view of the quantities of these consumable materials in natural reserves, resources, stockpile, and the quantities produced annually, the expenditure of such materials for operation of PVNGS is justified by the benefits of the electrical energy produced.

5.7.2 CONSUMPTIVE WATER USE

Plant operation requires a significant commitment of water resources. Based upon annual average requirements, a total of approximately 66,300 acre-ft of water will be used to operate PVNGS. Approximately 97% of this water requirement will be satisfied by using wastewater effluent from the Cities of Phoenix and Tolleson Sewage Treatment Plants. The remaining 3%, requiring a potable water source, will be obtained from groundwater. 4

5.7.3 ENVIRONMENTAL LOSSES

There are no significant environmental losses associated with operation of PVNGS.

5.7.4 LAND RESOURCES

The amount and types of land committed depend on the eventual decommissioning plan adopted (refer to section 5.8).

5.8 DECOMMISSIONING AND DISMANTLING

The information formerly presented in ER-CP Section 5.9 and the FES has been revised to reflect issuance of Regulatory Guide 1.86 and other studies.

5.8.1 DECOMMISSIONING AND DISMANTLING POLICIES

Arizona Public Service Company's plans and policies regarding ultimate disposition of PVNGS Units 1,2&3 cannot be finalized at this time in view of the unforeseeable changes in rules and regulations and the technological advancement which will take place over the useful life of the units. Toward the end of the units' useful lifetime, a proposed decommissioning plan will be submitted to the NRC for review. The plan will comply with NRC rules and regulations then in effect.

The decommissioning of reactors is not new. Since 1960, five licensed nuclear plants, four demonstration nuclear power plants, six licensed test reactors, 28 licensed research and 22 licensed critical facilities have been or are in the process of being decommissioned(1).

APS intends to retain possession of the PVNGS site for power generation purposes for an indefinite period of time beyond the useful life of Units 1,2&3. Generally, the land commitment at the PVNGS site is retrievable. The actual degree of retrievability is dependent on the level of decommissioning and dismantling. It is not anticipated that the transmission system will be decommissioned.

Environmental consequences of decommissioning are not expected to be greater than the temporary consequences which occur during construction.

The primary environmental impact of decommissioning and dismantling will be the cessation of those impacts described in sections 5.1, 5.2, 5.3, and 5.4.

DECOMMISSIONING AND DISMANTLING

Although no final plans for decommissioning can be made, the cost of immediate dismantlement of one PVNGS unit is estimated to be about $57 million ($1979)[2]. This estimate includes the following dismantling operations:

- Site and facility preparation
- Removal of spent fuel
- Decontamination of piping and equipment
- Removal of nuclear and containment systems components
- Shipment and burial of radioactive waste
- Demolition of remaining structures

Whether immediate dismantlement would be the most prudent course if electric generation were to continue at the PVNGS site after the useful lives of the units is not clear at this time. Other alternatives for decommissioning that could be considered for PVNGS are described in Regulatory Guide 1.86 and result in lower costs when decommissioning is ultimately required.

5.8.2 REFERENCES

1. P. B. Erickson and G. Lear, "Decommissioning and Decontamination of Licensed Reactors Facilities and Decomonstration Nuclear Power Plants," presented at Conference on Decontamination and Decommissioning in Idaho Falls, Idaho, August 19-21, 1975.

2. "Update of Estimated Costs for Decommissioning One of the Palo Verde Nuclear Generating Station (PVNGS) Units," Prepared for Arizona Nuclear Power Project by the S. M. Stoller Corporation, October 3, 1979.

APPENDIX 5A

RESPONSES TO NRC QUESTIONS

TABLE OF CONTENTS

2

APPENDIX 5A

QUESTION 5A.1 (NRC No. 290.4) 5.1

State the distance from the towers for which Figures 5.1-7 and 5.1-8 are valid. Are these values for 3-unit operation?

RESPONSE: The response is provided in the revised section 5.1.4.7.

QUESTION 5A.2 (NRC No. 290.5) 5.4

Describe in more detail how the value of 365 $\mu g/m^3$ of SO_2 was calculated in Table 5.4-2. Was it assumed that 1 or 3 units were in operation for the full 24 hours? Also, the NAAQS standard is that 365 $\mu g/m^3$ is not to be exceeded more than once per year (indicated as the second highest calculated value). 2

RESPONSE: The response is provided in the revised section 5.4.

QUESTION 5A.3 (NRC No. 290.6) 5.4

Please provide information on existing air quality at the site so that the staff can determine if applicable air quality standards will be violated by emissions from the plant. Are the air pollution standards given in Section 5.4 still valid? If not, present the new values.

RESPONSE: Calculations of expected airborne concentration of dry drift particles due to the operation of the cooling towers are presented in section 5.1.4.4.2.

Section 5.4.2 has been revised to include the expected ambient air quality impacts due to the traffic associated with the operational workforce for Units 1-3. Also, table 2.3-24A, Summary of Ambient Air Quality Standards, has been revised. 4

QUESTION 5A.4 (NRC No. 290.7) 5.6.1

Describe how the Buckeye Irrigation Company will receive its water from the 91st Avenue Sewage Plant during PVNGS operation. Identify the location where water for the Buckeye Irrigation Company is diverted from water sent to PVNGS. Describe the mitigation measures planned to preserve the riparian habitates and green belts (CP-FES Section 2.7) once the water is diverted from the 91st Avenue Sewage Treatment Plant to PVNGS.

RESPONSE: The Buckeye Irrigation Company diversion location is provided in the revised section 3.9.

2 The mitigation measures that can be taken to preserve the riparian habitats and green belts referred to in the question are dependent primarily upon the steps that are taken to process the treat wastewater produced in the Phoenix metropolitan area. Such steps hinge, in turn, upon the development and implementation of areawide water quality management plans pursuant to Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) and the Clean Water Act of 1977 (P.L. 95-217), which amends P.L. 92-500. Pursuant to such statutory provisions, the Maricopa Association of Governments (MAG) has been designated as Section 208 planning agency for Maricopa County. After extensive studies conducted for MAG by the Corps of Engineers with substantial public input, MAG adopted in 1979 its Point Source Metro Phoenix 208 Wastewater Management Plan (hereinafter, the "Plan"). The Plan has been approved, as required by law, by the Governor and by the U.S. Environmental Protection Agency (EPA). In July, 1979, the EPA issued its Final Environmental Impact Statement on the Maricopa Association of Governments Point Source Metro Phoenix 208 Wastewater Management Plan (EPA-FEIS).

Under the Plan, approximately 85% of the wastewater from the Phoenix area would be treated at the 91st Avenue and

23rd Avenue treatment plants in Phoenix, with the remainder treated at nine satellite plants. A more complete description of the Plan may be found in Section 2.2 of the EPA-FEIS. The sources of wastewater inflows to the 91st Avenue and 23rd Avenue Plants are essentially the same as contemplated in the Palo Verde CP-FES (NUREG 75-078) and as committed under Section 7.3 of Agreement No. 13904 between the multi-cities owning and operating the 91st Avenue Plant, Arizona Public Service Company (APS) and Salt River Project (SRP). The only exceptions are the provision of small additional inflows to the 91st Avenue Plant from Luke Air Force Base and from the communities of Surprise and El Mirage. All of the planned satellite plants are outside the drainage area which the 91st Avenue Plant was originally designed to serve.

The Plan requires the upgrading of the 23rd Avenue and 91st Avenue treatment plants and the expansion of the 91st Avenue Plant in two stages: In 1981, from its present design capacity of 90 MGD to 120 MGD and, in 1990, or sooner, from 120 MGD to 137 MGD. In implementation of the Plan, the Phoenix City Council awarded in early 1981 a contract for the first stage expansion of the 91st Avenue Plant. 2

In considering, adopting and approving the Plan, MAG, the Governor and EPA rejected one alternative that would have provided an even greater expansion of the 91st Avenue Plant to serve areas outside its normal drainage area. Such alternative, if adopted, would have resulted in greater effluent discharges from the 91st Avenue Plant and the potential, absent increased diversions for reuse, for more support to some riparian habitats in some segments of the Salt and Gila Rivers.

The other alternatives to the Plan that were considered and rejected (*i.e.,* no action and Alternatives 3 and 4) would

have resulted in reduced inflows into the 91st Avenue Plant and, consequently, reductions in effluent discharges and the potential for reuse to support riparian habitats in the Salt and Gila Rivers, as well as for reuses for agriculatural irrigation and power production. Accordingly, it may be concluded that the Plan preserves the originally planned mitigation of impacts upon wildlife habitats on the Salt and Gila Rivers.

With respect to the Plan, EPA concluded that "it satisfies the requirements of the Clean Water Act and there are no adverse impacts of sufficient magnitude to outweigh the benefits to be derived." [EPA-FEIS, pages iv and 2-81.]. In its consideration of the benefits of the Plan, the EPA recognized that the Phoenix area is semi-arid and water short, that there is a need to conserve water resources and that the reuse of wastewater would help conserve water resources and would make other better-quality water available for higher uses. [EPA-FEIS, page 2-11.] The reuses identified by EPA for effluent from the 91st Avenue and 23rd Avenue plants included agricultural irrigation, power production and support of riparian habitats. [EPA-FEIS, pages 2-44 to 2-46.]

With respect to impacts of effluent reuse on riparian habitats, EPA concluded:

> "Despite some habitat losses, net biological changes throughout the area are expected to be beneficial as a result of implementation of the plan (Table 4-3). This is expected because increased water supply will enhance riparian habitat and associated aquatic conditions that in turn will contribute to wildlife diversity, particularly aquatic, semiaquatic, riparian-dwelling, and certain upland wildlife. [EPA-FEIS, page 4-16; further, see pages 5-48.]

Respecting the specific riparian habitats downstream of the 91st Avenue Plant, EPA concluded that it was unlikely that the diversions through the effluent pipeline to Palo Verde and Buckeye would have any significant impact on vegetation

downstream of 115th Avenue because other flows into the river below that point (EPA-FEIS, page 4-24). EPA also concluded with respect to the 2-1/2 mile river segment from 91st Avenue to 115th Avenue that reduced effluent flows could lead to degradation of riparian habitat. This conclusion, however, was based upon the assumptions (i) that Palo Verde Units 4 and 5 would be built and in operation in 1988 and 1990, respectively, and that, consequently, (ii) diversions of effluent from both the 23rd Avenue Plant and the 91st Avenue Plant to provide 107,000 acre-feet to Palo Verde would reduce annual flows of effluent in the river to a minimal discharge of 7,300 acre-feet (EPA-FEIS, page 4-20). Since the plans for Palo Verde Units 4 and 5 have been cancelled, these assumptions are no longer valid.

With three Palo Verde units in operation, diversions for PVNGS are not expected to exceed 64,000 acre-feet per year. Diversion of this amount and other committed diversions for irrigation would still permit the annual discharge of effluent into the Salt River in 1987 (the first year when three Palo Verde units will be in operation for a full year) of more than 50,000 acre-feet and in 1990, more than 59,000 acre-feet to support riparian habitats in the 91st Avenue to 115th Avenue segment of the river -- more than eight times the minimal discharge assumed by EPA. */ Consequently, the

*/ Assumes EPA projections in effluent flows in 1985, as shown in Table 4.4 of the EPA-FEIS (page 4-1), effluent from the Tolleson plant in the amount of 2,800 acre-feet (EPA-FEIS, page 2-54), and annual increases from 1985 to 1987 in effluent discharges equal to EPA's projected average annual increases for the 1985-1990 time period, less diversions of effluent for PVNGS in the amount of 64,000 acre-feet, Buckeye Irrigation District in the amount of 30,000 acre-feet and Roosevelt Irrigation District in the amount of 20,000 acre-feet (EPA-FEIS, page 2-44). The later diversion was not included in EPA's Table 4.4. On the basis of EPA's 1990 projections of effluent flows and the same diversions, the total effluent available to support riparian habitat in the 91st Avenue to 115th Avenue river segment would be 59,000 acre-feet per year.

2

conclusion that riparian habitat in that segment of the Salt River may be degraded is no longer valid.

It may be noted that EPA also stated that it has asked NRC to ensure that PVNGS uses only the minimum amount of effluent necessary. (EPA-FEIS, pages 4-24 and 5-78.) In this connection, four points should be made. First, there are no facilities at Palo Verde nor have there been discharge permits obtained or requested that would permit the diversion of more effluent than is required for operation of the Palo Verde units. In fact, that is the reason that the contract for effluent permits APS and SRP to take only that amount of effluent required for Palo Verde operations.

Second, the costs of treating effluent for use in the Palo Verde circulating water systems provides adequate incentive to minimize the effluent usage.

Third, APS has made a concerted effort to minimize losses
2 from pipeline leakage and reservoir seepage and evaporation. This has been achieved through applicability of quality assurance programs to the design and installation of the pipeline, the decision to line the reservoir, and the design of the reservoir which minimizes the surface area of the reservoir.

Fourth, the design of the water reclamation facility, the cooling towers and the balance of the circulating water systems are state-of-the-art. The result is a total system designed to permit recycling of treated effluent through the cooling towers to 15 times original concentrations of TDS, to minimize losses due to evaporation and drift and to significantly reduce losses from blowdown.

<u>QUESTION 5A.5</u> (NRC No. 290.9) 5.5

Provide a description of the grounding systems and line clearances which will be used to reduce induced voltages

and currents in conducting objects, such as fences and large tractor-trailers, in the vicinity of the right-of-way.

RESPONSE: The response is provided in the revised section 5.5.1.1.2.

QUESTION 5A.6 (NRC No. 290.10) 5.3.1

Describe how the growth of vegetation, along the perimeter of the evaporation pond will be controlled, if any exists.

RESPONSE: Upon completion of evaporation pond berms, vegetation will be encouraged. This should assist in preventing berm erosion. Since revegetation is desired, it is not expected that a vegetation control program will be required.

QUESTION 5A.7 (NRC No. 291.12-5.6.2) 5.6.2 2

Provide the sound-power frequency spectrum and grid coordinates of each sound source used as input to the computer code SOCON. Include the elevation of each assumed source.

RESPONSE: The response is provided in the revised section 5.6.2.

QUESTION 5A.8 (NRC No. 291.13) 5.6.2

Provide documentation on the computer program SOCON.

RESPONSE: The response is provided in the revised section 5.6.2.

QUESTION 5A.9 (NRC No. 310.1) 5.6.3

Provide the updated number and distribution over time of operation workers including reclamation and contracted workers

as the three units come on line and during the first five years of operation of all three units.

RESPONSE: The response is provided in the revised section 5.6.3.

QEUSTION 5A.10 (NRC No. 310.2) 5.6.3

How many operation and reclamation workers would be hired from outside the area, and where would they be likely to live?

2 RESPONSE: The response is provided in the revised section 5.6.3.

QUESTION 5A.11 (NRC No. 310.7) 5.6.3

Provide an updated of 'operation vehicles' as provided in CP-ER Table 4.1-2.

RESPONSE: The response is provided in the revised section 5.6.3.

APPENDIX 5B

EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10CFR50 AND 40CFR190

TABLE OF CONTENTS

5B EVALUATION OF COMPLIANCE WITH APPENDIX I OF 10CFR50 AND 40CFR190

5B.1 INTRODUCTION

The objective of this appendix is to evaluate doses from the normal operation of PVNGS in accordance with Appendix I of 10CFR50 and 40CFR190 using NRC approved models. In addition, a cost-benefit analysis was performed. The cost-benefit analysis evaluates potential reductions of emissions and their cost effectiveness relative to $1,000 per man-rem of population dose reduction.

5B.2 SUMMARY AND CONCLUSIONS

Maximum individual and population doses were calculated based on the latest NRC Regulatory Guides, and compared with the design objectives of Appendix I and 40CFR190. A cost-benefit analysis was also performed in compliance with Section II of Appendix I. Only gaseous pathways were examined since PVNGS is designed to have no liquid radioactive releases.

The calculated maximum individual dose was found to be well within the Appendix I and 40CFR190 limitations. Based upon the calculated man-rem whole body and thyroid doses, and the cost-benefit analysis, no augments could be added which would be cost effective.

5B.3 INDIVIDUAL AND POPULATION ESTIMATED DOSES

In order to perform the dose evaluation from normal operation of PVNGS, several different types of input are necessary. Each type (demographic and land use, meteorological, and radioactivity releases) is discussed briefly below. More detailed information on each subject is contained in the appropriate section of the ER-OL.

A. Demographic and Land Use Information

During October 1978, a field survey was conducted within a 5-mile radius of Unit 2 to obtain recent demographic and land use information. Table 2.1-5 presents the approximate distance to the nearest house, vegetable garden, nearest potential milk cow and beef animal out to a limit of the 5 mile survey. A vegetable garden was assumed to be located at every residence. No goats were observed within 5 miles of PVNGS.

With regard to milk cows and beef locations, no milk cows were identified; however, several young cattle were seen. It was conservatively assumed for this radiological analysis that people would consume both milk and beef from their own stock at all cattle locations.

Figure 2.1-9 shows the projected population distribution for the year 2000. The year 2000 population was selected as representative of the estimated population present during the mid-plant life. The methodology of population projection is described in section 2.1.2.

Table 2.1-12 presents the 1977 meat production on feed lots within 50 miles of PVNGS. As was discussed in section 2.1.3.4, the feeding regime in feedlots for meat animals generally consists of 95% stored feed and 5% green chop during the period of March 1 to May 31. For the remainder of the year the meat animals are fed a diet of stored feed.

Table 2.1-10 lists the estimated 1978 milk production within 50 miles of PVNGS. The feeding regime of dairy cattle consists of 30-35% green chop during the months from March through November with the remaining 65-70% being silage or pre-mixed rations (see section 2.1.3.4

for further details). For the remainder of the year the dairy cattle are fed a diet of silage or pre-mixed rations.

Table 2.1-7 lists the estimated 1977 50 mile vegetable production. The methodology used in the collection of vegetable production data is discussed in section 2.1.3.4.

B. Meteorological Dispersion Parameters

The meteorological dispersion and deposition parameters were based on the PVNGS onsite data for the 5-year period, August 13, 1973 to August 13, 1978. A ground level release was assumed with ground level receptors. Due to the PVNGS site location, the "desert sigmas" were used in place of the standard Pasquill Gifford curves.

In order to be consistent with the various growing or green chop seasons, several different time periods were evaluated. The growing season for leafy vegetables can occur in either of two periods (August through January or November through June). In the evaluation of population meat ingestion doses, dispersion and deposition parameters were generated spanning the period March through May. In the grass-cow-milk pathway dose evaluation, a green chop period of March through November was evaluated. In addition, absolute humidity as a function of the various seasons as well as the annual absolute humidity was evaluated. Section 2.3 presents a more detailed evaluation of the meteorological methodology together with the appropriate dispersion and deposition parameters.

C. Radiological Source Terms

The estimated annual gaseous releases from PVNGS are shown in table 3.5-12. The methodology for the calculation of normal radiological source terms is given in section 3.5.1. As discussed in section 3.5 there are no liquid radioactive releases from PVNGS.

D. Maximum Individual and Population Doses

Combining the previously discussed demographic and land use, meteorological and source term information, a radiological dose evaluation at the receptor locations shown in table 2.1-5 was performed.

The radiological dose evaluation used the models as discussed in Regulatory Guide 1.109, Rev. 1, and implemented in an NUS version of GASPAR, an NRC generated computer code.

1. Maximum Individual Doses

Using the NUS version of GASPAR, the individual doses were evaluated for all three units. From an inspection of table 5B-1 it is apparent that the child-bone dose is limiting for releases from all units. The highest individual dose from exposure to radioiodines and particulates from Unit 1 releases was calculated to occur at the receptor located 2300 meters north of Unit 1. For the purposes of further analysis, this location will be called Location A. For Unit 2 the highest radioiodine and particulate dose occurred at the same receptor as for Unit 1. The highest dose from radioiodines and particulates from Unit 3 releases occurred at the house 4700 meters SSW from Unit 3 (Location B). Table 5B-1 presents the results of dose calculations by both organ and pathway for

all four age groups and both locations. For the vegetable pathway, the doses were calculated for both growing seasons. Assuming all vegetable consumption for a year resulted from one growing season, the higher organ dose of the two growing seasons was then used (November-June for total body and thyroid, August-January for bone). Although neither Locations A or B have cattle, for those locations which were identified as having cattle, it was assumed that both milk and meat would be obtained. It was also assumed that both cows and meat animals would obtain 35% of the dietary requirements from pasture or fresh cut silage (a similar feeding regime as is used in dairy feedlot practices).

For noble gas exposure the locations receiving the highest dose from each unit were the same as those for radioiodines and particulates. Table 5B-2 presents the noble gas doses for both the total body and skin from all units.

Direct radiation is a very small contributor to the doses. An individual at the closest site boundary would receive approximately 3.2 x 10^{-3} millirem/year per unit from direct radiation. Table 5B-3 presents the annual direct radiation doses for several locations. The direct radiation doses outside the site boundary were calculated by ratioing the site boundary dose by the inverse square of the distances.

Table 5B-4 compares the potential doses resulting from the normal operation of PVNGS with 10CFR50 Appendix I limits. The maximum organ as seen in table 5B-1 is the child bone. In order to compare

Table 5B-2
MAXIMUM INDIVIDUAL DOSES FROM NOBLE GASES

Dose Location	Unit of Release	Doses (mrem/yr/unit)			
		Total Body	Bone	Thyroid	Skin
Location A	1	2.99(-1)	2.99(-1)	2.99(-1)	4.11
	2	2.63(-1)	2.63(-1)	2.63(-1)	3.62
	3	2.55(-1)	2.55(-1)	2.55(-1)	3.51
Location B	1	2.26(-1)	2.26(-1)	2.26(-1)	3.11
	2	2.46(-1)	2.46(-1)	2.46(-1)	3.39
	3	2.70(-1)	2.70(-1)	2.70(-1)	3.71

Table 5B-3
DIRECT RADIATION DOSES

Dose Location	Unit of Release	Distance from Unit (meters)	Dose (mrem/yr/unit)
Site Boundary (highest dose)	3	871	$3.2x10^{-3}$
Location A	1	2300	$4.6x10^{-4}$
	2	2600	$3.6x10^{-4}$
	3	3000	$2.7x10^{-4}$
Location B	1	4700	$1.1x10^{-4}$
	2	5100	$9.3x10^{-4}$
	3	5500	$8.0x10^{-5}$
Population distances	-	8000	$3.7x10^{-5}$
	-	32200	$2.3x10^{-6}$

Table 5B-4
MAXIMUM INDIVIDUAL DOSES COMPARED TO APPENDIX I OF 10CFR50

	Dose (mrem/yr/unit)			Appendix I Limit (mrem/yr/unit)
	Unit 1	Unit 2	Unit 3	
Noble Gases				
Total Body	0.30	0.26	0.27	5
Skin	4.1	3.6	3.7	15
Radioactive Iodines and Particulates				
Maximum Organ	4.6	4.0	4.2	15

3

the potential doses from the normal operation of PVNGS with 40CFR190 limits, the total dose that an individual receives must be calculated. The total doses factor in all operating units on a site not only combine liquid and gaseous effluent doses but also direct radiation from the site. Since there are no liquid effluents from PVNGS during normal operation, liquids do not contribute to the 40CFR190 doses. Table 5B-5 compares the maximum individual doses with the limits of 40CFR190.

Table 5B-6 presents the highest Beta and Gamma air doses at the site boundary from each unit.

2. Population Doses

Population doses on a per unit basis were evaluated using appropriate meteorology. The population dose resulting from vegetable ingestion was evaluated assuming the 0-50 mile population would consume their yearly quantity of vegetables raised during either of the two seasons. The higher of

Table 5B-5

MAXIMUM INDIVIDUAL DOSES COMPARED TO 40CFR190

	Doses (mrem/yr)				
	Unit 1	Unit 2	Unit 3	Total for Site	40CFR190
Total Body					
Direct Radiation	0.0005	0.0004	0.0003		
Noble Gases	0.30	0.26	0.27		
Radioactive Iodine and Particulates	2.07	1.84	1.80		
Total	2.37	2.10	2.07	6.5	25
Thyroid					
Direct Radiation	0.0005	0.0004	0.0003		
Noble Gases	0.30	0.26	0.27		
Radioactive Iodine and Particulates	2.47	2.17	2.09		
Total	2.77	2.43	2.36	7.6	75
Maximum Organ (Bone)					
Direct Radiation	0.0005	0.0004	0.0003		
Noble Gases	0.30	0.26	0.27		
Radioactive Iodine and Particulates	4.57	4.03	4.18		
Total	4.87	4.29	4.45	13.6	25

Table 5B-6
SITE BOUNDARY AIR DOSES

Unit	Direction	Air Dose (mrad/yr/unit)		
		Beta	Gamma	
1	N	10.10	0.83	
2	SSW	11.0	0.91	3
3	SSW	12.5	1.02	

the two doses (November-June growing season) was then reported. Table 5B-7 presents the particulate doses by pathway for both the total body and thyroid doses. The population dose resulting from the exposure to noble gas plume immersion was
calculated to be 3.52 man-rem total body and 3
66.0 man-rem skin.

When calculating direct radiation doses to the population within 50 miles, the total population was grouped into concentric zones of 0 to 5 miles, 5 to 10 miles, and 10 to 50 miles. For the population within 5 miles, the dose rate at the site boundary was assumed. For the population in the 5 to 10-mile annulus, the dose rate at 5 miles was used; for the 10 to 50-mile annulus, the dose rate at 20 miles was used.

Using the population data presented, the population dose from direct radiation within 50 miles has
been projected to be approximately 1.0×10^{-1} 3
person-rem/year per unit in the year 2000.

Table 5B-7

0-50 MILE POPULATION RADIOIODINE AND PARTICULATE DOSES

	Including Tritium and Carbon-14		
	Pathway	Dose (man-rem/yr/unit) Total Body	Thyroid
	Ground plane	0.00795	0.00795
3	Inhalation	2.43	4.15
	Vegetable ingestion	17.6	19.5
	Cow milk ingestion	1.68	2.02
	Meat ingestion	0.529	0.530
3	Total	22.2	26.21
	Excluding Tritium and Carbon-14		
	Pathway	Dose (man-rem/yr/unit) Total Body	Thyroid
	Ground plane	0.00795	0.00795
	Inhalation	0.004	1.73
3	Vegetable ingestion	0.0077	1.98
	Cow milk ingestion	0.0014	0.342
	Meat ingestion	0.0000445	0.0003
	Total	0.0211	4.0603

5B.4 COST-BENEFIT ANALYSIS

The maximum individual doses presented in table 5B-2 are much less than the design objectives of Appendix I. However, section II of Appendix I to 10CFR50 requires not only that design objective dose limitations to the maximum individual be met but also that "...the radwaste system include all items of reasonably demonstrated technology that when added to the system sequentially and in order of diminishing cost-benefit return can, for a favorable cost-benefit ratio, effect reduction in dose to the population reasonably expected to be within 50 miles of the reactor."

This cost-effective ratio has been designated as $1,000 per total body man-rem and $1,000 per thyroid man-rem, annualized cost. Based on this requirement, a cost-benefit analysis was performed.

Based upon the population dose results discussed in the previous section, the total annual cost of any augment, which would reduce noble gas releases to zero and still be justified would be $3,520. For radioiodine and particulates this cost would be $4,060. The radioiodine and particulate cost is based on the total particulate dose of 4.06 thyroid man-rem, since H-3 and C-14 are excluded from the cost-benefit because with present technology it is impractical to remove or reduce the release of either nuclide. In reality, no augment will reduce releases to zero. Therefore, more benefit credit is calculated than would actually exist. 3

The following cost-benefit analysis was performed using the procedures and data outlined in Regulatory Guide 1.110. Since the annual cost of equipment cannot be greater than $3,520 for any augments for the reduction of noble gas doses and $4,060 for radioiodine and particulate doses, Tables A-2 and A-3 of Regulatory Guide 1.110 were first examined to determine what potential equipment, if any, could be maintained and operated 3

below these costs. Combining the annual costs of operating and
3 maintenance, costs yield three augments with less than an annual
cost of $4,500. Table 5B-8 shows these augments and the break-
down between operating and maintenance costs. Further cost-
3 benefit analysis were then performed only on these three
augments.

The direct labor cost for the particular augment was obtained from Table A-1 of Regulatory Guide 1.110. The appropriate labor cost correction factor for the Arizona area (1.2) was taken from Table A-4 of that guide and multiplied by the direct labor cost to obtain the labor cost in Arizona for that augment. To this value was added the direct cost of equipment and materials from Table A-1 of the guide to obtain the total direct cost (TDC). Table 5B-9 shows the total direct costs. The TDC was then multiplied by the indirect cost factor (ICF) of 1.58 from Table A-5 of the guide to produce the total capital cost (TCC), which was in turn multiplied by the capital recovery factor (CRF) to obtain the annual fixed cost (AFC).
3 In this analysis, the CRF was calculated to be 0.1318 based
upon the cost of money being 12.83% per year and a 30-year plant
lifetime and the equation presented in Table A-6 of Regulatory
Guide 1.110.

The total annualized cost is the sum of the annual fixed costs
(table 5B-10) plus the annual operating and maintenance costs
(table 5B-8). Table 5B-11 presents the total annualized cost.
3 As can be seen from table 5B-11 addition of none of the aug-
ments could be justified on a cost-benefit basis.

Table 5B-8

ANNUAL OPERATING AND MAINTENANCE COSTS OF SELECTED AUGMENTS

Item	1975 $1000				
	Operating Cost	+	Maintenance Cost	=	Total O+M Cost
3-ton charcoal absorber	neg[a]	+	neg[a]	=	neg[a]
600 ft^3 gas decay tank	neg[a]	+	neg[a]	=	neg[a]
1000 cfm charcoal/HEPA filtration system	2	+	0.6	=	2.6

a. Negligible

Table 5B-9

TOTAL DIRECT COSTS OF SELECTED AUGMENTS

Item	Direct Costs (1975 $1000)					
	Equipment/ Material	+	Arizona Labor Cost	=	Total Direct Cost	
3-ton charcoal absorber	53	+	16.8	=	69.8	2
600 ft^3 gas decay tank	33	+	28.8	=	61.8	2
1000 CFM charcoal/HEPA filtration system	28	+	12.0	=	40.0	3

Table 5B-10

ANNUAL FIXED COST OF SELECTED AUGMENTS

Item	1975 $1000										
	Total Direct Cost (TDC)	x	Indirect Cost Factor (ICF)	=	Total Capital Cost (TCC)	Total Capital Cost (TCC)	x	Capital Recovery Factor (0.1318)	=	Annual Fixed Cost (AFC)
3-ton charcoal absorber	69.8	x	1.58	=	110.3	110.3	x	0.1318	=	14.5
600 ft^3 gas decay tank	61.8	x	1.58	=	97.6	97.6	x	0.1318	=	12.9
1000 CFM charcoal/HEPA filtration system	40.0	x	1.58	=	63.2	63.2	x	0.1318	=	8.3

Table 5B-11

TOTAL ANNUALIZED COST FOR SELECTED AUGMENTS

Item	1975 $1000				
	Annual Fixed Cost	+	Annual O+M Cost	=	Total Annual Cost
3-ton charcoal absorber	14.5	+	neg(a)	=	14.5
600 ft^3 gas decay tank	12.9	+	neg	=	12.9
1000 CFM charcoal/HEPA filtration system	8.3	+	2.6	=	10.9

a. Negligible

APPENDIX 5C

SUMMARY OF THE INDUSTRIAL SOURCE COMPLEX MODEL (ISC) 2

APPENDIX 5C

A. INDUSTRIAL SOURCE COMPLEX MODEL (ISC)

<u>Reference</u>: Bowers, J. F., J. R. Bjorklund and C. S. Cheney. "Industrial Source Complex (ISC) Dispersion Model User's Guide, Volumes 1 and 2." Publication Nos. EPA-450/4-79-0, 1 (NTIS PB-80-133044, 133051, Magnetic tape PB-80-133036), Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711, December 1979.

<u>Abstract</u>: The ISC model is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial source 2
complex. This model can account for settling and dry deposition of particulates, downwash, area, line and volume sources, plume rise as a function of downwind distance, separation of point sources, and limited terrain adjustment. It operates in both long- and short-term modes.

<u>Equations</u>: The ISC short-term concentration model for point sources uses the steady-state Gaussian plume equation for a continuous elevated source. For each stack and each hour, the hourly ground-level concentration at downwind distance x and crosswind distance y is given by:

$$\chi\{x,y\} = \frac{KQ}{\pi\ \bar{u}\{h\}\ \sigma_y\ \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)\right]^2$$

{Vertical Term} {Decay Term}

APPENDIX 5C

The ISC area source model is based on the equation for a finite crosswind line source. The ground-level concentration at downwind distance x (measured from the downwind edge of the area source) and crosswind distance y is given by

$$\chi\{x,y\} = \frac{KQ_A\ x_o}{\sqrt{2\pi}\ \bar{u}\{h\}\ \sigma_z} \{\text{Vertical Term}\} \left\{ \text{erf} \left(\frac{x_o'/2 + y}{\sqrt{2}\ \sigma_y} \right) + \text{erf} \left(\frac{x'_o/2 - y}{\sqrt{2}\ \sigma_y} \right) \right\} \{\text{Decay Term}\}$$

Deposition for particulates in the n^{th} settling-velocity category or a gaseous pollutant with zero settling velocity V_{sn} and a reflection coefficient γ_n is given by

2

$$DEP_n\{x,y\} = \frac{KQ_\tau\ (1 - \gamma_n)\ \phi_n}{2\pi\ \sigma_y\ \sigma_z\ x} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \exp\left[-\psi\ x/\bar{u}\{h\}\right]$$

$$\left\{ \left[\bar{b}H + (1-\bar{b})\ V_{sn}\ x/\bar{u}\{h\}\right] \exp\left[-\frac{1}{2}\left(\frac{H-V_{sn}\ x/\bar{u}\{h\}}{\sigma_z}\right)^2\right] \right.$$

$$+ \sum_{i=1}^{\infty} \left[\gamma^{i-1} \left[\bar{b}\ (2iH_m - H) - (1 - b)\ V_{sn}\ x/\bar{u}\{h\}\right] \right.$$

$$\exp\left[-\frac{1}{2}\left(\frac{2iH_m - H + V_{sn}\ x/\bar{u}\{h\}}{\sigma_z}\right)^2\right]$$

$$+ \gamma^i \left[\bar{b}\ (2iH_m + H) + (1 - \bar{b})\ V_{sn}\ x/\bar{u}\{h\}\right]$$

$$\left. \left. \exp\left[-\frac{1}{2}\left(\frac{2iH_m + H - V_{sn}\ x/\bar{u}\{h\}}{\sigma_z}\right)^2\right] \right] \right\}$$

The parameter Q_τ is the total amount of material emitted during the time period τ for which the deposition calculation is made.

For area source emissions, the first line of the above equation is changed to the form

$$\chi_\ell\{r,\theta\} = \frac{2K}{\sqrt{2\pi}\ r\ \Delta\theta'} \sum_{i,j,k} \left[\frac{Q_{i,k,\ell}\ f_{i,j,k,\ell}}{u_{i,k}\ \{h\}\ \sigma_{z;k}} S\{\theta\}\ V_{i,k,\ell} \right.$$

$$\left. \exp\left[-\psi\ r/\bar{u}_{i,k}\{h\}\right] \right]$$

where

$Q_{i,k,\ell}$ = pollutant emission rate (mass per unit time), for the i^{th} wind-speed category, k^{th} stability category and ℓ^{th} season

$f_{i,j,k,\ell}$ = frequency of occurrence of the i^{th} wind-speed category, j^{th} wind-direction category and k^{th} stability category for the ℓ^{th} season

$\Delta\theta'$ = the sector width in radians

$S\{\theta\}$ = a smoothing function similar to that of the AQDM

$u_{i,k}\{h\}$ = mean wind speed (m/sec) at stack height h for the i^{th} wind-speed category and k^{th} stability category

$\sigma_{z;k}$ = standard deviation of the vertical concentration distribution (m) for the k^{th} stability category

$V_{i,k,\ell}$ = the Vertical Term for the i^{th} wind-speed category, k^{th} stability category and ℓ^{th} season

ψ = the decay coefficient (sec^{-1})

2

The seasonal deposition at the point (r,θ) with respect to the base of a stack or the center of a volume source for particulates in the n^{th} settling-velocity category or a gaseous pollutant with zero settling velocity V_{sn} and a reflection coefficient γ_n is given by

2

$$
\begin{aligned}
DEP_{\ell,n}\{r,\theta\} = \frac{K(1 - \gamma_n)\,\phi_n}{\sqrt{2\pi}\,r^2\,\Delta\theta'} \sum_{i,j,k} \Bigg[& \frac{Q_{\tau;i,k,\ell}\, f_{i,j,k,\ell}}{\sigma_{z;k}} \\
& \exp\left[-\psi\, r/\bar{u}_{i,k}\{h\}\right] S\{\theta\} \\
& \Bigg\{ \left[\bar{b}_k H_{i,k,\ell} + (1 - \bar{b}_k) V_{sn}\, r/\bar{u}_{i,k}\{h\}\right] \\
& \exp\left[-\frac{1}{2}\left(\frac{H_{i,k,\ell} - V_{sn}\, r/\bar{u}_{i,k}\{h\}}{\sigma_{z;k}}\right)^2\right] \\
& + \sum_{a-1}^{\infty} \Bigg[\gamma^{a-1} \Big[\bar{b}_k (2aH_{m;i,k,\ell} - H_{i,k,\ell}) \\
& - (1 - \bar{b}_k) V_{sn}\, r/\bar{u}_{i,k}\{h\}\Big] \\
& \exp\left[-\frac{1}{2}\left(\frac{2aH_{m;i,k,\ell} - H_{i,k,\ell} + V_{sn}\, r/\bar{u}_{i,k}\{h\}}{\sigma_{z;k}}\right)^2\right] \\
& + \gamma^{a}\left[\bar{b}_k (2aH_{m;i,k,\ell} + H_{i,k,\ell}) + (1 - \bar{b}_k) V_{sn}\, r/\bar{u}_{i,k}\{h\}\right] \\
& \exp\left[-\frac{1}{2}\left(\frac{2aH_{m;i,k,\ell} + H_{i,k,\ell} - V_{sn}\, r/\bar{u}_{i,k}\{h\}}{\sigma_{z;k}}\right)^2\right]\Bigg]\Bigg\}\Bigg]
\end{aligned}
$$

where $Q_{\tau;i,k,\ell}$ is the product of the total time during the ℓ^{th} season and the seasonal emission rate $Q_{i,k,\ell}$ for the i^{th} wind-speed category and k^{th} stability category.

$$DEP_{\ell,n}\{r,\theta\} = \frac{K(1 - \gamma_n)\,\phi_n\, x_o^2}{\sqrt{2\pi}\, R^2\, \Delta\theta'} \sum_{i,j,k} \left[\frac{Q_{A\tau;i,k,\ell}\, f_{i,j,k,\ell}}{\sigma_{z;k}} \exp\left[-\psi\, r/\bar{u}_{i,k}\{h\}\right] S\{\theta\} \ldots \right]$$

where

$Q_{A\tau;i,k,\ell}$ = the product of the total time during the ℓ^{th} season and the emission rate per unit area for the i^{th} wind-speed category and k^{th} stability category

a. <u>Input Requirements</u> 2

Emissions data: Location, emission rate, pollutant decay coefficient, elevation of source (MSL), stack height, stack exit velocity, stack inside diameter, stack exit temperature, particle size distribution with corresponding settling velocities, surface reflection coefficient, dimensions of adjacent buildings

Meteorological data: Short-term -- hourly surface weather data including cloud ceiling, wind direction, wind speed, temperature, opaque cloud cover. Daily mixing height is also required.*

Long-term -- stability wind rose (STAR deck), average afternoon mixing height, average morning mixing height, and average air temperature.

*These data are input into a preprocessor program which prepares the data for input to the model. The same preprocessor program is used for CRSTER, RAM, MPTER, and ISC.

b. Output

Concentration or deposition for any averaging time. High, second-high values and highest 50 table.

c. Model Options

Site-specific wind profile exponents, site-specific vertical temperature gradients, dry deposition, terrain effects (limited), variable emission rates, stack and building downwash

d. Model Limitations

Flat or gently rolling terrain

e. Pollutant Types

Non-reactive

Particulates with or without significant settling velocities

2 Reactive pollutants if they can be accounted for by the exponential decay term.

f. Source-Receptor Relationships

Arbitrary location for point, line, area, and volume sources

Arbitrary receptor locations or receptor rings

Receptors at ground level at elevation not exceeding stack height

g. Plume Behavior

Briggs plume rise formulas

Building downwash and stack tip downwash

If plume height exceeds mixing height, ground level concentrations set to zero

Does not treat fumigations

h. Horizontal Wind Field

Uses user-supplied hourly wind speeds

Uses user-supplied hourly wind direction (nearest 10 degrees), internally modified by addition of a random integer value between -4 degrees and +5 degrees

Wind speeds corrected for release height based on power law variation, different exponents for different stability classes, reference height = 10 meters

Constant, uniform (steady-state) wind assumed within each hour

i. Vertical Wind Field

Assumed equal to zero

j. Horizontal Dispersion

Semi-empirical/Gaussian plume

Hourly stability class determined internally by Turner procedure, 6 classes used 2

Dispersion coefficients from McElroy and Pooler (urban) or Turner (rural). No further adjustments made for variations in surface roughness or transport time

k. Vertical Dispersion

Semi-empirical/Gaussian plume

Hourly stability class determined internally

Dispersion coefficients from McElroy and Pooler (urban) or Turner (rural). No further adjustments made for variations in surface roughness

l. Chemistry/Reaction Mechanism

Exponential decay, user input time constant

Surface deposition when deposition calculations are requested

m. Physical Removal

Settling and dry deposition of particulates is accounted for

n. Boundary Conditions

Lower boundary: reflection efficiency supplied by user

2 Upper boundary: perfect reflection

Multiple reflections handled by summation of series until $\sigma_z = 1.6 \times$ mixing height

Uniform vertical distribution thereafter

o. Background

Not treated

p. Evaluation Studies

CHAPTER 6

EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

CONTENTS

CONTENTS (cont)

TABLES

FIGURES

6. EFFLUENT AND ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 APPLICANT'S PREOPERATIONAL ENVIRONMENTAL PROGRAMS

Environmental monitoring programs have been conducted in accordance with the guidelines described in the ER-CP. These programs have generally taken place in three phases - preconstruction programs, construction programs, and preoperational programs. Each major program (e.g., groundwater monitoring) is described in this section.

The programs of the preconstruction phase have not changed substantially from those described in ER-CP Section 6.1 and the FES.

Construction phase monitoring programs were proposed in the ER-CP. This section updates ER-CP construction phase program descriptions to characterize the monitoring that has actually taken place. Changes, if any, in modeling methods that have developed since the ER-CP are also described.

Preoperational programs will be significantly different from those described in the ER-CP because additional knowledge about the site and its environs has been gained as a result of construction monitoring programs, construction experience, and new environmental impact models.

Operational programs are described in section 6.2.

6.1.1 SURFACE WATER

Surface water monitoring programs have not changed significantly from those described in ER-CP Section 6.1 and the FES. New data has been obtained as noted in section 2.4.

6.1.1.1 Preconstruction Phase Surface Water Monitoring

A literature search was conducted to determine record streamflows, waterlevels and other surface water parameters. The results of this survey were presented in ER-CP Section 2.5.

6.1.1.2 Construction Phase Surface Water Monitoring

A literature search was conducted to update record streamflows, water levels, and other surface water parameters since the preconstruction phase survey. The results of this survey are presented in section 2.4.

6.1.1.3 Preoperational Phase Surface Water Monitoring

PVNGS is a dry site. Plant operations are designed not to result in discharge to surface waters. Since there will be no operational impacts to surface waters, and sufficient baseline data has been gathered by the preconstruction and construction phase surveys, preoperational surface water monitoring is not planned.

6.1.2 GROUNDWATER

Groundwater monitoring programs have not changed significantly from those described in ER-CP Section 6.1 and the FES. Additional data obtained during construction has been used to update these programs.

6.1.2.1 Pre Construction Phase Groundwater Monitoring

Monitoring of groundwater levels at the site began in 1973. The first water level measurements were made in borings drilled and sampled for geotechnical purposes. These measurements provided preliminary information about the groundwater conditions at the site and indicated the presence of a two-aquifer groundwater system consisting of a perched water zone and a deeper regional aquifer.

The second phase of groundwater observations was aimed at better defining the piezometric levels within the two aquifers and the aquitard between them. A series of shallow (50 to 70 feet deep) observation wells was installed in late 1973 to monitor the perched water zone. The water levels measured in these wells defined the perched water zone and were subsequently used to monitor the change in perched water levels caused by the cessation of irrigation and the start of construction. A number of piezometers were also installed at various depths (typically about 50, 150, and 300 feet) to measure the piezometric levels within the aquitard and the underlying aquifer.

In addition, hydrogeologic investigations and literature searches were performed to characterize groundwater conditions at the site and throughout the portions of the Lower Hassayampa-Centennial ground water basin that could be impacted by PVNGS. The results of preconstruction monitoring were presented in ER-CP Section 2.5.

6.1.2.2 Construction Phase Groundwater Monitoring

Groundwater wells have been and are routinely monitored during construction for water level and water quality. Additional shallow observation wells were installed during construction to monitor water level fluctuations in the perched water zone. These wells were installed to measure the impact of construction activities and to obtain a better definition of groundwater level contours. During the same period, the piezometric levels of the regional aquifer were measured in deep irrigation wells within and around the site. The results of this monitoring are presented in section 2.4.

Monitoring of construction activities is provided by the wells identified in this program. Selection of monitoring wells was based on the following criteria: (1) use of existing wells with established histories, where possible; (2) nearness to

construction activities expected to affect groundwater; (3) penetration to the groundwater system; (4) proximity to major cones of groundwater depression; and (5) location with respect to plant and construction facilities.

The depth to the water is measured using a field scale accurate to ±0.1 foot. Riser pipe elevations were determined by surveying. The water table elevation measurements were recorded and compiled in tabular form and plotted as hydrographs and groundwater contours to aid visual interpretation of water table variations.

The differential usage effects of construction and irrigation are made by comparing the onsite regional aquifer water levels with the water levels surrounding the site.

Water quality samples are collected semi-annually. Specific conductance and temperature data of samples are compiled in tabular form for each monitor well. These data are compared to past data to ensure that changes in water quality that may occur are detected.

Laboratory analyses are being performed according to appropriate techniques described in the following publications:

- American Public Health Association (APHA), Standard Methods for Examination of Water and Waste water, 13th Ed. APHA, New York, 1971
- American Petroleum Institute (API), Updated, Manual on Disposal of Refinery Wastes, Methods for Sampling and Analysis
- American Society for Testing and Materials (ASTM), Annual Book of American Society for Testing Materials Standards, Part 23, ASTM, Baltimore, Maryland, 1972
- Environmental Protection Agency (EPA), Methods for the Chemical Analysis of Water and Wastes, Water

Quality Control Office, Analytical Quality Control Laboratory, Cincinnati, Ohio, 1971

6.1.2.3 Preoperational Phase Groundwater Monitoring

Construction phase monitoring will be continued as preoperational phase monitoring.

6.1.3 METEOROLOGY

The onsite meteorological measurement program began on August 13, 1973 and has been used with minor changes during preconstruction, construction, and preoperational phases. The system includes two levels of instrumentation on a 200-foot guyed tower. The tower is located in a field on the northwest portion of the site as shown in figure 3.1-4.

Wind and temperature data are collected at the 35- and 200-foot levels of the tower. Precipitation data are obtained at the surface from a rain gauge near the base of the tower. Dewpoint data are collected at the 35-foot level. A minicomputer is used for digital recording (±0.1% accuracy) of meteorological parameters.

Specifically, the onsite instrumentation includes the following:

A. Wind instrumentation: One Climet wind direction and speed sensor at the 35 foot level and another at the 200-foot level

B. Temperature instrumentation:

   1. One Rosemount Resistant Temperature Bulb (RTB) at the 35-foot level and another at the 200-foot level

   2. Endevco signal conditioners

3. Geotech motor aspirated solar radiation shields to house the RTBs at the 35- and 200-foot levels

C. Dewpoint instrumentation: one Cambridge system dewpoint measuring unit (cooled-mirror type) at the 35-foot tower level

D. Precipitation instrumentation: one Belfort tipping bucket rain gauge at ground level

E. Analog recorders:

1. Two Esterline Angus strip-chart recorders

2. One six-point Esterline Angus recorder that records temperature at the 35-foot level, dewpoint at the 35-foot level, two records of the temperature differential between the 200- and 35-foot levels (ΔT_{200-35}) and precipitation; in addition, positive indication of the performance of the radiation shield aspirator motors provided by one of six channels

F. Digital recorder: one Digital Equipment Corporation PDP 8/E minicomputer

The specifications of the equipment for the meteorological system, which comply with the intent of Regulatory Guide 1.23, are provided in table 6.1-1. Using the data given in table 6.1-1, the sensor accuracies reflect all the equipment through the signal conditioners, and the overall system accuracy for each meteorological parameter can be calculated.

Accuracies for instantaneous recorded values are calculated using the root sum squares of the accuracies of each component. Time-averaged accuracies are computed by dividing the instantaneous accuracy by the square root of the number of samples taken per hour. Sampling rates for the digital system are 10 per record for each parameter. The analog strip chart recorders

Table 6.1-1

PVNGS METEOROLOGICAL SYSTEM EQUIPMENT SPECIFICATIONS

Instrument	Manufacturer	Model	Level	Specifications
Wind direction and windspeed sensors	Climet	Wind direction: WD-012-10	35 and 200 feet	Threshold: 0.75 mi/h; accuracy: $\pm 3^{\circ}$; full scale: 540°
		Windspeed: WS-011-1	35 and 200 feet	Threshold: 0.6 mi/h; accuracy: ±1% of the windspeed reading or 0.15 mi/h, whichever is greater; full scale: 50 mi/h
		Translator 025-2		
Temperature equipment	Endevco	4470.114 Universal signal conditioner 4473.1 RTB conditioner	T_{35}; ΔT_{200-35}	T and ΔT accuracy: ±0.1% of full scale Full scale for T = 0F to 120F
	Geotech	M327 aspirator		Full scale for first ΔT = -6F to 6F
	Rosemount	104MB12ADCA		Full scale for second ΔT = -6F to 18F
Precipitation equipment	Belfort	5-405 H rain gauge	Ground	Accuracy: ±2% (inches) for 1 in./h
Dewpoint equipment	Cambridge	Dewpoint measuring set 110S-M	35 feet	Accuracy: ±0.5F
Multipoint recorder for T_{35}; ΔT_{200-35}, precipitation and dewpoint	Esterline Angus	E1124E	Shelter	Accuracy: ±0.25% of full scale; full scale for dewpoint = 0F to + 120F; full scale for precipitation = 0 to 1.2 inches
Strip recorders (2) : windspeed/wind direction	Esterline Angus	E1102R	Shelter	Accuracy: ±1% of full scale
Minicomputer/ digital processor (digital data collection and reduction)	Digital Equipment Corporation	PDP 8/E	Shelter	Accuracy: ±0.1% of full scale

(wind speed and direction) are continuous, so the number of samples is essentially infinite. Therefore, the number of samples for the strip recorders is assumed equal to that of the digital system. The analog multipoint recorder (temperature, ΔT, dewpoint, and precipitation) samples each parameter approximately once per minute. The estimated overall system accuracies are listed in table 6.1-2.

These calculations indicate that the accuracies for time-averaged values greatly exceed the recommendations in Regulatory Guide 1.23, especially for the digital recording system.

The primary data collection method makes use of the digital data processor (minicomputer). In addition to data collection, the minicomputer is designed to reduce the basic data; perform data validity and system calibration/status checks; control the overall system operation; and provide all data records, once every 24 hours, for review. The secondary method of data collection is by analog strip-chart recorders. Analog data were used to supplement the digital data during minicomputer outages. The majority of the data was reduced from the minicomputer system. The first year of data was reduced from the analog system.

The meteorological data acquisition system consists of a computerized data processing system that collects data on a real-time basis. The average wind direction, wind speed, ambient temperature, temperature differential, dewpoint, and total precipitation are determined for four 15-minute samples each hours. The sampling rate for each parameter for each level is approximately 10 times per second.

Table 6.1-2
OVERALL SYSTEM ACCURACY

Parameter	Digital System	Analog System
Wind direction, instantaneous, degrees	±3.05	±6.2
Windspeed, time averaged (all windspeeds), mi/h	<±0.01	<±0.01
Temperature, °C	<±0.01	<±0.03
Temperature difference, time averaged (first ΔT range only), °C	<±0.01	<±0.01
Dewpoint, time averaged, °C	<±0.01	<±0.05

Strip-chart data, when used, were manually reduced. One 15-minute sample of strip-chart data is used for each 1-hour data period available. Average values of wind direction, wind speed, ambient temperature, temperature differential, and dewpoint are obtained by visually estimating a mean for the 15-minute sample of the analog traces. The precipitation trace cumulatively records precipitation amounts and recycles each hour so that hourly data are obtained.

Calibration and maintenance of the PVNGS meteorological system are conducted at scheduled intervals according to written procedures. Equipment surveillance and routine maintenance are

performed according to established checklists and procedures by local personnel twice a week to maintain maximum data recovery.

The majority of the offsite meteorological data used for comparison with onsite PVNGS data summaries were obtained from the National Weather Service (NWS) station at Phoenix. All measurements reported for Phoenix were made at Sky Harbor International Airport. Temperature and humidity measurements at Phoenix were made at 5 feet above ground level. Precipitation measurements were at 3 feet above ground level. Wind instrumentation was at 41 feet above ground level until December 12, 1960, then 18 feet above ground level until September 19, 1975, and at 36 feet to the present. The wind instrumentation consists of anemometers with starting threshold speeds higher than the instrumentation at the PVNGS site, approximately 1.1 mi/h. The instrumentation at the NWS station at Phoenix is the standard instrumentation in use at most NWS stations throughout the United States. Similar wind instruments were in use at Luke Air Force Base and Gila Bend.

6.1.3.1 Preconstruction Phase Meteorological Models

These models were described in ER-CP Section 6.1 and were based on 1 year of meteorological data.

6.1.3.2 Construction Phase Meteorological Models

Data collection was the only activity during this period.

6.1.3.3 Preoperational Phase Meteorological Models

In the preparation of the ER-OL, onsite meteorological data for the period August 13, 1973, through August 13, 1978 has been used to provide (1) diffusion estimates to evaluate the environmental effects of accidents in accordance with

Draft Regulatory Guide 1.XXX, (2) long-term diffusion and relative deposition estimates for the site area in accordance with Regulatory Guide 1.111, and (3) wind and stability parameters for use in assessing the effects of operation of the cooling towers.

6.1.3.3.1 Realistic Accident Diffusion Estimates

Realistic χ/Q values were calculated both on a directional basis (for the standard population distances between 0.5 and 50 miles) and on a direction-independent basis (for the site boundary). All calculations were evaluated at the 50th percentile probability level.

6.1.3.3.1.1 <u>Direction-Dependent Model</u>. χ/Q values were calculated at the population distances for time periods of 8 hours, 16 hours, 3 days, and 26 days. The χ/Q value for each sector was obtained by a logarithmic interpolation between a 2-hour value and the annual average (8760-hour) value at the distance of interest in the same direction sector. The annual average value was calculated for a ground-level release in accordance with Regulatory Guide 1.111.

The χ/Q values applicable for release durations less than or equal to 2 hours were calculated at the various population distances using the joint frequency distributions of windspeed and wind direction by atmospheric stability class. Winds were determined at the 35-foot level and the stability class was based on the vertical temperature gradient between the 200- and 35-foot levels (ΔT_{200-35}), in accord with Regulatory Guide 1.23.

The 2-hour χ/Q values for ground-level releases were determined using the following:[1]

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

or

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

such that the greater value is used, where

χ/Q - the relative concentration at ground level, s/m^3

$\bar{u}$ = the mean windspeed at 35 feet, m/s

σ_y = the lateral plume spread, a function of atmospheric stability and distance, m

σ_z = the vertical plume spread, a function of atmospheric stability and distance, m

A = the smallest vertical plane cross-sectional area of the containment building, 2466 m^2

The values used for the horizontal and vertical dispersion parameters (σ_y and σ_z) in equations 6.1-1 and 6.1-2 reflect the unique dispersion characteristics of a desert climate. As discussed in reference 2, the values of the standard dispersion parameters used for most calculations "apply strictly only to open, level country." For desert regimes, the NRC has stated:(2) ". . . it is our position that the atmospheric dispersion model for desert climatology, developed by the staff, will be used to calculate χ/Q values for the Palo Verde site. This model includes the effect of plume meander and decreased vertical dispersion encountered in desert regimes." These dispersion parameters are commonly referred to as "desert sigmas" and were used as the basis for determining the values of σ_y and σ_z in the equations.

Once 2-hour χ/Q values were calculated for each sector for each windspeed and atmospheric stability class combination, cumulative probability distributions of χ/Q values were determined. This was done for each distance of interest. Then, for each sector, at each distance, a χ/Q value that is exceeded no

more than 3.125% of the total time (50% divided by 16) was selected for use in the assessment. These values are presented in section 2.3.

6.1.3.3.1.2 Direction-Independent Model. For calculations of accident χ/Q values at the site boundary, a direction-independent method was used. This approach involves the same χ/Q model and equations that have been described for the direction-dependent calculations. However, the 2-hour value is determined by calculating χ/Q values for each sector at the site boundary distance and computing an overall (without regard to direction) cumulative probability distribution. From this distribution, the value that is exceeded no more than 50% of the total time was selected. Using this overall 50% 2-hour χ/Q value, the values for longer time periods (8 and 16 hours and 3 and 26 days) were logarithmically interpolated as with the direction-dependent approach; however, the maximum annual average χ/Q value over the 16 sectors was used as the other end point. Calculated values of χ/Q at the site boundary are provided in section 2.3.

6.1.3.3.2 Long-Term Diffusion and Relative Deposition Estimates

Atmospheric dilution factors (χ/Q) and relative deposition (D/Q) were determined for the site boundary and for distances out to 50 miles from the containment structures.

The χ/Q and D/Q values were determined using the methodology of Regulatory Guide 1.111 and the NRC computer code χOQDOQ[3] modified to use "desert sigmas." The calculations were made for the site boundary and at distances out to 50 miles. For conservatism, all releases were assumed to occur at ground level. Winds were obtained from measurements at the 35-foot level, and the stability class was based on the vertical temperature gradient between 200 and 35 feet (ΔT_{200-35}).

In accordance with Regulatory Guide 1.111, calms were distributed directionally in proportion to the directional distribution within a stability class of the lowest wind speed group. For the calculations, calms were assigned a speed of 0.375 mi/h, one-half the threshold wind speed of the wind vane.

The χ/Q values were determined by use of the following equation:

$$\left(\frac{\chi}{Q}\right)_D = \frac{2.032}{x} \sum_{ij} \frac{n_{ij}}{N \Sigma_{zj} \bar{u}_{ij}} \qquad (6.1\text{-}3)$$

where

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

x = downwind distance, m

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

N = Total number of hours of valid data

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

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

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

$$\Sigma_{zj} = \left(\sigma_{zj}^2 + \frac{cH^2}{\pi}\right)^{1/2} \qquad (6.1\text{-}4)$$

with the constraint

$$\Sigma_{zj} \leq (\sqrt{3})\sigma_{zj} \qquad (6.1\text{-}5)$$

where

σ_{zj} = vertical plume spread, a function of atmospheric stability j and distance x, m

c = building shape factor (0.5), dimensionless

H = maximum adjacent building height (58 m)

The χ/Q values were depleted because of deposition based on the curve in Figure 2 of Regulatory Guide 1.111. Radioactive decay was not considered. The D/Q values were calculated by using Figure 6 of Regulatory Guide 1.111 to obtain relative deposition rates. The deposition rate for a given distance is then multiplied by the fraction of the release transported into the sector (wind direction frequency) and divided by the arc length of the sector at the distance of interest. From this calculation, the relative deposition per square-meter unit area D/Q obtained.

Because these models do not directly consider the effects of spatial and temporal variations in airflow caused by terrain, appropriate adjustments were made to the calculated χ/Q and D/Q values, in accordance with Regulatory Guide 1.111. The terrain adjustment factors used are site-specific to PVNGS and were developed previously by comparing χ/Q values determined by this constant mean wind direction model and by the time-dependent, segmented-plume model NUSPUF.[(4)] The adjustment factors as a function of sector and distance are presented in table 6.1-3. Long-term χ/Q and D/Q estimates for PVNGS at the site boundary calculated with the appropriate terrain adjustment factors are provided in section 2.3.

6.1.3.3.3 Models to Predict Environmental Effects of Cooling Tower Operation

Environmental impacts that can result from the operation of an evaporation cooling system include the formation of ground level fog, elevated visible plumes, and the airborne

Table 6.1-3

PVNGS TERRAIN ADJUSTMENT FACTORS

Distance (meters)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
402	1.0	1.1	1.1	1.1	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0
805	1.0	1.1	1.2	1.1	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.3	1.2
1,207	1.2	1.2	1.3	1.2	1.3	1.4	1.2	1.2	1.1	1.2	1.2	1.3	1.2	1.2	1.4	1.4
1,609	1.4	1.4	1.4	1.3	1.4	1.5	1.4	1.3	1.1	1.2	1.4	1.7	1.6	1.4	1.5	1.7
2,414	1.6	1.6	1.5	1.3	1.4	1.4	1.4	1.3	1.1	1.2	1.6	1.7	1.6	1.5	1.7	1.7
3,219	1.8	1.6	1.5	1.4	1.4	1.4	1.4	1.3	1.2	1.3	1.7	1.7	1.8	1.6	1.8	1.9
4,023	1.8	1.6	1.5	1.3	1.4	1.4	1.3	1.3	1.3	1.3	1.6	1.9	1.8	1.5	1.9	2.0
4,828	1.7	1.6	1.5	1.2	1.3	1.3	1.2	1.3	1.4	1.5	1.6	1.9	1.5	1.6	2.0	2.1
5,633	1.8	1.6	1.5	1.2	1.2	1.2	1.2	1.3	1.5	1.5	1.8	1.9	1.5	1.6	2.0	2.2
6,437	1.8	1.5	1.5	1.1	1.0	1.2	1.2	1.3	1.5	1.5	1.8	2.0	1.5	1.6	2.0	2.1
7,242	1.6	1.5	1.4	1.0		1.0	1.1	1.3	1.6	1.6	1.7	2.0	1.5	1.6	1.9	2.0
8,047	1.6	1.4	1.4	1.0			1.0	1.2	1.5	1.6	1.7	1.8	1.5	1.5	2.0	2.0
12,070	1.3	1.2	1.2					1.1	1.3	1.3	1.4	1.4	1.3	1.3	1.5	1.5
16,093	1.0	1.0	1.0					1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
24,140	1.0															
32,187	1.0															
40,234	1.0															
48,280	1.0															
56,327	1.0															
64,374	1.0															
72,421	1.0															
80,467	1.0															

concentrations and ground deposition of dissolved solids contained in drift droplets released from the cooling system. Analysis of each potential impact is discussed below.

6.1.3.3.3.1 Induced Ground Level Fogging Model. The computer program FOG[5] was used to simulate plume dispersion from evaporative cooling systems using sequential meteorological data. This model simulates the cooling system plume as a bent over plume with an entrainment rate of 0.5 using the Briggs[6] plume rise equations to the point of plume leveloff, and Gaussian dispersion equations at all distances beyond this point. 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 multi-fan cooling towers, a plume merging is calculated from equations developed by Briggs[7] for a "cluster" of cells. No enhanced plume rise due to merging of plumes from neighboring towers is considered; this assumption is conservative in that it leads to lower plume rises and greater calculated ground level effects.

FOG makes calculations over a polar grid centered on the cooling system. This grid consists of 16 directions corresponding to the routinely observed wind directions, and up to 15 downwind distances. The plume is assumed to propagate rectilinearly, with any meandering effects due to wind shifts being neglected. This assumption of rectilinear propagation leads to conservatism in the calculation of ground-level centerline effects and in visible plume lengths. Required Pasquill stability classes are determined from the measured difference of dry bulb temperature from the two levels on the onsite meteorological tower. The dispersion parameters σ_y and σ_z used are the desert sigmas which are used to represent dispersion conditions at this desert site.[8] Formulations for the

critical wind speed resulting in the aerodynamic downwash of the exhaust plumes are also included in the FOG model.

For the purposes of this study, induced ground-level fog is defined as a reduction in ground level visibility to 1000 meters (5/8 miles) or less as a result of the operation of the cooling systems. According to international definition, 1000 meters is the limit on visibility above which fog is not considered to occur.[9] The liquid water content of the plumes at ground level is calculated from the Gaussian dispersion analysis discussed above, with all moisture in excess of that required to saturate the ambient air assumed to form condensed water droplets. An empirical equation presented by Petterssen[10] is then used to relate the atmospheric water content to the horizontal visibility.

6.1.3.3.3.2 Elevated Visible Plumes Model. The FOG program was used to calculate the frequencies of occurrence of elevated visible plumes over each grid point under consideration. 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 at a particular grid point if the mixed plume is calculated to be supersaturated.

6.1.3.3.3.3 Drift Analysis Model. The FOG program also calculated the transport and ground deposition rate of dissolved solids contained in the entrained drift droplets released from the cooling systems.

The drift deposition routines in FOG consist of the following three calculational procedures: (1) the sequential release of the entrained drift droplets from the effluent plume, (2) the subsequent horizontal transport of the drift droplets as they fall to the ground, and (3) the calculation of the airborne concentrations and deposition rates at pre-specified downwind distances for each of the 16 wind directions.

It is assumed in the FOG model that the excess water vapor, the temperature excess, the vertical velocity, and the concentration of drift droplets follow a Gaussian distribution normal to the plume axis. The plume is assumed to extend two standard deviations (i.e., $2\sigma_y$ and $2\sigma_z$) 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 droplets in the plume, 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. Any droplets remaining in the plume at the leveloff point are then released. Droplets released from the plume then 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 the liquid droplets and the surrounding air. For relative humidities below 50%, complete evaporation of the drift droplets to dry particles is possible. A stepwise

procedure is employed in FOG to compute the trajectory of the droplets by considering the above effects.

Drift deposition rates and airborne concentrations of dry drift particles are calculated for each of the sequential meteorological records included in the 5-year meteorological data set. These are then summarized to obtain the deposition (in terms of lb/acre-year) and airborne concentrations of dry particles (in $\mu g/m^3$) over the entire grid. The airborne concentration calculation is made at a height of 2 meters above the ground surface.

For the round mechanical draft cooling towers, the critical wind speed is developed from a discussion by Halitsky (1968) of flow fields near buildings. He indicates a wake boundary originating at the edge of a plate representing a building, which develops into a paraboloid of revolution. The curve of the boundary in a longitudinal section through the axis is given as

$$\frac{r_w}{L} = \left(\frac{X}{L}\right)^{1/4}$$

where

2 r_w = radial distance from the axis at longitudinal distance X,

L = length of side of plate.

For mechanical draft towers, downwash can be assumed to occur when the plume centerline intersects the wake boundary. In this circumstance the variable r_w is equal to the tower height plus the plume rise. Therefore, for each point on the wake boundary a corresponding wind speed can be calculated from the basic Briggs (1969) equation

$$\Delta h = 1.6F^{1/3} U^{-1} X^{2/3}$$

where

Δh is plume rise, m

F is buoyancy flux term, m^4/sec^3

U is wind speed at top of tower, m/sec.

These wind speeds are a function of downwind distance. From the previous two equations, the minimum critical wind speed is

$$U_{CR} = 2.933 \left(\frac{F}{L}\right)^{1/3}$$

where

L is defined as twice the tower height.

The above derivation is contained in reference 5.

For the round mechanical draft cooling towers at PVNGS, the buoyancy flux term (F) is calculated based on air flow from all 16 fans atop one tower. The calculated critical wind speed varies for each input meteorological case depending upon ambient temperature and relative humidity. Presented in table 6.1-3A are calculated critical wind speeds for selected ambient conditions. Note that calculations for the design case (first calculation in table 6.1-3A) yields a slightly negative buoyancy due to the cooling of the air stream through the tower. For the higher ambient temperature cases, downwash conditions would be calculated more frequently. 2

Since these cooling towers are round, no dependence is placed on wind direction. Also, adjacent cooling towers and other structures were not considered in the calculation of downwash conditions. Considering a grouping of three towers, there may be some sheltering effect on the downwind tower. The turbine buildings and containment buildings are approximately 60 meters in height and approximately 200 meters from the cooling towers. The cooling towers are most likely beyond the cavity zone

Table 6.1-3A

COOLING TOWER CRITICAL WINDSPEED

Ambient				Cooling Tower					
T	TW	RH	ρ	Tc	TWc	RHc	ρc	F	Ucr
116	75	13	1.0835	104	101	90	1.0845	-29	-
80	60	29	1.1576	95	95	100	1.1064	1399	9.7
50	40	38	1.2281	86	86	100	1.1305	2513	11.8
24	20	47	1.2953	78	78	100	1.1515	3511	13.1

T, Ambient dry bulb temperature, F

TW, Ambient wet bulb temperature, F

RH, Ambient relative humidity, percent

ρ, Ambient air density, kg/m^3

2 Tc, Effluent dry bulb temperature, F

TWc, Effluent wet bulb temperature, F

RHc, Effluent relative humidity, percent

ρc, Effluent density, kg/m^3

F, Buoyancy flux parameter, m^4/sec^3

Ucr, Critical wind speed for downwash, m/sec

(calculations at 1000 mb)

induced by the buildings (which is estimated[14] to extend to 2 to 3.5 times building height), but within the downwind wake zone. The wake zone would cause some increased dispersion due to the associated mechanically induced turbulence. Insight into the wind flow pattern for such a facility as well as any modification of cooling tower plume rise and dispersion could best be obtained through physical modeling.

6.1.3.3.3.4 Detailed Plume Analysis Model. Cooling tower plume trajectories were calculated by the Lagrangian Vapor Plume Model (LVPM).[11] LVPM is a one-dimensional numerical mmodel capable of predicting the detailed behavior of either wet or dry plumes for a given meteorological condition. The model incorporates the thermodynamics and microphysics of condensation and evaporation, superimposed upon a dynamic model of buoyant convection. In the case of wet plumes, the release of latent heat through the condensation of moisture enhances the vertical growth of the effluent plume. This situation is somewhat similar to the development of an isolated cumulus cloud, where condensation enhances the growth in the core of the plume, while mixing and evaporation take place near its edge. 2

The dynamic framework of LVPM is described by the equations of motion for a quasi-incompressible fluid. A steady-state plume is assumed to simulate the continuous efflux to a horizontally homogeneous atmosphere. This assumption simplifies the numerical computation and leads to practical and economical application. Ambient meteorological conditions are obtained by reducing standard rawinsonde data.

This page intentionally blank

6.1.4 LAND

6.1.4.1 Geology and Soils

The monitoring program for geology and soils has not changed significantly from that described in ER-CP Section 2.4 and the FES. Data obtained during construction has been used to update geologic models of the site.

6.1.4.1.1 Preconstruction Phase Geologic Monitoring

Preconstruction monitoring was performed as described in ER-CP Section 2.4.

6.1.4.1.2 Construction Phase Geologic Monitoring

Additional investigations of the site during construction included:

A. Research of pertinent published and unpublished geologic, seismologic, and hydrologic literature of Arizona and adjacent areas

B. Consultation with numerous local geologists from the universities and from various public agencies who are familiar with particular areas

C. Review of existing and specially prepared aerial photography and other remote-sensing imagery

D. Reconnaissance geologic mapping of the site region at a scale of 2000 feet to the inch

E. As-graded geologic mapping of excavations for Category I structures at scales of 10, 5, and 1 foot to the inch and geologic inspections of non-Category I construction excavations.

F. Subsurface investigations that included (totals include preconstruction activities):

1. Drilling of approximately 630 borings to depths ranging from 25 to 720 feet for geologic and engineering data

2. Logging of selected borings with high resolution, down-hole geophysics

3. Seven detailed cross-hole seismic surveys in and adjacent to the powerblock areas to define the in-situ engineering characteristics of the site soils

4. Excavation of 32 backhoe trenches totaling about 1800 linear feet

5. Twenty-one seismic refraction geophysical profiles (hammer energy source) totaling about 32,500 feet; three refraction profiles (explosive energy source) totaling about 49,600 feet

6. Reconnaissance and detailed gravity and magnetic geophysical surveys covering a 10-mile radius of the site

7. Installation and monitoring of perched and regional groundwater observation wells on and adjacent to the site

8. Six multiposition extensometers (MPEs) and 18 mechanical rebound (MR) anchors to monitor preconstruction- and postconstruction-related heave and settlement

9. One large tank percolation test, 3 perched water zone tests, 1 regional aquifer pump test, and approximately 25 in-situ injection permeameter tests to determine aquifer characteristics

10. Excavation of three large-diameter (6 feet) borings to depths of about 40 feet to obtain bulk undisturbed samples for engineering testing

G. Geologic sample analyses that included (totals include preconstruction activities):

1. Megascopic and microscopic lithologic analysis of bedrock samples
2. Potassium/argon age dating of volcanic rock samples
3. Analysis of approximately 550 samples of basin sediments for paleomagnetic polarity
4. Palynology studies of 20 samples of basin sediments
5. X-ray crystallography of selected clay samples

H. Engineering testing of foundation materials for static and dynamic properties including the following (includes preconstruction activities):

1. Moisture content and dry density
2. Atterburg limits for selected samples
3. Consolidation
4. Triaxial shear (dynamic and static)
5. Standard penetration (for granular materials within zones of possible liquefaction)
6. Relative density
7. Direct shear
8. Unconfined compression testing
9. Expansion or swell
10. Permeability

Soil sampling and testing has continued periodically. Of the more than 630 borings drilled during the site investigations, approximately 575 have been drilled within the site property and at site-specific powerblock areas. The remainder have been drilled around the site property at intervals ranging from 750 feet to 1 mile and extending up to 5 miles from the plant location.

The investigation of PVNGS conforms to accepted standard practice within the geology/engineering professions and to Nuclear Regulatory Commission acceptance criteria defined at the time. Sampling of undisturbed soils and soft sediments, for geologic and engineering requirements, was performed with a 12-inch drive sampler, a standard 18-inch split spoon drive sampler, a 30-inch pitcher tube, a 12-inch-diameter plastic cylinder for hand-excavated samples, and an NX core barrel. The soil samples were taken continuously or at intervals of 5 feet down to a depth of 100 feet, intervals of 10 feet down to a depth of 200 feet, and intervals of 20 feet down to a depth where material suitable for coring was encountered or at a specific completion depth determined by geologic or engineering considerations. The sampling procedures were dependent on expected loading conditions related to building geometry. Samples taken for the general suite of engineering tests of static and dynamic properties were taken from pitcher tube, 2.5-inch (inner diameter) drive sampler, and large-diameter hand-excavated samples. Standard penetration tests to American Society for Testing and Materials specifications were done with an 18-inch split spoon sampler.

Trenching incorporated an important phase of the Palo Verde subsurface investigation. Trenches were oriented in such situations as to intersect photo lineations or suspicious linear relationships found in the field investigation. Trenches were usually excavated to depths within the capabilities of the

excavating equipment. The walls were carefully cleaned, inspected, and logged for pertinent geologic evidence of faulting or other geologic conditions. Scales of the trench logs ranged from 5 to 2 feet to the inch.

To monitor the effects of construction excavation activity on the site soils and their response to structural loading following construction, a soil heave and settlement monitoring program has been established at PVNGS. The instrumentation installed prior to construction consists of 18 MR anchors (6 in each unit) and 6 electrical read-out MPEs (3 in Unit 1, 1 in Unit 2, and 2 in Unit 3). The MPEs are used to supplement the MRs during the rebound phase, but their primary function is to monitor construction and postconstruction settlement recompressions. Based on the data obtained to date, heave settlements are much less than predicted, on the order of one-third.

Even though subsidence has not been observed and is not expected to be significant, a subsidence monitoring program has been established at the site. The subsidence monitoring network consists of survey monuments located within the site boundary on soil. Movement of the survey monument (if any) is measured relative to benchmarks established on bedrock north and southwest of the site. The data collected and analyzed through March 1978 indicate that no measurable subsidence has taken place.

Two strong motion accelerometers were installed at the site in 1975 to monitor any earthquake-induced ground motion that may occur at the site. The instruments, which have not been triggered by earthquake-induced ground motion, have a trigger threshold of 0.009g.

The changes in soil condition caused by construction of the plant are essentially those produced by the earth-moving operations required to grade the area. The moderate-to-high

strengths exhibited by the soils indicate that engineered temporary and permanent slopes at the site were designed and constructed with reasonable allowable slope inclinations to minimize erosion and slope failures. No significant slope stability problems have been observed during construction to date. Fills are constructed of selected soils obtained from onsite excavations and borrow areas.

6.1.4.1.3 Preoperational Phase Geologic Monitoring

The preconstruction and construction phase programs have characterized the geotechnical nature of the site and its environs to the fullest extent possible based upon a thorough evaluation of the data obtained. Preoperational monitoring is not required or planned.

6.1.4.2 <u>Demographic and Land Use Monitoring</u>

6.1.4.2.1 Preconstruction Phase Demographic and Land Use Monitoring

Preconstruction programs were conducted as described in Section 2.1 of the ER-CP.

6.1.4.2.2 Construction Phase Demographic and Land Use Monitoring

Monitoring did not take place during this period.

6.1.4.2.3 Preoperational Phase Demographic and Land Use Monitoring

In the preparation of the ER-OL, new demographic and land use surveys were performed. The methodology and results of these surveys are presented in section 2.1.

6.1.4.3 Ecological Parameter Monitoring

6.1.4.3.1 Preconstruction Phase Ecological Parameter Monitoring

Baseline data on vegetation and wildlife at PVNGS was obtained from literature surveys, from interviews with regional authorities, and from field sampling. Standard qualitative and quantitative sampling techniques were employed and surveys were scheduled on a seasonal basis. Field sampling took place from May 1973 through August 1974; the results are presented in section 2.2.

6.1.4.3.2 Construction Phase Ecological Parameter Monitoring

A construction phase monitoring program was implemented in 1976 to:

A. Provide an opportunity for early detection of potentially significant ecological impacts

B. Provide a basis for considering possible mitigation measures for any significant adverse ecological impacts observed

C. Document the ecological changes resulting from plant construction

D. Observe the results of mitigation measures and modify the measures if necessary

The monitoring program was designed to achieve these objectives through semiannual surveys of the site and related facilities. Six sample plots were established within the site boundary to monitor gross ecological changes that might result from construction activities. The following procedures are employed in monitoring surveys:

A. Examining and interpreting site and vicinity color aerial photography (scale: 1 inch = 200 feet and 1 inch = 400 feet) taken shortly before each visit

B. Conducting an aerial survey of the site and vicinity to check photography and examine current conditions

C. Obtaining and reviewing noteworthy observational data taken by the onsite environmental personnel

D. Conducting ground surveys of the site and related facilities, including the ecological monitoring plots

E. Preparing a report documenting conditions and discussing any unexpected changes from the predicted impacts

F. Preparing a map illustrating the present extent of construction-related disturbance as a means of monitoring progress and deviations from anticipated development

Seven such surveys have been conducted between August 1976 and November 1979. The results of these surveys were used to update the ecological descriptions presented in the ER-CP. Updated descriptions are presented in sections 2.2 and 4.1.

6.1.4.3.3 Preoperational Ecological Parameter Monitoring

The construction phase program will continue until plant operation. This program will establish baseline data for use in evaluating ecological effects of plant operation.

6.1.5 RADIOLOGICAL MONITORING

6.1.5.1 Preconstruction Phase Radiological Monitoring

Preconstruction radiological monitoring was conducted as described in ER-CP Section 2.8.

6.1.5.2 Construction Phase Radiological Monitoring

Construction phase radiological monitoring was conducted as described in section 6.4.

6.1.5.3 Preoperational Phase Radiological Monitoring

The preoperational phase of the offsite program of sampling
and measuring radioactivity, shown in figure 6.1-1 and in 4
tables 6.1-4 and 6.1-5, permits a general characterization of
the radiation levels and concentrations in existence prior to
plant operation along with an indication of the degree of natural
variation to be expected.

Implementation of the preoperational monitoring program fulfills the following objectives:

A. Identification of pathways to be monitored during operation

B. Measurement of background levels and their variations along major pathways in the areas surrounding the plant

Implementation of the preoperational program began approximately
three years prior to the anticipated issuance of the operational
license with the collection of water, milk, and food product
samples. Direct radiation measurements began approximately 4
two years prior to commercial operation. Airborne monitoring
began one year prior to fuel loading.

The criteria for selecting sample types were based on the 4
sources of the radioactivity expected to be released to the
environment and the exposure pathways for these radionuclides
to man and important biota. Sampling locations were selected 4
on the basis of local meteorology, physical characteristics of
the terrain, demographic and cultural features of the region, 4
and availability of samples. The frequency of sampling and
the duration of the sampling period are dependent on the
radionuclide of interest, and the biological behavior of the
environmental media and the radionuclide. Sufficient samples
are included in the program to define the spatial and temporal
variation of radioactivity levels where necessary. It is 4

Table 6.1-4

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sampling and Collection Frequency	Type and Frequency of Analysis	Sampling Locations[a]	
Airborne radioiodine and particulates	Continuous sampling collected weekly	Gross beta weekly; I-131 weekly; gamma spectrum monthly; composite of filters	Twelve locations as listed in table 6.1-5	4
Direct radiation	TL dosimeters at each location changed quarterly, and annually	Gamma dose quarterly and annually	45 locations (Nos. 1-45) as described in section 6.1.5.3.2	4
Waterborne				
Surface	Composite sample over one-month period	Gamma spectrum monthly; tritium quarterly	On-site reservoir and evaporation pond[b]	4
Ground	Quarterly grab sample	Tritium and gamma spectrums quarterly	On-site well Nos. 34abb, 27ddc.	
Drinking (well)	Monthly composite of weekly grab sample	Gross beta and gamma spectrums monthly; tritium quarterly	24, 46, 49	
Ingestion				
Milk	Semimonthly for animals on pasture; otherwise, monthly	Gamma spectrum and radioiodine semimonthly or monthly	50, 51, 53-56	4
Food products	Monthly when available	Gamma spectrum and radioiodine monthly	46, 51, 52	4

a. Description of sampling site locations and distances from Unit 2 is given in table 6.1-5

b. As available, once units are in operation 4

Table 6.1-5

DESCRIPTION OF RADIOLOGICAL SAMPLING SITE LOCATIONS (Sheet 1 of 2) | 4

Sample Site Number	Sample Type	Location Designation(a)	Location Description
1	TLD, Air	E30	APS Goodyear Office
2	TLD	ENE24	Scott-Libby School
3	TLD	E25	Liberty School
4	TLD, Air	E20	APS Buckeye Office
5	TLD	ESE15	Palo Verde
6	TLD, Air	SSE35	APS Gila Bend Substation
7	TLD, Air	SE 8	Arlington School
8	TLD	SSE 5	Corner of 363rd Ave. & SPP Rd.
9	TLD	S 5	Corner of 371st Ave. & SPP Rd.
10	TLD	SE 5	Corner of 355th Ave. & Ward Rd.
11	TLD	ESE 5	Corner of 339th Ave. & Dobbins Rd.
12	TLD	E 5	Corner of 339th Ave. & B-S Rd.
13	TLD	N 1	N Site Boundary
14	TLD	NNE 2	NNE Site Boundary
14A	Air	NNE 2	Buckeye-Salome Rd. & 371st Ave. 4
15	TLD, Air	NE 2	NE Site Boundary
16	TLD	ENE 2	ENE Site Boundary
17	TLD	E 2	E Site Boundary
17A	Air	E 4	351st Ave., 1 mi. S of B-S Rd.
18	TLD	ESE 2	ESE Site Boundary
19	TLD	SE 2	SE Site Boundary
20	TLD	SSE 2	SSE Site Boundary
21	TLD, Air	S 3	S Site Boundary
22	TLD	SSW 3	SSW Site Boundary
23	TLD	W 5	Benchmark at Baseline
24	TLD, Water	SW 5	Ward Rd. @ Well 18bbb
25	TLD	WSW 5	Ward Rd. @ DF Well 2 Rd.
26	TLD, Water	SSW 5	Well 21 Cbb_2
27	TLD	SW 2	SW Site Boundary
28	TLD	WSW 1	WSW Site Boundary
29	TLD, Air	W 1	W Site Boundary

a. Table J-1, NUREG-0654; distances are from centerline of Unit 2 containment.

Table 6.1-5

DESCRIPTION OF RADIOLOGICAL SAMPLING SITE LOCATIONS (Sheet 2 of 2) 4

Sample Site Number	Sample Type	Location Designation[(a)]	Location Description
30	TLD	WNW 1	WNW Site Boundary
31	TLD	NW 2	NW Site Boundary
32	TLD	NNW 1	NNW Site Boundary
33	TLD	NW 5	Yuma Rd., 1/2 mi. W of Belmont Rd.
34	TLD	NNW 5	Corner Belmont Rd. & Van Buren Rd.
35	TLD, Air	NNW 9	Tonopah, Palo Verde Inn Fire Station
36	TLD	N 5	Corner of Wintersburg Rd. & Van Buren
37	TLD	NNE 5	Corner of 363rd Ave. & Van Buren
38	TLD	NE 5	Corner of 355th Ave. & Yuma Rd.
39	TLD	ENE 5	343rd Ave., 1/2 mi. S of L. Buckeye
40	TLD, Air, Water	N 3	Trailer Park; Water at Red Quail Str.
41	TLD	WNW20	Harquahala Valley School
42	TLD	N 8	Ruth Fisher School
43	TLD	N45	Vulture Mine Rd. School, Wickenburg
44	TLD, Air	ENE35	APS El Mirage Office (Sun City)
45	TLD	ENE50	APS Deer Valley Office
46	Water, Veg.	NNW 9	McArthurs Farm, Tonopah
47	Water	NNW 6	Winters' Wells
48	Water	SSE 4	Well 14dbb
49	Water	ESE 4	Glover Residence, 351st Ave. & Dobbins Rd.
50	Milk	NE 7	Baisley Dairy, 331st Ave. & Van Buren
51	Milk, Veg.	E15	Butler Dairy, Palo Verde Rd. & Southern
52	Vegetation	E15	Cambron Farm, Miller Rd. & Broadway
53	Milk	E20	Kerr Dairy, Dean & Buckeye Rds.
54	Milk	E25	Hoffman Dairy, Airport & Dobbins
55	Milk	E25	Lueck Dairy, Jackrabbit & Hazen Rds.
56	Milk	E50	Mineso Dairy, Kyrene & Guadalupe Rds.

4

This page intentionally blank 4

expected that the program may be modified periodically to take full advantage of the experience and knowledge obtained while conducting the program.

The following sections describe the program, including the
4 expected types of samples, the collection frequency, and the
analyses performed on each sample type.

6.1.5.3.1 Airborne Pathway

4 Airborne particulate and iodine activity will be sampled at
twelve locations using continuous low-volume air samplers.
These samplers will be equipped with filters for the retention of particulate material greater than 0.3 micrometer in diameter and charcoal canisters for adsorption of airborne iodine. The pumping rate will be automatically adjustable to compensate for resistance to air flow due to loading of dust on the filter. A constant, known rate of flow can then be maintained throughout the sampling period.

4 Six of the air sampling systems have been placed at or near the
site boundary. Because all releases will be at ground level
or from roof vents, the highest predicted offsite ground-level
concentrations of airborne releases occur at the site boundary
regardless of direction. The three sectors having the highest
annual average ground level D/Q are, from table 2.3-26, west,
west-northwest and north-northeast. The west and west-northwest
sector centerlines are approximately 0.25 miles apart at the
site boundary. Rather than place two samplers essentially side-
4 by-side, covering a direction with a minimum population, the
west-northwest sampler was moved to the north sector, the fourth
highest D/Q. Demographic conditions play an important part in
sampler location. It was felt that sectors around the site having
the highest population concentrations or in the most prominent wind
directions should be given preference for sampling points, as
well as sectors with higher D/Q values. Therefore, in addition

to the three samplers located in the highest D/Q sectors, two more samplers have been placed at or near the northeast and east boundaries. Another sampler was placed at the south boundary to ensure coverage in a southerly direction. Five samplers are located in areas of special interest in Tonopah 4
(NNW), Arlington School (SE), Buckeye (E), Goodyear (ENE) and Sun City (NE). The twelfth sampler is the control, located in Gila Bend (SSE).

Since Wintersburg is the only nearby community, it has the highest calculated community ground level D/Q, therefore, the 4
north sector air sampler is placed there, approximately 2.2 miles north of Unit 1.

The particulate filters and charcoal canisters will be exchanged at least once every 7 days. Gross beta activity on the filters and I-131 activity on the charcoal will be determined weekly. The gamma spectrum will be determined once per quarter.

6.1.5.3.2 Direct Radiation

Ambient external radiation is measured by thermoluminescent dosimeters (TLDs). Doses are determined quarterly and annually at each location.

Forty-five TLDs will be placed as follows:

A. An inner ring of stations at the site boundary, one in each of the 16 compass point sectors. 4

B. An outer ring of stations in the 4 to 5 mile range from the site, one station in each of the same sectors (with the exception of the WNW sector which is inaccessible).

C. Eleven additional dosimeter locations in the following areas of special interest: Tonopah, Ruth Fisher School,

4 Wintersburg, Arlington School, Palo Verde, Buckeye, Goodyear, Scott-Libby School, Liberty School, Harquehala School, Wickenburg.

D. Three control dosimeters located in: Gila Bend, Sun City, Phoenix.

6.1.5.4 Waterborne Pathway

4 Preoperational monitoring of offsite surface waters is not conducted. The onsite reservoir and evaporation pond will be sampled when water becomes available.

6.1.5.4.1 Groundwater

4 Groundwater samples of the regional aquifer are taken quarterly from the two onsite wells. Drinking water is sampled from wells at Ward Road (Desert Farms Well No. 1), and at Southern and 351st Avenues. These samples will be monthly composites of weekly grab samples. Gross beta and gamma spectrum analyses will be performed monthly; tritium will be determined in quarterly composites. A sample from Tonopah is taken for analysis as a control.

6.1.5.5 Ingestion Pathway

6.1.5.5.1 Milk

4 The grass-cow-milk or grass-goat-milk pathways for radioiodine are monitored. Gamma spectrum and I-131 analyses are performed. No milk is currently being produced within a 5 mile radius of the plant. The closest dairy, about 6 miles east is being sampled monthly. The next closest dairy is approximately 11 miles to the east. This and several other dairies further distant may be sampled as needs dictate. A dairy in Tempe, 50 miles from the plant, is sampled as a control.

There are isolated head of cattle within 5 miles of the plant; however, it appears that most of the cattle are on stored feed

and are not grazing on pasture. Potential milk locations are surveyed annually during the growing season to determine whether any milk is being produced for human consumption. 4

6.1.5.5.2 Fish and Invertebrates

There are no fish or invertebrates to be sampled.

6.1.5.5.3 Food Products

No vegetable gardens of any size have been observed within a 5-mile radius of Unit 2, since October, 1978. This information was presented in section 2.1.3.4.1 as a part of the general character of agricultural land use in the site vicinity. A 1
garden survey will be made annually to see if any vegetable 4
gardens greater than 500 ft.^{2} have appeared. Locally grown leafy vegetables will be sampled and analyzed by gamma spectroscopy, if available. 1
A vegetable garden in Tonopah (site number 46) was discovered in September, 1979, and permission has 4
been obtained to routinely collect samples for analysis of any vegetables available. This is the closest garden greater than 500 square feet found to date. 1

1 This page intentionally blank.

6.1.5.6 Program Summary

Table 6.1-4 summarizes the preoperational environmental radioactivity monitoring program.

Sampling and analysis will be initiated in the preoperational period in time to conform to the following schedule:

A. Two years before expected operation date

- Direct radiation
- Food products

B. One year before expected operation date

- Airborne particulates
- Milk or leafy vegetation
- Groundwater
- Drinking water

C. Six months before expected operation date: airborne iodine

To ensure the integrity of the samples and to prevent cross-contamination, the samples will be packaged in the field in labeled, leaktight containers; acid will be added to water samples to prevent sorption of radionuclides on the inner surface of the containers; formaldehyde will be added to milk samples to prevent spoilage; and perishable samples will be refrigerated to retard decomposition.

Table 6.1-6 lists typical attainable sensitivities at commercial laboratories for the various analyses that will be performed on samples collected in the program. These sensitivities are expressed as lower limit of detection (LLD)[a] values for the various analyses required by the radiological monitoring program.

---

a. As defined in NUREG-0472.

In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background shall include the typical contributions of other radionuclides normally present in the samples (e.g., potassium-40 in milk samples).

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally, background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. Such cases will be identified and described.

6.1.6 NOISE

In a residential environment, the time-weighted day-night outdoor average sound level, L_{dn}, of 55 dBa has been identified as compatible with the protection of public health and welfare.(12)

To determine the Ldn sound level, the equivalent sound level, L_{eq}, is first computed from the following equation;

$$L_{eq} = 10 \log \left[\frac{1}{100} \sum_i f_i \left(10^{L_i/10} \right) \right] \qquad (6.1\text{-}6)$$

where

f_i = percentage total analysis time represented by the ith time interval

L_i = sound level in the ith time interval, dBa

The time-weighted day-night outdoor average sound level, L_{dn}, is computed as follows:

$$L_{dn} = 10 \log \frac{1}{24} \left[15 \left(10^{L_d/10} \right) + 9 \left(10^{(L_n + 10)/10} \right) \right] \qquad (6.1\text{-}7)$$

where

$L_d = L_{eq}$ for daytime (0700 to 2200 hours)

$Ln = L_{eq}$ for nighttime (2200 to 0700 hours)

The Housing and Urban Development (HUD) noise-impact criteria specify that L_{dn} noise levels above 65 dBa are acceptable for residential areas. L_{dn} noise levels above 65 dBa but below 75 are classified as normally unacceptable. HUD approvals in areas experiencing noise levels in this range require additional sound attenuation for buildings having noise sensitive uses. L_{dn} noise levels above 75 dBa are classified as unacceptable for residential areas.[13]

6.1.6.1 Preconstruction Noise Monitoring

A background noise survey was conducted from December 16 through December 18, 1973 and is described in ER-CP Section 2.9. A summary of the background environmental sound levels is provided in section 2.7.

6.1.6.2 Construction Noise Monitoring

Sound levels were measured in the vicinity of PVNGS on October 27, 1978, to determine the impact of construction noise at the closest residence to the site. The sound levels were measured with a GenRad Model GR 1982 Type I precision sound-level meter.

Sound-level measurements were obtained at the following locations:

Site	Location
1	At the closest corner of the property line of the nearest residence (approximately 7600 feet from the center of PVNGS)

Table 6.1-6

MAXIMUM VALUES FOR THE LLD

Analysis	Water (pCi/l)	Airborne Particulates (pCi/m^3)	Milk (pCi/l)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross beta	4[(a)]	1×10^{-2}	--	--	--
^{3}H	2000	-- [(c)]	--	--	--
^{3}H	1000[(a)]	--	--	--	--
^{54}Mn	15	--	--	--	--
^{59}Fe	30	--	--	--	--
$^{58,60}Co$	15	--	--	--	--
^{65}Zn	30	--	--	--	--
^{95}Zr-Nb	15	--	--	--	--
^{131}I	1	7×10^{-2}	1	60[(b)]	--
$^{134,137}Cs$	15 (10),[(a)] 18	1×10^{-2}	15	80	150
^{140}Ba-La	15		15		

a. LLD for drinking water.

b. LLD for leafy vegetables.

c. Not applicable

Site	Location
2	At the main gate to PVNGS (approximately 2600 feet from the station center)
3	At the PVNGS sign on the main road (approximately 4800 feet from the station center)
4	At the top of the hill between PVNGS and the nearest residence (approximately 5600 feet from the station center)

The sound-level measurements obtained at site 1 consisted of a single series of measurements that included an A-weighted measurement and octave band measurements at intervals from 31.5 to 1000 hertz. Sound levels in octave bands above 1000 hertz at site 1 and above 2000 hertz at sites 2, 3, and 4 were below the minimum detectable level of the sound-level meter. The bands chosen were representative of construction noise. Two series of measurements were obtained at sites 2, 3, and 4 because the measurement variability was large enough to justify the second set of measurements. The sound levels measured at site 1 and the average sound levels at sites 2, 3, and 4 are presented in table 6.1-7.

6.1.6.3 Preoperational Phase Noise Monitoring

Monitoring is not required to supplement data obtained by the preconstruction and construction phase noise monitoring programs.

Table 6.1-7
SOUND LEVELS NEAR PVNGS SITE DURING CONSTRUCTION OF
UNITS 1, 2, AND 3

Frequency (Hz)	Sound Pressure Levels (dB)			
	Site 1	Site 2	Site 3	Site 4
A-Weighted scale	34	50.5	44.5	51.0
31.5	64	64.5	57.5	60.0
63	52	61.0	59.5	61.0
125	42	61.5	57.0	57.0
500	31	42.5	36.0	48.5
1000	26[a]	39.5	32.5	48.5
2000	--[b]	32.5	25.5[a]	37.5

a. Measurements are not considered to meet type 1 sound-level meter standards.

b. Sound pressure levels at this frequency and at the octave frequencies between 4000 and 16,000 Hz were below 25-dB sound pressure levels.

6.1.7 REFERENCES

1. Yansky, G. R., Markee, E. H., and Richter, A.T., "Climatography of the National Reactor Testing Station," U.S. Environmental Science Services Administration, IDO-12048, January 1966.

2. NRC Staff Question 322.14-PVNGS, August 13, 1975.

3. Sagendorf, J. F. and Goll, J. T., "χOQDOQ, Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," U.S. Nuclear Regulatory Commission, Draft NUREG-0324, September 1977.

4. NUS Corporation, "NUSPUF, A Segmented Plume Dispersion Program for the Calculation of Average Concentration Time-Dependent Meteorological Regime," NUS-TM-260, Rockville, Maryland, March 1976.

5. Fisher, G. E., FOG Model Description, NUS-TM-S-185, July 1974.

6. Briggs, G. A., Plume Rise, Atomic Energy Commission Critical Review Series, TID-25075, 1969.

7. Briggs, Gary A., Plume Rise from Multiple Sources, Cooling Tower Environment, Energy Research and Development Administration, Conf-740302, 1974.

8. Nuclear Regulatory Commission, Subroutine POLYN, developed by Bob Kornasiewiez to compute dispersion parameters σ_y and σ_z for desert like meteorological situations.

9. Huschke, R. E., Glossary of Meteorology, American Meteorological Society, Boston, Massachusetts, pp. 227-228, 1959.

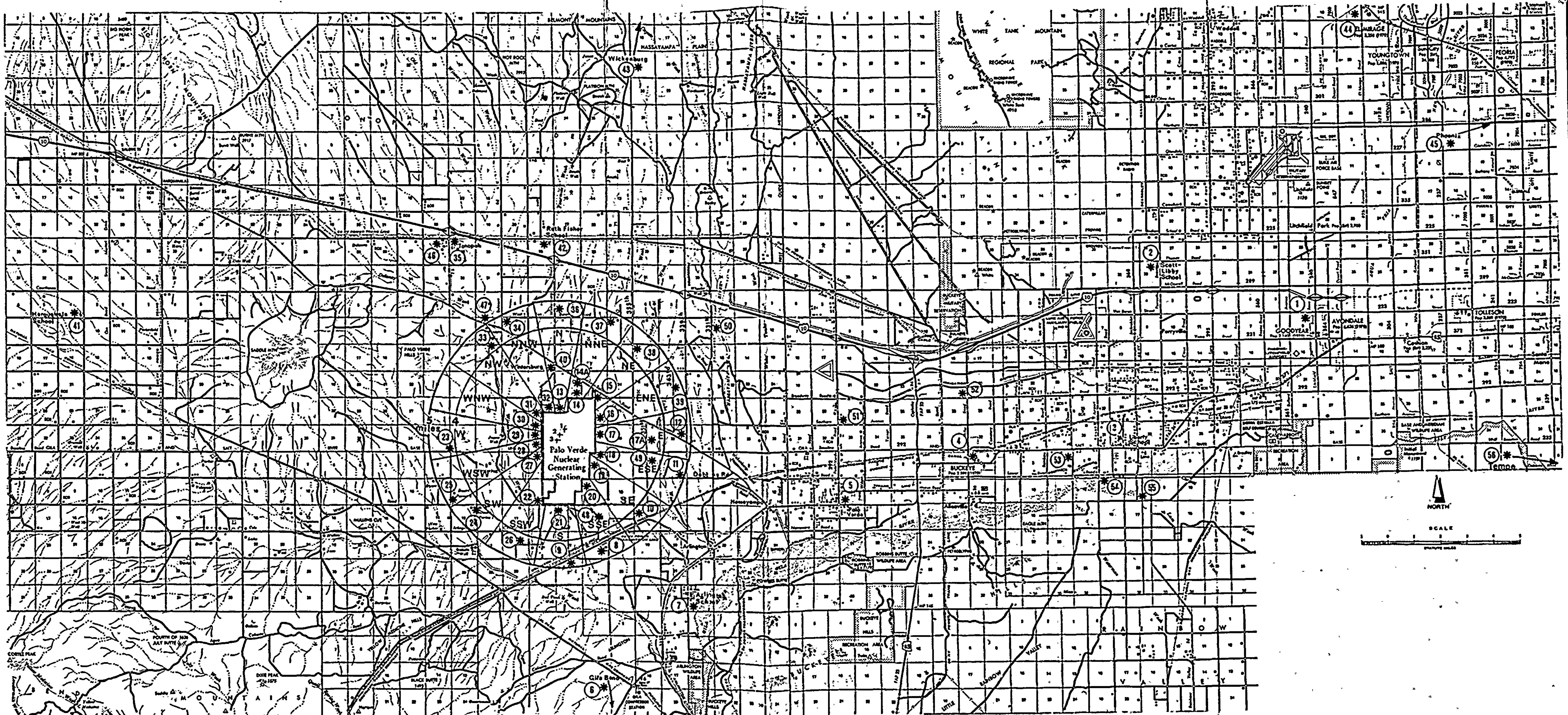
10. Petterssen, S., Weather Analysis and Forecasting, Volume II, McGraw-Hill, New York, 1956.

11. Lee, J., "The Lagrangian Vapor Plume Model - Version 3," NUS Corporation, NUS-TM-S-184, Rockville, Maryland, July 1974.

12. U. S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with Adequate Marginal Safety," EPA550/9-74-004, March 1974.

13. Department of Housing and Urban Development, "Environmental Criteria and Standards," (44FR 40860-6) July 12, 1979.

2 14. Briggs, G. A., 1973, "Diffusion Estimation for Small Emissions," Draft No. 79, Atmospheric Turbulence and Diffusion Laboratory, NOAA, Oak Ridge, Tenn.



Palo Verde Nuclear Generating Station
ER-OL

RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM SAMPLE SITES

Figure 6.1-1

6.2 APPLICANT'S PROPOSED OPERATIONAL MONITORING PROGRAMS

The proposed operational monitoring programs are designed to monitor possible environmental effects of the PVNGS operation. The operation of PVNGS is not expected to have a significant effect on the surrounding environment. Therefore, no environmental technical specifications are required.

6.2.1 SURFACE WATER MONITORING

PVNGS is a dry site. Plant operations are designed not to require discharge to surface waters. Since there will be no operational impacts to surface waters, surface water monitoring is not planned.

6.2.2 OPERATIONAL GROUNDWATER MONITORING

The purpose of the operational groundwater monitoring program is to satisfy the requirement of the Arizona Power Plant and Transmission Line Siting Committee Certificate of Environmental Compatibility for PVNGS. The program is designed to monitor changes in groundwater quality and levels both onsite and offsite by utilizing strategically placed observation wells. The well placement will allow the assessment of the direction and extent of movement of potential seepage and/or contamination from the structures.

The program will provide a quantitative data base relative to the performance of 1) the water storage reservoir, 2) the evaporation pond system, and 3) other potential point sources that may influence the perched and regional groundwater systems. It is designed to detect potential seepage problems at an early stage to allow possible implementation of mitigating measures.

6.2.3 METEOROLOGICAL MONITORING PROGRAM

The onsite meteorological monitoring program described in section 6.1.3 will be continued during operation. Results of this monitoring program will be reported in accordance with Regulatory Guide 1.21. When PVNGS becomes operational, site meteorological parameters will be provided in the control room. Notification of program modifications (e.g., upgrading of instrumentation to reflect state-of-the-art developments), will be made as appropriate.

6.2.4 OPERATIONAL ECOLOGICAL MONITORING

Preoperational information has identified potential ecological effects of plant operation. As noted in sections 5.1, 5.3, 5.4, 5.5, and 5.6, projected impacts are expected to be minor. However, the programs of section 6.1.4.3 will be conducted as deemed necessary to evaluate ecological conditions and confirm projected impacts are minor. Should this monitoring program detect significant impacts which were not projected, such impacts will be reported to the NRC.

6.2.5 RADIOLOGICAL MONITORING

Radiological monitoring will be in accordance with the radiological effluent technical specifications to be included in FSAR Chapter 16.

6.2.6 OPERATIONAL NOISE MONITORING

As noted in section 5.6.2, noise levels offsite are expected to be environmentally insignificant. Accordingly, operational noise monitoring is not planned.

6.3 RELATED ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

The information presented in ER-CP Section 6.3 and the FES has been updated. No significant changes have been noted since the ER-CP.

6.3.1 NONRADIOLOGICAL MONITORING PROGRAMS

6.3.1.1 Arizona Department of Game and Fish

The Arizona Department of Game and Fish (ADGF) conducts a spring and summer quail and dove population count in the site area each year as part of their wildlife conservation program. The nesting habitats of the white-winged dove have recently been recorded and population data is available in state publications.

6.3.1.2 Groundwater Monitoring

The United States Geological Survey (USGS) performs local groundwater monitoring on a system of index wells throughout the site area. These wells are monitored for water depth and the amount of groundwater pumped is calculated for each station.

6.3.1.3 Seismic Monitoring

The fundamental source for instrumental seismicity data in the Arizona region currently is the National Earthquake Information Service of the U. S. Geological Survey. Formerly this responsibility rested with the U. S. Department of Commerce, Environmental Science Services Administration (ESSA). This department has compiled all of the reported instrumental epicenters in the region since 1927. For many years the Tucson seismograph established in 1925 was the only station in the state. Several stations were installed near Lake Mead at Boulder City, Nevada in 1942 and still operate. A similar station has been

installed at Glen Canyon Dam. In 1963 the Tonto Forest Seismological Observatory was established with a sophisticated group of seismometers. However, this project was oriented towards teleseismic data and no attempt was made to locate local tremors. An amateur station was operated by W. L. Groene until his death in 1975. Arizona State University staff were performing studies of local seismicity through early 1976. Since that time the studies have been terminated and their station has been inoperative. No results have been reported. See table 6.3-1 for the locations of the stations.

Very few accelerographs have been installed in Arizona and the neighboring portions of Nevada because of the low levels of seismicity. Recent regulations have caused accelerographs to be placed in Veterans Administration hospitals, and some dam sites. Conversely, many accelerographs have been installed in the neighboring portions of California and Yuma, Arizona because of high seismicity associated with the San Andreas fault system and related features. The Arizona accelerograph locations, including the two strong motion accelerographs which were installed at PVNGS in 1975, are listed in table 6.3-2.

6.3.2 RADIOLOGICAL MONITORING PROGRAMS

Currently, a limited number of radiological monitoring programs are being conducted in the State of Arizona by both Federal and State agencies. The Arizona State Atomic Energy Commission has a radiological laboratory currently being certified for drinking water analyses in conformance with EPA requirements under 40CFR41. This laboratory will also carry out any radiological surveillance required by the NRC since Arizona is an Agreement state. At present, only gross alpha and gross beta radioactivity analyses are being performed on water samples. No publications are available from the laboratory at this date.

The Office of Radiation Programs (ORP), of the EPA, conducts the Environmental Radiation Ambient Monitoring System (ERAMS),

Table 6.3-1

SEISMIC STATIONS IN ARIZONA (Sheet 1 of 2)

Station	Location	Elev. (ft.)	Remarks
Tucson, TUC	32°18'32"N 110°46'55"W	985	Worldwide standardized seismograph station. The station was established with a Wood-Anderson seismograph in 1925. A Benioff short-period system was added in 1936, later supplemented with a longitudinal galvo. In 1962, the WWSSN standardized instruments were installed.
Tonto Forest Observatory, TFO	34°16'04"N 110°16'13"W	1492	Installed in 1963 with a 37-element, 30-km-diameter array of short-period (SP) instruments; a linear, cross array of 21 SP elements and a 50-km-diameter, 7-element (3 comp), long-period (LP) array. Intended primarily for teleseismic data, but local seismic events were noted.
Tonto Hills Observatory, THO	33°52'31"N 111°52'25"W	3681	Private station operated by Mr. W. L. Groene since January, 1973, when it replaced the Mummy Mountain Observatory started in May, 1967. Inoperative since 1975.
Arizona State University	Tempe		An LP instrument since 1971. Inoperative since 1976.
Boulder Dam, BDA	36°00'55.5"N 114°44'11.9"W	237	A Benioff SP installed in 1942.

Table 6.3-1

SEISMIC STATIONS IN ARIZONA (Sheet 2 of 2)

Station	Location	Elev. (ft.)	Remarks
Glen Canyon Dam, GCA	36°58'25"N 111°35'35"W	1339	
Sunset Crator, SCN	35°10'32"N 109°08'49"W	2134	An SP instrument operated by the National Park Service. Inadequate timing for use in locating events. Inoperative since late 1977.
Mummy Mountain Observatory, MMO	33°33'16"N 11°57'28.6"W	426	Private station operated by Mr. W. L. Groene from May 1967 to January 1973.

Table 6.3-2

ARIZONA ACCELEROGRAPH SITES

USGS No.	Name	Coordinates	Foundation	Structure	Placement	Agency[(a)]
2301	Alamo Dam	34.23°N 113.60°W	22m alluvium over gneiss	Earth Dam	Abutment, toe, crest	ACOE
2304	Glen Canyon Dam	36.97°N 111.59°W		Inst. Shelter	Ground level	USBR
2305	Phoenix VA Hosp.	33.49°N 112.07°W	125m alluvium over granite	4-story Bldg.	Basement	VA
2306	Tucson VA Hosp.	32.17°N 110.83°W		1-story Bldg.	Ground level	VA
2307	Prescott VA Hosp.	34.55°N 112.45°W	more than 17m alluvium	6-story Bldg.	Basement	VA
2316	Yuma, Srand Ave.	32.73°N 114.70°W	36m alluvium over granite-gneiss	Inst. Shelter	Ground level	USBR
----	Palo Verde Nuclear Generating Station	33.38°N 112.86°W	100m alluvium over volcano/sedimentary rock	Inst. Shelter	Ground level	Ariz. Public Service

a. Agencies: ACOE, Army Corps of Engineers
USBR, U. S. Bureau of Reclamation
VA, Veterans Administration

whose primary concern is identifying trends in the accumulation of long-lived radionuclides in the environment. Samples include air, surface and drinking water, and milk taken from locations selected to provide the best possible combination of radiation source monitoring and wide population coverage. Results of these analyses are published quarterly by the Eastern Environmental Radiation Facility, Montgomery, Alabama.

The ERAMS continuous sampling locations nearest to the PVNGS site are:

- Las Vegas, Nevada for airborne particulates and precipitation, with analyses for gross beta and tritium
- Boulder City, Nevada (near Las Vegas) for surface water tritium and gamma scans
- Las Vegas for drinking water tritium, gamma scan, gross alpha, gross beta, Pu-226, Si-90, and, annually, plutonium and uranium
- Phoenix, Arizona for pasteurized milk monthly analyses for I-131, Ba-140, Cs-137 by gamma spectroscopy, and annually for radiostrontium

6.4 PREOPERATIONAL ENVIRONMENTAL RADIOLOGICAL MONITORING DATA

The discharge from the Phoenix 91st Avenue Sewage Treatment Plant has been monitored for I-131 since August 1975. Table 6.4-1 presents the daily average I-131 discharge from the sewage treatment plant for representative months since August 1975.

Additional environmental monitoring data will be provided after the completion of six months of preoperational environmental radiological monitoring.

Table 6.4-1

91st Avenue Sewage Treatment Plant
Iodine-131
Average Daily Concentration
(pCi/l)

Month	1975	1976	1977[a]	1978[a]	1979[a]
January	--[b]	31.22	5.93	2.85	8.99
February	--	10.28	7.51	--	--
March	--	14.66	13.08	--	--
April	--	20.71	--	7.72	--
May	--	5.47	--	--	--
June	--	10.56	--	--	--
July	--	21.81	44.44	10.45	12.54
August	5.04	10.91	--	--	--
September	11.37	8.94	--	--	--
October	20.77	21.41	3.92	3.36	--
November	8.52	9.63	--	--	--
December	33.12	8.14[a]	--	--	

[a] All samples collected from the 91st Avenue Sewage Treatment Plant and the 23rd Avenue Sewage Treatment Plant after 12/7/76 were analyzed as separate samples. The values reported are the average of these samples.

[b] No sampling performed in period.

APPENDIX 6A

RESPONSES TO NRC QUESTIONS

TABLE OF CONTENTS

1

2

APPENDIX 6A

<u>QUESTION 6A.1</u> (NRC comment on section 6.1.5.5.3) (6/18/80) 6.1.5.5.3

Section 2.1.3.4.1 stated that no vegetable gardens were observed; therefore, no baseline provided.

RESPONSE: The response is given in revised section 6.1.5.5.3.

<u>QUESTION 6A.2</u> (NRC comment on section 6.2) (6/18/80) 6.2

No justification provided for not proposing environmental technical specifications.

RESPONSE: Environmental technical specifications incorporate "certain conditions and limitations corresponding to key parameters of the NEPA environmental review" (Regulatory Guide 4.8). Limiting conditions for operation have the basic objective of limiting "operation for each plant parameter, operation, and discharge that has a potential for adverse environmental impact if not controlled" (Regulatory Guide 4.8). In addition, technical specifications are to be consistent with requirements imposed pursuant to the FWPCA, including Section 401, Certifications [Reference (1)]. Implicit in these statements is the concept of a potential environmental impact or, in the worst case, a degradation of some ecological sub-system. 1

By far, the most prevalent impacts from nuclear power plant operations are the thermal, hydraulic and chemical effects of circulating water system effluent on aquatic systems. (Radiological environmental programs have been removed from the general environmental technical specifications and placed within the Appendix A, or safety-related programs, per the NRC Branch Technical Position of March, 1978.) The bulk of typical (such as Salem Nuclear Generating Station unit 2, Docket No. 50-311) environmental technical

specifications is concerned with these impacts. The very minor potential effect of cooling drift and biocide or herbicide application on terrestrial systems complete the typical technical specification.

The Palo Verde Nuclear Generating Station is a dry site. There are no intake or discharge structures to interact with biota of the water source or receiving waters. Effluent limitations and water quality standards are not applicable since there will be no water discharges offsite. Thus, operation of the heat dissipation and circulating-water systems will not affect the temperature of natural surface water bodies.

Water is lost from the site mainly via evaporation from the cooling towers, and salts are carried away from the towers in the drift. The calculated drift rate of
1 25.8 gallons per minute per unit derived by use of drift loss data presented in ER-OL table 3.4-1 will cause a maximum salt disposition rate of 12 pounds per acre per year at the site boundary, dropping off to 2 pounds per acre per year 9 miles away, and unmeasurable any further away (refer to ER-OL figure 5.1-4). Typical soil in the desert area now contains approximately 2900 to 4300 pounds of salt per acre [Reference (2)]. The projected 12 pounds per acre of salt will not be measurable. Therefore, there would be no adverse ecological impact from cooling tower drift.

The only other potential terrestrial impact would be from the operation of transmission lines and the wastewater conveyance pipeline. As discussed in ER-OL sections 5.5.1 and 5.5.2, there are no projected environmental impacts. Herbicides and pesticides will not be used for maintenance of transmission system corridors. a herbicide has been applied in certain restricted areas of the pipeline

right-of-way for weed control during construction only [Reference (3)]. For these reasons, environmental technical specifications (non-radiological) have not been proposed.

REFERENCES

1. U.S. NRC "Rules and Regulations", Title 10, Chapter 1, Part 50, Code of Federal Regulations

2. NUREG-75/078 Final Environmental Statement Palo Verde Nuclear Generating Station, Units 1, 2, and 3, Docket STN-528/529/530, September 1975, pages 5-17.

3. Letter to E. E. Van Brunt, Jr. from the Nuclear Regulatory Commission, dated November 30, 1979

QUESTION 6A.3 (NRC No. 290.1) 6.1.3.3.3

Describe the validation studies (done either by APS or others) of the FOG, drift and LVPM models since the References 6.1-5 and 6.1-7 were published.

RESPONSE: NUS submitted the machine language program for LVPM to Dr. Policastro in 1977 for inclusion into ANL's model evaluation program. The results of the validation work, including the review of the LVPM model, were presented in a paper at the winter meeting of the ANS, Nov. 12-16, 1979.[a] The LVPM model, identified in the paper as LEE (NUS), showed calculated plume rises in 29 out of 36 single tower data sets to be within a factor of 2 of the observed values, with no "failures." For the multiple tower data set, 19 out of 26 data sets were within a factor of 2, again with no "failures." The performance of the predictive trend of the LVPM model is stated in the paper to be "Balanced for plume rise; very short for plume length." It should be noted 2

that the ER-OL presents LVPM predictions with emphasis on plume heights and vertical variation of selected plume parameters. The FOG model was used for the detailed analysis of plume lengths and their frequencies of occurrence. A copy of the referenced 1979 ANL model verification results report[a] is being transmitted under separate cover.

During the latter part of 1974 the FOG and LVPM programs were used to calculate vertical profiles of plume temperature and mixing ratio based on preliminary field data collected at Florida Power & Light's Turkey Point Plant. These field data were collected under the direction of EPA NERC - Corvallis, Oregon. The model calculated plume profiles were sent to Mr. Larry Winiarski of EPA on October 4, 1974;[b] they showed reasonable agreement with the observed plume profiles. With permission from Mr. Winiarski, these model predictions were forwarded to Dr. James E. Carson of Argonne
2 National Laboratory on October 15, 1974.[c]

There is no separate computer model for the drift calculations. Subroutines for the drift related calculations are contained within the FOG model.

---

a. Policastro, A. J., R. A. Carhart, S. Ziemer, K. Haake, M. Wastag, W. E. Dunn, P. Gavin, and B. Boughton. "Investigation of Mathematical Models for Cooling-Tower Plumes and Drift." Presented at ANS Meeting, Nov. 12-16, 1979.

b. Taylor, John H. of NUS Corporation, Personal Communication to Mr. Larry Winiarski of USEPA, ESD-74-1035(AQ), October 4, 1974.

c. Taylor, John H. of NUS Corporation, Personal Communication to Dr. James E. Carson of Argonne National Labs., ESD-74-1090(AQ), October 15, 1974.

QUESTION 6A.4 (NRC No. 290.3) 6.1.3

Provide the critical wind speed for aerodynamic downwash for the circular mechanical-draft cooling towers. Describe the basis for this value. Describe how the presence of other structures near the towers and/or wind direction affect the critical windspeed. 2

RESPONSE: The response is provided in the revised section 6.1.3.3.3.3.

CHAPTER 7

ENVIRONMENTAL EFFECTS OF ACCIDENTS

CONTENTS

CONTENTS (cont)

TABLES

7. ENVIRONMENTAL EFFECTS OF ACCIDENTS

7.1 STATION ACCIDENTS INVOLVING RADIOACTIVITY

The information presented in ER-CP Section 7.1 and the FES has not changed significantly. This section updates and summarizes subsequent analyses and data obtained since ER-CP submittal.

7.1.1 INTRODUCTION

The PVNGS FSAR includes analyses based on extremely conservative assumptions of the radiological consequences of various postulated accidents. These assumptions create analyses that can be considered upper limits of accident consequences. Realistic assessments of the consequences of accidents presented here for the ER-OL use an alternative approach; that is, all parameters used in assessing the accident consequences are assumed to be at their nominal value. Consequently, the environmental effects indicated by ER-OL analysis are significantly less than those given in the FSAR for the same accident and can be considered realistic to the extent that the initiation of the event is considered realistic.

Accidents and occurrences are divided into eight accident classes and evaluated as required by Regulatory Guide 4.2, Revision 2. Class 1 events (trivial incidents) and class 2 events (small releases outside containment) are included and evaluated under the routine radioactive releases presented in section 5.2.

7.1.2 SHORT-TERM ACCIDENT WIND DIFFUSION ESTIMATES

Section 6.1.3 describes the methodology for short-term accident wind diffusion estimates. The site boundary χ/Q values used in accident analysis are given in table 2.3-26.

The 0- to 50-mile χ/Q values were combined with year 2000 population estimates in the determination of the population dose. The product of the 160 (10 distances by 16 directions) population and χ/Q values were then summed over each direction for each time period. The maximum sum obtained was then used in the dose calculations. Table 2.3-27 presents the χ/Q values used in the population dose calculations.

7.1.3 ACCIDENT DISCUSSION

In these accident analyses it was assumed that all equipment, except that specifically noted in each accident, was operating normally (i.e., heating, ventilating, and air conditioning (HVAC); service water; etc.). Further, particulates are either removed by high-efficiency particulate air (HEPA) filters or they deposit out within the PVNGS site boundary because of their weight or low release point. Therefore, it was assumed that particulates other than radioiodines make a negligible contribution to offsite doses.

No credit was taken for shielding reduction of whole body gamma doses. If shielding were included, reductions of about 30% for doses to individuals and 50% for doses to the total population could be realized.

Normal reactor coolant and secondary coolant radioactivity concentrations used in the accident analyses are presented in table 7.1-1 while table 7.1-2 presents the fuel radioactivity inventories. The noble gases plume immersion and thyroid inhalation dose conversion factors employed are those presented in Regulatory Guide 1.109, Rev 1. Breathing rates are based on the annual rates suggested in Regulatory Guide 1.109, Rev 1. Breathing rates for the periods of 0-8 hours and 8-24 hours after an accident were apportioned according to the assumptions presented in Regulatory Guide 1.4, Rev 2. Table 7.1-3 presents the breathing rates used in this analysis.

Table 7.1-1

PRIMARY AND SECONDARY COOLANT ACTIVITIES IN MICROCURIES PER GRAM

Nuclide	Primary Coolant	Secondary Coolant
Kr-83m	2.10(-02)[(a)]	<1(-8)
Kr-85m	1.10(-01)	3.80(-08)
Kr-85	1.50(-01)	5.21(-08)
Kr-87	6.00(-02)	2.05(-08)
Kr-88	2.00(-01)	6.89(-08)
Kr-89	5.00(-03)	<1(-8)
Kr-90	0.0[(b)]	0.0
Xe-131m	1.10(-01)	3.82(-08)
Xe-133m	2.20(-01)	7.64(-08)
Xe-133	1.80(+01)	6.25(-06)
Xe-135m	1.30(-02)	<1(-8)
Xe-135	3.50(-01)	1.21(-07)
Xe-137	9.00(-03)	<1(-8)
Xe-138	4.40(-02)	1.39(-08)
I-129	0.0	0.0
I-130	2.10(-03)	2.33(-07)
I-131	2.70(-01)	6.96(-05)
I-132	1.00(-01)	3.00(-06)
I-133	3.80(-01)	5.62(-05)
I-134	4.70(-02)	5.74(-07)
I-135	1.90(-01)	1.39(-05)

a. Standard exponential notation is used in this table; i.e., (-02) = $x\ 10^{-2}$.

b. 0.0 = $<1.00 \times 10^{-8}$.

Table 7.1-2

ACTIVITY IN CORE, GAP OF ONE ASSEMBLY AND GAP OF ONE ROW OF ONE ASSEMBLY

Nuclide	Core (Ci)	Gap, One Assembly (Ci)	Gap, One Row (Ci)
Kr-83m	0.0[(a)]	0.0	0.0
Kr-85m	3.48(+07)[(b)]	1.44(+03)	9.79(+01)
Kr-85	1.21(+06)	5.02(+01)	3.40
Kr-87	5.91(+07)	2.45(+03)	1.66(+02)
Kr-88	8.59(+07)	3.56(+03)	2.42(+02)
Kr-89	1.08(+08)	4.48(+03)	3.04(+02)
Kr-90	1.16(+08)	4.81(+03)	3.26(+02)
Xe-131m	6.17(+05)	2.56(+01)	1.76
Xe-133m	0.0	0.0	0.0
Xe-133	2.26(+08)	9.38(+03)	6.36(+02)
Xe-135m	6.38(+07)	2.65(+03)	1.79(+02)
Xe-135	5.31(+07)	2.20(+03)	1.49(+02)
Xe-137	2.09(+08)	8.67(+03)	5.88(+02)
Xe-138	2.05(+08)	8.51(+03)	5.77(+02)
I-129	1.61	6.68(-05)	4.53(-06)
I-130	0.0	0.0	0.0
I-131	1.13(+08)	4.69(+03)	3.18(+02)
I-132	1.16(+08)	4.81(+03)	3.26(+02)
I-133	2.32(+08)	9.63(+03)	6.53(+02)
I-134	2.54(+08)	1.05(+04)	7.15(+02)
I-135	2.21(+08)	9.17(+03)	6.22(+02)

a. $0.0 = <1.00 \times 10^{-8}$.

b. Standard exponential notation is used in this table, i.e., $(+07) = \times 10^{+7}$.

Table 7.1-3
BREATHING RATES

Age	Breathing Rates (m^3/s)			
	0 to 8 hours	8 to 24 hours	1 to 4 days	4 to 30 days
Infant	6.65(-05)[a]	3.30(-05)	4.40(-05)	4.40(-05)
Child	1.76(-04)	8.79(-05)	1.17(-04)	1.17(-04)
Teen	3.80(-04)	1.90(-04)	2.54(-04)	2.54(-04)
Adult	3.80(-04)	1.90(-04)	2.54(-04)	2.54(-04)

a. Standard exponential notation is used in this table; i.e., (-05) = x 10^{-5}.

7.1.3.1 Class 1.0--Trivial Incidents Inside Containment

Radioactivity release events of this class are considered to be minor perturbations of normal operating conditions. These are analyzed along with radioactivity releases due to normal operation in section 5.2.

7.1.3.2 Class 2.0--Small Releases Outside Containment

Class 2 events include small spills and leaks from equipment outside the reactor building. Small leaks from valves and pipes are expected during the liftime of the plant. This condition has been considered under normal operation, and the radionuclide releases resulting have been included in arriving at dose levels reported in section 5.2.

7.1.3.3 Class 3.0--Radwaste System Failures

Class 3 accidents are postulated to involve the release of radioactivity to the environment through a failure or malfunction in the radwaste system. The possibility of an equipment failure or serious malfunction is remote because of the general

design of the system, the quality control associated with manufacture and installation of the components of the system, and the inspections performed on the system.

Likewise the possibility of an accident from human error is small because of the strict administrative controls exercised during operation of the radwaste systems. Thus, no radwaste system failure is anticipated during the life of the plant. Nevertheless, failures in this system are postulated and evaluated.

7.1.3.3.1 Class 3.1--Equipment Leakage or Malfunction

The accident postulated is a failure of equipment that would cause the sudden release of 25% of the contents of the largest waste gas decay tank or and 25% of the contents of the refueling water tank. Gaseous release activities and liquid release activities are based on the maximum tank radionuclide concentrations that may result from normal plant operation.

7.1.3.3.1.1 Gases. The parameters and assumptions used in the analysis of gas leakage are:

A. 25% of the average inventory (see section 3.5) of the largest waste gas storage tank is assumed to be released.

B. The reactor coolant activity is based on American National Standards Institute ANSI-N237 source strength.

C. The period of release is 0-8 hours.

Table 7.1-4 presents the postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary would be 8.5×10^{-3} and 9.9×10^{-5} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant would be 1.9×10^{2} man-rem.

Table 7.1-4

CLASS 3 ACCIDENT DOSES

	Small Gaseous Release	Small Liquid Release	Large Gaseous Release	Large Liquid Release
Site Boundary Doses (Rem)				
Total Body				
0-8 hr Release Period	8.5(-03)	5.9(-06)	3.4(-02)	2.4(-05)
Thyroid Inhalation				
Child				
0-8 hr Release Period	9.9(-05)	2.2(-04)	4.0(-04)	9.0(-04)
Population Doses (Man-Rem)				
Total Body				
0-8 hr Release Period	1.9(+01)	1.3(-01)	7.7(+02)	5.3(-01)

7.1.3.3.1.2 Liquids. Liquid leakage is considered to occur in the refueling water tank, which is the outside tank containing the largest amount of radioactivity. This accident assumes that a line rupture occurs concurrent with operator error (i.e., a valve is left open). The parameters and assumptions used in this analysis are as follows:

A. 25% of the average inventory (see section 3.5) in the refueling water tank is assumed to be spilled.

B. The reactor coolant activity is based on failed fuel corresponding to ANSI-N237.

C. An air-to-water partition factor of 0.001 is assumed for iodines.

D. The period of release is 0-8 hours.

Table 7.1-4 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary would be 5.9×10^{-6} and 2.2×10^{-4} rem respectively. The total population whole-body dose to individuals living within 50 miles of the plant would be 1.3×10^{-1} man-rem.

7.1.3.3.2 Class 3.2--Release of Waste Gas Storage Tank Contents

This postulated accident is defined to be the sudden release of 100% of the average inventory of a waste gas storage tank. Other assumptions used in evaluating the consequences of this accident class are identical to those used in class 3.1 accidents involving gas releases. Table 7.1-4 presents postulated doses.

The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary would be 3.4 $\times 10^{-2}$ and 4.0×10^{-4} rem, respectively. The total population

whole-body dose to individuals living within 50 miles of the plant would be 7.7×10^2 man-rem.

7.1.3.3.3 Class 3.3--Release of Liquid Waste Storage Tank Contents

This accident is postulated to be the instantaneous release of 100% of the contents of the refueling water tank. Other assumptions used in evaluating the consequences of this accident class are identical to those used in class 3.1 accidents involving liquid releases. Table 7.1-4 presents postulated doses.

The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary would be 2.4 $\times 10^{-5}$ and 9.0×10^{-4} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant would be 5.3×10^{01} man-rem.

It is expected that any spilled liquid or contaminated ground that would be present as a result of this failure would be isolated and decontaminated. However, in the event no cleanup attempts were made, the groundwater concentration at the site boundary would be substantially below the maximum permissible concentration listed in 10CFR20, Appendix B, Table II (refer to FSAR Section 2.4.13.3).

7.1.3.4 Class 4.0--Fission Products Into Primary System

Class 4 accidents are applicable to a boiling water reactor. Analysis of this accident class is therefore not necessary.

7.1.3.5 Class 5.0--Fission Products Into Primary and Secondary System (Pressurized Water Reactor (PWR))

Class 5 accidents are postulated to involve the simultaneous conditions of a failed fuel fraction yielding a primary coolant

activity level for fission products and a transfer of radioactivity to the steam system by steam generator tube leakage or rupture.

7.1.3.5.1 Class 5.1--Fuel Cladding Defects and Steam Generator Leak

This condition has been considered under normal operation, and the radionuclide releases resulting have been included in arriving at dose levels reported in section 5.2.

7.1.3.5.2 Class 5.2--Off-Design Transients That Induce Fuel Failure Above Those Expected and Steam Generator Leak

In the unlikely event of a transient that would cause higher fuel failure than design levels and a coincident condition of steam generator leakage, the opportunity exists for release of gaseous radionuclides through the condenser air removal system.

The assumptions and parameters used in this analysis are as follows:

A. Core full-power operation at 3800 MWt during a 292-effective-full-power-day equilibrium cycle. One-third of the fuel has been irradiated for three full-power equilibrium cycles, one-third for two full-power cycles, and one-third for one full-power equilibrium cycle.

B. Transient releases 0.02% of the full-core inventory of noble gases and halogens.

C. RCS concentrations are based on ANSI-N237 source strengths and 100-lb/day steam generator leakage.

D. Iodine partition factor is 0.1 for the steam generators and 0.001 for the condenser.

E. The entire transient is assumed to take place over an 8-hour period.

F. All noble gases are released without any delay or treatment by the condenser air removal system. The iodines pass through a 95% efficient charcoal filter.

Table 7.1-5 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary during the whole course of the release would be 9.4×10^{-5} and 2.9×10^{-5} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant would be 2.1 man-rem.

7.1.3.5.3 Class 5.3--Steam Generator Tube Rupture

Should a steam generator tube rupture, activity present in the primary coolant would be transferred to the steam system at a rapid rate. Further, because of the depressurization of the primary system, there would be a reactor trip and a turbine trip. The noble gas and iodine activity transferred to the secondary system would be released through the main steam safety relief valves (MSSVs). Assumptions and parameters used in this analysis are as follows:

A. A release to the steam system of 15% of the primary coolant activity, based on ANSI-N237 source strength

B. Existing 100-lb/day steam generator leakage continues

C. A release of 510,000 pounds of steam during the 8-hour duration of the accident

D. Release of all noble gases and iodines without any delay or treatment through the MSSVs.

E. An iodine partition factor of 0.1 for the steam generator.

Table 7.1-5
CLASS 5 ACCIDENT DOSES

	Class 5.2	Class 5.3
Site Boundary Doses (Rem)		
Total Body		
0-8 hr Release Period	9.4(-05)	3.5(-05)
Thyroid Inhalation		
Child		
0-8 hr Release Period	2.9(-05)	3.3(-03)
Population Doses (Man-Rem)		
Total Body		
0-8 hr Release Period	2.1	7.9(-01)

Table 7.1-5 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary would be 3.5×10^{-5} and 3.3×10^{-3} rem, respectively. The total population whole-body dose to individuals within 50 miles would be 7.9×10^{-1} man-rem.

7.1.3.6 Class 6.0--Refueling Accidents Inside Containment

The possibility of damage to a fuel assembly as a consequence of mishandling or dropping is minimized by proper equipment design, redundant safety features, detailed operating procedure, and thorough operator training. The motion of the cranes that move the fuel assemblies are limited to low speeds. All handling operations of irradiated fuel are conducted under water. Adequate cooling of fuel is provided.

Despite the unlikely event of a refueling accident, two refueling accidents are postulated and evaluated: a fuel assembly drop and a heavy object drop onto fuel in core.

7.1.3.6.1 Class 6.1--Fuel Bundle Drop Onto Fuel in Core

The postulated accident is assumed to result in damage to one row of fuel rods in the fuel assembly. The subsequent release of gaseous radioactivity from the damaged fuel assembly will bubble through the covering water. This results in removal of most of the radioiodines. The following assumptions are postulated for a fuel assembly drop accident:

A. The gap activity (noble gases and halogens) in one row (16 fuel rods) of fuel pins is assumed to be released into water.

B. Decay time of 1 week before the accident occurs is assumed.

C. Iodine decontamination factor in water is 500; noble gases are not retained by water.

D. The containment volume is 2.6 x 10^6 cubic feet.

E. The containment building is vented before isolation at a rate of 30,000 ft^3/min without credit for filters.

F. The containment building is isolated 1 minute after the accident.

Table 7.1-6 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary are 9.0 x 10^{-7} and 1.0 x 10^{-4} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant is 2.0 x 10^{-2} man-rem.

7.1.3.6.2 Class 6.2--Heavy Object Drop Onto Fuel in Core

This postulated accident is assumed to result in damage to an average fuel assembly. The assumptions used in the fuel bundle drop accident apply with the exception that 100 hours

Table 7.1-6
CLASS 6 ACCIDENT DOSES

	Class 6.1	Class 6.2
Site Boundary Doses (Rem)		
Total Body		
0-8 hr Release Period	9.0(-07)	1.9(-05)
Thyroid Inhalation		
Child		
0-8 hr Release Period	1.0(-04)	2.0(-03)
Population Doses (Man-Rem)		
Total Body		
0-8 hr Release Period	2.0(-02)	4.3(-01)

of decay time is assumed before the object drop occurs and the entire fuel assembly is assumed to be damaged.

Table 7.1-6 presents postulated doses. The resultant whole-body and thyroid inhalation doses to individuals located at the PVNGS site boundary are 1.9×10^{-5} and 2.0×10^{-3} rem respectively. The total population whole-body dose to individuals living within 50 miles of the plant is 4.3×10^{-1} man-rem.

7.1.3.7 Class 7.0--Spent-Fuel-Handling Accidents

Class 7 accidents are postulated to include spent-fuel-handling accidents outside of containment. This class of accident can occur inside the fuel building for classes 7.1 and 7.2 and outside any buildings for class 7.3 accidents. The latter case would result in the release of radioactive material directly to the environment if the fuel cask and fuel were broken. For accidents occurring inside the fuel building, use of charcoal filters is assumed before release.

7.1.3.7.1 Class 7.1--Fuel Assembly Drop in Fuel Storage Pool

This postulated accident is assumed to result in damage to one row of fuel rods in the assembly. The subsequent release of gaseous radioactivity from the damaged fuel assembly will bubble through the covering water. This results in the removal of most of the radioiodines. The following assumptions are postulated for a fuel assembly drop accident:

A. The gap activity (noble gases and halogens) in one row (16 fuel rods) of fuel pins is assumed to be released into the water.

B. A decay time of 1 week before the accident occurs is assumed.

C. The iodine decontamination factor in water is 500; noble gases are not retained by water.

D. The volume of the fuel building affected is 800,000 cubic feet and is isolated 1 minute after the accident. The fuel building is vented at a rate of 43,500 ft^3/min prior to isolation. After isolation the fuel building is vented at a rate of 6,000 ft^3/min.

E. A charcoal filter efficiency of 95 percent is assumed after isolation.

Table 7.1-7 presents postulated doses. The resultant whole-body and thyroid inhalation doses to individuals located at the PVNGS site boundary are 7.7×10^{-5} and 8.8×10^{-4} rem, respectively. The total population whole-body dose to individuals living within 50 miles is 1.7 man-rem.

7.1.3.7.2 Class 7.2--Heavy Object Drop Onto Fuel Racks

This postulated accident assumes a similar release of radioactivity from a damaged fuel assembly similar to that postulated for the class 6.2 accident, with the exception that a 30-day

Table 7.1-7

CLASS 7 ACCIDENT DOSES

	Class 7.1	Class 7.2	Class 7.3
Site Boundary Doses (Rem)			
Total Body			
0-8 hr Release Period	7.5(-05)	5.5(-05)	8.3(-06)
8-24 hr Release Period	1.8(-06)	1.3(-06)	
1-4 day Release Period	0.0	0.0	
4-30 day Release Period	0.0	0.0	
Sum	7.7(-05)	5.6(-05)	
Thyroid Inhalation			
Child			
0-8 hr Release Period	8.8(-04)	1.8(-03)	3.9(-02)
8-24 hr Release Period	5.2(-06)	1.0(-05)	
1-4 day Release Period	0.0	0.0	
4-30 day Release Period	0.0	0.0	
Sum	8.8(-04)	1.8(-03)	
Population Doses (Man-Rem)			
Total Body			
0-8 hr Release Period	1.7	1.2	1.9(-01)
8-24 hr Release Period	3.3	2.5(-2)	
1-4 day Release Period	1.4(-5)	1.0(-5)	
4-30 day Release Period	0.0	0.0	
Sum	1.7	1.27	

decay period is assumed before the accident occurs. Assumptions C, D, and E of the class 7.1 accident also apply. Table 7.1-7 presents postulated doses as a function of time.

The whole-body and thyroid inhalation doses to an individual at the PVNGS site boundary as a result of the accident are 5.6×10^{-5} rem and 1.8×10^{-3} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant is 1.3 man-rem.

7.1.3.7.3 Class 7.3--Fuel Cask Drop

A fuel cask drop is postulated to occur outside any buildings. 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:

A. Gap activity from one fully loaded fuel cask (120-day cooling and decay) is assumed to be released.

B. It is assumed that a fully loaded cask contains 10 fuel assemblies.

Table 7.1-7 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary are 8.3×10^{-6} and 3.9×10^{-2} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant is 1.9×10^{-1} man-rem.

7.1.3.8 Class 8.0--Accident Initiation Events Considered in Design Basis Evaluation in the SAR

Accidents considered in this class include loss-of-coolant accidents (LOCA, small and large pipe breaks), rod ejection accidents, and steam line breaks (small and large) outside

containment. All instrument lines penetrating containment can be isolated; thus, a break of these lines is not considered.

These unlikely accidents are used, with highly conservative assumptions, as the basis for system design to establish the performance requirements of engineered safety features. Unlike the analyses of these postulated accidents in the FSAR, this analysis is evaluated on the more realistic basis that these engineered safety features will be available and will either prevent the progression of the accident or mitigate the consequences.

7.1.3.8.1 Class 8.1--LOCA

A LOCA is the loss of primary system coolant because of rupture of a reactor coolant system pipe or the rupture of any line connected to that system. A small quantity of coolant containing fission products normally present in the coolant would then be released to the containment.

The safety injection system acts to ensure subcriticality of the core by injection of borated water to mitigate or prevent fuel cladding failures by removal of heat from the core.

Fission products that are released to the containment building from cladding failures are partially removed from the building atmosphere by the containment spray system and by plateout on structures. Some of the remaining fission product gases in the building atmosphere are assumed to leak out of the containment building during the time the inside pressure is higher than outside atmospheric pressure.

Because of the conservatism and care involved in design, fabrication, and erection of reactor coolant components and periodic inspections, it is unlikely that a significant failure (rupture) could occur.

7.1.3.8.1.1 Small Pipe Break. In the case of a small pipe ruptures, primary coolant system depressurization causes a reactor trip, and steam is dumped to the atmosphere. The containment building is isolated and containment spray is initiated.

The following assumptions and parameters were used in evaluating this accident:

A. Reactor coolant activity only is released to containment (ANSI-N237 source strengths).

B. A reduction factor of 0.05 is used for the effect of sprays and plateout on iodines.

C. Containment leakage is 0.1 volume % per day for the first 24 hours and 0.05 volume % per day the remaining 29 days.

D. No other decontamination of containment leakage was assumed.

Table 7.1-8 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary during the 30-day leakage release would be 4.1×10^{-6} and 2.3×10^{-4} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant would be 6.3×10^{-2} man-rem.

7.1.3.8.1.2 Large Pipe Break. For this postulated accident, the assumptions and parameters of the small pipe break apply, with the exception that 2% of the core iodines and noble gases are assumed to be released to the containment by virtue of fuel cladding failures in addition to the activity already existing in the primary coolant.

Table 7.1-8 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at

Table 7.1-8

CLASS 8.1 AND 8.2(a) ACCIDENT DOSES

	Small LOCA	Large LOCA	Rod Ejection
Site Boundary Doses (Rem)			
Total Body			
0-8 hr Release Period	6.5(-07)	6.4(-03)	6.4(-04)
8-24 hr Release Period	8.6(-07)	1.8(-03)	1.8(-04)
1-4 day Release Period	1.1(-06)	1.1(-03)	1.1(-04)
4-30 day Release Period	1.5(-06)	1.5(-03)	1.5(-04)
Sum	4.1(-06)	1.1(-02)	1.1(-03)
Thyroid Inhalation			
Child			
0-8 hr Release Period	3.9(-05)	1.4	1.4(-01)
8-24 hr Release Period	3.1(-05)	1.1	1.1(-01)
1-4 day Release Period	5.4(-05)	1.8	1.8(-01)
4-30 day Release Period	1.0(-04)	3.4	3.4(-01)
Sum	2.2(-04)	7.7	7.7(-01)
Population Doses (Man-Rem)			
Total Body			
0-8 hr Release Period	1.5(-02)	1.4(+02)	1.5(+01)
8-24 hr Release Period	1.7(-02)	3.4(+01)	3.5
1-4 day Release Period	1.6(-02)	1.7(+01)	1.7
4-30 day Release Period	1.5(-02)	1.5(+01)	1.5
Sum	6.3(-02)	2.1(+02)	2.2(+01)

the PVNGS site boundary during the 30-day leakage release would be 1.1 x 10^{-2} and 7.7 rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant would be 2.1 x 10^{2} man-rem.

7.1.3.8.1.3 Break in Instrumentation Line From Primary System That Penetrates Containment. All primary system instrument lines have isolation capability inside containment; therefore, this accident is not applicable.

7.1.3.8.2 Class 8.2a--Rod Ejection Accident, PWR

The postulated rod ejection accident is a LOCA, and the general discussion of 7.1.3.8.1 applies. The assumptions and parameters of the large pipe break apply, except that 0.2% of the noble gases and iodines are assumed to be released from the fuel to the containment in addition to the activity already existing in the primary coolant.

Table 7.1-8 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary during the 30-day leakage release would be 1.1 x 10^{-3} and 7.7 x 10^{-1} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant would be 21 man-rem.

7.1.3.8.3 Class 8.3a--Steamline Breaks Outside Containment, PWR

A rupture of a steamline is considered to be any accident that results in an uncontrolled steam release from a steam generator. If there are no steam generator tube leaks, there would be no fission product release to the environment from this accident. With tube leaks, a portion of the activity in the steam system would be released. In addition, a portion of the activity in

the primary coolant leaks to the secondary system as the reactor is cooled down.

Under this class of accident, both a small break (break size equal to area of a safety valve throat) and a large break (such as severance of a main steam line) are analyzed. The resultant calculated doses are the same for both because the same set of assumptions and parameters are used:

A. Primary coolant activity is based on operation with ANSI-N237 source strength.

B. Primary-to-secondary leak rate through tubes in the steam generator is 100 lb/day.

C. An iodine reduction factor of 0.5 is applied to the primary coolant source.

D. Primary coolant continues to leak at 100 lb/day for 8 hours while the reactor coolant system is cooled and depressurized.

E. The activity in one steam generator is released over an 8-hour period to the environment with an iodine partition factor of 0.1.

Table 7.1-9 presents postulated doses. The resultant whole-body and thyroid inhalation doses to an individual located at the PVNGS site boundary during the 8-hour release would be 7.9×10^{-8} and 3.2×10^{-5} rem, respectively. The total population whole-body dose to individuals living within 50 miles of the plant would be 1.8×10^{-3} man-rem. As stated previously, these doses are applicable for both the small and large breaks.

7.1.4 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

Table 7.1-10 summarizes for the various accidents the whole-body and thyroid inhalation doses at the PVNGS site

Table 7.1-9
CLASS 8.3a ACCIDENT DOSES

Site Boundary Doses (Rem)	
Total Body	
0-8 hr Release Period	7.9(-08)
Thyroid Inhalation	
Child	
0-8 hr Release Period	3.2(-05)
Population Doses (Man-Rem)	
Total Body	
0-8 hr Release Period	1.8(-03)

boundary and the total population whole-body dose to individuals within 50 miles of the plant.

It can be seen, from the standpoint of estimated dose, that the most severe accident considering the whole-body dose is the complete release of the contents of a waste gas storage tank. This accident also delivers the highest total whole-body population dose to persons living within 50 miles of the plant. For thyroid inhalation dose, the most severe accident is the large break LOCA. Thus, the maximum doses resulting from accidents at the PVNGS site are 3.4×10^{-2} rem for the individual whole-body dose, 7.7×10^{2} man-rem for the total population whole-body dose, and 7.7 rem for the individual thyroid inhalation dose.

Table 7.1-10

SUMMARY OF DOSES RESULTING FROM POSTULATED ACCIDENTS (Sheet 1 of 4)

Accident Class	Description	Whole-Body Dose		Maximum Thyroid Inhalation Dose At Site Boundary (rem)
		Maximum Site Boundary Dose (rem)	Population Dose at 50 Miles (man-rem)	
1.0	Trivial incidents	(a)	(a)	(a)
2.0	Small releases outside containment	(a)	(a)	(a)
3.0	Radwaste system failures			
3.1	Equipment leakage or malfunction			
	Gases	8.5(-03)	1.9(+01)	9.9(-05)
	Liquids	5.9(-06)	1.3(-01)	2.2(-04)
3.2	Release of waste gas storage tank contents	3.4(-02)	7.7(+02)	4.0(-04)
3.3	Release of liquid waste storage tank contents	2.4(-05)	5.3(-01)	9.0(-04)

NA = Not applicable.

a. Incidents included and evaluated under routine releases contained in section 5.2.

Table 7.1-10

SUMMARY OF DOSES RESULTING FROM POSTULATED ACCIDENTS (Sheet 2 of 4)

Accident Class	Description	Whole-Body Dose		Maximum Thyroid Inhalation Dose At Site Boundary (rem)
		Maximum Site Boundary Dose (rem)	Population Dose at 50 Miles (man-rem)	
4.0	Fission products into primary system (BWR)	NA	NA	NA
5.0	Fission products into primary and secondary system (PWR)			
5.1	Fuel cladding defects and steam generator leak	(a)	(a)	(a)
5.2	Off-design transients that induce fuel failure above those expected and steam generator leak	9.4(-05)	2.1	2.9(-05)
5.3	Steam generator tube rupture	3.5(-05)	7.9(-01)	3.3(-03)
6.0	Refueling accidents inside containment			
6.1	Fuel bundle drop onto fuel in core	9.0(-07)	2.0(-03)	1.0(-04)

Table 7.1-10

SUMMARY OF DOSES RESULTING FROM POSTULATED ACCIDENTS (Sheet 3 of 4)

Accident Class	Description	Whole-Body Dose: Maximum Site Boundary Dose (rem)	Whole-Body Dose: Population Dose at 50 Miles (man-rem)	Maximum Thyroid Inhalation Dose At Site Boundary (rem)
6.2	Heavy object drop onto fuel in core	1.9(-05)	4.3(-01)	2.0(-03)
7.0	Spent-fuel-handling accident			
7.1	Fuel assembly drop in fuel storage pool	7.7(-05)	1.7	8.8(-04)
7.2	Heavy object drop onto fuel racks	5.6(-05)	1.3	1.8(-03)
7.3	Fuel cask drop	8.3(-06)	1.9(-01)	3.9(-02)
8.0	Accident initiation events considered in FSAR			
8.1	LOCA			
	Small pipe break	4.1(-06)	6.3(-02)	2.3(-04)
	Large pipe break	1.1(-02)	2.1(+02)	7.7

Table 7.1-10

SUMMARY OF DOSES RESULTING FROM POSTULATED ACCIDENTS (Sheet 4 of 4)

Accident Class	Description	Whole-Body Dose		Maximum Thyroid Inhalation Dose At Site Boundary (rem)
		Maximum Site Boundary Dose (rem)	Population Dose at 50 Miles (man-rem)	
	Break in instrumentation line from primary system that penetrates containment	NA	NA	NA
8.2	Control rod accidents			
	Rod ejection accident (PWR)	1.1(-03)	2.1(+01)	7.7(-01)
	Rod drop accident (BWR)	NA	NA	NA
8.3	Steamline break accidents outside containment			
	PWR			
	Small break	7.9(-08)	1.8(-04)	3.2(-05)
	Large break	7.9(-08)	1.8(-04)	3.2(-05)
	BWR	NA	NA	NA

7.2 TRANSPORTATION ACCIDENTS INVOLVING RADIOACTIVITY

The transportation of new fuel to the site, irradiated fuel from the site, and solid radioactive waste from the site to a waste disposal site is within the scope of paragraph (g) of 10 CFR 51.20. The environmental risks of such transportation are as set forth in Summary Table S-4 of 10 CFR 51.

7.3 OTHER ACCIDENTS

This information, previously presented in ER-CP Section 7.2 and the FES, has been updated to reflect the actual design. The only significant change since the PVNGS 1, 2 & 3 ER-CP is a shift to sodium hypochlorite from liquid chlorine for biological control.

7.3.1 ACCIDENTS INVOLVING THE SWITCHYARD

No significant environmental concerns have been identified relative to the switchyard. While there is a small probability that a transformer, shunt reactor, series capacitor or circuit breaker could explode or leak, the area potentially affected would be restricted to the immediate vicinity of the malfunctioning equipment. Any oil released from a transformer tank rupture would be caught in the retention basin around the transformer. No environmental damage would occur if the sulfur hexafluoride insulating media of large circuit breakers were liberated, since the gas is nonflammable, nontoxic, colorless, and odorless.

7.3.2 ACCIDENTS INVOLVING FUEL OIL AND LPG STORAGE TANKS

One diesel fuel oil storage tank is provided for each of the two diesel generators per unit. These tanks are located underground at the edge of the power block, and have an approximate capacity of 84,000 gallons each. Vent stack flame arrestors are provided. Possible accidents are spills which would result in flooding the transfer pump vault, or, in releasing oil to the immediate area. The vault would be pumped out by tank truck. The possibility of a fire is unlikely and explosion remote.

Two fuel oil storage tanks and two LPG tanks are located above ground in the water reclamation plant area. The fuel oil tanks have a combined capacity of approximately 226,400 gallons of No. 2 oil. Any oil spill will be contained within the dike and paved area. There is a pipeline connecting the fuel oil tanks and the auxiliary boiler. Since the pipeline is buried and the PVNGS site has no active faults (see section 2.5) no pipeline accidents are postulated. The LPG tanks have a combined capacity of 70,000 gallons and are protected by a water deluge fire protection system.

7.3.3 ACCIDENTS INVOLVING HAZARDOUS GASES

7.3.3.1 Hydrogen

Hydrogen gas (H_2) is stored in pressurized containers designed in accordance with ASME Boiler and Pressure Vessel Code Section VIII. Hydrogen is used for generator cooling and oxygen control in the reactor coolant system. It will be stored north of the turbine building in a bank of 14 steel cylinders per unit with a total capacity of approximately 125,000 standard cubic feet, at a pressure of 2200 to 2450 psia. Each bank will be provided with a pressure relief valve and a vent pipe to diffuse any gas into the atmosphere. Smoking and open flames will be prohibited. A leak or rupture of a pressurized H_2 container is unlikely because of the stringent precautions taken in materials fabrication and in container storage.

7.3.3.2 Chlorine

Chlorine is used at PVNGS for biological control. Chlorine is stored as sodium hypochlorite. Thus, potential accidents arising from liquid chlorine storage tanks are eliminated. Hypochlorite storage poses minimal potential hazard to the environment.

7.3.4 ACCIDENTS INVOLVING HAZARDOUS LIQUIDS AND CHEMICALS

7.3.4.1 Sulfuric Acid

Sulfuric acid is used to regenerate the demineralizers, to lower the pH of the water reclamation plant (WRP) clarifier effluent, and to acidify the circulating cooling water to prevent scale. Bulk storage facilities include five 11,000 gallon tanks located within the 40 ft by 120 ft sulfuric acid area (just south of the gravity filters) at the WRP, two 4,000 gallon tanks located just north of the water treatment plant; two 25,000 gallon tanks located near each circulating water intake structure; and two 11,000 gallon tanks located north of each turbine building. The tanks, designed and fabricated according to API-650, contain 66° Baumé, H_2SO_4. They are surrounded by concrete dikes designed to reduce the possibility of leakage to the environment. Any large volumes of H_2SO_4 accidently released would be contained within the dike, and retained for use or neutralized with caustic and disposed to the evaporation pond.

7.3.4.2 Carbon Dioxide

Four 45 ton horizontal carbon dioxide storage tanks, each seven feet in diameter, are located in the southwest corner of the water reclamation plant, just south of the clarifiers. A 7-1/2 ton tank is located near the radwaste building. Since they are maintained at a low pressure, an accidental tank rupture would allow a fraction of the total liquid volume to flash instantaneously into gaseous CO_2. The remaining CO_2 would slowly sublime. Neither the initial "puff" released from a rupturing tank nor the steady state plume emanating from the sublimation of CO_2 would affect anyone offsite.

7.3.4.3 Miscellaneous Plant Chemicals

Moderate quantities of sodium hydroxide and ammonium hydroxide are stored onsite. They are surrounded by concrete dikes designed to reduce the possibility of leakage to the environment. Due to the relative stability of these chemicals, they do not pose potential hazards to the environment.

APPENDIX 7A

RESPONSES TO NRC QUESTIONS

CHAPTER 8

ECONOMIC AND SOCIAL EFFECTS OF STATION CONSTRUCTION AND OPERATION

CONTENTS

TABLES

8. ECONOMIC AND SOCIAL EFFECTS OF STATION CONSTRUCTION AND OPERATION

8.1 BENEFITS

The economic and social benefits of PVNGS construction and operation were evaluated in ER-CP Supplement 6 and the FES. Benefits are updated in this section.

A summary of the direct and indirect benefits is presented in table 8.1-1.

8.1.1 DIRECT BENEFITS

The major direct benefit of the proposed facility will be the value of the generated electricity delivered to consumers. The PVNGS units will be operated as base load plants, each generating a nominal net 1270 megawatts (electric).

Expected average annual generation, generating capacity, proportional distribution of electricity by customer class and average revenue for PVNGS and the participating utilities are presented in table 8.1-2.

8.1.2 INDIRECT BENEFITS

This section addresses the economic and social benefits not directly related to the production and use of electrical power of PVNGS Units 1,2&3 in Maricopa County. Major benefits include those accruing from employment, taxes, and expenditures locally for materials and services. Secondary and tertiary economic and social benefits of a similar nature will be derived from these primary benefits.

8.1.2.1 Employment Benefits

The employment benefits will be divided between impact during the construction phase and impact during the much longer

Table 8.1-1

ANNUAL BENEFITS FROM FACILITY OPERATION

(Sheet 1 of 2)

DIRECT BENEFITS	
Expected average annual generation (kWh)	2.561×10^{10}
Capacity (kW)	3.81×10^{6}
Proportional distribution of electrical energy[(a)]	
Industrial	5.26×10^{9}
Commercial	7.71×10^{9}
Residential	6.64×10^{9}
Other	3.86×10^{9}
Losses	2.14×10^{9}
Expected average annual Btu of steam sold from the facility	0
Expected average annual delivery of other beneficial products	0
Revenues from delivered benefits[(b)]	
Electrical energy generated[(c)]	$\$1.581 \times 10^{9}$
Steam sold	0
Other products	0

a. Expected annual delivery in kWh.

b. Based on estimated 1979 revenues escalated at 7% per year to 1986 dollars.

c. Includes collection of applicable sales tax.

d. Estimated 1986 operating payroll.

e. Includes ad valorem tax revenues plus income and sales tax based on employee income. Ad valorem taxes are averaged for 1978 and 1979 escalated to 1986 dollars.

f. Based on purchase payment at $30/acre-foot in 1986.

Table 8.1-1
ANNUAL BENEFITS FROM FACILITY OPERATION
(Sheet 2 of 2)

INDIRECT BENEFITS	
Employment[(d)]	$\$18.7x10^6$
Annual taxes (local, state, federal)[(e)]	$\$126x10^6$
Research	minor
Regional product	not assessed
Environmental enhancement	minor
Education	minor
Others	minor
Revenues to municipalities for purchase of sewage effluent[(f)]	$\$1.92x10^6$

operating phase of the project. Some beneficial impacts will be derived during the construction phase for certain business sectors.

8.1.2.1.1 Construction

Work began in 1976 and is expected to terminate in 1986. At the height of construction activity, there were approximately 6200 workers actively involved in the project. These figures include skilled craftsmen, laborers, supervisors, engineers, technicians, and subcontractor workers on the site. Table 8.1-3 provides a breakdown of the average number of workers by time period and average direct payroll.

An estimate of secondary employment opportunities due to the construction of PVNGS indicates that substantial employment opportunities have developed or have been sustained in the Phoenix region. In a base study completed by the Bureau of

Table 8.1-2

DISTRIBUTION OF DIRECT BENEFITS

Benefit	PVNGS 1,2&3	APS	SRP	EPE	SCE	PNM	LADWP
Expected average annual generation in kilowatt-hours	25.61×10^{9}	7.45×10^{9}	5.99×10^{9}	4.05×10^{9}	4.05×10^{9}	2.61×10^{9}	1.46×10^{9}
Capacity in kilowatts	3810×10^{3} [a]	1109×10^{3}	892×10^{3}	602×10^{3}	602×10^{3}	389×10^{3}	217×10^{3}
Proportional distribution of electrical energy: [b]							
Industrial	5.26×10^{9}	1.36×10^{9}	1.18×10^{9}	0.88×10^{9}	1.07×10^{9} [c]	0.46×10^{9}	0.31×10^{9}
Commercial	7.71×10^{9}	2.06×10^{9}	1.84×10^{9}	1.22×10^{9}	1.29×10^{9} [c]	0.67×10^{9}	0.63×10^{9}
Residential	6.64×10^{9}	1.92×10^{9}	2.15×10^{9}	0.93×10^{9}	0.80×10^{9} [c]	0.50×10^{9}	0.34×10^{9}
Other	3.86×10^{9}	1.35×10^{9}	0.35×10^{9}	0.75×10^{9}	0.58×10^{9} [c]	0.79×10^{9}	0.04×10^{9}
Losses	2.14×10^{9}	0.76×10^{9}	0.47×10^{9}	0.27×10^{9}	0.31×10^{9}	0.19×10^{9}	0.14×10^{9}
Revenue from delivered benefits: [d]							
Electrical energy generated in $/yr. [e]	1.581×10^{9}	464×10^{6}	349×10^{6}	265×10^{6}	257×10^{6}	177×10^{6}	69×10^{6}

a. Total not in balance due to round-off.

b. Expected annual delivery in kWh.

c. Based on energy distribution by customer class in the year 2000.

d. Based on estimated 1979 revenues and escalated at 7%/year to convert to 1986 dollars.

e. Includes collection of applicable sales taxes.

Table 8.1-3

CONSTRUCTION STAGE MANPOWER AND DIRECT PAYROLL

(Sheet 1 of 2)

Time Period	Average Manpower	$1,000 Average Direct Payroll
1st Quarter 1976	176	1,115
2nd Quarter 1976	692	4,303
3rd Quarter 1976	864	5,418
4th Quarter 1976	1,036	6,533
1st Quarter 1977	1,048	6,533
2nd Quarter 1977	1,588	9,880
3rd Quarter 1977	1,760	10,995
4th Quarter 1977	2,272	14,182
1st Quarter 1978	2,996	18,485
2nd Quarter 1978	3,552	21,831
3rd Quarter 1978	4,416	27,250
4th Quarter 1978	5,328	32,827
1st Quarter 1979	6,028	50,454
2nd Quarter 1979	6,208	51,939
3rd Quarter 1979	5,676	47,489
4th Quarter 1979	5,316	44,518
1st Quarter 1980	5,316	44,518
2nd Quarter 1980	5,316	44,518
3rd Quarter 1980	5,316	44,518
4th Quarter 1980	5,120	43,035
1st Quarter 1981	4,644	38,587
2nd Quarter 1981	4,644	38,587
3rd Quarter 1981	3,716	31,166
4th Quarter 1981	3,540	29,683
1st Quarter 1982	3,540	29,683
2nd Quarter 1982	3,380	28,193
3rd Quarter 1982	3,176	26,711
4th Quarter 1982	3,176	26,711
1st Quarter 1983	3,176	26,711
2nd Quarter 1983	3,176	26,711
3rd Quarter 1983	2,676	22,261
4th Quarter 1983	2,676	22,261

Table 8.1-3

CONSTRUCTION STAGE MANPOWER AND DIRECT PAYROLL

(Sheet 2 of 2)

Time Period	Average Manpower	$1,000 Average Direct Payroll
1st Quarter 1984	2,320	19,290
2nd Quarter 1984	1,960	16,324
3rd Quarter 1984	1,592	13,357
4th Quarter 1984	1,592	13,357
1st Quarter 1985	1,220	10,385
2nd Quarter 1985	1,040	8,903
3rd Quarter 1985	872	7,420
4th Quarter 1985	708	5,938
1st Quarter 1986	352	3,012
April 1986	276	785
Approximate Total Direct Payroll		976,400

Economic and Business Research at Arizona State University[1], the employment multiplier for Maricopa County was determined to be 3.6; that is, for each new base job created, 2.6 secondary jobs would result.

8.1.2.1.2 Operation

2 A staff of approximately 844 will be required to operate and maintain PVNGS. In 1986 the full staff will be employed, at which time the annual payroll for permanent personnel will be approximately $28 million. Table 8.1-3A provides a breakdown
2 of the average number of operational workforce personnel by time period and average direct payroll. The actual secondary impact of these permanent employees will depend on how many of the jobs represent a net increase in utilities employment. When compared to a personal income of $10.1 billion for

Table 8.1-3A
OPERATIONAL MANPOWER AND DIRECT PAYROLL

Time Period	Average Manpower	$1,000 Average Direct Payroll (a) (b)
4th Quarter 1979	102	846
1st Quarter 1980	105	871
2nd Quarter 1980	117	970
3rd Quarter 1980	165	1,368
4th Quarter 1980	230	1,908
1st Quarter 1981	386	3,202
2nd Quarter 1981	435	3,608
3rd Quarter 1981	464	3,848
4th Quarter 1981	495	4,106
1st Quarter 1982	538	4,462
2nd Quarter 1982	591	4,902
3rd Quarter 1982	678	5,623
4th Quarter 1982	706	5,856
1st Quarter 1983	721	5,980
2nd Quarter 1983	740	6,138
3rd Quarter 1983	760	6,304
4th Quarter 1983	774	6,420
1st Quarter 1984	777	6,445
2nd Quarter 1984	799	6,627
3rd Quarter 1984	808	6,702
4th Quarter 1984	818	6,785
1st Quarter 1985	824	6,835
2nd Quarter 1985	835	6,926
3rd Quarter 1985	842	6,984
4th Quarter 1985	844	7,001
Approximate Total Direct Payroll		120,717

2

a. Based on 1980 dollars
b. $2765 average loaded monthly salary

Maricopa County in 1978[2], the net addition of PVNGS payroll is not likely to have significant impact on county-wide employment.

8.1.2.2 Tax Benefits

Major tax benefits in the area of income, excise, and ad valorem taxes will accrue to the Federal Government and the State of Arizona as a result of the construction and operation of PVNGS. State and local political subdivisions affected are as follows:

- State of Arizona
- Maricopa County, Arizona
- Ruth Fisher Elementary District No. 90
- Arlington Elementary District No. 47
- Buckeye Union High School District
- Maricopa County Community College District
- Central Arizona Water Conservation District
- Flood Control District of Maricopa County

8.1.2.2.1 Income Tax

Income tax revenues resulting from employment during the construction phase can be estimated for both the State of Arizona and the United States. The estimates are based on existing tax rates.

Approximately 1.3% of personal income earned in Arizona is paid in taxes to the state.[3] The United States income tax estimates are based on the assumption of a typical worker with a family of four who uses the standard deduction. This results in an average tax rate of 20%, based on tax schedules in effect from 1977 to 1979. Table 8.1-4 presents the annual payroll and estimated state and federal income taxes expected during the

Table 8.1-4

ANNUAL CONSTRUCTION STAGE PAYROLL INCOME AND SALES TAX ESTIMATES (in Millions of Dollars)

Year	Estimated Average Direct Payroll	Estimated Arizona Income Tax	Estimated United States Income Tax	Estimated Sales Tax Revenue
1976	17.4	0.226	3.48	0.574
1977	41.6	0.541	8.32	1.373
1978	100.4	1.305	20.08	3.313
1979	194.4	2.527	38.88	6.415
1980	176.6	2.296	35.32	5.828
1981	138.0	1.794	27.60	4.554
1982	111.3	1.447	22.26	3.673
1983	97.9	1.273	19.58	3.231
1984	62.3	0.810	12.46	2.056
1985	32.7	0.425	6.54	1.079
1986	3.8	0.049	0.76	0.125
Total	976.4	12.69	195.3	32.2

construction phase. Taxes on the 1986 operating payroll are estimated to be $364,000 for Arizona income tax and $5,610,000 for United States income tax. 2

Table 8.1-4A presents the annual payroll and estimated state and federal income taxes expected during the operational phase. 2

8.1.2.2.2 Excise Taxes

In addition to the state income tax revenues, the State of Arizona and its municipalities will benefit from the sales tax revenues which can be anticipated on the basis of payroll generated by PVNGS. Approximately 3.3% of personal income is paid in the form of state sales tax levies[4]. Table 8.1-4

Table 8.1-4A

ANNUAL OPERATIONAL PAYROLL INCOME AND SALES TAX ESTIMATES (in Millions of Dollars)

2

Year	Estimated Average Direct Payroll	Estimated Arizona Income Tax	Estimated United States Income Tax	Estimated Sales Tax Revenue
1983[(a)]	12.7	0.165	2.55	0.420
1984	26.6	0.345	5.32	0.876
1985	27.7	0.360	5.55	0.916
1986	27.7	0.364	5.61	0.924
1987	27.7	0.364	5.61	0.924
1988[(b)]	14.0	0.182	2.80	0.462
Total	136.4	1.78	27.44	4.52

a. 3rd and 4th Quarters

b. 1st and 2nd Quarters

provides an estimate of the annual sales tax collected during the construction phase. It has been assumed that all wages generate sales tax. Sales tax revenues for the 1986 operating payroll are estimated to be $617,000.

8.1.2.2.3 Ad Valorem Taxes

The Property and Special Taxes Division of the Arizona Department of Revenue is charged by statute with the responsibility of fixing the full cash value of utilities for ad valorem tax purposes. Past experiences indicate that the value for tax purposes of PVNGS is estimated to be $3,238,389,000. Electric utilities are assessed at 50% of full cash value. Hence, the assessed value of the PVNGS is estimated to be $1,619,194,500. Each taxing district having jurisdiction then applies its tax rate to that value. For the purposes of estimating tax benefits, actual tax rates for 1978 and 1979 have been used for all political subdivisions unless otherwise noted.

At the present time, the statewide general property tax is used to balance the state's budget. First, total state requirements for the fiscal year are determined, then tax revenues from all sources other than the property tax are estimated. This and any cash surpluses from the preceding year are added together and subtracted from the total amount required. A state property tax is then levied to provide the difference. For fiscal years 1978 and 1979 the state property tax rates were $1.10 and $0.48 per $100 of assessed value, respectively. Based on these rates, the state's estimated annual property tax revenue from PVNGS is shown in table 8.1-5 to range from about $7.7 million to about $17.8 million.

PVNGS Units 1,2&3 powerblocks are located within the jurisdiction of the Ruth Fisher Elementary School District, whose tax rates were set at $0.78 and $0.57 per $100 of assessed value for 1978 and 1979, respectively. Based on these rates, the Ruth Fisher Elementary School District estimated annual property tax revenue from PVNGS is shown in table 8.1-5 to range from about $9.2 million to about $12.6 million.

The southern portion of the site is located within the jurisdiction of the Ruth Fisher and Arlington Elementary School Districts and the Buckeye Union High School District. Their respective 1978 tax rates were $0.78, $3.51, and $2.86 per $100 assessed value, respectively. For 1979 their rates were $0.57, $3.82, and $3.10 per $100 assessed value, respectively. It should be noted that at this time it is difficult to project what revenues would accrue to the Arlington Elementary School District or to the Buckeye Union High School District. PVNGS property lies in both Ruth Fisher and Arlington Elementary School Districts. This presents assessment problems that will only be solved when APS and the Arizona Department of Revenue, Property and Special Taxes Division agree as to how units of land which do not contain improvements are to be treated. Upon agreement, precise tax yield estimates can be made. For the purposes of this report, it is assumed that revenue benefits accrue only to the Ruth Fisher Elementary School District. The effect of this assumption is to understate potential revenue benefits that would develop if PVNGS is assessed in multiple school districts.

A significant portion of the Maricopa county's revenue is generated through the property tax levy. The rate for both fiscal 1978 and 1979 was $2.30 per $100 of assessed value. Based on this rate, Maricopa County annual property tax revenue generated from PVNGS is shown in table 8.1-5 as $37,241,485.

The Maricopa County Junior College District derives its revenue from a county-wide tax levy, the state, and student tutition and fees. In fiscal 1978 and 1979, the community college tax rate was set at $0.84 and $0.94 per $100 of assessed value, respectively. Based on these rates, the estimated annual property tax revenue from PVNGS is shown in table 8.1-5 to range from about $13.6 million to about $15.2 million.

It should be emphasized that the tax rates used in table 8.1-5 are for 1978 and 1979 only. Actual rates for future years are not known; however, it is felt that such rates will be in excess of those for 1979.

A transaction privilege tax is collected in Arizona and will be paid to the State of Arizona by the prime construction contractor (Bechtel). This payment will be made in accordance with the provisions of the Arizona Use Tax Law for work performed in the State of Arizona. Also, additional state taxes in an amount as yet undetermined are expected to be paid by subcontractors who may perform parts of the work.

Table 8.1-5

ESTIMATED AD VALOREM TAXES

Jurisdiction	Estimated Value	Actual Tax Rate		Annual Tax Yield	
		1978	1979	1978	1979
Arizona	$1,619,195,000	$1.10	$0.48	$17,811,145	$ 7,772,136
Maricopa County	$1,619,195,000	2.30	2.30	37,241,485	37,241,485
Maricopa County Community College District	$1,619,195,000	0.84	0.94	13,601,238	15,220,433
Ruth Fisher Elementary District	$1,619,195,000	0.78	0.57	12,629,721	9,229,412
Flood Control District of Maricopa County	$1,619,195,000	(a)	(a)	-0-	-0-
Central Arizona Water Conservation District	$1,619,195,000	(b)	(b)	485,759	485,759
Total				$81,769,348	$69,949,225

a. Flood Control Districts may levy a tax not to exceed 20¢ per $100 of assessed valuation of land and improvements. No estimated annual tax yield is given because the separate value of land and improvements is not known.

b. The Central Arizona Water Conservation District may levy a tax not to exceed 10¢ per $100 of assessed valuation of all property. In 1978 and 1979, 3¢ per $100 was levied.

8.1.3 OTHER BENEFITS

8.1.3.1 Local Expenditures

A substantial amount of the total expenditures during construction for materials, equipment, and services will be spent in Arizona. The experience of the participating utilities and the constructor indicates that approximately $285 million will be spent in Maricopa County. This impacts secondary employment, personal income, and local taxes in a favorable manner. Local purchases will be approximately equivalent to 40% of the
annual operations budget during the years 1981 to 1986. The 2
percentage could increase based upon qualifications of local suppliers.

8.1.3.2 Purchase of Wastewater Effluent

8.1.3.2.1 Multi-Cities Wastewater Purchase Contract 4

A current benefit of PVNGS is the revenue received by Phoenix and five other municipalities through an option and purchases agreement with APS and Salt River Project for the sale of wastewater effluent not committed as of the contract date (April 1973) to other parties (hereafter referred to as uncommitted effluent). The City of Phoenix operates two sewage treatment plants near the Salt River. The first, at 23rd Avenue, is owned by Phoenix; the second, at 91st Avenue, is a joint venture of Phoenix and five other municipalities. At the present time, the participants pay $2.00 per year per acre-foot option payment for uncommitted wastewater effluent being discharged by these plants. The contract provides that APS and Salt River Project may purchase uncommitted effluent, when available, up to a maximum amount of 140,000 acre-feet per year for electric generation purposes.

For the period, April 23, 1979, to April 22, 1980, the participants made option payments for 89,192 acre-feet of uncommitted effluent; 30,604 acre-feet from the 23rd Avenue

plant and 58,588 acre-feet from the 91st Avenue plant, based on actual effluent flow records for 1978. Table 8.1-6 shows the option revenue derived by each of the cities participating in the 91st Avenue plant. The option payment for the 23rd Avenue discharge goes solely to the City of Phoenix.

The price to be paid for uncommitted effluent purchased for PVNGS is tied to the price for Central Arizona Project municipal and industrial water subject to a minimum price of $20 per acre-foot and a maximum price of $30 per acre-foot.

When Unit 3 becomes operational, it is expected that the price for the purchased uncommitted effluent will be $30 per acre-foot. In addition to purchase payments, the participating utilities will make option payments of $2 per acre-foot per year, for each acre-foot of effluent, reserved for use at PVNGS but not delivered. Each of the communities will share the revenue generated on that portion of the effluent coming from the 91st Avenue plant on the basis of their respective deliveries of sewage for treatment at the 91st Avenue plant.

A range of minimum revenues which could be realized by each of the participating cities is presented in table 8.1-6. This projection is based on:

- Influent ratios of the participating cities being constant with 1978 values.
- Annual station water use of 64,050 acre-ft (21,350 acre-ft/yr/unit).
- Availability of no uncommitted effluent in excess of the annual station requirement of 64,050 acre-ft/year.
- Payments of $20 and $30 per acre-ft of delivered effluent.
- 4 6,384 acre-feet/year of effluent for PVNGS will come from the Tolleson Wastewater Treatment Plant.

Table 8.1-6

PROJECTED MINIMUM ANNUAL REVENUE RECEIVED FOR UNCOMMITTED EFFLUENT FROM THE CITY OF PHOENIX 91st AVENUE SEWAGE TREATMENT PLANT

City	Percent of Revenue[a]	1979 Actual Option Revenue	Range of Anticipated Revenue[b] [c]	
			$20 per Acre-Ft Delivered	$30 per Acre-Ft Delivered
Phoenix	51.76	$ 60,650	$ 596,958	$ 895,438
Glendale	13.79	16,176	159,043	238,564
Tempe	12.75	14,936	147,048	220,572
Mesa	10.93	12,810	126,058	189,087
Scottsdale	10.45	12,242	120,522	180,783
Youngtown	0.32	382	3,691	5,536
Total	100.0	$117,176	$1,153,320	$1,729,980

a. Calculated, based on a letter dated March 19, 1979 from P. W. Slagel, City of Phoenix Wastewater Operations to the 91st Avenue Sewage Treatment Plant Multi-City Participants.

b. Based on station water use of 57,666 acre-ft/yr with no additional uncommitted effluent available from 91st Avenue or 23rd Avenue.

c. Assumed 6,384 acre-feet/yr as minimum flow contributed from the Tolleson WWTP which will be taken ahead of multi-cities effluent.

4

4

4

4 • Balance of effluent supply (57,666 acre-feet) will come from the 91st Avenue plant.

It is assumed that all residents of the cities participating in the 91st Avenue Plant will derive economic benefits.

8.1.3.2.2 City of Tolleson Wastewater Purchase Contract

In June of 1981, the City of Tolleson entered into a contract for the sale and purchase of up to 8.3 MGD of effluent to APS and the Salt River Project. Tolleson is a small community (population 4,500) located west of Phoenix and whose sewage treatment plant exists along the route of the Palo Verde pipeline. Tolleson is expanding its treatment plant in cooperation with the cities of Peoria and Glendale who will effectively lease capacity in the facility. The agreement states that APS and SRP will take Tolleson effluent first before any other sources of effluent and the pricing reflects this in a take-or-pay arrangement which will commence in April of 1983, one month prior to commercial operation of the first Palo Verde unit. Between the date of execution and April of 1983, APS/SRP will
4 pay Tolleson an option payment of $2.00 per acre-foot per year. At a minimum, Tolleson can realize as much as $18,530 in option payments in the intervening period prior to April 1983. The purchase price for any effluent requested and delivered under this agreement is initially $35.00 per acre-foot with subsequent adjustments to reflect inflation and changes in the value of effluent. The Tolleson agreement is subject to prior commitments to a local turf grass farmer of 2.0 MGD; however, the sod operation currently uses only approximately .6 MGD, and an additional .6 MGD reserved by the city for its use. Taking these reserved quantities into account, APS and SRP would have a minimum of 5.7 MGD available to them, or 6,384 acre-foot per year. At today's price the sale of this effluent would produce a minimum financial benefit to Tolleson amounting to $223,440 per year. If the full 8.3 MGD capacity were available to the

participants, the revenue to Tolleson could be as high as $325,353 per year at today's sale price. 4

8.1.4 IMPACTS IF OPERATION IS DELAYED

As discussed in chapter 1, load requirements for the PVNGS participants will increase substantially during the early 1980s. In order for the participants to reliably meet the needs of their customers in those years (1980 to 1986), additional generation of 7385 megawatts will be required from new resources. PVNGS makes a major contribution toward meeting these needs.

Any delays in the construction of these units could seriously affect the reliability of the system. The level of impact of the delay varies with the participant. If PVNGS Unit 1 is not put into operation as planned, the reserve margin for PVNGS Units 1,2&3 participants will drop as described in section 1.3.

The service areas of the participants cover sizable portions of four states; consequently, significant differences exist in the geographic, demographic, economic, and social characteristics as well as total load and load characteristics of each participant. These differences make it difficult to quantify the impact of electrical shortages. Some electric utilities have experienced some major bulk power failures during the last several years. The severity of these failures varies. Major power failures are very costly. There are no dollar figures on the cost of load shortages for the participants. However, the blackout of the northeast portion of the U.S. in 1965 affected approximately 30 million people and cost an estimated $100 million. The New York City blackout in 1978 led to widespread looting and rioting.

8.1.5 REFERENCES

1. Arizona State University, College of Business Administration, Bureau of Economic and Business Research, "Maricopa County: An Economic Base Analysis", Tempe Arizona, December 1973.

2. Ellis, T., Marketing Services Staff, First National Bank of Arizona, Phoenix, Arizona, personal communication, June 27, 1979.

3. Merrill, R., Income Tax Division, Arizona Department of Revenue, personal communication, June 27, 1979.

4. Townsend, J., Sales Tax Division, Arizona Department of Revenue, personal communication, June 27, 1979.

8.2 COSTS

Cost information presented in ER-CP Section 8.2 and the FES has been updated to reflect the latest PVNGS cost estimate and schedule. Observed and projected external costs resulting from construction and operation are also updated.

8.2.1 ESTIMATED INTERNAL COSTS[a]

The internal costs associated with the facility are those costs associated with site and plant development and include the capital investment in land, facilities and incremental transmission facilities; operating, maintenance, and fuel costs; and decommissioning costs. No research and development costs are anticipated. The capital cost of land for PVNGS is $5,779,000. The estimated capital cost for construction is $4,884,000,000, exclusive of interest and taxes. With these annualized indirect costs included, the capital cost of construction is $6,640,000,000. Additionally, there will be incremental capital costs of approximately $427 million for transmission facilities.

Operations and maintenance costs for the total 40-year design life are estimated to be $1,893,000,000. Using the combined Participants' discount rate of 9.45%, levelized fuel costs are estimated to be 11.759, 13.708, and 15.860 mills/kWh for units 1, 2 & 3 respectively. Plant decommissioning costs at the end of plant life are estimated to be $273 million, as discussed in section 5.8.

Table 8.2-1 presents a summary of the internal costs in 1986 dollars.

8.2.2 EXTERNAL COSTS

There are two types of costs associated with the siting, construction and operation of PVNGS: (1) those which relate

---

a. All cost estimates in this section are in 1986 dollars.

Table 8.2-1
ESTIMATED INTERNAL COSTS SUMMARY[a]

Item	Cost
Capital cost of land	$ 5,779,000
Capital cost of facility construction[b]	4,884,000,000
Operating & Maintenance costs[c]	1,893,000,000
Decommissioning costs	273,000,000
Incremental capital costs of transmission facilities	427,000,000
TOTAL	7,482,779,000

a. Costs are in 1986 dollars.

b. Excludes allowance for funds used during construction and switchyard construction costs. Cost of the facility is based on a cash flow estimate by unit escalated at 7% per year to convert amounts to 1986 dollars.

c. Operations and Maintenance (O&M) costs are based on Unit 1 O&M costs escalated at 7% per year for the 40-year design lives. The total for the 40 years was then converted to 1986 dollars at a rate of 9.45%.

directly to construction and the consequent disruption to the site environment, and (2) those which appear largely as opportunity costs involving alternative uses of the site, loss of personal income or reduction of regional product, reduction of recreational values, increased public service costs, encroachment upon historical and aesthetic values, and intrusion upon the existing environment. The first type of cost is confined largely to the site and is usually of short-term duration. The second type of cost generally accrues to the surrounding region and typically has a long-term effect. The nature of both types of costs, in most instances, precludes their quantification and, as such, they can best be evaluated in qualitative terms identifying their estimated magnitude and duration.

The costs which can be attributed to development and operation will be examined in the following sections.

8.2.2.1 Short-Term External Costs

The temporary external costs associated with constructing PVNGS, such as strains on local community facilities and services and the resultant declines in the quality of life caused by a large influx of workers into the area, have been small and localized. This is due primarily to the location of the plant relative to the metropolitan Phoenix area.

After 3 years of construction, growth impacts to the area immediately surrounding the plant site have been minor and for the most part beneficial rather than detrimental. Local infrastructure has been improved, i.e., county roads widened and paved, and telephone service expanded. A few businesses have developed such as two trailer parks and several commercial establishments (see section 2.1).

Given the relatively small number of construction workers who have opted to live in the immediate vicinity of the plant and since most live there singly, there have been no incidences of the following conditions: inflationary rentals or housing prices, overloading of water supply and sewage treatment facilities, crowding of local schools, hospitals or other public facilities, and overtaxing of community services.

The only apparent external costs felt by the local community are congestion of local streets and highways at shift changes with their attendant noise, and temporary aesthetic disturbances. The number of persons affected by these temporary external costs are small. Economic and social impacts are not quantifiable, but have been observed to be small. Mitigation measures have already included county- and contractor-financed road improvements. These temporary external costs are expected

to be declining as the peak in construction labor force was reached during the second quarter of 1979.

8.2.2.2 Long-Term External Costs

The long-term external costs associated with operating PVNGS, such as irreversible and/or irretrievable losses in adjacent land uses caused by the normal functioning of the plant are minimal. This is due primarily to the plant's location in an area removed from sensitive dedicated land uses, such as wildlife refuges, recreational, scenic, and cultural areas, and urban centers. Expected long-term external costs associated with changes in the physical environment are minimal and are described in chapter 5. It is expected that these minor environmental changes will not impair any existing or proposed land uses planned in the vicinity of the plant (see section 2.1).

APPENDIX 8A

RESPONSES TO NRC QUESTIONS

TABLE OF CONTENTS

QUESTION 8A.1 (NRC No. 310.8) 8.1.2

Provide annual estimates of the operation work force as the three units come on line and during the first five years of operation of all three units. This data should be presented in the format of Tables 8.1-3 through 8.1-6. Provide yearly dollar estimates of local purchases for goods and services (including contract workers) based on 1981 dollars.

RESPONSE: The response is provided in the revised sections 8.1.2.1.2, 8.1.2.2.1, and 8.1.3.1.

QUESTION 8A.2 (NRC No. 310.9) 8.1.2

Estimate the average annual tax revenues from sale of electricity as the three units come on line and during the first five years of operation of all three units.

RESPONSE: 2

AVERAGE ANNUAL TAX REVENUES
FROM THE SALE OF ELECTRICITY AT PVNGS
FOR THE STATE OF ARIZONA

Year[c]	APS[a] Tax Revenue $/Yr	SRP[b] Tax Revenue $/Yr
1983	5.03×10^6	4.7×10^6
1984	10.76×10^6	10.0×10^6
1985	11.51×10^6	10.7×10^6
1986	18.49×10^6	17.3×10^6
1987	19.97×10^6	18.6×10^6
1988	21.57×10^6	20.1×10^6
1989	23.30×10^6	21.7×10^6
1990	25.16×10^6	23.5×10^6
1991	27.17×10^6	25.3×10^6

(a) Tax revenues determined by applying average tax rate to revenue figure. Average tax rate used in calculations

for APS was 4.15%. Revenue figures derived from table 8.1-2.

2 (b) Tax rate used in calculations for SRP was 5.20%.

(c) Based on estimated 1979 revenues and escalated at 7%/year to 1986, then escalated at 8%/year from 1986 to 1991.

CHAPTER 9

ALTERNATIVE ENERGY SOURCES AND SITES

CONTENTS

9. ALTERNATIVE ENERGY SOURCES AND SITES

Information on alternative energy sources and sites was presented in the ER-CP and FES. It was concluded that PVNGS was the best available alternative for supplying power in the required time frame.

APPENDIX 9A

RESPONSES TO NRC QUESTIONS

CHAPTER 10

STATION DESIGN ALTERNATIVES

CONTENTS

10. STATION DESIGN ALTERNATIVES

Information on station design alternatives was presented in the ER-CP, FES, and Atomic Safety and Licensing Board (ASLB) Construction Permit Hearings, February 23 through 27, 1976. It was concluded that the PVNGS design represented the best alternative station design.

APPENDIX 10A

RESPONSES TO NRC QUESTIONS

CHAPTER 11

SUMMARY COST-BENEFIT ANALYSIS

CONTENTS

11. SUMMARY COST-BENEFIT ANALYSIS

The information presented in ER-CP Chapter 11 and the FES is generally unchanged. This chapter presents updated information based on studies conducted since ER-CP submittal and reflects current interest rates.

11.1 INTRODUCTION

This chapter demonstrates through a benefit-cost analysis that the aggregate benefits of PVNGS outweigh the aggregate costs. This conclusion is derived from the analysis of (1) the need for power, (2) the economic and social benefits and costs of the project, and (3) consideration of the environmental impacts of construction and operation of the facility.

11.2 BENEFITS

11.2.1 DIRECT BENEFITS

Chapter 1 demonstrates that in the 1980s there will be need for new generating capacity in the areas served by the PVNGS participants. This generating capacity is necessary to meet forecasted load demands and retain the reserve margins required for reliable service. Therefore the direct benefits of the plant, as indicated in table 8.1-1, will be the availability of electrical energy for the use within the participants' service areas.

11.2.2 INDIRECT BENEFITS

The indirect benefits of PVNGS (refer to section 8.1) appear primarily as substantial tax revenues accruing to federal, state, and local governments. These tax benefits include income, excise and ad valorem taxes. There will be benefits in the form of revenues to cities in the metropolitan Phoenix area due to the sale of wastewater effluent for use at PVNGS.

Additionally, energy from PVNGS will displace the use of oil-fired generation, resulting in cost savings and the conservation of scarce fuel oil resources.

11.3 COSTS

11.3.1 DIRECT COST

The direct costs of the plant (refer to section 8.2) will be borne by the consumers within the participants' service areas. These direct costs will be less than the benefits (refer to section 8.1) to be derived from the operation of PVNGS.

11.3.2 INDIRECT COST

11.3.2.1 Socioeconomic Impacts

The temporary external costs associated with constructing PVNGS, such as strains on local community facilities and services and the resultant declines in the quality of life caused by a large influx of workers into the area, have been small and localized. This is due primarily to the location of the plant relative to the metropolitan Phoenix area.

After 3 years of construction, growth impacts to the area immediately surrounding the plant site have been minor and for the most part beneficial rather than detrimental. Local infrastructure has been improved, i.e., county roads widened and paved, and telephone service expanded. A few businesses have also developed in the site area.

Given the relatively small number of construction workers who have opted to live in the immediate vicinity of the plant, there have been no incidences of inflationary rentals or housing prices, overloading of water supply and sewage treatment facilities, crowding of local schools, hospitals, or other public facilities, or overtaxing of community services.

The only apparent external costs felt by the local community are congestion of local streets and highways at shift changes, with their attendant noise, and temporary aesthetic disturbances. The number of persons affected by these temporary external costs is small. Economic and social impacts are unquantifiable, but have been observed to be small. Mitigation measures have already included road improvements. These temporary external costs are expected to be declining as the peak in construction labor force was reached during the second quarter of 1979.

11.3.2.2 Environmental Impacts

The primary environmental impacts associated with the operation of PVNGs are the displacement of approximately 4050 acres of land from other potential uses, the use of approximately 64,050 acre-feet per year of wastewater effluent, the use of about 1300 acre-feet per year of groundwater, the esthetic impact of the facility and its transmission system, and the localized and limited impacts of transmission system maintenance. It should be noted that no significant impact on the biotic community is expected from operation. The overall environmental costs of PVNGS are small, particularly in comparison to the benefits to be derived from operation.

More detailed assessments of the impacts experienced during construction and expected as a result of operation of PVNGS are provided in chapters 4 and 5, respectively.

11.4 CONCLUSION

PVNGS electrical energy production will ensure a reliable source of economical electrical energy to the population of the PVNGS participants' service areas. This energy fulfills the many growing and vital needs of their respective communities and represents the major benefit of PVNGS.

SUMMARY COST-BENEFIT ANALYSIS

The environmental and socio-economic costs associated with PVNGS are very low. In addition, the participants are resolved to identify and avoid potential environmental conflicts. Efforts to optimize environmental compatibility are reflected in such design factors as the use of treated wastewater rather than ground or natural surface water for other than domestic purposes, and in the reclamation and reuse of the treated wastewater to minimize consumptive water losses. Although the avoidance of all environmental costs is impossible, construction and operation practices at PVNGS will minimize environmental impacts to the extent economically and technologically practicable.

The proposed site and plant combination is the most environmentally and economically cost-effective solution to future needs for reliable power in the service areas of the PVNGS participants.

APPENDIX 11A

RESPONSES TO NRC QUESTIONS

CHAPTER 12

ENVIRONMENTAL APPROVALS AND CONSULTATIONS

CONTENTS

TABLES

12. ENVIRONMENTAL APPROVALS AND CONSULTATIONS

12.1 STATUS OF LICENSES, PERMITS AND APPROVALS

Table 12.1-1 lists the status of licenses, permits and approvals required for the protection of the environment by Federal, State, local and regional authorities to construct or operate PVNGS facilities exclusive of transmission facilities.

12.2 STATUS OF TRANSMISSION SYSTEM PERMITS

Table 12.2-1 lists the status of licenses, permits and approvals required for the protection of the environment in connection with the construction of transmission facilities installed for PVNGS. Rights-of-way across lands owned by the State of Arizona and under the jurisdiction of the State Land Department were obtained for installation of transmission facilities. It was necessary to obtain permits for crossing roads, highways and railroads from State and County agencies.

12.3 WATER QUALITY CERTIFICATION UNDER SECTION 401 OF THE FEDERAL WATER POLLUTION CONTROL ACT, AS AMENDED

A water quality certification under Section 401 of the Federal Water Pollution Control Act, as amended, is not required for construction of PVNGS. Provisions have been made for the retention on site of runoff from site construction areas associated with a 10-year, 24-hour rainfall event. Accordingly, guidelines established by the U.S. Environmental Protection Agency for silt loads from construction runoff will be fully met and a discharge permit is not required. PVNGS will not discharge any liquid radioactive waste offsite.

12.4 STATUS OF CONTACTS WITH STATE, LOCAL AND REGIONAL PLANNING AUTHORITIES

Table 12.4-1 indicates the contacts made with various state, local and regional planning agencies in the state of Arizona and public hearings held in connection with PVNGS.

Table 12.1-1

ENVIRONMENTAL LICENSES, PERMITS AND APPROVALS REQUIRED (Sheet 1 of 3)

Authorization Required	Agency	Statutory Authority	Status
Construction Permits and Operating Licenses and Related Special Nuclear and By-Product Material Licenses	U.S. Nuclear Regulatory Commission	Atomic Energy Act of 1954, as amended, 42 USCA Section 2133 et seq National Environmental Policy Act, 42 USCA Section 4321 et seq	Construction permits issued Operating license application filed
Certificate of Environmental Compatibility Required Prior to Commencement of Construction	Arizona Corporation Commission and Arizona Power Plant and Transmission Line Siting Committee	Arizona Revised Statutes, Sections 40-360 and 40-360.1 et seq. State of Arizona Administrative Rules and Regulations, Title 14, Chapter 3, Article 2	Certificate issued
Special Use Permit	Maricopa County Board of Supervisors and Maricopa County Planning and Zoning Commission	Arizona Revised Statutes, Section 11-802 1969 Amended Zoning Ordinance of Maricopa County, Section 2401	Special use permit issued
Building Permits for Certain Structures	Maricopa County Building Safety Department	Arizona Revised Statutes, Section 11-861 1969 Amended Zoning Ordinance of Maricopa County, Section 2602	Building permit exemptions issued
Certificate of Public Convenience and Necessity Authorizing Participation in PVNGS	Public Utility Commission of Texas	Revised Civil Statutes of the State of Texas, Article 1446C. Title 32, Article VII, Section 50	Certificate issued

Table 12.1-1

ENVIRONMENTAL LICENSES, PERMITS AND APPROVALS REQUIRED (Sheet 2 of 3)

Authorization Required	Agency	Statutory Authority	Status
Certificates of Public Convenience and Necessity Authorizing Participation in PVNGS	State of New Mexico Public Service Commission	New Mexico Statutes Annotated 68-7-1	Certificates issued.
Certificate of Public Convenience and Necessity Authorizing Participation in PVNGS	State of California Public Utilities Commission	West's Annoted Public Utility Code, Section 1002	Certificate issued
Temporary Earth Moving Permits	Maricopa County Health Department	Maricopa County Health Code Chapter XII, Regulation II, Rule 20(c)	Permits issued
Sewage System Permits a. Package Treatment Plant b. Power Block Sewage Collection System	State Department of Health	Arizona Revised Statutes, Sections 36-132, 36-136. State of Arizona Administrative Rules and Regulations Title 9, Chapter 8, Article 3	Construction and operating approvals issued
c. Water Reclamation Facility Collection System	Maricopa County Health Department	Maricopa County Health Department Sanitary Code Chapter III, Section 2, Regulation 2	
Wastewater Handling Permits a. Water Reclamation Facility	State Department of Health	Arizona Revised Statutes, Sections 36-132, 36-136. State of Arizona Administrative Rules and Regulations, Title 9, Chapter 8, Article 3	Construction and operating approvals issued
b. Hassayampa Pump Station c. Water Conveyance Pipeline	Maricopa County Health Department	Maricopa County Health Department Sanitary Code Chapter II, Section 2, Regulation 1 & 2	

Table 12.1-1

ENVIRONMENTAL LICENSES, PERMITS AND APPROVALS REQUIRED (Sheet 3 of 3)

Authorization Required	Agency	Statutory Authority	Status
Potable Water System Approval	State Department of Health	Arizona Revised Statutes Section 36-132 and 36-136. State of Arizona Administrative Rules and Regulations Title 9, Chapter 8, Article 2	Construction and operating approval issued
	Maricopa County Health Department	Maricopa County Health Department Sanitary Code, Chapter V, Section 2, Regulation 1	
Approval to Remove Protected Native Plants	Arizona Commission of Agriculture and Horticulture	Arizona Revised Statutes Section 3-904. State of Arizona Administrative Rules and Regulations Title 3, Chapter 1, Article 6.	Approvals issued

Table 12.2-1

LICENSES, PERMITS AND APPROVALS REQUIRED FOR THE PROTECTION OF THE ENVIRONMENT IN CONNECTION WITH THE CONSTRUCTION OF TRANSMISSION FACILITIES

Authorization Required	Agency	Statutory Authority	Status
Certificates of Environmental Compatibility Required Prior to Commencement of Construction	Arizona Corporation Commission and Arizona Power Plant and Transmission Line Siting Committee	Arizona Revised Statutes, Section 40-360 and 40-360.1, et seq, State of Arizona Administrative Rules and Regulations, Titlo 14, Chapter 3, Article 2	Certificates issued
Certificate of Public Convenience and Necessity Required to Construct Transmission Lines To and In California	State of California Public Utilities Commission	West's Annotated Public Utility Code, Section 1002	Certificate issued
Construction Permits and Operating Licenses	U.S. Nuclear Regulatory Commission	Atomic Energy Act of 1954, as amended, 42 USCA Section 2133, et seq. National Environmental Policy Act, 42 USCA Section 4321, et seq.	Construction Permits issued Operating License application filed
Acquisition of Rights-of-Way on Public Land Controlled by the BLM	U.S. Department of Interior Bureau of Land Management (BLM)	National Environmental Policy Act, 42 USCA Section 4321, et seq.	Draft Environmental Statement issued

Table 12.4-1

MEETINGS WITH STATE, LOCAL AND REGIONAL PLANNING AUTHORITIES AND PUBLIC HEARINGS (Sheet 1 of 7)

Date of Contact	Name of Authority	Description of Meeting
10/06/72	Office of State Parks Director, Phoenix, AZ	Discussion of proposed park sites
10/06/72	Offices of Maricopa County Planning and Zoning Department	Information on land development
10/17/72	Maricopa County Parks Office, Phoenix, AZ	Discussion on park land
7/05/73	State of Arizona, Office of Economic Planning and Development	Informational
7/06/73	Arizona Water Commission	Obtained information on water projects
7/06/73	Arizona Game and Fish Department	Discussed Gila River, Green Belt, and big horn sheep areas
7/06/73	Maricopa Association of Governments (MAG)	Information on land use planning, parks, and recreational studies
7/09/73	Maricopa County Parks and Recreational Department	Information on parks and open space studies
7/10/73	Arizona State Parks Board	Obtain proposed location of future state parks (preliminary only)
7/11/73	Maricopa County Highway Department	Proposed county road improvements and traffic volumes

Table 12.4-1

MEETINGS WITH STATE, LOCAL AND REGIONAL PLANNING AUTHORITIES AND PUBLIC HEARINGS (Sheet 2 of 7)

Date of Contact	Name of Authority	Description of Meeting
7/17/73	Maricopa Association of Governments (MAG)	Requested copy of 1990 Comprehensive Plan
7/18/73	Pima County Parks and Recreation Dept./Pima County Planning and Zoning (joint meeting)	Future plans for parks
7/18/73	Pima County Highway Department	Discussion of county roads and traffic volumes
7/22/73	Pinal County Planning and Zoning	Information
7/26/73	Pima County Planning and Zoning	Information
7/27/73	Arizona State Land Department	Information
8/01/73	State of Arizona, Department of Economic Planning and Development	Information
8/02/73	State of Arizona, Land Department	Discussion of State lands
8/06/73	Pinal County Planning and Zoning	Information
8/06/73	Maricopa Association of Governments (MAG)	Information
8/07/73	Maricopa County Planning Department	Discussion of land uses
8/07/73	State Land Department - Range Management	Information

Table 12.4-1

MEETINGS WITH STATE, LOCAL AND REGIONAL PLANNING AUTHORITIES AND PUBLIC HEARINGS (Sheet 3 of 7)

Date of Contact	Name of Authority	Description of Meeting
8/08/73	Arizona State Parks Board	Discussion of proposed parks
8/08/73	Santa Cruz County Planning and Zoning Department	Discussion of land use
8/08/73	Cochise County Planning and Zoning	Discussion of current and proposed land use
8/08/73	Pima County Planning and Zoning	Information of land use
8/08/73	Pinal County Planning and Zoning	Discussion of proposed land use
8/10/73	City of Phoenix Planning and Zoning	Information on current and proposed land use
8/10/73	Department of Economic Planning and Development	Information on subdivision
8/10/73	Cochise County Planning and Zoning	Information
8/20/73	City of Tucson Planning Division	Discussion of population projections
8/21/73	Pinal County Planning and Zoning	Verification of current and projected land use
8/21/73	Department of Community Development	Discussion of land use in Tucson
9/28/73	Arizona State Land Department	Information

Table 12.4-1

MEETINGS WITH STATE, LOCAL AND REGIONAL PLANNING AUTHORITIES AND PUBLIC HEARINGS (Sheet 4 of 7)

Date of Contact	Name of Authority	Description of Meeting
10/18/73	Governor Lewis - Gila River Indian Tribal Office	Procedure to follow for proposing transmission line on Indian land
10/18/73	Arizona Power Plant and Transmission Line Siting	Information on Palo Verde site selection
10/23/73	State Land Office	Information on mines, land ownership, and land use
11/13/73	Phoenix City Parks Department	Transmission lines near city parks
1/25/74	Maricopa County Board of Supervisors	Information
7/06/74	Arizona Atomic Energy Commission	Information
12/09/74	Maricopa Association of Governments (MAG)	Information
1/06/75	Arizona Corporation Commission	Information
1/14/75	Arizona House of Representatives	Information
1/23/75	Atomic Safety and Licensing Board	Pre Hearing Conference
2/27/75	Atomic Safety and Licensing Board	Pre Hearing Conference
4/22/75	Arizona Attorney General	Information

Table 12.4-1

MEETINGS WITH STATE, LOCAL AND REGIONAL PLANNING AUTHORITIES AND PUBLIC HEARINGS (Sheet 5 of 7)

Date of Contact	Name of Authority	Description of Meeting
10/20/75	Advisory Committee on Reactor Safeguards	Subcommittee Meeting
10/23/75	Atomic Safety and Licensing Board	Pre Hearing Conference
11/06/76	Advisory Committee on Reactor Safeguards	Full Committee Meeting
12/02/75-12/05/75	Arizona Power Plant and Transmission Line Siting Committee	PVNGS Site and Transmission Line Public Hearing
2/04/76	Arizona Atomic Energy Commission	Information
2/23/76-2/27/76	Atomic Safety and Licensing Board	PVNGS Public Hearing
3/16/76	Maricopa County Planning and Zoning Committee	Site Tour
5/03/76	Maricopa County Board of Supervisors	Information
7/20/76	Texas Public Utility Commission	PVNGS Public Hearing
7/22/76	City of El Paso	City Council Hearing
9/02/76	Arizona Corporation Commission	Information
2/08/77	New Mexico Public Service Commission	PVNGS Public Hearing
3/18/77	Arizona Corporation Commission	Site Tour
3/30/77	Maricopa County Board of Supervisors	Site Tour

Table 12.4-1

MEETINGS WITH STATE, LOCAL AND REGIONAL PLANNING
AUTHORITIES AND PUBLIC HEARINGS (Sheet 6 of 7)

Date of Contact	Name of Authority	Description of Meeting
6/09/77	Arizona Corporation Commission	Information
12/17/77	Maricopa Association of Governments (MAG)	208 Committee
1/23/78	Arizona Corporation Commission	Information
3/02/78-3/03/78	Arizona Power Plant and Transmission Line Siting Commission	Devers Transmission Line Public Hearing
5/04/78	Arizona Corporation Commission	Site Tour
5/10/78	Maricopa County Planning Department	Information
7/24/78	Arizona Corporation Commission	Site Tour
8/16/78	Arizona Corporation Commission	Decommissioning
8/21/78	Maricopa Association of Governments (MAG)	208 Study
8/23/78	Maricopa Association of Governments (MAG)	208 Study
1/23/79-1/26/79	California Public Utilities Commission	Devers Transmission Line Public Hearing
3/12/79	Interim House (AZ) Committee on PVNGS	Site Tour
6/28/79	Interim House (AZ) Committee on PVNGS	Legislative Hearing

Table 12.4-1

MEETINGS WITH STATE, LOCAL AND REGIONAL PLANNING AUTHORITIES AND PUBLIC HEARINGS (Sheet 7 of 7)

Date of Contact	Name of Authority	Description of Meeting
7/06/79	Interim House (AZ) Committee on PVNGS	Legislative Hearing
9/20/79	Interim House (AZ) Committee on PVNGS	Legislative Hearing
10/18/79	Interim House (AZ) Committee on PVNGS	Legislative Hearing

APPENDIX 12A

RESPONSES TO NRC QUESTIONS

CHAPTER 13

REFERENCES

CONTENTS

13. REFERENCES

Both the references that were cited and the bibliographies of sources used in preparation of this environmental report are included at the end of each section to which they pertain.

APPENDIX 13A

RESPONSES TO NRC QUESTIONS