DESCRIPTION OF RISK AND RISK EXTREMES IN SANDIA SITING STUDY

NOVEMBER 10, 1982

On Monday, November 1, 1982 the Washington Post carried a news story about an NRC-sponsored siting study which was performed by Sandia National Laboratories. That story has led to widespread interest and further reporting here in the U.S., and in other parts of the world as well, on the purported contents and significance of the Sandia study. The concerns expressed arise in great part, but not entirely, from the original report in the Washington Post. In brief, these concerns are: (1) that the Sandia study constitutes a new set of estimates of severe accident risks at nuclear power plants which greatly surpasses the estimates of the Reactor Safety Study; (2) that these new estimates are a cause for great public concern, especially because of the great doubts about the predictions of low probabilities; and (3) that the NRC is misleading the public when it is not honest about what the worst-case possibility is.

Our purpose today is to brief the Commission on this work and to address the concerns expressed. Before turning to my staff and our contractor for the detailed briefing, I wish to present a brief summary of the substance and the conclusions of this briefing.

The Sandia study, NUREG/CR-2239 (or SAND81-1549), is entitled "Technical Guidance for Siting Criteria Development." Its purpose was to develop the technical guidance to support the formulation and comparison of possible siting criteria for nuclear power plants. It includes information on (1) consequences of hypothetical severe accidents; (2) characteristics of population distributions around current reactor sites; (3) site availability within the continental United States; and (4) socioeconomic impacts of reactor siting.

The Sandia study is not a new generic analysis of the risk of reactor accidents, it merely assumes the occurrence of severe accidents of different severity and calculates the range of possible consequences at U.S. reactor sites. Although the Sandia study provides us with useful analyses of the importance of various siting factors, it does not change our overall perception of reactor risk. On the contrary, the results presented in this report are consistent with those presented in the Reactor Safety Study (WASH-1400) and later publications. The results in the Sandia study also give us assurance that our present reactor siting criteria are not seriously flawed, and that it is reasonable to postpone further consideration of changes in siting criteria until new information on radioactive source terms is available next year.

The news stories have concentrated on the peak, or maximum calculated values of consequences. The likelihood of occurrence of these most severe consequences is very low. The exact value of this low probability is, of course, quite uncertain. But the fact that it is very low is beyond reasonable dispute, since the necessary sequence of events is a combination of low probability events. This report assumes that the annual probability of full scale core melt at a typical plant is 1 chance in 10,000 and that the probability of large scale release~~, if there is~~ resulting from a full scale core melt, is 1 chance in 100,000. These assumptions are supported reasonably well by existing risk studies including both predictive studies and analysis of operating experience. The siting study merely assumes these probabilities of core melt and large release, but it calculates further probabilities based on meteorology and population data. The analyses indicate an annual probability of 1 chance in 10 that anyone at all will be killed if a large release occurs~~-and-1~~. Further, there is 1 chance in 10,000 that weather sequences and wind direction could combine to produce the very unlikely scenarios which led to the maximum calculated consequences. The staff estimates that these are 1 chance in 1 billion events even without recognizing the further reduction in either probability or severity which should be made to account for known conservatism in radioactive release source terms and other factors. Significant reductions in source terms are expected based on current work and they alone are expected to lead to a very large decrease in the estimates for early fatality or injury. In addition, the present calculations incorporate a conservative bias in the emergency response assumptions for the extreme cases which leads to a conservative overestimation of the number of deaths or injuries.

The Reactor Safety Study attempted to display the nature and range of severe accident consequences and the probabilities which should be associated with them. Probabilistic risk analysis has been further refined since then and both NRC-sponsored and industry publications have displayed a range of consequences with extreme values similar to those associated with the siting study. Example publications include the 1978 report SAND78-0556, "An Investigation of the Adequacy of the Composite Population Distributions Used in the Reactor Safety Study;" the 1980 report NUREG-0715, "Task Force Report on Interim Operation of Indian Point;" and the many Environmental Impact Statements which have been published since the Commission adopted the policy of describing severe or Class 9 accident risk in such statements. A similar range of consequences can be found in recent industry-sponsored risk analyses such as the Zion Probabilistic Safety Study and the Indian Point Probabilistic Safety Study. The NRC has even invited the Congress' attention to this range of estimates as a possible basis for change in the liability limits of the Price-Anderson Act in a 1980 letter to the Chairman of the Senate Committee on Governmental Affairs.

The maximum consequences cited in the current news reports are pessimistically overstated estimates for very low probability sequences of events; they are not a cause for great public concern. The results of the Sandia study have not increased our estimates of reactor risk. On the contrary, they give us further assurance of the acceptability of past and current reactor siting policy.

<u>FIVE POINTS</u>

1. SANDIA REPORT IS NOT A NEW RISK ASSESSMENT WHICH SHOULD BE A CAUSE FOR PUBLIC CONCERN.

2. CURRENT SITING POLICY IS NOT SERIOUSLY FLAWED.

3. THE PUBLICIZED MAXIMUM CONSEQUENCES ARE PROBABLY OVERSTATED DUE TO CONSERVATIVE MODELING ASSUMPTION.

4. THE SCENARIOS FOR WORST CASES ARE EXTREMELY IMPROBABLE.

5. THE RANGE OF CONSEQUENCES AND THE EXTREMELY LOW PROBABILITY VALUES HAVE BEEN PUBLISHED AND DISCUSSED FOR YEARS.

SITING

- NUREG-0625 (1979) CALL FOR MORE REMOTE SITING
- KEMENY AND ROGOVIN REPORTS
- 1980 CONGRESSIONAL CALL FOR REVISED SITING POLICY
- WORK IN 1980 AND 1981 ON TECHNICAL BASIS
- EXPECTED SIGNIFICANT REDUCTIONS IN SOURCE TERMS DELAYED ACTION ON SITING

NUREG/CR-2239
SAND81-1549

TECHNICAL GUIDANCE FOR SITING CRITERIA DEVELOPMENT

D. C. Aldrich
J. L. Sprung
(Project Coordinators)

D. J. Alpert
K. Diegert
R. M. Ostmeyer
L. T. Ritchie
D. R. Strip

Sandia National Laboratories
Albuquerque, New Mexico 87185

J. D. Johnson
Dikewood Corporation
Albuquerque, New Mexico

K. Hansen, J. Robinson
Dames and Moore
Los Angeles, California

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Sandia National Laboratories
Albuquerque, New Mexico 87185
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Sandia Corporation
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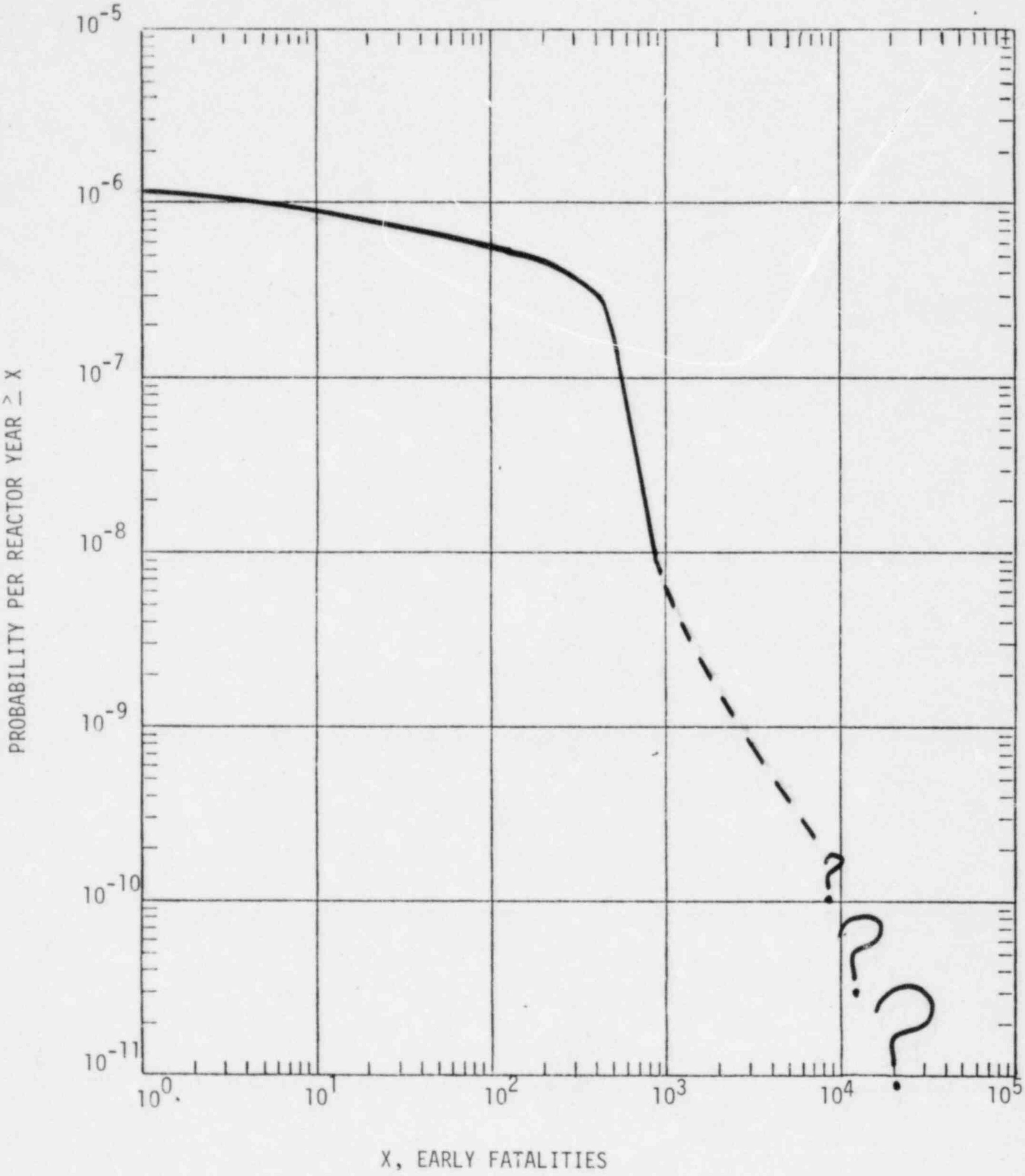
TECHNICAL APPROACH

SCOPE OF STUDY

- o DESIGN INDEPENDENT ACCIDENT CONSEQUENCES
- o CHARACTERISTICS OF POPULATION DISTRIBUTION
- o SITE AVAILABILITY
- o SOCIOECONOMIC IMPACTS

RISK PORTION

- o SET OF SEVERE ACCIDENT RELEASES
- o ANALYZE 91 U.S. SITES
- o CONDUCT SENSITIVITY ANALYSES

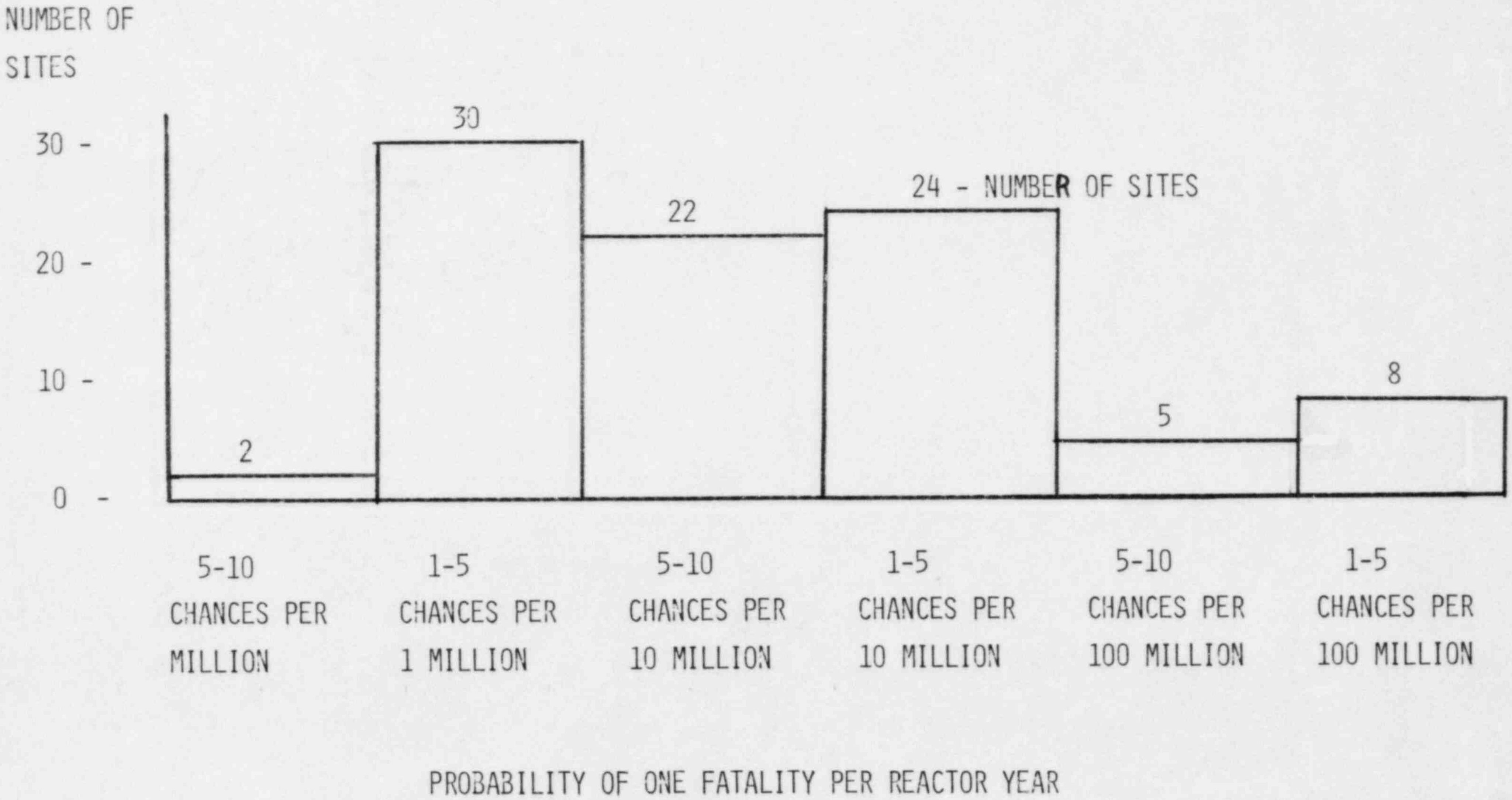


ALLEN'S CREEK RISK CURVE

* * * * FINAL RESULTS * * * *

ID:1 SITE:ALLENSCREEK MET:FTWTH SHELTER:3 STATE:37 INVENTORY:1
ACCIDENT SEQUENCE SST 1 , EVACUATION SCHEME SUMMAR

** DESCRIPTION **	*** MEAN ***	* VARIANCE *	* P(NOT 0) *	*** PEAK ***	** P(PEAK)
163 ACUTE FATALITIES	3.07E+01	1.40E+04	1.12E-01	7.41E+03	2.45E-05
164 ACUTE INJURIES	9.31E+01	8.21E+04	4.32E-01	2.35E+04	2.64E-05
165 POP W/BMR DS>200	9.98E+01	7.90E+04	1.61E-01	1.50E+04	4.67E-05
166 RSK OF FAT- 1MI	4.94E-02	7.53E-04	7.36E-01	1.41E-01	1.86E-02
167 RSK OF FAT- 2MI	1.14E-02	2.50E-04	3.15E-01	8.82E-02	1.05E-02
168 RSK OF FAT- 5MI	6.50E-05	5.51E-08	7.40E-02	1.18E-02	7.71E-05
169 RSK OF FAT- 10MI	0.	0.	0.	0.	0.
170 FATAL RADIUS(MI)	1.78E+00	2.74E+00	9.85E-01	2.50E+01	1.11E-03
171 RSK OF INJ- 1MI	8.11E-02	2.70E-04	9.85E-01	1.47E-01	3.09E-03
172 RSK OF INJ- 10MI	1.30E-04	2.41E-07	3.37E-02	1.30E-02	3.68E-04
173 RSK OF INJ- 20MI	1.95E-04	1.02E-05	6.34E-02	9.28E-02	1.11E-03
174 RSK OF INJ- 30MI	4.92E-05	9.16E-07	5.45E-03	2.36E-02	1.11E-03
175 RSK OF INJ- 50MI	0.	0.	0.	0.	0.
176 INJUR RADIUS(MI)	7.62E+00	4.72E+01	1.00E+00	3.50E+01	3.22E-03
177 ACU BMR DS- 1MI	9.78E+02	8.52E+05	1.00E+00	7.76E+03	2.17E-03
178 ACU BMR DS- 5MI	7.23E+01	4.36E+03	1.00E+00	4.42E+02	7.71E-05
179 ACU BMR DS- 10MI	2.11E+01	3.01E+02	1.00E+00	1.99E+02	3.68E-04
180 ACU BMR DS- 20MI	2.31E+01	7.79E+02	1.00E+00	5.79E+02	1.11E-03
181 ACU BMR DS- 30MI	1.12E+01	1.69E+02	1.00E+00	2.00E+02	1.11E-03
182 ACU BMR DS- 50MI	3.21E+00	8.97E+00	1.00E+00	1.75E+01	1.20E-03
183 ACU THY DS- 1MI	2.90E+04	9.97E+08	1.00E+00	2.29E+05	2.90E-03
184 ACU THY DS- 5MI	1.78E+03	3.47E+06	1.00E+00	1.02E+04	1.03E-02
185 ACU THY DS- 10MI	4.82E+02	1.94E+05	1.00E+00	4.72E+03	3.68E-04
186 ACU THY DS- 20MI	2.03E+02	3.50E+04	1.00E+00	1.59E+03	8.28E-04
187 ACU THY DS- 30MI	9.82E+01	8.41E+03	1.00E+00	6.98E+02	8.28E-04
188 ACU THY DS- 50MI	2.96E+01	7.77E+02	1.00E+00	1.46E+02	7.19E-03
189 ACU THY DS-100MI	6.04E+00	4.62E+01	1.00E+00	2.32E+01	2.39E-02



NUMBER OF SITES
30 -
20 -
10 -
0 -
2
30
22
24 - NUMBER OF SITES
5
8
5-10 CHANCES PER MILLION
1-5 CHANCES PER 1 MILLION
5-10 CHANCES PER 10 MILLION
1-5 CHANCES PER 10 MILLION
5-10 CHANCES PER 100 MILLION
1-5 CHANCES PER 100 MILLION
PROBABILITY OF ONE FATALITY PER REACTOR YEAR

SENSITIVITY ANALYSES

PURPOSE - INVESTIGATE DEPENDENCE OF PREDICTED CONSEQUENCES ON SITE AND ACCIDENT CHARACTERISTICS SUCH AS:

- o POPULATION DISTRIBUTION
- o METEOROLOGY
- o EMERGENCY RESPONSE
- o SOURCE TERMS
- o INTERDICTION/DECONTAMINATION

MAXIMUM PREDICTED CONSEQUENCES INCREASE WITH EXTREME ASSUMPTIONS

TYPICAL SITE

PROBABILITY OF OCCURRENCE

	EVENT	PROBABILITY PER YEAR CONDITIONAL	CUMULATIVE
1.	LARGE SCALE CORE MELT	$1x10^{-4}$	$1x10^{-4}$
2.	LARGE (SST-1) RELEASE IF 1. OCCURS	$1x10^{-1}$	$1x10^{-5}$
3.	AN EARLY FATALITY IF 2. OCCURS	$1x10^{-1}$	$1x10^{-6}$
4.	THE "MAXIMUM CALCULATED" WEATHER SEQUENCE AND POPULATION COMBINATION OCCURS IF 3. OCCURS	$1x10^{-3}$	$1x10^{-9}$

AN INVESTIGATION OF THE ADEQUACY OF THE COMPOSITE POPULATION DISTRIBUTIONS USED IN THE REACTOR SAFETY STUDY

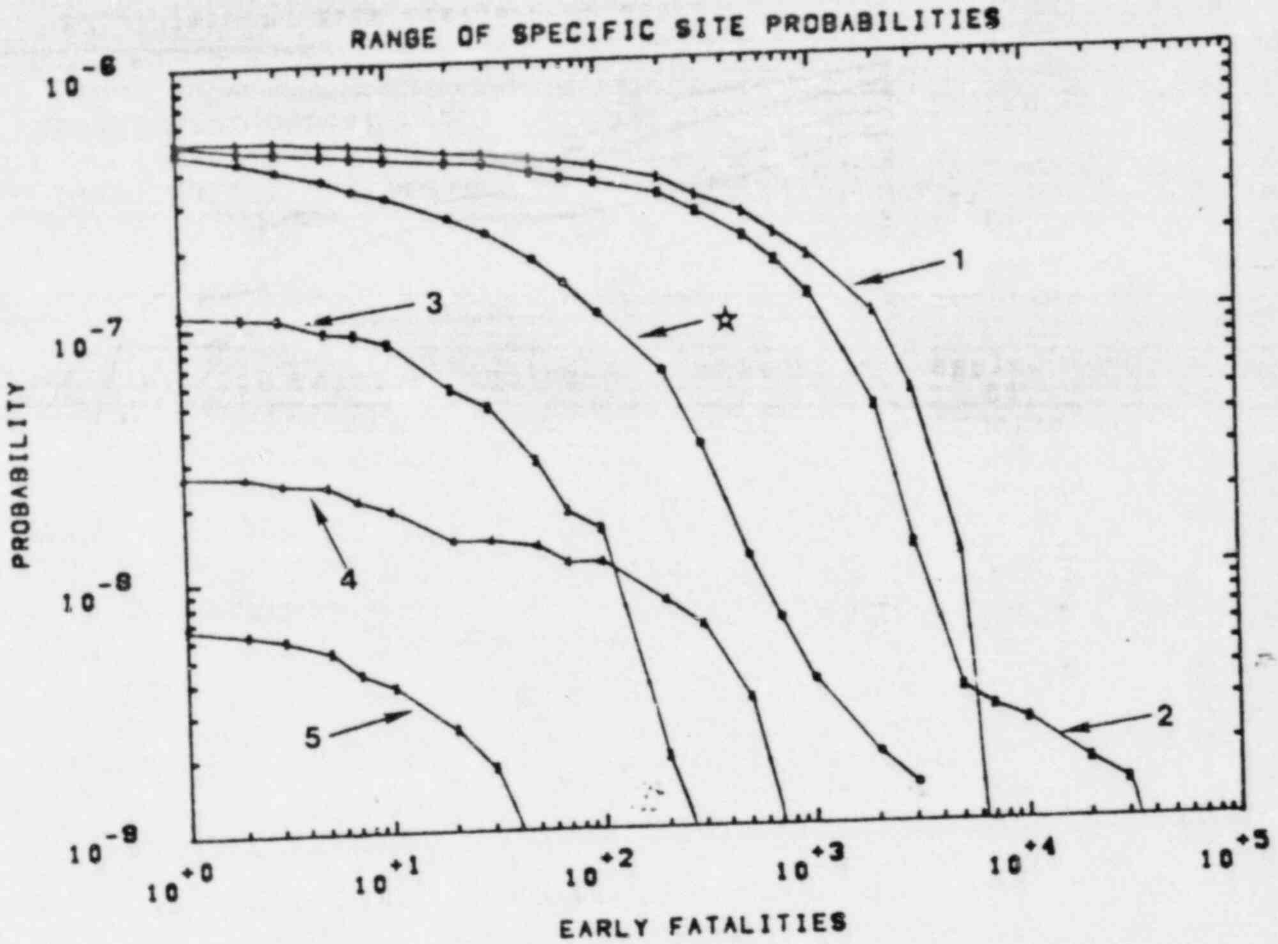


Figure 16: Log-Log plot of probability (per reactor-year versus early fatalities showing the dispersion of site specific CCDF's about the Reactor Safety Study CCDF.

1 = Indian Point (2985 MWt)
2 = Zion (3150 MWt)
3 = Palo Verde (3713 MWt)
4 = Millstone BWR (1956 MWt)
5 = San Onofre (1290 MWt)
* = Reactor Safety Study

PUBLISHED DOCUMENTS WHICH HAVE PRESENTED EXTREME RESULTS

- SAND 78-0556, AN INVESTIGATION OF THE ADEQUACY OF THE COMPOSITE POPULATION DISTRIBUTION USED IN THE REACTOR SAFETY STUDY, OCTOBER 1978.
- NUREG-0715, TASK FORCE REPORT ON INTERIM OPERATION OF INDIAN POINT, AUGUST 1980.
- ZION PROBABILISTIC SAFETY STUDY, SEPTEMBER 1981.
- TWENTY ENVIRONMENTAL STATEMENTS

NUREG-0848	BYRON	NUREG-0490	SAN ONOFRE
NUREG-0813	CALLAWAY	NUREG-0895	SEABROOK
NUREG-0921	CATAWBA	NUREG-0842	ST. LUCIE
NUREG-0854	CLINTON	NUREG-0719	SUMMER
NUREG-0775	COMANCHE PEAK	NUREG-0564	SUSQUEHANNA
NUREG-0769	FERMI	NUREG-0779	WATERFORD
NUREG-0777	GRAND GULF	NUREG-0878	WOLF CREEK
NUREG-0537	MIDLAND	NUREG-0812	WNP-2
NUREG-0841	PALO VERDE	IN PUBLICATION	HARRIS
NUREG-0884	PERRY	IN PUBLICATION	BELLEFONTE

CONCLUSIONS

- SITING POLICY IS NOT SERIOUSLY FLAWED, DELAY FOR REVISED SOURCE TERM IS LOGICAL

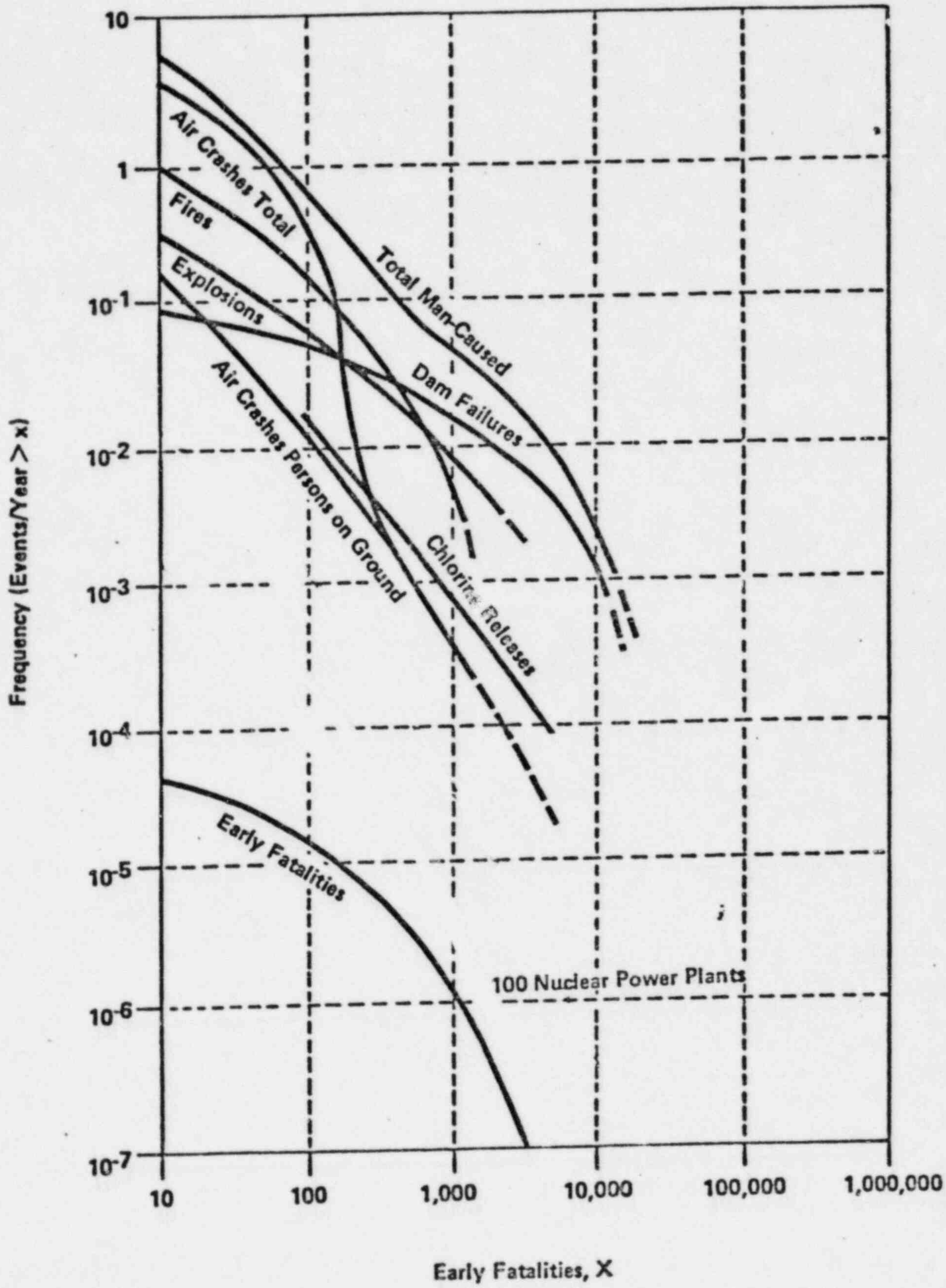
- THERE IS NO CAUSE FOR INCREASED PUBLIC CONCERN BECAUSE OF MAXIMUM CALCULATED VALUES

SEVERE ACCIDENT
SITING SOURCE TERMS

SST Category	Description
1	Gross core melting. Essentially involves loss of all installed safety features (core and containment). Severe direct breach of containment (analogous to Reactor Safety Study PWR Category 2).
2	Gross core melting. Containment fails to isolate. Fission product release mitigating systems (e.g., sprays, suppression pool, fan coolers) operate to reduce release (analogous to Reactor Safety Study PWR Categories 4 and 5).
3	Gross core melting. Containment fails by basemat melt-through. All other release mitigation systems have functioned as designed (analogous to Reactor Safety Study PWR Categories 6 and 7).
4	Limited to moderate core damage (no gross core melting). Containment systems operate but in somewhat degraded mode (TMI-2 equivalent).
5	Limited core damage. No failures of engineered safety features beyond those postulated by the various design basis accidents are assumed.

REPRESENTATIVE PROBABILITIES

SST-1	1×10^{-5}/RYR
SST-2	2×10^{-5}/RYR
SST-3	1×10^{-4}/RYR



Frequency (Events/Year > x)
10
1
10-1
10-2
10-3
10-4
10-5
10-6
10-7
10
100
1,000
10,000
100,000
1,000,000
Early Fatalities, X
Air Crashes Total
Fires
Explosions
Total Man-Caused
Dam Failures
Air Crashes Persons on Ground
Chlorine Releases
Early Fatalities
100 Nuclear Power Plants

PREVIOUS REPORT TO CONGRESS

- o COMMENTS ON GAO PRICE-ANDERSON RECOMMENDATIONS
- o CHAIRMAN AHEARNE TO SENATOR RIBICOFF (12/31/80)
- o RANGE OF ESTIMATES BASED ON NUREG-0715

EARLY FATALITIES

10^{-6}/RYR	0 - 5,000
10^{-9}/RYR	700 - 50,000

PROPERTY DAMAGE (1974 DOLLARS)

10^{-6}/RYR	\$2M - \$2B
10^{-9}/RYR	\$8B - \$100B

Roger Blond

NUREG/CR - 2326

CALCULATIONS OF

REACTOR ACCIDENT CONSEQUENCES

VERSION 2

CRAC2

COMPUTER CODE

INPUT DATA DESCRIPTION

L. T. Ritchie
J. D. Johnson*
R. M. Blond**
Sandia National Laboratories
Albuquerque, New Mexico 87185

*The Dikewood Corporation
**US Nuclear Regulatory Commission

INPUT DATA DESCRIPTION

A. Introduction

The input data to the CRAC2 model consist of a title card, 15 sets of data which are called "subgroups," and a terminator card. The subgroups describe the site specific parameters, the characteristics of the postulated accidents, the health effects to be considered, the ~~emergency~~ protective measures to be taken, the number and types of consequences to be studied, and the options controlling the output to be produced by the program.

The model has a reference or base data case which is input at the beginning of each execution. This reference case consists of a title card and the 15 subgroups with a standard reference set of data. The reference set of data is terminated by an "END" card. The user may then modify the reference case by inputting a new title card describing the change case, and redefining one or more of the subgroups. To use the base case with no modifications, only the title card is required. The modifications are also terminated with an "END" card, after which the program evaluates the modified data and computes the results. Upon completing the computation of the results, the program automatically reinstates the initial reference case and the user can input a new title card and another set of modifications for the program to evaluate. There is no limit to the number of modification studies or change cases which a user may try in one execution of the program. Any or all of the subgroup modifications may be made permanent for all succeeding trials.

The ability to change only a portion of the data without having to respecify the entire input file simplifies the work of the user while allowing a considerable amount of flexibility in performing parametric studies. The output from the model provides a complete record of each study.

B. Input Data Organization

The input data to the consequence model consists of five major data divisions:

- Site Specification,
- Accident Description,
- Evacuation,
- Health Effects and Property Damage, and
- Output Specification.

All of the input data to the CRAC2 model is assigned to distinct sets or subgroups of data which describe a specific function and is a part of one of these five divisions.

1. Site Specification.[1] Five subgroups are used to describe and characterize the site.

   1) Spatial - This subgroup defines the radial intervals around the site. These annuli are basic to the calculational steps of CRAC2.

   2) Site - This subgroup indicates the location of the site to be modeled, the type of meteorological sampling to be performed, and the number of meteorological samples to be taken. In addition, it can specify

[1]See Chapters 5, 10, and 12 of Appendix VI, Reactor Safety Study.

the site data file as the source of the population and land usage data for the site.

3) Population - This subgroup defines the population sectors to be run and, optionally, the population distribution around the site.

4) Topography - The state location and land fraction data for the spatial intervals within the 16 sectors around the site are specified by this subgroup.

5) Economic - This subgroup inputs cost data for computation of economic effects.

With these five subgroups of data, the model has the required information to perform a consequence calculation for a specific location.

2. Accident Description.[1] Three subgroups are used to describe the potential reactor accidents.

1) Isotope - The isotopes which are to be released at the time of the accident, their inventories, and associated parameters are defined by this subgroup.

2) Leakage - This subgroup describes the accident in terms of probability, timing, heat, and leakage fractions.

[1]See Chapters 2 and 3 of Appendix VI, Reactor Safety Study.

3) <u>Dispersion</u> - The building wake dimensions, and wake and rain option parameters are defined in this subgroup.

3. Ev[illegible].[1] The evacuation subgroup has a single subgroup associated with it. The evacuation model parameters are input by the subgroup EVACUATE. Velocity and delay/shelter/movement models are available.

4. Health Effects and Property Damage.[2] There are three subgroups which are required for the processing of health effects and property damage:

1) <u>Acute</u> - This subgroup specifies the organs to be considered for the acute effects of (fatalities and injuries) from the early exposure to the radioactive material.

2) <u>Latent</u> - This subgroup specifies the latent effects and organs to be processed for the cancer fatality calculations from the early and chronic exposure to the radioactive material.

3) <u>Chronic</u> - This subgroup specifies the chronic exposure pathways data for determining the protective action measures appropriate to the level of chronic exposure and to calculate chronic doses

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[1]See Chapter 11 of Appendix VI, Reactor Safety Study.
[2]See Chapters 8 and 9 of Appendix VI, Reactor Safety Study.

5. Output. The output division has three subgroups associated with it:

1) Results - This subgroup indicates the type of output results to be generated.

2) Scale - This subgroup specifies the discrete magnitude bins into which the consequences will be grouped and presented.

3) Options - This subgroup indicates which print options are in effect for detailed analyses.

With all of these subgroups properly ~~input,~~ specified CRAC2 will generate the requested set of results and will present them in a manner which can be utilized in the risk assessment process.

CRAC2 has been developed to give the analyst a relatively easy method for performing parametric and sensitivity studies. A reference set of data containing all of the subgroups is input at the beginning of every program execution. The analyst determines which subgroups are to be modified and includes the modified subgroups at the end of the reference set. The program allows for many such modifications with the reference set of data reset after the completion of each study.

C. Input Data Deck

The CRAC2 input data deck defines the reference or base data case to be used by the model. The accident to be analyzed by the model must be described in the input data deck by the base case and the subsequent data modification. The deck is made up of title cards, subgroup header cards, subgroup data cards, and end cards. The format and use of these cards in the input data deck is described in the following sections. All names under the heading of mnemonics correspond to the FORTRAN variable names in the CRAC2 computer code.

D. Title Card

The title card must be entered at the front of the reference case and each change case. The card is alpha numeric. The reference or change case title and description is punched in columns 1 through 72. Column 80 functions as a switch for printing the input data deck. When Column 80 is non-blank, the input data is not printed.

Column	Mnemonic	Format	Description
1-72	ID	18A4	Case title and identifying information. The data is read into the array ID as (ID(I), I = 1, 18).
80	ICD	A1	Print switch for input data. Blank - print input data. Non-blank - do not print input data.

E. Subgroup Header Card

The 15 subgroups are each introduced by a header card. The header card has the following format:

Column	Mnemonic	Format	Description
1-2	SUBGRP	A2	Subgroup name (the first two characters of the subgroup name identify the subgroup).

give all allowable names

Column	Mnemonic	Format	Description
21-25	NUM	I5	Number of logical sets of data to be input for the subgroup.
30-32	PARMOD	A3	Parameter modification switch. "YES" - parameters within the subgroup are to be algebraically modified. "NO" or blank - no parameter modification requested.
40-42	PERM	A3	Permanent change switch. "YES" - permanent change requested. This change becomes part of the reference case for this analysis. "NO" or blank - temporary change requested.

If a parameter is to be algebraically modified, PARMOD = "YES", an additional card must follow the header card. This card specifies the parameter multiplers (see individual subgroups). The multiplier 1.0 must be supplied for parameters which are <u>not</u> to be modified. Blank fields are taken as zeros. The reference case should contain no permanent change requests.

F. Subgroup Data Cards

Table II-1 gives a brief description of the 15 subgroups and the page location of each subgroup description. Each subgroup is described in detail in the sections that follow.

Table II-1. Input Subgroup Description

Subgroup Name	Data Count Name	Page	Description
1. SPATIAL	NSI		Specifies the radii of annular spatial intervals

Subgroup Name	Data Count Name	Page	Description
2. SITE	--		Specifies the site description. Specifies meteorology, population, and topographic data for the site; and specifies the sampling method and number of trials to be run.
3. POPULATION	NPB(4)		Specifies population option switch and, optionally, the population for each spatial interval within the 16 sectors around the plant.
4. TOPOGRAPHY	--		Specifies the state code and land fraction data for each spatial interval within the 16 sectors around the plant.
5. ECONOMIC	NCT		Specifies cost data for computation of economic effect.
6. ISOTOPE	NIS		Specifies the isotope inventory and associated parameters.
7. LEAKAGE	NPB(2)		Specifies the accident group leakage fractions and associated accident parameters.
8. DISPERSION	--		Specifies the reactor building dimensions, and other options.
9. EVACUATE	NEVAC		Specifies the emergency protective actions parameters.
10. ACUTE	NEARLY		Specifies the data for computing the acute health effects of fatalities and injuries from early exposure to the radioactive cloud.
11. LATENT	NLA		Specifies the data for computing the latent health effects of cancer fatalities from early exposure to the radioactive cloud and chronic exposure to the ground contamination.

Subgroup Name	Data Count Name	Page	Description
12. CHRONIC	NEXP		Specifies the data for computing the latent health effects of cancer fatalities from chronic exposure and the protective action levels for land contamination.
13. SCALE	NCT		Specifies the x-axis scale for tabulating the complementary cumulative distributions of the named results.
14. RESULTS	NRES		Specifies the result names for which mean, variance and complementary cumulative distributions are computed.
15. OPTIONS	--		Specifies the selected print options for detailed output.

1. Subgroup SPATIAL - specifies the radii of the annular spatial intervals or rings around the accident site.

Sample input cards:

The NUM field, 34 in the sample header card above, specifies the number of spatial intervals, NSI, to be input. If the site data file is requested by the subgroup SITE, NSI must be set to 34 to correspond to the data on the site data file. If the site data file is not requested, NSI may be any positive integer $\leq$ 34.

The CRAC2 model assumes a spatial grid around each site as shown in the diagram below:

The spatial grid consists of 16 sectors, each is 22-1/2 degrees wide. Each sector is centered on a compass direction. Sector 1 lies east of north and its left hand boundary is directed due north. The remaining sectors are numbered clockwise, 2 through 16. There are NSI*16 area elemtns, where NSI is the number of rings or spatial intervals defined in this subgroup.

The format for the data cards for this subgroup is described below. Each card contains 8 radii.

Column	Mnemonic	Format	Description
1-10 11-20 71-80	R	8E10.3	Outer radius in miles for each spatial interval or ring. If the site data file is going to be referenced, the 34 radii are required to have the following values: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 6.0, 7.0, 8.5, 10.0, 12.5, 15.0, 17.5, 20.0, 25.0, 30.0, 35.0, 40.0, 45.0, 50.0, 55,0, 60.0, 65.0, 70.0, 85.0, 100,0, 150.0, 200.0, 350.0, 500.0. The data is read into the array R as follows, (R(I), I = 1, NSI), eight items per card.

No parameter modification is permitted for this subgroup.

Printed listing of the sample data for subgroup SPATIAL is shown below.

2. <u>Subgroup SITE</u> - specifies the site identification data, the parameters that define the sampling method and the source of the meteorological data, the source of the topographic data, and the source of the population data for the reactor site. Meteorological data may be ~~read~~ defined by this subgroup depending on the sampling option selected.

<u>Sample input cards</u>:

The NUM field is not used by the site subgroup. One site must be specified in the subgroup.

One card with the following format must be input to identify the site, the site data, and the sampling option.

Column	Mnemonic	Format	Description
1-20	ISITE	5A4	Site identification data.
21-30	P(1,3)	E10.3	Probability associated with this site. The program normalizes this probability to one.
31-32	ISTART	I2	Start code - determines the number and type of meteorological trials to be run.

Column	Mnemonic	Format	Description
			0 - User must input meteorological data for each spatial interval. The description of the additional input for start code 0 is shown below. Subgroups POPU, and TOPO must be used to supply the population and topographic data for the site. A single trial is processed.
			1 - Meteorological data for the site is taken from the meteorological data file. Population and topographical data may be taken from the site data file or from subgroups POPU and TOPO depending on the value of IPO (see cols. 39-40 below). N stratified random day and night trials are run, where N = MO*100 + IDA (see cols. 33-34, 35-36 below). N should be a multiple of 24 to get an equal number of day and night trials in each month.
			2 - Same as start code 1, except that only day trials are run and N should be a multiple of 12.
			3 - Same as start code 1, except that only night trials are run and N should be a multiple of 12.
			4 - User must input 5 days of meteorological data. The description of additional input for start code 4 is shown below. Subgroups POPU and TOPO must be used to supply the population and topographic data for the site. A single trial is processed.
			5 - Meteorological, topographical, and population data are supplied as for start code 1. Meteorological sampling is performed using the meteorological bins. The sampling strategy is given by the additional input for start code 5. The description of this ~~input is shown~~ below. The number meteorological of trials processed is the sum of the samples

Column	Mnemonic	Format	Description
			from each bin. If the meteorological data has been processed previously, then MØ must be nonzero to read the processed data from TAPE 28. If the wind rose data from the meteorological bins is to be used, IDA must be nonzero.
			6 - Same as start code 1, except that N completely random trials are processed, i.e., the start time of the accident is random.
			7 - Meteorological, topographical, and population data are supplied as for start code 1. User specifies a particular start time using the fields MO, IDA, IHR as described below. One trial is processed using this start time.
			8 - Meteorological, topographical, and population data are supplied as for start code 1. User specifies sample interval for month, day, and hour using the fields, MO, IDA, IHR (see cols. 33-34, 35-36, 37-38 below). Trials are processed for one year period using the given intervals, i.e., if MO=1, IDA=4, IHR=13, there will be a trial every 4 days on 13 hour intervals (1:00 PM, 2:00 AM, 3:00 PM, 4:00 AM, etc.) until the end of the current month. The month number is then incremented by MO and the process is repeated until the end of the month, etc. This is continued until the month number exceeds 12.
			9 - One or more invariant meteorologies must be supplied together with the probabilities for each combination of stability, windspeed, and rain condition. Subgroups POPU and TOPO must be used to supply the population and topographical data for the site. The number of trials depends on the number of invariant weathers input and their probabilities.

Column	Mnemonic	Format	Description
			The same meteorological conditions are used for each spatial interval for a given trial. See the description of additional input for start code 9 below).
33-34	MO	I2	For start codes 1, 2, 3 and 6, the number of trials is given by 100*MO+IDAY. For start code 5 MO indicates source of the meteorological bin data. If MO is zero, the data is processed from the meteorological data file on Tape 27. If MO is nonzero, the previously processed meteorological bin data on TAPE 28 is utilized. For start code 7, MO is the month in which the single trial occurs. For start code 8, MO is the sample interval for the month. For start codes 0, 4 and 9, MO is not used.
35-36	IDA	I2	For start codes 1, 2, 3, and 6, the number of trials is given by 100*MO+IDA. For start code 5, MO indicates the wind rose source. If IDA is nonzero, the wind rose data calculated from the meteorological bins is substituted for the annual wind rose. For start code 7, IDA is the day on which the single trial occurs. For start code 8, IDA is the number of days between trials. For start codes 0, 4, and 9, IDA is not used.
37-38	IHR	I2	For start code 7, IHR is the hour in which the trial occurs. For start code 8, IHR is the number of hours between trials. For start codes 1-6 and 9, IHR is not used.
39-40	IPO	I2	Site population and topographical data option. Valid for start codes 1, 2, 3, 5, 6, 7, and 8. 0 - Individual site population and topographical data are taken from the site data file.

Column	Mnemonic	Format	Description
			1 - Site population and topographic data are supplied by the subgroups POPU and TOPO, respectively. No data is supplied from the site data file.
			2 - Topographic data is read from the site data file, and subgroup POPU must supply the population data.

When the ISTART code 0, 4, 5 or 9 is specified, the additional data required for these cases must immediately follow this card.

Additional Card Input Required for Start Code Zero:

Mnemonic	Format	Description
ISTA	16I5	Stability in each spatial interval (1=A, 2=B, 3=C, 4=D, 5=E, 6=F). NSI values must be input, where NSI is the number of spatial intervals specified in subgroup SPATIAL. The data is read into the array ISTA as follows, (ISTA(I), I=1, NSI). Use as many cards as required, 16 values to a card.
VEL	8E10.3	Wind speed at each spatial interval in meters per second. NSI values must be input, starting on a new card and using as many cards as required. The data is read into the array VEL as follows, (VEL(I), I=1, NSI).
IRAIN	16I5	Rain indicator (0=no rain, 1 = rain) for each spatial interval. NSI values must be input, starting on a new card and using as many cards as required. The data is read into the aray IRAIN as follows, (IRAIN(I), I=1, NSI).
ZMAX(1) ZMAX(2)	E10.3 ~~E10.3~~	Mixing heights (meters) for unstable and stable weather conditions, respectively. These heights must start on a new card.

Additional Card Input Required for Start Code 4:

Mnemonic	Format	Description
METEOR	12I5	Hourly weather data for 5 consecutive days. Use 10 cards with 12 entries per card. Each entry is a 5 digit integer: ijkkk where i is the rain indictor (0=no rain, 1 = rain) j is the stability class (1=A, 2=B, ..., 6=F) kkk is 10 times the windspeed (mi/hr). The data is read into the array METEOR as follows, ((METEOR(J,K), J=1,24), K=1,5).

Additional Card Input Required for Start Code 5:

Card	Columns	Mnemonic	Format	Description
1	1-5	NBIN	I5	Number of defined weather bins.
	5-10	NCON	I5	Number of trials to be selected from each bin. If NCON=0 the number of trials from each bin must be individually specified on the next set of cards.
2	1-60	IWGHT	12I5	Individual number of trials to be selected from each bin. The data is read into the array IWGHT as follows, (IWGHT(I), I=1, NBIN). Use as many cards as required.

Additional Card Input Required for Start Code 9:

Card	Column	Mnemonic	Format	Description
1	1-5	NSTAB	I5	Number of stability classes (max=6)
	6-10	NVEL	I5	Number of wind speeds (max=8)
	11-15	NRA	I5	2 if rain is being considered, 1 otherwise.
2	1-30	ISTA1	6I5	NSTAB stability classes (1=A, 2=B, ..., 6=F). The data is read into the array ISTA1 as follows, (ISTA1(I), I=1, NSTAB).
3	1-80	VEL1	8E10.3	NVEL wind speeds (meters/sec). The data is read into the array VEL1 as follows, (VEL1(I), I=1, NVEL).

Card	Column	Mnemonic	Format	Description
4	1-80	PMATRX	8E10.3	Cards 4 through 4+ (NSTAB*NVEL*NRA)/ 8 contain the probabilities for each combination of stability, wind speed, and rain/no rain. These val some of which may be zero, must add up to one. They are read into arra PMATRX as follows: (((PMATRX(I,J,K K=1, NRA), J=1, NVEL), I=1, NSTAB). The number of trials run will be equal to the number of non-zero values in array PMATRX.
Last	1-10	ZMAX(1)	E10.3	Mixing heights (meters) for unstabl and stable weather conditions, respectively.
	11-20	ZMAX(2)	E10.3	

No parameter modification is allowed for this subgroup.

Printed listing of the sample data for subgroup SITE is shown below:

3. Subgroup POPULATION - specifies the population option and the population sectors to be processed. Optionally, the population distribution around the site may be defined. This subgroup must be input after subgroup SPATIAL.

Sample input cards:

The NUM field, 1 in the sample header card above, specifies the total number of population sectors, NPB4, to be run. Up to 16 sectors are allowed. The population values to be input are the number of people in each area element of the 16 sectors. Note that the population must be defined for all 16 sectors even if less than 16 sectors are to be processed. This is necessary because the radioactive cloud may overlap sectors adjacent to the ones being processed. Specifying a sector to be run is essentially the same as saying that the midpoint of the cloud will travel in the direction defined by the radius bisecting the spacified sector.

After the header card, an options card with the following format must be supplied.

Column	Mnemonic	Format	Description
1-3	IPOPT	I3	Population option indicator. IPOPT=0 means the population data for 34 rings and 16 sectors are to be read in from the site data file. No further cards are required for this subgroup. IPOPT=1 means a uniform population density is to be read in on the next card. The description of the additional input follows. NPB4 is set to 1 for this option. IPOPT=2 means that for each sector, the sector probability and the population for each of the NSI rings are read from the cards that follow. The description of the additional input is below. IPOPT=3 means that for each sector, the sector probability and the population for each of the NSI rings are read along with the seasonal wind roses from the cards that follow. The description of the additional input is below. Note that the value of IPOPT should non-zero when variable IPO ≠ 0 in subgroup SITE and IPOPT should be zero when IPO is zero.
5-51	ISECNO	16I3	The sector numbers of the NPB4 sectors to be processed. If for example, NPB4=1 and ISECNO (1) = 8, only the 8th sector will be run. The data is read into the array ISECNO as (ISECNO(I), I = 1, NPB4). If ISECNO is not input,

Column	Mnemonic	Format	Description
			i.e., columns 4 through 51 are blank, or if $1 < ISECNO(I) > 16$, ISECNO(I) is set to I for I = 1 to NPB4.

When IPOPT=1, the following additional card is required:

Column	Mnemonic	Format	Description
1-10	POPDEN	E10.3	Population density (people per square mile).
11-15	IEXINT	I5	Exclusion intervals; the number of spatial intervals from which the population is excluded, counting from the accident site.

When IPOPT=2, additional cards are required consisting of 16 sets of population values, one for each of the 16 sectors with 1+NSI/8 cards per sector. A description of the data cards for each sector is presented below. The order of input of the 16 sets determines the sector number of the set.

Card	Column	Mnemonic	Format	Description
1	1-80	IDENT	20A4	Identification of the population data. It is stored in the array IDENT as (IDENT(J), J = 1, 20).
2	1-10	P(I,4)	E10.3	Probability associated with the wind blowing toward population sector I, i.e., the annual wind rose probability. The program automatically normalizes the probabilities.
	11-80	POP	7E10.3	Population values for the first seven of the NSI area elements in this sector starting with the element closest to the site. The remaining population values for this sector. There are eight values per card. Use as many cards as necessary to supply the remaining population values.

Card	Column	Mnemonic	Format	Description
3	1-80	POP	8E10.3	The population data is stored in the array POP as follows, (POP(I,K), K = 1, NSI), where I is the index of the sector.

The above set of cards is repeated for each of the 16 sectors, starting with a new card for each sector.

When IPOPT=3, additional cards are required for the sector population and seasonal wind rose data. The population data corresponds identically to that required for the IPOPT=2 option above. The wind rose data follows the population data and is required for each of the four seasons. One data card, which is described below, must be included for each seasonal wind rose. The wind rose data must appear in the order winter, spring, summer, fall.

Column	Mnemonic	Format	Description
1-80	ROSE	16F5.4	Wind rose probabilities for each sector for one season. Wind rose probabilities represent the wind blowing toward the sector. The data is read into the array ROSE as follows, (ROSE(K,I), K=1,16) where K is the sector index and I is the season index.

No parameter modification is allowed for this subgroup.

Printed listing of the sample data for subgroup POPULATION is shown below.

4. Subgroup TOPOGRAPHY - specifies the state code and land fraction for each area element of the spatial grid. This subgroup must be input after subgroup SPATIAL. This subgroup supplies the topographic data when no site data file is referenced or when no topographic data is requested from the site file.

Sample input cards:

The NUM field must either be 16 or zero for this subgroup. If it is 16, the state codes and land fraction are read in for each area element of the spatial grid (see subgroup SPATIAL). If it is zero, as in the example above, a single state code and land fraction is applied to the complete spatial grid.

If NUM=0, the following card is required:

Column	Mnemonic	Format	Description
1-3	LSTATE	I3	Two digit state code (number corresponding to order of states in subgroup ECONOMIC).

Column	Mnemonic	Format	Description
4-5	FRLAN	F2.1	Fraction of land multiplied by 10 (10 = 100%, 09 = 90%, etc.

If NUM=16, one set of cards for each of the 16 sectors, must be input according to the following format:

Columns	Mnemonic	Format	Description
1-3 4-5	ISTATE(J,1) FRLAND(J,1)	I3 F2.1	Two digit state code and fraction of land for first area element of sector J.
6-8 9-10	ISTATE(J,2) FRLAND(J,2)	I3 F2.1	State code and fraction of land for the second area element of sector J.
. .	. .	. .	
76-78 79-80	ISTATE(J,16) FRLAND(J,16)	I3 F2.1	State code and fraction of land for the sixteenth area element of sector J. The data is read into the pair of arrays ISTATE and FRLAND as follows: (ISTATE(J,K), FRLAND(J,K), K=1, NSI), where NSI is the number of spatial intervals. Each card contains the data for 16 area elements.

The above set of cards is repeated for each of the 16 sectors. Data for a new sector begins with a new card.

No parameter modification is allowed for this subgroup.

Printed listing of the sample data for subgroup TOPOGRAPHY is shown below.

5. Subgroup ECONOMIC - specifies the cost data used in computing economic effects.

<u>Sample input cards:</u>

The NUM field, 54 in the sample header card above, specifies the number of sites or geographic regions, NST, for which economic data is to be input. The indices of the arrays containing this economic data correspond to the order of the state and regional data in this subgroup. The state codes used in the subgroup TOPOGRAPHY must coincide with these indices. If the topography is read from the site data file, economic data must be supplied for 54 regions (the 48 continental states plus Nova Scotia, Quebec, Ontario, Baja California, Sonora, and Chihuahua), as given in the sample data. A maximum of 54 geographical regions may be input.

One card having the following format must be input after the header card.

Columns	Mnemonic	Format	Description
1-10	DCFLD	E10.2	Decontamination cost for farm areas ($/acre).
11-20	DCRBP	E10.2	Decontamination cost for residential, business, and public areas ($/person).
21-30	RATE	E10.2	Compensation rate per year for residential, business, and public areas (fraction of value).
31-34	VRBP	E10.2	Value of residential, business, and public areas ($/person).
41-50	CRELOC	E10.2	Relocation cost ($/person).
51-60	CONMLK	E10.2	Cost of milk consumption ($/person).
61-70	CONCRP	E10.2	Cost of non-dairy products consumed ($/person).

After the above card, one card must be input for each of the NST regions. The format of each of the region cards is described below.

Columns	Mnemonic	Format	Description
1-8	STATE(I)	A8	Name of state or region.
11-15	MONST(I)	I5	Seeding month for state.
16-20	MONEND(I)	I5	Harvesting month for state.
21-30	FARML(I)	E10.2	Fraction of land devoted to farming for state.
31-40	DPF(I)	E10.2	Fraction of farm sales resulting from dairy production for state.
41-50	ASFP(I)	E10.2	Annual average farm sales for state ($/acre).
51-60	VFARM(I)	E10.2	Average farm land value for state ($/acre).

The index I corresponds to the order of the states and regions in this subgroup.

No parameter modification is allowed for this subgroup.

Printed listing of the sample data for subgroup ECONOMIC is shown below.

6. Subgroup ISOTOPE - specifies the isotope inventory and associated parameters.

Sample input cards:

The NUM field, 54 in the sample header above, specifies the total number of isotopes, NIS, in the inventory. A maximum of 54 isotopes can be specified. NIS cards, one for each isotope, must be input following the header card. One isotope and its associated parameters are defined on each card. The format for each isotope card is described below.

Columns	Mnemonic	Format	Description
1-8	NAME(I)	A8	Isotope name (left justified).
10	IGRP(I)	I1	Index of the isotope leakage group for this isotope (see subgroup LEAKAGE).

Columns	Mnemonic	Format	Description
12-19	PARENT(I)	A8	Name of parent (left justified). The parent must be among the NIS isotopes in the inventory.
21-30	SACT(I)	E10.3	Amount of the isotope present in the core at the time of the accident (curies).
31-40	HALF(I)	E10.3	Half-life (days).
41-50	VD(I)	E10.3	Deposition velocity (m/sec).
51-60	RLAM(I)	E10.3	Rain coefficient C in the $\{sec^{-1} (mm/hr)^{-1}\}$ washout coefficient λ = CR of the rain depletion equation.

The index I corresponds to the order of the isotopes in the inventory list. The isotope and parent names must be spelled exactly as shown in Table II-2 below. Only the 54 isotopes given in this this table may be used.

Table II-2. List of Valid Isotopes

1	CO-58	28	SB-127
2	CO-60	29	SB-129
3	KR-85	30	I-131
4	KR-85M	31	I-132
5	KR-87	32	I-133
6	KR-88	33	I-134
7	RB-86	34	I-135
8	SR-89	35	XE-133
9	SR-90	36	XE-135
10	SR-91	37	CS-134
11	Y-90	38	CS-136
12	Y-91	39	CS-137
13	ZR-95	40	BA-140
14	ZR-97	41	LA-140
15	NM-95	42	CE-141
[illegible]	MO-99	43	CE-143
[illegible]	TC-99M	44	CE-144
[illegible]	RU-103	45	PR-143
[illegible]	RU-105	46	ND-147
[illegible]	RU-106	47	NP-239
21	RH-105	48	PU-238
22	TE-127	49	PU-239
23	TE-127M	50	PU-240
26	TE-131M	53	CM-242
27	TE-132	54	CM-244
24	TE-129	51	PU-241
25	TE-129M	52	AM-241
26	TE-131M	53	CM-242
27	TE132	54	CM-244

If parameter modification (PARMOD = "YES") is specified in the header, the following card is required between the header and isotope cards.

Columns	Mnemonic	Format	Description
1-10	CSACT	E10.3	Multiplier for SACT(I), I = 1, NIS.
11-20	CVD	E10.3	Multiplier for VD(I), I = 1, NIS.
21-30	CRLAM	E10.3	Multipler for RLAM(I), I = 1, NIS.

The printed listing of the sample data for subgroup ISOTOPE is shown below.

7. Subgroup LEAKAGE - specifies the accident identification, the associated accident parameters, and the percentage of the total core inventory which is released for each isotope leakage group. This subgroup must be input after subgroup ISOTOPE.

Sample input cards:

The NUM field, 15 in the sample header card above, indicates the total number of leakage categories, NPB2, to be evaluated. A maximum of 15 release categories can be specified. The set of data cards for one leakage category is presented below. There are NPB2 sets of cards in the complete subgroup, with (1+NGRP)/8+1 cards per set. NGRP is the number of isotope leakage groups, i.e., the number of groups of isotopes having the same leakage fraction. NGRP is the maximum value of IGRP for the isotopes input by the ISOTOPE subgroup.

Card 1 in the set identifies the accident and specifies the associated accident parameters.

Column	Mnemonic	Format	Description
1-8	LNAME(J)	A8	Name of accident or release category.
11-20	P(J,2)	E10.3	The probability associated with this accident. The program will automatically normalize the probabilities if more than one release category is input.
21-30	TL(J)	E10.3	Time between either shutdown or core melt and release into the atmosphere (hours). Used for isotope decay.
31-40	DR(J)	E10.3	Duration of release (hours). This parameter is used to compute the cloud expansion factor, EF where $EF(J) = (DR(J)/.05)^Q$. Q is defined as .2 for $DR(J) \leq 1$ .25 for $DR(J) \geq 1$.
41-50	TLL(J)	E10.3	Warning time to evacuate before release into atmosphere (hours), used in evacuation modeling.
51-60	FPR(J)	E10.3	Sensible heat rate (calories/sec) due to thermal heat of the released gases. Used in plume rise calculation.
61-70	RH(J)	E10.3	Release height of plume (meters). If the release height is less than the building height, the plume is assumed to be entrained in the building wake and the release height is set to ground level.

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The remaining cards in the set define the leakage fractions for each of the accident leakage groups.

Column	Mnemonic	Format	Description
1-80	FLEAK	8E10.3	Fraction of each isotope group to be released into atmosphere. No more than 10 isotope leakage groups can be defined. The leakage fraction data is read into the array FLEAK as follows, (FLEAK(J,I), I=1, NGRP).

The above set of cards must be repeated for each leakage category. The index J corresponds to the order of the leakage categories in this subgroup.

If parameter modification (PARMOD = "YES") is specified, the following card is required after the header card:

Column	Mnemonic	Format	Description
1-10	CTL	E10.3	Multiplier for TL(I), I = 1, NPB2
11-20	CEF	E10.3	Multiplier for EF(I), I = 1, NPB2
21-30	CTLL	E10.3	Multiplier for TLL(I), I = 1, NPB2
31-40	CFQR	E10.3	Multiplier for FPR(I), I = 1, NPB2
41-50	CRH	E10.3	Multiplier for RH(I), I = 1, NPB2

The printed listing of the sample data for subgroup LEAKAGE is shown below.

8. Subgroup DISPERSION - specifies the reactor building dimensions and the special wake and rain depletion options.

Sample input cards:

The NUM field is ignored for this subgroup. One card with the format described below must be input following the header card:

Column	Mnemonic	Format	Description
1-10	BUILDL	E10.3	Reactor building length (meters).
11-20	BUILDH	E10.3	Reactor building height (meters).
21-25	MWAKE	I5	Number of spatial intervals for special effects of a wake dominated plume. For no wake dominated plume, set MWAKE = 0.
26-30	LIRAIN	I5	Rain option switch. 0 - observed rain, i.e., the hourly rain data from the meteorological information. 1 - rainfall ignored, i.e., all rain information in the meteorological data is ignored.

Column	Mnemonic	Format	Description
			2 - incident rain, i.e., an hourly rainfall rate of .5 mm/hr is substituted for all hours of rainfall in the meteorological information.
31-35	IRDEPL	I5	Rain depletion switch.
			34 - The radius of the 34th spatial interval is redefined to be 2000 miles. The average population density for the U.S. of 78 people per square mile is assumed for this area. The activity left in the cloud is depleted in this interval by incident rain. 79
			0 - Unaltered depletion model.

The printed listing of the sample data for subgroup DISPERSION is shown below.

9. Subgroup EVACUATE - specifies the emergency action data, including the choice of evacuation model and the constants for sheltering, shielding and evacuation.

Sample Input Cards:

The NUM field, 6 in the sample header card above, specifies the number of evacuation strategies, NEVAC, to be defined. No more than six strategies are allowed. The weighted evacuation scenario is the weighted sum of the strategies. The impact of each evacuation strategy on early effects consequences is evaluated. In addition, the impact on early effects consequences for the weighted evacuation scenario is evaluated. The impact of evacuation on the latent effects and evacuation costs is based on the emergency action data defined in the last evacuation strategy.

Following the header card, one card corresponding to each evacuation strategy is required. The format of each strategy card is described below.

Column	Mnemonic	Format	Description
1-10	EVCON(1,J)	E10.3	Probability of evacuation with strategy J in the weighted evacuation scenario.
11-20	EVCON(2,J)	E10.3	Time delay ~~between officially being warned and beginning evacuation~~ before population begins actually evacuating (moving) (hours).
21-30	EVCON(3,J)	E10.3	Evacuation speed (meters/sec)
31-40	EDIST(J) ~~EVCON(4,J)~~	E10.3	Maximum evacuation distance for downwind sectors (~~meters~~ intervals). Spatial intervals laying within this distance will be evacuated according to the evacuation scheme specified in EVCON(7,J). People's exposure to air and ground contamination will depend on the scheme selected. People living in spatial intervals beyond this distance will be exposed to ground contamination for either 1 or 7 days. The exposure model is determined by the switch IEXPD.
41-50	EVCON(5,J)	E10.3	End of evacuation distance for evacuees (meters). Distance from the accident site at which evacuees complete their evacuation.
51-60	SDIST(J) ~~EVCON(6,J)~~	E10.3	Maximum sheltering distance for downwind sectors (~~meters~~ intervals). People living in sectors lying within this distance will be sheltered if they do not evacuate. The maximum sheltering distance cannot be less than the maximum evacuation distance.
61-70	EVCON(7,J)	E10.3	Evacuation model option: 1.0 - constant velocity evacuation model (WASH-1400 model) 2.0 - detailed tracking of evacuees, allowing for delay, shelter, and movement of the evacuee.

This evacuation card corresponds to evacuation scheme J.

The shielding data, breathing rate data, evacuation cost data, and duration of exposure switch do not change between evacuation strategies. These data are read from the three cards which follow the evaucation strategy cards. The format of these cards is described below.

Card	Column	Mnemonic	Format	Description
1	1-10	SHFAC(1,1)	E10.3	Cloud shielding for stationary evacuees (effectiveness factor (multiplier) between 0 and 1).
	11-20	SHFAC(2,1)	E10.3	Cloud shielding for moving evacuees (effectiveness factor between 0 and 1).
	21-30	SHFAC(3,1)	E10.3	Cloud shielding with sheltering (effectivness factor between 0 and 1).
	31-40	SHFAC(4,1)	E10.3	Cloud shielding with no emergency action (effectivness factor between 0 and 1).
	41-50	SHFAC(1,2)	E10.3	Ground shielding for stationary evacuees (effectiveness factor between 0 and 1).
	51-60	SHFAC(2,2)	E10.3	Ground shielding for moving evacuees (effectivness factor between 0 and 1).
	61-70	SHFAC(3,2)	E10.3	Ground shielding with sheltering (effectivness factor between 0 and 1).
	71-80	SHFAC(4,2)	E10.3	Ground shielding with no emergency action (effectivness factor between 0 and 1).
2	1-10	BRATE(1)	E10.3	Breathing rate for stationary evacuees (cubic meters/sec).
	11-20	BRATE(2)	E10.3	Breathing rate for moving evacuees (cubic meters/sec).
	21-30	BRATE(3)	E10.3	Breathing rate with sheltering (cubic meters/sec).
	31-40	BRATE(4)	E10.3	Breathing rate with no emergency action (cubic meters/sec).
3	1-10	EVCOST(1)	E10.3	Radius of circular evacuated area near the reactor (meters).
	11-20	EVCOST(2)	E10.3	~~Width~~ Angle of evacuation arc for downwind sectors (degrees).
	21-30	EVCOST(3)	E10.3	Direct evacuation cost (dollars per evacuee per day).

Card	Columns	Mnemonic	Format	Description
	31-40	EVCOST(4)	E10.3	Maximum release duration (hours) for which the keyhole shaped evacuation model is to be applied.
	41-45	IEXPD	I5	Duration of exposure switch: 0 - People in the non-evacuating intervals will be relocated after 24 hours. 1 - People in the non-evacuating interval will be relocated after 7 days. But if the 7-day whole body dose approaches leathal levels (200 rem), relocation occurs at 24 hours. - Explicit exposure time

No parameter modification is allowed for this subgroup.

The printed listing of the sample data for subgroup EVACUATE is shown below.

10. Subgroup ACUTE - specifies the acute effects from early exposure to the radioactive cloud that are to be studied and the supporting dose - mortality and injury data for each organ.

Sample input cards:

The NUM field, 6 in the example header above, specifies the total number of acute health effects, NEARLY, to be studied. Up to 8 acute effects are permitted. After the header card, one card with the following format must be input for each acute effect.

Columns	Mnemonic	Format	Description
1-8	ERLORG(I)	A8	Affected organ name. This name must be one of the 13 organs listed in Table II-3, which follows.
11-50	DL	4E10.3	Four dose limit values (rems). The dose values for effect I are read into the array DL as (DL(J,I), J =1,4). DL(1,I) is the threshold below which the probability of the effect is zero. DL(4,I) is the dose value above which

Columns	Mnemonic	Format	Description
			the probability of the effect is 1. DL(2,I) and DL(3,I) are intermediate values with corresponding probabilities given by PL(1,I) and PL(2,I) respectively. The model linearly interpolates in the table to determine the probability of the effect. Arrays DL and PL together specify the probability of the given effect over the entire dose range. The early exposure model assumes that the points described by DL and PL are connected by straight lines; see the Figure II-1 below.
51-70	PL	2E10.3	Two probabilities corresponding to the intermediate dose limits in array DL. See the description of DL above. The data for effect J is read into the aray PL as (PL(J,I), J=1,2).
71-80	FATFAC(I)	E10.3	Mortality factor: 0.0 means no fatalities, i.e., the health effect or injury is a non-fatal illness; 1.0 means everyone with this health effect dies; intermediate values mean that the given fraction of the people with this acute effect die and the rest survive.

No parameter modification is permitted for subgroup ACUTE.

Figure II-1. Dose Effectiveness Model

Table II-3

Organ Name		Definition
1.	LUNG	Lungs
2.	T MARROW	Total bone marrow
3.	SKELETON	Skeletal bone
4.	T E C L	Total endosteal cells (interior bone surface)
5.	ST WALL	Stomach wall
6.	SI+CONT	Small intestine and contents
7.	SUL WALL	Upper large intestine wall
8.	LLI WALL	Lower large intestine wall
9.	THYROID	Thyroid
10.	OTHER	Tissues other than lungs, skeleton, stomach bone marrow, walls of G.I. track, and thyroid
11.	W BODY	Whole body
12.	TESTES	Testes
13.	OVARIES	Ovaries

The printed listing of the sample data for subgroup ACUTE is shown below.

11. Subgroup LATENT - specifies the latent effects from early exposure to the radioactive cloud and chronic exposure to the ground contamination that are to be studied, the supporting man rem conversion factors, and the choice of latent effects model.

Sample input cards:

The NUM field, 7 in the sample header card above, specifies the number of latent effects from radiation exposure, NLA, to be studied. Up to 8 latent effects are permitted.

Following the header card, an options card with the format described below is required. The last four items of data on the card are required only when the central estimate option has been requested.

Column	Mnemonic	Format	Description
1-5	INTIME	I5	Number of time periods to be used for computing latent effects from radiation exposure, normally 10.
6-7	CENT	A2	Latent effects model switch. Blank - the linear hypothesis or BEIR method will be used for estimating latent effects. CE - the "Central Estimate" method will be used for estimating latent effects. The remaining data fields on this card apply only to the CE option.
16-25	THRESH(1)	E10.3	First threshold (in rem) for central estimate.
26-35	FACT(1)	E10.3	Dose effectiveness factor applied to doses below THRES(1) for central estimate.
36-45	THRESH(2)	E10.3	Second threshold (rems) for central estimate.
46-55	FACT(2)	E10.3	Dose effectivness factor applied to doses between THRESH(1) and THRESH(2) for central estimate.

Following the latent effects option card, two cards with the format described below must be input for each latent effect.

Card	Columns	Mnemonic	Format	Description
1	1-8	LAORG(I)	A8	Affected organ name. This name must be one of the 13 organs listed in Table II-3.
	11-18	LAEFF(I)	A8	Name of the latent effect, e.g., "CANCER," "LEUKEMIA," etc. This field is used to identify the latent effect.
	21-80	MRCON	6E10.3	Manrem conversion factors for time periods 1 through 6 periods. The man rem data from this card is read into the array MRCON as (MRCON(I,K), K=1,6).

Card	Columns	Mnemonic	Format	Description
				The 10 time periods are 1, 1-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-80, and 80 years. The program multiplies the number of manrem for organ I and time period K by MRCON(I,K) to get the number of latent effects for that organ and time period.
2	1-40	MRCON	4E10.3	The manrem conversion factors for time periods 7 through 10. The manrem data from this card is read into the array MRCON as (MRCON(I,K), K=7,10).
				For time period K, following the exposure, these conversion factors account for changes, with time, of the exposed population distribution only.
	41-50	ORGFAC(I)	E10.3	Central estimate organ compensation factor. Dose effectiveness factors are applied to the organ dose only if the organ compensation factor times the organ dose is less than the central estimate thresholds.

No parameter modification is permitted for subgroup LATENT.

The printed listing of the sample data for subgroup LATENT is shown below.

12. Subgroup CHRONIC - reads the data used in computing radiation doses from chronic exposure and the protective action measures appropriate to the level of chronic exposure.

Sample input cards:

The NUM field, 6 in the sample header card above, specifies the number of exposure pathways to be considered, NEXP, when determining maximum acceptable chronic dose levels. To function properly, the program requires exactly six exposure pathways to be defined. After the header card, six sets of cards are required, one set for each pathway. In general, the data for the six exposure pathways should be used as it appears in the sample data. The number of isotopes in each set and the values of the variables may be changed, but the general format including the number of sets and set ordering (1-inhalation of resuspended particles, 2-ingestion of exposed crops, 3-ingestion of milk products, 4-ingestion of milk, 5-ingestion of crops contaminated via root uptake, and 6-exposure to contaminated ground) must not be altered. The format of the six sets is described below.

Card 1 for exposure pathway I.

Columns	Mnemonic	Format	Description
1-5	NIE(I)	I5	Number of isotopes to be considered for the exposure pathway.
6-10	NCRIT(I)	I5	Organ number (index) of the critical organ for this exposure path (see Table II-3).
11-20	PROFAC(I)	E10.3	Protection factor in the exposure mechanism, e.g., for external gamma radiation - shielding factor between 0.0 and 1.0.
21-30	DAYS1(I)	E10.3	Integration time for computing maximum allowable dose RDLIM(I,1) (not used).
31-40	DAYS2(I)	E10.3	Integration time for computing maximum allowable lifetime dose RDLIM(I,2)
41-50	TAGE(I)	E10.3	Weathering half-life in days for isotopes in this exposure pathway.
51-60	RDLIM(I,1)	E10.3	Radiation exposure limit in rem corresponding to DAYS1(I) (not used).
61-70	RDLIM(I,2)	E10.3	Radiation exposure limit in rem corresponding to DAYS2(I).

After card 1, enter NIE(I) sets of cards as described below. The index I represents the exposure pathway index J represents the isotope index, where J = 1, NIE(I).

Card Type A:

Columns	Mnemonic	Format	Description
1-8	NUCLID(I,J)	A8	Isotope name (must be one of the isotopes entered in the ISOTOPE subgroup).
11-20	CF(I,J,1)	E10.3	Concentration factor relating ground contamination level to total human intake of the isotope from crops ($ci/ci/m^2$). Omit for exposure pathway 6.
21-30	CF(I,J,2)	E10.3	Concentration factor relating ground contamination level to total human intake of the isotope from milk ($ci/ci/m^2$). Omit for exposure pathway 6.

For exposure paths 2-5 only, follow each card A with 13 cards one for each organ in Table II-3, each card having the following format (the 13 cards must be in the order of the organs in Table II-3):

Card Type B:

Columns	Mnemonic	Format	Description
1-8	-	8	Organ name
11-20	CSING (pathway 2) or SRING (pathway 3) or RIING (pathway 4) or RTING (pathway 5)	6E10.3	Ingestion dose conversion factors for six time periods, following exposure, (0-10, 10-20, 20-30, 30-40, 40-50, 50 years) for the named organ and current isotope. The data is stored in the arrays CSING, SRING, RIING, RTING as the pathway represent crops, milk products, milk and roots respectively. The data is read as (CSING(J,N,L), L=1,6) for the crops pathway, where J is the isotope index, N the organ or index, and L the time period index.
21-30			
31-40			
41-50			
51-60			
61-70			

Repeat the set of cards consisting of one A card and 13 cards (omit the B cards for pathways 1 and 6) for each isotope considered under the exposure pathway.

No parameter modification is permitted for subgroup CHRONIC.

The printed listing of the sample data for subgroup CHRONIC is shown below.

13. Subgroup SCALE - specifies the scaling magnitude values for tabulating the complementary cumulative distributions of the final results.

Sample input cards:

The NUM field, 36 in the sample header above, specifies the number of final result magnitudes, NCT, to be used. Up to 40 values are allowed. The values are input according to the following format:

Column	Mnemonic	Format	Description
1-10	AMAG	8E10.3	Consequence magnitude values. The values are stored in the array AMAG as (AMAG(I), I=1, NCT). Each card contains eight values. Use as many cards as required.

If parameter modification (PARMOD = "YES") is specified, the following card is required after the header card.

Column	Mnemonic	Format	Description
1-10	CAMAG	E10.3	Multiplier for the consequence magnitude values, (AMAG(I), I=1, NCT).

The printed listing of the sample data for subgroup SCALE is shown below.

peak value (maximum value of the total results), probability and identification of the peak value

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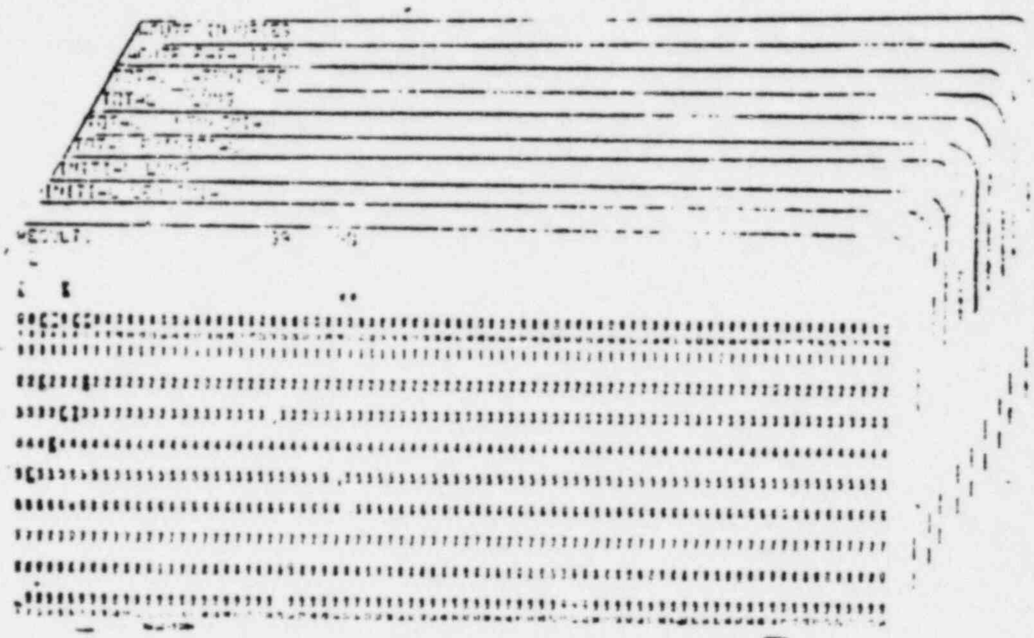
14. Subgroup RESULTS ~~(mandatory)~~ - specifies the ~~consequences~~ final results for which the ~~moments~~ {mean, variance, ~~third, and fourth~~} and complementary cumulative distribution are to be computed and printed.

Sample input cards:



The NUM field ~~(39)~~ 84 in the sample header above, ordinarily indicates the number, NRES, of final results or consequences to be included in the output ~~(NRES)~~ when NROPT has the value 0. A maximum of ~~39~~ 84 final results are allowed with this option. ~~If NROPT (see below) >0,~~ For all other options the NUM field is ignored as defined by NROPT.

One card having the following format must be input after the header card for all options.

Column	Mnemonic	Format	Description
1-5	NROPT	I5	Final results option ~~where~~ 0 - ~~means that the NUM field gives~~ The number of final results computed and printed is given by NRES. ~~consequences to be included in the output.~~ The names of the final results must be supplied on subsequent cards described below. 1 - ~~means that~~ Print acute fatalities vs. distance from the reactor and number of people vs. dose to the ~~a specified~~ organ named in NORGAN is printed. No additional cards are required.

Column	Mnemonic	Format	Description
			2 - means that latent effects vs. distance from the reactor is printed. No additional cards are necessary. 3 - means radioactive cloud area vs. distance from the reactor is printed. No additional cards are necessary. 4 - means decontamination factor vs. distance from the reactor, and the size of the interdiction areas are printed. No additional cards are necessary. 5 - means that dose to organ ORGNAM vs distance from the reactor is printed. No additional cards are necessary.
6-13	ORGNAM	A8	Organ name for people vs. dose and dose vs. distance options. Used only if NROPT=1 or 5. The allowable organ names are listed in Table II-3. The name must be spelled exactly as in the table. For NROPT=1, the default value is W BODY, for NROPT=5, the default value is T MARROW.
16-20	IORGTM	I5	Index of the latest time period over which the dose to organ ORGNAM is to be summed where 1= acute time period, 2=1 yr, 3=1-10 yrs, 4=10-20 yrs, 5=20-30 yrs, 6=30-40 yrs, 7=40-50 yrs, 8=50-60 yrs, 9=60-70 yrs, 10=70-80 yrs, 11=>80 yrs. Used only when NROPT=1 or 5. For NROPT=1, the default value is 1, for NROPT=5, the default value is 11.
21-25	NSCALE	I5	Number of dose values in DSCALE (≤10). Used only when NROPT=1. Default value=8.
26-30 31-35 . . . 71-75	DSCALE	10F5.0	Up to 10 dose values in increasing order. When NROPT=1, the number of people receiving a dose to organ ORGNAM for the intervals defined by the values in array DSCALE are reported in the final results. Default values are 0, 1, 10, 25, 100, 320, 400 and 615.
76-80	SCALE	F5.0	Multiplier for the consequence magnitude values (see subgroup SCALE).

insert on next page

When NROPT=0, the NUM field on the header card specifies the number of final results (NRES) to be printed. In this case, NRES cards with the following format must be input. The index of the final result names is represented by K.

The additional data required for the case when NROPT=0 must immediately follow this card.

Additional Card Input Required for NROPEO

Insert from previous page

Columns	Mnemonic	Format	Description
1-16	RESNAM(I,K), I=1,2	2A8	One of the 89 allowable 16 character final result names listed on table ... Result names of the form "TOTAL ..." and "INITIAL ..." are valid only if the ... is one of those input in subgroup ... The names must be spelled exactly as in the table. The order of the result name cards determines the order that the results will appear in the output.
21-30	RESFAC(K)	E10.3	Scaling factor by which the named final result is to be multiplied.
31-40	RSCALE(K)	E10.3	Scaling multiplier for the consequence magnitude values (see subgroup SCALE) for the named final result.

No parameter modification is permitted for this subgroup

A printed listing of the sample data for subgroup RESULTS is shown below.

TABLE II-4

Result Name	Result Description
ACUTE FATALITIES	Number of acute fatalities occurring within one year due to initial exposure to the radioactive cloud (ie., mortalities occurring due to damage to the organs input in subgroup ACUTE).
ACUTE INJURIES	Number of acute injuries or illnesses occurring with one year due to initial exposure to the radioactive cloud (ie., morbidities occurring due to damage to the organs input in subgroup ACUTE).
POP W/BMR>DS 200	Number of people with an acute bone marrow dose greater than 200 rems. Includes people counted as acute fatalities.
RSK OF FAT- 1MI - 2MI - 5MI - 10MI	Risk of incurring a fatality within one year due to initial exposure to the radioactive cloud in a distance interval whose outer bound is the distance specified.
FATAL RADIUS (MI)	Greatest distance (in miles) from the reactor at which acute fatalities occur.
RSK OF INJ- 1MI - 10MI - 20MI - 30MI - 50MI	Risk of incurring an injury or illness within one year due to initial exposure to the radioactive cloud in a distance interval whose outer bound is the "distance" specified.
INJUR RADIUS (MI)	Greatest distance (in miles) from the reactor at which acute injuries occur.
ACU BMR DS- 1MI - 5MI - 10MI - 20MI - 30MI - 50MI	Acute bone marrow dose (rems) due to initial exposure to the radioactive cloud in the distance interval whose outer bound is the "distance" specified.
ACU THY DS- 1MI - 5MI - 10MI - 20MI - 30MI - 50MI -100MI	Acute thyroid dose (rems) due to initial exposure to the radioactive cloud in the distance interval whose outer bound is the "distance" specified.
TOT LAT/INITIAL	Total latent effects occurring due to initial exposure to the radioactive cloud (i.e., sum of the effects from all organs input in subgroup LATENT except for thyroid and whole body).

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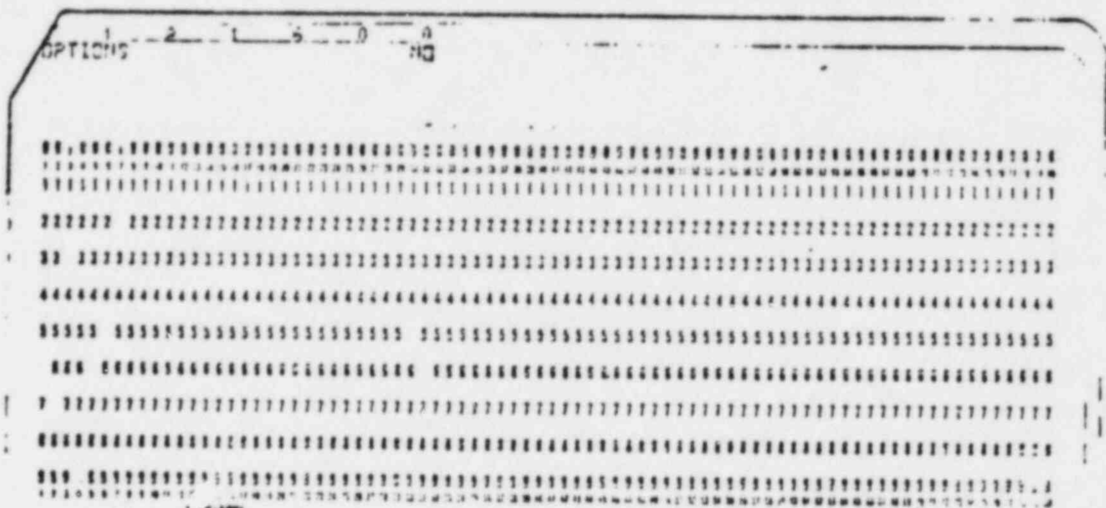
Result Name	Result Description
TOT LAT/TOTAL	Total latent effects occurring due to both initial and chronic exposure (i.e., sum of the effects from all organs input in subgroup LATENT except for thyroid and whole body).
WBODY MANREM	Whole body population dose (i.e., sum of the (number of people exposed) x (whole body dose received) at each dose level).
CANCER RSK - 1 MI - 10 MI - 20 MI - 30 MI - 50 MI - 100 MI	Risk of incurring cancer due to initial exposure to the radioactive cloud in the distance interval whose outer bound is the distance specified, (i.e., sum of the risks from all organs input in subgroup LATENT except for whole body and thyroid).
INITIAL # (latent effect)	Number of specified "latent effects" incurred due to initial exposure to the radioactive cloud. The latent effect must be specified in subgroup LATENT.
TOTAL # (latent effect)	Number of specified "latent effects" incurred due to both initial and chronic exposure. The latent effect must be specified in subgroup LATENT.
INTERD POP	Number of people occupying the area which is permanently interdicted (greater than 30 years).
INTERD COST	Cost (1980 dollars) of permanent land interdiction, (i.e., sum of both the land interdiction cost with decontamination and the relocation cost with decontamination).
INTERD AREA	Total land area (square miles) from which people are permanently interdicted (>30 years).
INTERD DIST	Maximum distance (miles) from the reactor at which land is permanently interdicted (greater than 30 years).
INTERD RSK- 10MI - 30MI - 50MI	Risk of permanently interdicting land in the distance interval whose outer bound is the distance specified.
DECON POP	Number of people occupying the area which may be decontaminated within a period of 30 years.
DECON COST	Cost of recovery of land contaminated above limits for occupancy but below limits for permanent interdiction (1980 dollars).
DECON AREA	Total land area (square miles) from which people are temporarily interdicted (less than 30 years).

Result Name	Result Description
DECON DIST	Maximum distance (miles) from the reactor at which land is temporarily interdicted (less than 30 years).
DECON RISK- 10MI - 50MI -100MI	Risk of temporarily interdicting land in the distance interval whose outer bound is the distance specified.
INT CROP COST	Cost of disposal of contaminated crops (1980 dollars).
INT CROP AREA	Total land area (square miles) in which only crops are interdicted.
INT CRPRSK- 10MI - 50MI -100MI -200MI	Risk of interdicting crops in the distance interval whose outer bound is the distance specified.
INT MILK COST	Cost of disposal of contaminated milk (1980 dollars).
INT MILK AREA	Total land area (square miles) for the interdiction of milk only.
INT MILK DIST	Maximum distance (miles) from the reactor at which milk is interdicted.
INT MLKRSK- 10MI	Risk of interdiction milk in the distance interval whose outer bound is the distance specified.
RELOCATION COST	Cost of relocating people occupying the permanently interdicted area (1980 dollars).
EVACUATION COST	Cost of evacuating people according to the last evacuation scheme specified in subgroup EVACUATE (1980 dollars).
TOT COST W/O DEC	Total cost without decontamination (ie., sum of evacuation, agricultural, interdiction, and relocation costs assuming no decontamination procedures take place (1980 dollars)).
TOT COST W/DECON	Total cost with decontamination (ie., sum of evacuation, agricultural, decontamination, interdiction, and relocation costs assuming that decontamination procedures take place (1980 dollars)).

and options to bypass normalization of probabilities and to skip the latent and chronic calculations.

15. Subgroup OPTIONS (mandatory) - specifies the print options for detailed output.

Sample input cards:



The NUM field is ~~ignored for~~ not used by this subgroup. One card having the format described below must be input after the header card.

Column	Mnemonic	Format	Description
1-5	NPL	I5	(see NPL insert) ~~If NPL>0, detailed output showing interdiction and decontamination parameters is printed for each spatial interval in [illegible].~~
6-10	NPD	I5	(see NPD insert) ~~If NPD>0, detailed output showing the [illegible] of the radioactive cloud at [illegible] is printed in [illegible].~~
11-15	NPH	I5	(see NPH insert) ~~If NPH>0, detailed output showing the doses and number of acute effects from early exposure to the radioactive cloud is printed in subroutine EARLY. If NPH>1, detailed output showing the doses and number of latent effects from early exposure to the radioactive cloud at each spatial interval is printed in subroutine EARLY. If NPH>2, detailed output showing the doses and and number of latent effects from chronic exposure at each spatial interval is printed in subroutine [illegible].~~

A complete account of the options for the detailed output together with examples of the output is included in the Output discription of Section II.

16-20	NPP	I5	see NPP manual. If NPP>0, the consequence values computed for each trial are printed.
21-25	NPA	I5	see NPA manual. If NPA>0, the initial activity of each isotope at the time of release is printed in subroutine ACTIVE. If NPA>1, the air concentration for each isotope at each spatial interval is printed in subroutine ACTIVE.
26-30	NRE	I5	see NRE manual. If NRE>0, the population and topography data (if any) read from the site data file is printed in subroutine SITE. If NRE>1, cost and economic effects data for each spatial interval is printed in subroutine PROPAM.

No parameter modification is allowed for this subgroup.

A printed listing of the Sample data for subgroup OPTIONS is shown in the print below.

```
SUBGROUP OPTIONS
PARAMETER        SET TO   0

            * * * INPUT PRINT OPTIONS * * *

NPL=0 OR 1          PRINT OPTION FOR INTERDICT. & DECON.                 0
NPD=0 OR 1          PRINT OPTION FOR DISPERSION                          0
NPH=0.1.2.OR 3      PRINT OPTION FOR HEALTH EFFECTS                      0
NPP=0 OR 1          PRINT OPTION FOR TRIAL RESULTS                       0
NPA=0.1. OR 2       PRINT OPTION FOR ACTIVITY & AIR CONC.                0
NRE=0.1. OR 2       PRINT OPTION FOR ECONOMIC COSTS                      0
```

31-35 NORM I5 Switch to skip the normalization of the leakage category and population sector direction probabilities.

NORM=0 normalize Probabilities

NORM>0 Do not normalize probabilities

36-40 NLC I5 Switch to bypass the latent and chronic calculations

NLC=0 Perform latent and chronic calculations

NLC>0 skip the calculation of total health effects and property damage

NLC=1 Skip the chronic exposure calculations.

NLC=2 Skip the latent and chronic calculations.

III

NPL insert

Output option switch to control the detailed printing of interdiction, decontamination, chronic dose commitment, and evacuation data.

NPL≤0 No detailed print.

NPL=1 Print interdiction and decontamination data by spatial interval

NPL=2 Print chronic dose commitment by spatial interval.

NPL≥3 Print detailed evacuation data by spatial interval.

NPD insert

Output option to control the detailed printing of dispersion data by spatial interval

NPD≤0 No detailed print.

1≤NPD≤2 Print trial identification and dispersion data

NPD≥3 Print trial identification and the sum of the released inventory.

JTK

NPH insert

Output option to control the detailed printing of organ dose and health effects data by spatial interval.

NPH ≤ 0 No detailed print.

NPH ≥ 0 Print acute effects from early exposure.

NPH > 1 Print latent effects from early exposure.

NPH > 2 Print latent effects from chronic exposure.

NPP insert

Output option to control the printing of the contribution to the final result values from each trial and to delete the printing of the frequency distributions of the final results.

NPP < 0 Delete printing of the frequency distributions of the final results.

NPP > 0 Print the contribution to the individual and societal results for each trial.

JTK

NPA insert — Output option to control the detailed printing of isotope activity at the time of release and isotope air concentration in each spatial interval.

NPA ≤ 0 No detailed print.

NPA > 0 Print the activity at the time of release for each isotope.

NPA > 1 Print the air concentrations for each isotope within each spatial interval.

NRE insert — Output option to control the printing of the data from the site data file cost and economic effects data by spatial interval.

NRE = 0 No detailed print.

NRE ≠ 0 Print the population and topographical data requested from the site data file

NRE ≥ 2 Print the cost and economic effects data for each spatial interval.

6. END Card

The end card is used to terminate the reference case and each successive change case in the input data. The card is aphanumeric and contains the word "END" punched in ~~col~~ columns 1 through 3.

Columns	Contents
1 – 3	END

An end card must appear as the last card of the reference case and of each change case.

IV. FILE DESCRIPTION

The following data files are used in the CRAC2 code.

1. File 5 (program variable NIT) Standard input file

   Standard input file supplied by the user (normally cards). Contains input subgroups necessary to run one or more consequence studies (cases).

   File format: 80 character logical records

   File contents: See previous sections for a detailed description of the input data.

2. File 6 (program variable NOT) Standard output file

   Standard output file (normally the printer)

   File format: 133 character logical records

   File contents: All output produced by the model except error messages which are written using the FORTRAN "PRINT" statement.

3. File 10 (program variable NTAPE) Final results file

   File used to store the final results for each trial of a particular study (One complete set of card input data delimited by an END card constitutes a set of "trials" or "study"). After the last trial for the study, entry point FSUM rewinds file NTAPE, reads in the data for all the trials, and processes it to produce a complementary cumulative distribution function, mean, variance, 3rd moment, and 4th moment for each final result. If the user wishes to combine the results of 2 or more studies, he may do so by saving the NTAPE file for each study and using the program FINAL to process the files at a later time.

   Must be Rewritten for NTAPE!

   File format: Unformatted sequential disk or tape data set. The file may be deleted after the run unless the FINAL program is to be used. The number of records written on the file per study is NCI*NLEAK*NPOP*NTIM where NCI is the number of core inventories, NLEAK is the number of leakage groups, NPOP is the number of population sectors, and NTIM is the total number of start times for all sites run.

   File contents: Unformatted records containing the following data:

variable name	type	Description
MONTH	integer	start month of trial
IDAY	integer	start day of trial
IHOUR	integer	start hour of trial
NP(1)	integer	core inventory number for event case in effect

Variable name	type	Description
NP(2)	integer	leakage number in effect
NP(3)	integer	site number in effect
NP(4)	integer	population sector number in effect
NP(5)	integer	start time count
PROB	double precision	probability of this trial
(Result(I), I=1, NRES)	real	NRES final results for this case (max 45)

4. File 11 (program variable NAT) Reference subgroup change file

Temporary file used to store reference case subgroups, so that they may be reinstituted in subsequent cases.

File format: Formatted sequential temporary disk data set with logical record length = 80 characters

File contents: Copies of the card images of user-specified reference case subgroups.

5. File 12 Concentration file

Temporary file used to save the isotope air and ground concentrations, effective cloud height, and plume rise data for each core inventory and leakage sequence when the number of core inventories and/or the number of leakage sequences is greater than 1. The file is written in subroutine ACTIVE and read in subroutine DAMAGE.

File format: Unformatted sequential temporary disk data set. The number of records written on this file per study is NCI*NLEAK where NCI is the number of core inventories and NLEAK is the number of leakages. If NCI=NLEAK=1, no records are written.

File contents: Records containing the following data:

variable name	type	Description
AC(54, 34)	real	air concentration for each isotope at each spatial interval
GC(54, 34)	real	ground concentration for each isotope at each spatial interval
EFHGHT(34)	real	effective height of the cloud at each spatial interval
HITE(34)	real	plume rise at each spatial interval

6. File 20 Site data file

Permanent reference file containing the site identification, ~~stability ceilings,~~ seasonal windroses, population, and land data for one nuclear power plant site. The file is read by subroutine SITE.

File contents: Formatted sequential-disk or tape data set. The file has 155 ~~219~~ card image records corresponding to one plant site.

File format: The file consists of the following data:

Data Array and Dimension	Data Format	Data Description
IDENT(20)	20A4	Site identification information. The data is read as (IDENT(I), I=1,20).
ROSE (16,4)	16F5.3	Windrose probability in each of 16 directions for each of 4 seasons. The data is read as ((ROSE(I,J), I=1,16), J=1,4).
POP1(16,34)	4(8F10.0,/), 2F10.0	Individual site population for each of 16 sectors and 34 pre-defined spatial intervals. The data is read as ((POP1(I,J), J=1,34), I=1,16).
FRLAND(16,34)	16F5.2	Fraction of habitable land for each of 16 sectors and 34 spatial intervals. The data is read as ((FRLAND(I,J), I=1,16), J=1,34).
INSTATE(16,34)	34I2	State code for each of 16 sectors and 34 spatial intervals. The data is read as ((ISTATE(I,J), J=1,34), I=1,16).

7. File 21 Dose conversion file

Permanent reference file used to store ground, cloud, and inhalation dose conversion factors for 13 organs and 54 isotopes. This data is used in the computation of the health effects. File 21 is read by subroutine CHRON.

File contents: Formatted sequential disk or tape data set. The file has 1423 card image records.

File format:

Records 1 through 6 contain the names of the 54 isotopes for which data is stored on the file. The order of the names corresponds to the order of the data in subsequent records. These six records have the format 10A8.

Records 7 through 1423 contain the organ names and dose conversion factors. There are 109 records for each of the 13 organs. Records 7 through 115 pertain to organ 1, records 116 through 224 to organ 2 and so forth. The set of records pertaining to organ I has the format described below:

The first record of the set contains the name of the organ in A8 format.

The second through 109th records of the set contain the dose conversions for organ I in the order ((INCON(I,J,K), J=1,7), (CRCON(I,J,K), J=1,3), CLCON(I,K), K=1,54). The format of these records is (7E10.4/4E10.3).

A description of the data follows.

Variable Name	Type	Description
GRCON(i,j,k)	real	Array containing the dose conversion factors for exposure to contaminated ground in rem/ci/m^2, where i is the organ number (between 1 and 13), j is the time index (1 to 3), k is the isotope index (1 to 54). GRCON(i,1,k) contains the conversion factor, which, when multiplied by the initial ground concentration of isotope k, gives the 8-hour integrated dose to organ i from isotope k. GRCON(i,2,k) contains the conversion factor, which, when multiplied by the ground concentration of isotope k, gives the 7 day integrated dose to organ i from isotope k. GRCON(i,3,k) is the conversion factor, which when multiplied by the initial ground concentration of isotope k, gives the 1 year integrated dose to organ i from isotope k.
CLCON(i,k)	real	Array containing the dose conversion factors for exposure to contaminated air in rem/ci-sec/m^3, where i is the organ number, k is the isotope number. CLCON(i,k) contains the dose conversion factor, which when multiplied by the exposure (ci-sec/m^3) gives the dose to organ i from isotope k.
INCON(i,j,k)	real	Array containing the dose conversion factors for inhaled radionuclides (rem/ci inhaled), where i is the organ number, j is the time period index, 1 to 7, representing the periods: 1 - time period for acute exposure (1 year for lung; 7 days for marrow, skeletal bone, endosteal cells, stomach wall, small intestine, upper large intestine and lower large intestine; 2 days fo thyroid, whole body, testes, ovaries and other tissues), 2 - 1 year, 3 - 1-10 years, 4 - 10-20 years,

5 - 20-30 years,
6 - 30-40 years,
7 - 40-50 years),

k is the isotope index.
INCON(i,j,k) is the conversion factor, which when multiplied by the number of curies of isotope k inhaled, gives the dose to organ i over time period j, from isotope k.

8. File 27 ~~Site direction weather~~ Meteorological Data file

Permanent reference file used to store ~~directional weather~~ meteorological data for one nuclear power plant site. The file is read by the SITE or subroutine BINMET.

File contents: Formatted sequential-disk or tape data set. The file has ~~1096~~ 8762 card image records corresponding to one site.

File format:

Record 1 contains the reactor site identification information with format 5A4.

Records 2 through ~~1096~~ 8761 contain the hourly directional weather data for the site, ~~three~~ one record~~s~~ per ~~day~~ hour. Each record consists of ~~one~~ two words identifying the day and time of day, and ~~eight~~ one word~~s~~ of packed meteorological data in the format ~~9(I7,1X)~~ (1X,I5,1X,I2,1X,I9). The day and time data are ~~not retained.~~ used as indices to store the data. A description of the weather data follows.

Data Array Name and Dimension	Data Type	Data Description
IDTA(24,365)	Integer	Hourly directional weather data. The data is packed with wind direction stored in the 1000000's and 100000's digits, the windspeed in 1000's and 100's digits, the stability category in the 10's digit, and the rain intensity in the 1000's, 100's and 1's digit. The data is read as ((IDTA(I,J), I=1,24), J=1,365).