Probability and Risk Assessment

for Toxic Chemical Shipments on Interstate 5

San Onofre Nuclear Generating Station
Units 2 and 3

Bechtel Western Power Corporation
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1.0 EXECUTIVE SUMMARY

An analysis was performed to develop technical justification for an exemption from a condition of the San Onofre Units 2 and 3 (SONGS 2&3) operating license. That condition presently requires Southern California Edison Company (SCE) to perform a resurvey of hazardous commodity shipments on Interstate 5 (I-5) every three years throughout the lifetime of the plant [SER Supplement 2, pages 2-1 and 2-2 (NUREG-0712)]. The following analysis utilizes probabilistic methodology in conjunction with nationwide, California, and I-5 specific accident rates and historical hazardous material spill release data to demonstrate that the annual probability of the SONGS 2&3 control room becoming uninhabitable due to the accidental release of a toxic chemical on I-5 (considering the total risk from all toxic chemicals) is less than a median value of 10^{-6} per year (90% confidence interval $2x10^{-7}$ to $2x10^{-6}$ per year). The analysis further shows that the probability of the SONGS 2&3 control room becoming uninhabitable due to a toxic chemical spill on I-5 will remain acceptably low even if future changes occur in the types, quantities, and mix of toxic chemicals transported on I-5 past SONGS. On this basis, it is concluded that future surveys of hazardous commodity shipments on I-5 are unwarranted, and that the risks to SONGS 2&3 from toxic chemical shipments on I-5 meet SRP acceptance criteria and pose no undue risk to the plant.

SECTION 2

2.0 INTRODUCTION/OBJECTIVES

2.1 BACKGROUND

At various stages during the design, construction, and operation of SONGS 2&3, evaluations have been performed to assess the risk to the Station from hazardous commodity shipments on I-5 near the plant. An initial survey of such shipments was performed in 1977, at which time data were collected on the types, quantities, and shipment frequencies of commodities that had the potential - if accidentally released - to cause the SONGS 2&3 control room to become uninhabitable. Several organizations used these data to identify "design basis" commodities, representing those whose calculated annual probability of release with subsequent creation of uninhabitable conditions inside the SONGS 2&3 control room, exceeded the numerical criteria of SRP Section 2.2.3.

The SRP Section 2.2.3 numerical acceptance criteria apply to offsite hazards that have the potential to cause offsite exposures in excess of 10 CFR Part 100 guidelines. The criteria state that postulated events capable of producing such consequences need not be classified design basis events unless the expected rate of occurrence of offsite exposures exceeding 10 CFR 100 guidelines exceed the NRC staff objective of approximately 10^{-7} per year (10^{-6} per year if conservative analysis assumptions are utilized and it can be shown by reasonable qualitative arguments that the realistic probability is lower).

Previous toxic chemical hazard evaluations performed for San Onofre have utilized criteria and deterministic "worst case" analysis assumptions contained in Regulatory Guide 1.78 as a screening tool to aid in identifying toxic chemicals that had the potential to make the SONGS 2&3 control room uninhabitable. Chemicals so identified were then analyzed on a chemical-by-chemical basis to estimate the annual probability of operator incapacitation due to a transportation accident involving these chemicals. All studies conservatively assumed that the conditional probability of an offsite release exceeding 10 CFR Part 100 exposure guidelines, given exceedance of the chemical's toxicity limit inside the control room, was 1.0. Thus, each

chemical with a calculated probability of greater than 10^{-7} per year of producing uninhabitable conditions inside the SONGS 2&3 control room was characterized as a "design basis" chemical. Appropriate design features were then incorporated into the Station design to protect the control room operators from postulated accidental releases of design basis chemicals. (It is to be emphasized that in all of the previous toxic gas hazard evaluations, probabilistic risk assessments, and comparison of estimated annual probability of operator incapacitation with SRP Section 2.2.3 acceptance criteria, the findings were applied to individual chemicals -- not to all chemicals collectively).

In the Safety Evaluation Report for SONGS 2&3, the NRC concluded that the risks to the SONGS 2&3 control room from toxic chemical releases (taking credit for provisions planned by SCE to protect against design basis chemicals) were acceptable and met the criteria of SRP Section 2.2.3. However, the conclusion was accompanied by the caveat that while the risk was acceptably low based on a knowledge of the present sizes and frequencies of hazardous cargo shipments past the plant, the future risk could be different if there were significant changes in traffic densities, transportation conditions, commodity types, size, or mix, transportation frequencies, or other factors. Accordingly, as a condition of the SONGS 2&3 operating license, SCE was required to monitor hazardous cargo traffic on I-5 periodically throughout the lifetime of the plant. This was incorporated into plant operating procedures as Technical Specification 6.9.1.14.

The first I-5 hazardous commodity survey required under Technical Specification 6.9.1.14 was completed in 1984. Results were analyzed in accordance with approved methodology and the findings submitted to NRC. A second survey has been tentatively scheduled for late 1987, pending NRC review of this report and a decision on whether or not SCE should be granted an exemption from future I-5 survey requirements on the basis of the technical showings presented herein.

2.2 PROBABILISTIC ANALYSIS BASIS

This analysis differs from previous studies in that it uses historical accident data to classify chemical spills by toxicity limit and mass release quantity to demonstrate that the risk of the SONGS 2&3 control room becoming uninhabitable due to a toxic chemical spill on I-5 is acceptably low based on current hazardous commodity transport patterns, and will remain acceptably low even if there are future changes in the commodity spectrum or mix. The premise which underlies this assertion had its origin in the following line of reasoning which was critically evaluated during this study:

Department of Transportation (DOT) regulations (49 CFR 171 et seq.) establish standards for vehicles and shipping containers used in hazardous commodity transportation. Specific hazardous commodities are only permitted to be shipped in certain volumes and container types. The allowed container types and volumes have been selected by DOT considering both the physical properties of the commodity as well as the magnitude of the hazard posed by the commodity if it should be accidentally released during transportation. Furthermore, DOT construction standards mandated for various types of shipping containers invariably influence the probability of a container breach in an accident and, correspondingly, the commodity release frequency and quantity for products for which their use has been authorized.

DOT, through the Division of Hazardous Materials Transportation, maintains computerized historical data on hazardous commodity releases in highway transportation accidents. These historical spill occurrences can be categorized into a 2-dimensional matrix, in which the rows of the matrix indicate the toxicity class of the released material and the columns of the matrix indicate the magnitude of the release. These matrices, depicting the joint distribution of toxicity and mass release quantity for hazardous chemical spills can then be combined with truck accident spill rate data to demonstrate that the probability of control room uninhabitability is acceptably low, and that the matrices will appear similar for the United States as a whole, major geographic subregions, and major transportation thoroughfares. Similarities should be greatest for geographic regions and major transportation routes which have a large number and diverse spectrum of

toxic chemical shipments. Moreover, for any geographic region or major transportation thoroughfare having a sufficient volume of hazardous chemical truck traffic to satisfy the above criterion, the joint distribution of mass release quantity versus toxicity should not change appreciably for that region/thoroughfare over time despite changes in the commodity mix or spectrum. The principal reason is that changes in commodities - averaged over all such changes - will involve replacement of a commodity in one toxicity range by another in this same range, their container requirements being similar due to the DOT regulations.

Specifically, I-5 is a major transportation thoroughfare connecting the Los Angeles and San Diego, California metropolitan areas. Based on previous I-5 specific hazardous commodity transportation surveys performed by SCE, as well as discussions with hazardous commodity transportation specialists within the California Highway Patrol, it is concluded that:

a. The spectrum of hazardous commodities transported on I-5 and nationwide are similar and can be treated as samples from the same parent population.

b. The following is a tabulation of data collected by SCE during two previous I-5 specific surveys during 1977 and 1984, in which projected annual truck shipments are segregated into commodities belonging to different toxicity limit groups (the same groupings utilized in this study):

Survey Year	Toxicity Limit Range (mg/m^3)			
	0-10	10-100	100-1000	>1000
1977	0.01[a]	0.14	0.13	0.72
1984	0.00	0.14	0.17	0.69

(a) Value shown is the projected number of annual shipments of chemicals within this toxicity group, divided by the total projected annual number of shipments of hazardous chemicals identified during the survey.

Thus, the <u>toxicity classes</u> of the chemicals in the survey are similar despite the fact that the <u>commodities</u> they represent are not exactly the same. This adds further evidence that the toxicity vs. mass release distribution for a major transportation route such as I-5 will not change significantly over time even if changes in the commodity spectrum or mix occur.

c. The joint probability distribution of mass release quantity versus toxicity limit for potential hazardous chemical releases on I-5 will be similar to that for the United States as a whole and will remain stable over time despite possible future changes in the commodity types, volumes or mix.

2.3 SCOPE OF ANALYSIS

The subsequent sections of this report describe a series of investigations and analyses which were undertaken to test the hypotheses of the preceding paragraphs and assess the total risk to SONGS 2&3 from all hazardous chemicals that could be transported on I-5 past the plant, either now or in the future. The following section summarizes the major findings and conclusions of the analysis. The methodology, risk model, and sources of data used in the analysis are described beginning in section 4.0.

SECTION 3

3.0 CONCLUSIONS

The study as described in section 2.0 was completed, and the results can be summarized as (1) sufficient DOT hazardous material accident data exists to calculate the probability of control room uninhabitability, (2) this probability is low enough to meet the Standard Review Plan acceptance criteria and (3) it will remain low over the life of the plant. The following three paragraphs explain these in detail.

1. A toxicity versus mass release matrix for the entire United States (1972-1986) was constructed and incorporated into an overall risk model in which the annual probability of SONGS 2&3 operators being incapacitated due to a toxic chemical spill on Interstate 5 was calculated. A number of conservative assumptions were incorporated into various segments of the model. Uncertainty of parameters was also explicitly considered. Using Monte Carlo simulation, the annual probability of a toxic chemical spill on I-5 causing the SONGS 2&3 control room to become unhabitable is estimated to be 8×10^{-7} per year for all chemicals combined (median estimate), with a 90 percent confidence interval of 2×10^{-7} to 2×10^{-6} per year.

2. Matrices were constructed for the entire United States (1972-1986); United States for the years 1977-1979; United States for the years 1980-1982; United States for the years 1983-1985; and for the state of California (1972-1986). CHI-square statistical tests were then performed on the matrices to determine: (1) whether or not the three 3-year period U.S. matrices, and state of California matrix, could be statistically enveloped by the toxicity vs. mass release matrix for the entire United States (all years); and, (2) whether or not the three different 3-year period United States matrices

represented samples from the same parent distribution or different parent distributions. It was determined that:

(a) Each of the submatrices for the United States during different three year periods, and for the State of California, are enveloped by the toxicity vs. mass release distribution for the entire United States over the 1972-1986 period of record.

(b) There is no statistically significant difference (at the 10 percent significance level) between the toxicity versus mass-release distributions for the United States during the three different 3-year time periods analyzed. Thus, at this significance level, the true toxicity vs. mass release distribution is stable over time, and that the parameters of this distribution can be determined from the toxicity vs. mass release matrix constructed from the DOT hazardous material truck spill data for the entire United States (all years).

3. The estimated median annual probability of operator incapacitation from a toxic chemical spill on I-5, considering all hazardous chemicals that - now or in the future - could be transported past the Station on I-5, is lower than the Standard Review Plan (SRP) Section 2.2.3 acceptance criteria for offsite accidents that could result in offsite doses exceeding 10 CFR 100 guidelines. Considering that operator incapacitation would not necessarily result in core damage and a breach of the containment, the SRP acceptance criteria are clearly met. It is concluded that toxic chemical shipments on I-5 do not constitute an undue risk to SONGS 2&3, and that additional SCE-funded surveys of toxic chemical shipments on I-5 are unnecessary and should no longer be required as a condition of the SONGS 2&3 operating license.

SECTION 4

4.0 METHODOLOGY

4.1 OVERALL RISK MODEL

To evaluate the overall probability of control room uninhabitability, the following three individual probabilities must be assessed:

1. Probability of a truck accident with toxic chemical spill per year (transportation model, section 4.2).

2. Joint probability of the mass release Q (or mass released rate $\dot{Q}$) and toxicity limit X_{TL} (mass release/toxic limit model, section 4.3).

3. Joint probability of certain meteorological conditions (temperature, wind speed, wind direction, Pasquill stability - meteorological model, section 4.4).

The following tasks were undertaken to implement these probability models.

1. Acquisition of Caltrans and California Highway Patrol (CHP) historical data on truck accidents, both on a 10.3-mile segment of I-5 near SONGS and for California in general.

2. Acquisition of a DOT Hazardous Material Information System data base data tape of historical data on hazardous commodity spills in in-route transportation accidents involving motor carriers (Appendix A summarizes this data), and the screening of the above data to exclude commodities posing no potential hazard to the SONGS 2&3 control room.

3. Placement of each resultant historical spill incident represented in the data base into a 2-dimensional matrix in which the rows and columns represent toxicity limit class and mass release class.

4. Quantification of the risk model, including propagation of uncertainty, to determine the probability of the SONGS 2&3 control room becoming uninhabitable. This was done by the Monte Carlo similation technique with traffic and matrix parameters taking on different values for each simulation run (1000 simulation runs were made).

5. Testing of the toxicity versus mass release matrix for statistical stability over time and geographic subregion to show that this probability will not change during the life of the plant.

The following assumptions and conservatisms were used in the analysis:

1. Centerline (maximum) concentrations were used for both puff and plume releases; i.e., if the control room intake fell within a plume, the centerline concentration was used.

2. The Wind Rose sector with the higher frequency of occurrence was used for the probability of wind direction from all sectors.

3. Constant 100°F temperature was assumed for purposes of calculating mass release rates.

4. No credit is taken for sheltering of the intake by other buildings.

5. No credit is taken for wake dilution.

6. No credit for initial release size (i.e., point source is assumed).

7. Thirty-minute (IDLH) toxicity limit values were used (if available) to signify concentrations capable of incapacitating control room operators (other long-term human values used if IDLH unavailable).

The following sections describe the various aspects in more detail.

4.2 TRANSPORTATION MODEL

The probability, P_s, of the accident with a toxic chemical spill per mile per year is:

$$P_s = \frac{N_a}{L} f_1 f_2 f_3$$

Where:

N_a = number of truck accidents per year in the 10.3 miles of I-5 near San Onofre

L = segment of 10.3 miles of I-5 containing the San Onofre site

f_1 = fraction of all truck accidents involving trucks carrying hazardous materials

f_2 = fraction of all hazardous material accidents resulting in spill

f_3 = fraction of all hazardous material spills resulting in the spill of chemicals included in the final matrices (tables 1 and 2)

Note: The 10.3 miles referenced above is from the Orange County line (about 3.5 miles north of San Onofre) to Las Pulgas Road. This segment was selected because (1) it contains San Onofre and most of a 5-mile radius around the plant, and (2) CHP and CalTrans keep traffic data keyed to this stretch of highway.

Appendix B discusses the traffic data in more detail, and includes the reference data used to calculate values for the above equation. In addition to accident rate, knowledge of truck content was required. This was determined by purchase of a data tape from the DOT Hazardous Material Information System. (NOTE: This data base is the data base referred to in 49 CFR Articles 171.15 and 171.16. These sections require form DOT F5800.1 to be completed and sent to the Information Systems Manager. 49 CFR Articles 171.1 and 171.8 define conditions under which incidents must be reported.)

This data tape shows a total of 4795 incidents involving 321 chemicals in the data base covering the years 1973-1986. Appendix A shows a breakdown of all the incidents by chemical and year. The data base did not contain spill quantities for most incidents in the 1973-1975 time frame, and a spot check of source documents by DOT showed that most of these incidents did have spills. DOT did agree to provide us with spill quantities for the California

accidents. Also, there were about 100 incidents with zero spill from 1976-1986 (DOT regulations, 49 CFR reporting if injuries/fatalities/large damage occurs as a result of the accident even though a spill may not have occurred). As a result, the final number of incidents available for analysis was 3946.

Analyses of these 3946 incidents indicate:

a. Approximately 65 percent of historical in-route truck accident hazardous material spills involve gasoline, oil and related petroleum products. Previous deterministic toxic chemical hazard analysis for SONGS indicate that these do not pose a hazard to the SONGS 2&3 control room.

b. Major releases of anhydrous ammonia have occurred in the past and could - if postulated to occur on I-5 near SONGS without provision for automatic detection and control room isolation - cause the SONGS 2&3 control room to become uninhabitable. However, the SONGS 2&3 FSAR (Reference 18) requires the control room the have automatic detection and isolation features designed to protect the control room against any ammonia spill, including an onsite aqueous ammonia storage tank spill.

c. About 22 percent of the historical spill incidents contained in the DOT data base represent commodities that either do not pose a hazard to the SONGS 2&3 control room (e.g., simple asphxiants) or are not relevant to the type of hazard being considered in this analysis. The latter include substances such as solids, non-volatile liquids, and ammunition and solid explosives.

d. Only about 13 percent (526) historical in-route hazardous material truck accident spills in the DOT data base involved commodities for which the SONGS 2&3 control room is unprotected and which could - if present in sufficient concentration - cause the SONGS 2&3 control room to become uninhabitable. This group was selected for incorporation into the risk model; commodities referenced in a through c above were omitted.

Tables 1 and 2 show the chemical sets included in the analysis. A complete list of all accidents in the data base, summarized by year, is attached as Appendix A. These remaining incidents were divided into continuous release and puff release categories based on chemical properties (table 3), and grouped into a mass release/toxicity matrix. This results in a continuous release matrix of 427 incidents and a puff release matrix of 99 (total of 526).

4.3 MASS RELEASE/TOXICITY LIMIT MODEL

These 526 toxic chemical incidents were quantified into toxicity mass release matrices as shown on tables 4 and 5 (continuous and puff release chemicals, respectively). These matrices show the conditional joint probability P_{ij} that for a given accident with toxic chemical spill we will observe a chemical belonging to the toxicity group "i" and having a mass release rate of the "j^{th}" release category. Each element in the matrix is assigned the mid-point value for both the allowable toxicity value, and for mass release. Also shown in tables 4 and 5 are the overall fraction for each combination.

The toxicity values used were determined from National Institute for Occupational Safety and Health (NIOSH) data. Specifically, the Immediate Danger to Life or Health (IDLH) values were used whenever given (long term human values were used if no IDLH values exist). The values are also shown on table 3, and discussed in Appendix C.

TABLE 1

CHEMICALS INCLUDED IN CONTINUOUS RELEASE MODEL

CHEMICAL	NO. OF SPILLS
Hydrochloric and other misc. acids	116
Benzene and other misc. solvents	61
Ethanol and other misc. alcohols	45
Sulfuric Acid	64
Methanol	18
Nitric Acid	17
Methylethyl Ketone	17
Toluene	17
Xylene	16
Acetone	16
Acetic Acid	6
Hexane	6
Ethyl Acetate	6
Methyl Methacrylate	5
Butyl Acetate	4
Pyridine	3
Formaldehyde	2
Heptane	2
Acrylonitrile	2
Aniline	2
Bromine	1
Formic Acid	1
	427

Note: Gasoline, oil and their derivatives accounted for over 2700 spills, but had been previously shown deterministically not to be capable of incapacitation and so were excluded.

TABLE 2

CHEMICALS INCLUDED IN PUFF RELEASE MODEL

CHEMICAL	NO. OF SPILLS
LPG and Compressed Gas NOS* (Flammable)	76
CO_2	11
Acetylene	7
Methyl Bromide Chloride	3
Chlorine	1
Fluorine	1
	99

*Not otherwise specified.

TABLE 3
(Sheet 1 of 2)

CONTINUOUS RELEASE CHEMICAL PROPERTIES*

Chemical	Toxicity Limit (mg/m^3)	Molecular Weight $\left[\frac{lb}{lb\ mol}\right]$	Density of Liquid at 100°F (g/cm^3)	Vapor Pressure of Liquid at 100°F (psia)	Diffusivity of Vapor at 100°F (cm^2/S)	DOT Category
Acetic Acid	2400	60.05	1.04	0.58	0.1413	E
Acetone	47000	58.08	0.797	7.25	0.132	M
Acrylonitrile	8600	53.06	0.806	1.9342	0.0955	E
Aniline	380	93.12	1.01	0.035	0.07483	E
Benzene	6400	78.11	0.8845	3.3	0.10762	E
Bromine	65	159.8	3.05	6.9937	0.10762	M
Butyl Acetate	38000	116.16	0.87	0.50	0.0686	E
Ethyl Acetate	36000	88.10	0.88	3.1	0.0829	M
Ethyl Alcohol	9400	46.07	0.7916 (25°C)	2.3125	0.1237	M
Formaldehyde	122	30.02	1.12 (18°C)	0.9	0.14504	E
Formic Acid	188	46.02	1.2	1.47	0.1695	E
Heptane	17000	100.20	0.6883	1.65	0.06942	M
Hexane	17000	86.17	0.664	5.00	0.07677	M
Hydrochloric Acid	150	36.46	1.1513	0.1934	0.16898	E
Methanol	33000	32	0.7963	4.631	0.1653	M
Methyl Ethyl Ketone	8800	72.10	0.785	3.2	0.09355	M
Methyl Methacrylate	16000	100.12	0.936	1.5	0.07659	E
Nitric Acid	260	63.02	1.474	0.004	0.2	E

* Obtained from References (4-15)

TABLE 3
(Sheet 2 of 2)

CONTINUOUS RELEASE CHEMICAL PROPERTIES*
(Continued)

Chemical	Toxicity Limit (mg/m^3)	Molecular Weight [lb / lb mol]	Density of Liquid at 100°F (g/cm^3)	Vapor Pressure of Liquid at 100°F (psia)	Diffusivity of Vapor at 100°F (cm^2/S)	DOT Category
Pyridine	12000	79.1	0.983	0.75	0.08857	M
Sulfuric Acid	80	98.08	1.816	3.887×10^{-5}	0.104	E
Toluene	7500	92.13	0.866	1.2	0.0873	E
Xylene	43000	106.16	0.86	0.34	0.0742	E

PUFF CHEMICAL PROPERTIES*

Chemical	Toxicity Limit (mg/m^3)	Molecular Weight [lb / lb mol]	Boiling Point Temp (°F)	Density of Liquid at Boiling Pt (lb/ft^3)	Heat Capacity of Liquid at Boiling Pt (Btu/lb °F)	Heat of Vaporization at Boiling Point Temp (Btu/lb)	DOT Category
Carbon Dioxide	90,000	44	-109	96.764	0.318	246	M
Chlorine	72	71	-29	97.326	0.226	123.7	E
Fluorine	39	38	-305	94.267	0.3605	74.9	M
Acetylene	106,000	26.038	-115	43.262	0.5	276	M
Liquid Propane Gas	33,000	42	-40	36.190	0.525	185.6	M
Methyl Bromide Chloride	27	130.39	38	107.376	0.198	111.9	M

* Obtained from References (4-15)

TABLE 4
CONTINUOUS - HAZARDOUS MATERIALS RELEASES (U.S. ALL YEARS)

NUMBER OF OCCURRENCES

ICITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0	0
10 - 100	19	19	26	0	0	0	0	1	0	65
100 - 1000	1	6	11	16	24	79	1	0	0	138
10^3 - 10^4	0	0	0	1	27	34	86	0	0	148
10^4 - 10^5	0	0	0	7	7	16	33	13	0	76
OVER 100000	0	0	0	0	0	0	0	0	0	0
TOTAL	20	25	37	24	58	129	120	14	0	427

FRACTION OF TOTAL OCCURRENCES

CITY MIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0445	0.0445	0.0609	0.0000	0.0000	0.0000	0.0000	0.0023	0.0000	0.1522
100 - 1000	0.0023	0.0141	0.0258	0.0375	0.0562	0.1850	0.0023	0.0000	0.0000	0.3232
10^3 - 10^4	0.0000	0.0000	0.0000	0.0023	0.0632	0.0796	0.2014	0.0000	0.0000	0.3466
10^4 - 10^5	0.0000	0.0000	0.0000	0.0164	0.0164	0.0375	0.0773	0.0304	0.0000	0.1780
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	0.0468	0.0585	0.0867	0.0562	0.1358	0.3021	0.2810	0.0328	0.0000	1.0000

TABLE 5

PUFF - HAZARDOUS MATERIALS RELEASES (U.S. ALL YEARS)

NUMBER OF OCCURRENCES

TOXICITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0
10 - 100	0	0	2	2	1	0	0	0	5
100 - 1000	0	0	0	0	0	0	0	0	0
10^3 - 10^4	0	0	0	0	0	0	0	0	0
10^4 - 10^5	0	0	2	8	10	10	12	45	87
OVER 100000	0	0	0	0	0	0	0	7	7
TOTAL	0	0	4	10	11	10	12	52	99

FRACTION OF TOTAL OCCURRENCES

TOXICITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0000	0.0000	0.0202	0.0202	0.0101	0.0000	0.0000	0.0000	0.0505
100 - 1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^3 - 10^4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^4 - 10^5	0.0000	0.0000	0.0202	0.0808	0.1010	0.1010	0.1212	0.4545	0.8788
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0707	0.0707
TOTAL	0.0000	0.0000	0.0404	0.1010	0.1111	0.1010	0.1212	0.5253	1.0000

Mass release rates were calculated for the continuous and puff release chemicals using the same model and equations as in Reference (2) with continuous release area and puff release fraction based on the spill amounts from the DOT tape. The equations are as follows:

For continuous releases:

$$Q = M_a \, 3.471 \times 10^{-2} \, A \, D_{ab}^{2/3} \sqrt{\frac{u}{L}} \; \ln \left[\frac{P_a}{P-P_a} + 1 \right] \text{ mg/sec} \quad \text{(laminar) (EQ 1)}$$

$$Q_{w_a} = M_a \, 1.397 \times 10^{-3} \, A \, D_{ab}^{2/3} \left(2.305 \, u^{0.8} \, L^{-0.2} - 12800/L \right) \ln \left[\frac{P_a}{P-P_a} + 1 \right] \text{ mg/sec} \quad \text{(turbulent) (EQ 2)}$$

For a liquefied gas puff release (the matrix contains no compressed gas), a portion will flash to vapor taking away the heat of vaporization and cooling the remainder to sub-boiling temperature. A heat balance is written as:

$$M_L \, C_p \, (T_0 - T_B) = M_v \, h_{fg}$$

If $M_L + M_v = M$ and f is the fraction flashing to vapor,

then $f = M_v/M$ and $M = M_L + M_v$ (EQ 3)

$$f = \frac{1}{1 + \dfrac{h_{fg}}{c_p \, (T_o - T_B)}}$$

$$Q = (.45 \times 10^6) \, (f) \, (M)$$

DESCRIPTION OF VARIABLES

Q	=	mass release rate (mg/sec)
M_a	=	molecular weight (g/g mole)
A	=	surface area of spill (cm^2)
D_{ab}	=	diffusion coefficient for air-chemical pair (cm^2/s)
u	=	wind speed (cm/sec)
L	=	characteristic spill length (cm)
P_a	=	vapor pressure of chemical (psia)
P	=	ambient pressure (14.7 psia)
M	=	total mass of chemical spilled (lbs)
M_V	=	mass of chemical which flashes to vapor (lb)
M_L	=	mass of chemical remaining as liquid after flash (lb)
f	=	fraction of total mass which flashes to vapor
h_{fg}	=	heat of vaporization (Btu/lb)
c_p	=	heat capacity (Btu/lb°F)
T_0	=	ambient air temperature (°F)
T_B	=	boiling temperature of chemical (°F)

4.4 METEOROLOGICAL MODEL

A complete meteorological model would use a joint distribution for ambient temperature T, Pasquill's category P, wind speed u and wind direction Υ. However, to simplify our model we conservatively assume the ambient temperature T = 100°F for all parts of the year and all hours of the day. Also, to simplify the model in a conservative manner, an isotropic wind rose is assumed for additional decoupling. This is done by increasing the probability function by a factor K_θ which represents a worst-case ratio of wind direction probability over all wind directions, stability condition, and

wind speeds. The wind speed variable is divided into eleven wind speeds with average velocities of .375, .75, 1.25, 1.75, 2.5, 3.5, 4.5, 5.5, 6.5, 7.5, and 9.0 m/s. Table 6 shows the wind speed, wind direction and frequency of occurrences.

Standard Gaussian dispersion models were used in this analysis but for conservatism, this study assumed centerline (maximum) concentration if the intake is included in the plume angle.

The buildup of toxic gas concentration within the control room was modelled by the following first order equation:

$$\frac{dX_{cr}(t)}{dt} = \frac{F}{V_{cr}} \left[X_a - X_{cr}(t) \right] \qquad \text{(EQ 6)}$$

For constant (steady state) outside concentration, the control concentration becomes:

$$X_{cr}(t) = X_a \left[1 - e^{-\frac{F}{V_{cr}}t} \right] \qquad \text{(EQ 7)}$$

DESCRIPTION OF TERMS

$X_{cr}(t)$ = control room chemical concentration at time t (g/m^3)

F = HVAC flowrate into the control room (m^3/s)

V_{cr} = volume of the control room (m^3)

Xa = outside concentration (mg/M^3)

For this analysis a conservative assumption of infinite time to control isolation was assumed for plume (continuous) chemicals while a 10-minute cloud passage time was assumed for puff chemicals (about a 1-mile long cloud at the median velocity of 3 m/s).

TABLE 6

WIND DIRECTION AND VELOCITY PROBABILITY

Direction	Probability of Occurrence
N	.0344
NNE	.1108
NE	.1340
ENE	.0281
E	.0161
ESE	.0224
SE	.0494
SSE	.0699
S	.0654
SSW	.0614
SW	.0544
W	.0883
WNW	.1089
MW	.0600
MNW	.0312

$$\text{Average Sector Probability} = \frac{1.0}{16} = .0625$$

$$\frac{\text{Max. Probability}}{\text{Average}} = \frac{.134}{.625} = 2.144$$

Average Velocity	Probability of Occurrence
.375	.0042
.75	.0427
1.25	.0955
1.75	.1197
2.5	.2532
3.5	.2207
4.5	.1334
5.5	.0640
6.5	.0329
7.5	.0147
9.0	.0188

NOTE: All data taken from SONGS 2&3 FSAR, Appendix 2.3B

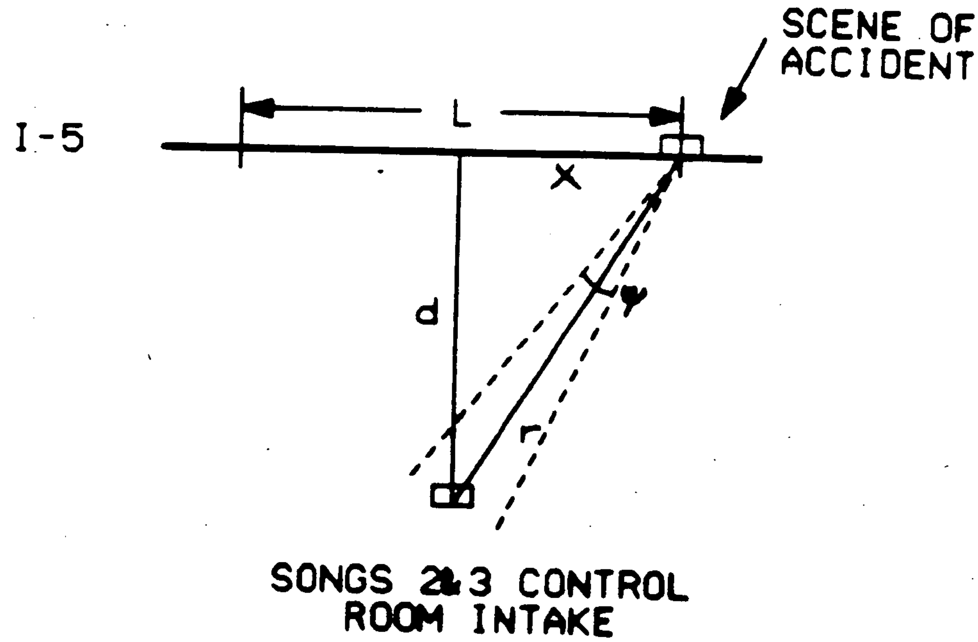
SECTION 5

5.0 MODEL EVALUATION

5.1 MODEL IMPLEMENTATION AND RESULTS

The overall PRA model for analyzing each spill incident for plant operator incapacitation was developed and is shown in figures 1 and 2. The implementation consists of three steps: (1) probability of a truck accident spilling a chemical of the type in the matrices, (2) conservative determination of the zone within which the concentrations could exceed the toxicity limit, and (3) the probability of the control room concentration exceeding the allowable limit, if the zone includes the control room. A Monte Carlo simulation program was used to allow for the potential range of the major variables. Specifically, for a given matrix combination (Pc consisting of toxic group i, and release category j), meteorological combination (PM, wind speed interval q, and Pasquill's category p), the maximum segment of the I-5, L, for which $P(X_{CR} \geq X_{TL}) = 1$ was calculated. Then (P_s) (L) gives the probability of the accident with a toxic chemical spill per year at this segment. If we multiply this value by the probability that the plume hits the control room intake given the wind direction sector and the forecast probability of occurrence of parameters i, j, q, p and sum up over all potential values of these parameters we obtain the final annual probability of exceeding the toxicity threshold limit in the control room. The use of the Monte Carlo technique allows the major variables such as matrix distribution and traffic parameters to assume a range of values (with a BETA distribution) to determine the full range of total probability of control room uninhabitability.

FIGURE 1
CONCEPTUAL MODEL



GIVEN CONDITIONS

		No. of Conditions Evaluated
P_M	1. Pasquill Stability Category	(7)
	2. Wind Speed	(11)
P_C	3. Mass Release Quantity	(9)
	4. Toxicity Limit	(7)

- o For each combination of the above given conditions (4851 possible combinations), there is some length (will be 0.0 for many combinations) of I-5 which has the potential for causing the control room to become uninhabitable
  - $P_S \cdot L$ (probability per year of a spill occurring in length L of I-5)
  - P_W (probability of control room intake included in plume or puff area)
- o Absolute probability of this event is given by

$$P_E = P_S \cdot P_W \cdot P_M \cdot P_C \cdot L$$

<u>NOTE</u>: Figure 2, next page, defines these terms.

FIGURE 2

MODEL DESCRIPTION

$$P_T = \sum P_E = \sum (P_S)(P_C)(P_M)(P_W)(L)$$

P_T = Total probability of operator incapacitation (per year)

P_S = Probability of accident with spill of a toxic chemical of the type in the model (per mile-year) (from traffic model)

P_C = Probability of combination of mass release and toxicity limit for chemical given an accident (from mass release/toxicity limit model)

P_M = Probability of wind speed and Pasquill stability category (from meteorological model)

P_W = Probability of control room intake included in plume area (from meteorological model)

L = Length of I-5 (miles) which would produce a control room concentration greater than the human incapacitation concentration.

The above steps were developed on a FORTRAN computer program, with the following probability distribution for the U.S. as a whole and California:

TOTAL PROBABILITY OF OPERATOR INCAPACITATION

		Using All U.S. Data	Using Just California Data
5 Percent	=	2.1-007 *	1.4-007
10 Percent	=	2.9-007	1.9-007
15 Percent	=	3.7-007	2.4-007
20 Percent	=	4.3-007	2.7-007
25 Percent	=	4.8-007	3.1-007
30 Percent	=	5.4-007	3.5-007
35 Percent	=	5.9-007	4.0-007
40 Percent	=	6.5-007	4.3-007
45 Percent	=	7.2-007	4.7-007
50 Percent	=	8.0-007	5.1-007 Median
55 Percent	=	8.8-007	5.7-007
60 Percent	=	9.7-007	6.4-007
65 Percent	=	1.1-006	7.0-007
70 Percent	=	1.2-006	7.7-007
75 Percent	=	1.3-006	8.6-007
80 Percent	=	1.5-006	9.8-007
85 Percent	=	1.6-006	1.2-006
90 Percent	=	1.9-006	1.3-006
95 Percent	=	2.3-006	1.7-006

* 2.1-007 = 2.1×10^{-7}

Thus, it can be seen that the median value for total probability of operator incapacitation is less than 10^{-6} per year.

5.2 UNCERTAINTY ANALYSIS

To evaluate the probability of variations over time and for California as a region, two approaches were combined. First, subsets of the main matrix were constructed (three, 3-year periods and California incidents only) and second, each matrix element (cell) was allowed to vary. The matrix subsets were extracted directly from the DOT data tape and the element variations were assumed to follow a BETA distribution as described in reference 17. In this technique all elements but one are decoupled and allowed to vary independently. The last element picks up the probability left to meet $P_T = \Sigma p_u = 1.0$.

The results of the statistical analysis are as follows:

1. A Chi-square statistical test (Reference 19, section 12.2 and Reference 20, page 596) was used to determine whether the toxicity versus mass release distribution for the entire United States, United States for three different time periods, and for the state of California were the same or significantly different. The results show that the apparent differences between the sample matrices and the complete toxicity versus mass release matrix for the United States (1972-1986) are likely to represent random fluctuation rather than a true difference in the toxicity versus mass release distribution, and thus, the matrix for the entire United States (1972-1986) is appropriate for use in the risk model. The following table shows the computed X^2 statistic for each submatrix, and the 90th percentile value of the X^2 distribution for the corresponding number of degrees of freedom:

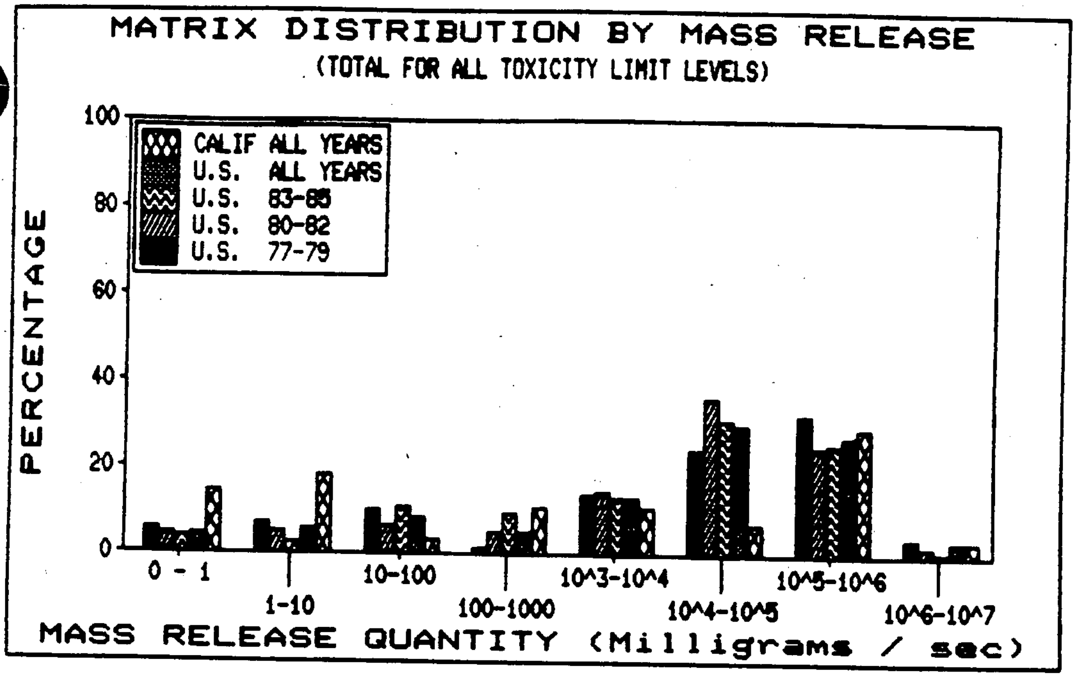
Matrix Tested	Degrees of Freedom (ν)	Computed X^2 Sample	90th Percentile Value of the X^2 Distribution for ν Degrees of Freedom
United States, 1977-1979	12	8.8039	18.5494
United States, 1980-1982	12	10.4576	18.5494
United States, 1983-1985	10	12.3340	15.9871
California, all years	4	6.0887	7.77944

In each case, the sample statistic is smaller than the 90th percentile value of X^2 distribution, which shows that all subsets can be represented by the entire matrix.

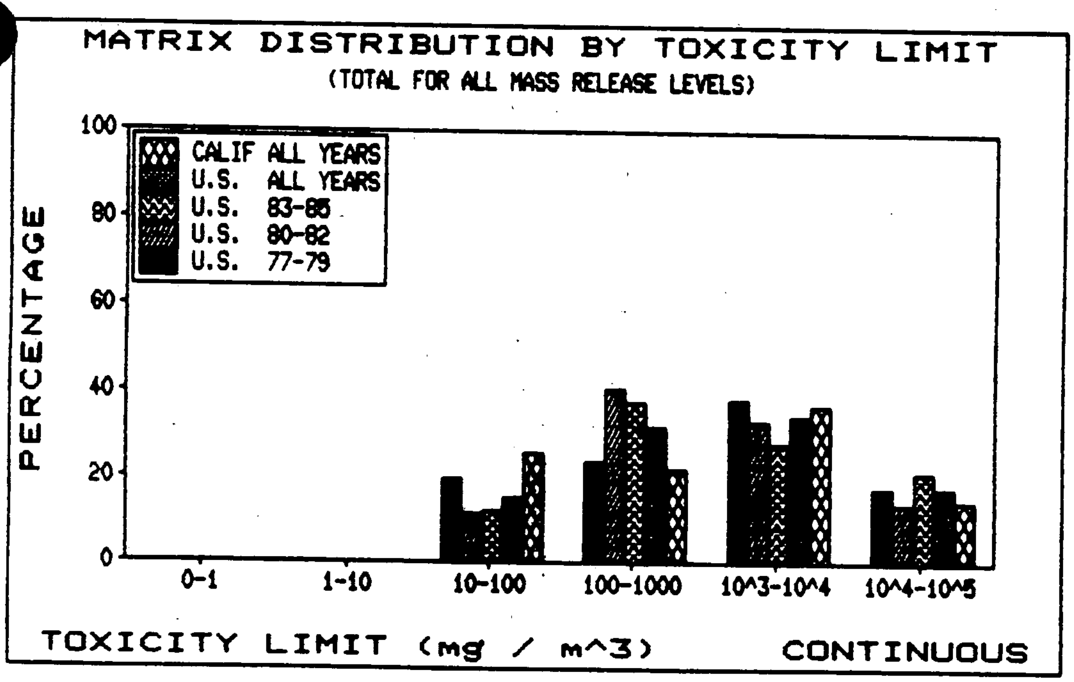
2. A second X^2 test (Reference 20, page 596) was utilized to directly compare the toxicity versus mass release matrices for the United States during three different 3-year periods. Again, a 10 percent significance level was adopted for the test, and the computed X^2 statistic is 27.9548 (ν = 20 degrees of freedom), versus a 90th percentile value of the X^2 distribution of 28.4120. Thus, it can be inferred that the conditional joint distribution of toxicity level versus mass release does not vary over time, in spite of changes in the spectrum and mix of hazardous commodities transported. Furthermore, it is concluded that the toxicity versus mass release matrix for the entire United States (all years) is appropriate to use in estimating the current and future risk to SONGS 2&3 from hazardous commodity shipments on I-5.

3. To help visualize these results, figure 3 shows the percent distribution for the actual DOT data tape spills of continuous release chemicals (table 3, section 4). As can be seen, there is general agreement between the subsets and the total matrix. Also, figure 4 shows the results of the uncertainty band and the median value for the total probability of control room unhabitability. These bands were created by running 1,000 simulation runs for each of the five cases (main matrix, three, 3-year subsets, and just California) with the elements allowed to vary as described above. The G-test, as described in Appendix D (statistical analysis), was used to test the significance of these bands. This test says that any sets of data can be considered similar if there is complete overlap of the uncertainty bands or if the maximum likelihood value of each set is within the band of the other set(s). The overlap in figure 4 for all subsets relative to the U.S. all years is sufficient to meet this criteria for median probability, and the median values (slightly greater than maximum likelihood values) are within the U.S. all years band, and visa versa.

FIGURE 3



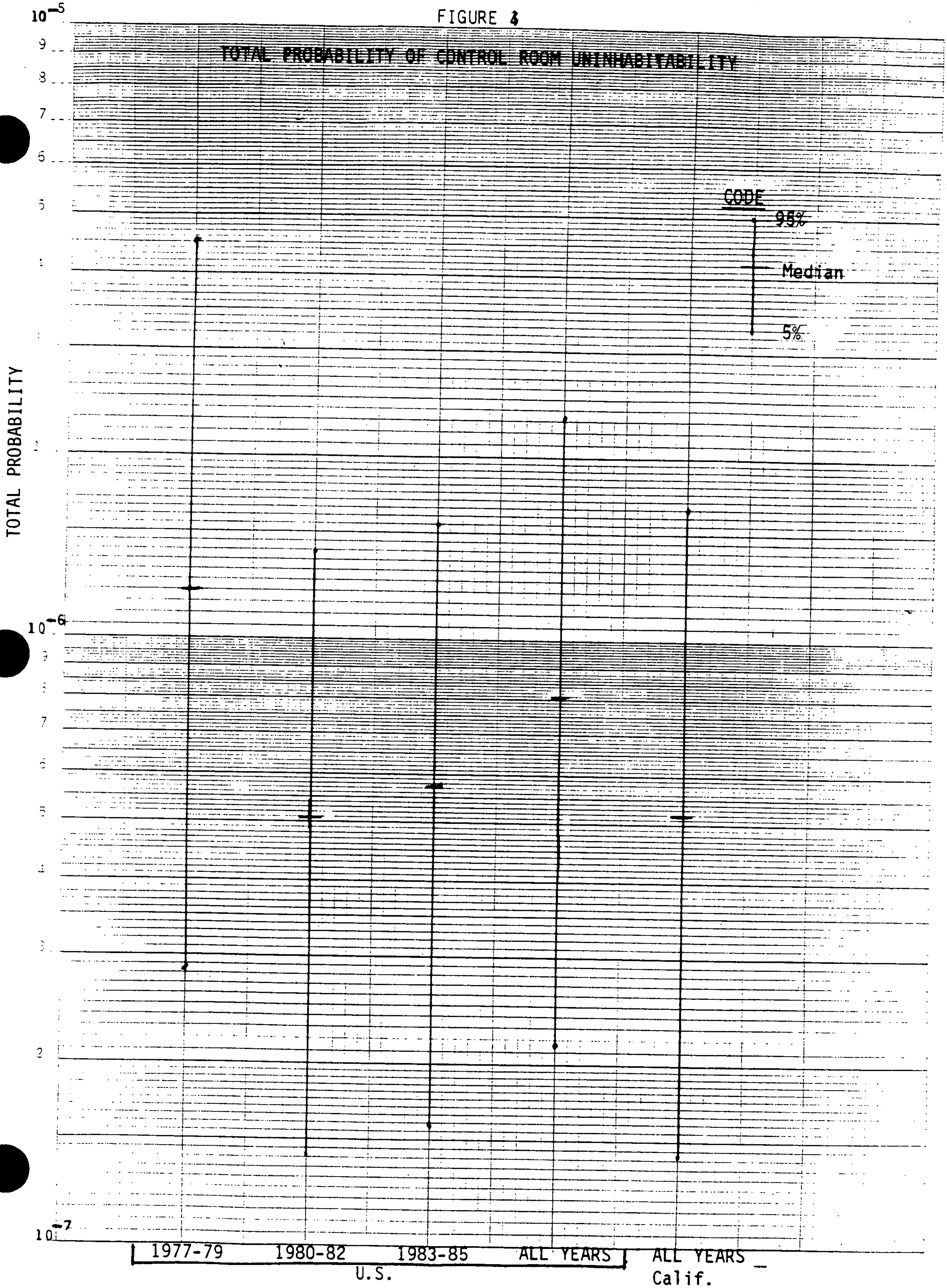
MATRIX DISTRIBUTION BY MASS RELEASE
(TOTAL FOR ALL TOXICITY LIMIT LEVELS)
CALIF ALL YEARS
U.S. ALL YEARS
U.S. 83-85
U.S. 80-82
U.S. 77-79
PERCENTAGE
100
80
60
40
20
0
0 - 1
1-10
10-100
100-1000
10^3-10^4
10^4-10^5
10^5-10^6
10^6-10^7
MASS RELEASE QUANTITY (Milligrams / sec)



MATRIX DISTRIBUTION BY TOXICITY LIMIT
(TOTAL FOR ALL MASS RELEASE LEVELS)
CALIF ALL YEARS
U.S. ALL YEARS
U.S. 83-85
U.S. 80-82
U.S. 77-79
PERCENTAGE
100
80
60
40
20
0
0-1
1-10
10-100
100-1000
10^3-10^4
10^4-10^5
TOXICITY LIMIT (mg / m^3)
CONTINUOUS

FIGURE 4

TOTAL PROBABILITY OF CONTROL ROOM UNINHABITABILITY



SECTION 6

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APPENDIX A

APPENDIX A

DEPARTMENT OF TRANSPORTATION DATA

The attached listing summarizes all the incidents on the data tape received from the Department of Transportation (Reference 1A). The summary is by DOT commodity code and shows chemical name, hazard classification (see below), number of incidents, percent and cumulative percent, and breakdown by year.

Class Code	Hazard Class	Definition (CFR 49)
02	Other Regulated Material, Class A	173.500(a)1
04	Other Regulated Material, Class B	173.500(a)2
06	Other Regulated Material, Class C	173.500(a)3
08	Other Regulated Material, Class D	173.500(a)4
09	Other Regulated Material, Class E	173.500(a)5
10	Organic Peroxide	173.151(a)
12	Blasting Agent	173.114A(a)
20	Combustible Liquid	173.115(b)
25	Flammable Liquid	173.115(a)
30	Flammable Solid	173.150
35	Oxidizer	173.151
45	Nonflammable Compressed Gas	173.300(a)
50	Flammable Compressed Gas	173.300(b)
55	Poison Gas or Liquid, Class A	173.326
60	Poison Liquid or Solid, Class B	173.343
65	Irritating Material	173.381
70	Radioactive Material	173.389
75	Explosives, Class A	173.53
80	Explosives, Class B	173.88
85	Explosives, Class C	173.100
90	Etiological Agent	173.386
95	Corrosive Material	173.240

APPENDIX A
DEPARTMENT OF TRANSPORTATION DATA*

CODE	COMMODITY	CLASS	NO.	PERCENT	CUMM. PCT	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
5360	GASOLINE	25	1496	31.20	31.20	0	84	146	159	129	173	144	147	90	75	84	76	65	98	26
5203	FUEL OIL 1 2 4 OR 5	20	363	7.57	38.77	0	0	0	1	12	43	46	51	30	26	42	31	34	32	15
[illegible]	FUEL OIL	20	299	6.24	45.01	0	0	0	3	24	49	48	50	42	20	29	16	6	11	1
[illegible]	CRUDE OIL	25	273	5.69	50.70	0	4	16	22	18	22	13	28	17	18	27	29	26	20	13
3475	COMBUSTIBLE LIQ NOS	20	132	2.75	53.45	0	0	9	16	53	6	7	11	3	10	6	2	3	6	0
5130	FLAM LIQUIDS N.O.S.	25	124	2.59	56.04	0	3	6	10	5	13	14	14	11	12	9	5	8	10	4
6300	LIQ PETROLEUM GAS	50	93	1.94	57.98	0	5	6	10	8	11	7	4	4	6	6	6	9	9	2
5700	HYDROCHLORIC ACID	95	91	1.90	59.87	0	3	2	6	7	9	6	8	9	10	10	8	10	2	1
8060	PAINT ENAM LAQ STAN	25	81	1.69	61.56	0	3	6	16	19	7	4	7	8	6	1	2	1	0	1
3730	CORR LIQ N.O.S.	95	75	1.56	63.13	0	0	3	4	4	10	16	9	7	6	1	2	4	6	3
9930	SULFURIC ACID	95	72	1.50	64.63	0	5	5	3	4	8	10	7	6	6	4	3	4	4	3
5201	FUEL AVIA TURBIN EN	25	71	1.48	66.11	0	0	1	0	4	5	11	9	11	3	4	6	9	2	6
9575	SODIUM HYDROXIDE LQ	95	56	1.17	67.28	0	1	4	2	7	5	8	4	4	4	2	5	3	5	2
1190	ALCOHOL N.O.S.	25	44	0.92	68.20	0	1	2	2	2	5	8	6	8	4	3	2	0	1	0
3030	RESIN SOLUTION	25	42	0.88	69.07	0	0	0	2	2	2	6	1	2	2	2	8	4	11	0
7930	OIL N.O.S.	25	40	0.83	69.91	0	2	4	5	5	4	8	6	2	2	0	2	0	0	0
3490	COMP CLEANING	95	38	0.79	70.70	0	0	3	2	2	6	9	3	3	2	5	1	1	0	1
1926	ASPHALT CUT BACK	20	34	0.71	71.41	0	0	0	0	4	4	4	9	4	2	2	2	1	2	0
3771	CRUDE OIL PETROL	20	34	0.71	72.12	0	0	0	0	0	5	2	0	1	3	3	7	7	5	1
8365	PHOSPHORIC ACID	95	33	0.69	72.81	0	0	1	3	0	2	2	3	7	0	2	4	5	1	3
3560	COMP PAINT REMOVE F	25	31	0.65	73.45	0	0	8	2	3	7	4	2	1	2	2	0	0	0	0
5720	HYDROCHLORIC ACID	95	28	0.58	74.04	0	0	1	0	0	0	0	1	3	4	7	5	5	1	1
7490	MOTOR FUEL N.O.S.	25	27	0.56	74.60	0	1	10	12	4	0	0	0	0	0	0	0	0	0	0
1620	ANHYDROUS AMMONIA	45	26	0.54	75.14	0	1	2	4	4	3	3	4	1	1	1	0	2	0	0
0820	WOOD ALCOHOL	25	26	0.54	75.68	0	1	4	1	0	1	3	6	1	0	2	2	3	2	0
6170	KEROSENE	20	25	0.52	76.20	0	0	0	0	1	3	5	5	0	2	3	2	1	3	0
5459	HAZARD WASTE L/S	09	25	0.52	76.73	0	0	0	0	0	0	0	0	1	1	1	6	5	10	1
[illegible]	BATTS STORAGE WET	95	23	0.48	77.21	0	2	10	2	2	1	2	0	0	4	0	0	0	0	0
[illegible]	TOLUENE	25	22	0.46	77.66	0	1	2	3	3	1	1	3	1	1	2	1	1	0	2
[illegible]	R.A.M. N.O.S.	70	22	0.46	78.12	0	0	1	11	0	0	0	1	0	3	2	2	0	2	0
8320	PETROLEUM NAPHTHA	25	20	0.42	78.54	0	1	1	2	1	0	1	2	3	1	4	1	1	2	0
1010	ACETONE	25	20	0.42	78.96	0	1	3	1	2	1	4	0	2	2	1	0	0	3	0
8520	POISONOUS LIQ NOS B	60	19	0.40	79.35	0	1	2	2	3	2	1	2	0	2	2	2	0	0	0
1925	ASPHALT	06	18	0.38	79.73	0	0	0	0	0	0	2	0	3	1	4	2	3	3	0
7040	METHYL ETHYL KETONE	25	18	0.38	80.10	0	0	0	1	0	1	2	0	3	0	3	3	1	3	1
0890	XYLENE (XYLOL)	25	18	0.38	80.48	0	0	1	1	1	0	2	2	1	2	1	1	3	3	0
2840	CEMENT LIQUID N.O.S	25	17	0.35	80.83	0	0	2	3	2	1	5	0	1	1	1	1	0	0	0
4560	ELECTR BATT FL	95	16	0.33	81.17	0	0	2	2	0	6	5	0	0	0	0	0	0	1	0
5470	HELIUM	45	16	0.33	81.50	0	0	0	3	0	4	2	1	1	1	2	0	1	0	1
7931	OIL NOS PETROL CL	20	15	0.31	81.81	0	0	0	0	1	3	1	4	1	2	1	1	0	1	0
5810	HYDROGEN	50	15	0.31	82.13	0	1	0	2	2	0	3	1	1	0	0	3	1	1	0
8050	PAINT FL	25	14	0.29	82.42	0	0	0	0	0	0	0	0	0	0	0	0	7	4	3
3735	CORR SOLID N.O.S.	95	14	0.29	82.71	0	0	1	1	1	3	1	3	1	0	1	0	1	1	0
2560	CA HYPOCHLORITE MIX	35	13	0.27	82.98	0	2	0	0	1	5	0	0	1	3	0	0	0	1	0
1270	ALKALINE LIQ	95	13	0.27	83.25	0	0	1	1	0	3	1	0	0	2	0	0	4	1	0
5870	HYPOCHLORITE SOL	95	13	0.27	83.52	0	0	1	0	1	2	0	1	2	1	1	0	3	1	0
9574	CAUSTIC SODA DRY	95	12	0.25	83.77	0	0	1	1	3	0	0	1	0	1	2	1	2	0	0
7701	NITRIC ACID >40%	35	12	0.25	84.03	0	0	0	0	0	0	1	3	0	3	0	1	1	3	0
9720	SOLVENTS N.O.S.	25	12	0.25	84.28	0	1	1	0	2	1	0	1	1	1	1	1	2	0	0
1927	ASPHALT CUT BACK F	25	12	0.25	84.53	0	0	2	0	3	2	2	1	0	0	0	0	1	1	0
1336	AQUA AMMONIA	95	12	0.25	84.78	0	0	0	0	0	0	1	1	0	2	1	1	5	0	1
1120	ACID	95	12	0.25	85.03	0	0	1	1	0	2	1	0	1	1	3	1	0	1	0
2710	CO2 LIQUIFIED	45	12	0.25	85.28	0	0	0	0	1	1	2	0	2	1	1	2	1	1	0
[illegible]	INK	25	11	0.23	85.51	0	0	1	1	2	2	0	0	4	0	1	0	0	0	0
[illegible]	AMMON NITRATE FERTI	35	11	0.23	85.74	0	0	1	2	0	2	1	1	0	0	2	2	0	0	0
3670	COMPR GASES NOS FG	50	11	0.23	85.96	0	0	2	2	0	0	2	0	1	1	2	0	1	0	0

*From reference 1A

CODE	COMMODITY	CLASS	NO.	PERCENT	CUMM. PCT	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
[illegible]	NITRO CARBO NITRATE	35	11	0.23	86.19	0	1	3	0	3	2	1	0	1	0	0	0	0	0	0
[illegible]	RAM NOS	70	9	0.19	86.38	0	0	1	1	2	2	0	1	0	1	0	0	1	0	0
8319	PETROLEUM NAPTHA CL	20	9	0.19	86.57	0	0	0	0	0	1	0	2	0	0	1	3	1	1	0
1340	AMMONIUM NITRATE-NC	35	9	0.19	86.76	0	0	0	1	1	2	1	1	3	0	0	0	0	0	0
5206	FUEL AVIATION TURBI	20	9	0.19	86.94	0	0	0	0	0	0	0	0	0	0	0	0	1	4	4
8300	CRUDE OIL	25	9	0.19	87.13	0	1	2	2	0	0	1	0	1	0	1	0	0	1	0
1100	ACETYLENE	50	8	0.17	87.30	0	0	0	0	0	0	3	0	0	1	0	2	0	1	1
2070	BENZENE	25	8	0.17	87.47	0	0	0	1	0	2	1	0	0	0	0	2	2	0	0
5600	HIGH EXPLOSIVES	75	8	0.17	87.63	0	0	0	2	3	0	0	0	1	0	0	0	1	1	0
9874	STYRENE MONOMER INH	25	8	0.17	87.80	0	0	0	0	0	1	1	2	0	1	0	1	2	0	0
4860	EXPLOSIVES CLASS A	75	8	0.17	87.97	1	0	0	0	1	0	1	2	2	1	0	0	0	0	0
7700	NITRIC ACID	95	8	0.17	88.13	0	1	1	1	1	1	1	0	1	0	1	0	0	0	0
5980	INSECTICIDE LIQUID	60	8	0.17	88.30	0	0	0	1	0	2	0	2	0	1	0	2	0	0	0
8301	PETROLEUM DISTIL CL	20	8	0.17	88.47	0	0	0	0	0	2	0	1	1	2	1	0	0	1	0
7100	METHYL METHACRYLATE	25	7	0.15	88.61	0	0	1	0	1	0	1	1	0	0	0	0	0	2	1
2260	BOILER COMP LIQ	95	7	0.15	88.76	0	0	0	0	0	2	1	4	0	0	0	0	0	0	0
8575	POLYCHLOR BIPHENYLS	09	7	0.15	88.91	0	0	0	0	0	0	0	0	0	1	1	2	2	1	0
7520	NAPHTHA COMBUST LIQ	25	7	0.15	89.05	0	1	0	0	1	1	0	2	0	1	0	0	0	0	1
5580	HEXANE	25	7	0.15	89.20	0	0	1	0	3	0	1	1	1	0	0	0	0	0	0
7980	ORGANIC PHOSPHATEMD	60	7	0.15	89.34	0	0	1	0	0	0	3	0	0	0	2	0	0	0	1
8010	OXI MATERIAL N O S	35	7	0.15	89.49	0	0	0	0	1	1	0	2	1	0	1	0	0	1	0
3600	COMP TR & WD KILLER	60	6	0.13	89.61	0	1	0	0	0	1	2	1	0	0	0	0	0	0	1
4660	ETHYL ACETATE	25	6	0.13	89.74	0	1	0	0	0	0	1	0	2	1	1	0	0	0	0
9719	SOLVENT NOS CL	20	6	0.13	89.86	0	0	0	0	0	1	1	2	0	1	0	1	0	0	0
8415	PHOSPHORUS PENTASUL	30	6	0.13	89.99	0	0	0	0	0	1	1	3	1	0	0	0	0	0	0
[illegible]	AMMON NITR MIX FERT	35	6	0.13	90.11	0	0	0	1	4	1	0	0	0	0	0	0	0	0	0
[illegible]	COMP TR-WD KILL FL	25	6	0.13	90.24	0	0	0	1	1	0	2	0	0	0	0	1	0	0	1
[illegible]	NITROGEN PRESS LIQ	45	6	0.13	90.36	0	0	0	0	0	0	0	0	0	0	0	0	1	4	1
10650	VINYL ACETATE	25	6	0.13	90.49	0	2	0	1	0	0	0	1	0	2	0	0	0	0	0
.0730	WATER TREAT COMP LI	95	6	0.13	90.62	0	0	1	0	0	0	2	0	1	0	1	1	0	0	0
3860	SODIUM CYANIDE SOL	60	6	0.13	90.74	0	0	0	0	0	1	2	1	1	0	0	0	1	0	0
4360	DINITROPHENOL SOLUT	60	6	0.13	90.87	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0
5992	INSECTICIDE LQ NOS	20	5	0.10	90.97	0	0	0	0	0	0	0	1	0	3	0	0	1	0	0
9360	SMALL-ARMS AMMO	85	5	0.10	91.07	0	2	0	0	1	0	0	0	0	0	0	1	0	1	0
9570	SODIUM HYDROSULFITE	30	5	0.10	91.18	0	0	0	0	1	0	0	1	0	0	3	0	0	0	0
6000	INSECTICIDE LIQ FL	25	5	0.10	91.28	0	0	0	0	0	1	1	2	1	0	0	0	0	0	0
5187	FORMALDEHYDE>110GL	20	5	0.10	91.39	0	0	0	0	0	0	0	1	2	0	0	1	1	0	0
5457	HAZARD SUBST L/S	09	5	0.10	91.49	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0
1004	ACETIC ACID AQU SLN	95	5	0.10	91.60	0	0	0	0	0	0	0	1	0	0	0	1	0	1	2
5851	HYDROGEN PEROX 8-40	35	5	0.10	91.70	0	0	0	0	0	0	1	1	1	0	0	1	1	0	0
3540	COMP RUST REMOVER	95	5	0.10	91.80	0	1	0	0	1	0	1	0	1	0	0	0	0	0	1
10336	TOLUENE DIISOCYANAT	60	5	0.10	91.91	0	0	0	0	0	0	0	0	0	1	0	2	1	0	1
8540	POISONOUS SOL NOS B	60	5	0.10	92.01	0	0	0	1	2	0	0	0	0	1	1	0	0	0	0
8030	OXYGEN	45	5	0.10	92.12	0	0	0	0	2	1	0	0	0	0	0	0	0	2	0
8628	POTASS HYDROXIDE LQ	95	5	0.10	92.22	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1
2535	CALCIUM CARBIDE	30	5	0.10	92.33	0	0	0	0	0	0	0	1	0	0	2	0	0	2	0
2199	BLASTING AGENT NOS	12	5	0.10	92.43	0	0	0	0	0	0	0	0	0	1	2	0	0	2	0
4060	DICHLORODIFLUOROMET	45	4	0.08	92.51	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0
9031	RESIN SOLUTION CL	20	4	0.08	92.60	0	0	0	0	0	0	0	2	0	1	0	1	0	0	0
5970	INSECTICIDE DRY	60	4	0.08	92.68	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0
1006	ACETIC ACID GLACIAL	95	4	0.08	92.76	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1
[illegible]	CREOSOTE COAL TAR	20	4	0.08	92.85	0	0	0	0	0	0	0	1	2	0	0	0	1	0	0
[illegible]	CARBOLIC ACID LIQ	60	4	0.08	92.93	0	0	1	0	0	0	0	1	2	0	0	0	0	0	0
2470	BUTYL ACETATE	25	4	0.08	93.01	0	0	0	0	1	0	0	0	0	0	0	0	1	2	0

CODE	COMMODITY	CLASS	NO.	PERCENT	CUMM. PCT	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
[illegible]	ETHYL ALCOHOL	25	4	0.08	93.10	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1
[illegible]	SULFURIC ACID SPENT	95	4	0.08	93.18	0	0	0	0	0	0	1	0	0	0	0	1	0	0	2
[illegible]	HYDROFLOURIC ACID	95	4	0.08	93.26	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0
7995	ORM B NOS	04	4	0.08	93.35	0	0	0	0	0	2	0	0	0	1	1	0	0	0	0
10040	TAR LIQUID	25	4	0.08	93.43	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
2860	CEMENT ROOFING LIQ	25	4	0.08	93.51	0	0	0	1	0	0	0	0	0	0	0	0	1	0	2
5840	LIQUIFIED HYDROGEN	50	4	0.08	93.60	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0
8740	PROPELLANT CLASSB S	80	4	0.08	93.68	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0
8810	PYRIDINE	25	4	0.08	93.76	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1
3351	COAL TAR DISTILL CL	20	4	0.08	93.85	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0
5140	FLAM SOLIDS N.O.S.	30	4	0.08	93.93	0	0	1	0	0	0	2	0	0	0	0	0	0	0	1
3660	COMPR GASES NOS NFG	45	3	0.06	93.99	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
6940	METHYL BROMIDE CHLO	60	3	0.06	94.06	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
8040	OXYGEN PRESS LIQUID	45	3	0.06	94.12	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
1194	ALCOHOL NOS	20	3	0.06	94.18	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0
9566	SODIUM HYDROSULFIDE	95	3	0.06	94.24	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0
4650	ETHYL ETHER	25	3	0.06	94.31	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0
7276	MONOETHANOLAMINE	95	3	0.06	94.37	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0
5340	GAS DRIPS HYDROCARB	25	3	0.06	94.43	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0
1140	ACRYLONITRILE	25	3	0.06	94.49	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0
7521	NAPTHA COMB LIQ	20	3	0.06	94.56	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0
3510	COMP CL LIQ W/HCL	95	3	0.06	94.62	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
3527	COMP CL LIQ W/PHOS	95	3	0.06	94.68	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0
2870	CEMENT RUBBER	25	3	0.06	94.74	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1
7760	NITROGEN	45	3	0.06	94.81	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0
[illegible]	HEPTANE	25	3	0.06	94.87	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0
[illegible]	CHROMIC ACID	35	3	0.06	94.93	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0
[illegible]	TRICHLOROETHYLENE	02	3	0.06	94.99	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0
1431	AMMON THIOSULFATE	09	3	0.06	95.06	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
6100	ISOPROPANOL	25	3	0.06	95.12	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0
7994	ORM A NOS	02	3	0.06	95.18	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0
3354	COAL TAR DYE LIQ	95	3	0.06	95.25	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0
4880	EXPLOSIVES CLASS C	85	2	0.04	95.29	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
4930	EXPLO PROJECTILE	75	2	0.04	95.33	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
4980	EXTRACTS LIQ FLAVOR	25	2	0.04	95.37	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
5125	FLAM LIQ N.O.S.>73	25	2	0.04	95.41	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
3202	CHLORPYRIFOS	02	2	0.04	95.45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
8330	CARBOLIC ACID SOLID	60	2	0.04	95.50	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
2220	BLST CAPS >1000	75	2	0.04	95.54	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
6110	ISOPROPYL ACETATE	25	2	0.04	95.58	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
5186	FORMALDEHYDE	02	2	0.04	95.62	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
1640	ANILINE OIL LIQUID	60	2	0.04	95.66	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
5514	MALATHION	02	2	0.04	95.70	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
6924	METHYLAL	25	2	0.04	95.75	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
2290	BOOSTERS EXPLOSIVES	75	2	0.04	95.79	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
1850	ARSENICAL COMPS	60	2	0.04	95.83	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
3766	PROPIONIC ACID	95	2	0.04	95.87	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
1151	ADHESIVE	25	2	0.04	95.91	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
7110	METHYL	60	2	0.04	95.95	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
7131	METHYL PARATHION	60	2	0.04	96.00	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
3950	R.A.M. SPEC. FORM	70	2	0.04	96.04	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
[illegible]	CYANIDE SOLUTION	60	2	0.04	96.08	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
[illegible]	POTASSIUM CYANIDE S	60	2	0.04	96.12	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
[illegible]	CERTREX	06	2	0.04	96.16	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0

CODE	COMMODITY	CLASS	NO.	PERCENT	CUMM. PCT	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
	COMP CLEANING LIQ F	25	2	0.04	96.20	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
	SODIUM ALUM LIQUID	95	2	0.04	96.25	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
9520	SODIUM CHLORATE	35	2	0.04	96.29	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
9550	SODIUM DICHL TRIAZ	35	2	0.04	96.33	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
4005	DENATURED ALCOHOL	25	2	0.04	96.37	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
1132	ACRYLIC ACID	95	2	0.04	96.41	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
1008	ACETIC ANHYDRIDE	95	2	0.04	96.45	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
7720	NITROBENZOL LIQUID	60	2	0.04	96.50	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
9630	SODIUM NITRITE	30	2	0.04	96.54	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
9710	COMPOUNDS	30	2	0.04	96.58	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
4410	DISTILLATE	25	2	0.04	96.62	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
2730	CARBON DIOXIDE	45	2	0.04	96.66	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
1470	AMMO-CANNON EXPLO	75	2	0.04	96.71	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
1570	AMYL ACETATE	25	2	0.04	96.75	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
5710	HCL MIXTURES	95	2	0.04	96.79	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0
4661	ETHYL ACRYLATE	25	2	0.04	96.83	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
0088	TETRACHLOROETHYLENE	02	2	0.04	96.87	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
10184	TETRAHYDROFURAN	25	2	0.04	96.91	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
1346	AMMON NITR-FUEL OIL	12	2	0.04	96.96	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
5800	HYDROFLUOSILIC ACID	95	2	0.04	97.00	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
10409	1,1,1-TRICHLOROETHA	02	2	0.04	97.04	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
7996	ORM C N.O.S.	06	2	0.04	97.08	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
4720	ETHYLENE DICHLORIDE	25	2	0.04	97.12	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
4840	EXPLOSIVE BOMB	75	2	0.04	97.16	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
3140	CHLORINE	45	2	0.04	97.21	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
	EXPLOSIVES CLASS B	80	2	0.04	97.25	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
	AMMON PERCHLORATE	35	1	0.02	97.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
4418	DODECYLBENZENESULFO	95	1	0.02	97.29	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
6865	MERCURY METALLIC	04	1	0.02	97.31	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
6867	MESITYL OXIDE	25	1	0.02	97.33	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
6920	METHYL ACRYLATE INH	25	1	0.02	97.35	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
4480	DRUGS CHEMICALS COR	95	1	0.02	97.37	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
6932	METHYL AMYL KETONE	20	1	0.02	97.39	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2040	BATTS W/AUTOS	95	1	0.02	97.41	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
6970	METHYL BROMIDE LIQ	60	1	0.02	97.43	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
4610	ENGINE START FLUID	50	1	0.02	97.46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7070	METHYL ISOMTYL KETO	25	1	0.02	97.48	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
4630	ETCHING ACID N.O.S.	95	1	0.02	97.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
7105	METHYL METHACRYL UN	25	1	0.02	97.52	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
3350	COAL TAR DISTILLATE	25	1	0.02	97.54	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
7130	METHYL PARATHION ML	60	1	0.02	97.56	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
1424	AMMONIUM SULFATE	06	1	0.02	97.58	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
7152	MEVINPHOS	60	1	0.02	97.60	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
7192	MINING REAGENT LIQ	95	1	0.02	97.62	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
1312	ALUMINUM PHOS SLN	95	1	0.02	97.64	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
7278	MONETHANOLAMINE	95	1	0.02	97.66	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
7310	MONOMETHYTAMINE	25	1	0.02	97.69	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
3360	COAL TAR LIGHT OIL	25	1	0.02	97.71	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
4710	ETHYLENE	50	1	0.02	97.73	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
4711	ETHYLENE	50	1	0.02	97.75	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
7535	NAPTHALENE	02	1	0.02	97.77	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	NITRATE NOS	35	1	0.02	97.79	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	NITRATING ACID SPNT	95	1	0.02	97.81	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
3371	COAL TAR NAPHTHA CL	20	1	0.02	97.83	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

CODE	COMMODITY	CLASS	NO.	PERCENT	CUMM. PCT	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
[illegible]	ETHYLEN GLYCOL MEEA	20	1	0.02	97.85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
[illegible]	NITRIC ACID FUMING	35	1	0.02	97.87	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
4727	ETHLGLYC 1METH E AC	20	1	0.02	97.89	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
4752	ETHYL HEXANOL	20	1	0.02	97.91	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
3390	COATING SOLUTION	25	1	0.02	97.94	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
7780	NITROGEN FERTILIZER	45	1	0.02	97.96	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
3430	COLLODION	25	1	0.02	97.98	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
7810	NITROGEN TETROXIDEL	55	1	0.02	98.00	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7870	NITROUS OXIDE	45	1	0.02	98.02	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1326	AMMON BISULFITE SLN	95	1	0.02	98.04	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1332	AMMONIUM HYDROGEN F	95	1	0.02	98.06	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
7940	OIL WELL CARTRIDGES	85	1	0.02	98.08	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
7950	OLEUM	95	1	0.02	98.10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
7960	ORGANIC PHOSPHATE	60	1	0.02	98.12	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
7965	ORGANIC PHOSPHATE D	60	1	0.02	98.14	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
7970	ORGANIC PHOSPHATE	60	1	0.02	98.17	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
7972	ORGANOPHOS PEST L B	60	1	0.02	98.19	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
4900	EXPLOSIVE MINE	75	1	0.02	98.21	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
3495	COMPOUND CLEANING	20	1	0.02	98.23	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
1000	ACETALDEHYDE	25	1	0.02	98.25	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
5005	FERRIC CHLORIDE	95	1	0.02	98.27	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
5014	FERROUS CHLORIDE SL	95	1	0.02	98.29	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
5016	FERROUS SULFATE	09	1	0.02	98.31	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
5110	FISSILE R.A.M.	70	1	0.02	98.33	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2330	BORON TRIFLUORIDE	45	1	0.02	98.35	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
[illegible]	WASTE PAINT	20	1	0.02	98.37	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
[illegible]	COMP CL LIQ W/HFL	95	1	0.02	98.39	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
[illegible]	PARATHION LIQUID	60	1	0.02	98.42	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8160	PENTANE	25	1	0.02	98.44	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
8290	PEROXIDE ORGANIC L	35	1	0.02	98.46	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8295	PEROX ORGANICNOSL/S	35	1	0.02	98.48	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2390	BROMINE	95	1	0.02	98.50	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5142	FLAMMABLE SOLID POI	30	1	0.02	98.52	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
5165	FLUOBORIC ACID	95	1	0.02	98.54	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
5170	FLUORINE	45	1	0.02	98.56	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
2463	BUTYL ALCOHOL	25	1	0.02	98.58	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
3550	COMP PAINT REMOVE L	95	1	0.02	98.60	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
5190	FORMIC ACID	95	1	0.02	98.62	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
3551	COMP LAQ,PNT RM CL	20	1	0.02	98.64	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8440	PHOSPHORUS TRICL2	95	1	0.02	98.67	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
3495	PINE OIL	20	1	0.02	98.69	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
8510	POISONOUS LIQ/GSNOS	55	1	0.02	98.71	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
1158	ADIPIC ACID	09	1	0.02	98.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3570	COMP PAINT REMOVE C	95	1	0.02	98.75	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3587	WEED KILLER	95	1	0.02	98.77	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
5230	FUSE IGNITERS	85	1	0.02	98.79	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
3631	POTASS HYDROXIDE DR	95	1	0.02	98.81	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8670	POTASSIUM	35	1	0.02	98.83	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
5280	FUZES DETON EXPLO C	85	1	0.02	98.85	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2500	BUTYL ALDEHYDE	25	1	0.02	98.87	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1670	ANTI-FREEZE PR LIQ	25	1	0.02	98.90	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
[illegible]	ARGON PRESS LIQUID	45	1	0.02	98.92	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
[illegible]	CARBON BISULFIDE	25	1	0.02	98.94	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
3940	R.A.M. SMALL QUANTY	70	1	0.02	98.96	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

CODE	COMMODITY	CLASS	NO.	PERCENT	CUMM. PCT	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
[illegible]	CONSUMER COMMODITY	08	1	0.02	98.98	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	COPPER CYANIDE	60	1	0.02	99.00	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
5570	HEXAMETHYLENE DIA S	95	1	0.02	99.02	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
9170	ROCKET MOTORS CL B	80	1	0.02	99.04	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
3720	CORDEAU DETON FUSES	85	1	0.02	99.06	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
9310	SILICON CHLORIDE	95	1	0.02	99.08	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1740	ARSENIC ACID LIQUID	60	1	0.02	99.10	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
9410	SMOKELESS PWDR (100	30	1	0.02	99.12	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
5660	HYDRIODIC ACID	95	1	0.02	99.15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9500	SODIUM BROMATE	35	1	0.02	99.17	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1830	ARSENIC TRIOXIDE	60	1	0.02	99.19	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
9540	SODIUM CHLORITE(43S	95	1	0.02	99.21	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2750	CARBON REMOVER LIQ	25	1	0.02	99.23	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
9552	SODIUM DICHROMATE	02	1	0.02	99.25	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
3751	CRESOL	95	1	0.02	99.27	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
2752	CARBON TETRACHLOR	02	1	0.02	99.29	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2760	CRT BGS MT W/BP/IG	85	1	0.02	99.31	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
3820	CYANIDE OR MIXTURES	60	1	0.02	99.33	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1182	ALCOHOLIC BEVERAGE	25	1	0.02	99.35	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
9640	SODIUM NITRITE	35	1	0.02	99.37	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
5850	HYDROGEN PEROXIDE	95	1	0.02	99.40	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1305	ALUMINUM CHLORDE AN	95	1	0.02	99.42	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
5852	HYDROGEN PEROX40-52	35	1	0.02	99.44	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
9730	SPECIAL FIREWORKS	80	1	0.02	99.46	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1361	AMMON NITR SOL	35	1	0.02	99.48	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
[illegible]	SODIUM CHLORATE	35	1	0.02	99.50	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
[illegible]	CHLOROBENZENE	25	1	0.02	99.52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
[illegible]	NITROPHENOL PEST.	60	1	0.02	99.54	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
4030	DETONNATORS	85	1	0.02	99.56	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
4057	DICHLOROBENZENE ORT	02	1	0.02	99.58	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
10041	TAR LIQUID CL	20	1	0.02	99.60	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1310	AMMONIUM NITRATE	35	1	0.02	99.63	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
4122	2 4-DICHLOROPHENOXY	02	1	0.02	99.65	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
10230	THIONYL CHLORIDE	95	1	0.02	99.67	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
6090	ISOPRENE	25	1	0.02	99.69	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
3181	MONOCHLORODIFLUORME	45	1	0.02	99.71	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
4397	DISINFECTANT LQ COR	95	1	0.02	99.73	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
4409	DIURON	09	1	0.02	99.75	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10430	TRICHLORO-S-TRIAZIN	35	1	0.02	99.77	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
10480	TRIMETHYLAMINE ANHY	50	1	0.02	99.79	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
10568	TURPENTINE FLAM	25	1	0.02	99.81	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
10584	URANIUM 6FLUOR FISS	70	1	0.02	99.83	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
6190	LAQUER BASE	25	1	0.02	99.85	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
6242	LEAD PEROXIDE	35	1	0.02	99.88	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10760	NITROCELL 30%A WET	25	1	0.02	99.90	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
10780	NITROCELL FLAKE WET	30	1	0.02	99.92	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
6260	LEATHER DRESSING	25	1	0.02	99.94	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
6290	NON FLAM GAS NOS	45	1	0.02	99.96	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
10934	ZINC BROMIDE	09	1	0.02	99.98	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
10942	ZINC CHLORIDE SLN	95	1	0.02	100.00	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
			4795			1	154	301	355	409	493	490	491	353	321	341	304	316	335	131

REFERENCES

1A. Department of Transportation Hazardous Materials Information System - Nationwide Data.

APPENDIX B

APPENDIX B

TRUCK ACCIDENT PROBABILITY

This appendix summarizes the traffic accident data obtained from the California Department of Transportation (CalTrans) and the California Highway Patrol (CHP), and calculates the base probability of a truck accident near San Onofre spilling a chemical of the type in the matrices (the Monte Carlo computer model allows the variables to have a range of values).

An analysis of truck traffic and hazardous material incidents was performed to determine the probability of a truck carrying a toxic substance (of the type that could potentially incapacitate a control room operator) being involved in an accident which results in a release of part or all of its load on the subject 10 mile section of Interstate 5 (I-5). The data base used in the analysis was obtained from statewide and site-specific traffic and hazardous material incident data from the California Department of Transportation (CalTrans) and the California Highway Patrol (CHP)[6B-9B]. The reliability of the data base is enhanced by these two main factors: (1) the San Onofre Truck Weigh Station, where passing trucks are counted and typed by both CalTrans and the CHP, is located only 2-1/2 miles from SONGS, and (2) California is a leader in the control of toxics and information regarding the transporting of hazardous materials.[1B-4B]

An estimate of the frequency of spill of a material of the type in this study is listed below along with an explanation of each value used in the equation. The set of values chosen for use in the equation was determined to be the combination with the least amount of uncertainty after an evaluation of the data available. The final values were determined from tables B1-B3 and discussions with CalTrans and CHP personnel on how they obtained their data. The information in these tables was extracted from both raw data in computerized data bases (6B-9B) and reports (1B-5B) prepared by CalTrans, CHP, California Hazardous Substance Task Force, Department of Industrial Relations, and Division of Occupational Safety and Health.

From the main report, $PS = \frac{NA}{L} f_1 f_2 f_3$. The average value is as follows:

$$\underset{\text{A.(MA)}}{(\underline{20\ \text{Truck Accidents}})}\ \underset{\text{B.(L)}}{\left(\frac{1}{10.3\ \text{mi.}}\right)}\ \underset{\text{C.(f1)}}{\left(\frac{0.02\ \text{H.M. Truck Accidents}}{\text{Total Truck Accidents}}\right)}$$

$$\times\ \underset{\text{D.(f2)}}{\left(\frac{0.25\ \text{H.M. Spills}}{\text{H.M. Accidents}}\right)}\ \underset{\text{E.(f3)}}{\left(\frac{0.133\ \text{Toxic Spills}}{\text{H.M. Spills}}\right)} = \underset{\text{(Ps)}}{\left(\frac{.0013\ \text{Toxic Spills}}{\text{Year-Mile}}\right)}$$

A. The truck accident data obtained from the CHP's computerized data base(8) of the number truck-involved accidents from the Orange County/San Diego County line to Las Pulgas road over the last 11 years. This is a 10.3-mile section of highway which is representative of the 10-mile section of interest in this study (table B3).

B. The section of highway studied is 10.3 miles in length(8B).

C. The ratios of the number of accidents involving a hazardous material transporter to the number of truck accidents. This data was taken on the section of I-5 from the Orange County/San Diego line to Vandegrift Road by CalTrans(7B). (Table B1, 2 HM accidents in 28 + 38 + 35 = 101 truck accidents)

D. This value was derived from data which were obtained from statewide data for the years 1984 and 1985(1B). [Table B2, (36 + 24)/(139 + 103) = .25].

E. Not all hazardous material spills are "dangerous" with respect to this particular study. This fraction represents the fraction of the hazardous spill being a chemical in our matrices (526 out of 3946; 526 = sum of main report tables 1 and 2; 3946 total non-zero spills, see section 4.2 of main report.)

The above value agrees with the data shown below [from reference (5E)]. Since most of these highways include city miles, their incident rate would be expected to be higher than the rate for the study.

Highway	Highway Length in Miles(1)	Number	Incidents Per 100 Miles(2)	Toxic Spills(3) Per 100 Miles
5	797	39	4.8	.51
101	804	16	1.9	.20
99	499	10	2.0	.21
7	21	6	28.5(4)	-
80	200	6	2.0	.21
10	242	4	1.6	.17
14	116	4	3.4	.36
405	72	4	5.5	.59
680	70	4	5.7	.61
This Study				.13(5)

(1) Mileage data from CalTrans.
(2) Total incidents in 6 months - truck accidents are about 40% of the incidents (incidents also include abandoned material and fixed facility releases).
(3) Incidents x 2 x .4 x .133 (see 2 above and E above).
(4) Long Beach Freeway through industrial area - see reference (5E).
(5) This is lower than I-5 as a whole due to the straight, open nature of I-5 near the plant. I-5 as a whole includes several cities plus older, narrow, freeway streches (i.e., through Santa Ana, Downtown L.A.).

TABLE B1 (REF. 7B)

TASAS SELECTIVE RECORD RETRIEVAL
TRUCK ACCIDENTS ON I-5 FROM SD/OC LINE
TO VANDEGRIFT ROAD (1984-1987)

YEAR	# ACCIDENTS	# VEHICLES INVOLVED	# TRUCKS INVOLVED	# HM INCIDENTS	HM INCIDENTS / TRUCK ACCIDENTS
1984	25	43	≥ 28	1	≤ 0.036
1985	35	≥ 73	≥ 38	0	0
1986	31	≥ 60	≥ 35	1	≤ 0.028
1987	6	11	≥ 6	0	0

TABLE B2 (REF. 1B)

HAZARDOUS MATERIAL ACCIDENTS
(State Highways Only)

	1984	1985
Accidents	139	103
Fatalities*	5	9
Injuries*	104	66
Fire	1	4
Spills	36	24
Overturns	28	19

* Not necessarily due to hazardous material exposure.

TABLE B3 (REF. 9B)

1976 - 1986 ACCIDENTS ON I-5 FROM
THE ORANGE COUNTY/SAN DIEGO COUNTY
LINE TO LAS PULGAS ROAD

YEAR	TOTAL NUMBER OF ACCIDENTS (All Vehicles)	TOTAL NUMBER OF TRUCKS INVOLVED IN ACCIDENTS
1976	129	16
1977	148	13
1978	161	18
1979	139	19
1980	136	18
1981	133	17
1982	146	18
1983	142	16
1984	135	19
1985	137	20
1986	179	20

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7B. CalTrans. TASAS selective record retrieval of truck accidents on I-5 from the Orange County/San Diego County line to Vandegrift Road (1984-1987)

8B. CHP. Telephone notes and computerized data base printout of San Onofre truck weigh station truck counts (1980-1986)

9B. CHP. Oceanside Area Accidents (1976-1986)
Computerized data base.

10B. CHP. Information Bulletin - HM Incident
Summary for 1985-1986. March 9, 1987

APPENDIX C

APPENDIX C

TOXICITY CATEGORIZATION AND FINAL CHEMICAL SELECTION

This appendix details the selection of chemicals for use in constructing the matricies, and sets the toxicity level for each chemical.

Chemical commodities recorded in the Department of Transportation (DOT) national hazardous material spill incident data tape were reviewed for the toxicity limits to generate a toxicity matrix for modeling purpose. The evaluation concentrated on short term health effects and the approximate toxicity levels in light of potential incapacitation of control room operators. The health effects of main concern are those causing immediate symptoms (i.e., irritation on eyes and respiratory system) that as a result, the control room operators might not be able to operate the plant safely.

First, however, all chemical commodities contained in the DOT data tape were evaluated for inclusion since not all chemicals were treated individually or were appropriate for inclusion in the final matrix toxicity table. Several screening procedures were taken to select the most pertinent chemicals that warrant special concerns for the purpose of this particular study. These criteria are as follows:

A. First, solids and nonvolatile liquids were eliminated since they would not reach the control room. Typical items are shown in table C1.

B. Chemicals with common names that no individual toxicity limits could be identified are classified by groups and represented by one typical chemical commodity or a specific constituent which warrants special concern. Table C2 provides a list of chemicals classified by groups.

C. Chemicals which cannot be assigned an appropriate toxicity limit are listed in table C3. These were then reviewed for material type and recorded spill incidents and quantities. It was determined that only one of them (Inhibited Styrene Monomer) could have any noticeable impact (all others had one or more of the following: small liquid spill quantity, low volatility, dilute solutions, few incidents, unlikely to have low toxicity level, etc.) on the overall distribution even if certain toxicity limits could be assigned. Therefore, all of these chemicals are deleted from further study (the uncertainty analysis will be sufficient to bound any contribution from the Styrene Monomer. The effect of the inhibitor on toxicity and chemical properties is unknown, or it could not be clarified or included with some other chemical).

The remaining chemicals were then assigned a toxicity value using the following guidelines:

A. Wherever possible the Immediately Dangerous to Life and Health (IDLH) levels are used as the toxicity limit. IDLH levels are defined by the National Institute for Occupational Safety and Health (NIOSH) to be the maximum exposure levels from which workers could escape within 30 minutes without irreversible or permanent health effects and without causing any reactions that could impair the operator's ability to take mitigating steps. Chemicals with available IDLH levels are listed in table C4.

B. If IDLH levels are not available, other human acute, longer than 30 minutes, toxic concentrations are used.

C. If human acute toxic concentrations are not available, human long term exposure levels (i.e., TLVs) are preferable to animal short term toxic concentrations. This is to avoid uncertainties involved in interspecies sensitivities.

D. For organic compounds with more than one structure configurations and therefore different toxicity limits (i.e., N-Amyl acetate and sec-Amyl acetate), the lower toxicity limit is used for conservatism if the source data does not identify specific compounds.

E. Liquid or gaseous chemicals with a toxicity limit greater than 1000 mg/m^3 and only 1 or 2 incidents (see Appendix A) were excluded as not contributing significantly to the final probability. These represent only about 30 incidents, all of which would enveloped by the uncertainty range in the Monte Carlo simulation runs.

After the above screening procedures the list of remaining chemicals was reviewed for inclusion in the final matrices. Table C5 shows additional chemicals that were excluded in this final review and the reason for exclusion. Table C6 shows the final chemicals selected grouped by toxicity category.

TABLE C1

CHEMICAL TYPES DETERMINED TO BE
NOT PERTINENT TO THE EXPOSURE MODEL

COMMODITY	COMMODITY
CORROSIVE SOLID N.O.S. *	Ca HYPOCHLORITE MIX
ALKALINE LIQ N.O.S.	HAZARD WASTE L/S
HYPOCHLORITE SOL.	POISON B LIQ N.O.S.
NaOH LIQ/SOLID	OXYGEN
FERTILIZERS	EXPLOSIVES & AMMUNITION
INSECTICIDES, WEED KILLERS, ETC.	COAL TAR, TAR
FLAM SOLIDS N.O.S.	WATER TREATMENT COMPOUNDS
CHROMIC ACID SOLID	PHOSPHORIC ACID
NITRO CARBO NITRATE	ORGANIC PHOSPHATE
ADHESIVES	BATTERIES
ARGON	ANTIFREEZE
R.A.M. SMALL QUANTITY	SODIUM CHLORITE
ROCKET MOTORS	ALCOHOLIC BEVERAGES
FIREWORKS	PAINTS, LACQUERS

* Not Otherwise Specified

TABLE C2

CHEMICAL GROUPINGS

DOT DATA
TAPE CODE
GASOLINE/OILS

3560 GASOLINE
3770/1 CRUDE OIL
8300/1 PETROLEUM DIST.
5201/6 AVIATION FUEL
7930/1 OIL N.O.S.
7490 MOTOR FUEL
5340 GAS DRIPS NOS
5130 FLAM. LIQ. NOS*
5202/3 FUEL OILS
3475 COMBUSTIBLE LIQ. NOS*
6170 KEROSENE
3351 COAL TAR DIST.
1925/6/7 ASPHALT
7521 NAPTHA CL.

DOT DATA
TAPE CODE
BENZENE/SOLVENTS

2070 BENZENE
3560 PAINT THINNER
8320 PETROLEUM NAPTHA
7520 NAPTHA
9720 SOLVENT NOS

ETHANOL/MISC.
ALCOHOLS

4668 ETHANOL
1190/4 ALCOHOL NOS

HYDROCHLORIC/MISC.
ACIDS

5700/20 HYDROCHLORIC ACID
1120 ACID

LPG/FLAMMABLE
COMP. GAS

6300 LPG
3670 FLAM. COMP. GAS N.O.S.

* Since N.O.S. (Not Otherwise Specified) solvents, alcohols, acids each have their own listings, most of these are probably gasoline/oil type liquids

TABLE C3

LIST FOR CHEMICALS WITH UNKNOWN TOXICITY LEVELS

	DOT DATA TAPE CODE	COMMODITY
	3730	CORR. LIQ. N.O.S.**
	9030/1	RESIN SOLUTION
	3490/3510/3527	COMP CLEANING LIQ
	2030	BATTS STORAGE WET
	8930	R.A.M. N.O.S.*
	4560	ELECTR BATT FL
	5960	INK
	8920	R.A.M. N.O.S.
**	9874	STYRENE MONOMER INH
	9719	LAQ SOL
	4360	DINITROPHENOL SOL. (one, 5-gal. spill)
	3540	COMP RUST REMOVER
	8740	PROPELLANT CL. B.S.
	3660	COMP GASES N.O.S NFG (NON FLAM.)
	7994	ORM A N.O.S.
	8050	PAINT FL
	8060	PAINT. ENAM, LAQ
	2840	CEMENT LIQUID N.O.S.
	2870	CEMENT RUBBER
	2860	CEMENT ROOFING LIQ
	7996	ORM C N.O.S.
	8950	R.A.M. SPEC FORM
	3500	COMP CLEANING LIQ
	9710	COMPOUNDS
	5110	FISSILE R.A.M.

* N.O.S. is not otherwise specified

** Only chemical that had several large spills may be volatile and could be sufficiently concentrated to cause a problem.

TABLE C4

CHEMICALS IN DATA BASE WITH KNOWN IDLH LEVELS*

DOT DATA TAPE CODE COMMODITY
1140 ACRYLONITRILE
1620 ANHYDROUS AMMONIA
5700/20 HYDROCHLORIC ACID
5770 HYDROFLUORIC ACID
9760,9930 SULFURIC ACID
10820 WOOD ALCOHOL
1004/6 ACETIC ACID
1008 ACETIC ANHYDRIDE
1010 ACETONE
1570 AMYL ACETATE
1336,1620 AMMONIA
2070 BENZENE
2710/30 CARBON DIOXIDE
2752 CARBON TETRACHLORIDE
6940 METHYL BROMIDE CHLORIDE
2930 CHLORINE
5170 FLUORINE
1640 ANILINE
5580 HEXANE
1100 ACETYLENE

DOT DATA TAPE CODE COMMODITY
3075 CHLOROBENZENE
8319 NAPTHA
7700 NITRIC ACID
7276 MONOETHANOLAMINE
5490 HEPTANE
10420 TCE
5186/7 FORMALDEHYDE
7535 NAPTHALENE
4060 DICHLORODIFLUOROMETHANE
4660 ETHYL ACETATE
4650 ETHYL ETHER
10890 XYLENE
10340 TOLUENE
8810 PYRIDINE
7040 METHYL ETHYL KETONE
6300 LPG
6100 ISOPROPANOL
5140 FORMIC ACID
2470 BUTYL ACETATE
7100 METHYL METHACRYLATE

* Excluding chemicals of the type in Table C1

TABLE C5

CHEMICALS EXCLUDED

10650 VINYL ACETATE - Forms a solid on exposure to light

5470 HELIUM 5810/40 HYDROGEN 7760/7800 NITROGEN 4060 DICHLORODIFLUOROMETHANE	Toxicity Level Greater Than 10^5

5770 HYDROFLUORIC ACID - weak, dilute solution
5850/1 HYDROGEN PEROXIDE - weak solution, nonvolatile

GASOLINE/OILS (Listed in Table C3) - According to the SONGS FSAR (10C) gasoline was shown by previsous analyses to not pose a hazard to control room habitability. Hence, related compounds are also not expected to pose a hazard. Oils are excluded due to their low volatility.

1620 ANHYDROUS AMMONIA, 1336 AQUEOUS AMMONIA - According to the SONGS FSAR (10C) onsite storage of ammonia requires the presence of a detector at the control room outside air intake. Onsite storage cannot be evaluated using probabilistic methods.

110336 TOLUENE DIISOCYANATE 2330 BORON TRIFLUORIDE 8440 PHOSPHOROUS TRIFLUORIDE 7810 NITROGEN TETROXIDE	Chemical Properties Not Available - Few Incidents Will Not Impact Matrices

8520 POISON (LIQUID), N.O.S. - Chemical make-up unknown, only 2 large spills.

TABLE C6

TOXICITY CATEGORIES (mg/m3)
OF FINAL CHEMICALS SELECTED

0-1	1-10	10-100	100-1000	10E3-10E4	10E4-10E5	>10E5
None	None	9930,9760, H2SO4 6940 METH. BROMIDE CHLORIDE 2930 BROMINE 3140 CHLORINE 5170 FLUORINE	7700/1 HNO3 5700,5720 HCL 5186/7 FORMALDEHYDE 7105 METHYL METHACRYLATE 1640 ANILINE OIL LIQUID 5190 FORMIC ACID 1120 ACID(a)	10340 TOLUENE 7040 METHYL ETHYL KETONE 5580 HEXANE 4668 ETHYL ALCOHOL 1004/6 ACETIC ACID 2070 BENZENE 1140 ACRYCONITRILE 3560 PAINT THINNER(b) 8320 PETROLEUM NAPTHA(b) 9720 SOLVENT N.O.S.(b) 1190 ALCOHOL N.O.S.(c) 1194 ALCOHOL N.O.S.(c)	1010 ACETONE 6300 LPG 10820 WOOD ALCOHOL 2710/30 CO2 10890 XYLENE 5490 HEPTANE 4660 ETHYL ACETATE 8810 PYRIDINE 2470 BUTYL ACETATE 7100 METHYL METHACRYLATE 3670 FLAM COMP GAS N.O.S.(d)	1100 ACETYLENE

(a) EVALUATED AS HCl
(b) EVALUATED AS BENZENE
(c) EVALUATED AS ETHYL ALCOHOL
(d) EVALUATED AS LPG

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APPENDIX D

APPENDIX D

STATISTICAL MODEL FOR UNCERTAINTY

This appendix provides the detailed explanation of the statistical theory used in determining the probability distribution due to uncertainties in the basic parameters.

1. <u>Uncertainty Distributions</u>

Risk evaluation has two different dimensions: randomness and uncertainty. Randomness represents a variability or a chance outcome of the repeated experiment under the same controlled conditions. These can be quantified by probability density functions.

Goodman[5D] suggests that the probability related to randomness be called the R-probability. The R-probability is always related to the observed frequency: The R-probability is a limit of frequency when number of observations increases indefinitely.

Uncertainty represents a lack of knowledge of parameters of interest. Uncertainty can be quantified with confidence intervals (classical statistics) or state-of-knowledge distributions (Bayesian statistics). In fact, we can always recover distributions corresponding to confidence intervals and estimate confidence intervals for the known uncertainty distributions. Therefore, consider confidence intervals as a short representation of uncertainty distributions, called the U-distribution.

There is a fundamental difference between R- and U-distributions. R-distributions can be measured experimentally by counting frequencies. U-distributions cannot be measured in principle. That is, every measurement changes the state-of-knowledge, and, therefore,

changes the shape of the corresponding U-distribution. The U-distribution represents the likelihood of different values of the parameter of interest.

The mean of the R-distribution has a real meaning because it estimates an average of many measurements; however, the U-distribution has no advantages to any other point estimates. The relevant parameters are median and confidence interval.

The best short representation of a U-distribution is the best confidence interval[2D] and the maximum likelihood estimate. The best confidence interval will provide the shortest confidence interval consistent with available information and the maximum likelihood estimate is related to the observed sample values. However, because the corresponding analytical and computational methods are not developed for experimental data, the standard use of 5%, median (50%), and 95% values will be used. This presentation is more conservative because the confidence interval is larger and the median is greater than the maximum likelihood value for state-of-knowledge distributions incorporated in this study.

There are three typical cases for developing a U-distribution.

<u>Case 1</u>. There are plenty of specific data. In this case the most appropriate method is a classical statistical approach[8D].

<u>Case 2</u>. There are few specific data and plenty of generic data. In this case the most appropriate method is a Bayesian approach[13D].

<u>Case 3</u>. There are few specific data and no preliminary or generic information. In this case the most appropriate method is a likelihood density function approach[3D,4D,6D].

For example, in our study, meteorological data are abundant and should be treated with classical statistics. However, uncertainty of these data is so small relative to other data that it can be neglected. In contrast, transportation and release data are rather limited. Therefore, we use Case 3, the likelihood density function method for uncertainty propagation. This is done as described in the following paragraphs.

A random attribute can be described with probability p of the favorable outcome (the opposite outcome has probability 1-p). The probability, P(k; p, n), that in the n tests the favorable outcome with the known probability P will appear exactly k times is a binomial distribution:

$$P(k; p, n) = \begin{bmatrix} n \\ k \end{bmatrix} p^k(1 - p)^{n-k} \tag{1}$$

Note: Variables and complete theory are described in reference (3D).

Assume now, that we do not know the true probability p, but we measure numbers k and n.

Let us construct a likelihood function L(p; k, n)

$$L(p; k, n) = \begin{bmatrix} n \\ k \end{bmatrix} p^k(1 - p)^{n-k} \tag{2}$$

Now consider L(p; k, n) as a function of the parameter p (see figure 1).

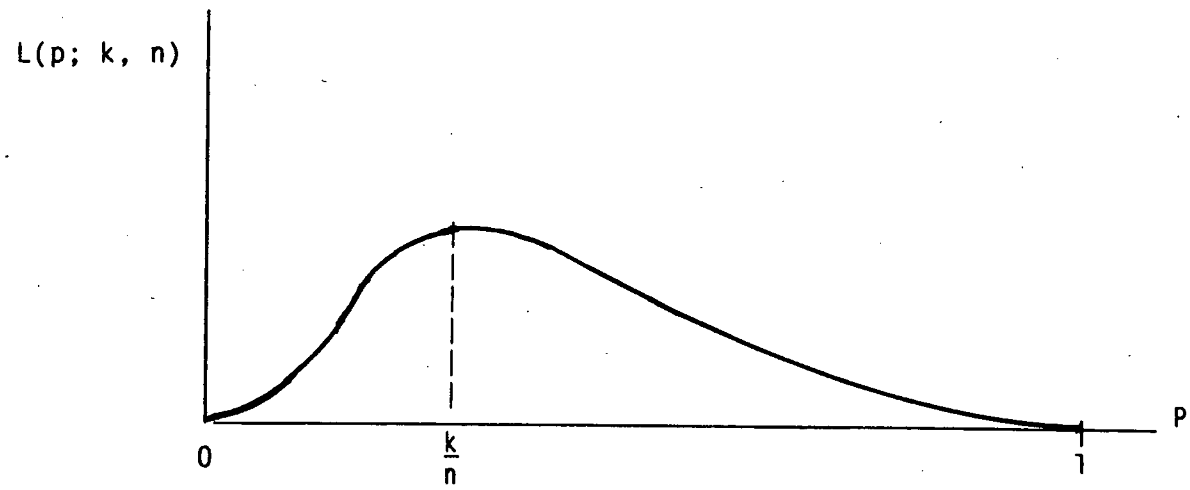

FIGURE 1

For some values p the likelihood function[2] is greater, for some less. The observed result categorized with numbers k and n has a different likelihood depending on the true value of the unknown parameter p. The basic assumption of the likelihood density function method is that the probability (or likelihood) that a given value of the parameter p is a true value for the R-probability in question is proportional to the likelihood function L(p; k, n). To obtain the probability density function we should normalize the likelihood function:

(3) $$fu(p; k, n) = \frac{L(p; k, n)}{\int_0^1 L(p'; k, n)\, dp'}$$

Inserting (2) into (3) we obtain:

$$fu(p;\ k,\ n) = \frac{(n+1)!}{k!(n-k)!} p^{k}(1-p)^{n-k} \tag{4}$$

Multiple events, such as the mass release/toxicity matrix can be described with a polynomial distribution:

$$P(k_1,\ k_2,\ldots k_m;\ P_1,\ P_2,\ldots P_m) = \frac{n!}{k_1!,\ k_2!\ldots k_m!} P_1^{k_1},\ P_2^{k_2},\ldots P_m^{k_m} \tag{5}$$

Where the following identities are held:

$$k_1 + k_2 + \ldots + K_m = n \tag{6}$$

$$P_1 + P_2 + \ldots + P_m = 1.0 \tag{7}$$

Therefore, among m probabilities $P_1,\ P_2,\ldots P_m$ there are only m-1 independent. According to Goodman(7D), we may select m-1 independent probabilities as follows:

$$q_i = \frac{P_i}{1 - \sum_{j=1}^{i-1} P_j},\quad i \neq m \tag{8}$$

After transformation (8) we will have m-1 independent binomial distributions:

$$P_i(k_i;\ q_i,\ n_i) = \begin{bmatrix} n_i \\ k_i \end{bmatrix} q_i^{k_i} (1 - q_i)^{n_i - k_i} \tag{9}$$

where:

$$n_i = n - \sum_{j=1}^{i-1} k_j \qquad \begin{matrix}(i \neq 1)\\(i \neq m)\end{matrix} \tag{10}$$

$$n_1 = n$$

The corresponding likelihood density function distributions are:

$$f_u^{(i)} = \frac{(n_i + 1)!}{k_i!(n_i - k_i)!} P_i^{k_i}(1 - P_i)^{n_i - k_i} \tag{11}$$

Consider the class of random variables x described with the Edgeworth-Kapteyn distribution, which is applicable to the traffic accident model:

$$f_R(x;\ \mu,\ \sigma) = \frac{1}{\sqrt{2\pi}\ \sigma} \exp \left\{ -\frac{1}{2} \left[\frac{y(x) - \mu}{\sigma} \right]^2 \right\} \left| \frac{dy}{dx} \right| \tag{12}$$

Assume that we have n random observations of the parameter x: x_1, $x_2, \ldots x_n$. According to Goodman[6], the likelihood function for parameters μ and σ is:

$$L(\mu,\ \sigma;\ m,\ S,\ n) = \frac{1}{(2\pi)^{n/2}\ \sigma^n} \exp \left\{ -\frac{n}{2\sigma^2} \left[S^2 + (\mu - m)^2 \right] \right\} \tag{13}$$

and the likelihood density function is:

$$f_u(\mu,\ \sigma;\ m,\ S,\ n) = X^2_{n-2}(x)\ \emptyset\ (z) \tag{14}$$

where:

$$m = \frac{1}{n} \sum_{i=1}^{n} Y(n_i) \tag{15}$$

$$S^2 = \frac{1}{n} \sum_{i=1}^{n} \left[Y(n_i) \right] - m^2 \quad (16)$$

$$x = n \left[\frac{S}{\sigma} \right]^2 \quad (17)$$

$$z = \frac{\mu - m}{\sigma / \sqrt{n}} \quad (18)$$

2. <u>Uncertainty Propagation</u>

Because of uncertainty of data, the expected total risk P_T (i.e., probability of control room uninhabitability) depends on numerous uncertainty parameters $\alpha_1, \alpha_2, \ldots \alpha_N$:

$$P_T = \psi (\alpha_1, \alpha_2, \ldots \alpha_N)$$

Each of these parameters will have an uncertainty distribution of one of the three types described above. Using Monte Carlo Simulation, we can generate random sets of parameters $\alpha_1, \alpha_2, \ldots \alpha_N$ to estimate a random value of the expected risk P_T. Repeating this simulation many times we obtain the distribution function for P_T (see figure2).

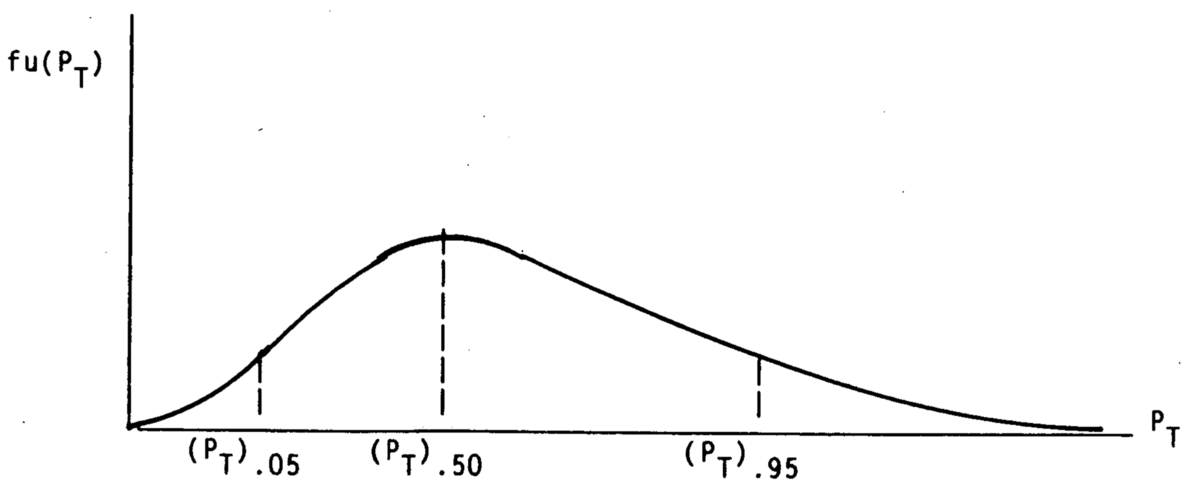

FIGURE 2

Using this distribution we evaluate 5th, 50th and 95th percentiles. The 50th percentile is median. We use median for comparison with acceptance criteria. The 5th and 95th percentiles are lower and upper limits of the 90 percent confidence interval. We use this confidence interval as a measure of uncertainty of our risk estimate.

3. <u>G-Test of Belonging of Two Random Samples to the Same Data Base</u>

In data treatment and decision-making we have to solve two typical problems:

a. Whether two samples belong to the same population (two representative samples from the same data base)?

b. Whether a smaller sample is a biased or unbiased sample from the population represented by a larger sample?

A random sample can be generated by an R-distribution with some population parameters. Using the same distribution with the same parameters we can generate several different random samples. However, if we have two random samples it is not clear whether they belong to the same population, i.e., can they be considered as two random samples generated with the same distribution. This indecisiveness lies in the fact that population parameters can only be can determined with some degree of uncertainty. Actually, for every sample we can construct a U-distribution for population parameters. If these two U-distributions completely overlap, we may say that two samples belong to the same population. If these two U-distributions are not overlapping at all we have a definite case of two different data bases. However, in the case of partial overlapping the decision is not obvious.

This portral overlapping problem can be addressed by the G-test developed by Goodman(4D). This test is based on Jeffreys measure of divergence between two distributions in information theory. Actually, it is an analog of the likelihood ratio test(8D) applied to the U-distributions.

According to the G-test we should estimate the best Υ-confidence interval and the maximum likelihood value for both distributions. If the maximum likelihood value of the first distribution is within the best Υ-confidence interval of the second one and vice-versa, then with the confidence Υ we cannot reject the hypothesis that both samples belong to the same data base. In this case we can merge both samples together and reduce total uncertainty. As a rule, every sample will pass a G-test with a combined sample.

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APPENDIX E

APPENDIX E

MATRICES USED IN OVERALL MODEL STABILITY ANALYSIS

This appendix includes all the matrices used in this study for the testing of stability over time and for California as a region (see main report sections 3.0 and 5.2). Tables E1-E3 show the continuous release incidents for the three, 3-year subsets (1977-79, 80-82, 83-85), and table E4 contains only California incidents (1972-1986). Tables E5-E8 are the same as E1-E4, but for puff release chemicals.

APPENDIX E

TABLE E1

CONTINUOUS - HAZARDOUS MATERIALS RELEASES (U.S. YEARS 77-79)

NUMBER OF OCCURRENCES

CITY MIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0	0
10 - 100	8	7	11	0	0	0	0	1	0	27
100 - 1000	0	3	3	1	5	21	0	0	0	33
10^3 - 10^4	0	0	0	1	10	9	33	0	0	53
10^4 - 10^5	0	0	0	0	4	4	12	5	0	25
VER 100000	0	0	0	0	0	0	0	0	0	0
TOTAL	8	10	14	2	19	34	45	6	0	138

PERCENTAGE OF TOTAL OCCURRENCES

CITY IT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0580	0.0507	0.0797	0.0000	0.0000	0.0000	0.0000	0.0072	0.0000	0.1957
100 - 1000	0.0000	0.0217	0.0217	0.0072	0.0362	0.1522	0.0000	0.0000	0.0000	0.2391
0^3 - 10^4	0.0000	0.0000	0.0000	0.0072	0.0725	0.0652	0.2391	0.0000	0.0000	0.3841
10^4 - 10^5	0.0000	0.0000	0.0000	0.0000	0.0290	0.0290	0.0870	0.0362	0.0000	0.1812
VER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	0.0580	0.0725	0.1014	0.0145	0.1377	0.2464	0.3261	0.0435	0.0000	1.0000

TABLE E2

CONTINUOUS - HAZARDOUS MATERIALS RELEASES (U.S. YEARS 80-82)

NUMBER OF OCCURRENCES

TOXICITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0	0
10 - 100	6	5	5	0	0	0	0	0	0	16
100 - 1000	0	2	4	7	11	31	0	0	0	55
10^3 - 10^4	0	0	0	0	9	11	25	0	0	45
10^4 - 10^5	0	0	0	0	0	7	9	3	0	19
OVER 100000	0	0	0	0	0	0	0	0	0	0
TOTAL	6	7	9	7	20	49	34	3	0	135

PERCENTAGE OF TOTAL OCCURRENCES

TOXICITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0444	0.0370	0.0370	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1185
100 - 1000	0.0000	0.0148	0.0296	0.0519	0.0815	0.2296	0.0000	0.0000	0.0000	0.4074
10^3 - 10^4	0.0000	0.0000	0.0000	0.0000	0.0667	0.0815	0.1852	0.0000	0.0000	0.3333
10^4 - 10^5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0519	0.0667	0.0222	0.0000	0.1407
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	0.0444	0.0519	0.0667	0.0519	0.1481	0.3630	0.2519	0.0222	0.0000	1.0000

TABLE E3

CONTINUOUS - HAZARDOUS MATERIALS RELEASES (U.S. YEARS 83-85)

NUMBER OF OCCURRENCES

[illegible]ITY [illegible]IT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0	0
10 - 100	3	2	7	0	0	0	0	0	0	12
100 - 1000	1	1	4	4	4	23	1	0	0	38
10^3 - 10^4	0	0	0	0	7	5	17	0	0	29
10^4 - 10^5	0	0	0	6	3	4	8	1	0	22
OVER 100000	0	0	0	0	0	0	0	0	0	0
TOTAL	4	3	11	10	14	32	26	1	0	101

PERCENTAGE OF TOTAL OCCURRENCES

[illegible]CITY [illegible]T ([illegible]m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0297	0.0198	0.0693	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1188
100 - 1000	0.0099	0.0099	0.0396	0.0396	0.0396	0.2277	0.0099	0.0000	0.0000	0.3762
10^3 - 10^4	0.0000	0.0000	0.0000	0.0000	0.0693	0.0495	0.1683	0.0000	0.0000	0.2871
10^4 - 10^5	0.0000	0.0000	0.0000	0.0594	0.0297	0.0396	0.0792	0.0099	0.0000	0.2178
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	0.0396	0.0297	0.1089	0.0990	0.1386	0.3168	0.2574	0.0099	0.0000	1.0000

TABLE E4

CONTINUOUS - HAZARDOUS MATERIALS RELEASES (CAL. ALL YEARS)

NUMBER OF OCCURRENCES

TOXICITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0	0
10 - 100	4	3	0	0	0	0	0	0	0	7
100 - 1000	0	2	1	1	1	1	0	0	0	6
10^3 - 10^4	0	0	0	0	2	1	7	0	0	10
10^4 - 10^5	0	0	0	2	0	0	1	1	0	4
OVER 100000	0	0	0	0	0	0	0	0	0	0
TOTAL	4	5	1	3	3	2	8	1	0	27

PERCENTAGE OF TOTAL OCCURRENCES

TOXICITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams/sec) 0 - 1	1 - 10	10 - 100	100 - 1000	10^3-10^4	10^4-10^5	10^5-10^6	10^6-10^7	OVER 10^7	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.1481	0.1111	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2593
100 - 1000	0.0000	0.0741	0.0370	0.0370	0.0370	0.0370	0.0000	0.0000	0.0000	0.2222
10^3 - 10^4	0.0000	0.0000	0.0000	0.0000	0.0741	0.0370	0.2593	0.0000	0.0000	0.3704
10^4 - 10^5	0.0000	0.0000	0.0000	0.0741	0.0000	0.0000	0.0370	0.0370	0.0000	0.1481
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	0.1481	0.1852	0.0370	0.1111	0.1111	0.0741	0.2963	0.0370	0.0000	1.0000

TABLE E5

PUFF-HAZARDOUS MATERIALS RELEASES (U.S. YEARS 77-79)

NUMBER OF OCCURRENCES

...ITY ...IT (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0
10 - 100	0	0	0	0	1	0	0	0	1
100 - 1000	0	0	0	0	0	0	0	0	0
10^3 - 10^4	0	0	0	0	0	0	0	0	0
10^4 - 10^5	0	0	2	3	2	3	3	14	27
OVER 100000	0	0	0	0	0	0	0	3	3
TOTAL	0	0	2	3	3	3	3	17	31

PERCENTAGE OF TOTAL OCCURRENCES

...ITY ...T (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0000	0.0000	0.0000	0.0000	0.0323	0.0000	0.0000	0.0000	0.0323
100 - 1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^3 - 10^4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^4 - 10^5	0.0000	0.0000	0.0645	0.0968	0.0645	0.0968	0.0968	0.4516	0.8710
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0968	0.0968
TOTAL	0.0000	0.0000	0.0645	0.0968	0.0968	0.0968	0.0968	0.5484	1.0000

TABLE E6

PUFF - HAZARDOUS MATERIALS RELEASES (U.S. YEARS 80-82)

NUMBER OF OCCURRENCES

ITY IT (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0
10 - 100	0	0	2	2	0	0	0	0	4
100 - 1000	0	0	0	0	0	0	0	0	0
10^3 - 10^4	0	0	0	0	0	0	0	0	0
10^4 - 10^5	0	0	0	2	4	3	1	11	21
OVER 100000	0	0	0	0	0	0	0	1	1
TOTAL	0	0	2	4	4	3	1	12	26

PERCENTAGE OF TOTAL OCCURRENCES

CITY IT (m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0000	0.0000	0.0769	0.0769	0.0000	0.0000	0.0000	0.0000	0.1538
100 - 1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^3 - 10^4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^4 - 10^5	0.0000	0.0000	0.0000	0.0769	0.1538	0.1154	0.0385	0.4231	0.8077
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0385	0.0385
TOTAL	0.0000	0.0000	0.0769	0.1538	0.1538	0.1154	0.0385	0.4615	1.0000

TABLE E7

PUFF - HAZARDOUS MATERIALS RELEASES (U.S. YEARS 83-85)

NUMBER OF OCCURRENCES

[illegible]ITY [illegible]IT (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0
10 - 100	0	0	0	0	0	0	0	0	0
100 - 1000	0	0	0	0	0	0	0	0	0
10^3 - 10^4	0	0	0	0	0	0	0	0	0
10^4 - 10^5	0	0	0	3	3	2	6	12	26
OVER 100000	0	0	0	0	0	0	0	2	2
TOTAL	0	0	0	3	3	2	6	14	28

PERCENTAGE OF TOTAL OCCURRENCES

[illegible]ITY [illegible]IT (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
100 - 1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^3 - 10^4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^4 - 10^5	0.0000	0.0000	0.0000	0.1071	0.1071	0.0714	0.2143	0.4286	0.9286
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0714	0.0714
TOTAL	0.0000	0.0000	0.0000	0.1071	0.1071	0.0714	0.2143	0.5000	1.0000

TABLE E8

PUFF - HAZARDOUS MATERIALS RELEASES (CAL. ALL YEARS)

NUMBER OF OCCURRENCES

CITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0	0	0	0	0	0	0	0	0
1 - 10	0	0	0	0	0	0	0	0	0
10 - 100	0	0	0	0	0	0	0	0	0
100 - 1000	0	0	0	0	0	0	0	0	0
10^3 - 10^4	0	0	0	0	0	0	0	0	0
10^4 - 10^5	0	0	1	0	2	1	0	4	8
OVER 100000	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	0	2	1	0	4	8

PERCENTAGE OF TOTAL OCCURRENCES

CITY LIMIT (mg/m^3)	MASS RELEASE QUANTITY (milligrams) 0 - 1000	10^3 - 10^4	10^4 - 10^5	10^5 - 10^6	10^6 - 10^7	10^7 - 10^8	10^8 - 10^9	OVER 10^9	TOTAL
0 - 1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1 - 10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10 - 100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
100 - 1000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^3 - 10^4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10^4 - 10^5	0.0000	0.0000	0.1250	0.0000	0.2500	0.1250	0.0000	0.5000	1.0000
OVER 100000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TOTAL	0.0000	0.0000	0.1250	0.0000	0.2500	0.1250	0.0000	0.5000	1.0000