PERSONAL PRIVACY INFORMATION
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DUANE ARNOLD ENERGY CENTER

EVACUATION TIME ESTIMATES

FOR

LINN COUNTY, IOWA

AND

BENTON COUNTY, IOWA

50-331

IOWA ELECTRIC LIGHT AND POWER COMPANY

January, 1980

PERSONAL PRIVACY INFORMATION
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TABLE OF CONTENTS

I. INTRODUCTION

This report has been prepared in response to the Nuclear Regulatory Commission's request for evacuation time estimates contained in the November 29, 1979, letter from Mr. Brian K. Grimes. Contained in this report are the various requested evacuation time estimates for the area associated with the plume exposure pathway emergency planning zone (EPZ) for the Duane Arnold Energy Center. The evacuation time estimates include the evacuation of the general public during normal and adverse weather conditions, the evacuation of special facilities during normal and adverse weather conditions, the time required for confirmation of evacuation, and the time required to notify the public to evacuate. These preliminary evacuation time estimates are based upon realistic but conservative assumputions and, as such, are believed to accurately reflect the time frames necessary to implement the evacuation protective response option. Detailed evacuation plans are being prepared and will be issued with the radiological emergency response plans for Linn County, Iowa and Benton County, Iowa. The appropriate local officials responsible for evacuation planning and/or traffic engineering have had an opportunity to review and discuss the assumptions, methodology, and conclusions of this report. As a result of these reviews and discussions no area of disagreement has been identified.

II. BACKGROUND

The Duane Arnold Energy Center is located on the Cedar River in Linn County, Iowa, approximately ten miles northwest of the Cedar Rapids-Marion metropolitan area. This report describes evacuation times estimates for the ten-mile area covered by plume exposure pathway EPZ for Linn County and Benton County, Iowa. This area is shown on Figure 1.

The projected 1980 population distribution within a 10-mile area around the DAEC for Linn County and Benton County, Iowa, was utilized in this analysis. The population is broken down by 22-1/2° sectors, as shown in Table 1. Of the total population of 160,977 considered in this report, 150,000 are residents of the Cedar Rapids-Marion-Hiawatha metropolitan area. The 10-mile boundary bisects this metropolitan area, with the closest portion located approximately five miles and the most distant portion located approximately 15 miles from the DAEC. In conducting the study it was assumed that the average vehicle occupancy would be three persons, and this factor was used to obtain the vehicle distribution information as shown in Table 2. The total number of vehicles to be evacuated from within the study area was estimated to be 53,674.

Using the standard 16 emergency planning 22-1/2° radial sectors as a base, 12 primary evacuation sectors were defined for this analysis, as shown in Table 3. For the 0-to-2-mile area, 180° sectors oriented perpendicular to the prevailing winds were assumed to be evacuated. Reference is made to Figure 1, which illustrates the

entire area encompassed by the 12 evacuation sectors. The four sectors within the 2-to-5-mile area each encompass 90°. The same is true for the 5-to-10-mile sectors, except near Cedar Rapids where an additional 5-mile distance is considered in order to include the entire metropolitan area.

Twenty-one evacuation scenarios have been developed based on the 12 primary evacuation sectors. A summary of these scenarios is listed in Table 4. The first 10 scenarios represent the evacuation times for the two 180° sectors and the eight 90° sectors. Scenarios 11 and 12 represent rotating Sectors I and II to be oriented perpendicular to the non-prevailing wind direction. The remaining nine scenarios -- 13 through 21 -- represent various combinations of the primary evacuation sectors assuming simultaneous evacuation of inner and outer sectors.

The capacity figures utilized in this analysis are for vehicles in the direction of evacuating traffic. For all state highways and county roads employed in the evacuation analysis, only the outbound lane for these two-lane facilities is assumed to have evacuating vehicles. The inbound, or opposing lane, is to be kept open to handle some traffic, such as emergency vehicles, and to allow for passing maneuvers that may be needed due to breakdown of vehicles.

III. METHODOLOGY

A total of 13 evacuation routes were used in this analysis, as summarized in Tables 5 and 6. Table 5 describes the evacuation routes for areas outside of the Cedar Rapids metropolitan area. The routes selected generally radiate from the area to be evacuated away from the DAEC. In the Cedar Rapids metropolitan area, the seven routes selected generally are distinct from the evacuation routes for the remaining three-quarters of the 10-mile area.

The capacity figure utilized in this analysis is 600 vehicles per hour in the direction of evacuating travel for the county roads indicated in Table 5. This figure is relatively conservative and represents a six-second headway between vehicles. In actual practice, road capacities of up to 1200 vehicles per hour (three-second headways) are not unusual during busy commute or recreation periods, so it is possible that during periods of evacuation even higher capacity figures would be achieved. The utilized capacity figure would allow for intersecting, turning, or merging streams of traffic to be serviced without the capacity figure being exceeded. For a thorough discussion of highway capacity, refer to the Highway Capacity Manual (Special Report 87, Highway Research Board, 1965).

Within the metropolitan area, a detailed capacity analysis was made of each of the potentially available evacuation routes. The Transportation System Management Plan, FY80-84, for the Linn County Metropolitan Area contains calculated capacity figures for all major streets in the metropolitan area. The figures quoted in

this publication are for a 24-hour period in both travel directions. For utilization in this analysis, the capacity figures have been converted to represent a single peak-hour in the outbound direction only. The conversion factor assumes that 10% of the 24-hour traffic can be accommodated in the peak period and that 60% of the peak-hour traffic can be accommodated in the peak direction. The conversion factor, therefore, is 24-hour capacity x 0.06.

This method of calculation has taken into account the lowest, or governing, capacity sections of highway to be evacuated, and assumes some traffic will travel in opposite directions and on intersecting streets during evacuation periods in the urban area. Seven primary evacuation routes were utilized with evacuation to the west, the south, and the east. Because of the relationship of the metropolitan area to the DAEC, no evacuation to the north has been contemplated. In the future, when Interstate 380 extends northerly, it is logical to assume that some evacuating traffic would proceed northerly unless instructed otherwise.

The evacuation speed for normal conditions was assumed to be 25 mph on all routes. For adverse weather conditions, where marginally passable road conditions exist, the speed was lowered to 10 mph.

IV. TIME ESTIMATES FOR THE EVACUATION OF THE GENERAL PUBLIC

This section details evacuation routes and time estimates for the various evacuation scenarios. The evacuation time estimates developed here represent the time required to evacuate a particular sector after the public has been notified that an evacuation is required. Estimates of the notification time requirements for the general public in the evacuation sectors are discussed in Section VII. Evacuation time estimates are presented in this section for evacuations during both normal and adverse weather conditions. The evacuation times developed here represent the time until the last evacuee in a particular evacuation scenario is at least 15 miles from the DAEC.

Tables 7 through 11 summarize the evacuation data and the estimated evacuation times for the twenty-one evacuation scenarios. The number of vehicles assigned to each evacuation route is listed, along with the associated service time and travel time. The service time is the period of time it would take for all vehicles to start their evacuation, if everyone tried to start simultaneously. The service time, expressed in minutes is a measure of the demand placed on the evacuation route, divided by the capacity of the route in question. The total time represents the maximum evacuation time required for the last evacuee and is the sum of the service time and the travel time.

IV.A. EVACUATION FROM 0 TO 2 MILES

Table 7 summarizes the 0-to-2-mile evacuation for Scenarios 1, 2, 11, 12, and 13. A service time to accommodate each vehicle onto the evacuation route was

used to correspond with the capacity figure for the evacuation route. A service time of six seconds per vehicle was used on all county roads within the 0-to-2-mile evacuation circle. As can be seen from Table 7, the critical evacuation time estimate is 45 minutes for Route L, which is Route W26 across the Cedar River, to connect with Highway 150 north to the 15-mile boundary. During adverse weather conditions, this time becomes 106 minutes. In this evacuation area, most normal weather evacuation time estimates are in the 40 to 45-minute range, and most adverse weather time estimates are in the 90 to 106-minute range.

IV.B. EVACUATION FROM 2 TO 5 MILES

A listing of Scenarios 3 through 6, which encompass the 2-to-5-mile evacuation, is shown in Table 8. In this case the critical evacuation time during normal conditions is along evacuation route H, which is due easterly along Route E34. The estimated evacuation time using this route is 59 minutes during normal weather conditions and 105 minutes during adverse conditions. The range of evacuation times during normal conditions is 43 minutes to 59 minutes, and during adverse conditions 86 minutes to 105 minutes.

IV.C. EVACUATION FROM 5 TO 10 MILES

The 5-to-10-mile evacuation time estimates are summarized in Scenarios 7, 8, 9, and 10, shown on Table 9. Outside of the Cedar Rapids metropolitan area, the most critical time involves evacuation along Route K, State Highway 150 to the north. In this case, the estimated evacuation time during normal weather is 121 minutes. During

adverse weather conditions, this increases to 149 minutes. The range of evacuation time for the 5-to-10-mile circle, not including the Cedar Rapids metropolitan area, is 37 minutes to 121 minutes during normal weather conditions and 58 minutes to 149 minutes during adverse weather conditions.

The Cedar Rapids metropolitan area has an assumed population of 150,000 -- all residing within one 90° evacuation sector, Sector IX. At three people per vehicle, the population would require 50,000 vehicles for evacuation. As indicated in Table 6, the seven evacuation routes have a peak-hour outbound capacity of 7,764 vehicles. If all routes were used proportionate to their capacity, evacuation could be accomplished in six and one-half hours. The travel time to clear the 15-mile boundary would vary depending upon where in the metropolitan area the evacuee begins the trip. A conservative travel time of approximately 30 minutes when added to the service time would indicate an estimated evacuation time for this metropolitan area of seven hours under normal conditions.

Due to the delays inherent in the evacuation of such a sizeable metropolitan area, the adverse weather conditions have a relatively small impact on the estimated evacuation time. Conservatively, an eight-hour total evacuation time is estimated for adverse weather conditions, although, based on the calculations shown in Table 9, this period may be as short as seven hours.

IV.D. EVACUATION FROM 0 TO 5 MILES

The 0-to-5-mile evacuation is a combination of the 0-to-2-mile and the 2-to-5-mile sectors, as shown in Table 10. The time estimates in this table are similar to those of the 2-to-5-mile evacuations. In this case, the slowest route is Route H, the route to the east along E 34 which requires 69-minutes to evacuate during normal weather conditions and 123-minutes to evacuate during adverse weather conditions. The range in estimated evacuation times, for these scenarios, is from 37 minutes to 69 minutes during normal weather and from 91 to 123 minutes during adverse weather conditions.

IV.E. EVACUATION FROM 0 TO 10 MILES

Table 11 summarizes Scenarios 18 through 21, which include evacuation of the 0 to 10-mile area in four 90^{o} evacuation sectors. In this analysis, the simultaneous evacuation of inner and outer evacuation sectors is assumed. Again the most critical sector is the Cedar Rapids-Marion area in Scenario 20, with times identical to those described in the 5-to-10-mile evacuation. The estimated evacuation times are in the seven to eight hour range. For the remaining three-quarters of the area around the DAEC, the critical evacuation scenario is Scenario 18 -- the evacuation of the northwest sector using State Highway 150 to the north. In this case, the estimated time requirements are 138 minutes during normal weather and 192 minutes during adverse weather.

IV.F. GENERAL SUMMARY OF EVACUATION SCENARIOS

A summary of the evacuation time estimates for the evacuation scenarios as described in Sections IV.A. through IV.E. is presented in Table 12. For each evacuation scenario the critical evacuation route is indicated along with the estimated maximum evacuation time for both normal and adverse weather conditions.

V. TIME ESTIMATES FOR SPECIAL FACILITIES EVACUATION

The preceding evacuation time estimates are applicable for members of the general public; this section discusses the evacuation time estimates for special facilities. Special facilities for the purpose of this report are defined as those facilities containing individuals for whom evacuation by normal means (regular automobile) would not be advisable or feasible.

The special facilities within the plume exposure pathway EPZ for the DAEC consist of two hospitals and approximately nine nursing homes situated in the Cedar Rapids-Marion metropolitan area of Linn County, approximately ten miles southeast of the DAEC. There have been no special facilities identified in the plume exposure pathway EPZ within Benton County.

In the event that a special facilities evacuation was necessary, these evacuees would be relocated to medical facilities in the Iowa City, Iowa, area, approximately 30 miles to the south of the special evacuation area. The special facilities evacuation times for normal and adverse weather conditions are estimated to be 165 minutes and 192 minutes, respectively. These estimates assume an average evacuation speed of 40 miles per hour during normal conditions and 25 miles per hour during adverse weather conditions. Also included in the estimates is a two-hour allowance for medical facility ingress and egress.

The special facilities evacuation operation will be discussed in detail in the Linn County Radiological Emergency Response Plan. Planning for this operation

will include provisions for the use, where feasible, of medical air evacuation helicopters, local selective sheltering for critically-ill patients, and use of intermediate, although smaller, medical facilities where available to further minimize the impact of evacuation on certain patients.

VI. TIME ESTIMATES FOR EVACUATION CONFIRMATION

In order to determine the completeness or effectiveness of an evacuation, it is considered necessary to execute a confirmation of evacuation operation. This confirmation operation will be executed in conjunction with the law-enforcement security patrolling of evacuated areas. It is estimated that a confirmation time of from one to two hours would be required for evacuation confirmation for the various evacuation sectors.

This operation will be discussed in detail in the radiological emergency response plans for Linn County and Benton County. Planning for the confirmation of evacuation operation will include consideration of emergency personnel operations in radiation areas, special instruction to the public (i.e. displaying white handkerchiefs or cloths), search and rescue provisions for reported missing persons, and provisions for checking on handicapped residents.

VII. TIME ESTIMATES FOR EVACUATION NOTIFICATION

This section presents estimates of the time required to notify the general public in a particular evacuation sector of the need to evacuate. Table 13 summarizes the evacuation notification time estimates associated with the DAEC plume exposure pathway EPZ. The estimated times in Table 13 were determined by multiplying the number of households in a particular evacuation sector by time required to notify each household, then dividing this total by the number of available emergency notification personnel. These notification times assume non-simultaneous notification of the primary evacuation sectors.

The notification time estimate for evacuation Sector IX, the Cedar Rapids-Marion urban area, assumes employing the existing civil defense siren system and law-enforcement vehicles, using sirens and loudspeakers to alert the public of the existance of an emergency situation and to instruct them to listen to a local radio station for emergency instructions. Also, several helicopters and light aircraft are available in Linn County to augment the available emergency notification personnel in both urban and rural areas.

A notification system capable of notifying the general public in critical areas within 15 minutes is presently under development. Details of the design, deployment, and operation of the 15-minute notification will be presented in the radiological emergency response plans for Linn County and Benton County.

TABLE 1

PROJECTED 1980 POPULATION WITHIN 10-MILE RADIUS

Direction	22-1/2° Sector	0 to 2 Mi.	2 to 5 Mi.	0 to 5 Mi.	5 to 10 Mi.	0 to 10 Mi.
N	1	5	154	159	2,017	2,176
NNE	2	17	126	143	326	469
NE	3	17	121	138	317	455
ENE	4	17	148	165	734	899
E	5	22	189	211	492	703
ESE	6	17	191	208		
SE	7	55	287	342	150,000*	150,924
SSE	8	28	246	274		
S	9	22	78	100		
SSW	10	11	494	505	1,015	1,520
SW	11	14	78	92	343	435
WSW	12	20	144	164	317	481
W	13	25	466	491	524	1,015
WNW	14	23	95	118	317	435
NW	15	11	89	100	327	427
NNW	16	2	51	53	985	1,038
		306	2,957	3,263	157,714	160,977

* Cedar Rapids/Marion/Hiawatha Metroplitan Area includes Sectors 6-9 between 5-mile and 15-mile circles.

TABLE 2

ESTIMATED VEHICLES* TO BE EVACUATED

Direction	22-1/2° Sector	0 to 2 MI.	2 to 5 MI.	0 to 5 MI.	5 to 10 MI.	0 to 10 MI.
N	1	2	52	54	673	727
NNE	2	6	42	48	109	157
NE	3	6	41	47	106	153
ENE	4	6	50	56	245	301
E	5	8	63	71	164	235
ESE	6	6	64	70		
SE	7	19	96	115	50,000**	50,311
SSE	8	10	82	92		
S	9	8	26	34		
SSW	10	4	165	169	338	507
SW	11	5	26	31	115	146
WSW	12	7	48	55	106	161
W	13	9	156	165	175	340
WNW	14	8	32	40	106	146
NW	15	4	30	34	109	143
NNW	16	1	17	18	329	347
		109	990	1,099	52,575	53,674

*Assume 3 persons/vehicle
**Cedar Rapids/Marion/Hiawatha Metropolitan Area

TABLE 3

ESTIMATED VEHICLES BY EVACUATION SECTORS

Evacuation Sector No.	22-1/2° Radial Number	Radial Mileage Range	No. of Vehicles
I	1-3, 12-16	0 - 2	43
II	4-11	"	66
I'	1-7, 16	"	54*
II'	8-15	"	55*
III	1, 14-16	2 - 5	131
IV	2-5	"	196
V	6-9	"	268
VI	10-13	"	395
VII	1, 14-16	5 - 10	1,217
VIII	2-5	"	624
IX**	6-9	"	50,000
X	10-13	"	734
			53,674

* Not included in total. Already counted in Sectors 1 and 2.

** Includes Cedar Rapids/Marion/Hiawatha Metropolitan Area.

TABLE 4

SUMMARY OF SCENARIOS

Scenario	Sectors
1	I
2	II
3	III
4	IV
5	V
6	VI
7	VII
8	VIII
9	IX
10	X
11	I'
12	II'
13	I + II
14	III + I
15	IV + I
16	V + II
17	VI + II'
18	VII + III + I
19	VIII + IV + I'
20	IX + V + II
21	X + VI + II'

TABLE 5

EVACUATION ROUTES

Route	Description
H	E34 East
J	W58 North
K	150 North
L	W26 North
M	E30 West
N	E40 East

TABLE 6

EVACUATION ROUTES AND ASSUMPTIONS
CEDAR RAPIDS/MARION/HIAWATHA URBAN AREA

Evacuation Route			Route Capacity 24-Hours* (vehicles)	Route Capacity Outbound, Peak Hour** (vehicles)
A.	Hwy 30-218	WEST	8,900	534
B.	Hwy 149	SOUTHWEST	9,100	546
C.	6th Street	SOUTH	7,700	462
D.	I-380	SOUTH	60,000	3,600
E.	Hwy 30	EAST	8,900	534
F.	Mt. Vernon Road	EAST	15,500	930
G.	Hwy 151	EAST	19,300	1,158
				7,764

* SOURCE: Pages 38-71, "Major Street Network Volume/Capacity Analysis," Transportation System Management Plan FY80-84 for the Linn County Metropolitan Area, Linn County Regional Planning Commission, August 1979.

** Outbound, peak-hour capacity = 24-hour route capacity x .06.

TABLE 7

0 TO 2 MILE EVACUATION

Evacuation Scenario	Evacuation Sectors	Evacuation Routes	Vehicles	Service Time*	Travel Distance To 15 Miles	Travel Time* Normal	Travel Time* Adverse	Total Time* Normal	Total Time* Adverse
1	I	K	12	2	15	36	90	38	92
		L	31	4	17	41	102	45	106
			43						
2	II	M	9	1	15	36	90	37	91
		H	57	6	15	36	90	42	96
			66						
11	I'	H	63	7	15	36	90	43	97
12	II'	M	46	5	15	36	90	41	95
13	I+II	K	12	3	15	36	90	39	93
		L	31	4	17	41	102	45	106
		M	9	1	15	36	90	37	105
		H	57	6	15	36	90	42	96
			109						

* In Minutes

TABLE 8

2 TO 5 MILE EVACUATION

Evacuation Scenario	Evacuation Sectors	Evacuation Routes	Vehicles	Service Time*	Travel Distance To 15 Miles	Travel Time* Normal	Travel Time* Adverse	Total Time* Normal	Total Time* Adverse
3	III	L	131	14	12	29	72	43	86
4	IV	K	196	20	15	36	90	56	110
5	V	H	268	27	13	32	78	59	105
6	VI	N	191	20	12	29	72	49	92
		M	204	21	12	29	72	50	93
			395						

* In Minutes

TABLE 9

5 TO 10 MILE EVACUATION

Evacuation Scenario	Evacuation Sectors	Evacuation Routes	Vehicles	Service Time*	Travel Distance To 15 Miles	Travel Time* Normal	Travel Time* Adverse	Total Time* Normal	Total Time* Adverse
7	VII	K	1002	101	8	20	48	121	149
		L	215	22	6	15	36	37	58
			1217						
8	VIII	K	215	22	10	24	60	46	82
		H	409	41	9	22	54	63	95
			624						
9	IX	A-G	50,000	390	5	12	30	402	420
10	X	A	453	46	11	27	66	73	112
		M	281	29	9	22	54	51	83
			734						

* In Minutes

TABLE 10

0 TO 5 MILE EVACUATION

Evacuation Scenario	Evacuation Sectors	Evacuation Routes	Vehicles	Service Time*	Travel Distance To 15 Miles	Travel Time* Normal	Travel Time* Adverse	Total Time* Normal	Total Time* Adverse
14	III+I	K	12	2	15	36	90	38	92
		L	162	17	17	41	102	58	119
			174						
16	V+II	M	9	1	15	36	90	37	91
		H	325	33	15	36	90	69	123
			334						
15	IV+I'	H	63	7	15	36	90	43	97
		K	196	20	15	36	90	56	110
			259						
17	VI+II'	M	250	25	15	36	90	61	115
		N	191	20	15	36	90	56	110
			441						

* In Minutes

TABLE 11

0 TO 10 MILE EVACUATION

Evacuation Scenario	Evacuation Sectors	Evacuation Routes	Vehicles	Service Time*	Travel Distance To 15 Miles	Travel Time* Normal	Travel Time* Adverse	Total Time* Normal	Total Time* Adverse
18	VII+III	K	1014	102	15	36	90	138	192
	+I	L	477	48	17	41	102	89	150
			1491						
19	VII+IV	K	411	42	15	36	90	78	132
	+I'	H	472	48	15	36	90	84	138
			883						
20	IX+V+II	A-G	50,000	390	5	12	30	402	420
		M	9	1	15	36	90	37	91
		H	325	33	15	36	90	69	123
			50,334						
21	X+VI+II'	A	453	46	11	27	66	73	112
		M	531	54	15	36	90	90	144
		N	191	20	12	29	72	49	92
			1175						

* In Minutes

TABLE 12

CRITICAL EVACUATION TIME ESTIMATES BY SCENARIO

Evacuation Scenario	Critical Route	Evacuation Time in Minutes	
		Normal	Adverse
1	L	45	106
2	H	42	96
3	L	43	86
4	K	56	110
5	H	59	105
6	M	50	93
7	K	121	149
8	H	63	95
9	A-G	402	420
10	A	73	112
11	H	43	97
12	M	41	95
13	L	45	106
14	L	58	119
15	K	56	110
16	H	69	123
17	M	61	115
18	K	138	192
19	H	84	138
20	A-G	402	420
21	M	90	144

TABLE 13

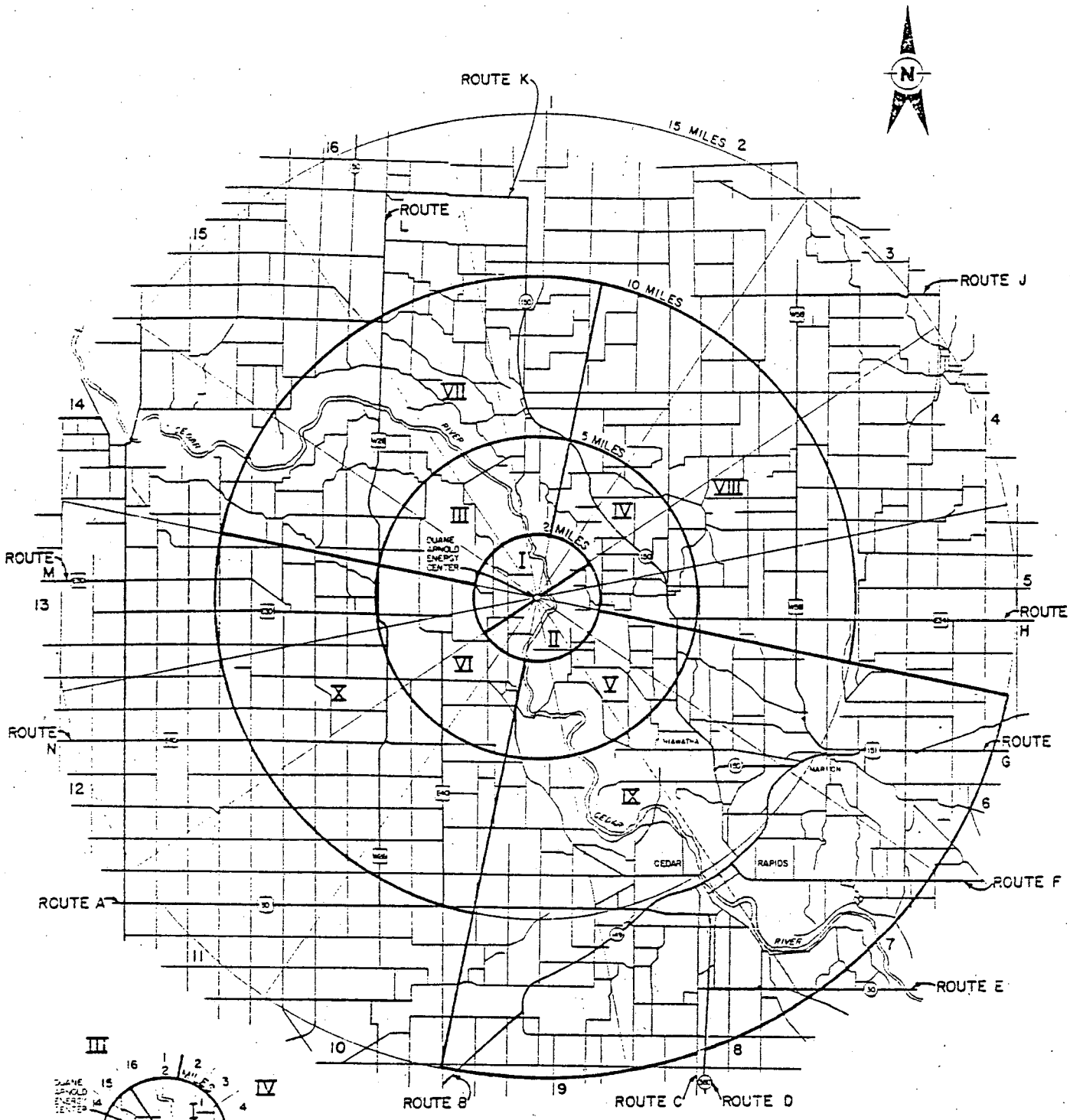
EVACUATION NOTIFICATION TIME ESTIMATES

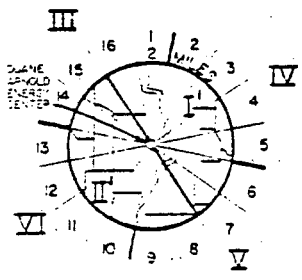
Evacuation Sector	Households To Be Notified*	Notification Time (Mins)**	Notification Personnel	Total Time (Mins)
I	33	5	25	10
II	50	5	25	10
III	99	5	25	20
IV	147	5	25	30
V	201	5	25	41
VI	297	5	25	60
VII	913	5	35	130
VIII	468	5	35	67
IX	37,500	--	198	***
X	551	5	35	79

* Assumes four persons per household

** Per Household

*** Estimated to be 180 minutes; refer to Section VII for a detailed discussion





ALTERNATE EVACUATION SECTORS - 0 to 2 MILES

LEGEND

I = EVACUATION SECTOR
1 = SECTOR NUMBER
A = EVACUATION ROUTE

FOR CRITICAL EVACUATION TIME ESTIMATES REFER TO TABLE 12

FIGURE 1
EVACUATION SECTORS
FOR
DUANE ARNOLD ENERGY CENTER