June 1, 1994

Docket No. 52-003

APPLICANT: Westinghouse Electric Corporation

FACILITY: AP600

SUBJECT: SUMMARY OF MEETING TO DISCUSS THE SHIELDING DESIGN AND LAYOUT OF THE MANAGEMENT MEETING WITH WESTINGHOUSE

On May 3, 1994, representatives of the Westinghouse Electric Corporation, Bechtel North American Power Corporation, and the Nuclear Regulatory Commission met to discuss the shielding design of the AP600. Enclosure 1 is a list of attendees. Enclosure 2 is the slide presentation.

Westinghouse discussed the containment source term assumptions, the release distribution outside of the containment, the radiation sources after an accident, and the shielding design for the sample station and the fuel transfer canal upender pit. The applicant traced the leakage paths that the AP600 design could have following a design basis accident.

(Original signed by)
Thomas J. Kenyon, Project Manager
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Enclosures:
As stated

cc w/enclosures:
See next page

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DATE:	05/26/94	05/26/94	05/ /94

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WESTINGHOUSE AP600
MEETING ATTENDEES
MAY 3, 1994

<u>Name</u>	<u>Organization</u>
Dale Dexheimer	Bechtel
Jorge Schulz	Bechtel
Vijay Parameswaran	Bechtel
Naum Alper	Westinghouse
Heinrich Parin	Bechtel
Thomas Kenyon	PDST
Don Lindren	W AP600
James Sejvar	W AP600
D. Michael O'Connor	Bechtel
Bryan Broadhead	Oakridge Natl Lab.
Dan Carter	NRC/PRPB

Enclosure 1

AP600 RADIATION PROTECTION PRESENTATION

TO

UNITED STATES NUCLEAR REGULATORY COMMISSION

BECHTEL POWER CORPORATION
SAN FRANCISCO, CA
3 MAY 1994

Enclosure 2

AGENDA

•	Introduction	M. O'Connor
•	Containment Source Term	J. Seyvar
•	Outside Containment Release Distribution	J. Schulz
•	Post-Accident Radiation Source Descriptions	D. Dexheimer
•	Post-Accident Sample Station Shielding from Containment Source	D. Dexheimer
•	Fuel Transfer Canal Upender Pit Shielding	D. Dexheimer

AP600 POST-ACCIDENT SOURCES

- CORE / CONTAINMENT INVENTORIES
  - METHODS
  - ASSUMPTIONS
- COMPARISON OF SOURCE TERM BASES
  - TID
  - EPRI
  - NUREG
- DOSE RATES INSIDE CONTAINMENT
  - TID VERSUS EPRI SOURCES

POST-ACCIDENT SOURCE BASES

- EXPECTED CASE
  - MINIMAL CORE DAMAGE
- DESIGN BASIS FOR ACCIDENT DOSE ANALYSES
  - TID-14844 — "CALCULATION OF DISTANCE FACTORS FOR POWER AND TEST REACTORS," MARCH 1962
  - EPRI SOURCE TERM — "PASSIVE ALWR SOURCE TERM," FEBRUARY 1991
  - NUREG-1465 — "ACCIDENT SOURCE TERMS FOR LIGHT-WATER NUCLEAR POWER PLANTS" (Draft Report For Comment), JUNE 1992

METHODS

- CORE INVENTORIES BASED ON ORIGEN COMPUTER CODE ANALYSES
- ORNL-4628, "ORIGEN - THE ORNL ISOTOPE GENERATION AND DEPLETION CODE," MAY 1973
  - MATRIX EXPONENTIAL METHOD FOR SOLVING COUPLED, LINEAR, FIRST-ORDER ORDINARY DIFFERENTIAL EQUATIONS WITH CONSTANT COEFFICIENTS
  - GENERAL EXPRESSION

$$\frac{dX_i}{dt} = \sum_{j=1}^{N} l_{ij}\lambda_j X_j + \bar{\phi}\sum_{k=1}^{N} f_{ik}\sigma_k X_k - \left(\lambda_i + \bar{\phi}\sigma_i\right)X_i \qquad (i = 1\ldots)$$

where:

X_i	is the atom density of nuclide i
λ_i	is the decay constant for nuclide i
σ_i	is the spectrum-averaged neutron absorption cross section of nuclide i
l_i and f_{ik}	are the fractions of radioactive disintegration and neutron absorption by other nuclides which lead to the formation of species I
$\bar{\phi}$	is the average neutron flux
N	is the number of nuclides

EPRI SOURCE TERMS - RELEASE SCENARIO

0 - 1 HOUR	NO FUEL DAMAGE OR RELEASE OF CORE ACTIVITY
1 - 5 HOURS	EARLY IN-VESSEL RELEASE 75% CORE MELT WITH RELEASE OF 80% OF NOBLE GASES, 38% OF IODINES, 30% OF CESIUMS, AND 8% OF TELLURIUM
5 HOURS	VESSEL FAILURE ASSUMED TO OCCUR
5 - 24 HOURS	LATE IN-VESSEL RELEASE RELEASE OF 20% OF NOBLE GASES, 17% OF IODINES, 18% OF CESIUMS, AND 3% OF TELLURIUM
24 HOURS	NO ADDITIONAL RELEASES

TIMING OF EPRI AND NUREG-1465 RELEASES

	Gap Release		Early In-Vessel		Ex-Vessel		Late In-Vessel	
	EPRI	NUREG	EPRI	NUREG	EPRI	NUREG	EPRI	NUREG
Duration (Hrs)		0.5	1-5	1.3		2	5-24	10
Noble Gas		0.05	0.8	0.95		0.0	0.2	0.0
Iodine		0.05	0.38	0.35		0.29	0.17	0.07
Cesium		0.05	0.3	0.25		0.39	0.18	0.06
Tellurium			0.08	0.15		0.29	0.03	0.025
Strontium			0.004	0.03		0.12	–	–
Barium			0.004	0.04		0.10	–	–
Ruthenium			0.004	0.008		0.004	–	–
Cerium			0.004	0.01		0.02	–	–
Lanthanum			0.004	0.002		0.015	–	–

CORE RELEASES INTO CONTAINMENT

	TID-14844	EPRI	NRC Proposed NUREG	NRC Proposed 2/92 Memo
Duration	0	1-24 hrs	$\geq$ 10 sec-13.3 hrs	
Fraction of Core Inventory Released				
Noble Gas	1.0	1.0	1.0	1.0
Iodine	0.5*	0.55	0.76 (0.5)**	0.40
Others	0.01			
Cesium		0.48	0.75 (0.4)	0.30
Tellurium		0.11	0.46 (0.2)	0.15
Strontium		0.004	0.15 (0.042)	0.03
Barium		0.004	0.14 (0.05)	0.04
Ruthenium		0.004	0.012 (0.0084)	0.008
Cerium		0.004	0.03 (0.012)	0.01
Lanthanum		0.004	0.017 (0.0035)	0.002

* - INSTANTANEOUS PLATEOUT REDUCES THE FRACTION RELEASED FROM CONTAINMENT TO 0.25 (Reg. Guide 1.4)

** - ( ) WITH DF OF 10 FROM POOL SCRUBBING ASSUMING 10 FT OF WATER OVER THE MOLTEN CORE (NUREG-1465, Section 5.4)

CHEMICAL FORM OF IODINE

- TID (REG. GUIDE 1.4) FOR AIRBORNE IODINE (25% OF TOTAL CORE INVENTORY)

  ELEMENTAL – 91 %

  ORGANIC – 4 %

  PARTICULATE – 5 %

- EPRI

  ELEMENTAL – 2.85 %

  ORGANIC – 0.15 %

  PARTICULATE – 97 %

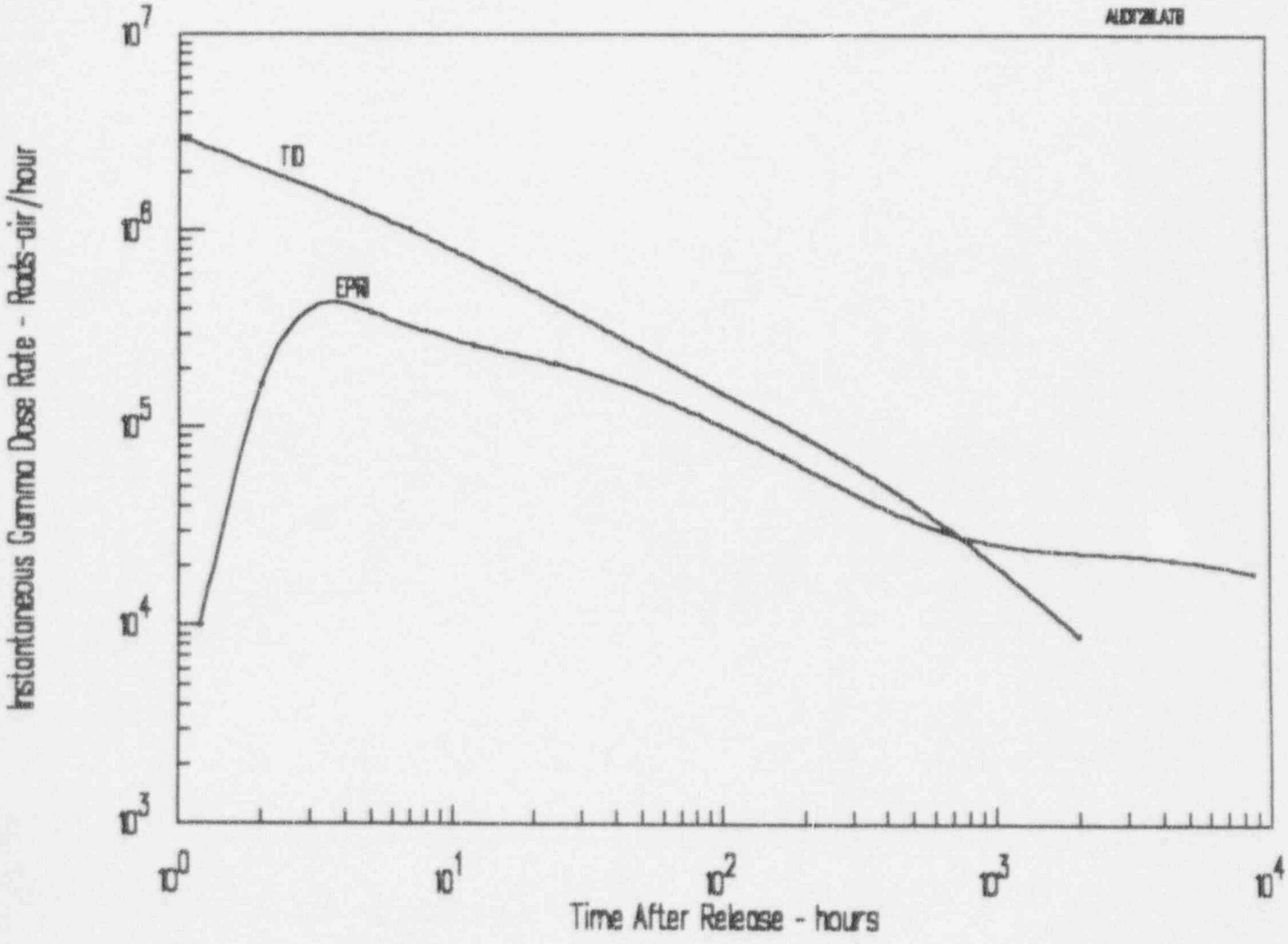
- NUREG

  VOLATILE - 5 %

  PARTICULATE - 95 %

  – VOLATILE FRACTION ASSUMED TO BE 4.75% INORGANIC AND 0.25% ORGANIC PER DRAFT COMMISSION PAPER DATED FEBRUARY 1992

CONTAINENT DOSE RATE



REVISED SOURCE TERMS

- LEVEL OF REALISM IS INCREASED OVER TID ASSUMPTIONS WITH RESPECT TO
  - TIMING
  - MAGNITUDE OF RELEASES
  - FORM OF IODINE
- DESIGN BASIS ACCIDENT RELEASES STILL CONSERVATIVE RELATIVE TO EXPECTED ACCIDENT RELEASES

OUTSIDE CONTAINMENT RELEASE DISTRIBUTION

- POST-LOCA ACTIVITY DISTRIBUTION IN BUILDINGS

- POST-LOCA GAMMA EMISSION RATES

POST-LOCA ACTIVITY DISTRIBUTION BASES:

- **Thermal Power Level - 1972 MWT**

  (Ref: AP600 Radiation Analysis Design Manual Section 5.2.1)

- **The emission rates E in Mev/watt-sec for the equilibrium core for 6 isotope groups**

  (Ref: AP600 Radiation Analysis Design Manual Tables 5-5 toto 5-10. Data for 64 hrs, 72 hrs, & 100 hrs are supplied by Westinghouse.)

- **Fraction of Core Fission Product Inventory Released to Containment by Isotope Group**

Isotope Group	0 - 1 hr	1 - 5 hrs	5 - 24 hrs
Noble Gases	0.0	2.0E-1/hr	1.05E-2/hr
Iodines	0.0	9.5E-2/hr	8.95E-3/hr
Cesium	0.0	7.5E-2/hr	9.47E-3/hr
Tellurium	0.0	2.0E-2/hr	1.58E-3/hr
Sr, Ba ,Ru	0.0	1.0E-3/hr	0.0
Remaining Isotopes	0.0	1.0E-5/hr	0.0

(Ref: AP600 Radiation Analysis Design Manual Section 5.2)

POST-LOCA ACTIVITY DISTR BASES (CONT'D):

- **Containment Leakage Rate:**

0 to 24 hrs	0.12% per day
24 hrs & on	0.06% per day

- **Deposition Rates:**

Elemental Iodine		1.6/hr to DF of 200
Particulates	0 to 5 hrs	0.35/hr
	5 to 5.5 hrs	1.3/hr
	5.5 hrs & on	0.5/hr to DF of 1000

- **Assume Containment leakage is directed into the Radiological Controlled Areas (RCA) of the Auxiliary Building areas only.**

- **Assume no active Post-Accident HVAC systems in Auxiliary or Annex buildings.**

- **Leakage between buildings is only through doors and is based on a 1/8" WG pressure differential:**

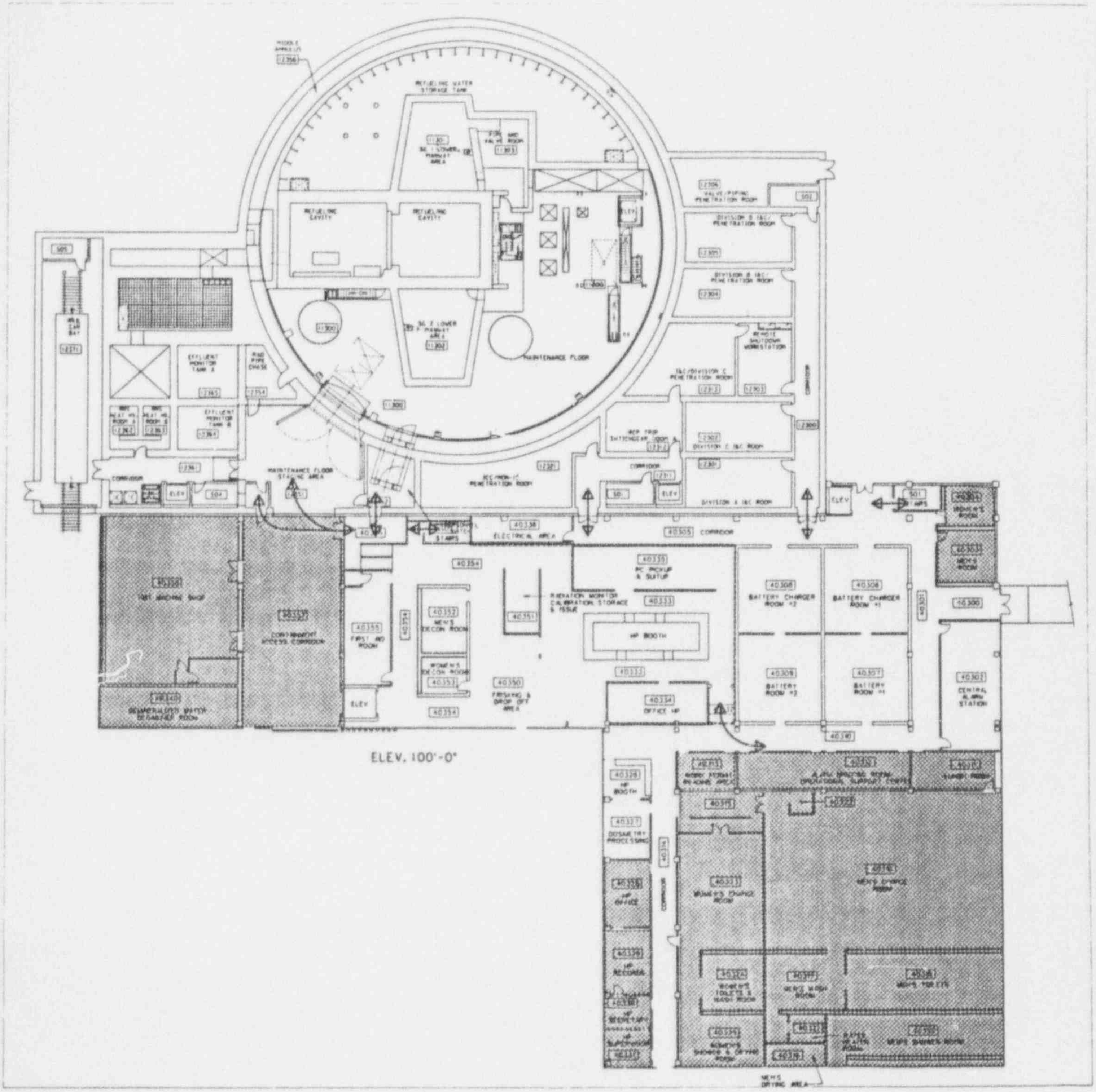
Single Doors	80 cfm
Double Doors	210 cfm

POST-LOCA ACTIVITY DISTR BASES (CONT'D):

- **Assume no leakage from Auxiliary and Annex Buildings to outside air**

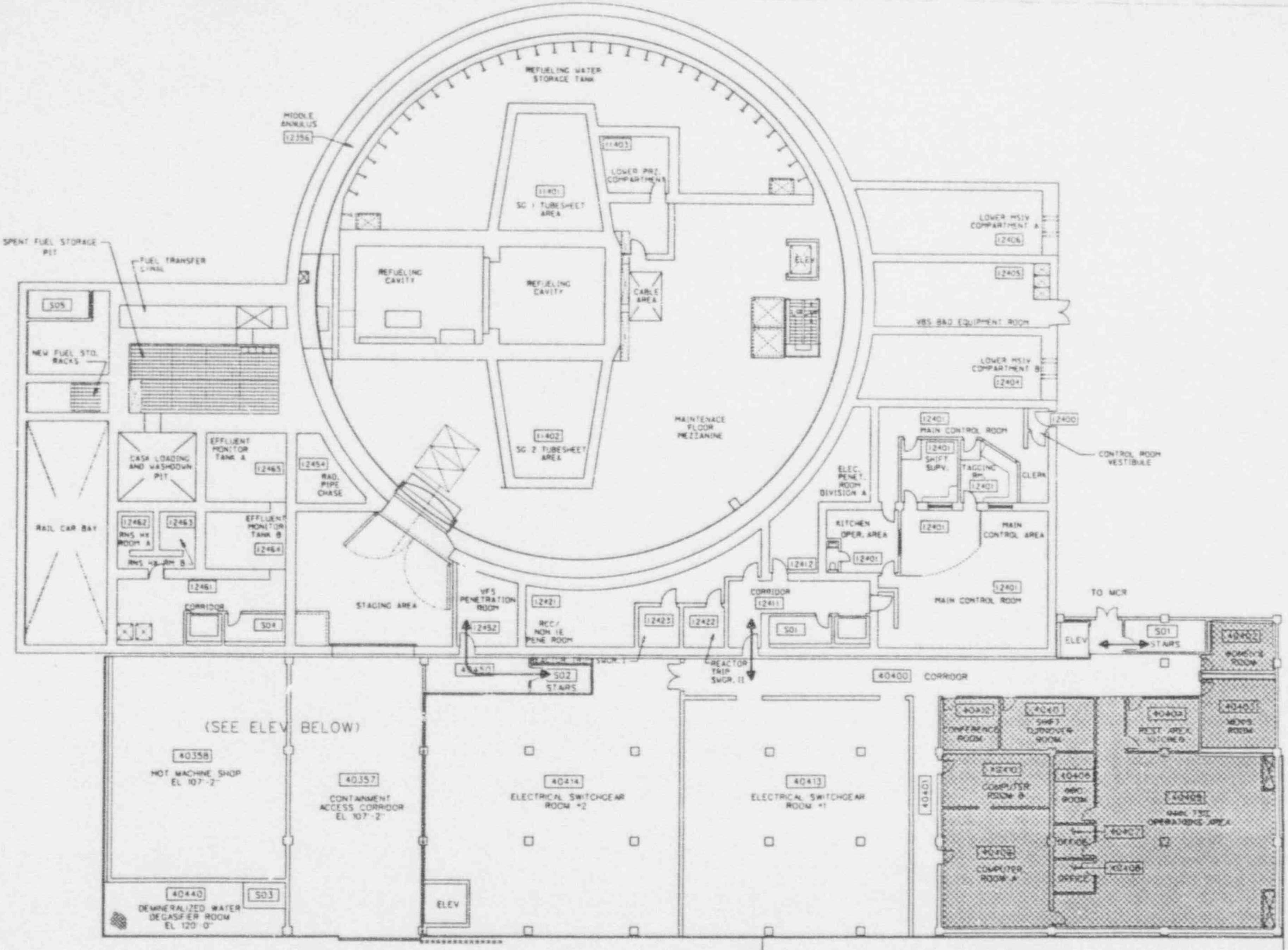
- **Building Free Air Volumes in cubic feet:**

Containment		1,830,000
RCA Auxiliary Building		616,500
Non-RCA Auxiliary Building		401,000
Annex II Bldg	Elev 100'0"	101,500
Annex I Bldg	Elev 100'0"	103,000
	Elev 117'6"	128,000
	Elev 135'3"	105,000
	Stairwell	6,970

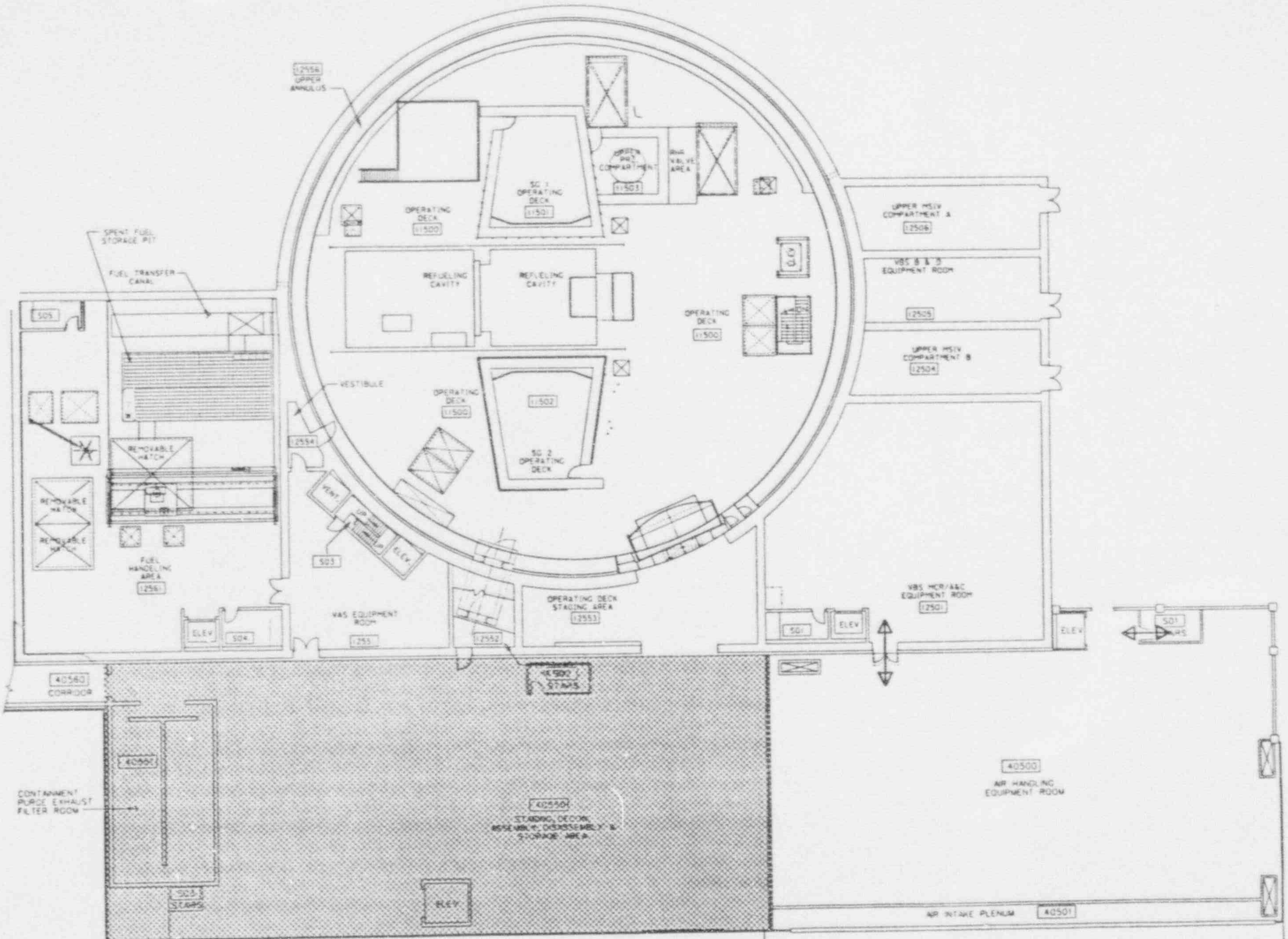


REFUELING WATER STORAGE TANK
REFUELING CAVITY
REFUELING CAVITY
MAINTENANCE FLOOR
EFFLUENT MONITOR TANK A
EFFLUENT MONITOR TANK B
CORRIDOR
MAINTENANCE FLOOR STAGING AREA
VALVE/PIPING PENETRATION ROOM
REMOTE SHUTDOWN WORKSTATION
DIVISION C I&C ROOM
DIVISION A I&C ROOM
CORRIDOR
ELECTRICAL AREA
CORRIDOR
BATTERY CHARGER ROOM #2
BATTERY CHARGER ROOM #1
BATTERY ROOM #2
BATTERY ROOM #1
CENTRAL ALARM STATION
HP BOOTH
OFFICE HP
FIRST AID ROOM
MEN'S DECON ROOM
WOMEN'S DECON ROOM
ELEV
HP BOOTH
DOSIMETRY PROCESSING
CORRIDOR
HP OFFICE
HP RECORDS
HP SECRETARY
HP SUPERVISOR
MEN'S DRYING AREA

ELEV. 100'-0"

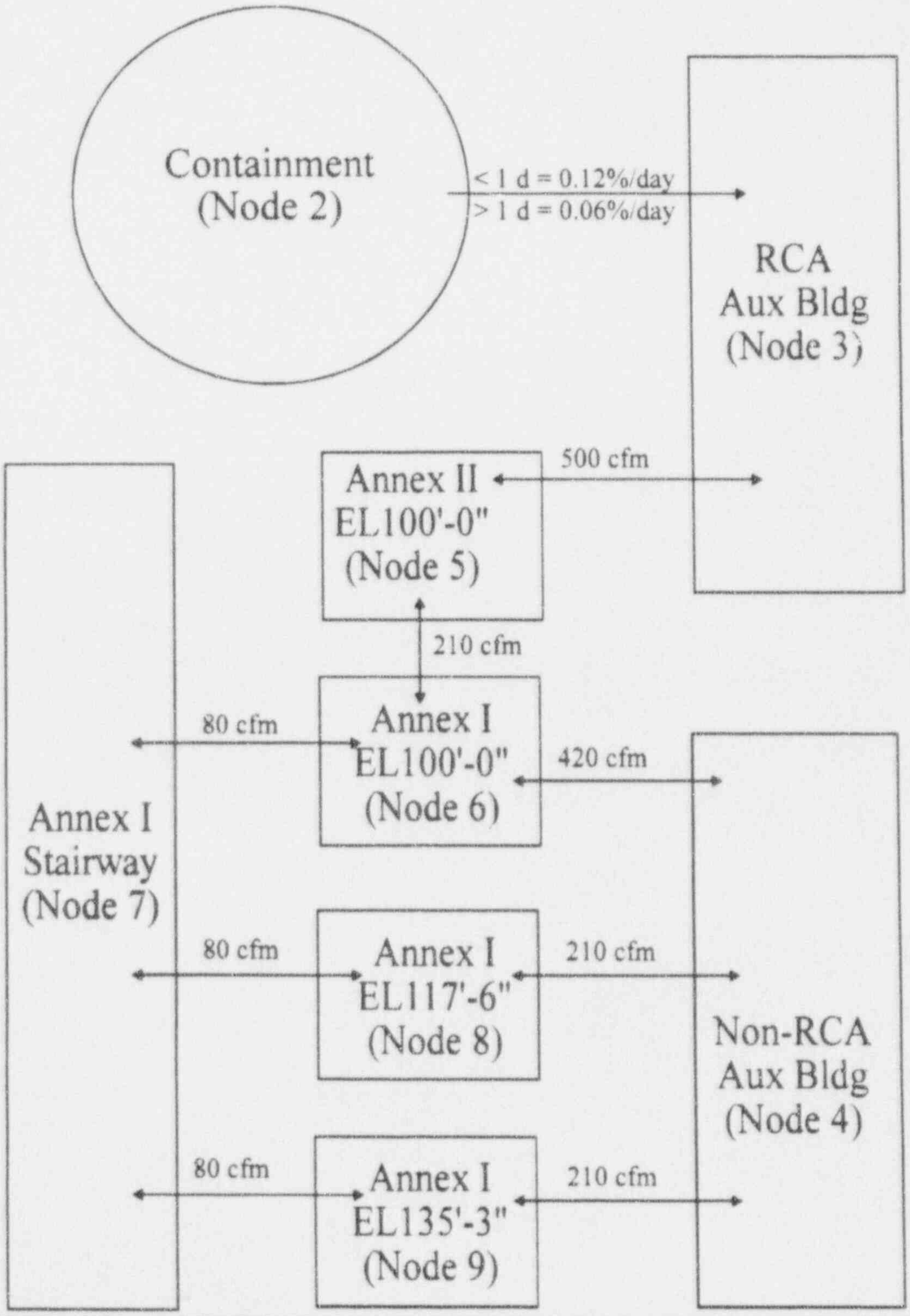

REFUELING WATER STORAGE TANK
MIDDLE ANNULUS
12356
11403
LOWER PRZ. COMPARTMENT
11401
SG 1 TUBESHEET AREA
SPENT FUEL STORAGE PIT
FUEL TRANSFER CANAL
REFUELING CAVITY
REFUELING CAVITY
CABLE AREA
ELEV
LOWER MSIV COMPARTMENT A
12406
12405
VBS B&D EQUIPMENT ROOM
LOWER MSIV COMPARTMENT B
12404
505
NEW FUEL STO. RACKS
MAINTENACE FLOOR MEZZANINE
11402
SG 2 TUBESHEET AREA
12401
MAIN CONTROL ROOM
12400
CONTROL ROOM VESTIBULE
SHIFT SUPV.
TAGGING RM.
CLERK
ELEC. PENET. ROOM DIVISION A
CASK LOADING AND WASHDOWN PIT
EFFLUENT MONITOR TANK A
12465
12454
RAD. PIPE CHASE
RAIL CAR BAY
12462
RNS HX ROOM A
12463
RNS HX RM B
EFFLUENT MONITOR TANK B
12464
12461
CORRIDOR
504
STAGING AREA
VFS PENETRATION ROOM
12452
12421
RCC/ NON 1E PENE ROOM
12423
12422
12412
CORRIDOR
12411
501
KITCHEN OPER. AREA
MAIN CONTROL AREA
MAIN CONTROL ROOM
TO MCR
ELEV
501
STAIRS
REACTOR TRIP SWGR. I
REACTOR TRIP SWGR. II
502
STAIRS
40400
CORRIDOR
(SEE ELEV BELOW)
40358
HOT MACHINE SHOP
EL 107'-2"
40357
CONTAINMENT ACCESS CORRIDOR
EL 107'-2"
40414
ELECTRICAL SWITCHGEAR ROOM #2
40413
ELECTRICAL SWITCHGEAR ROOM #1
40401
40440
503
DEMINERALIZED WATER DEGASIFIER ROOM
EL 120'-0"
ELEV
COMPUTER ROOM B
COMPUTER ROOM A
OFFICE
OFFICE

ELEV. 117'-6"


12556 UPPER ANNULUS
SPENT FUEL STORAGE PIT
FUEL TRANSFER CANAL
505
OPERATING DECK 11500
SG 1 OPERATING DECK 11501
COMPARTMENT 11503
VALVE AREA
REFUELING CAVITY
UPPER MSIV COMPARTMENT A 12506
VBS B & D EQUIPMENT ROOM 12505
UPPER MSIV COMPARTMENT B 12504
VESTIBULE
12554
11502
SG 2 OPERATING DECK
REMOVABLE HATCH
VENT
503
ELEV
FUEL HANDLING AREA 12561
504
VAS EQUIPMENT ROOM 1255
OPERATING DECK STAGING AREA 12553
12552
VBS MCR/A&C EQUIPMENT ROOM 12501
501
STAIRS
40560 CORRIDOR
40580
CONTAINMENT PURGE EXHAUST FILTER ROOM
40550
40500
AIR HANDLING EQUIPMENT ROOM
503 STAIRS
AIR INTAKE PLENUM 40501

ELEV. 135'-3"

LOCADOSE Model for Post Accident Activity Distribution



POST-LOCA ACTIVITY DISTRIBUTION:

- **Use LOCADOSE NE319 Release 3 to generate time dependent activity distribution fractions in each node for each isotope group with an initial unit activity.**

  Figure above presents a schematic diagram of the LOCADOSE Model used.

- **Determine the total Post-Accident gamma emission rates E_{Tjk} in Mev/watt-sec by energy group as a function of time in each node.**

$$Er_{jk}(t) = \sum_{i=1}^{6} f_{ik}(t) \times E_{ij}(t)$$

where: $f_{ik}(t)$= fraction of the activity of isotope group i in node k from the LOCADOSE runs at time t

$E_{ij}(t)$ = gamma energy emission rate for isotope group i in energy group j from AP600 Radiation Analysis Manual Tables 5-5 to 5-10 at time t

- **Determine C_2 multiplication factors (watt/cc) to convert total emission rates E_{Tjk} to volumetric gamma sources in Mev/cc-sec.**

For all nodes except the environmental cloud:

$$C_2 = \frac{1972(MW) \times 10^6 \ (W/MW)}{Volume_{node}\ (ft^3) \times 2,831.74 (cc/ft^3)}$$

POST-LOCA ACTIVITY DISTRIBUTION (CONT'D):

- **For the environmental cloud:**

$$C_2 = \frac{\lambda_L(t)\,(1/\text{day}) \times 1972(\text{MW}) \times \chi/Q(t)\,(\text{sec}/m^3)}{24 \times 3600}$$

where: $\lambda_L(t)$ = containment leakage rate at time t

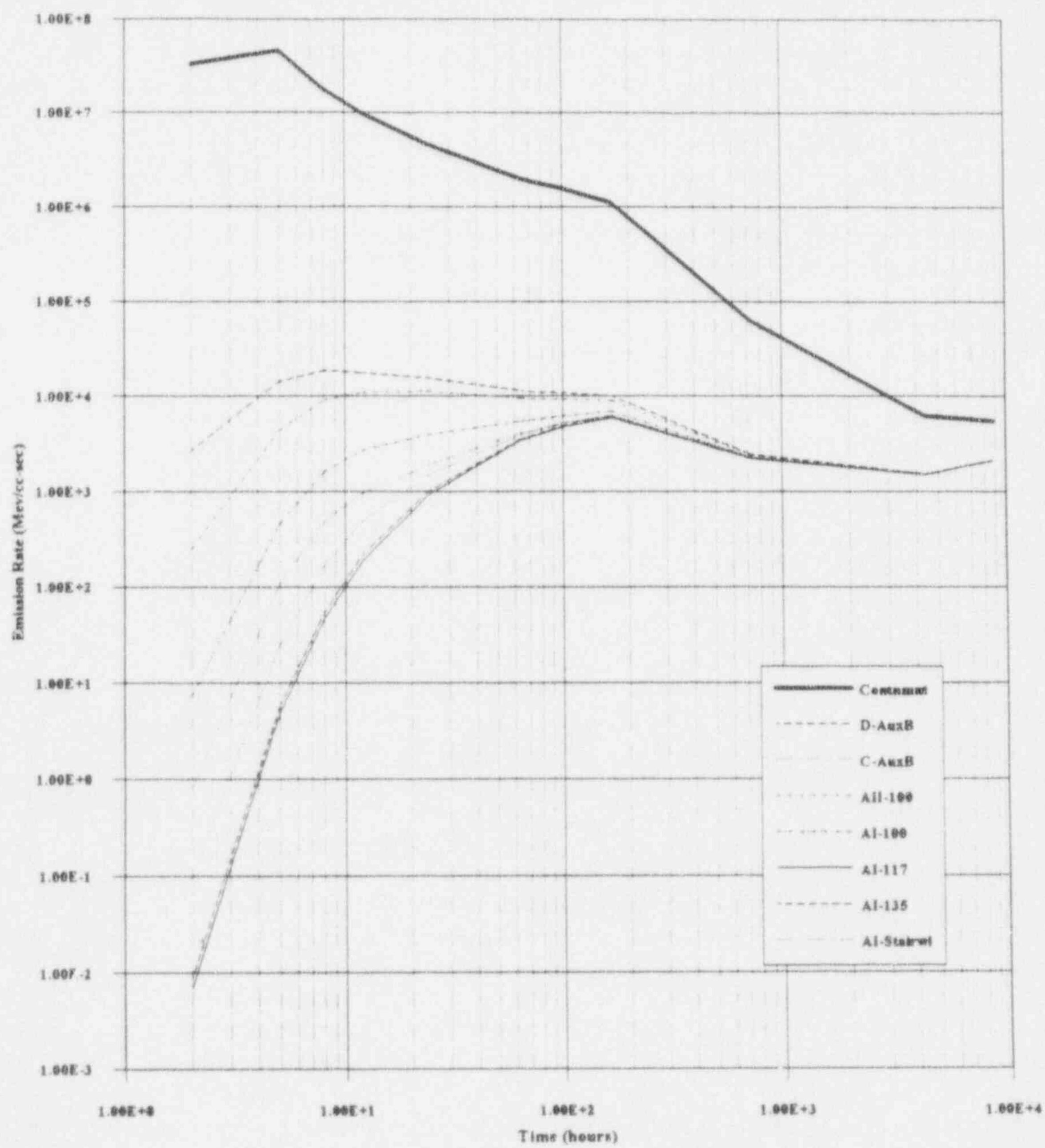
*$\chi/Q(t)$ = atmospheric dispersion factors at time t for the control room (shown below) are used

0 - 2 hrs	2.18×10^{-3}
2 - 8 hrs	1.50×10^{-3}
8 - 24 hrs	1.30×10^{-3}
24 - 96 hrs	8.40×10^{-4}
96 - 720 hrs	4.80×10^{-4}

* Ref: AP600 Calc GW N1C 001 Rev A

The C_2 factor is then applied to E_{Tjk} in Mev/watt-sec for the containment to get E_{Tjk} in Mev/cc-sec for the environmental cloud.

POST-LOCA GAMMA EMMISSION RATES



AP600

- **Post-Accident Radiation Source Descriptions**

POST-ACCIDENT RADIATION SOURCES ON AGENDA

- Unshielded Containment Cloud (UCC)
- Shielded Containment Cloud (SCC)
- Radiologically Controlled Areas of Auxiliary Building (RAC)
- Post-Accident Sample Piping (PAS)

UNSHIELDED CONTAINMENT CLOUD (UCC) GEOMETRY

- **Airborne sources uniformly distributed in containment air volume**

- **UCC for dose point locations <u>inside</u> containment**

- **Containment Cloud Geometry**

  - Cylindrical cloud (IR = 65'-0")
    (BOT = 107'-2")
    (TOP = 256'-4")

  - Spaces below 107'-2" embedded in concrete slab

- **Containment Internal Shield Geometry**

  - Internal wall shielding - SG, refueling water storage tank and reactor cavity walls from El. 107'-2" to 135'-3"

  - Internal slab shielding - operating floor El. 135'-3"

- **Dose Point Location**

  - Containment dose point taken at middle of upper containment free volume El. 195'-9"

SHIELDED CONTAINMENT CLOUD (SCC) GEOMETRY

- For dose point locations <u>outside</u> containment and not adjacent to containment penetrations

- Containment Cloud Geometry - same as UCC

- Containment External Shield Geometry

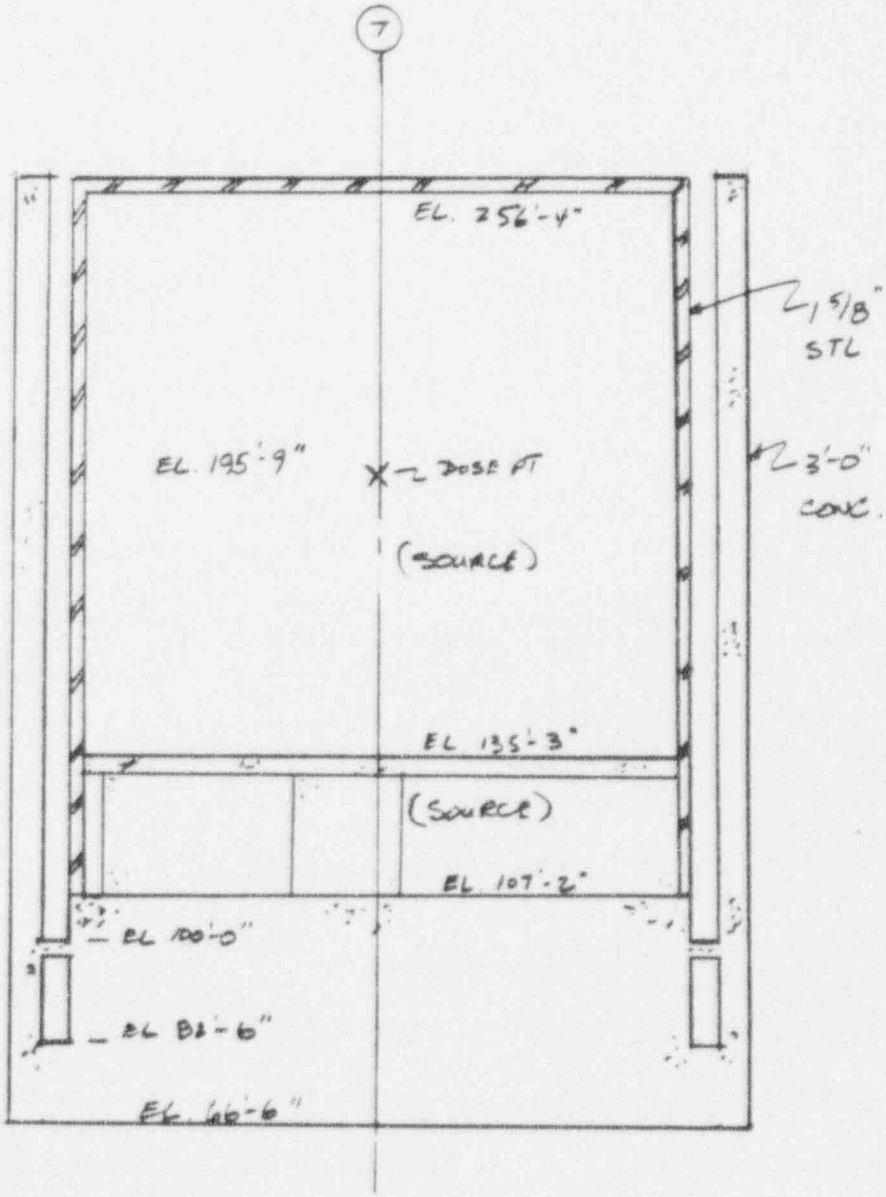
  - 1-5/8" containment steel liner (IR = 65'-0")

  - 3'-0" containment shield wall (IR = 69'-6")

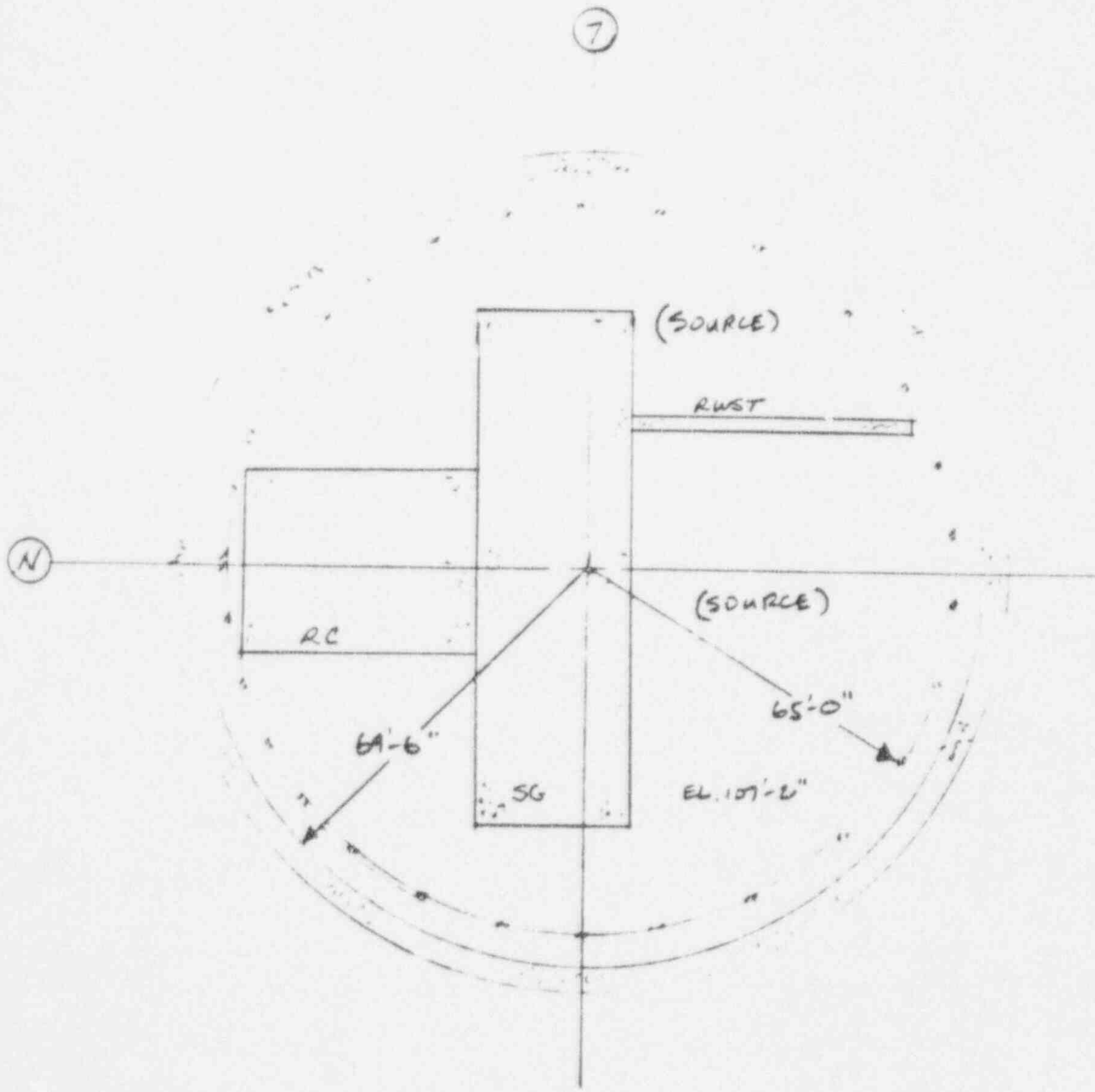
- Dose Point Location

  - External dose point taken at their elevation and plant building or yard location

CONTAINMENT CLOUD (SCC & UCC) SECTION



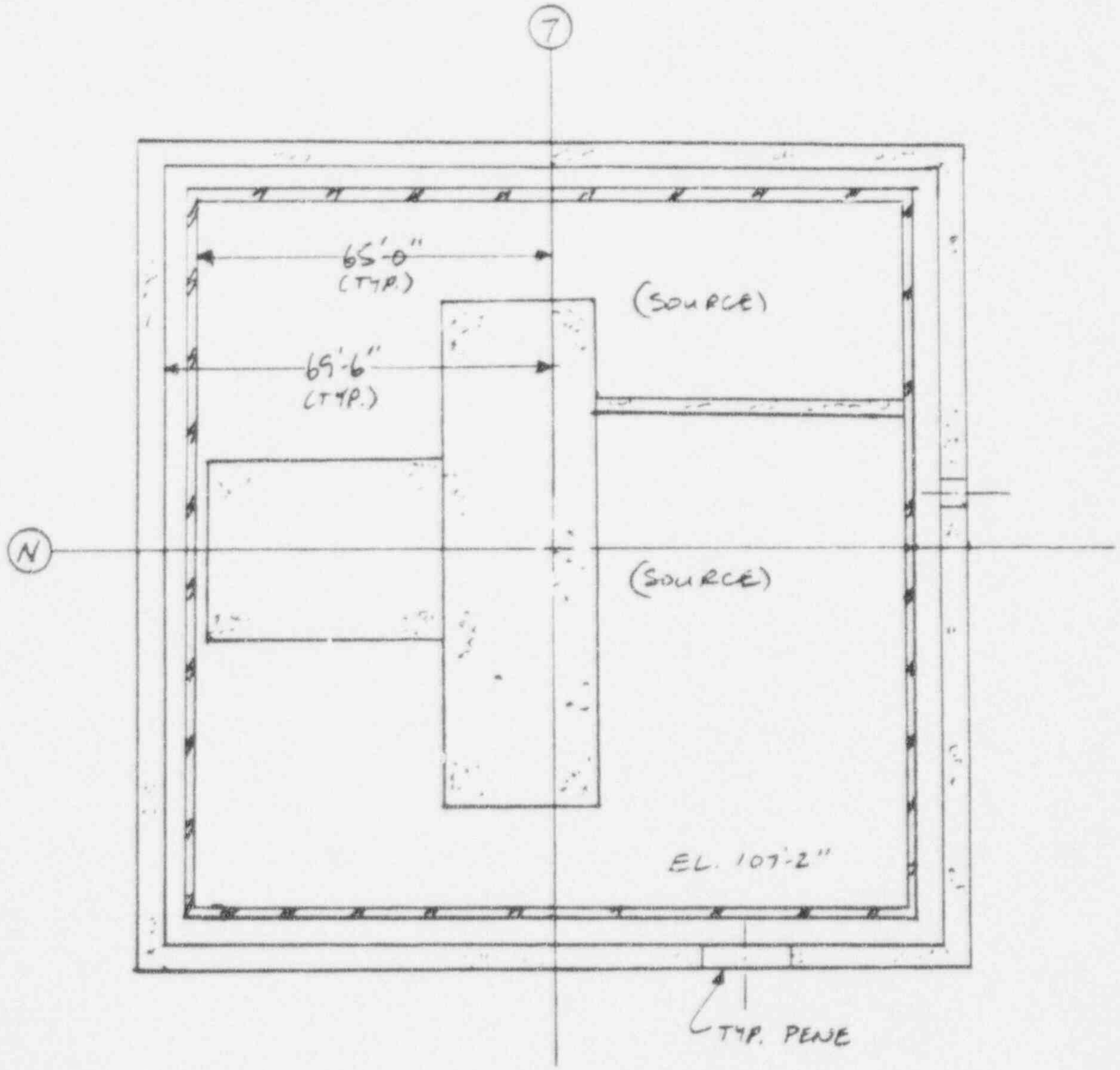
CONTAINMENT CLOUD (SCC & UCC) PLAN AT 107'-2"



CONTAINMENT PENETRATION STREAMING (CPS) GEOMETRY

- For dose point locations outside containment and near to containment penetrations
- Containment Cloud Geometry - similar to UCC but using rectangular box versus cylinder
- Containment External Shield Geometry
  - 1-5/8" containment steel liner (Width=130'-0")
  - 3'-0" containment shield wall (Inner Width = 139'-0")
- Shield Building Penetration Geometry
  - Shield building penetrations (hatches, doors, etc.) to external areas modeled as air filled bodies

CONTAINMENT CLOUD (SCC & CPS) PLAN AT 107'-2"

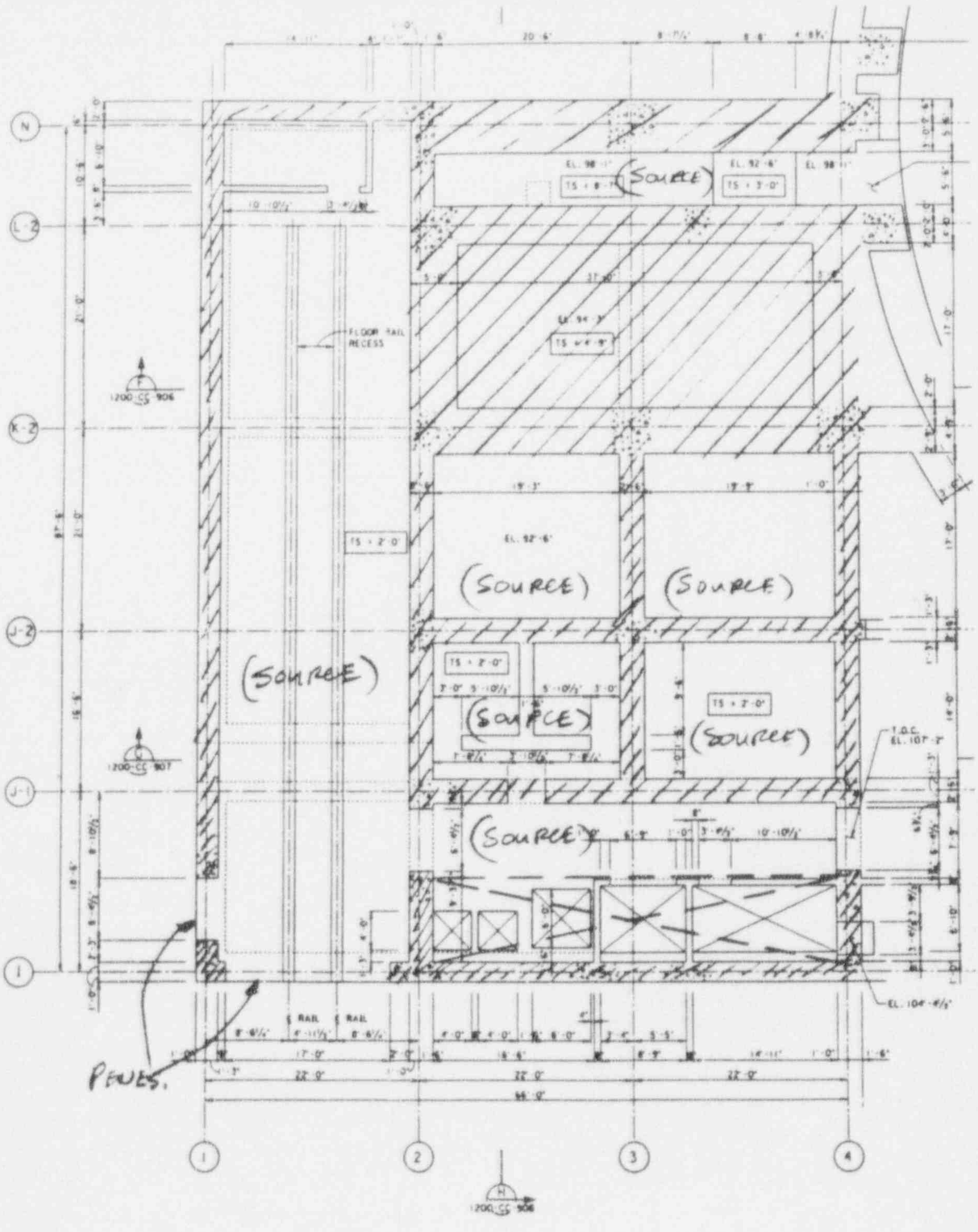


AP600

Radiologically Controlled Areas of Auxiliary Building (RAC)

- **Building Cloud Sources**
  - Airborne sources uniformly distributed in the entire air volumes for auxiliary buildings and each air volume for Annex building HVAC regions
  - Location of building cloud boundaries shown on SAR Figures for Post-Accident Zoning
  - Room size clouds used for access areas and routes. (Internal building structural walls and slabs around vital access areas included in model)
- **Dose Point Locations**
  - Representative room dose rates at center at 3' from floor
- **Cumulative Dose Rates**
  - Building dose rates summed where appropriate with penetrations contributions from adjacent buildings (e.g. containment penetrations to auxiliary and annex buildings)
  - Peak dose rates at any Post-Accident time are then used to determine Zoning for each area.
- **Auxiliary Building Modeled as Air Filled Box with Internal Concrete Walls and Slabs**
  - Floor and wall openings modeled as air filled bodies

TYPICAL RAC SOURCE-SHIELD GEOMETRY



FLOOR EL. 100'-0"

LEGEND:

A. POST-ACCIDENT RADIATION ZONES:

DESIGNATION	MAXIMUM DESIGN DOSE RATE	DESCRIPTION
0	$\leq$ 0.05 mRem/hr	NO RADIATION SOURCES
I	$\leq$ 0.25 mRem/hr	VERY LOW OR NO RADIATION SOURCES
II	$\leq$ 2.5 mRem/hr	LOW RADIATION SOURCES
III	$\leq$ 15.0 mRem/hr	LOW-TO-MODERATE RADIATION SOURCES
IV	$\leq$ 100 mRem/hr	MODERATE RADIATION SOURCES
V	$\leq$ 1 Rem/hr	HIGH RADIATION SOURCES
VI	$\leq$ 10 Rem/hr	SAME AS ZONE V ABOVE
VII	$\leq$ 100 Rem/hr	SAME AS ZONE V ABOVE
VIII	$\leq$ 500 Rad/hr	SAME AS ZONE V ABOVE
IX	> 500 Rad/hr	VERY HIGH RADIATION SOURCES

B. DRAWING SYMBOLS:

VI / ECS – RADIATION ZONE NUMERAL AT POST-ACCIDENT PEAK / DOMINANT POST-ACCIDENT RADIATION SOURCE(S)

– NON-RADIOACTIVE AREA BOUNDARY

– RADIOACTIVE AREA BOUNDARY

– ANNEX AREA BOUNDARY

– RADIATION ZONE BOUNDARY

– POST-ACCIDENT ACCESS ROUTE

C. POST-ACCIDENT SOURCES:

SYMBOL	POST-ACCIDENT RADIATION SOURCE
ECS	EXTERNAL CLOUD SHINE
NRA	NON-RADIOACTIVE AUXILIARY BUILDING AREA CLOUD
RAC	RADIOACTIVE AUXILIARY BUILDING AREA CLOUD
SCC	SHIELDED CONTAINMENT CLOUD
UCC	UNSHIELDED CONTAINMENT CLOUD
CPS	CONTAINMENT AND PENETRATION RADIATION STREAMING
AXC	ANNEX BUILDING AREA CLOUD
PAS	POST-ACCIDENT SAMPLE PIPING

D. GENERAL DRAWING NOTES:

1. ZONING IS BASED ON PEAK POST-ACCIDENT DOSE RATES IN THE DESIGNATED AREA.
2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBRONE CLOUD SOURCES.

	HIGH RADIATION SOURCES
hr	SAME AS ZONE V ABOVE
/hr	SAME AS ZONE V ABOVE
/hr	SAME AS ZONE V ABOVE
/hr	VERY HIGH RADIATION SOURCES

1. ZONING IS BASED ON PEAK POST-ACCIDENT DOSE RATES IN THE DESIGNATED AREA.
2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBORNE CLOUD SOURCES.

N ZONE NUMERAL AT POST-ACCIDENT PEAK
POST-ACCIDENT RADIATION SOURCE(S)

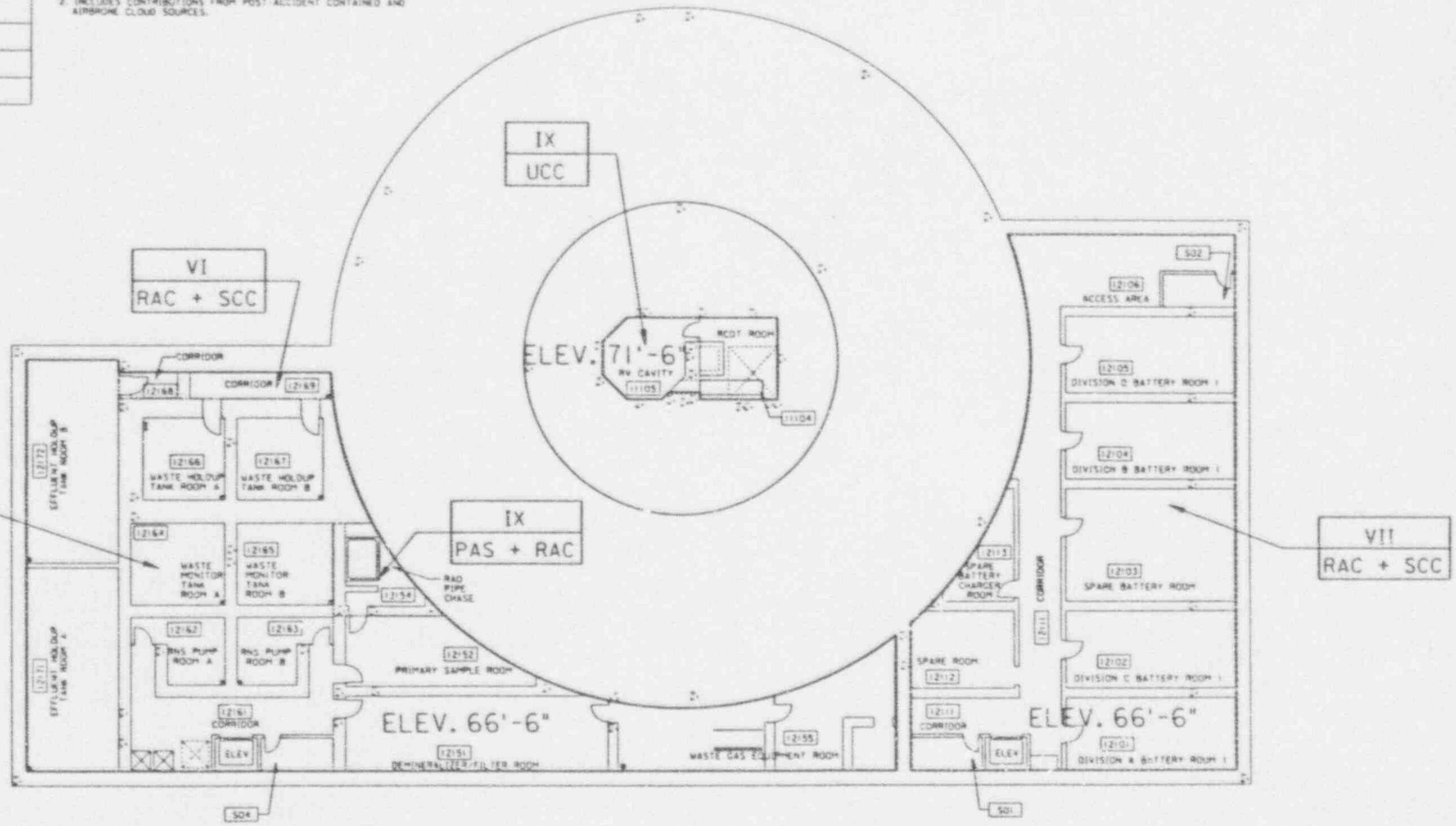
DACTIVE AREA BOUNDARY

IVE AREA BOUNDARY

EA BOUNDARY

N ZONE BOUNDARY

IDENT ACCESS ROUTE



ELEV. 66'-6"

r	HIGH RADIATION SOURCES
/hr	SAME AS ZONE V ABOVE
s/hr	SAME AS ZONE V ABOVE
s/hr	SAME AS ZONE V ABOVE
s/hr	VERY HIGH RADIATION SOURCES

1. ZONING IS BASED ON PEAK POST-ACCIDENT DOSE RATES IN THE DESIGNATED AREA.
2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBRONE CLOUD SOURCES.

ON ZONE NUMERAL AT POST-ACCIDENT PEAK
T POST-ACCIDENT RADIATION SOURCE(S)

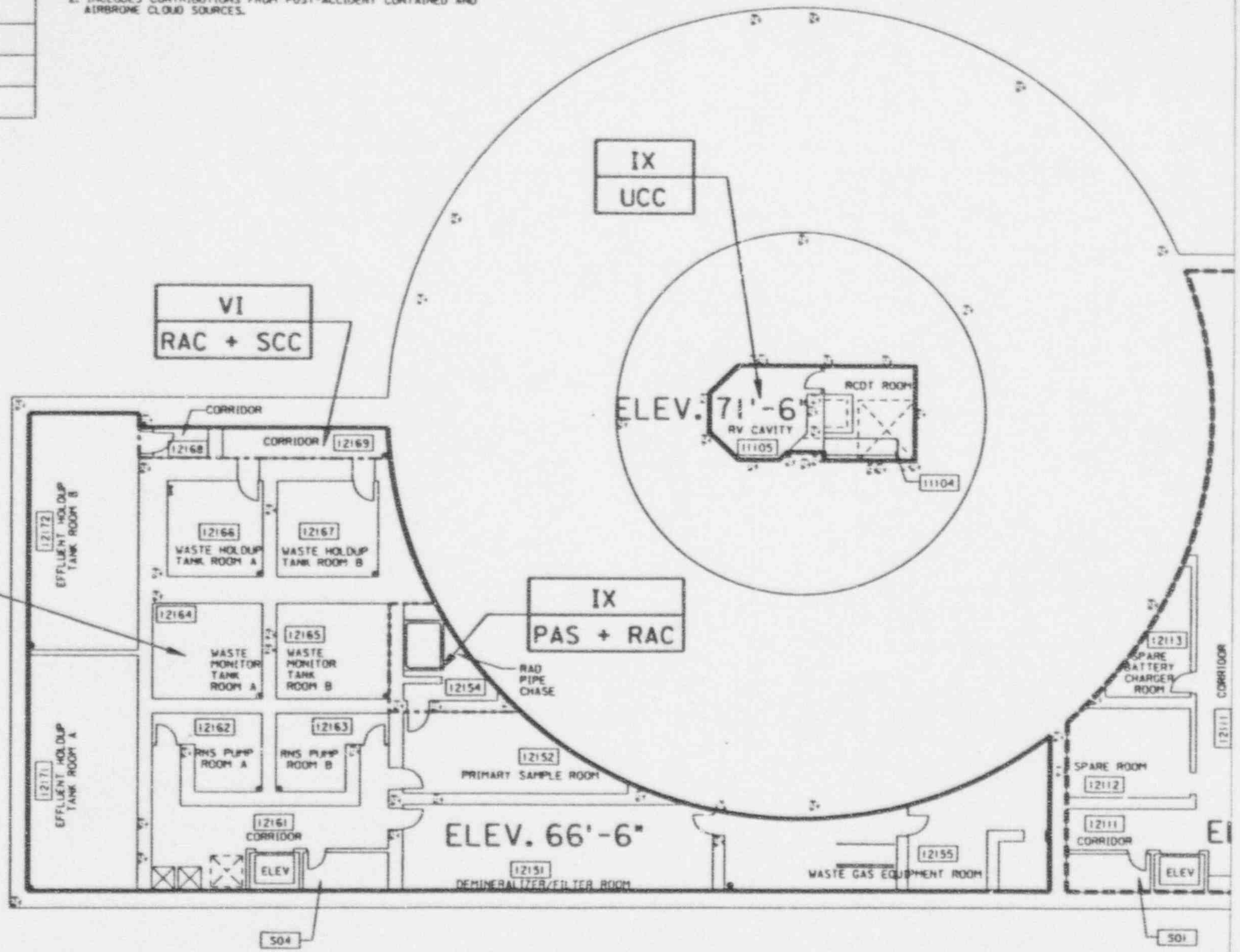
IOACTIVE AREA BOUNDARY

TIVE AREA BOUNDARY

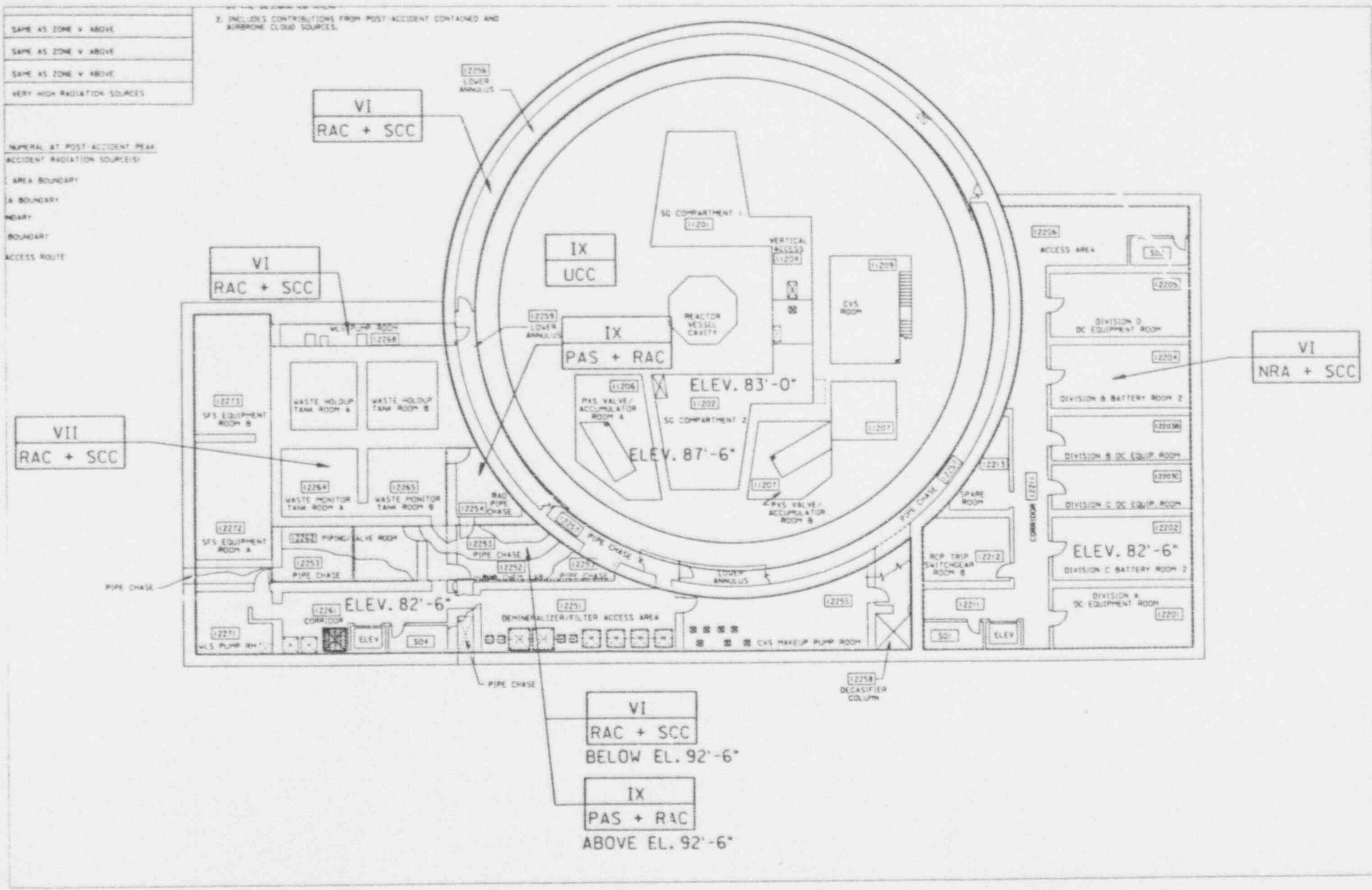
REA BOUNDARY

N ZONE BOUNDARY

CIDENT ACCESS ROUTE



ELEV. 66'-6"

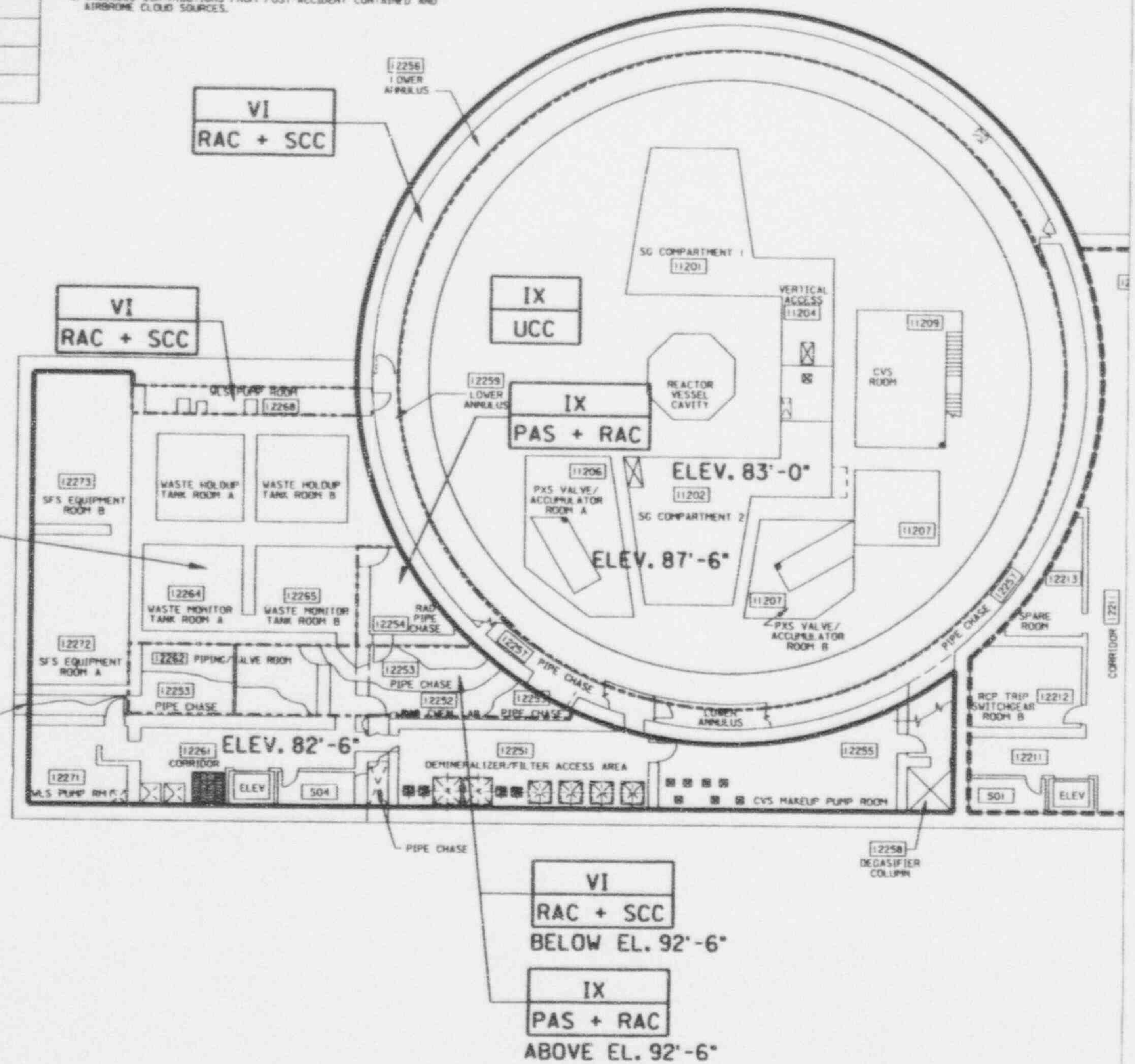


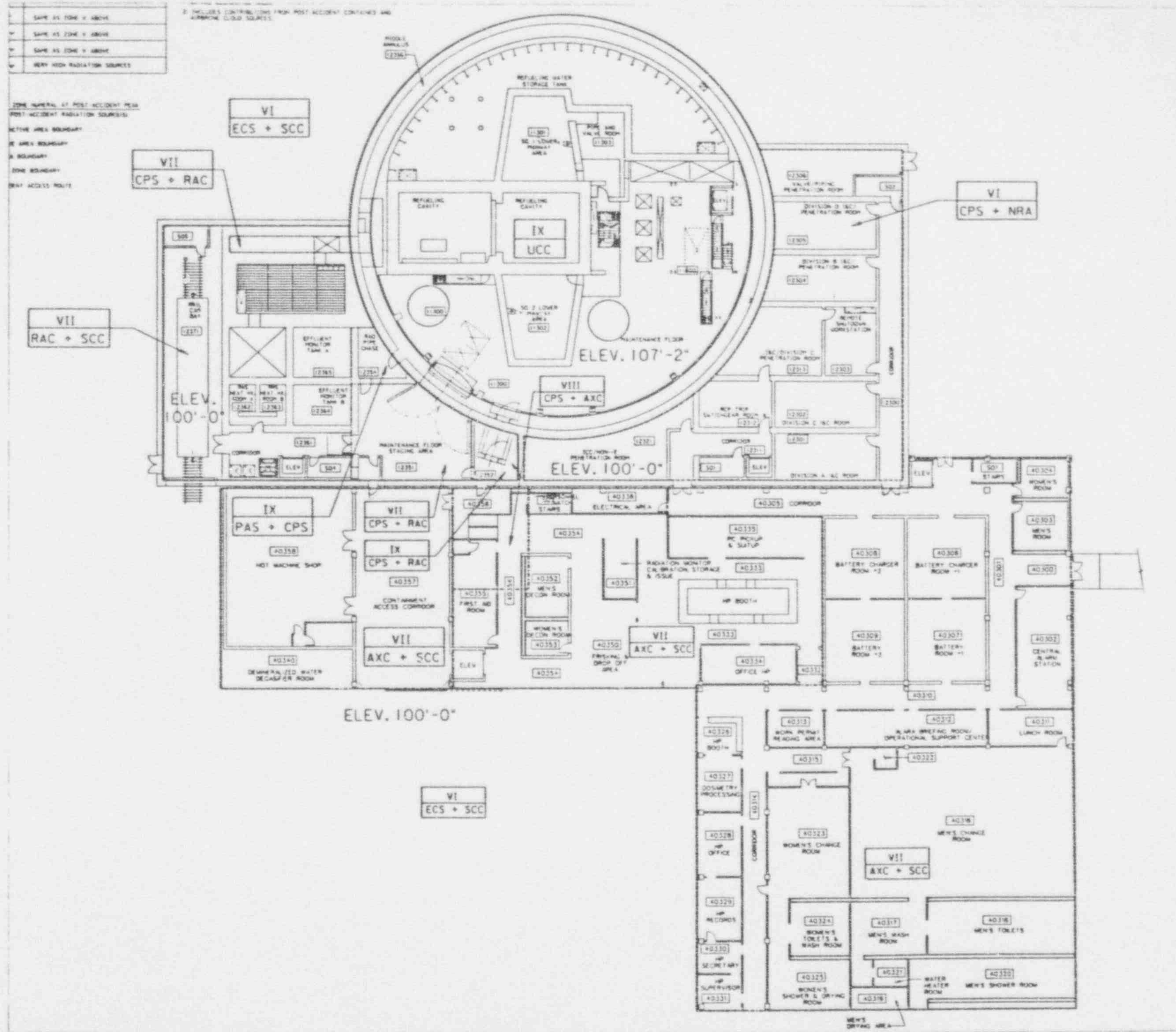
2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBORNE CLOUD SOURCES.
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
VERY HIGH RADIATION SOURCES
NUMERAL AT POST-ACCIDENT PEAK
ACCIDENT RADIATION SOURCE(S)
AREA BOUNDARY
BOUNDARY
ACCESS ROUTE
VI
RAC + SCC
VI
RAC + SCC
VII
RAC + SCC
IX
UCC
IX
PAS + RAC
VI
NRA + SCC
VI
RAC + SCC
BELOW EL. 92'-6"
IX
PAS + RAC
ABOVE EL. 92'-6"
12256
LOWER ANNULUS
SG COMPARTMENT 1
11201
VERTICAL ACCESS
11204
11209
CVS ROOM
REACTOR VESSEL CAVITY
ELEV. 83'-0"
11206
PXS VALVE/ ACCUMULATOR ROOM A
11202
SG COMPARTMENT 2
ELEV. 87'-6"
11207
PXS VALVE/ ACCUMULATOR ROOM B
12259
LOWER ANNULUS
12268
12273
SFS EQUIPMENT ROOM B
WASTE HOLDUP TANK ROOM A
WASTE HOLDUP TANK ROOM B
12264
WASTE MONITOR TANK ROOM A
12265
WASTE MONITOR TANK ROOM B
12254
RAD PIPE CHASE
12272
SFS EQUIPMENT ROOM A
12262
PIPING/VALVE ROOM
12253
PIPE CHASE
12252
PIPE CHASE
12257
PIPE CHASE
PIPE CHASE
ELEV. 82'-6"
12261
CORRIDOR
12271
ELEV
S04
12251
DEMINERALIZER/FILTER ACCESS AREA
LOWER ANNULUS
12255
CVS MAKEUP PUMP ROOM
12258
DEGASIFIER COLUMN
PIPE CHASE
12206
ACCESS AREA
S02
12205
DIVISION D DC EQUIPMENT ROOM
12204
DIVISION B BATTERY ROOM 2
12203B
DIVISION B DC EQUIP. ROOM
12203C
DIVISION C DC EQUIP. ROOM
12202
ELEV. 82'-6"
DIVISION C BATTERY ROOM 2
DIVISION A DC EQUIPMENT ROOM
12201
12213
SPARE ROOM
CORRIDOR
RCP TRIP SWITCHGEAR ROOM B
12212
12211
S01
ELEV

HIGH RADIATION SOURCES
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
VERY HIGH RADIATION SOURCES

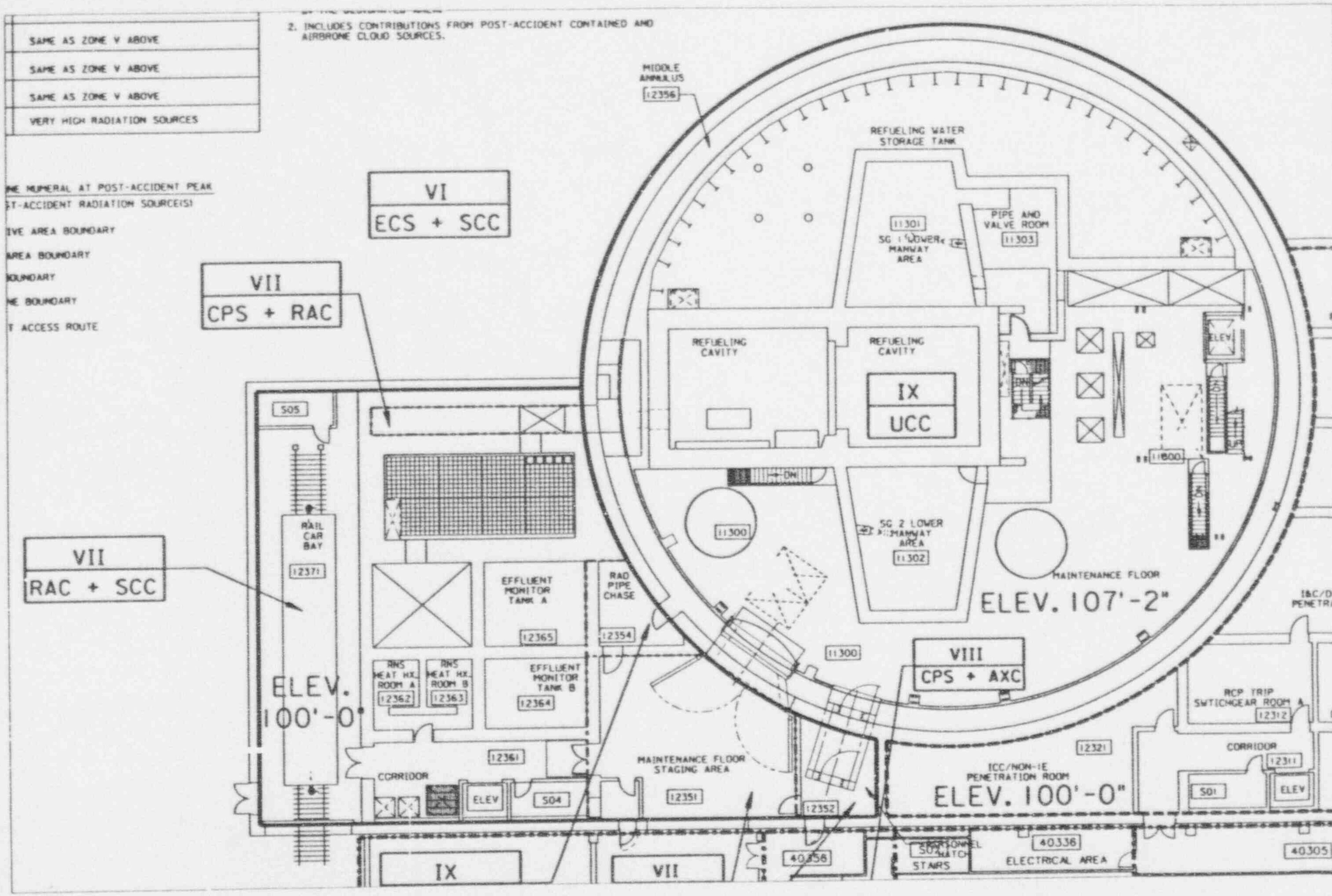
1. ZONING IS BASED ON PEAK POST-ACCIDENT DOSE RATES IN THE DESIGNATED AREA.
2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBORNE CLOUD SOURCES.

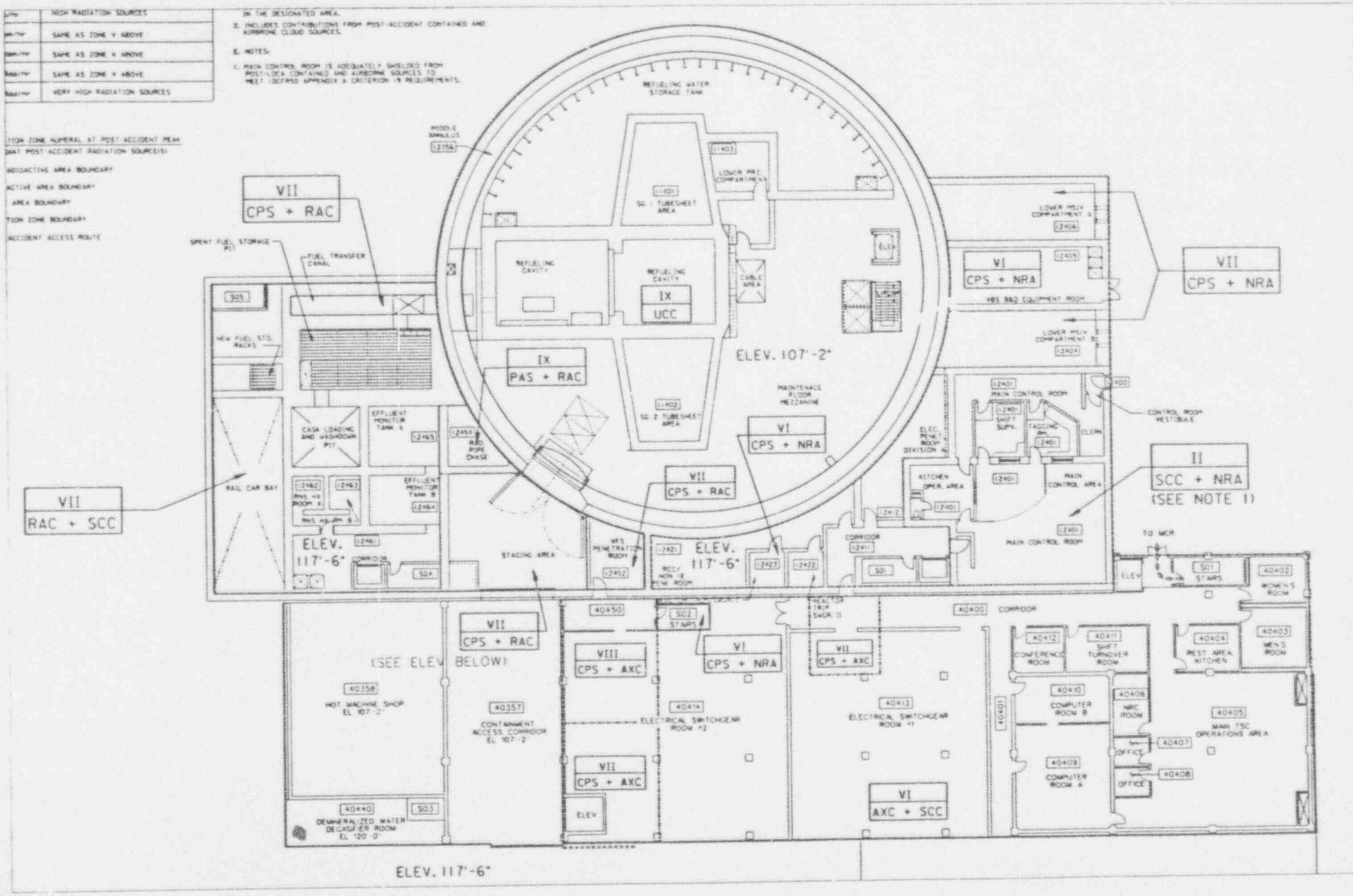
NUMERAL AT POST-ACCIDENT PEAK
ACCIDENT RADIATION SOURCE(S)
AREA BOUNDARY
A BOUNDARY
NDARY
BOUNDARY
ACCESS ROUTE



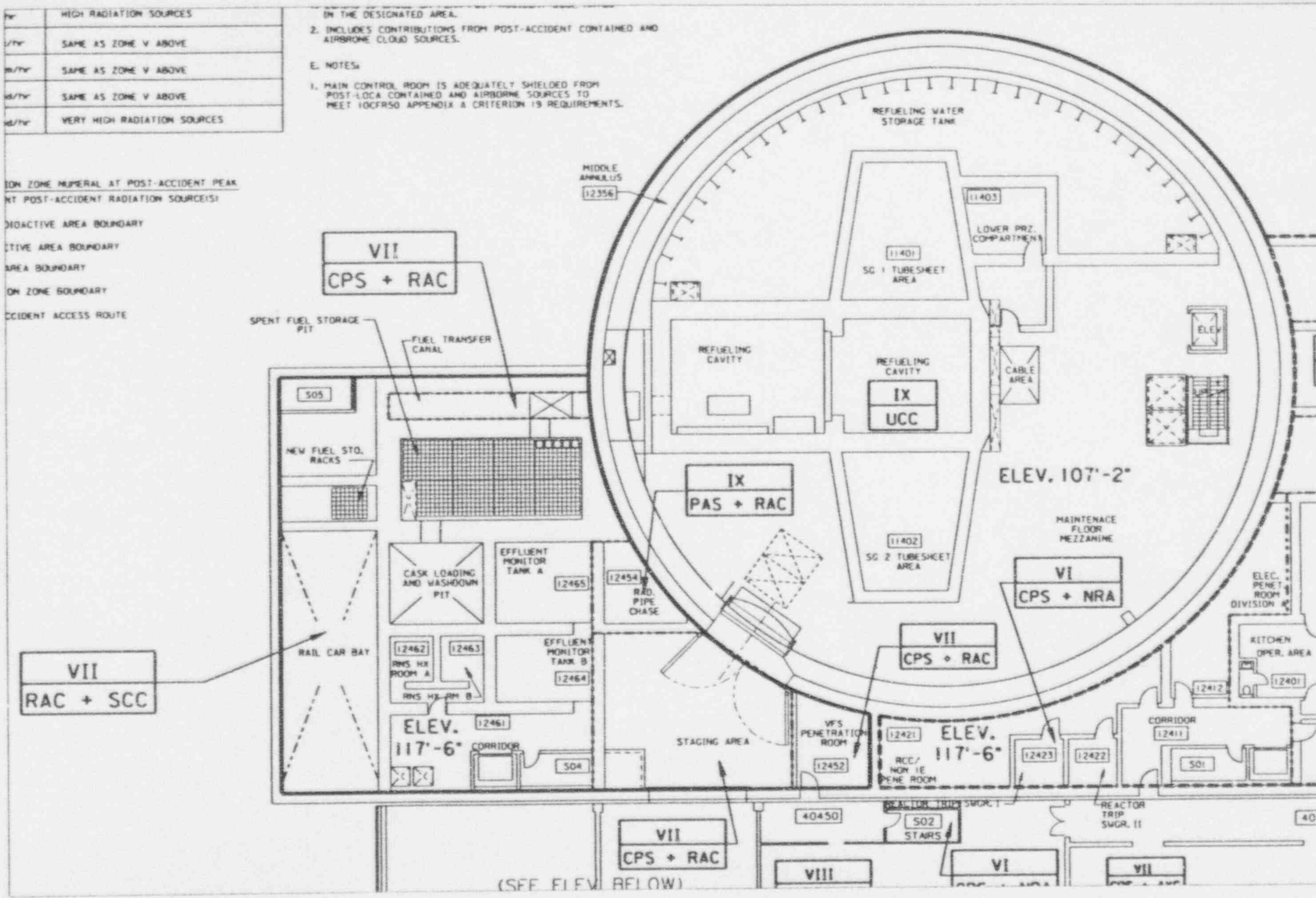


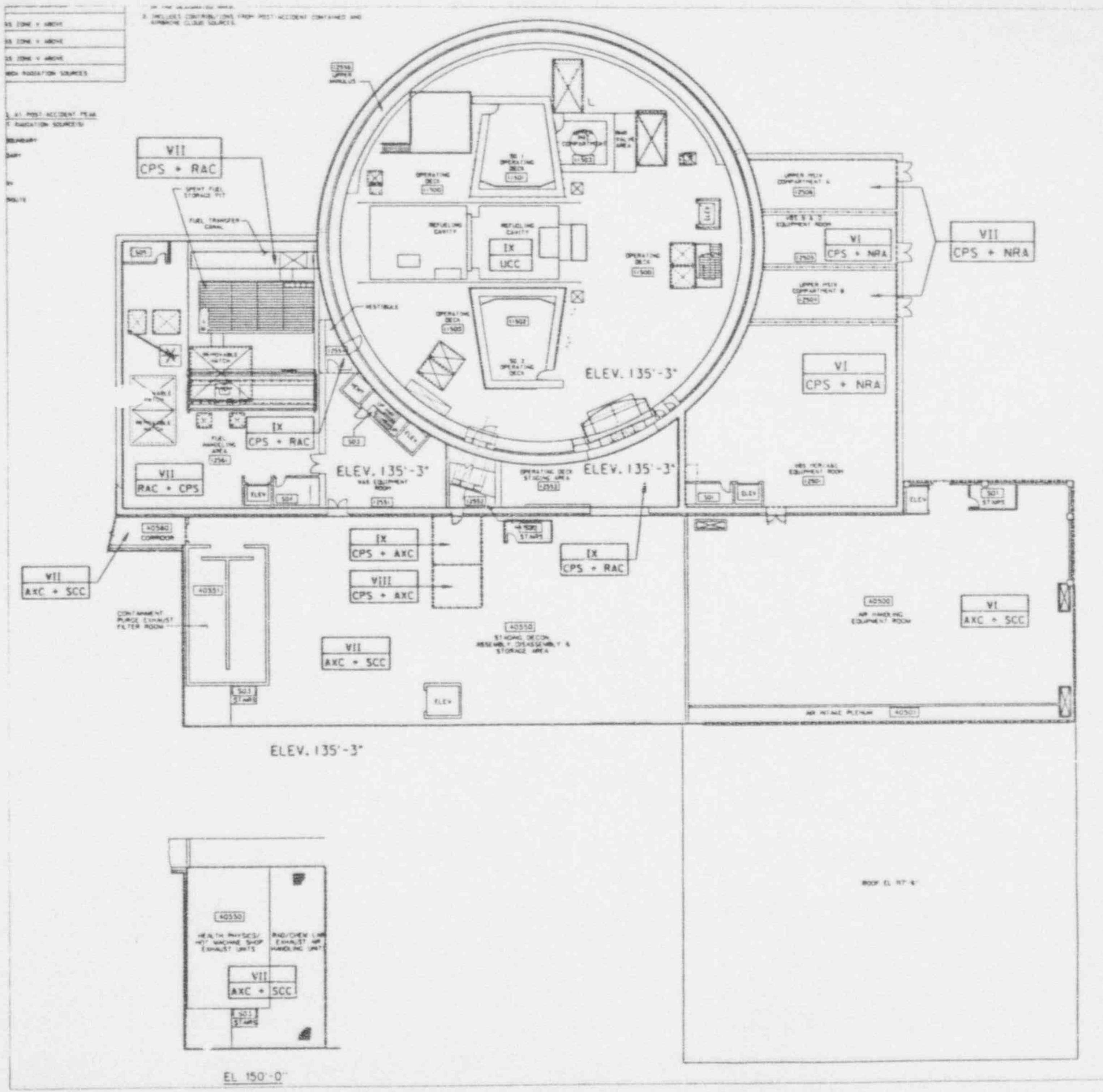
ELEV. 107'-2"
ELEV. 100'-0"
ELEV. 100'-0"
ELEV. 100'-0"
VI
ECS + SCC
VII
CPS + RAC
VII
RAC + SCC
IX
UCC
VIII
CPS + AXC
VI
CPS + NRA
IX
PAS + CPS
VII
CPS + RAC
IX
CPS + RAC
VII
AXC + SCC
VII
AXC + SCC
VII
AXC + SCC
VI
ECS + SCC
REFUELING WATER STORAGE TANK
REFUELING CAVITY
MAINTENANCE FLOOR
HOT MACHINE SHOP
CONTAINMENT ACCESS CORRIDOR
DEMINERALIZED WATER DEGASIFIER ROOM
FIRST AID ROOM
ELECTRICAL AREA
HP BOOTH
OFFICE HP
BATTERY CHARGER ROOM #2
BATTERY CHARGER ROOM #1
CENTRAL ALARM STATION
LUNCH ROOM
WOMEN'S CHANGE ROOM
MEN'S CHANGE ROOM
MEN'S TOILETS
MEN'S SHOWER ROOM
MEN'S DRYING AREA
CORRIDOR


SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
VERY HIGH RADIATION SOURCES
2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBRONE CLOUD SOURCES.
NE NUMERAL AT POST-ACCIDENT PEAK
ST-ACCIDENT RADIATION SOURCE(S)
IVE AREA BOUNDARY
AREA BOUNDARY
BOUNDARY
NE BOUNDARY
T ACCESS ROUTE
VI
ECS + SCC
VII
CPS + RAC
VII
RAC + SCC
MIDDLE ANNULUS
12356
REFUELING WATER STORAGE TANK
11301
SG 1 LOWER MANWAY AREA
PIPE AND VALVE ROOM
11303
REFUELING CAVITY
REFUELING CAVITY
IX
UCC
ELEV
11600
11300
SG 2 LOWER MANWAY AREA
11302
MAINTENANCE FLOOR
ELEV. 107'-2"
I&C/DIV PENETRAT
VIII
CPS + AXC
11300
505
RAIL CAR BAY
12371
EFFLUENT MONITOR TANK A
12365
RAD PIPE CHASE
12354
RNS HEAT HX. ROOM A
12362
RNS HEAT HX. ROOM B
12363
EFFLUENT MONITOR TANK B
12364
ELEV. 100'-0"
12361
CORRIDOR
ELEV
504
MAINTENANCE FLOOR STAGING AREA
12351
12352
RCP TRIP SWITCHGEAR ROOM A
12312
12321
CORRIDOR
12311
ICC/NON-1E PENETRATION ROOM
ELEV. 100'-0"
501
ELEV
IX
VII
40358
PERSONNEL HATCH
STAIRS
40336
ELECTRICAL AREA
40305



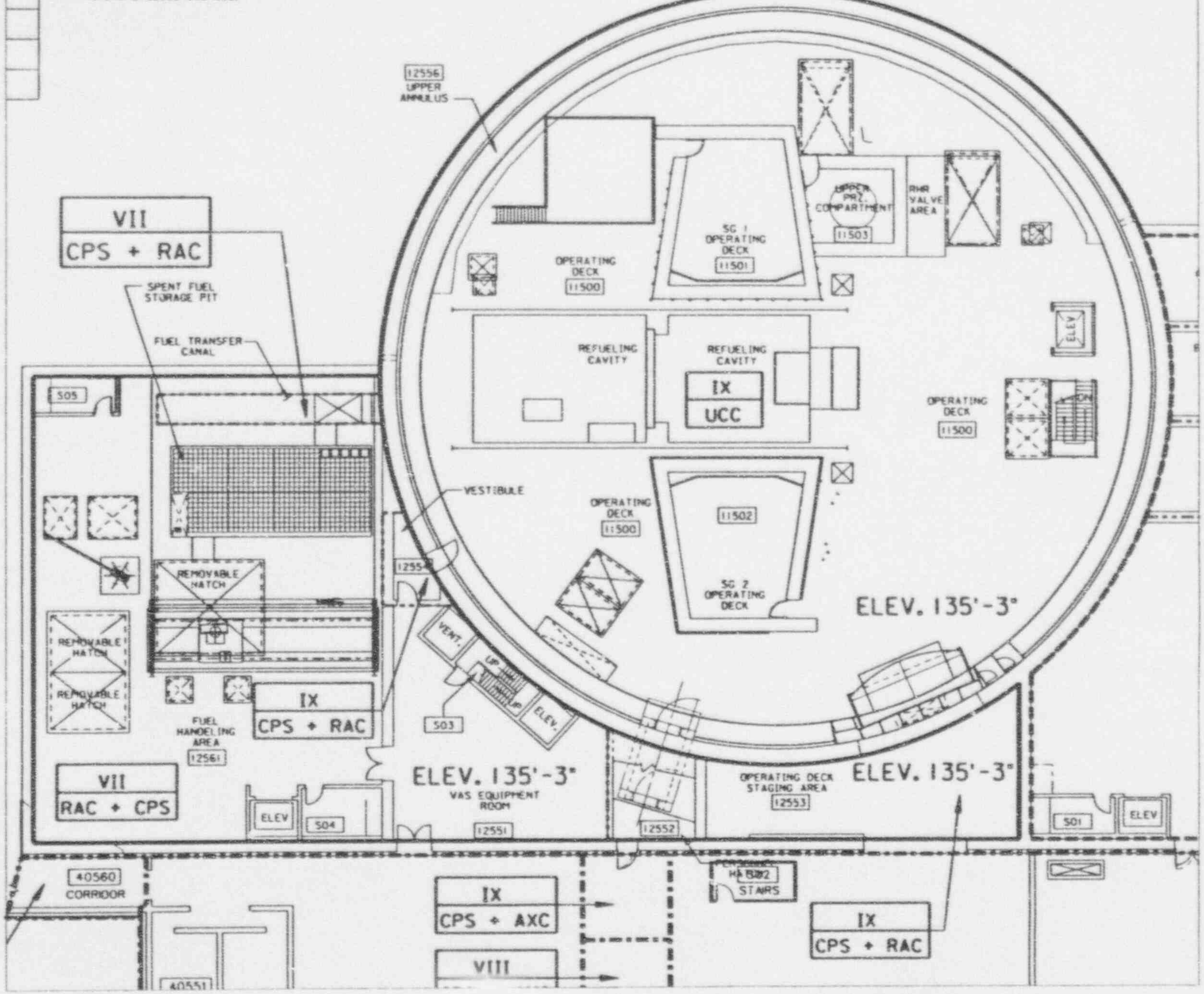
HIGH RADIATION SOURCES
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
VERY HIGH RADIATION SOURCES
IN THE DESIGNATED AREA.
2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBORNE CLOUD SOURCES.
II. NOTES:
1. MAIN CONTROL ROOM IS ADEQUATELY SHIELDED FROM POST-LOCA CONTAINED AND AIRBORNE SOURCES TO MEET 10CFR50 APPENDIX A CRITERION 19 REQUIREMENTS.
REFUELING WATER STORAGE TANK
MIDDLE ANNULUS
12156
VII
CPS + RAC
SPENT FUEL STORAGE PIT
FUEL TRANSFER CANAL
11401
SG 1 TUBESHEET AREA
11403
LOWER PRI. COMPARTMENT
REFUELING CAVITY
REFUELING CAVITY
IX
UCC
CABLE AREA
ELEV
LOWER MSIV COMPARTMENT A
12406
12405
VI
CPS + NRA
VBS B&D EQUIPMENT ROOM
VII
CPS + NRA
LOWER MSIV COMPARTMENT B
12404
ELEV. 107'-2"
505
NEW FUEL STG. RACKS
IX
PAS + RAC
MAINTENACE FLOOR MEZZANINE
11402
SG 2 TUBESHEET AREA
12401
MAIN CONTROL ROOM
12400
CONTROL ROOM VESTIBULE
SHIFT SUPV.
TAGGING RM.
CLERK
CASK LOADING AND WASHDOWN PIT
EFFLUENT MONITOR TANK A
12465
12451
RAD. PIPE CHASE
VI
CPS + NRA
ELEC. PENET. ROOM DIVISION A
KITCHEN OPER. AREA
MAIN CONTROL AREA
II
SCC + NRA
(SEE NOTE 1)
VII
RAC + SCC
RAIL CAR BAY
12462
12463
EFFLUENT MONITOR TANK B
12464
VII
CPS + RAC
ELEV. 117'-6"
12461
CORRIDOR
504
STAGING AREA
VBS PENETRATION ROOM
12452
12421
ELEV. 117'-6"
12423
12422
CORRIDOR
12411
12412
501
MAIN CONTROL ROOM
TO MCR
ELEV
501
STAIRS
40402
WOMEN'S ROOM
40450
502
STAIRS
REACTOR TRIP SWGR. II
40400 CORRIDOR
VII
CPS + RAC
VIII
CPS + AXC
VI
CPS + NRA
VII
CPS + AXC
40412
CONFERENCE ROOM
40411
SHIFT TURNOVER ROOM
40406
REST AREA KITCHEN
40403
MEN'S ROOM
(SEE ELEV BELOW)
40358
HOT MACHINE SHOP EL 107'-2"
40357
CONTAINMENT ACCESS CORRIDOR EL 107'-2"
40414
ELECTRICAL SWITCHGEAR ROOM #2
40413
ELECTRICAL SWITCHGEAR ROOM #1
40401
40410
COMPUTER ROOM B
40406
NRC ROOM
40405
MAIN TSC OPERATIONS AREA
40407
OFFICE
40409
COMPUTER ROOM A
OFFICE
40408
VII
CPS + AXC
VI
AXC + SCC
ELEV
40440
503
DEMINERALIZED WATER DEGASIFIER ROOM EL 120'-0"
ELEV. 117'-6"


HIGH RADIATION SOURCES
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
SAME AS ZONE V ABOVE
VERY HIGH RADIATION SOURCES
IN THE DESIGNATED AREA.
2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBRONE CLOUD SOURCES.
E. NOTES:
1. MAIN CONTROL ROOM IS ADEQUATELY SHIELDED FROM POST-LOCA CONTAINED AND AIRBORNE SOURCES TO MEET 10CFR50 APPENDIX A CRITERION 19 REQUIREMENTS.
ION ZONE NUMERAL AT POST-ACCIDENT PEAK
NT POST-ACCIDENT RADIATION SOURCE(S)
DIOACTIVE AREA BOUNDARY
CTIVE AREA BOUNDARY
AREA BOUNDARY
ON ZONE BOUNDARY
CCIDENT ACCESS ROUTE
VII
CPS + RAC
SPENT FUEL STORAGE PIT
FUEL TRANSFER CANAL
MIDDLE ANNULUS
12356
REFUELING WATER STORAGE TANK
11403
LOWER PRZ. COMPARTMENT
11401
SG 1 TUBESHEET AREA
REFUELING CAVITY
REFUELING CAVITY
IX
UCC
CABLE AREA
ELEV
505
NEW FUEL STO. RACKS
IX
PAS + RAC
ELEV. 107'-2"
MAINTENACE FLOOR MEZZANINE
11402
SG 2 TUBESHEET AREA
CASK LOADING AND WASHDOWN PIT
EFFLUENT MONITOR TANK A
12465
12454
RAD. PIPE CHASE
VI
CPS + NRA
ELEC. PENET. ROOM DIVISION 4
VII
RAC + SCC
RAIL CAR BAY
12462
RNS HX ROOM A
12463
RNS HX RM B
EFFLUENT MONITOR TANK B
12464
VII
CPS + RAC
KITCHEN OPER. AREA
12412
12401
ELEV. 117'-6"
12461
CORRIDOR
504
STAGING AREA
VFS PENETRATION ROOM
12452
12421
RCC/ NON 1E PENE ROOM
ELEV. 117'-6"
12423
12422
CORRIDOR
12411
501
REACTOR TRIP SWGR. I
REACTOR TRIP SWGR. II
40450
502
STAIRS
VII
CPS + RAC
VIII
VI
VII
(SEE ELEV. BELOW)


VII
CPS + RAC
VII
RAC + CPS
IX
CPS + RAC
IX
UCC
VI
CPS + NRA
VII
CPS + NRA
VI
CPS + NRA
ELEV. 135'-3"
ELEV. 135'-3"
ELEV. 135'-3"
IX
CPS + AXC
VIII
CPS + AXC
IX
CPS + RAC
VII
AXC + SCC
VII
AXC + SCC
VI
AXC + SCC
ELEV. 135'-3"
VII
AXC + SCC
EL 150'-0"

IN THE DESIGNATED AREA.

2. INCLUDES CONTRIBUTIONS FROM POST-ACCIDENT CONTAINED AND AIRBRONE CLOUD SOURCES.



PASS PIPING SOURCE DESCRIPTION (PAS)

- Liquid source term based on Post-Accident core release activity distributed uniformly throughout the reactor coolant system volume 7,354 ft^3

- Liquid activity model is same as time dependent release model for containment previously discussed and includes

  - 100% Noble gases
    55% Iodine
    48% Cesium
    11% Tellurium
    0.4% Sr, Ba, Ru
    0.004% Others

  (Ref: AP600 Radiation Analysis Design Manual Section 5.2 and Tables 5-5 to 5-10)

- Liquid sample dose rates are not additive to building airborne since same activity source

- Containment atmosphere sample activity same as containment airborne activity previously discussed

- Sample pipes located in a single Auxiliary Building pipe chase.

  - 3/8" liquid sample inlet pipe

  - 3/8" containment atmosphere sample inlet pipe

  - 1" sample return pipe

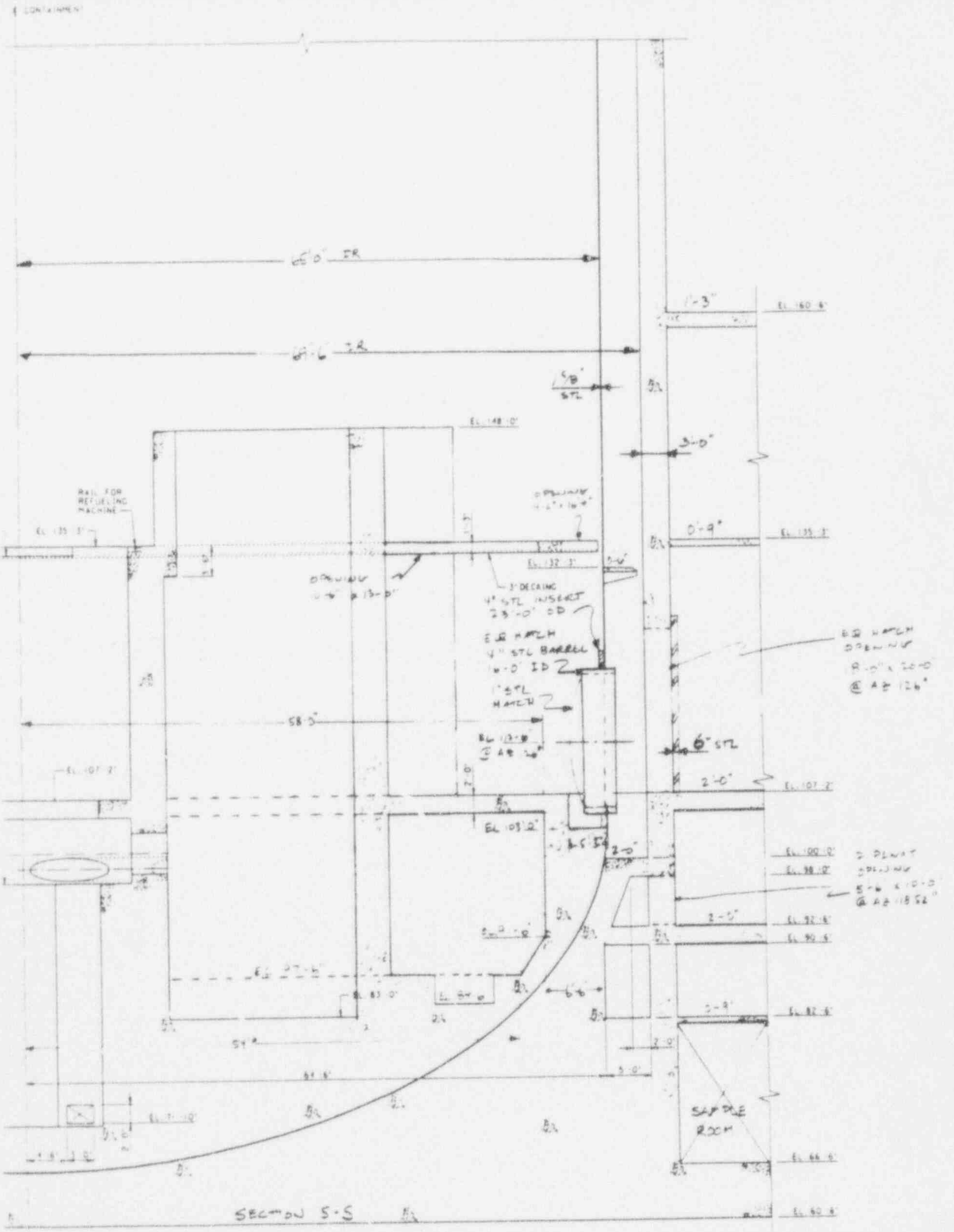
AP600

- **Post-Accident Sample Station Shielding from Containment Source**

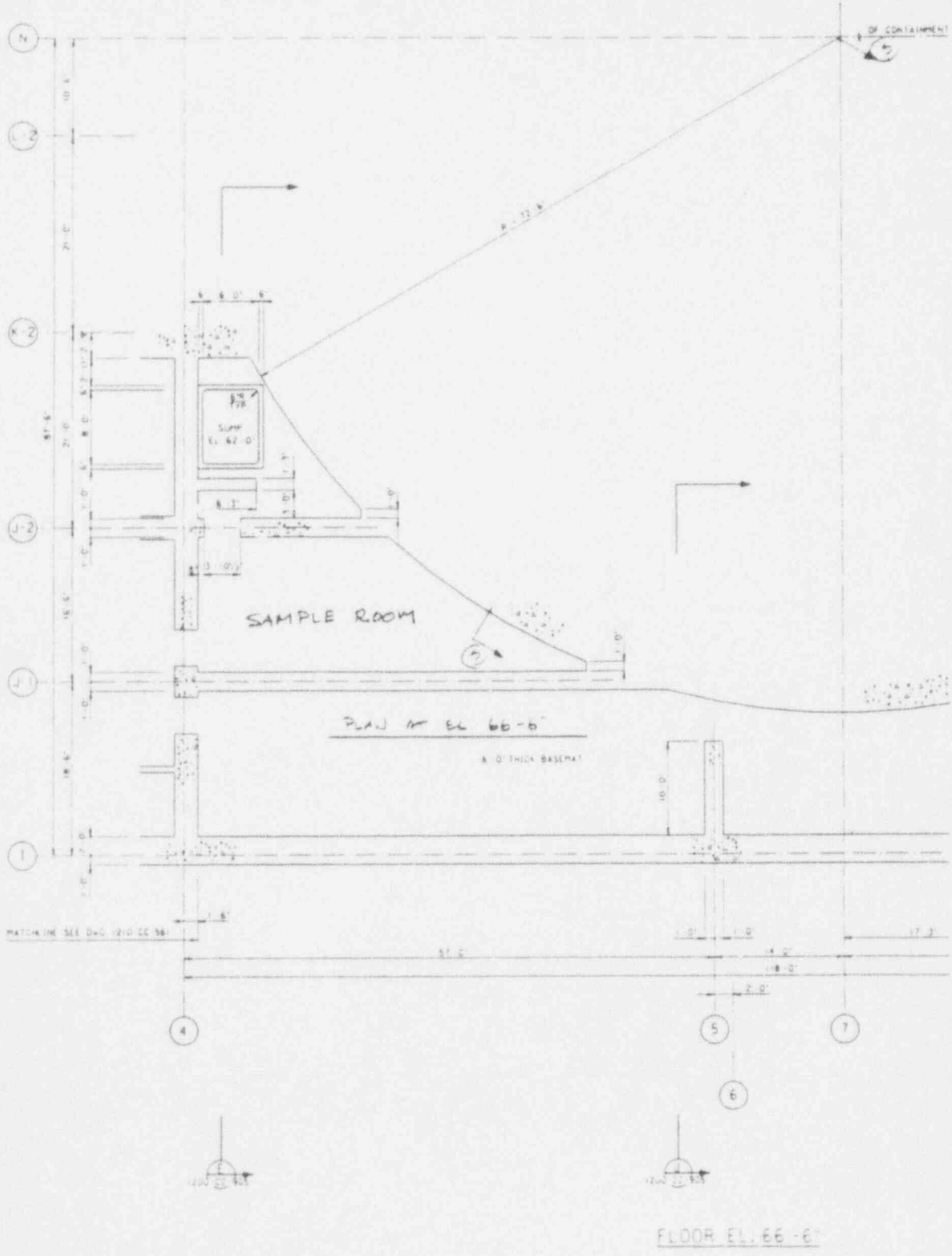
CONTAINMENT SHIELDING TO PASS ROOM

- **Major Containment Shields**
  - 1-5/8" containment steel liner (ID = 65'-0")
  - 3'-0" containment shield building wall (ID = 69'-6")
  - containment concrete fill to El. 107'-2"
  - containment shield building concrete fill to El. 82'-6"
  - equipment hatch 6" steel door shielding
- **Major Auxiliary Building Shields**
  - 2'-0" concrete floor slab El. 107'-2"
  - 2'-0" concrete floor slab El. 92'-6"
  - 0'-9" concrete floor slab El. 82'-6"

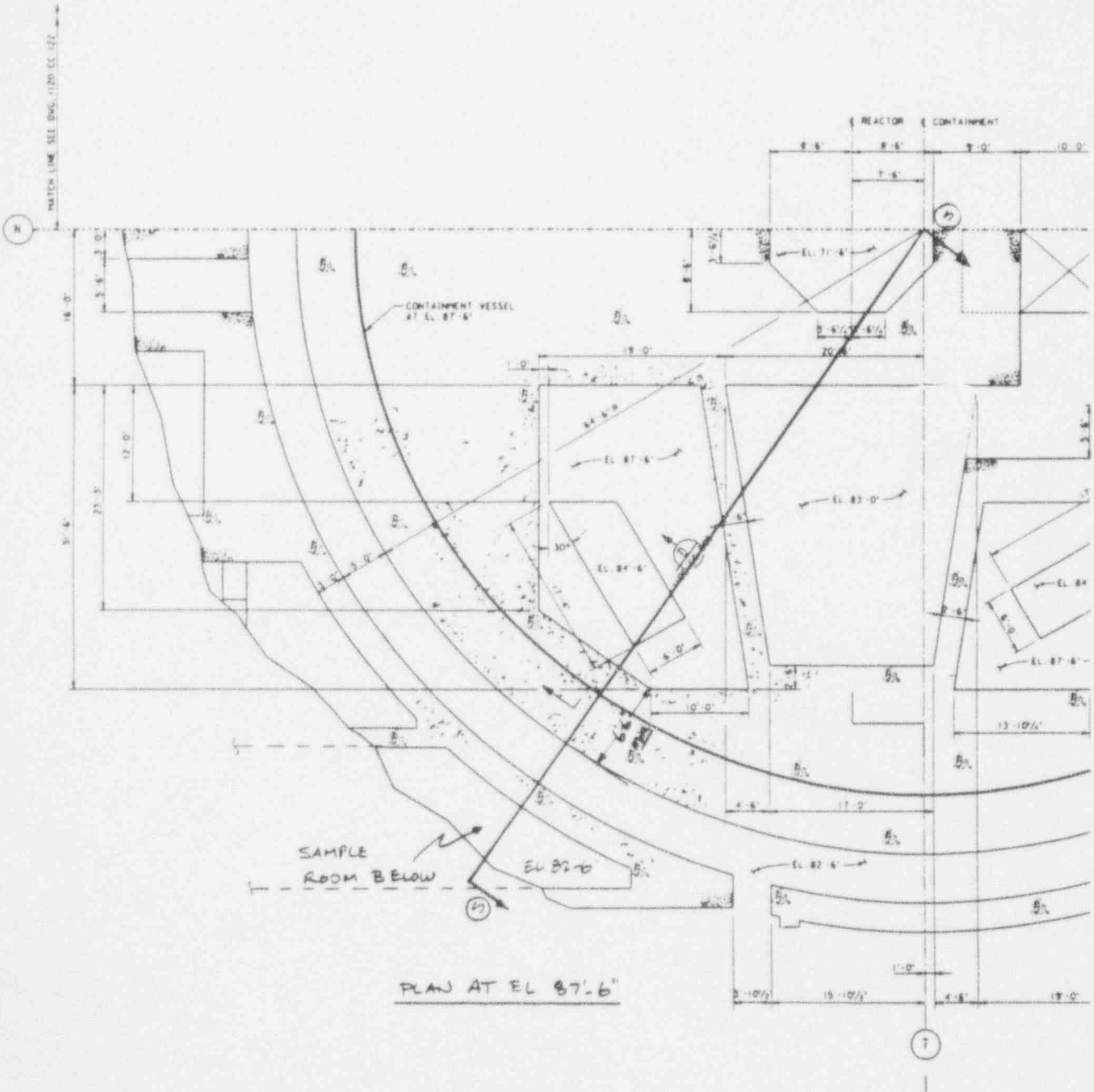
CONTAINMENT-PASS ROOM SHIELD SECTION



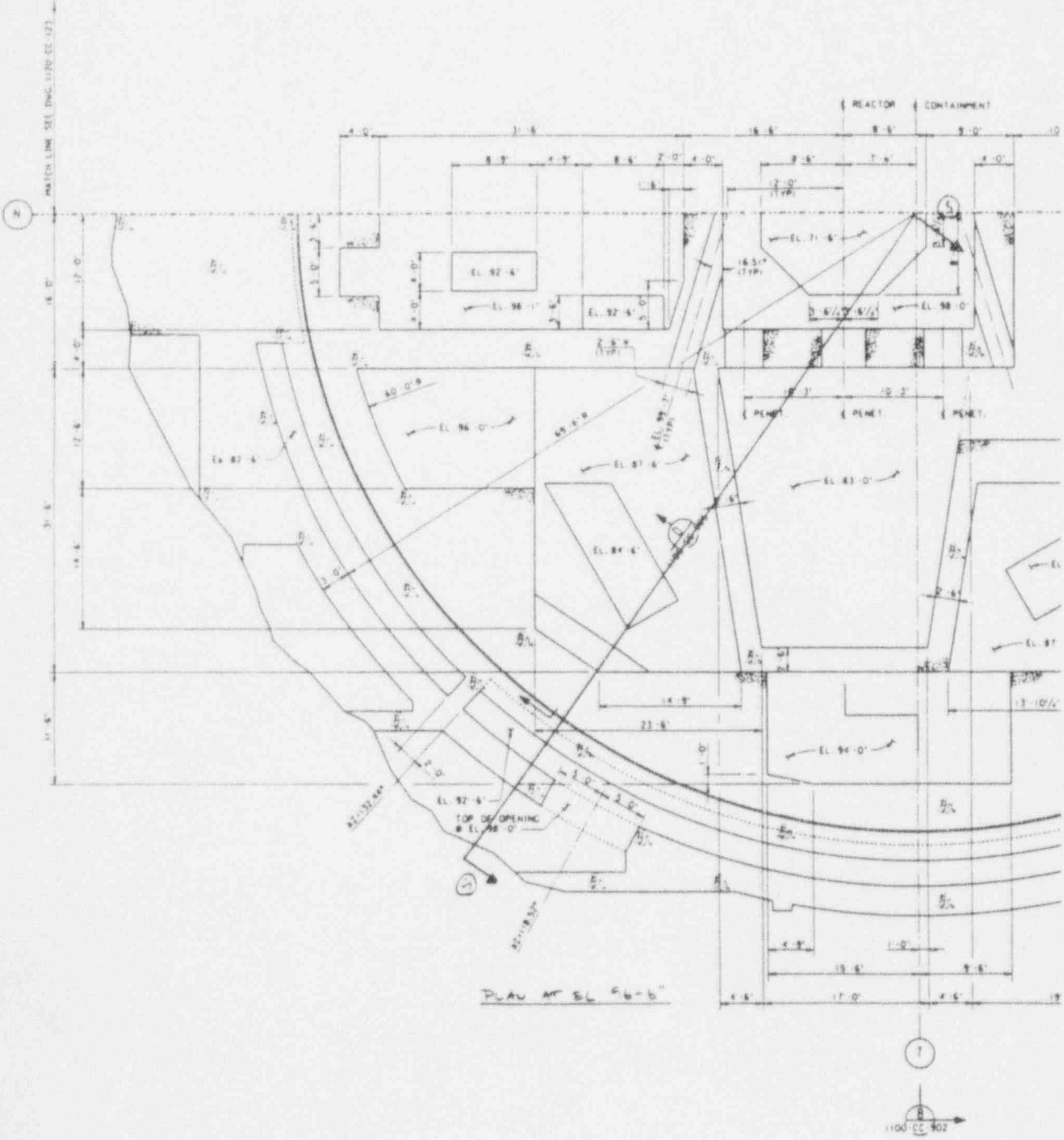
CONTAINMENT-PASS ROOM SHIELDING-66'-6"



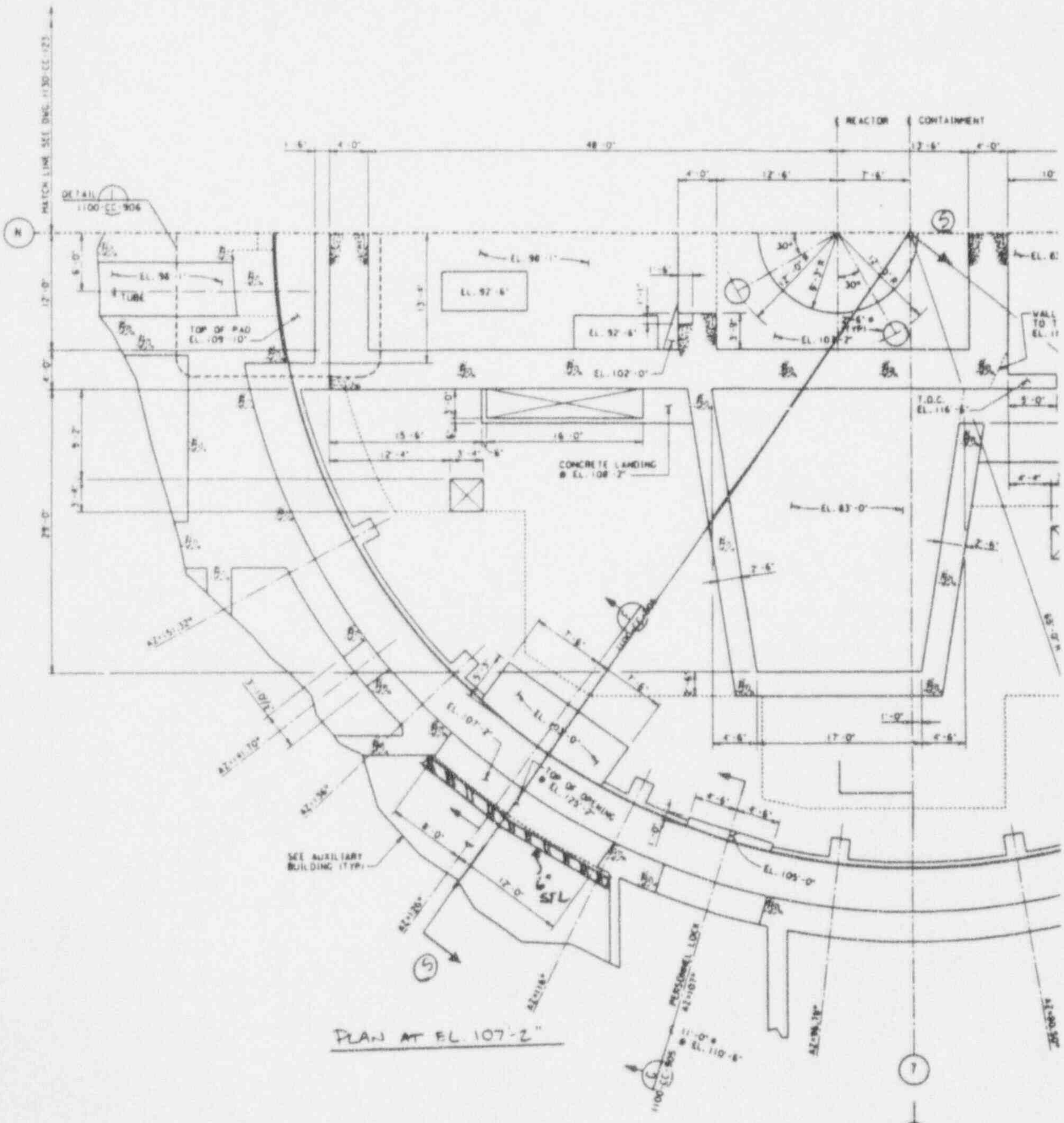
CONTAINMENT-PASS ROOM SHIELDING-87'-6"



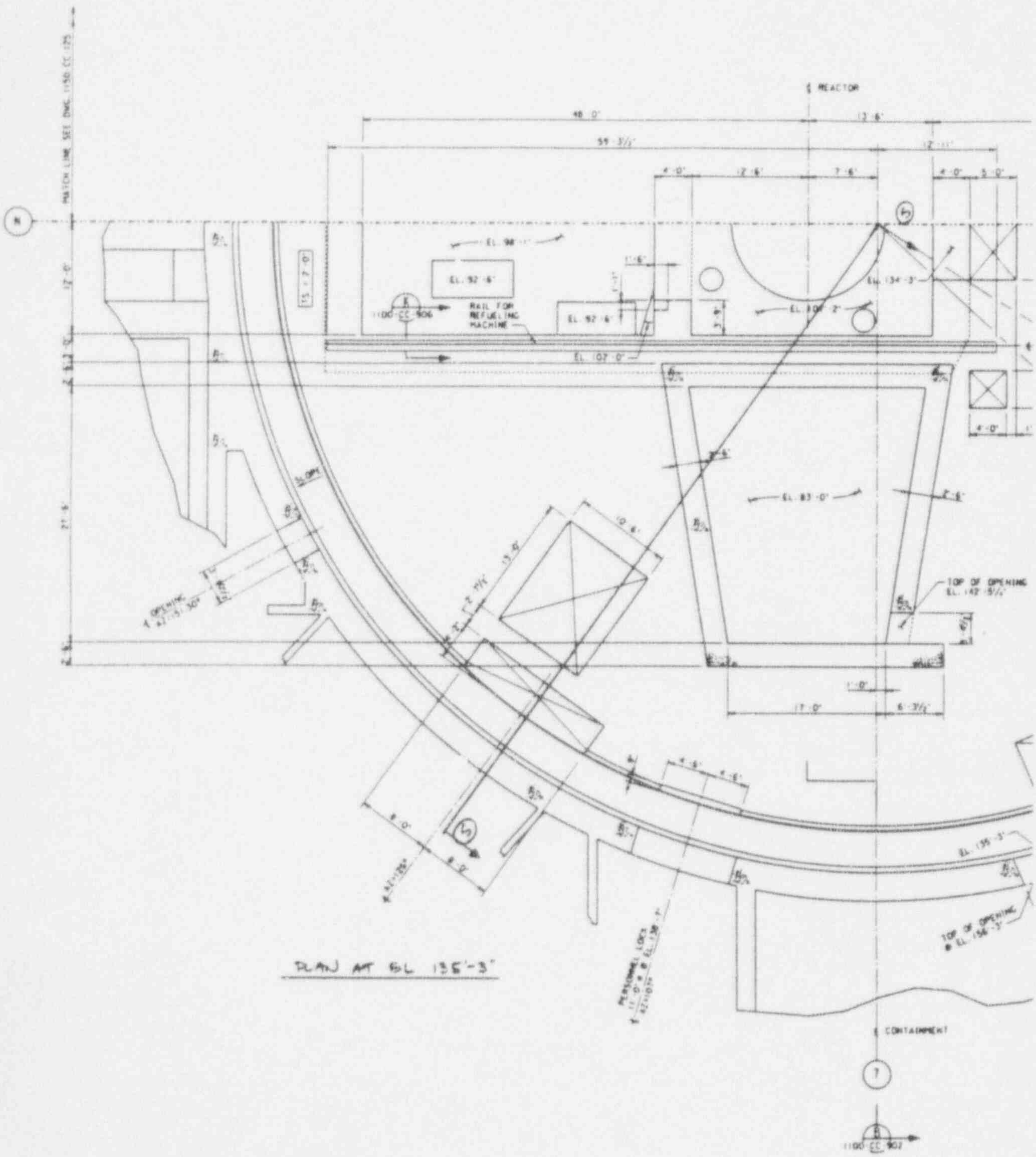
CONTAINMENT-PASS ROOM SHIELDING-96'-6"



CONTAINMENT-PASS ROOM SHIELDING-107'-2"



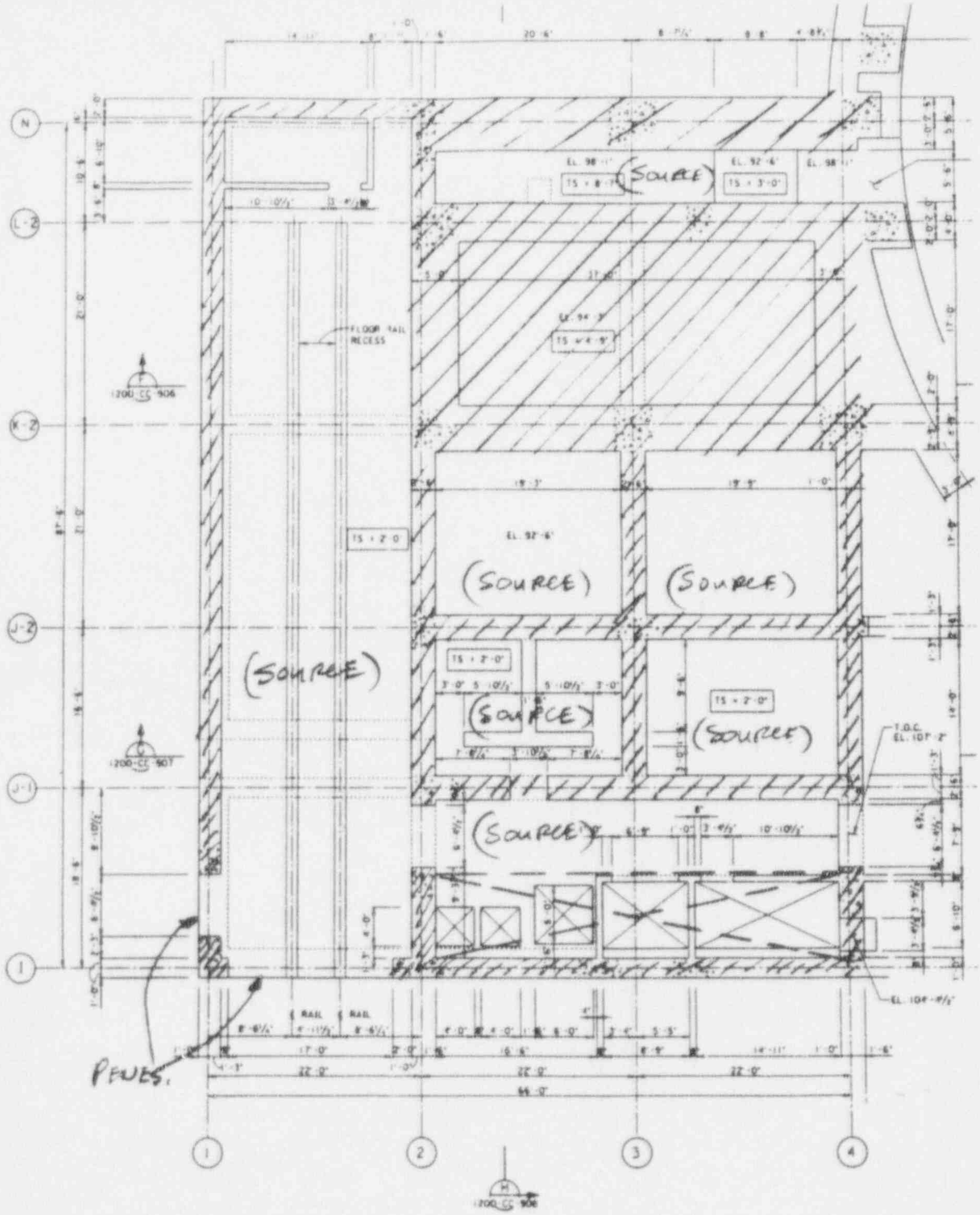
CONTAINMENT-PASS ROOM SHIELDING-135'-3"



Radiologically Controlled Areas of Auxiliary Building (RAC)

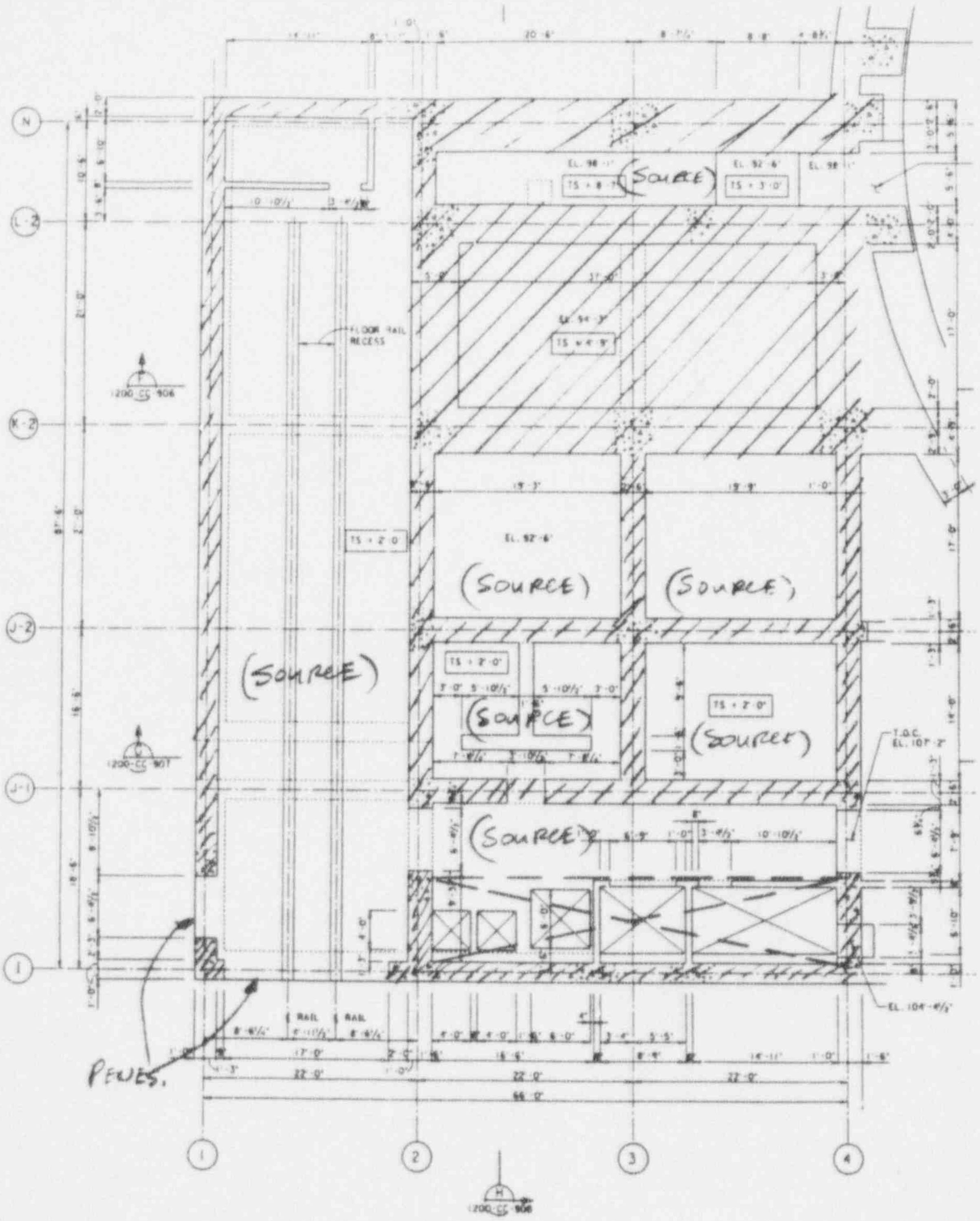
- **Building Cloud Sources**
  - Airborne sources uniformly distributed in the entire air volumes for auxiliary buildings and each air volume for Annex building HVAC regions
  - Location of building cloud boundaries shown on SAR Figures for Post-Accident Zoning
  - Room size clouds used for access areas and routes. (Internal building structural walls and slabs around vital access areas included in model)
- **Dose Point Locations**
  - Representative room dose rates at center at 3' from floor
- **Cumulative Dose Rates**
  - Building dose rates summed where appropriate with penetrations contributions from adjacent buildings (e.g. containment penetrations to auxiliary and annex buildings)
  - Peak dose rates at any Post-Accident time are then used to determine Zoning for each area.
- **Auxiliary Building Modeled as Air Filled Box with Internal Concrete Walls and Slabs**
  - Floor and wall openings modeled as air filled bodies

TYPICAL RAC SOURCE-SHIELD GEOMETRY



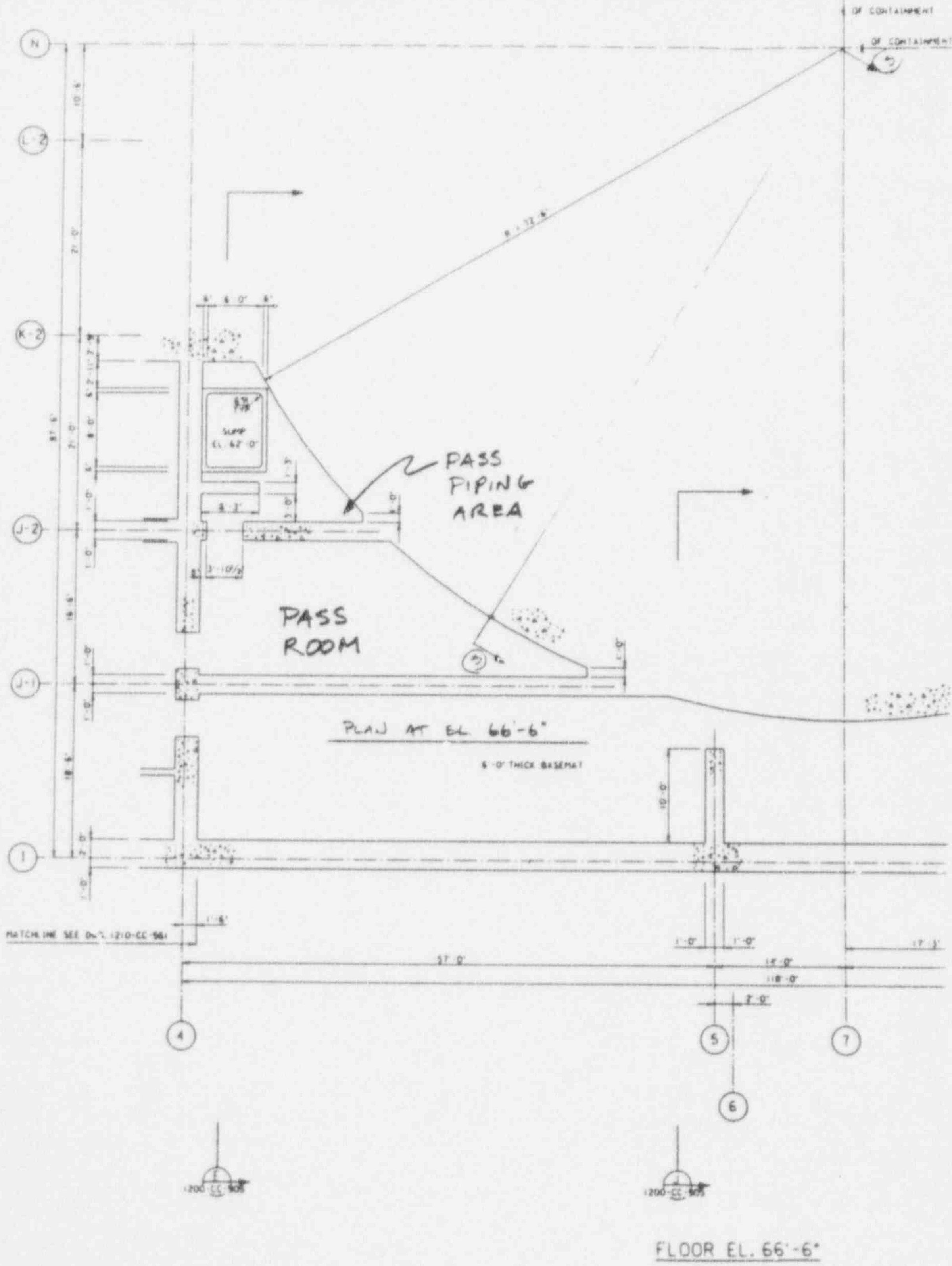
FLOOR EL. 100'-0"

TYPICAL RAC SOURCE-SHIELD GEOMETRY

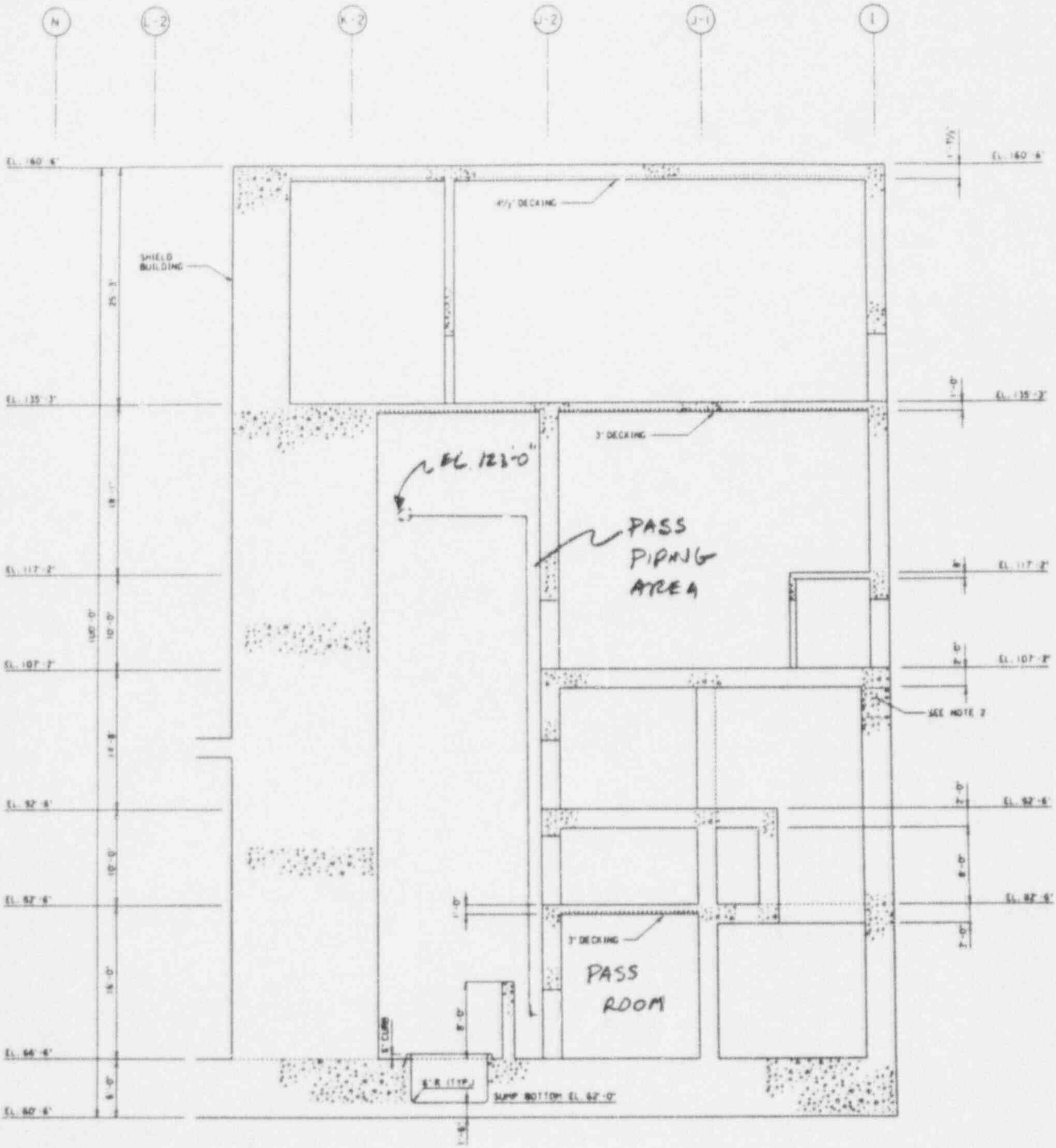


FLOOR EL. 100'-0"

PASS PIPING LOCATION - PLAN 66'-6"



PASS PIPING LOCATION - PIPEWAY SECTION

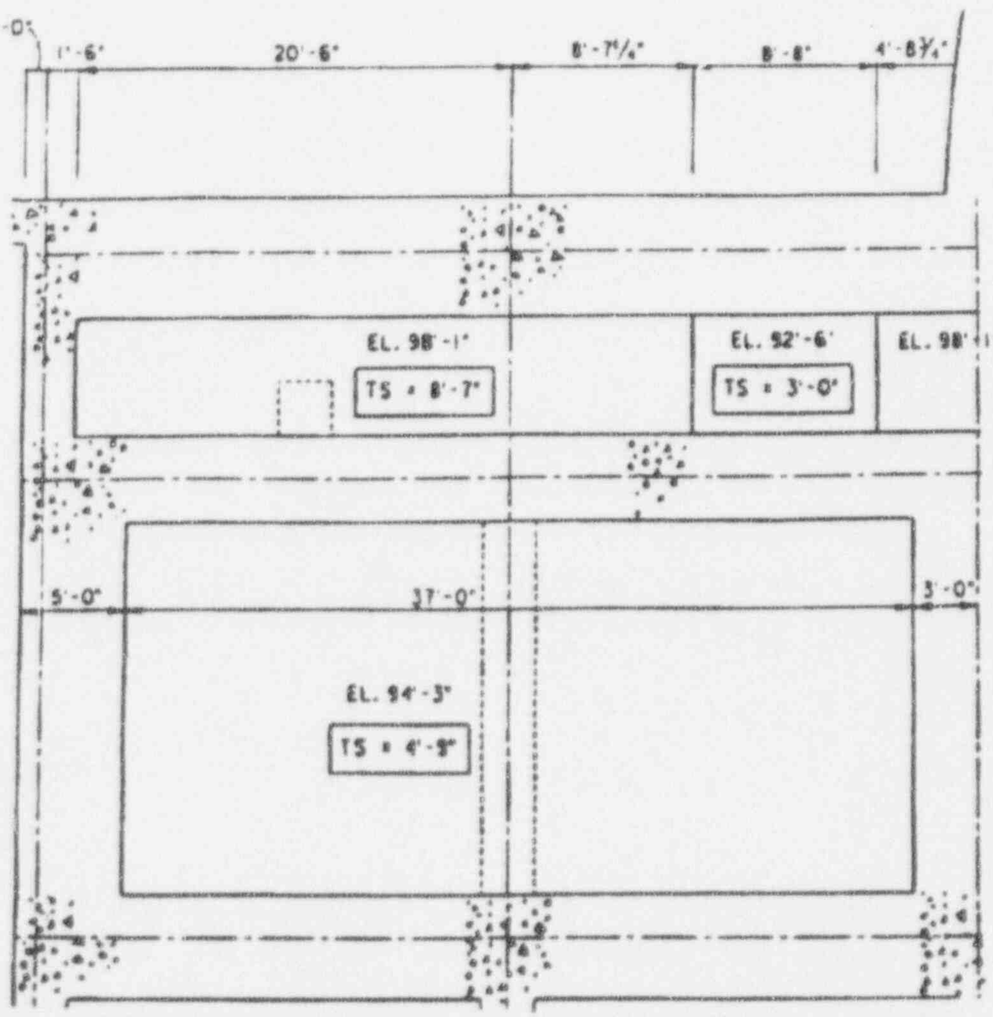


AP600

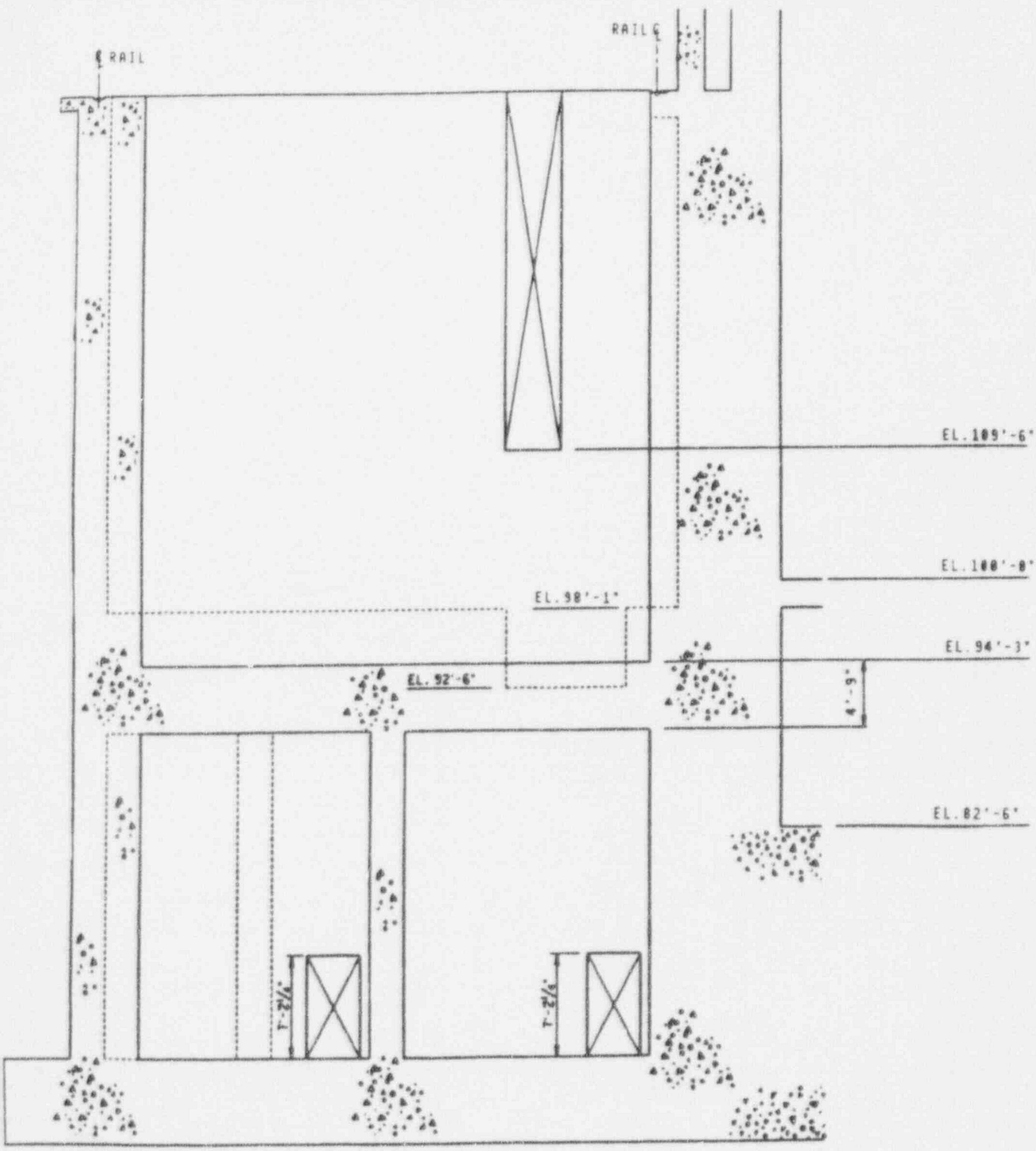
- **Fuel Transfer Canal Upender Shielding**

AP600

FUEL UPENDER AREA LAYOUT - PLAN



FUEL UPENDER AREA LAYOUT - SECTION



FUEL UPENDER SHIELDING PROVISIONS

- **Shielding Provisions For Upender Pit**
  - Concrete slab
    - 8'-7" thick at Elev. 98'-1"
    - 3'-0" below upender pit at Elev. 92'-6"
  - In horizontal fuel position, (fuel carriage Elev. 100'-5 3/4")
    - Water ≈7'-4"at 1.0 g/cc
  - In vertical fuel position, active fuel region ≈22.9" from top of upender pit slab
    - Fuel plenum 9.7" at 1.8 g/cc
    - Bottom nozzle 3.2" at 2.7 g/cc
    - Water 10" at 1.0 g/cc

FUEL UPENDER SHIELDING EVALUATION

- WLS Pump room at Elev 82'-6" below upender pit is designated Zone V (< 1000 mR/hr) due to normal WLS piping sources

- 3'-0" concrete slab in upender pit reduces spent fuel radiation levels at roof elevation to 90-100 mR/hr with two fuel assemblies in vertical position

- Zoning drawings annotated to indicate WLS pump room has Zone IV (< 100 mR/hr) contribution from spent fuel in vertical position in upender above

- WLS Pump room access control provisons include a barricade (e.g. rope, chain, etc.)