A

FEASIBILITY REPORT

on Evacuation

of the

Area around the

MILLSTONE

NUCLEAR POWER STATION

Prepared By

STORCH ENGINEERS

161 Main Street

Wethersfield, Connecticut 06109

and

NORTHEAST UTILITIES SERVICE COMPANY

for

Northeast Nuclear Energy Company

P.O. Box 270

Hartford, Connecticut 06101

March, 1980

A

FEASIBILITY REPORT

on Evacuation of the Area around the MILLSTONE NUCLEAR POWER STATION

Prepared By

STORCH ENGINEERS

161 Main Street

Wethersfield, Connecticut 06109

and

NORTHEAST UTILITIES SERVICE COMPANY

for

Northeast Nuclear Energy Company

P.O. Box 270

Hartford, Connecticut 06101

March, 1980

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

ACKNOWLEDGMENT

This report was prepared by Lionel M. Rodgers, P.E., Director, Transportation Engineering and Barry M. Pell, P.E., Senior Engineer of Storch Engineers. Mr. Edward J. Molloy of Northeast Utilities Service Company (NUSCO) prepared the Notification Time portion of Section II, "Metholodgy and Assumptions" and "Public Authority Notification Time" and "Public Notification Time Analysis" of Section III, "Zone by Zone Analyses".

The input and review of the Connecticut Department of Transportation (ConnDOT), Connecticut State Police and Office of Civil Preparedness of the State of Connecticut provided a valuable resource base without which the time frame to complete this report would have been extended considerably.

I. INTRODUCTION

General

On December 10, 1979, Northeast Utilities received a letter from the United States Nuclear Regulatory Commission (USNRC) Office of Nuclear Reactor Regulation requesting information on times required both to notify people and evacuate them (inclusive of special groups; i.e., schools, recreational areas, hospitals, etc.) from the following areas during normal and adverse weather conditions:

Distance	Area
0-2 Miles	Two 180° Sectors
0-5 Miles	Four 90° Sectors
0-10 Miles	Four 90° Sectors

In order to accomplish this task by the specified date of January 31, 1980, NUSCO retained the services of the Consulting Engineering Firm of Storch Engineers of Wethersfield, Connecticut.

It was felt that a time frame in excess of that permitted by the January 31st deadline was justified, and accordingly, a time extension was requested.

While an even greater time could result in refinement of the evacuation times, it was felt that the use of worst case conditions, giving times longer than those which could be realistically expected, would develop a usable study within the allowed time frame.

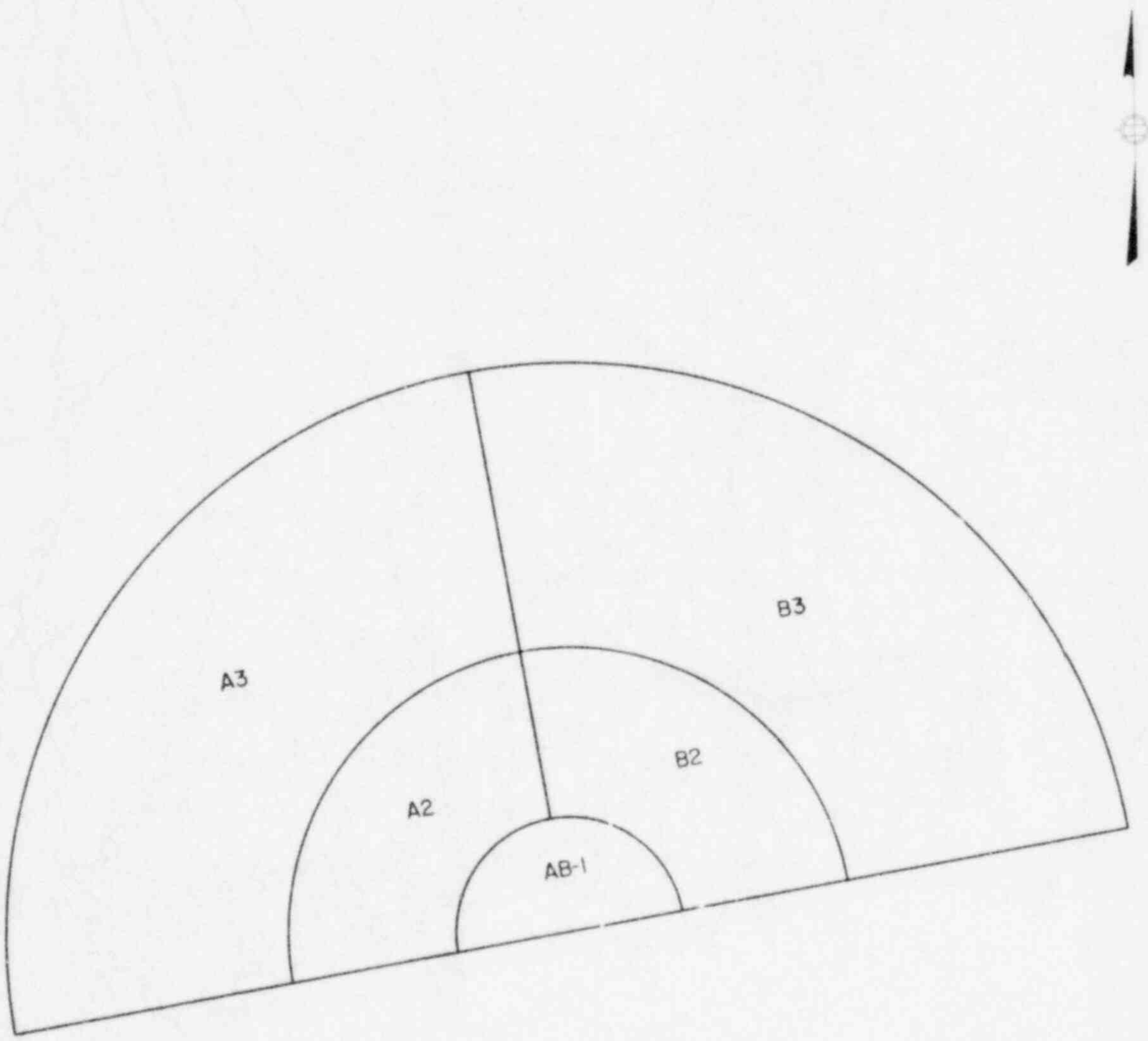
In the course of developing the evacuation times, meetings were held with administrative heads of ConnDOT, including the manager of the bus transportation system, with commanding officers of area State Police Troops and with other officials. The purpose of these meetings was to identify evacuation routes, the capacities of such routes, and the availability of personnel to control the evacuation movements.

It is expected that meeting will also be held with local officials during the upgrading of the State of Connecticut Radiological Emergency Response Plan (RERP) in mid 1980-1981. It is anticipated that these meetings could refine the public notification methods and optimize the evacuation routes and procedures for mobilizing resources in such a manner as to result in reduced evacuation and notification times.

Studies such as these generally do not distinguish between the time required for notification, the time required to implement evacuation, and the time required to confirm that an evacuation has taken place. In an effort to distinguish between these components, the current study has employed methods outlined in Section II to determine the time required to notify public authorities of an evacuation and the time to implement evacuation.

Therefore, in compliance with the above USNRC request, this study was undertaken to determine time estimates for an area within a 10-mile radius of the Millstone Nuclear Power Station as shown in Figure 1. Further, the study also provides an estimate of the time required for public authority notification prior to actual evacuation.

For the purposes of notification and evacuation time estimate analyses, the 10-mile radius study area has been divided into two, 90 degree sectors and further defined by distance from the power station as 0-2 miles, 0-5 miles, and 0-10 miles. For the 2-mile radius area, a single 180 degree zone was considered. Fishers Island and Plum Island, to the southeast and south, respectively, are considered separately in this report. Particular attention



NOTE:
SEE APPENDIX FOR PRINT OF EVACUATION ROUTES AT A SCALE OF 1"=1 MILE

NORTHEAST UTILITIES SERVICE COMPANY
EVACUABILITY STUDY AT MILLSTONE NUCLEAR POWER STATION
AREA MAP – SECTOR ANALYSIS — FIGURE NO. 1
Prepared By STORCH ENGINEERS 161 MAIN STREET – WETHERSFIELD, CONNECTICUT

has been directed to the needs of special facilities such as schools and hospitals. Separate evacuation time estimates have been prepared for good and adverse weather conditions.

Scope of Study

For each of the five defined zones comprising the study area, the following scope of work has been performed:

1. Obtain and review data -- Information was collected from NUSCO including area population densities, previous reports and area mapping.
2. Prepare preliminary evacuation routings -- Evacuation routings out to a distance of about 3 miles were obtained from the State of Connecticut RERP with the use of area mapping provided by NUSCO. Additional routings from 3 to 10 miles were prepared for the Millstone study area.
3. Collect plans and analyze preliminary findings -- Meetings with State of Connecticut officials were conducted to obtain existing mapping, traffic counts and opinions of routing suitability. Furthermore, each routing was reviewed in the field and a tabulation made of items restricting traffic flow.
4. Prepare initial time estimates -- With the use of the preliminary routings and with the knowledge of the physical limiting factors of each, evacuation time estimates were prepared. In addition, based upon information collected from State and local officials, in combination with the results of a drill held by the Town of Waterford on June 15, 1978, estimates were made of the time required to notify all persons in each zone.

5. Hold meetings and coordinate -- Review and comment on the preliminary evacuation routings and initial time estimates were obtained from the ConnDOT and the Connecticut State Police.
6. Modify and finalize initial evaluations -- Based upon the review comments, revisions were made in the preliminary routings, additional field reviews were conducted and restrictions were tabulated. The routing plans were finalized and notification and evacuation time estimates were prepared for the final routings.
7. Prepare Report -- All of the data collection and analyses is presented in the following sections of this report. The text describes the methodology developed to calculate the estimates and all assumptions used. The report includes graphic presentation of routings for each of the zones within the 10-mile radius study area.
8. Obtain final written comments -- The report will be reviewed with State and local officials to obtain their comments.

II. METHODOLOGY AND ASSUMPTIONS

Notification Time

It is recognized that a smooth and timely evacuation will depend, in part, upon the time required to notify the population to evacuate. As stated in the RERP, notification will be made to the public by means of town and State Police vehicles having public address (PA) capability. Based on the available vehicles in each town, an analysis was undertaken to determine the Notification Time.

The following methodology was developed to determine the Notification Times. This methodology is largely based on information obtained during a drill conducted at the Millstone Nuclear Power Station.

$$NT = \frac{(60)\ (\Sigma Mi)}{(Z)\ (V)}$$

where:

NT = Notification time in minutes for affected zones in the study area

Mi = Square mile area of any town in zone being analyzed

ΣMi = Summation of square miles for towns within the zone being analyzed

Ni = Number of public notification vehicles in a town (area of zone)

Z = The sum of the products of each town's number of vehicles, Ni, multiplied by the percentage of the zone which that town occupies,

$$\left[N_1\left(\frac{M_1}{\Sigma M_i}\right) + N_2\left(\frac{M_2}{\Sigma M_i}\right) + \cdots N_i\left(\frac{M_i}{\Sigma M_i}\right) \right]$$

Only town vehicles equipped with PA systems are to be considered in this formula. $\left(\frac{Mi}{\Sigma M}\right)$ is a weighting factor which proportions vehicles by the percent of the zone area occupied by a given town. Therefore, the town with the largest area within a given zone would have a greater percentage of its vehicles committed than other towns; conversely, the town with the smallest area within a given zone would have a smaller percentage of its vehicles committed than other towns

V = Number of square miles covered by each public notification vehicle within one hour. This factor was determined as a result of a drill held in Waterford, Connecticut on June 15, 1978. This factor is equivalent to 1.097 mi^2/hour-vehicle.

The above methodology is extremely conservative in that it entails the following assumptions:

a. Not all of the town vehicles are committed to notify people within a given zone since some of these vehicles would be necessary for other functions (i.e., law enforcement etc.) as illustrated in the State of Connecticut RERP.

b. Only vehicles within a particular town boundary plus available vehicles from State Police Troop E, Montville, are used to notify the public who live within the affected zone. Of course, as a result of mutual agreements among towns (as well as aid available from other State Police Troops), the number of available public notification vehicles would increase greatly. This would reduce the notification time proportionately.

c. Radio and television notification is not considered, which would no doubt also reduce, to a great degree, the notification times.

Evacuation Time

In order to develop the evacuation time estimates, a methodology was formulated based upon currently adopted traffic engineering principles. In addition, the methodology incorporates a set of site data inputs and/or assumptions which reflect the roadway conditions of the particular geographical area surrounding the nuclear power station.

For the purposes of this report, evacuability is defined as the capability of the road system to accommodate the departure of all persons present within a specific area. The study area consists of a circular area 10 miles in diameter with the Millstone Nuclear Power Station located at the center. However, since this station is situated adjacent to Long Island Sound excepting Fishers and Plum Islands, only the northern half of the circle is land area with population to be evacuated. The study area was divided into two, 90 degree sectors identified as Sectors A and B, with the small remaining populated areas added to each adjacent sector. The sector boundaries were selected so as not to divide concentrations of population. Each sector was divided into three annuli, called zones, covering the area between 0 and 2 mile radius, 2 and 5 mile radius, and 5 and 10 mile radius (Figure 1). These zones are numbered consecutively from 1 to 3 with zone 1 being nearest to the plant site (i.e., the 0-2 miles zone). For the circular area with a radius of 2 miles from the power station, the analysis required only one, 180 degree zone; thus, for this distance only, the two, 90 degree zones were aggregated into one, 180 degree zone and identified as Zone AB1.

Evacuation time is defined as the time required for the available road system to pass the expected number of vehicles evacuating each zone. The methodology used the following data to determine the evacuation time:

1. Evacuation routes and roadway link capacities (vehicles per hour).
2. Population within each sector to be evacuated.
3. Average car occupancy for each population group.

In addition, the analysis considered limitations such as the special requirements and constraints of schools, hospitals, etc. located within a specific zone. While the analysis resulted in a best estimate for evacuation time during normal weather conditions, a second set of calculations was also performed for estimated adverse weather conditions.

Once the above information was determined, the evacuation time for each specified zone was calculated using the following formula:

$$EVT = (Pr/Fr + Pt/Ft + N)(60/C)$$

where:

EVT = Evacuation Time, in minutes

Pr = Residential population

Pt = Transient population

N = Number of additional vehicles (from schools, etc.)

C = Capacity of roadway in vehicles per hour

60 = Converts the capacity to vehicles per minute

Fr = Average number of people in a car for residents

Ft = Average number of people in a car for transients

Travel time within a zone has not been considered by this formula because it is less than 10 minutes; hence, it is not significant in comparison with the delays resulting from limited capacity of links.

The evacuation time has been calculated with the above formula for the 180 degree zone within a 2-mile radius and then for each of the two, 90 degree zones considering the 0-5 mile radius and 0-10 mile radius. In the evacuation of the outer zones, it is assumed that the inner adjacent zones are being evacuated simultaneously.

The discussions below describe the methods used for each of the steps in the determination of the Evacuation Time.

a. <u>Evacuation Routes and Roadway Link Capacities</u>

Evacuation routes, out to a distance of about a 3-mile radius, were taken from the State of Connecticut RERP - Figure 401.2-1. Based upon field reconnaissance review of the ConnDOT roadway data and knowledge of the study area's transportation system, evacuation routes from 3 to 10 miles were selected based upon their capacity and accessability for people within the study area. However, capacity estimates were added for the major separate routes wihtin each zone limit. State and federal designated roadways were used in most cases, since these routes incorporate the best design features. Also, they are well posted, and provide the greatest capacity, continuity and connection to other major routes leaving the area to be evacuated. Total capacity estimates used were the less of the major routes leading from the zone or the sum of the feeder routes to these major routes within the evacuation zone limit. The Connecticut State Police reviewed and concurred with the route selection.

After the selection of available evacuation routes, the specific characteristics of each roadway were evaluated by segment with consideration of limiting conditions such as pavement width, lateral clearance and grade. For each of these roadway segments, the capacity was calculated. The roadway capacity is defined as the maximum number of vehicles per hour that can be accommodated on a particular street or highway with existing conditions.

The method utilized for determining capacity is described in the subsection of Chapter 10 of the 1965 Highway Capacity Manual entitled "Two Lane Highways" and Chapter 9 entitled "Freeways and Other Expressways". With the exception of Route 52 and Interstate 95, which are multi-lane limited access facilities and Route 32 which is a multi-lane divided highway, all roads to be used for evacuation are two-lane highways. This method assumes the maximum capacity of a two-lane road to be 2,000 vehicles per hour and develops two modifying factors (each having a numerical value of less than one) for use in calculating the estimated capacity of the road in question. The first factor, W_c, is determined from the pavement width and lateral clearance and includes the effect of opposing traffic flows. For this study, lateral clearances and pavement widths for each segment of roadway were obtained from our field investigations and from data in the form of roadway photologs (i.e., pictures of roadway clearances every 100 feet) provided by ConnDOT. The numerical value of factor W_c was then determined by use of Table 10.8 of the 1965 Highway Capacity Manual.

The second factor, T_c, takes into account the effect of truck traffic and is a function of terrain. It was conservatively estimated that trucks will not exceed 10 percent of the total traffic, and this figure has been used. The character of the terrain (rolling or level) is that identified from field investigations or from data of ConnDOT. The numerical value of this factor was determined by using Table 10.9b of the 1965 Highway Capacity Manual.

A listing of the sections of evacuation route roadways of particular interest, their characteristics and W_c and T_c factors are summarized in Table 1. A map which highlights these roads is given in Figure 2.

The capacity obtained by the above procedure for two-lane roadways is an estimate of the number of vehicles which can pass over a segment of road (called a link) in an hour. It is the number of vehicles traveling in one direction plus the number of vehicles traveling in the opposite direction on the same link. This takes into account the fact that the capacity of a two-lane two-way road is in part a function of the traffic flowing in the opposite direction, since the ability to pass a slower moving vehicle is an important factor in determining the capacity in one direction.

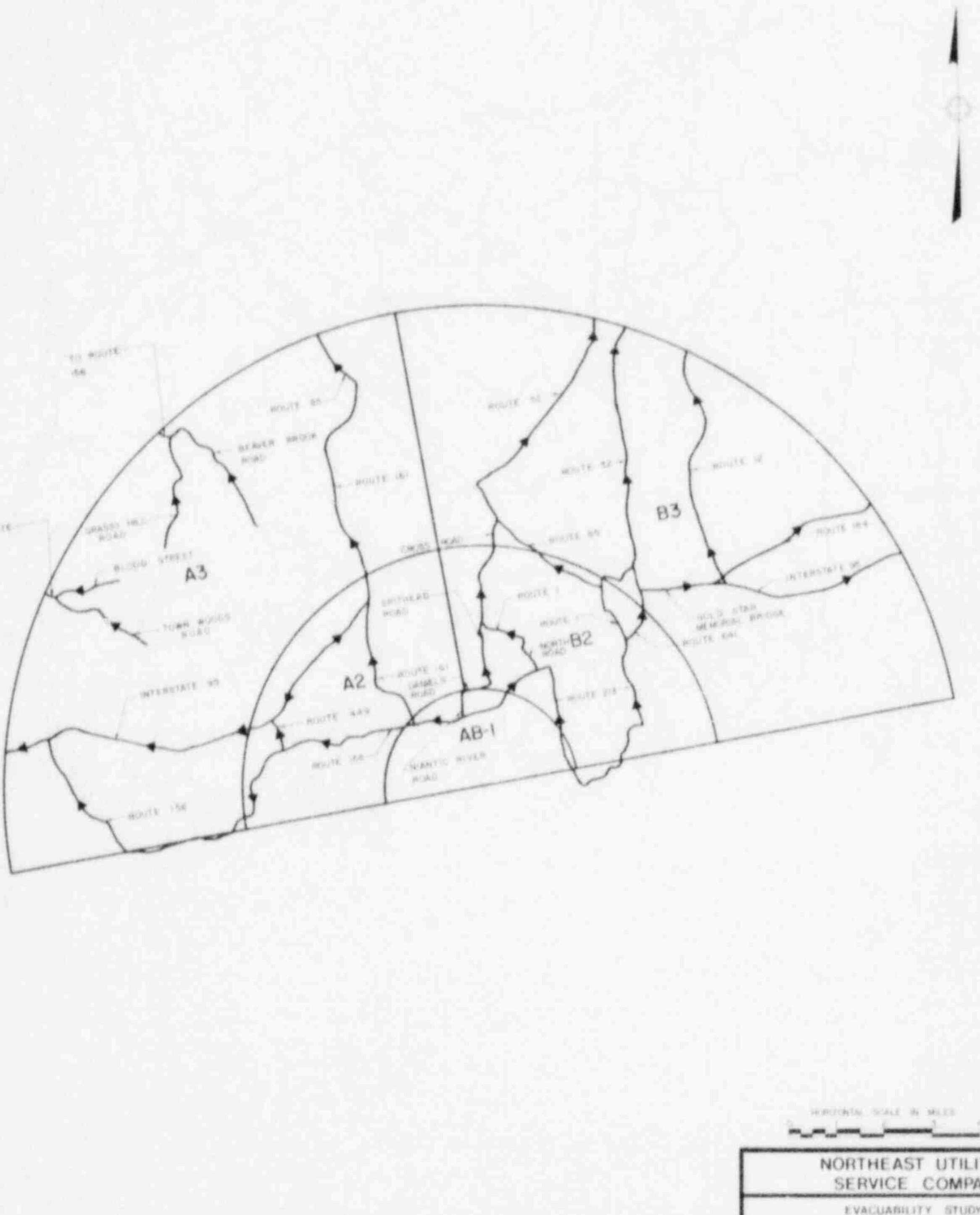
TABLE 1

EVACUATION ROUTE CAPACITY

Street	Limits	Side Clear (ft)	Pavement Width (ft)	Terrain	W_c	T_c	Capacity Vehicles Per Hour (vph) 2-Way	1-Way
Route 156	Niantic River-Interstate 95	3	20	** R	0.77	0.71	1094	766
Rocky Neck Connector	Route 156-Interstate 95	8	24	R	1.00	0.77	NA	2772
Interstate 95	Route 161-Connecticut River	8	24	R	1.00	0.77	NA	2772
Interstate 95	Bridge over Connecticut River	1	22	R	0.90	0.77	NA	2486
Route 161	Route 156-Interstate 95	3	20	R	0.77	0.71	1094	766
Route 161	Interstate 95-Route 85	4	20	R	0.79	0.71	1122	786
Route 85	Route 161-Sector Limit	2	20	R	0.75	0.71	1065	746
Route 156	Niantic River-Route 213	3	20	R	0.77	0.71	1094	766
*Niantic River Rd.	Route 156-Daniels Avenue	-	--	-	--	--	--	500
*Daniels Avenue	Niantic River Road-Spithead Road	-	--	-	--	--	--	500
*Spithead Road/ Cross Road	Daniels Avenue-Route 85	-	--	-	--	--	--	500
Route 213	Route 156-Goshen Cove	1	19	R	0.70	0.71	994	696
Route 213	Route 1-Goshen Cove	2	20	R	0.75	0.71	1065	746
U.S. 1	Route 213-Route 85	0	32	R	0.88	0.71	1250	875
Route 85	U.S. 1-Route 52	2	20	R	0.75	0.71	1065	746
Route 52	Route 85-Sector Limit	8	24	R	1.00	0.77	NA	2772
Route 32	Gold Star Memorial Bridge-Sector Limit	4	22	R	0.94	0.77	NA	2606
Gold Star Memorial Bridge	Bridge over Thames River	10	60	R	1.00	0.77	NA	6930
Interstate 95	Gold Star Memorial Bridge-Sector Limit	8	36	R	1.00	0.77	NA	4158
Route 12	Interstate 95-Sector Limit	7	24	R	1.00	0.71	1420	994
Route 184	Interstate 95-Sector Limit	7	22	R	0.88	0.71	1250	875
*Blood Street/ Town Woods Road	U.S. 1-Sector Limit	-	--	-	--	--	--	500
*Beaver Brook/ Grassy Hill Road	Within Zone A2	-	--	-	--	--	--	500

* Local Road Capacity Estimated as 500 vph

** Rolling Terrain



NOTE
SEE APPENDIX FOR PRINT OF EVACUATION ROUTES AT A SCALE OF 1"=1 MILE

NORTHEAST UTILITIES SERVICE COMPANY	
EVACUABILITY STUDY AT MILLSTONE NUCLEAR POWER STATION	
EVACUATION ROUTES	FIGURE NO. 2
Prepared By STORCH ENGINEERS 161 MAIN STREET - WETHERSFIELD, CONNECTICUT	

For the purposes of this study, during an evacuation all traffic on a particular roadway segment would necessarily be traveling in the same direction. Nevertheless, it was conservatively estimated that the single directional capacity will be 70 percent of the two-way capacity determined by the Highway Capacity Manual. At a flow rate approaching capacity, the speed of traffic is normally on the order of 20-25 mph on two-lane roads of the type found in the study area.

For the divided multi-lane at-grade and freeway facilities, capacity has been determined to be 1,800-2,000 vehicles per lane per hour, and the lower figure has been used as the more conservative approach. As with two-lane facilities, downward adjustments have been made for restricted lane width and lateral clearance and for the effect of trucks and terrain. Also, the use of reversed flow on the opposing lanes was not considered for major routes; i.e., I-95 and Connecticut Route 52. The factors for freeways and expressways were obtained from Tables 9.2 and 9.3b of the Highway Capacity Manual. The factors for multi-lane at-grade highways were taken from Figure 10.2 of the Highway Capacity Manual. However, no additional adjustment is necessary to account for single direction flow.

In addition to the state highways and other state maintained roads which comprise the majority of the evacuation facilities, there are locally designated roads and streets which will assist in either direct evacuation or as collectors leading to major routes. For these two-lane roadways, a very conservative figure of 500 vehicles per hour has been used for evacuation capacity.

The capacity figure which is obtained by the above technique is an estimate of the ability of a road link to handle vehicles under normal conditions. It should be recognized that under "forced flow" conditions which occur when vehicles attempting to enter a link exceed its theoretical capacity, the actual number of vehicles moving through a link could be less than theoretical capacity. This could be the case at major restrictions to evacuation traffic flow such as the river bridges, but it is assumed that adequate police direction will be available to maintain capacity flow through the critical links. In fact, the State of Connecticut RERP has provision for State and local access control points to both aid evacuees and prevent people from entering affected areas.

Inclement weather may restrict driver visibility and affect speed and vehicle spacing, thus reducing roadway capacity. The extent of the capacity loss can be quite variable and snow and icy pavements can, in the extreme, reduce the capacity of a facility to zero. In the case of a major snowstorm, emergency response may require alternate protective action if evacuation is unattainable due to impassable roadways. However, consideration and evaluation of average precipitation conditions within the study area, as well as the impact reported by other studies, suggests that a capacity loss of 10 to 20 percent could be anticipated for two-lane roadways and a reduction of 20 to 30 percent would result for freeways and expressways[1]. For our analysis, the more conservative figures were used, namely a reduction in capacity due to normally experienced inclement weather of 20 percent for two-lane facilities and 30 percent for Route 52 and Interstate 95.

Catastrophic inclement weather, such as major snowfalls or hurricanes, would render certain evacuation routes impassable. In these cases, other protective actions (i.e., notifying people to stay indoors) would be advisable, and no doubt would already be occuring under such conditions.

[1] Transportation and Traffic Engineering Handbook, Institute of Transportation Engineers, 1976.

b. Population to be Evacuated

In addition to the roadway system capacity analysis, the other most important factor affecting evacuation time is the number of persons to be evacuated. In this regard, three separate groups of the population have been identified, namely, residents, transients (i.e., workers and attendees at recreational facilities) and school children.

The data used for resident population by annulus zone is given in the 1980 projected population given in Figure 108.1-5 of the Millstone Section of the State of Connecticut RERP.

The 90 degree sectors used in this evacuability study correspond to four of the 22.5 degree wide sectors used in the State of Connecticut RERP from which the resident population was extracted. The resulting two sectors are divided along a line 11.25 degrees west of true north, with the southern boundary of both sectors being Long Island Sound. To insure the complete evacuation of all population within the required 10-mile radius from the nuclear power station, the remaining small areas south of each of the two sectors was added to its respective adjacent sector.

The transient population consists of workers at their jobs, visitors, and other temporary inhabitants. For the purpose of this study, the predominant transient population groups are employees at industries and other special facilities and the summer population attracted by the area's recreational facilities. By evaluating summer population demand, workers and other special population, the maximum transient population to be evacuated was obtained.

There are three major industries within the study area, all located in Zone B3, with a current total of 16,724 employees. In addition, the U.S. Navy Submarine Base employs 15,000 persons on its largest day shift.

To determine the summer incremental population, Figure 2.1.3.4-1 of the Millstone Unit 3 Preliminary Safety Analysis Report was used. The data in this figure, which provides 1970 summer incremental population, was projected to the year 1980 using the ratio of 1980 to 1970 permanent population in the zone of summer population concern. The resulting expansion factors, which were separately calculated for each analysis zone, were in a range of from 12 to 37 percent increase in summer incremental population beyond the 1970 level.

The summer population data from the Preliminary Safety Analysis Report includes dwelling capacity of lodging, camping facilities and State Parks within the study area. Day transients for the numerous private beaches in the area were not included separately. In the case of public beaches (not located in public parks), the largest is Ocean Beach, with a peak load of approximately 15,000 persons per day[2]. Most of these transients represent only a change in location of people who have already been accounted for as residents in the immediate area; however, they were still included in the summer incremental population.

School populations were determined from the 1979 Connecticut Education Directory of the Connecticut State Department of Education. Current enrollments were used and consideration was not given to design capacity or additional growth since recent demographic trends project smaller families in the future. It was assumed that school locations would remain constant and

[2]State of Connecticut RERP, Page 108-1.5

that the facilities would be capable of handling any increased student populations. It was felt that any alternative approach would be highly speculative.

Based upon the collected and analyzed data, a summary of residential, transit, and school population for each zone is given in Table 2. A detailed breakdown of the affected schools contained within each zone is shown in Table 3. A listing of major governmental, public and private institutions and employers are given in Table 4.

To estimate the population to be evacuated for the purpose of this study, an exceptionally conservative methodology was used. It was assumed that, for a given zone, the resident, transient, and school populations are all present in the zone simultaneously. This assumption results in a very conservative estimate of the zone population. School children are counted in the resident population, and counted again for a second time in the school population. Moreover, persons who work or use recreational facilities in the study area are similarly double-counted as both residents and transients. The purpose behind this double-counting of certain groups is to assure that evacuation times will provide for any population group which might be in a given area at any time. Account is not taken of the persons who leave the study area for jobs, schools, or any other reason.

The assumption, stated another way, is that all residents are in their homes, and that all transients and school attendees come into the study area from other places. This results in a worst case estimate of population to be evacuated, particularly during adverse weather conditions, when schools are not in session and park use is minimal; and, therefore, results in conservatively large traffic volumes and longer evacuation times.

TABLE 2

STUDY AREA POPULATION

Zone		Sector A	Sector B	Total
1 (0-2 mi.)	R	1,619	4,468	6,087
	T	442	654	1,096
	S	---	606	606
2 (2-5 mi.)	R	11,041	37,310	48,351
	T	15,279	11,588	26,867
	S	2,038	5,455	7,493
3 (5-10 mi.)	R	11,009	53,178	64,187
	T	8,566	44,500	53,066
	S	2,721	8,252	10,973
Total	R	23,669	94,956	118,625
	T	24,287	56,742	81,029
	S	4,759	14,313	19,072

R = Resident T = Transient S = School

TABLE 3

STUDY AREA SCHOOLS

Name of School	Grades	Sector	Zone	Enrollment[3]
Niantic	K-5	A	2	397
Lillie B. Haynes	K-5	A	2	427
East Lyme Jr. High	6-8 & sp.	A	2	867
Mile Creek	K-6	A	2	347
Center	K-6	A	3	273
Lyme-Old Lyme Jr./Sr. High	7-12	A	3	697
Flanders	K-5 & sp.	A	3	568
East Lyme High	9-12	A	3	1183
Great Neck	K-6	B	1	230
Southwest	K-6	B	1	376
Nathan Hale	K-6	B	2	456
Harbor	K-6	B	2	432
Oswegatchie Elementary	K-6	B	2	237
Clark Lane Jr. High	7-8	B	2	639
Waterford High	9-12	B	2	1248
Edgerton	K-6	B	2	299
Jennings	K-6	B	2	328
New London Jr. High	7-8	B	2	635
New London High	9-12	B	2	1181
Noank	K-6	B	3	305
Fitch Senior High	10-12	B	3	1349
Claude Chester	PK-6	B	3	548
Fitch Jr. High	7-9	B	3	767
Colonel Ledyard	K-3	B	3	198
Eastern Pt.	PK-6	B	3	538
Groton Heights	PK, 4-6	B	3	188
Mary Morrison	K-6	B	3	616
Pleasant Valley	K-6	B	3	534
William Seely	K-6	B	3	326
West Side Jr. High	7-9	B	3	321
Charles Barnum	K-6	B	3	538
Gates Ferry	K-6	B	3	247
Palmer Memorial	K-6	B	3	169
Winthrop	K-6	B	3	326
Cohanzie Elementary	K-6	B	3	344
Quaker Hill Elementary	K-6	B	3	235
Dr. Charles E. Murphy	7-8	B	3	703

[3] Connecticut State Department of Education
1979 Connecticut Education Directory

TABLE 4

MAJOR GOVERNMENTAL, PUBLIC, AND PRIVATE INSTITUTIONS AND EMPLOYERS

Institution	Location	Occupants
Hospitals		Staff/Patients
U.S. Navy Submarine Base	Groton, Connecticut	30/30
U.S. Coast Guard (First Aid Station)	New London, Connecticut	10/20
Lawrence and Memorial Hospital	New London, Connecticut	1,200/327
Seaside Sanitarium	Waterford, Connecticut	318/218
Colleges		Staff and Enrollment
Connecticut College	New London, Connecticut	2,070
Mitchel College	New London, Connecticut	1,185
Mohegan College	Norwich/New London, Connecticut	745
U. Conn. Extension	Groton, Connecticut	525
U. Conn. Marine Research Laboratory	Noank, Connecticut	
State and City Prisons		Staff/Inmates
State Correctional Institute for Women	Niantic, Connecticut	60/162
State Correctional Institute for Men	Montville, Connecticut	45/104
Federal Institutions		All Personnel
U.S. Navy Submarine Base	Groton, Connecticut	16,250
U.S. Coast Guard Academy	New London, Connecticut	1,630
State Institutions		All Personnel
State Department of Health	New London, Connecticut	20
Mystic Oral School	Mystic, Connecticut	50
State Parks and Forests		
Bluff Point State Park	Groton, Connecticut	
Harkness Memorial	Waterford, Connecticut	
Mohantic State Forest	Lyme, Connecticut	(Included in Transient Population)
Rocky Neck State Park	East Lyme, Connecticut	
Fort Griswold State Park	Groton, Connecticut	
Bates Woods & Riverside City Parks	New London, Connecticut	
Major Employers		Employees
Dow Chemical	Ledyard, Connecticut	224
Pfizer	Groton, Connecticut	2,500
Electric Boat	Groton, Connecticut	14,000

c. Car Occupancy (Load Factor)

The third factor which will determine the total vehicles to be evacuated, and thus the evacuation time, is the average load or number of persons per vehicle. To compute this figure, vehicle registration data was obtained from the State of Connecticut 1978 assessment records for each of the individual towns comprising the study area. The resultant average load of 2.36 persons per automobile was determined. Since a lower load factor would, for the given population, increase vehicular traffic, a load factor of 2.0 was used in calculating traffic due to evacuation of the residential population.

The load factor for the transient population is derived from data shown in the Transportation and Traffic Engineering Handbook, 1976 edition, of the Institute of Transportation Engineers. Table 5.17 shows the average load factor (called Urban Car Occupancy) for various uses. This factor ranges from a low of 1.1 for work related trips to a high of 2.35 for social or recreational trips. A conservative estimate of 1.5 has been taken for this study.

There will also be personal vehicles at schools belonging to teachers, administrators, and students. These vehicles are assumed to be transporting only the driver.

Assumptions

Innumerable combinations of circumstances are possible during the occurrence of an actual evacuation. Nevertheless, based upon given or collected data and an evaluation of probable events, certain assumptions were incorporated in the development of the preceding formulae and their use in calculating notification and evacuation times. These assumptions are listed below.

1. Only one of the aforementioned sectors is to be evacuated at any one time.
2. Automobiles will continue to be the predominant means of transportation with the exception of the use of school buses to evacuate schools.
3. Future population characteristics such as age distribution, number of cars per family, etc. are not expected to change dramatically. It is recognized that currently discernible trends in demographic data indicate decreases in school age children and in size of families. Therefore, use of this assumption results in conservative estimates.
4. The roadway network is not expected to change, both as to available routes and maintenance.
5. The bus service to the schools will have the same characteristics and number of buses in proprotion to students as at present.
6. Traffic controls, such as signals, stop signs, etc. will be removed from service as needed to aid evacuation.
7. It is anticipated that means will be provided to remove disabled vehicles from the roadways and in particular from the bridges used by evacuation traffic.
8. It is expected that sufficient manpower will be available to manage the evacuation routes and to provide access control if the need arises. A reduced evacuation time is possible if, as a result of planning, additional manpower is available to orderly control the flow of vehicles (e.g., setting up control points to allow one-way flows of traffic).

III. ZONE BY ZONE ANALYSES

Each zone will now be discussed in detail. Each will be described, evacuation routes and factors of particular importance considered, and the evacuation and notification times computed.

An important factor is the provision of buses to remove children from schools in session when notification to evacuate is given. One of the critical aspects of this factor is the need to mobilize bus drivers as well as other emergency workers and have them report to the location where the school buses or other emergency vehicles are garaged. For this study, it has been assumed that all school buses are located at the schools for the computation of evacuation time. Also, mobilization times for other types of emergency workers has not been specifically addressed. As to special facilities which have incapacitated people, the most limiting cases with the highest staff and patient load in the study area are Seaside Regional Center (Waterford) and Lawrence and Memorial Hospitals (New London). The evacuation of these hospitals are considered separately in a discussion of Zones B1 and B2.

In the case of Fishers and Plum Islands, a conservative notification time was calculated based on available public notification vehicles and land area to be covered. Evacuation time for Fishers Island takes into account the maximum population during the peak recreation season, as well as the average ferry capacity and travel time of the Fishers Island Ferry. Plum Island is a United States Department of Agriculture Station. It has a small staff which could easily be evacuated to Long Island by boat ferry.

III.a. PUBLIC AUTHORITY NOTIFICATION TIME

The notification of public authorities by the Millstone Nuclear Power Station is of prime importance. In fact, th Millstone Section of the State of Connecticut RERP delineates town agency (towns within 3 miles of the plant) as well as State agency responsibilities in the notification process. Basically, Millstone Nuclear Power Station is required to notify the Waterford Emergency Communications Center. This center, in turn, is required to notify the New London Police Headquarters, the East Lyme First Selectman and the Waterford First Selectman. The Millstone Nuclear Power Station is also required to notify the Montville State Police, Troop E, who, in turn, are responsible for notifying the State of Connecticut Office of Civil Preparedness, Department of Environmental Protection, and the Governor. It should be noted that the communication systems involving the Millstone Nuclear Power Station, the towns and the State agencies utilize both radio and telephones.

The results of the June 15, 1978 drill held at Waterford, Connecticut will be used as the basis of time estimates in this section. This drill was very extensive, involving all of the above town and State agencies for an 8-hour period.

In summary, on June 15, 1978, a drill was held in the Towns of East Lyme and Waterford and the City of New London. This drill consisted of a State of Connecticut Class A Incident (as per the classification system used in the State of Connecticut RERP) being advised for three zones out to a distance of 1.8 miles and a Class B Incident from 1.8 to 4.5 miles.

During the course of the drill, eight messages originated from the Millstone Nuclear Power Station to the Waterford Emergency Communications Center. A log of message origination times (with verification) was kept by the Waterford

Police during the drill. It is estimated from the log that it requires approximately 7 to 15 minutes for towns to receive and verify messages. If the same type of system is used to notify the local officials in the updated State of Connecticut, RERP, an additional 10 minutes would be required to accommodate the enlarged area (for all towns within 10 miles of the power station). Therefore, for purposes of the study, 17 to 25 minutes would be required for each emergency message originating from the plant to be communicated to each town within 10 miles of Millstone. In the course of further development of the State and town RERPs in mid 1980-1981, new or modified methods of communication could reduce this time significantly.

III.b. PUBLIC NOTIFICATION TIME ANALYSIS

Once public authorities have been notified by the Millstone Nuclear Power Station that a State of Connecticut Class A Incident is in progress, these public authorities will then be responsible for notifying all residents and transients (e.g. at state parks, etc.) to evacuate the affected areas. These authorities will use many types of resources to notify individuals within the affected areas. The main method will consist of announcements and mobile notification by means of town and State vehicles with public address systems as specified in the RERP.

As to confirmation by public authorities that evacuation has acutally taken place, the time for its accomplishment is not clearly specified since the methodology (i.e., tieing handkerchiefs on doors, etc.) has not been developed by all towns and cities within 10 miles of Millstone. However, in the case of Waterford (comprising most of this area), the methodology has been developed and consists of a home being clearly identified by a previously prepared sign after people have evacuated it. In general, it may be stated that evacuation could be confirmed by public notification vehicles covering the same area. Therefore, confirmation time would be less than or equal to the time for notification of the public to evacuate.

The methodology used as the basis for determining the Notification Times within the zones is defined in Part II of this report. This methodology is based on a weighted average of town vehicles available for each zone. Also described in Part II are the conservative assumptions used in this methodology.

In Part IV of this report, a composite of the information in Part III.a. "Notification of Public Authorities" and Part III.b. "Public Notification Times" will be presented together with the information contained in Part

III.c. "Evacuation Time Analysis". However, Part IV will not provide an addition of Notification Times from Part III.a. and III.b. to the Evacuation Times contained in Part III.c. This latter summation would be erroneous since it does not consider the fact that the total time to notify the public in outer zones would be simultaneous with the times required by the public to evacuate inner zones.

The following factors were used in the formulae specified in Part II:

1. Summation of Square Miles for Towns within Specified Zones (M_i)[4]

Zone	M_i	Radius
AB1	6.781 mi^2	2 miles (180°)
A1, A2	20.13 mi^2*	5 miles (90°)
B1, B2	19.634 mi^2	5 miles (90°)
A1, A2, A3	79.04 mi^2*	10 miles (90°)
B1, B2, B3	78.53 mi^2	10 miles (90°)

* Inclusive of Black Point in East Lyme

2. Public Address System Vehicles Available in each Town for Public Notification

Town	Vehicles[5]	
a. East Lyme	Police -	4 Cruisers
	Fire - (Niantic)	12 Trucks
	(Flanders)	9 Trucks
	Highway -	4 Trucks
	Total	29 Vehicles
b. Waterford	Police -	11 Cruisers
	Fire - (Cohanzie)	4 Trucks
	(Goshen)	4 Trucks
	(Jordan)	3 Trucks
	(Oswagatchie)	6 Trucks
	(Quakerhill)	5 Trucks
	Public Works -	7 Trucks
	Total	40 Vehicles

[4]Factors of $M_i/\Sigma M_i$ used to calculate N_i were determined from areas illustrated in Figure 401.2.1 (Millstone Nuclear Power Station Section of RERP) and maps from Appendix C of Millstone FSAR Site Plan (Revision 6).

Town (Continued)		Vehicles[5]
c. New London	Police -	6 Cruisers
	Fire -	13 Trucks
	Parks & Recre.	2 Vehicles
	Public Works	20 Vehicles
	Total -	41 Vehicles
d. Groton (City)	Police -	8 Cruisers
	Fire -	3 Trucks
Groton (Town)	Police -	5 Cruisers
	Fire -	6 Trucks
	Total	22 Vehicles
e. Lyme	Police -	1 Cruiser
	Fire -	5 Trucks
	Total -	6 Vehicles
f. Ledyard	Police -	5 Cruisers
	Fire -	8 Trucks
	Total -	13 Vehicles
g. Montville	Police -	3 Cruisers
	Fire -	5 Trucks
	Chesterfield Fire	2 Trucks
	Mohegan Fire -	5 Trucks
	Hopedale Fire -	2 Trucks
	Total -	17 Vehicles
h. Old Lyme	Police -	2 Cruisers
	Fire -	5 Trucks
	Total -	7 Vehicles
i. Fishers and Plum Islands	-	5 Vehicles on Fishers Island and 1 Vehicle on Plum Island

Troop E of the Connecticut State Police has a total of 43 Troopers at Montville (not inclusive of Resident State Troopers). These Troopers have vehicles as pointed out on Page 501.2-A-4 of the RERP. Assuming three shifts and that 7 vehicles and troopers would be needed for access control, 7 vehicles would remain to notify people to evacuate.

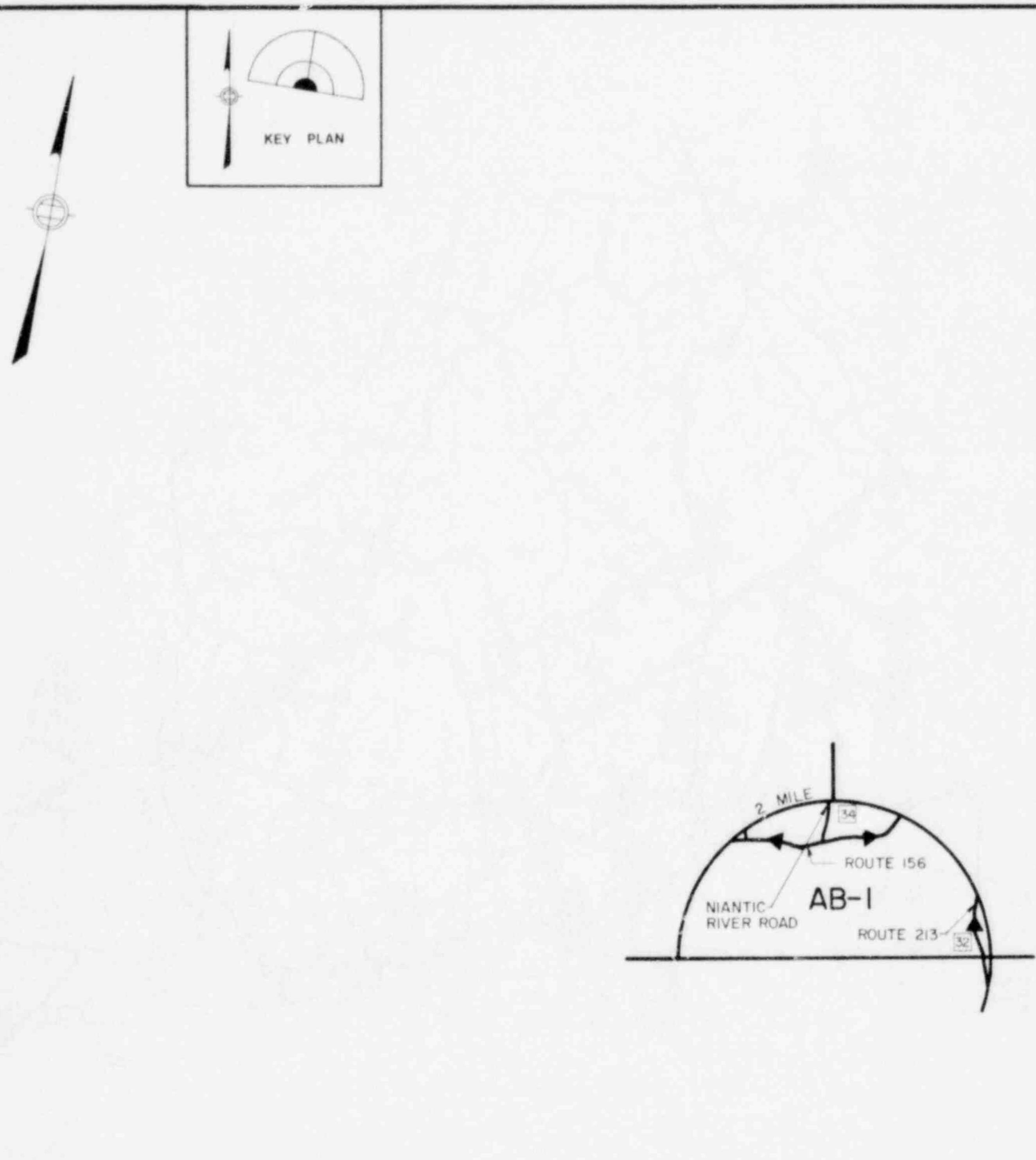
[5]Information on public notification vehicles were derived from the RERP (Section 500). For towns not included in the RERP, information was obtained from town agencies; (i.e., in the case of Montville, Groton, Old Lyme, Ledyard, Lyme and Fishers and Plum Islands).

3. <u>Number of Square Miles Covered by Public Notification Vehicles Within 1 Hour (V)</u>

V = 1.097 $miles^2$ /hour - vehicle, as determined from a drill held at Waterford, Connecticut on June 15, 1978.

Based upon the above data, notification times for public authorities to notify the resident and transient population by emergency public address equipped vehicles were calculated. The results of these calculations are given in Table 5, Part IV.

Table 5 is a worst case analysis of Public Notification Time and does not consider other available means of notification; i.e., radio, television and sirens. These other methods will be addressed during the preparation of new RERPs by the State/towns during 1980-1981.



CHOOLS				
NO	NAME	ENROLLMENT	GRADES	TOWN
1	Flanders School	568	K-5 & Sp. Ed.	East Lyme
2	Niantic School	397	K-5	East Lyme
3	Lillie B. Haynes School	427	K-5	East Lyme
4	East Lyme Jr. H.S.	867	6-8 & Sp. Ed.	East Lyme
5	East Lyme H.S.	1183	9-12	East Lyme
8	Mile Creek School	347	K-6	Old Lyme
9	Center School	275	K-6	Old Lyme
10	Old Lyme Jr. Sr. H.S.	687	7-12	Old Lyme
13	Great Neck Elementary School	230	K-6	Waterford
14	Southwest Elementary School	376	K-6	Waterford

MAJOR RECREATION FACILITIES	
NO	NAME
1	Bluff Point State Park
2	Harkness Memorial State Park
3	Harkness Memorial State Park

NORTHEAST UTILITIES SERVICE COMPANY

EVACUABILITY STUDY AT MILLSTONE NUCLEAR POWER STATION

ZONE AB-1

FIGURE NO. 3

Prepared By
STORCH ENGINEERS
161 MAIN STREET - WETHERSFIELD, CONNECTICUT

POOR ORIGINAL

III.c. EVACUATION TIME ANALYSIS

ZONE AB1

Reference: Figure 3

Zone AB1, a combination of Zones A1 and B1, encompasses the area from 0-2 miles of the nuclear power station site in the two Towns of East Lyme and Waterford. Since the western half of this area is composed chiefly of Niantic Bay, nearly all of the population is located north and east of the nuclear power station. The greatest concentration of resident population is in the Great Neck area of the Town of Waterford. Transient population consists of the incremental summer population and is contained primarily in the recreational areas directly east of the power station at Long Island Sound and in the northwest on the west side of the Niantic River.

There are two elementary schools in the zone both in the Town of Waterford, with a combined school enrollment of 606 students. The Town of Waterford, has a fleet of 21 school buses available, all with seating capacity of 66 passengers each.

Evacuation Routes

The main route available for evacuation is State Highway 156, which travels approximately east-west and crosses the Niantic River. However, it will not be necessary for evacuating traffic to cross Niantic Bay since adequate routes exist on either side through both towns. Route 156 in this sector has a speed limit varying from 25 to 30 miles per hour. Intersecting with Route 156, State Highway 161 in East Lyme and Niantic River Road and Daniels Avenue provide additional northbound street capacity out of this sector. For the concentrated resident and summer populations at the east edge of the sector, State Highway 213 provides an accessible evacuation route, although curves restrict the speed limit to 25 mph.

Evacuation Time

Since the Niantic River divides this zone, Evacuation Time has been separately computed for both sides in the Towns of East Lyme and Waterford.

West Side of River

Evacuation Route: Routes 156, 161 (Capacity 1,532 vehicles per hour)

Resident Population	=	1,619
Transient Population	=	442
School Population	=	0

$$EVT = (1619/2 + 442/1.5)(60/1532) = 43 \text{ minutes}$$

East Side of River

Evacuation Route: Routes 156, 213, Niantic River Road

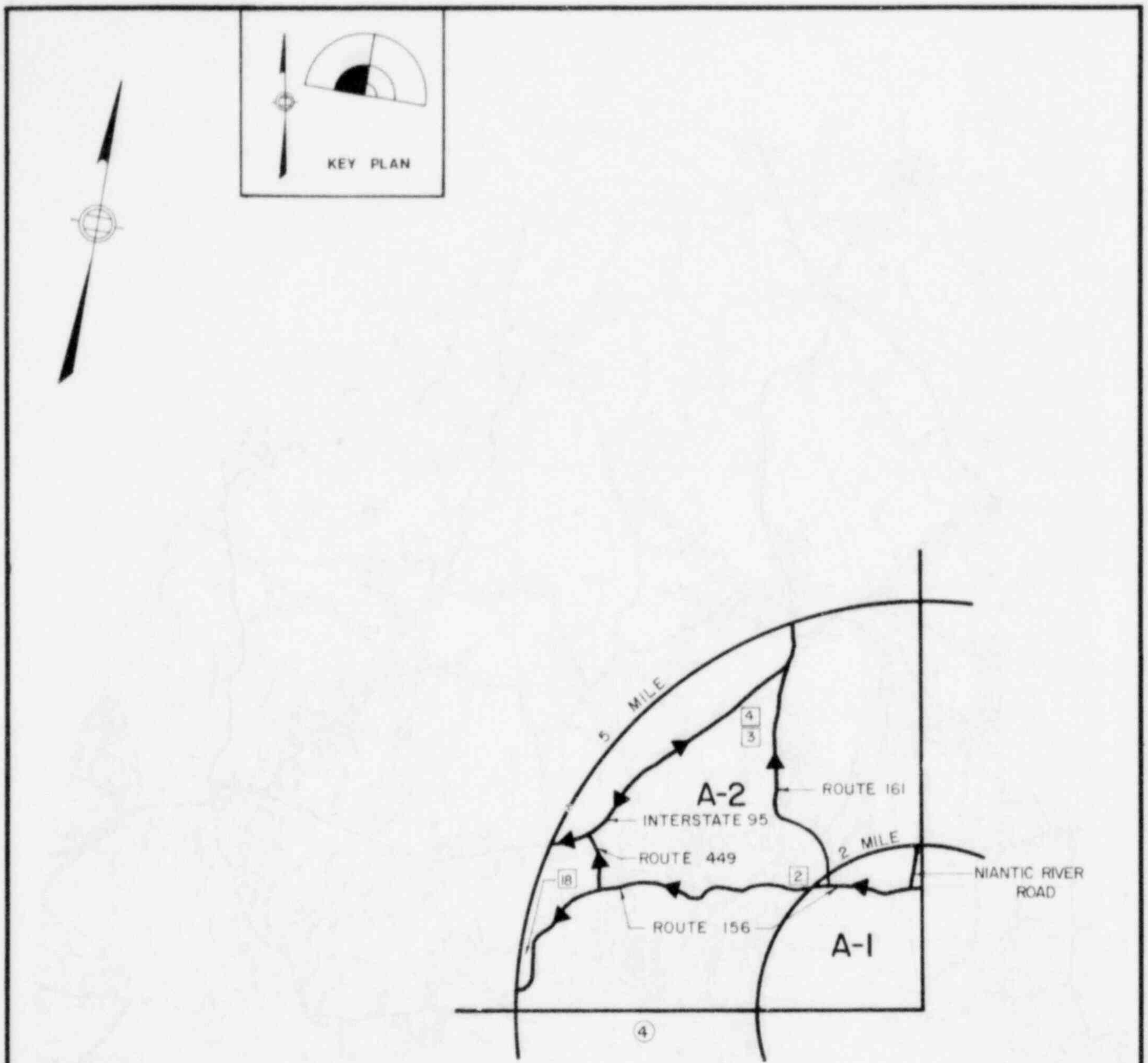
(Capacity 1,962 vehicles per hour)

Resident Population	=	4,468
Transient Population	=	654
School Population	=	606

Available school buses have a seating capacity of 66 students. Thus, the number of school buses required will be 606/66 = 9.2 or 10 buses. The available buses are more than adequate to provide student transportation in the event of evacuation.

$$EVT = (4468/2 + 654/1.5 + 10)(60/1962) = 82 \text{ minutes}$$

Thus, the limiting evacuation time for this 0-2 mile, 180° zone will be 82 minutes.



SCHOOLS				
NO	NAME	ENROLLMENT	GRADES	TOWN
1	Flanders School	568	K-5& Sp Ed	East Lyme
2	Niantic School	397	K-5	East Lyme
3	Lillie B. Haynes School	427	K-5	East Lyme
4	East Lyme Jr. H.S.	887	6-8& Sp Ed	East Lyme
5	East Lyme H.S.	1163	9-12	East Lyme
18	Mile Creek School	347	K-6	Old Lyme
19	Center School	275	K-6	Old Lyme
20	Old Lyme Jr. Sr. H.S.	697	7-12	Old Lyme
32	Great Neck Elementary School	230	K-6	Waterford
34	Southwest Elementary School	376	K-6	Waterford

MAJOR RECREATION FACILITIES	
NO	NAME
①	Bluff Point State Park
②	Haley Farm State Park
③	Harkness Memorial State Park

HORIZONTAL SCALE IN MILES
0 1 2 3

NORTHEAST UTILITIES SERVICE COMPANY

EVACUABILITY STUDY AT MILLSTONE NUCLEAR POWER STATION

ZONE A-1, A-2

FIGURE NO. 4

Prepared By
STORCH ENGINEERS
161 MAIN STREET - WETHERSFIELD, CONNECTICUT

POOR ORIGINAL

ZONE A1, A2

Reference: Figure 4

Zones A1, A2 encompass a 90 degree sector, 0-5 miles north and west of the nuclear power station site in the Town of East Lyme and smaller portions of Old Lyme and Waterford. Residential population is concentrated in the northwest and north-northwest portions of Zones A1, A2. Transient population from summer recreation users is located primarily directly west of the nuclear station on Long Island Sound and in Rocky Neck State Park. There are three elementary and one junior high schools in Zones A1, A2 with a combined enrollment of 2,038 pupils. Three of the schools are in East Lyme, which has available 21 buses with seating for 66 passengers each. The Town of Old Lyme has 17 buses available with a seating capacity of 66 passengers each. As previously mentioned, the Town of Waterford has 21 school buses each with a capacity of 66 passengers.

Evacuation Routes

State Highways 156 and 161 are the key arterial evacuation routes leading from the nuclear power station to the west and north, respectively. Route 156 has a number of curves restricting capacity and is posted for a speed of 30 mph. Route 161 has few curves and is designed for speeds varying between 25 and 35 mph. There is a traffic signal at the intersection of State Highways 156 and 161.

In addition, the limited access four-lane Interstate 95 provides evacuation routing for population near the northwestern outer edge of Zones A1, A2. The Rocky Neck Connector (Route 449) is a four-lane roadway link from Route 156 to Interstate 95, providing a shorter and more direct outlet from this zone.

Evacuation Time: Route 156 and Interstate 95 (Capacity 3,538 vehicles per hour)

Population	Residential	Transient	School
Zone A1	163	---	---
Zone A2	4735	13492	347
Total	4898	13492	347

Available school buses have a seating capacity of 66 passengers. Thus, the number of school buses required will be 347/66 = 5.3 or 6 buses. The number of buses available are more than adequate to provide evacuation of students from the area.

EVT = (4898/2 + 13492/1.5 + 6) (60/3538) = 194 minutes

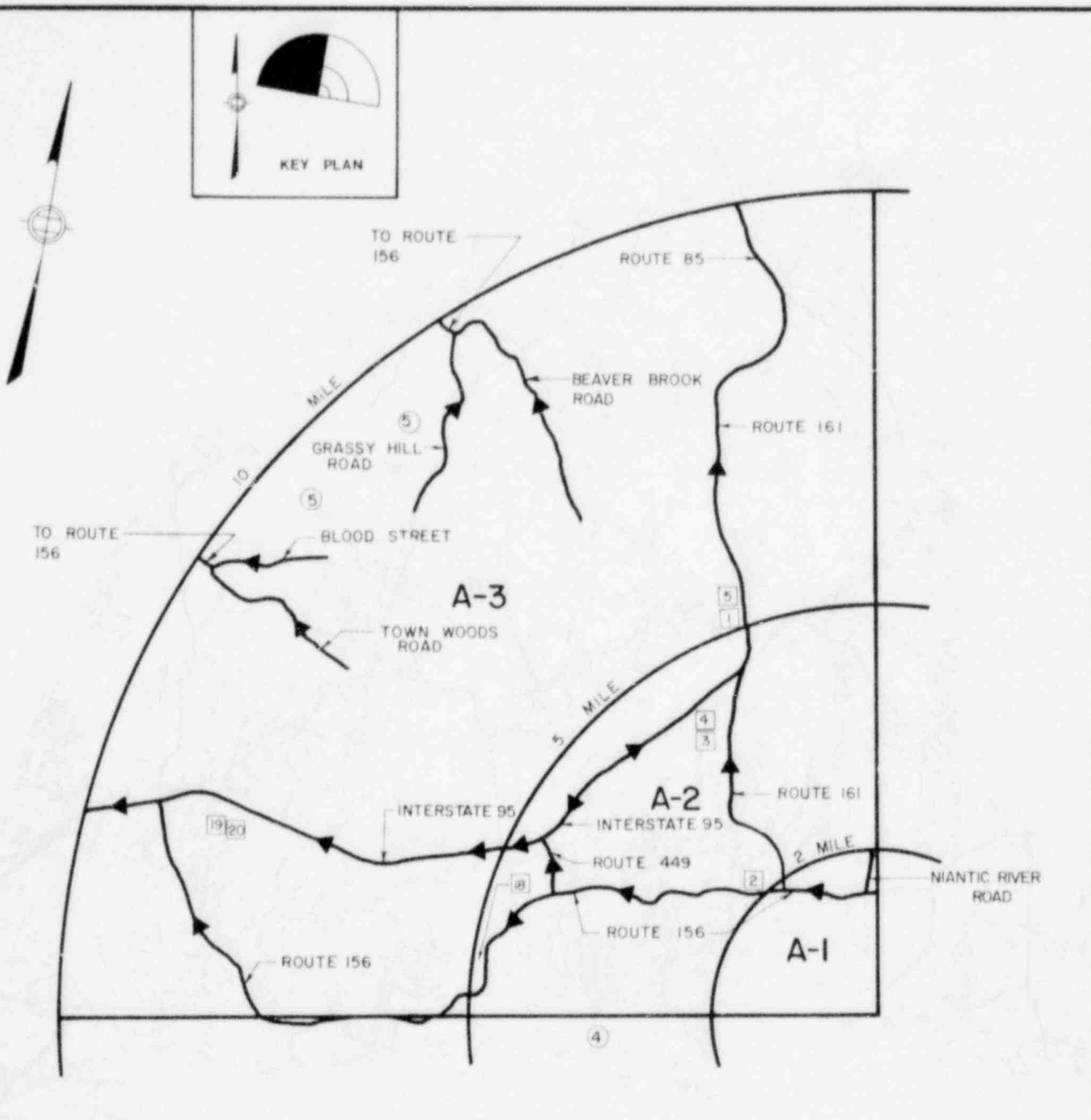
Evacuation Time: Route 161 and Interstate 95 (Capacity 3,538 vehicles per hour)

Population	Residential	Transient	School
Zone A1	1456	442	---
Zone A2	6306	1787	1691
Total	7762	2229	1691

School buses required = 1691/66 = 25.6 or 26. Once again, the number of school buses are more than adequate to provide evacuation of students from the area.

EVT = (7762/2 + 2229/1.5 + 26) (60/3538) = 91 minutes

Thus, the limiting evacuation time for this 0-5 mile, 90 degree combination of Zone A1 and Zone A2 is 194 minutes.



SCHOOLS				
NO.	NAME	ENROLLMENT	GRADES	TOWN
1	Flanders School	565	K-6 & Sp Ed	East Lyme
2	Niantic School	397	K-5	East Lyme
3	Lillie B. Haynes School	427	K-5	East Lyme
4	East Lyme Jr. H.S.	887	6-8 & Sp Ed	East Lyme
5	East Lyme H.S.	[illegible]	9-12	East Lyme
18	Mile Creek School	347	K-6	Old Lyme
19	Center School	273	K-6	Old Lyme
20	Old Lyme Jr. Sr. H.S.	687	7-12	Old Lyme
[illegible]	Great Neck Elementary School	230	K-6	Waterford
24	Southeast Elementary School	376	K-6	Waterford

MAJOR RECREATION FACILITIES	
NO.	NAME
1	Bluff Point State Park
2	Haley Farm State Park
3	Harkness Memorial State Park

HORIZONTAL SCALE IN MILES

0 1 2 3

NORTHEAST UTILITIES SERVICE COMPANY

EVACUABILITY STUDY AT MILLSTONE NUCLEAR POWER STATION

Zone A-1, A-2, A-3

FIGURE NO. 5

Prepared By
STORCH ENGINEERS
161 MAIN STREET – WETHERSFIELD, CONNECTICUT

POOR ORIGINAL

ZONES A1, A2, A3

Reference: Figure 5

Zones A1, A2, A3 encompass the entire 90 degree sector, 0-10 miles north and west of the nuclear power station in the Towns of Lyme, East Lyme, and Old Lyme and smaller portions of Montville, Waterford, and Old Saybrook, plus the additional population south of the quadrant. Additional residents in Zone A3 (5-10 miles) are fewer than the resident population in Zone A2 (2-5 miles), with slightly greater concentrations located directly west of the power station. Transient population also decreases from Zone A2 to Zone A3, with most of the incremental summer population found along the coast. There are four additional schools in Zone A3, an elementary and junior/senior high school in Old Lyme, and an elementary and senior high school in East Lyme. Thus, Zones A1, A2, A3 contain a total of 8 schools with a combined enrollment of 4759 pupils. There are 4 buses in Lyme, 21 buses in East Lyme, and 17 buses in Old Lyme, 15 buses in Montville, and 21 buses in Waterford. All buses have a capacity of 66 passengers.

Evacuation Routes

The evacuation routes for Sector A may be divided between eastbound and northbound facilities with State Highway 156 and Interstate 95 providing westbound capacity and State Highways 161 and 85 and the Connecticut Turnpike (Interstate 95 and Route 52) providing northbound capacity. In addition, there are certain local roads which will provide additional capacity for the evacuation of Zone A3. These roads are Town Woods Road, Blood Street, Grassy Hill Road, and Beaver Brook Road, all of which connect to Route 156. Route 156 follows Long Island Sound and then proceeds north along the Connecticut River. As it approaches the interchange with Interstate 95, the design for Route 156 improves and the speed limit increases to 45 mph. Route 161 permits a 45 mph speed limit in Zone A3 and this speed limit is also posted at its junction with Route 85 proceeding north out of Zones A1, A2, A3. There are two traffic signals on Route 161, at U.S. 1 and at State Highway 85. The western edge of Zones A1, A2, A3 is on the west side of the Connecticut River just beyond the bridge. While the bridge is designed to Interstate highway standards, it is the junction of two evacuation routes (Interstate 95 and Route 156) and would require traffic direction for efficient evacuation.

Evacuation Time: Route 156 and Interstate 95, Blood Street/Town Woods Road (westbound routes)

(Capacity = 4,038 vehicles per hour)

Population	Residential	Transient	School
Zone A1	163	---	---
Zone A2	4735	3492	347
Zone A3	8001	7270	970
Total	12899	20762	1317

The Town of Old Lyme has available 17 buses with a seating capacity of 66 passengers each. One of the schools, Old Lyme Junior/Senior High, has a portion of its enrollment eligible to drive. Assuming half the school population is eligible to drive and that there is one vehicle for every four students, the number of school buses required will be (1317 - 350/4)/66 = 18.6 or 19 buses. It should be noted that though the number of required buses exceeds the number of available buses, additional buses could be provided by means of Mutual Aid Agreement Towns in close proximity to the affected areas.

EVT = (12899/2 + 20765/1.5 + 107*) (60/4038) = 303 minutes

* 88 vehicles + 19 school buses = 107

Evacuation Time: Route 156 and Interstate 95, Blood Street/Town Woods Road (westbound routes) (Capacity = 4,038 vehicles per hour)

Population	Residential	Transient	School
Zone A1	163	---	---
Zone A2	4735	3492	347
Zone A3	8001	7270	970
Total	12899	20762	1317

The Town of Old Lyme has available 17 buses with a seating capacity of 66 passengers each. One of the schools, Old Lyme Junior/Senior High, has a portion of its enrollment eligible to drive. Assuming half the school population is eligible to drive and that there is one vehicle for every four students, the number of school buses required will be (1317 - 350/4)/66 = 18.6 or 19 buses. It should be noted that though the number of required buses exceeds the number of available buses, additional buses could be provided by means of Mutual Aid Agreement Towns in close proximity to the affected areas.

EVT = (12899/2 + 20765/1.5 + 107*) (60/4038) = 303 minutes

* 88 vehicles ÷ 19 school buses = 107

Evacuation Time: Connecticut Turnpike, and State Highways 161 and 85, Beaver Brook/Grassy Hill Road, (northbound routes) (Capacity = 4,018 vehicles per hour)

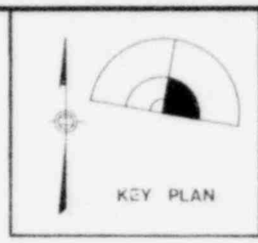
Population	Residential	Transient	School
Zone A1	1456	442	---
Zone A2	6306	1787	1691
Zone A3	3008	1296	1751
Total	10770	3525	3442

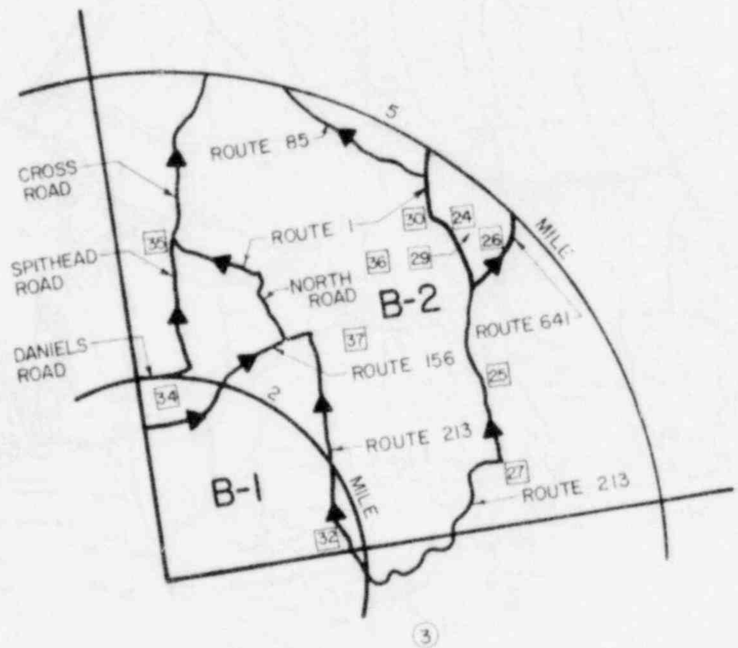
Available school buses in East Lyme have a seating capacity of 44 passengers (20 buses) and 66 passengers (21 buses) or an average of 55 passengers. Assuming that there is one vehicle for every four students at East Lyme High School, the number of school buses required will be (3442 - 1183/4)/55 = 57 buses. It should be noted that through the number of required buses exceed the number of available buses, additional buses could be provided by means of Mutual Aid Agreement Towns in close proximity to the affected areas.

EVT = (10770/2 + 3525/1.5 + 353*) (60/4018) = 121 minutes

*296 vehicles + 57 school buses = 353

Thus, the limiting evacuation time for this 0-10 mile, 90 degree combination of Zone A1, Zone A2 and Zone A3 is 303 minutes.





MAJOR EMPLOYERS			
NO.	NAME	EMPLOYMENT	TOWN
1	Dow Chemical	224	Ledyard
2	Pfizer	2600	Groton
3	General Dynamics Electric Boat Division	14,000	Groton
4	U.S. Navy Submarine Base	5,000	Groton

HORIZONTAL SCALE IN MILES

0 1 2 3

SCHOOLS									
NO.	NAME	ENROLLMENT	GRADES	TOWN	NO.	NAME	ENROLLMENT	GRADES	TOWN
[illegible]	Charles Barnum	558	K-6	Groton	24	Edgerton School	299	K-6	New London
[illegible]	Claude Chester	545	PK-6	Groton	25	Harbor School	452	K-6	New London
[illegible]	Colonel Ledyard	198	K-3	Groton	26	Jennings School	528	K-6	New London
[illegible]	Eastern Point	598	PK-6	Groton	[illegible]	Nathan Hale School	456	K-6	New London
[illegible]	Groton Heights	188	PK, 4-6	Groton	[illegible]	Winthrop School	326	K-6	New London
[illegible]	Mary Morrison	615	K-6	Groton	29	New London Jr. H.S.	631	7-8	New London
[illegible]	Noank	305	K-6	Groton	30	New London Sr. H.S.	[illegible]	9-12	New London
[illegible]	Pleasant Valley School	556	K-6	Groton	[illegible]	Cohanzie Elementary School	344	K-6	Waterford
[illegible]	William Seely	326	K-6	Groton	32	Great Neck Elementary School	230	K-6	Waterford
[illegible]	Fitch Jr. H.S.	767	7-9	Groton	[illegible]	Quaker Hill Elementary School	235	K-6	Waterford
[illegible]	West Side Jr. H.S.	521	7-9	Groton	34	Southwest Elementary School	375	K-6	Waterford
[illegible]	Fitch Senior H.S.	1569	10-12	Groton	35	Oswegatchie Elementary School	257	K-6	Waterford
[illegible]	Gales Ferry School	247	K-6	Montville	36	Clark Lane Jr. H.S.	639	7-8	Waterford
[illegible]	Palmer Memorial School	169	K-6	Montville	37	Waterford H.S.	1248	9-12	Waterford
[illegible]	Dr. Charles E. Murphy	703	7-8	Montville					

NORTHEAST UTILITIES SERVICE COMPANY

EVACUABILITY STUDY AT MILLSTONE NUCLEAR POWER STATION

ZONE B-1, B-2

FIGURE NO. 6

Prepared By:

STORCH ENGINEERS
161 MAIN STREET - WETHERSFIELD, CONNECTICUT

ZONES B1, B2

Reference: Figure 6

Zones B1, B2 encompass a 90 degree sector, 0-5 miles north and east of the power station in the Towns of Waterford and New London. Resident population is centered in New London between 4 and 5 miles northeast from the power station. Transient population is primarily located near the shoreline and at the Harkness Memorial State Park directly east of the nuclear power station. There are 11 schools in Zones B1, B2 with nine of them located in Zone B2 and six schools of those in the Town of New London. Waterford has 21 school buses with a capacity of 66 passengers for the transport of students while New London contracts for bus service with the Monroe Bus Company which provides 14 buses of 66 passenger seating capacity. As to Seaside Regional Center (Waterford) and Lawrence and Memorial Hospital (New London), it is estimated by the State of Connecticut, Department of Health, Office of Emergency Medical Services that four to five hours is required to evacuate since one third of the patients are non-ambulatory.

Evacuation Routes

The Thames River serves as an impediment to evacuation in the eastbound direction from Zones B1, B2. Therefore, evacuation is entirely oriented towards the northbound State Highways. These facilities are State Highways 213, 85, and 156, U.S. Route 1, and also the combination of Niantic River Road/Daniels Avenue/Spithead Road (leading to State Highway 85) and the North Road connection between Route 156 and U.S. 1 in the western part of Zones B1, B2. Route 213 has limited capacity at its southern end due to the curvilinear alignment. Traffic signals are located at the intersection of U.S. 1 at Cross Road and at Route 213.

Evacuation Time

Evacuation Routes: Route 85, 156, Spithead Road/Cross Road, Route 32

(Capacity = 4,618 vehicles per hour)

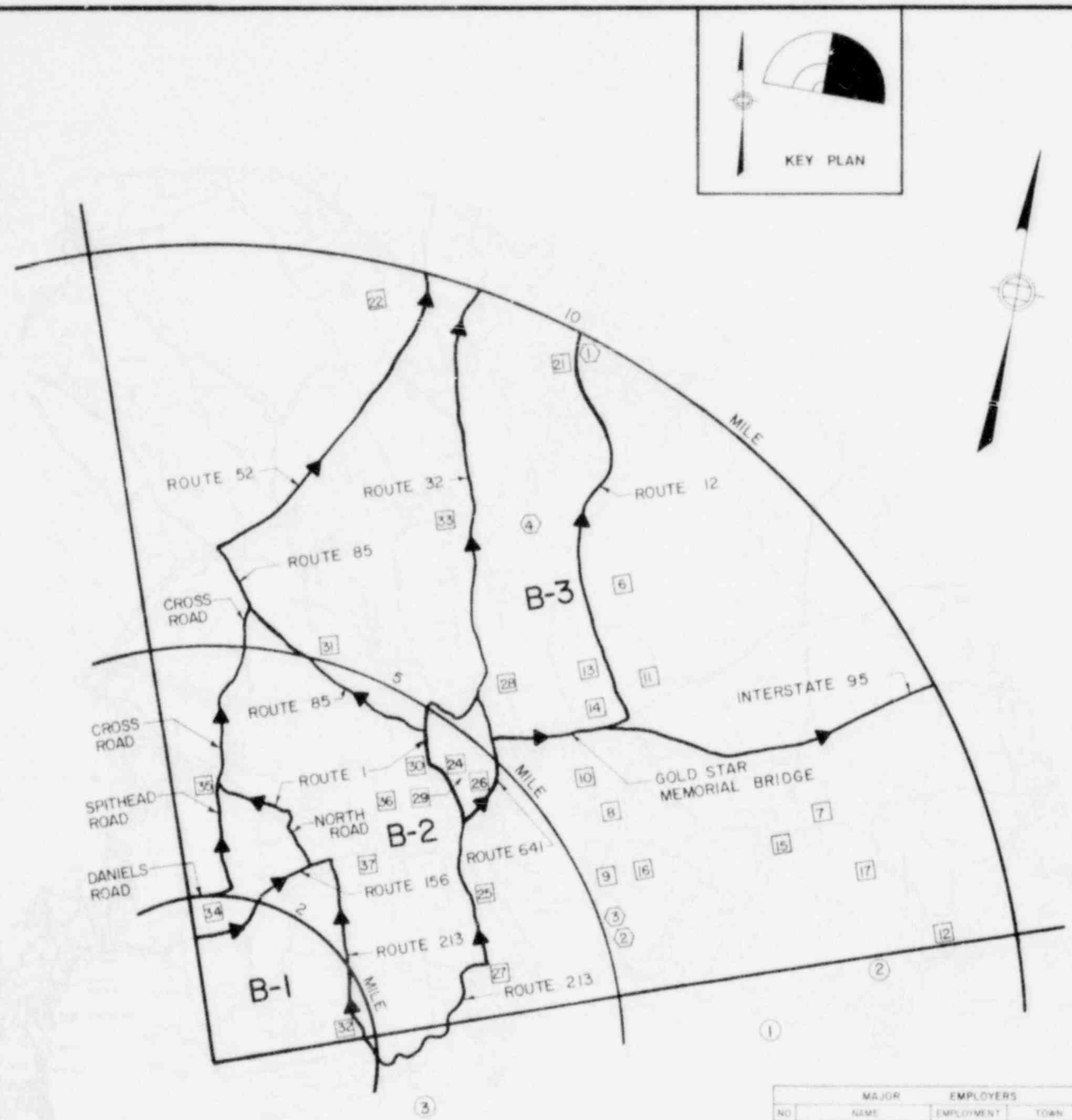
Population	Residential	Transient	School
Zone B1	4468	654	606
Zone B2	37310	11588	5455
Total	41778	12242	6061

Available school buses have a seating capacity of 66 passengers. High school enrollment represents 2,429 students. Assuming a car ownership of one vehicle for every four high school students, the number of school buses required is (6061 - 2429/4)/66 = 83 buses. It should be noted that though the number of required buses exceeds the number of available buses, additional buses could be provided by means of Mututal Aid Agreement Towns in close proximity to the affected areas.

EVT = (41778/2 + 12242/1.5 + 691*) (60/4618) = 386 minutes

*608 vehicles plus 83 school buses

Thus, the evacuation time for this 0-5 mile, 90 degree combination of Zone B1 and Zone B2 is 386 minutes.



MAJOR EMPLOYERS			
NO	NAME	EMPLOYMENT	TOWN
1	Dow Chemical	224	Ledyard
2	Pfizer	3500	Groton
3	General Dynamics Electric Boat Division	18,000	Groton
4	U.S. Navy Submarine Base	15,000	Groton

HORIZONTAL SCALE IN MILES
0 1 2 3

SCHOOLS									
NO	NAME	ENROLLMENT	GRADES	TOWN	NO	NAME	ENROLLMENT	GRADES	TOWN
6	Charles Barnum	378	K-6	Groton	24	Edgerton School	299	K-6	New London
7	Claude Chester	549	PK-6	Groton	25	Harbor School	432	K-6	New London
8	Colonel Ledyard	198	K-5	Groton	26	Jennings School	328	K-6	New London
9	Eastern Point	336	PK-6	Groton	27	Nathan Hale School	456	K-6	New London
10	Groton Heights	188	PK, 4-6	Groton	28	Winthrop School	324	K-6	New London
11	Mary Morrison	614	K-6	Groton	29	New London Jr. H.S.	615	7-8	New London
12	Noank	305	K-6	Groton	30	New London Sr. H.S.	1361	9-12	New London
13	Pleasant Valley School	554	K-6	Groton	31	Lakeside Elementary School	566	K-6	Waterford
14	William Seely	305	K-6	Groton	32	Great Neck Elementary School	230	K-6	Waterford
15	Fitch Jr. H.S.	767	7-9	Groton	33	Quaker Hill Elementary School	235	K-6	Waterford
16	West Side Jr. H.S.	821	7-9	Groton	34	Southwest Elementary School	376	K-6	Waterford
17	Fitch Senior H.S.	1349	10-12	Groton	35	Oswegatchie Elementary School	237	K-6	Waterford
21	[illegible] School	247	K-6	Montville	36	Clark Lane Jr. H.S.	639	7-8	Waterford
22	Palmer Memorial School	169	K-6	Montville	37	Waterford H.S.	[illegible]	9-12	Waterford
23	Dr. Charles E. Murphy	705	7-8	Montville					

NORTHEAST UTILITIES SERVICE COMPANY

EVACUABILITY STUDY AT MILLSTONE NUCLEAR POWER STATION

Zone B-1, B-2, B-3

FIGURE NO. 7

Prepared By
STORCH ENGINEERS
161 MAIN STREET - WETHERSFIELD, CONNECTICUT

POOR ORIGINAL

ZONES B1, B2, B3

Reference: Figure 7

Zones B1, B2, B3 encompass the entire 90 degree sector, 0-10 miles north and east of the nuclear power station in the Towns of Waterford, Montville, New London, Ledyard and Groton, plus the additional population south of the sector along Long Island Sound. Additional residents in Zone B3 (5-10 miles) are principally located within the 5-8 mile annulus ring. Incremental summer population is again chiefly along the shoreline and in Buff Point and Haley Farm State Parks. Further, there are three major industries in Zone B3, adding 56,724 transient population. There are 18 additional schools in Zone B3, resulting in a total of 29 schools in Zones B1, B2, B3 with combined enrollment of 14,313 pupils. There are 21 buses in Waterford, 15 buses in Montville, 14 contracted buses in New London, 32 buses in Ledyard, and 55 buses in Groton. Each of the above buses have a capacity of 66 passengers.

Evacuation Routes

Within Zone B3, the Gold Star Memorial Bridge has five travel lanes across the Thames River for eastbound evacuating vehicles. Interstate 95 (three lanes eastbound) and Route 184 provide a direct connection from the Bridge and continue east beyond the 10-mile limit. Route 184 is a divided, four-lane highway for the first one-half mile east of Interstate 95 and then narrows to a two-lane, divided highway with a speed limit of 45 mph. There are traffic signals on Route 184 within Zone B3 near the Route 12 interchange and at Route 117. Northbound capacity is amply provided by the combination of State Highways 85 and 52 and State Highways 32 and 52 on the west side of the Thames River and State Highway 12 on the east side of the Thames River. Route 52 is a limited access facility with good grades and alignment and a speed limit of 55 mph. Further, a truck climbing lane is provided north of its interchange with Route 85. Route 32 is an at-grade divided four-lane roadway with a posted speed of 45 mph. There are two traffic signals along Route 32 north of Interstate 95.

Evacuation Time

Evacuation Routes: State Highways 85 and 52, State Highway 32
State Highway 12, Interstate 95, and State Highway 184
(Capacity = 11,405 vehicles per hour)

Population	Residential	Transient	School
Zone B1	4468	654	606
Zone B2	37310	11588	5455
Zone B3	53178	44500	8252
Total	94956	56742	14313

Available school buses have a capacity of 66 passengers. High school enrollment represents 3,778 students. Assuming a car ownership of one vehicle for every four high school students, the number of school buses required is (14313 - 3778/4)/66 = 203. It should be noted that though the number of required buses exceeds the number of available buses; nonetheless, additional buses could be provided by means of Mutual Aid Agreement Towns in close proximity to the affected area.

EVT = (94956/2 + 56742/1.5 + 1148*) (60/11405) = 455 minutes

* 945 vehicles plus 203 school buses

Thus, the evacuation time for this 0-10 mile, 90 degree combination of Zone B1, Zone B2 and Zone B3 is 455 minutes.

Fishers Island and Plum Island

Fishers Island is about 7.5 miles southeast of Millstone point. The 10-mile radius around Millstone envelopes approximately 60 percent of Fishers Island. Although Fishers Island has approximately 350 to 400 permanent residents, its peak summer population (inclusive of day time visitors) is maximally estimated to be 2,500 people. The island has four fire service vehicles and one police criuser which have capability for notifying people on the island. Plum Island is approximately 8 miles due south of Millstone. Approximately 70 percent of this island land mass is within the 10-mile radius of Millstone.

Inhabitants of Fishers and Plum Islands would rely on the Fishers Island Ferry Service District and Orient Point (Long Island, New York) ferry service respectively, for transportation in the event of evacuation.

It has been conservatively estimated that, negating privately owned boats, the evacuation time of inhabitants of Fishers Island would require about 8 or 9 hours assuming that only one ferry is available from the Fishers Island Ferry District. However, in reality, the Orient Point - New London Ferry would, no doubt, be available. Since this latter ferry has a much larger capacity, the evacuation time of Fishers Island could be considerably reduced. As for the U.S. Department of Argriculture's employees on Plum Island, they could be evacuated within 45 minutes by use of the Orient Point Ferry.

Also, the inhabitants of both islands could relocate themselves to other ends of the islands not included within the 10-mile radius of Millstone.

Based on conversations with ferry line personnel, it appears that inclemen weather (i.e., rain, etc.) could increase the time for each trip by 10 to 15 percent.

IV. CONCLUSIONS

The objective of this study of the transportation system of the area around to the Millstone Nuclear Power Station has been to determine the notification and evacuation times for various designated zones of the area within a 10-mile radius.

While much of the study area is not densely populated, there are concentrated centers of residential settlement, primarily in New London, which substantially increase the evacuation time. The study area's location on Long Island Sound, combined with the presence of numerous state and local parks, heavily attracts recreational users especially during the summer months. Additionally, three major industries and the U.S. Navy Submarine Base in Groton add significant population group to be accommodated. This transient recreational and worker population induces nearly 70 percent additional population into the study area during the day if it is assumed that the entire transient group lives outside the area.

The high residential population is also accompanied by a proportionally high school enrollment, particularly in the 10-mile zone northeast of the power station which accounts for over 75 percent of the total 19,072 enrollment at 37 public schools within the study area. According to the evacuation analysis, additional school buses would be required to evacuate the zone's school population if schools were in session. This may require reassignment of school buses from one school system to another (or use of commercial and/or state buses) and also involves control of vehicle departure to insure that all buses are fully loaded. Also, as pointed out in the previous text, most of these towns, by virtue of their Mutual Aid Agreements, can provide additional school buses to affected towns. Further, the number of students per private vehicle (assumed as one) at the high schools is extremely conservative.

The major roadway network available for evacuation is primarily oriented to the north; east and west; Routes 156 and Interstate 95 are the two key east-west outlets. While the number of major roadway facilities is greater in the northeast than in the northwest quadrant, the total population is markedly greater also, resulting in a longer evacuation time for the northeast quadrant.

As previously discussed, adverse weather conditions would reduce capacity and increase evacuation time by 20 to 30 percent for average precipitation conditions.

Table 5 summarizes the maximum evacuation times computed for good and adverse weather conditions. A review of this data shows that the longest evacuation time will be 7 hours, 35 minutes for the northeast quadrant in good weather and this would increase to 10 hours, 35 minutes under adverse weather conditions.

It is emphasized that this report addresses notification times and evacuation times using very conservative assumptions. For example, the calculation of the public notification times relies on mobile vehicles equipped with PA systems, although radio and television would certainly be available for notification. Moreover, the public notification analysis for this study relied on using only town and some State Police vehicles (from nearby Troops) even though the Connecticut State Police Headquarters, the National Guard and other towns could be able to provide vehicles. Also, the townwide PA system was not considered for notification of Waterford residents. With regard to evacuation time estimates, as previously pointed out, the same individual is in some cases counted both in the resident and transient work force and recreational population which increases the number of vehicles to be evacuated and the total evacuation time. Further, it is very conservative to assume that the transient population (70 percent of the resident population) is present in its entirety during adverse weather conditions when recreational areas would probably not be in use. To add workers into the transient population is again conservative since major industrial plants would probably be closed on holiday weekends when peak recreation population occurs.

Towns may elect to have embarkation/debarkation points established for the orderly movement of people during an evacuation and this arrangement should considerably reduce evacuation times due to less reliance on privately owned vehicles. Roadways used for evacuation during this study could change based upon State and local input during the upgrading of the RERP expected to take place in mid 1980-1981. Thus, Table 5 times are a worst case of the expected evacuation times for all zones within the study area.

In summary, while all of the assumed conditions have resulted in a high estimate of the public notification and evacuation times, they are a basis for optimizing future emergency planning efforts.

TABLE 5

NOTIFICATION AND EVACUATION TIMES[6]

Zone	Maximum Population*	Notification Time (Minutes[1,2])	Evacuation Time[4] Good Weather	Adverse Weather
AB1	7,789	8	82	98
A1, A2	30,419	33	194	270
A1, A2, A3	52,715	163	303	401
B1, B2	60,081	21[3]	386[7]	519
B1, B2, B3	166,011	121[3]	455	635
Plum Island	50	15	45[5]	50 to 60
Fishers Island	2,500	28	420 to 540[5]	462 to 594

[1] The Notification Time does not include 17 to 25 minutes to notify public authorities

[2] Notification Time could increase by 20 to 30 percent during adverse weather in line with evacuation time, both of which in this study rely on the use of vehicles

[3] Notification Time for Waterford within each zone could be reduced since Waterford has fixed public address systems

[4] Inclusive of special facilities (i.e., parks, schools, industries and hospitals)

[5] Evacuation Time for the islands has been computed for removing all inhabitants by ferry even though more than one-half of each island is beyond the 10-mile limit

[6] The Notification and Evacuation Times may overlap and are not directly additive

[7] Inclusive of Seaside Regional Center (Waterford and Lawrence and Memorial Hospitals (New London)

*Resident, transient and students

APPENDIX

DOCUMENT/ PAGE PULLED

ANO. 8004020418

NO. OF PAGES 1

REASON

☐ PAGE ILLEGIBLE

☐ HARD COPY FILED AT: PDR CF

OTHER ____________

☐ BETTER COPY REQUESTED ON ___/___/___

☒ PAGE TOO LARGE TO FILM

☒ HARD COPY FILED AT: (PDR) CF

OTHER ____________

☒ FILMED ON APERTURE CARD NO 8004020418