UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 1 8 1978

MEMORANDUM FOR: W. Houston, Chief, Accident Analysis Branch, DSE
G. Knighton, Chief, Environmental Evaluation Branch, DOR

THRU: Don K. Davis, Chief, Systematic Evaluation Program Branch, DOR

FROM: Herbert M. Fontecilla, Nuclear Engineer, Systematic Evaluation Program Branch, DOR

SUBJECT: CALCULATION OF TARGET AREA FOR AIRCRAFT IMPACT

I have recently prepared a detailed explanation of how to calculate the target area of a facility for use in aircraft crash probability analysis. This was done for possible use in the Three Mile Island 2 Appeals Board Hearings. A copy is attached for your information.

Herbert M. Fontecilla, Nuclear Eng.
Systematic Evaluation Program Branch
Division of Operating Reactors

cc: D. G. Eisenhut
V. Stello
B. Grimes
R. Vollmer
E. Adensam
L. Barrett
L. Soffer
G. Chipman

CALCULATION OF TARGET AREA FOR AIRCRAFT IMPACT

An aircraft approaching a structure is exposed to a horizontal or ground area referred to as the "target area." This target area may include the physical ground area covered by the structure plus a "shadow area" as illustrated in Figure 1.

The magnitude of the shadow area is a function of the approach or impact angle, α , as shown in Figure 2. Accordingly, an aircraft approaching in a vertical direction will see no shadow area; while for very shallow angles the shadow area will be much larger than the actual area covered by the structure.

A main effect of the impact angle is the "shadowing" of one structure by another, as illustrated in Figure 3. In this example, the smaller building on the right does not contribute to the total target area.

This shadowing effect is particularly important when non-safety buildings (i.e., not contributing to the target area) shadow safety buildings. This is illustrated in Figures 4 and 5. In the former, the effective target area of a safety building is substantially reduced by the shadowing of a non-safety building. In the latter, a non-safety building totally shadows a safety building making its effective target area equal to zero.

As an example, Figure 6 shows a plan of the main buildings of the Three Mile Island Unit 2 plant. Figure 7 through 10 show the target areas for these buildings as seen by an aircraft approaching from four different directions at an angle of 45°.[1] Of particular interest is the shadowing (e.g., protection) offered by the turbine building and the Unit 1 buildings for aircraft approaching from the South and North directions, respectively.

The variation of the target area with impact angle for the Three Mile Island Unit 2 plant is illustrated in Figure 11.

---

(1)Only head-on impacts have been considered. As a result, the edges of the containment building have been excluded.

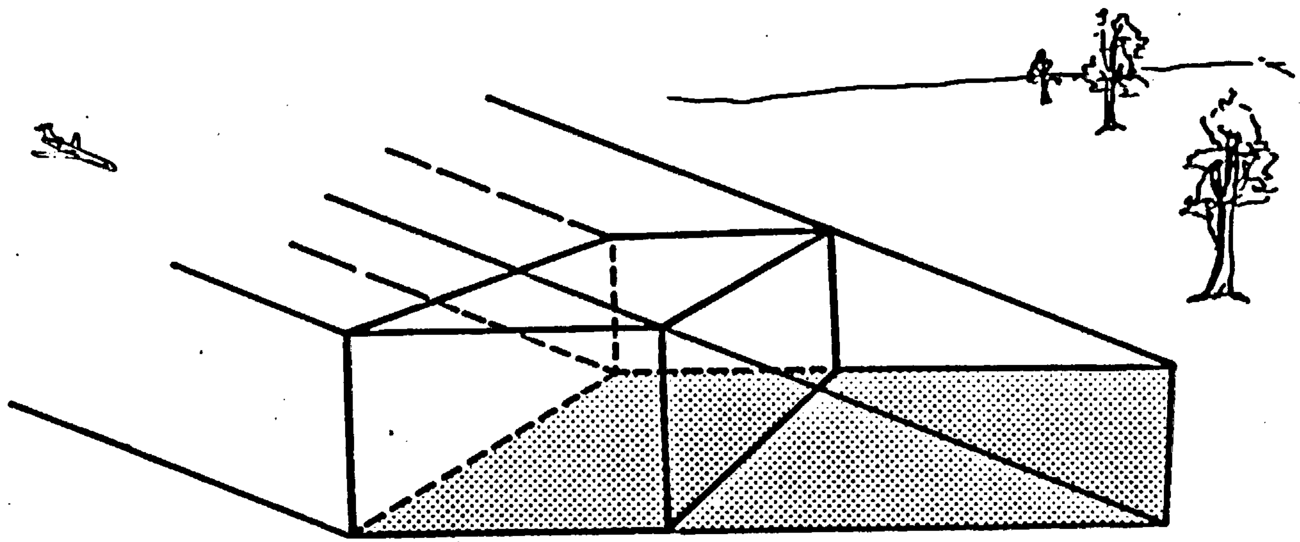
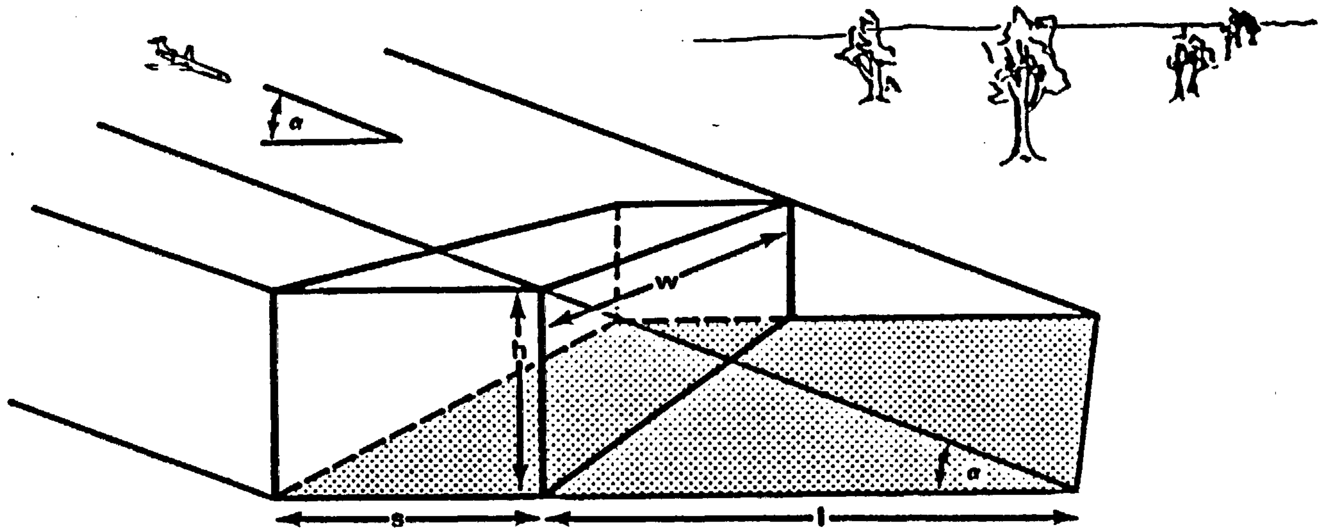


Figure 1. Impact Area



$l = h/\tan \alpha$

Impact Area = $s \cdot w + w \cdot l$

Figure 2. Calculation of Impact Area

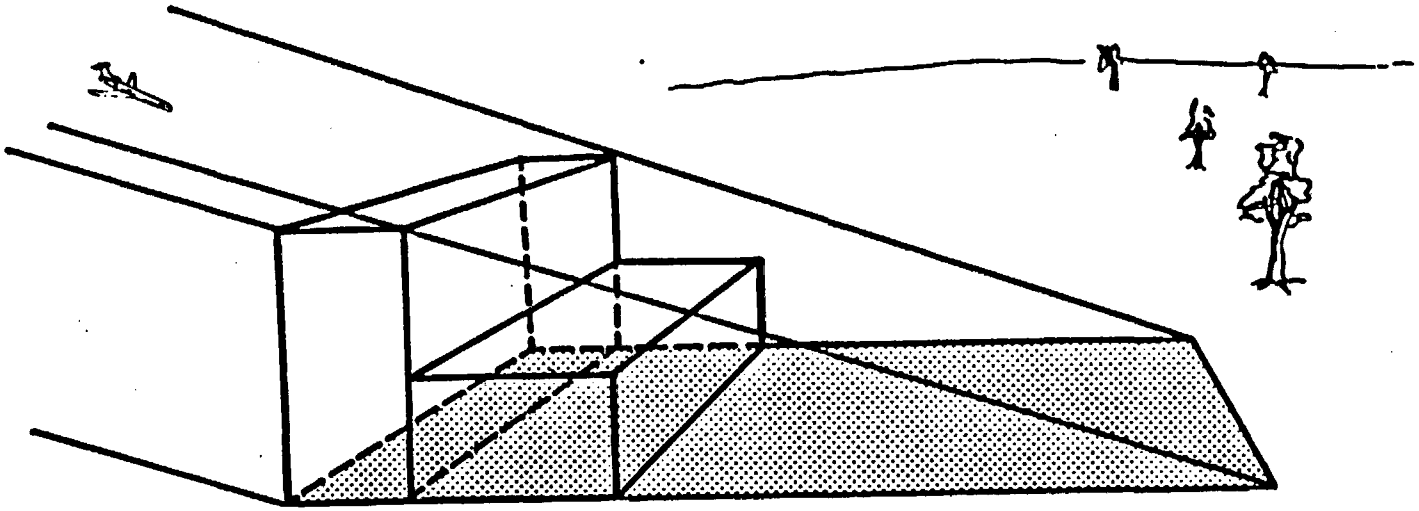


Figure 3. Shadowing Effect

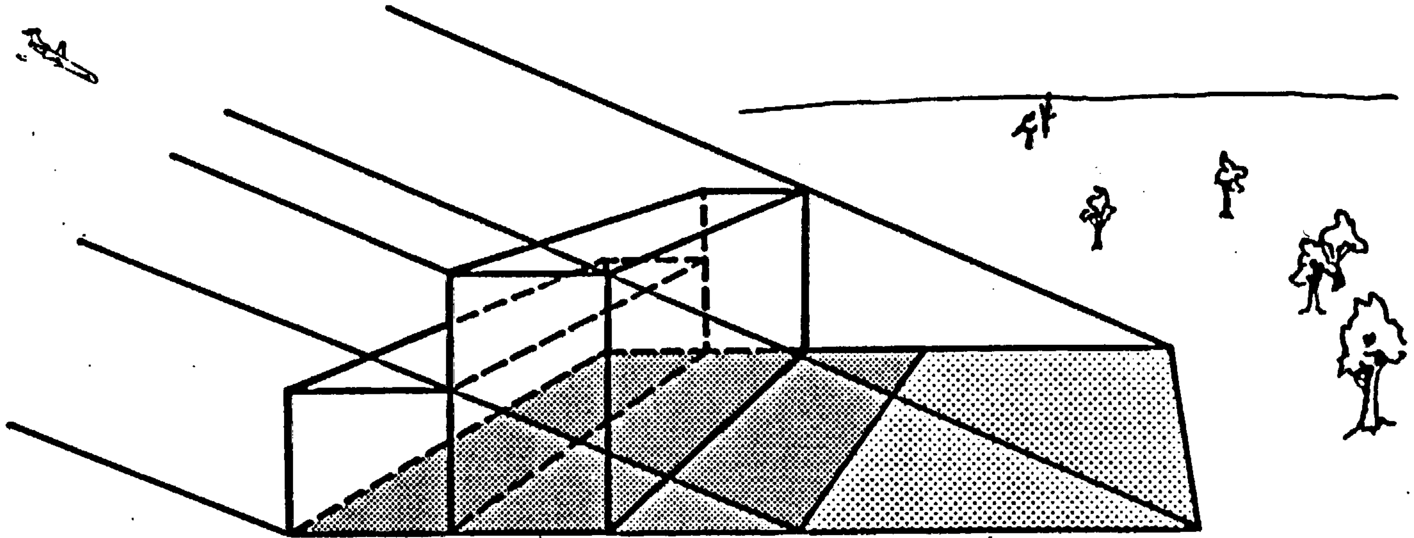


Figure 4. Shadowing of Safety Building by Non-Safety Building

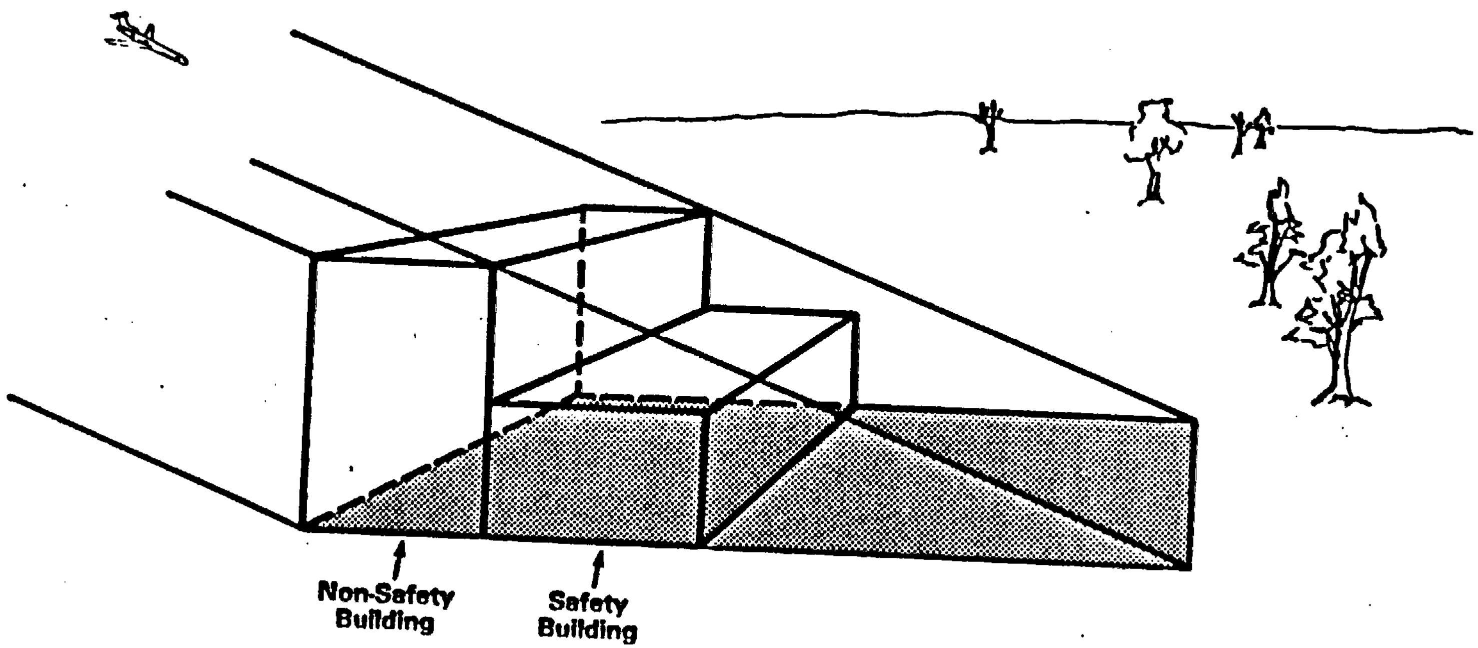


Figure 5. Shadowing of Safety Building by Non-Safety Building

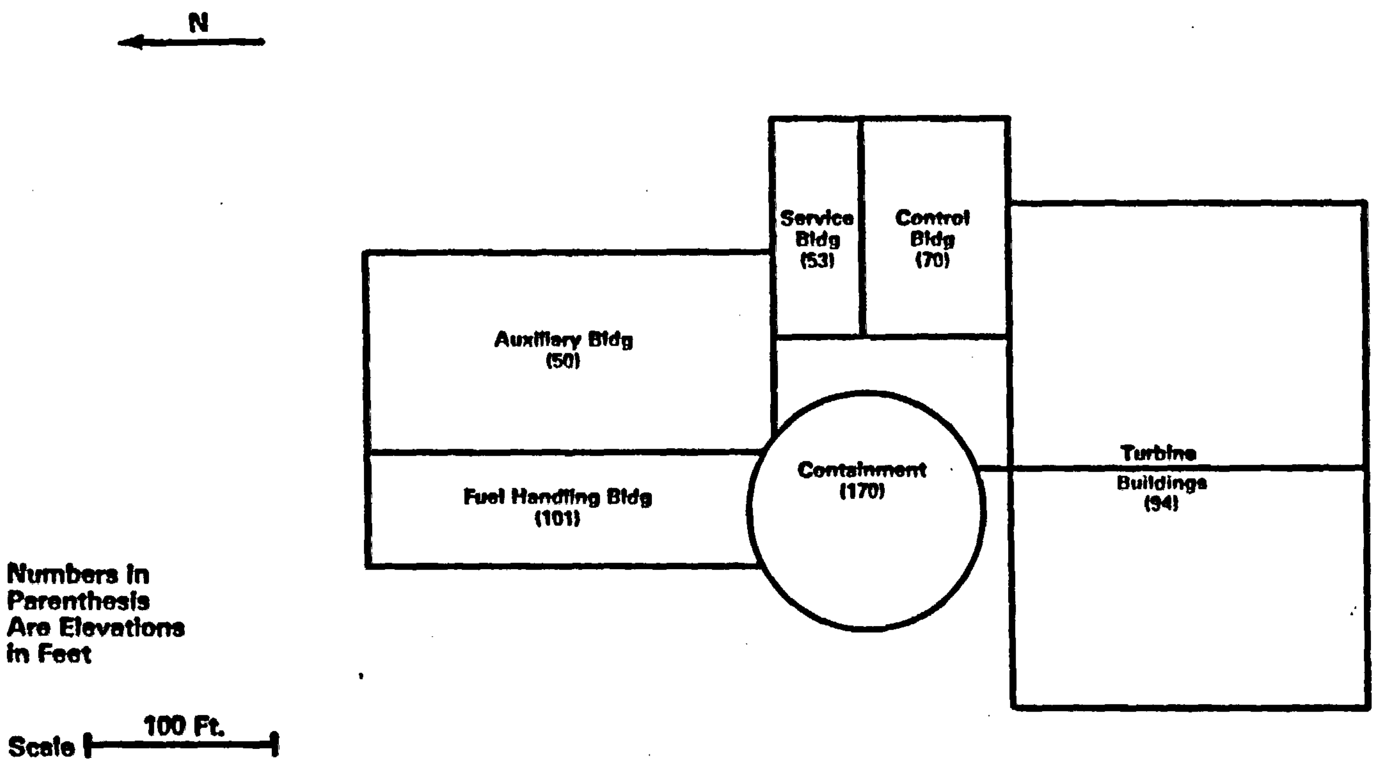


Figure 6. Three Mile Island 2

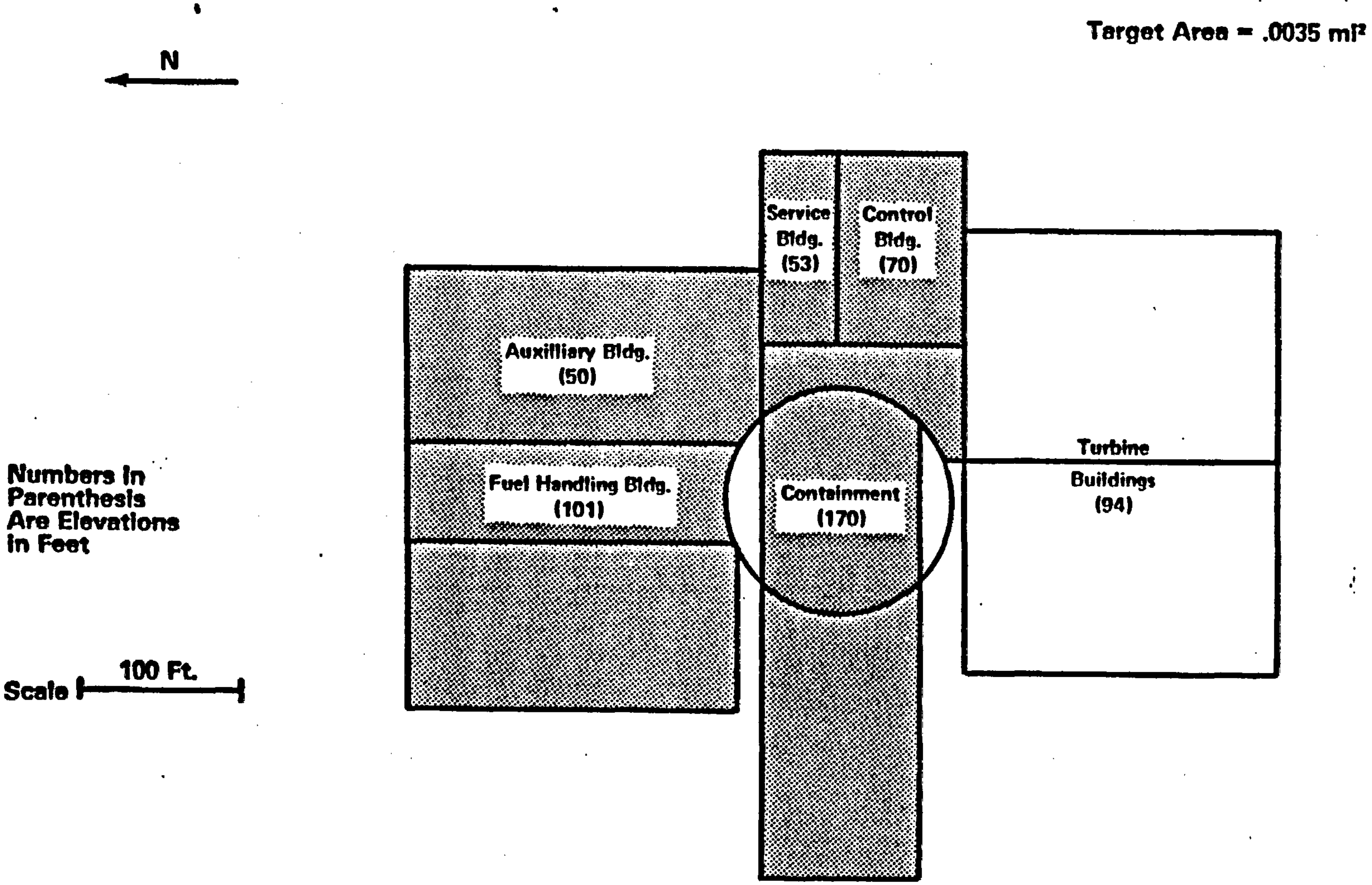


Figure 7. Three Mile Island 2 Target Area for Aircraft Approaching from the East at 45°

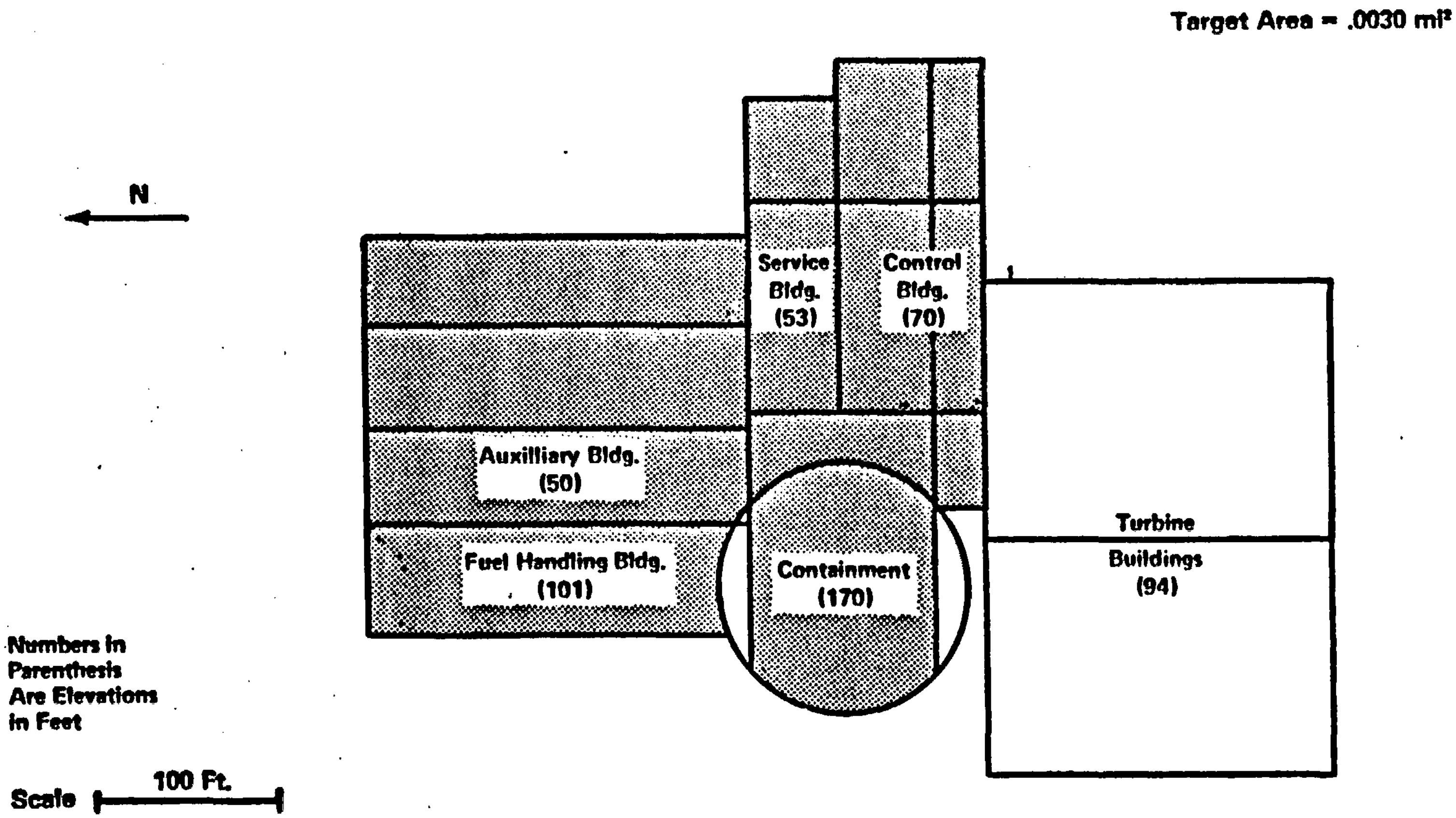


Figure 8. Three Mile Island 2 Target Area for Aircraft Approaching from the West at 45°

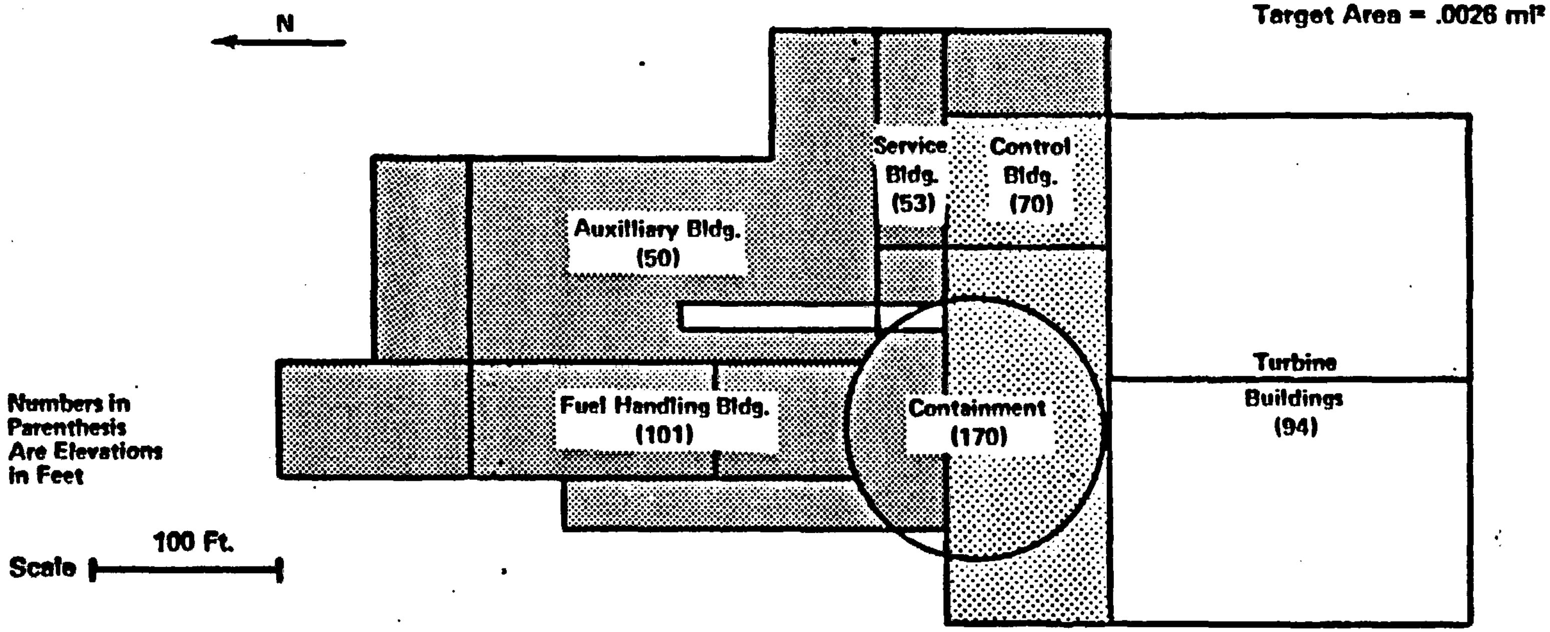


Figure 9. Three Mile Island 2 Target Area for Aircraft Approaching from the South at 45°

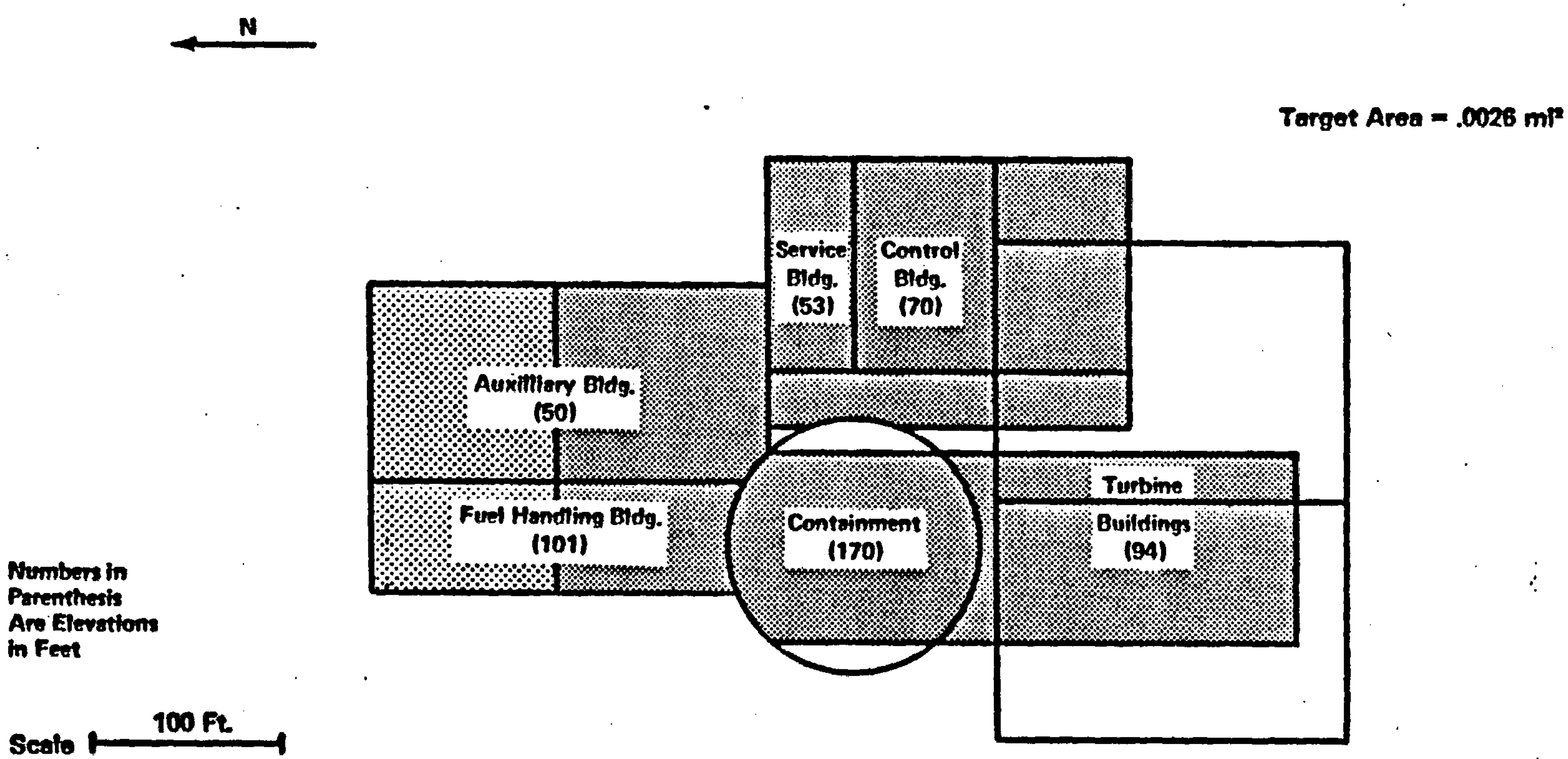


Figure 10. Three Mile Island 2 Target Area for Aircraft Approaching from the North at 45°

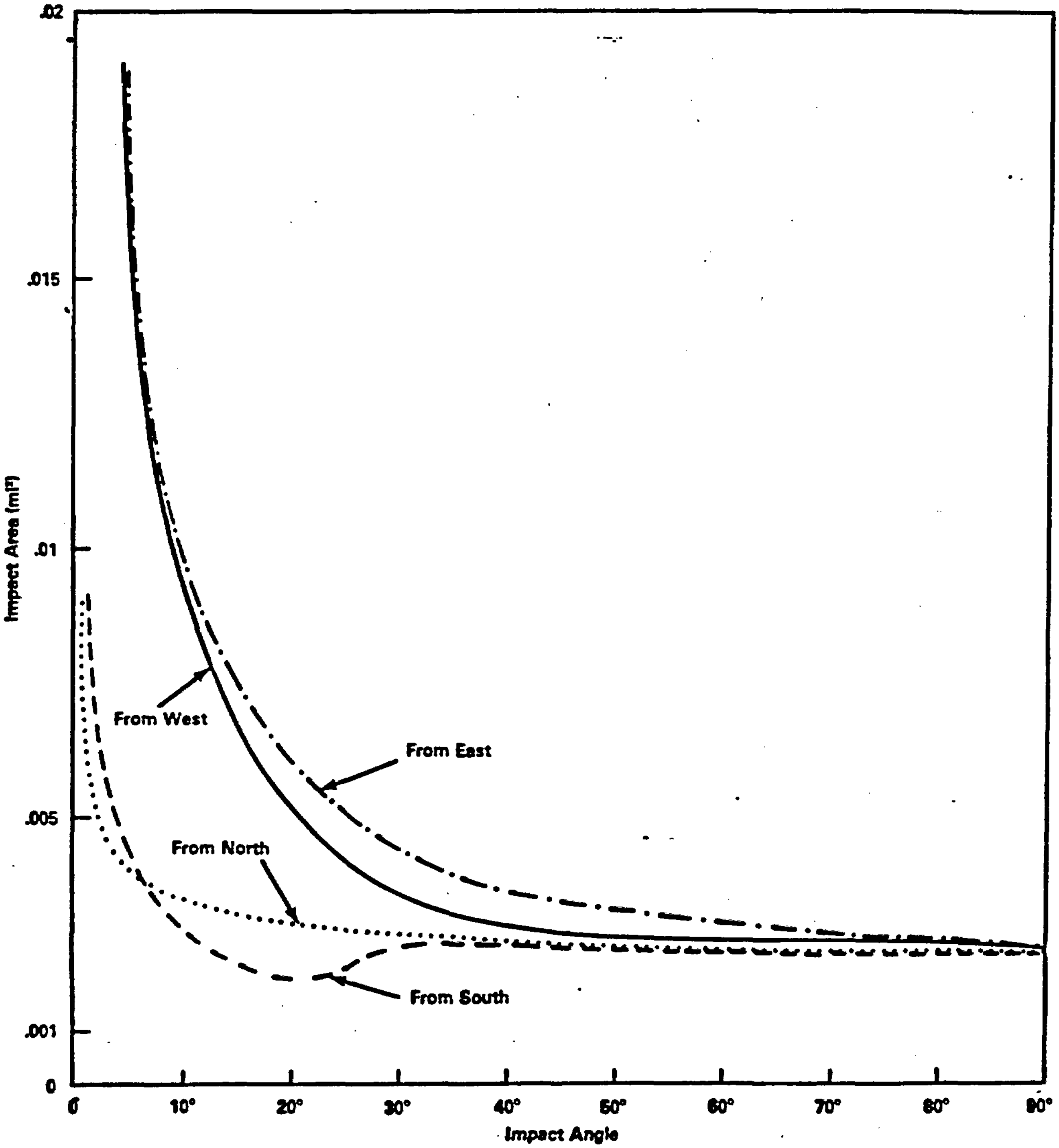


Figure 11. Aircraft Target Area for Three Mile Island 2

SUNDESERT   PSAR- March 1977

2.2 NEARBY INDUSTRIAL, TRANSPORTATION, AND MILITARY FACILITIES

Nearby industrial, transportation, and military facilities are described in detail in Section 2.2 of Appendix A which is the Early Site Review Report. The following sections provide updated information regarding nearby industrial, transportation, and military facilities. This information consists of a change in Department of Defense (DOD) policy regarding the separation of low-level, high-speed training routes and nuclear power plants, a discussion of a standard instrument departure (SID) from the Marine Corps Air Station (MCAS) at Yuma, and potential changes in the Blythe Airport activities.

2.2.1 Locations and Routes

Current locations of low-level routes are described in PSAR Appendix 2.2A. At the time the ESRR was prepared, DOD policy required a five-nautical mile separation between the centerline of a low-level, high-seppd training route for miliary jet aircraft and a nuclear power plant. Since that time, the DOD policy has been changed to require that low-level, high-speed military training routes shall be located such that nuclear power plants will be beyond the route perimeter. Current route perimeters and the effect of this change in DOD policy are evaluated in PSAR Appendix 2.2A. PSAR Appendix 2.2A reevaluates the probability of low-level aircraft impacting the Sundesert plant. About 2,100 flights currently pass within 10 miles of the site each year.

A standard instrument departure (SID) from MCAS Yuma is used by aircraft proceeding to training areas generally north of Blythe. Depending on the type of training exercise, such aircraft may carry live ordnance along the "CARGO-1" SID. This route from the Marine Corps Air Station currently passes over, or within one mile of, the site. The Applicant has met with the FAA and the Navy Department to discuss relocation of the SID. SDG&E has been informed that the SID will be changed in 1977 and that the change is currently being processed by the appropriate agencies. The new SID will be designated "KOCH-1," and as shown on Fig. 2.2.2-1, it passes about 8 nautical miles west of the site at its closest point. At this location there is sufficient separation such that activities along this route would not present a hazard to the plant.

Additional information has also been obtained regarding the Tacan and Vortac holding patterns for MCAS Yuma. About 3,000 aircraft per year use these approaches. Portions of the holding patterns described in Appendix A, associated with these approaches, utilize air space near the proposed site area. Aircraft using this air space will not cause any hazard to the site, since they are at a high altitude. Also, this type of flight is not conducive to accidents, since the aircraft and pilots are not under stress.

A Military Operating Area (MOA) designated REFUGE currently is located about 12 miles south of the site. At the request of the Applicant, the FAA redefined the northern boundary of the MOA so that the operating area would not include air space above the site. The FAA responded (Ref. 1), indicating that the northern boundary of the MOA would be defined at a distance 12 nautical miles south of the site, as shown in Appendix A Fig. 2.2-3. The REFUGE MOA generally replaced area BRAVO which was discontinued. Military use of air space above the site is characteristic of that conducted in unrestricted air space.

2.2.2 Descriptions

See Appendix A, Section 2.2.2. Further information regarding low-level, high-speed training routes is provided in Appendix 2.2A.

At the present time, the "CARGO-1" SID passes over the site. It is estimated that an average of 1,400 aircraft utilize the SID annually. Most of these aircraft carry external stores of practice inert, or live ordnance. Information concerning all types and sizes of ordnance is provided in Reference 2.

Many flights originate at MCAS Yuma and use the SID while enroute to the Twenty-Nine Palms training area. Navigational procedures dictate that the centerline of the SID be flown whenever possible, although the normal deviation can vary up to 5 miles either side of centerline. The normal enroute altitudes in the area of the proposed site are between 18,000 to 24,000 ft (Ref. 2).

2.2.2.1 Description of Facilities

See Appendix A, Section 2.2.2.1

2.2.2.2 Description of Products and Materials

See Appendix A, Section 2.2.2.2

2.2.2.3 Pipelines

See Appendix A, Section 2.2.2.3

2.2.2.4 Waterways

See Appendix A, Section 2.2.2.4

2.2.2.5 Airports

See Appendix A Section 2.2.2.5. Blythe Airport personnel project that the total number of aircraft operations will reach 92,000 per year by 1995 and at the present time, the commercial pilot training operations are planned to be discontinued (Ref. 3).

2.2.2.6 Projections of Industrial Growth

See Appendix A, Section 2.2.2.6

2.2.3 Evaluation of Potential Accidents

Although the DOD policy requires that the low-level, high-speed routes will be moved so that the route perimeters are beyond the site, the Applicant conducted a probability study to establish that the risk to the plant from this activity is indeed low. The study, included as PSAR Appendix 2.2A, "Probability of a Military Aircraft in Low-Level Flight Impacting the Sundesert Plant," concluded the probability is less than 1.1×10^{-7} per year per unit that a fighter-type aircraft would impact the plant. Appendix 2.2A includes additional information on flight frequency and crash statistics for aircraft currently used on these routes. Appendix 2.2A replaces the ESRR Appendix 2.2B in its entirety.

The increased projected aircraft activity at the Blythe Airport does not exceed the number of operations allowed for a distance of 13 miles (the distance to the airport) by Regulatory Guide 1.70—8.

2.2.3.1 Determination of Design Basis Events

See Appendix A, Section 2.2.3.1.

2.2.3.2 Effects of Design Basis Events

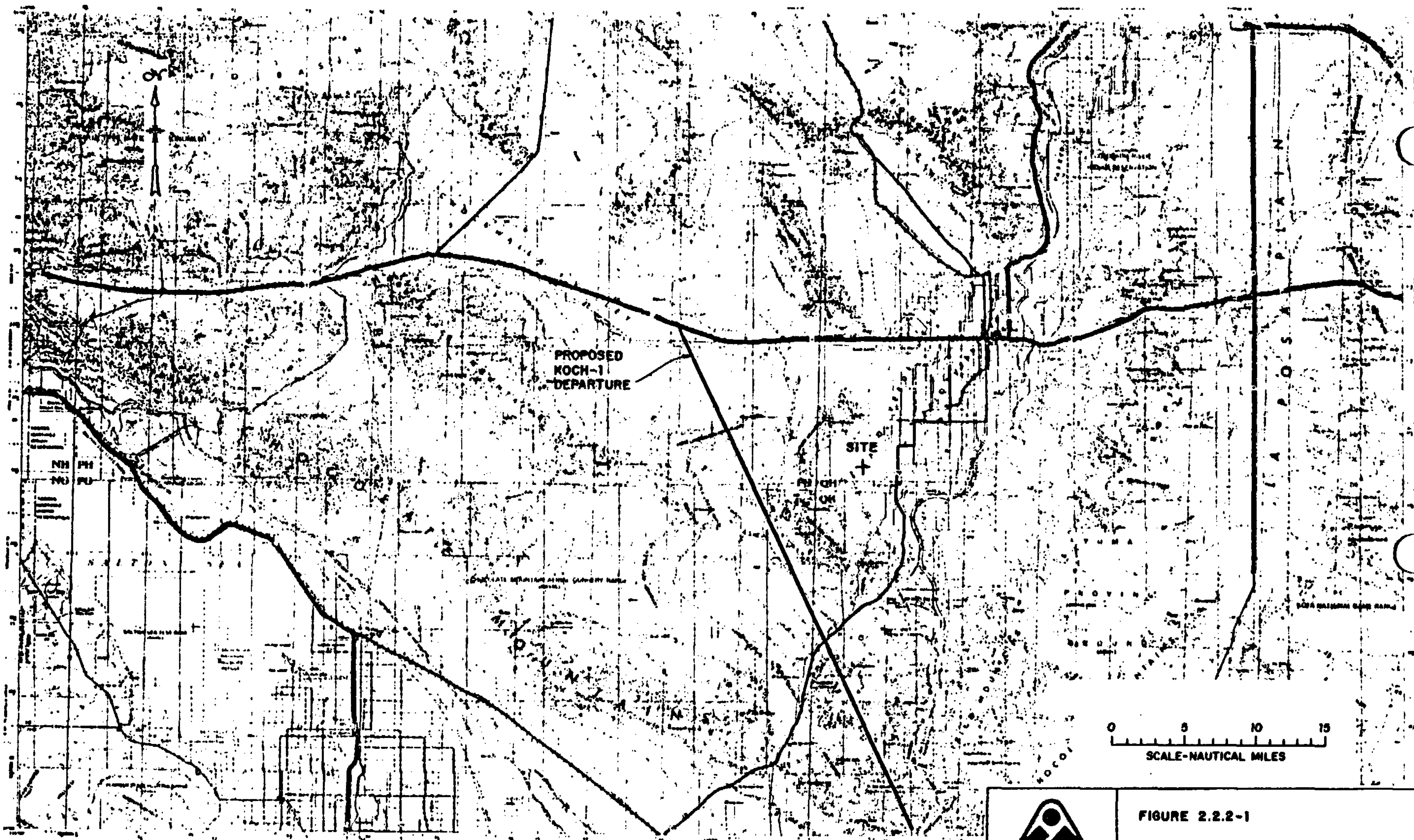
See Appendix A, Section 2.2.3.1.

2.2.4 References for Section 2.2

1. Letter from Chief, Aerospace and Procedures Branch, Air Traffic Division, Federal Aviation Administration, DOT, to SDG&E, October 20, 1975.

2. Letter from Commanding General, Marine Corps Air Bases, Western Area, to Pickard, Lowe, and Garrick, Inc., concerning air operations in the Yuma, Arizona - Blythe, California area, dated May 28, 1976.

3. Personal communication from Riverside County Airport Director, to Pickard, Lowe, and Garrick, Inc., November 25, 1976.



Sundesert Nuclear Plant
UNITS 1 & 2

FIGURE 2.2.2-1

PROPOSED KOCH-1 SID

PRELIMINARY SAFETY ANALYSIS REPORT

APPENDIX 2.2A

PROBABILITY OF A MILITARY AIRCRAFT IN LOW-LEVEL FLIGHT IMPACTING THE SUNDESERT PLANT

APPENDIX 2.2A

TABLE OF CONTENTS

APPENDIX 2.2A

LIST OF TABLES

APPENDIX 2.2A

LIST OF FIGURES

APPENDIX 2.2A

1.0 INTRODUCTION

This appendix presents an estimate of the probability that a military aircraft flying along a low-level training route would impact the proposed Sundesert plant. At present there are eight low-level, high-speed training routes within ten miles of the plant site (see Fig. 2.2A-1). Department of Defense policy (Ref. 1) requires that all routes be aligned so that the route perimeter is clear of nuclear power plants. Therefore, for this estimate it is assumed that the routes which presently have the plant site within their perimeters will be relocated such that the plant is at a distance from the route centerline equivalent to route width. Route width is defined as the distance on either side of centerline, and the perimeter is assumed to be at the edge of the route. The other routes in the area (see Table 2.2A-1) are assumed to remain at their present locations. Direction of flight is not important in this analysis.

The probability estimate developed in this appendix is based on estimates of the usage of these routes provided by the Air Force (Ref. 2), Navy (including Marine Corps) (Ref. 3), and Federal Aviation Administration, and on crash statistics which were obtained from the Air Force Inspection and Safety Center (Refs. 4, 9, 11) and the Naval Safety Center (Refs. 5, 12). The area of the proposed Sundesert plant which is considered to represent a "target" for aircraft impact includes all safety-related (Seismic Category I) buildings and equipment.

2.0 RESULTS

Based on current low-level military activity in the area, the estimated probability that a fighter or attack type aircraft flying on a low-level mission would impact the plant is less than 1.1×10^{-7} per year per unit. The probability that such an impact would cause an accident which would release radioactive materials resulting in offsite doses in excess of 10CFR100 guidelines is judged to be small. Therefore, the combined probability of an accident resulting from a military aircraft strike causing significant offsite consequences is well below 10^{-7} per year. Accident probabilities for the types of aircraft flown along routes near the site are based on statistics compiled for four years by the Air Force (world-wide) and for eight years by the Navy (world-wide). These statistics encompass more than eight million hours of flying time. Due to the difficulty in realistically evaluating certain factors used in the analysis, some degree of conservatism is inherent in the analysis as discussed below.

(1) The target area is overestimated primarily due to inclusion of buildings which are not Category I, due to not accounting for shielding of Category I areas by other structures.

(2) The lateral locations of accidents from route centerlines are conservatively based on available information from accident records, however, the pilot would have some control to avoid the plant in most cases.

(3) Future aircraft and personnel will have the advantage of more sophisticated equipment and training which should reduce pilot and equipment malfunction, thus lowering the accident rate compared with past experience.

(4) The accident rate used was based on the average over the past several years; however, in recent years there has been a continuing decline in the accident rate which is not reflected in these probabilistic studies for future operations.

3.0 ANALYTICAL MODEL

Aircraft activity in the site area falls in the category of "in-flight" since it is not associated with takeoff and landing operations near an airfield. Therefore, the appropriate model would be applicable to operations involving aircraft which are flying along a pre-designated low-level route. The model is shown pictorially in Fig. 2.2A-2. Since none of the flights will be directly over the plant area, the model assumes the plant is at a distance y perpendicular to the flight path x with an area $\Delta l \Delta w$. Diminishing likelihood of aircraft crash locations at increasing distances perpendicular to the route centerline is accounted for. The model is as follows:

$$P = \frac{R}{V} \Delta l \sum_{i=1}^{n} N_i D_i(y) \Delta w \qquad (1)$$

or

$$P = \frac{RA}{V} \sum_{i=1}^{n} N_i D_i(y) \qquad (2)$$

where:

P = mean annual probability of an aircraft impact (yr^{-1})

R = in-flight "low-level flight" accident rate (hr^{-1})

A = plant effective target area, $\Delta l \Delta w$ (NM^2)

V = assumed average velocity of aircraft in low-level flight (kts)

N_i = annual number of aircraft flights on route i (yr^{-1})

n = number of routes considered

and

$D_i(y)$ = probability density function per unit of perpendicular distance (y) from route i (NM^{-1}).

Note: both exponential and Gaussian distributions are used to demonstrate sensitivity to assumed accident location distributions.

$$D_i^e(y) = \frac{1}{2} Ke^{-k|yi|} \quad \text{(exponential form)} \quad (3)$$

and

$$D_i^g(y) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left[\frac{y_i}{\sigma}\right]^2} \quad \text{(Gaussian form)} \quad (4)$$

where:

$1/k$ = location of the mean of the absolute distances of crash locations from route centerline for the exponential form of the probability density function (=1.0 NM^{-1} for this analysis)

$\frac{2}{\sqrt{2\pi}}\sigma$ = location of the mean of the absolute distances of crash locations from route centerline for the Gaussian form of the probability density function $D_i(y)$ (NM^{-1})

σ = standard deviation of assumed Gaussian distribution of crash locations perpendicular to the route centerline (σ= 1.25 NM for this analysis)

y_i = perpendicular distance of plant from centerline of route i (NM)

This model assumes that the pilot does not take evasive action to avoid the plant. The development of factors used in determining the probability density function incorporate the effect of the pilot not always being exactly on the centerline prior to experiencing difficulties.

4.0 LOW-LEVEL, HIGH-SPEED TRAINING ROUTES NEAR THE SITE

As noted previously, at the present time there are eight low-level, high-speed training routes within 10 nautical miles of the proposed site. These are shown on Fig. 2.2A-1 as taken from the FLIP document (Ref. 1) which describes the location of, and restrictions for, military training routes. Table 2.2A-1 includes estimates of the current usage of these routes obtained from Air Force (Ref. 2) (for 1976) and Navy (Ref. 3) (for 1975) representatives of the FAA, Western Region Office. The probability analysis is done for the case assuming that any training route which had the plant location within its present perimeter was moved such that the plant was at the perimeter distance from the route centerline as required by Department of Defense policy (Ref. 1). Military personnel indicate that the present route use data may be considered typical of future utilization (Ref. 3). The Air Force projection for 1976 (Ref. 2) is considered typical of future use.

The purpose of these low-level, high-speed missions is to train and to maintain proficiency of air crews in low altitude navigation. As shown in Table 2.2A-1, most of the site activity involves Navy aircraft. Use of these routes is coordinated by the bases conducting the missions. Altitudes during these sorties are maintained between 500 and 1,500 ft AGL with speeds varying from about 350-450 kts depending on type of aircraft. No live ordnance is carried. Pilots of all experience levels are involved; however, an Instructor Pilot (IP) usually follows the progress of each training mission in a separate aircraft.

In discussions with pilots, they indicated that in a distress situation the pilot would attempt to gain altitude, try to determine the problem during the climb, and, if he had control, head for the nearest base, preferably one with adequate accident mitigation equipment. If the aircraft had no power or was uncontrollable, the pilot would eject after taking all possible measures to avoid populated areas.

Aircraft on low-level training missions do not normally use navigational aids, although such equipment is available in the aircraft for use if necessary. The IP would normally follow progress of the flight using navigational aids in his own aircraft. The aircraft are normally below radar observation limits. All flights on these routes are conducted when weather conditions meet Visual Flight Rule (VFR) minimums, and a weather forecast is obtained before conducting a mission. A mission in progress is to be terminated if other than VFR conditions prevail. Experience indicates that pilots may deviate from the proper course and can become lost. However, military representatives consider that being several miles off course would represent a large error and would be extremely unlikely, because the IP would terminate the mission or advise the trainee of such a large error. If a pilot were separated from the IP and became lost he would gain altitude and use his onboard navigational aids to determine the proper course. In any event, a lost or off-course pilot would not fly below 500 ft AGL and therefore would be above the highest structure at the site. Additionally, under the required VFR conditions the pilot would clearly see and avoid structures as massive as those constituting the nuclear plant.

5.0 IN-FLIGHT (LOW-LEVEL FLIGHT) ACCIDENT RATE

Statistics on noncombat in-flight major accidents were received from the Air Force Inspection and Safety Center (Ref. 4) and the Naval Safety Center (Ref. 5). Accidents considered applicable to this probability analysis are those in which the pilot does not have adequate control to safely land the aircraft. Tactical type aircraft under these conditions would likely be destroyed. Therefore, only accidents in which the aircraft was destroyed were used. Accidents associated with takeoff and landing were not applicable. The data were further separated by type of in-flight maneuver with low-level flight, which characterizes the type of missions along the low-level VFR routes, being of primary interest. Narrative descriptions of each in-flight accident were studied, and if conditions prior to the accident were not similar to activities conducted on the low-level VFR routes in the site vicinity, the accident was not used. An example of a deleted case would be an accident in which an aircraft flying well above 1,500 ft AGL prior to crash impacted a mountain in bad weather. Table 2.2A-2 presents accident statistics including in-flight statistics for the specific attack and fighter aircraft currently used along the routes in the site vicinity.

To estimate the rate of low-level accidents per hour flown at low-level, the number of hours spent in low-level flight must be determined. However, only records of total flying hours by aircraft are maintained. Estimates of low-level flying time, made by military training personnel, vary with aircraft and military department. The Navy (Ref. 10) estimates that about 10.7 percent of all A-4 and A-7 hours and less than 2 percent of all F-4 hours are flown at low-level (the lower percentage for the Navy F-4 was accounted for in the rates given in Table 2.2A-2). The Air Force estimates for 1975 (Ref. 8) that F-4 aircraft spent 8.7 percent of all hours in low-level training. For this evaluation 10 percent of all hours for all aircraft (other than the Navy F-4) were assumed to be flown at low-level.

Inspection of Table 2.2A-2 indicates that accident rates for each type of aircraft in low-level flight vary between 0.15 and 0.27 per ten thousand hours (10^{-4} hr^{-1}) of flying time. The combined Navy and Air Force rate used in this analysis for the attack and fighter aircraft utilized in low-level training near the site is 0.21×10^{-4} hr^{-1}.

6.0 PROBABILITY DENSITY FUNCTION D_i (y)

The first terms ($\frac{R}{V}\Delta \ell$) of the probability equation (equation (1) above) give the probability that an aircraft will crash in the distance $\Delta \ell$ along the flight path centerline. The probability that a location Δw at a distance y (see Fig. 2.2A-2) perpendicular to the flight path is impacted is represented by the probability density function D (y) (equations (3) and (4) above) times Δw as shown in equation (1). The probability of the joint occurrence for any one flight is obtained by the product of these two elements. Summation of the flight frequency weighted density function is computed for each low-level route as shown in Table 2.2A-3 for both the exponential and Gaussian relationships.

Equations (3) and (4) assume a symmetrical exponential and Gaussian distribution, respectively, of impact locations perpendicular to the flight centerline.

A study of the crash locations of in-flight commercial aircraft (Ref. 6) showed good agreement with the exponential equation. For the commercial study the value of k was about 0.33 mi^{-1}. Since 1/k in the exponential relationship represents the mean crash distance y on either side of the flight centerline, the average crash distance would be three miles. For an aircraft flying at much lower levels (below 1,500ft AGL), the lateral crash distribution should be closer to the centerline on the average. Based on a review of the accident narratives provided by the Navy (Ref. 12) and Air Force (Ref. 11), and on discussions with accident investigators, it is believed that the mean accident location should be less than one nautical mile from the centerline. This assumption has been partially confirmed by accident statistics involving fighter aircraft flying on low-level missions using available military data. This estimate is in agreement with the value used in a report by Dr. C.A. Cornell (Ref. 7) concerning aircraft accident risks due to military operations at the Carty site. Therefore, for the analyses presented in this appendix, the value of 1/k equal to 1.0 nautical mile is considered to be realistic. This is equivalent to using a value of σ = 1.25 in the Gaussian relationship.

7.0 EFFECTIVE PLANT AREA

The effective "target" area applicable to both Sundesert units was estimated using dimensions which encompass the main plant structures including all Category I structures and equipment. The target area is separated into three components including a skid area, the plant area itself, and a "shadow" area determined by the building heights and assumed angle of aircraft impact. In these calculations the target area is represented by assuming the aircraft approaches from the north or south direction perpendicular to the largest plant width. No reduction in the skid portion of the target area is assumed due to shielding by the turbine building for aircraft approaching from the south direction or due to shielding of one unit by another.

Since the initial impact is assumed to occur at high speed, the momentum could carry heavier parts of the aircraft to the plant even if the impact were a considerable distance "in front" of the plant. Accident investigators indicated that in most cases involving fighter type aircraft, the impact is at a fairly high angle (at least 30° from horizontal). In such cases the heavier components are buried in the ground or are found near the crash site. Pilots are instructed not to try to land this type of aircraft on other than a proper airstrip, and they would not attempt to fly at a low angle and land. This is especially true if power has been lost. Experience has shown that any attempt to land on an unimproved surface is usually fatal. Therefore, a pilot in distress would eject at as high an altitude as possible. When ejection occurs, the controls are no longer functional and the aircraft would likely nose down out of control before impact. Data obtained from the military indicates that the density of large parts usually decreases with distance. Of the low-level accidents considered in this report, some information on the location of heavy debris with respect to impact was available. These data indicated that the maximum distance for parts of any size was 2600 ft with the maximum engine travel distance being 2000 ft. The average for all debris was about 1400 ft and for engines it was about 1000 ft. A slide (or "skid") distance of 1400 ft was chosen for the analysis.

The effective plant area is represented by a large block with dimensions exceeding those of the Category I structures (refer to Figs. 3.8.4-1 and 3.8.4-2 for a drawing of the plant layout). To estimate the effective target area represented by vertical plant surfaces, the shadow area "behind" the plant is computed. The approach angle was computed by averaging the cotangents of the dive angles just prior to impact for the low-level accidents considered in this report (for which dive angle information was available) and then determining the angle corresponding to this average. An approach angle of about 15° resulted. This angle was realistically chosen since it represented the angle which gives the average shadow area based on past accident data. This is conservative when compared with the 30° approach angle typical of probability analyses involving commercial aircraft (Ref. 6).

Target area (A) is calculated as follows:

Skid Area, A_s

$$A_s = w \times d_s = 0.046 \text{ NM}^2$$

where:

w = width of north or south face of plant structures (∿1200 ft)

d_s = length of skid path (1400 ft)

Plant Area, A_p

$$A_p = w \times l = 0.023 \text{ NM}^2$$

where:

l = north-south length of plant structures including emergency cooling towers (700 ft)

Shadow Area, A_w

$$A_w = w \times h \cot \Theta = 0.016 \text{ NM}^2$$

where:

h = approximate average height of plant structures along east-west vertical section through the two containments (= 125 ft)

Θ = dive angle of aircraft on impact (15°)

$$A = A_s + A_p + A_w = 0.085 \text{ NM}^2$$

8.0 PROBABILITY CALCULATIONS

Using equations (2), (3), and (4) and the parameter values developed above, the probability of an aircraft impact is computed as follows:

Exponential distribution

$$P = \frac{RA}{V} \sum_{i=1}^{n} N_i D_i^e (y)$$

where:

R = Accident rate (0.21×10^{-4} hr^{-1})

A = Target area (0.085 NM^2)

$\sum_{i=1}^{n} N_i D_i^e (y)$ = From Table 2.2A-3 (40.4 NM^{-1})

n = number of routes

V = Average velocity of aircraft (400 kts)

$$P = \frac{(0.21 \times 10^{-4}\ (40.4)\ (0.085)}{400} = 1.8 \times 10^{-7}/2$$

$$= 9.0 \times 10^{-8} \text{yr}^{-1}/\text{unit}$$

Gaussian distribution

$$P = \frac{R\ A}{V} \sum_{i=1}^{n} N_i D_i^g (y) = \text{From Table 2.2A-3 } (49.9 \text{ NM}^{-1})$$

where

$$P = \frac{(0.21 \times 10^{-4})\ (49.9)\ (0.085)}{400} = 2.2 \times 10^{-7}/2$$

$$= 1.1 \times 10^{-7} \text{ yr}^{-1}/\text{unit}$$

References for Appendix 2.2A

1. FLIP, AP/1B, Department of Defense, Area Planning, Military Training Routes, May 20, 1976.

2. Letter from Maj. R.L. Maurer (Air Force Representative, FAA Western Region) to Pickard, Lowe and Associates, August 21, 1975.

3. Letter from Lt. Col. H.W. Roder (Navy Representative, FAA Western Region) to Pickard, Lowe and Associates, August 21, 1975.

4. Letter from R.G. Crewse, Air Force Inspection and Safety Center, to Pickard, Lowe and Associates, August 28, 1975.

5. Letter from R. Lewis, Naval Safety Center, Norfolk, Virginia, to K. Woodard (Pickard, Lowe and Associates), September 4, 1975.

6. Preliminary Safety Analysis Report, Alantic Generating Station, Units 1 and 2, Public Service Electric and Gas, Page 2.2-20 (Amendment 9).

7. Cornell, C.A., "Final Report to Oregon Nuclear and Thermal Energy Council on Naval Aircraft Accident Risks at the Carty Site," May 31, 1973.

8. Letter from James Hines, Col. USAF, Chief, Bases and Units Division, to Pickard, Lowe and Garrick, December 4, 1975.

9. Letter from R.G. Crewse, Air Force Inspection and Safety Center, to Pickard, Lowe and Associates, October 21, 1975.

10. Letter from W.P. Lawrence, Department of the Navy, Office of the Chief of Naval Operations, to Mr. Cotton of San Diego Gas & Electric, October 15, 1975.

11. Letter from R.G. Crewse, Air Force Inspection and Safety Center, to Pickard, Lowe and Associates, August 28, 1975.

12. Letter from R. Lewis, Naval Safety Center, Norfolk, Virginia, to K. Woodard, Pickard, Lowe and Garrick, Inc., January 16, 1976.

TABLE 2.2A-1

MILITARY USAGE OF LOW-LEVEL TRAINING ROUTES NEAR THE SUNDESERT SITE

Route Number	Approximate Direction of Flight	Width[1] (NM)	Present Distance from Site (NM)	Assumed Distance from Site for Analysis (NM)	Annual Flights: Navy (1975) Estimated Number of Flights	Annual Flights: Navy (1975) Type of Aircraft	Annual Flights: Air Force (1976) Estimated Number of Flights	Annual Flights: Air Force (1976) Type of Aircraft	Assumed Total Number of Flights
Paso Robles 361	NNW	2.0	6.3	6.3	295	A7/A4	55	F4/F105	350
Los Angeles 362	SSE	2.0	1.6	2.0	522	A7/A4	40	F4/F105	562
Thermal 364	SW	2.0	7.0	7.0	377	A7/A4	0	-	377
Santa Barbara 365	SE	2.0	5.7	5.7	90	A7/A4	0	-	90
Yuma 394	NNW	5.0	0.5	5.0	366	A4	20	F4/F105	386
Yuma 395	NW	2.0	10.0	10.0	132	A4	0	-	132
Yuma 396	WSW turning to SSE	5.0	3.5	5.0	102	A4	0	-	102
Yuma 396	NNW	5.0	5.7	5.7	102	A4	0	-	
						Assumed Total per Year			2,101

[1]Distance either side of centerline

TABLE 2.2A-2 [5]

MAJOR ACCIDENT RATES FOR FIGHTER AND ATTACK AIRCRAFT OF THE TYPE FLOWN IN THE SITE AREA

Aircraft Type	Total House Flown Considered in this Study (x1000) Navy	Air Force	Numoer of In-Flight Accidents Navy	Air Force	In-Flight Accident Rate (10^{-4} hr^{-1}) Navy	Air Force	Number of In-Flight[6] "Low-Level Flight" Accidents Navy	Air Force	Low-Level Flight[1] Accident Rate (10^{-4} hr^{-1}) Navy	Air Force	Total[3] Low-Level Flight Accident Rate (10^{-1} hr^{-1})
A-4	2,776	N/A	254	N/A	0.91	N/A	4	N/A	0.15	N/A	0.15
A-7	1,328	235	162	16	1.20	0.68	3	1	0.23	0.43	0.26
F-4	1,513	2,200	194	87	1.28	0.4	0[7]	6	0.0[7]	0.27	0.27
F-105	N/A	222	N/A	9	N/A	0.4	N/A	0	N/A	0.0	0.0
Total of above air-craft flown in site area	5,617	2,657	610	112	1.10	0.42	7	7	0.13	0.27	0.21
All attack[2] and fighter	6,403	4,585	-	224	-	0.49	18	22	0.28	0.48	0.36
All aircraft	23,000	-	1,063	-	0.46	0.3[4]	-	-	-	-	-

\- Information not available at this time

N/A Not applicable

(1) Assumes 10 percent of all glying hours are at low-level

(2) As fraction of total hours flown for Navy and Air Force combined

(3) Includes A-1, A-7, A-37, F-4, F05, F-84, F-100, F-101, F-102, F-104, F-105, F-106, and F-111 for Air Force; and A-4, A-6, A-7, and F-4 for Navy

(4) Includes takeoff and landing

(5) Based on fiscal year 1968 through 1975 for Navy, and 1970 through 1973 for Air Force

(6) Includes only those accidents which occurred following maneuvers typical of low-level operations in the site area

(7) Navy flies F-4 on low-level missions less than 2 percent of time, thus for low-level F-4 total hours flown use .02 of 1512 hrs = 30,000 hrs

TABLE 2.2A-3

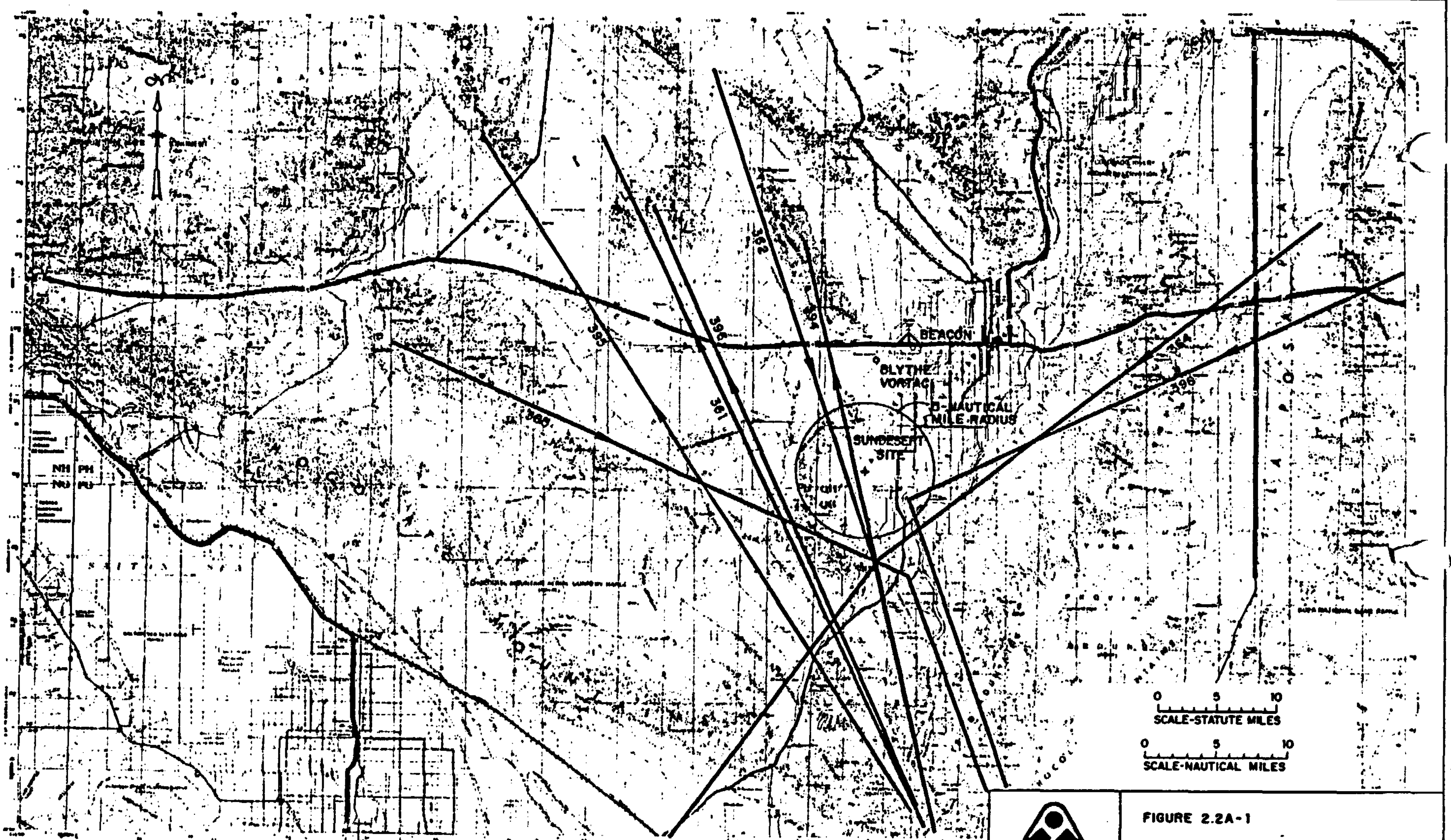
CALCULATION OF $\sum N_i D_i (y)$ FOR EACH LOW-LEVEL ROUTE

FOR EXPONENTIAL AND GAUSSIAN DISTRIBUTIONS

Route	Present Centerline Distance (y) from Site (NM)	Assumed Centerline Distance from Site (NM)	Assumed Exponential D_i^e (y) (NM^{-1})	Assumed Gaussian D_i^g (y) (NM^{-1})	Flight Frequency N_i (yr^{-1})	$N_i D_i^e$ (y)	$N_i D_i^g$ (y)
361	6.3	6.3	9.2-4(2)	9.7-7	350	3.2-1	3.4-4
362	1.6	2.0*	6.7-2	8.9-2	562	38	49.8
364	7.0	7.0	4.5-4	4.9-8	377	1.7-1	1.8-5
365	5.7	5.7	1.7-3	9.7-6	90	1.5-1	8.7-4
394	0.5	5.0(1)	3.4-3	1.1-4	386	1.3	4.1-2
395	10.0	20.0	2.3-5	4.0-15	132	3.0-3	5.3-13
396	3.5	5.0(1)	3.4-2	1.1-4	102	3.5-1	1.1-2
396	5.7	5.7	1.7-3	9.7-6	102	1.7-1	9.9-4
					$\sum$ =	40.4	49.9

(1)Route centerline is assumed to be relocated to a distance from the plant equal to route width (see Table 2.2A-1)

(2)Notation 9.2-4 means 9.2×10^{-4}

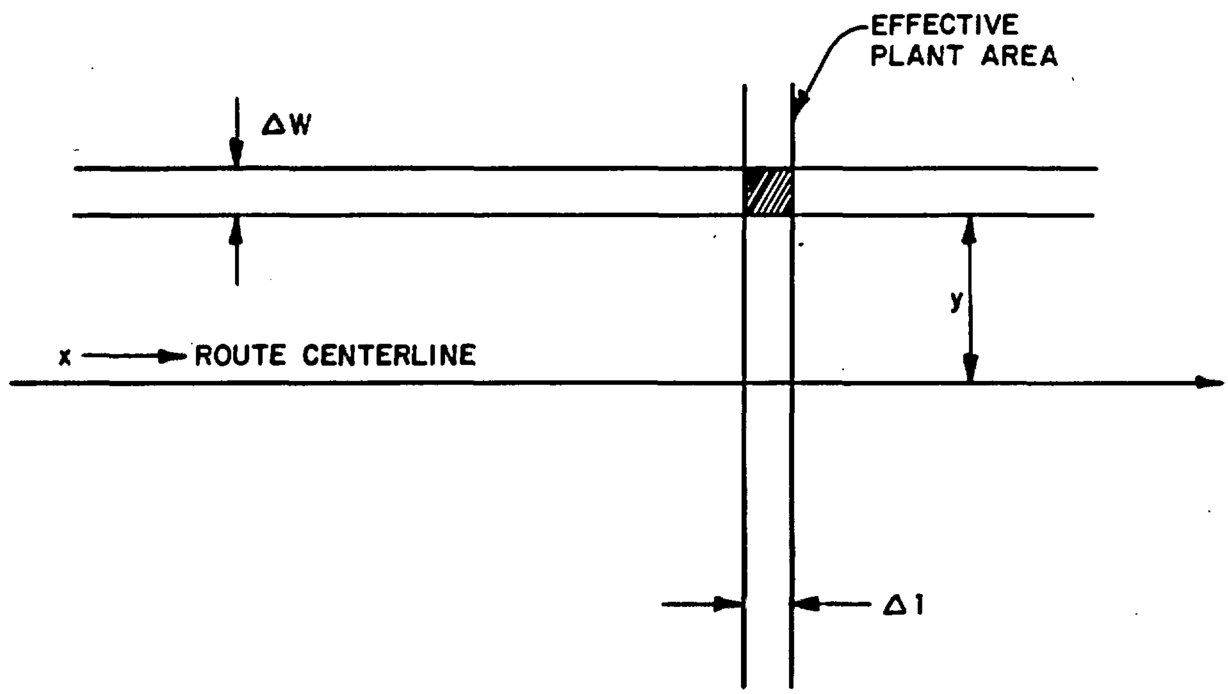


Sundesert Nuclear Plant
UNITS 1 & 2

FIGURE 2.2A-1

LOCATION OF LOW-LEVEL HIGH SPEED TRAINING ROUTES

PRELIMINARY SAFETY ANALYSIS REPORT



Sundesert
Nuclear Plant
UNITS 1 & 2

FIGURE 2.2A-2

PICTORIAL REPRESENTATION OF MODEL

PRELIMINARY SAFETY ANALYSIS REPORT