Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

October 9, 1984
Ref: ADC-84-P505

Mr. Donald M. Carlson
Fuel Facility Safeguards Licensing Branch
Division of Safeguards, 881-SS
Office of Nuclear Material Safety and Safeguards
US Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Carlson:

SUBJECT: CONSEQUENCES OF SABOTAGE OF NONPOWER REACTORS (A7153-4)

Enclosed are six copies of Los Alamos National Laboratory proposal entitled "Consequences of Sabotage of Nonpower Reactors." If you have any questions on the technical aspects of this proposal, please contact the Principal Investigator, T. F. Bott at FTS 843-9207. For information of a programmatic nature, please contact the Program Manager, Harold Sullivan at FTS 843-9820.

Sincerely,

Allen L. Jennings
Associate Director/Controller

ke

Enc: a/s

cy: R. W. Barber, DOE
R. L. Holton, AL (2)
H. E. Valencia, LAAO, MS A316
J. F. Jackson, ADES, MS A145
J. E. Boudreau, ES-NP, MS F671
W. J. Parras, BUD, MS B244
G. J. Garcia, Q-DO, MS E561
L. H. Sullivan, Q-DO/RS, MS K552
R. A. Haarman, Q-6, MS K557
T. F. Bott, Q-6, MS K557
CRM-4, MS A150 (2)

B/17

NRC FORM 189 (3-81)

U.S. NUCLEAR REGULATORY COMMISSION

PROJECT AND BUDGET PROPOSAL FOR NRC WORK

DATE OF PROPOSAL: 10/1/84

☒ NEW ☐ REVISION NO.

PROJECT TITLE: Consequences of Sabotage at Nonpower Reactors

FIN NUMBER: A 7153-4

NRC B&R NUMBER: 50-19-02-00

NRC OFFICE: NMSS

DOE CONTRACTOR: Los Alamos National Laboratory

CONTRACTOR ACCOUNT NUMBER: R21W

DOE B&R NUMBER:

SITE: Los Alamos New Mexico

COGNIZANT PERSONNEL	ORGANIZATION	FTS PHONE NUMBER
NRC PROJECT MANAGER: D. Carlson	NMSS	427-4712
OTHER NRC TECHNICAL STAFF		
DOE PROJECT MANAGER		
CONTRACTOR-PROJECT MANAGER: L. H. Sullivan	Q-DO	843-9821
PRINCIPAL INVESTIGATOR(S): T. F. Bott	Q-6	843-9207

PERIOD OF PERFORMANCE
STARTING DATE: 9/9/84
COMPLETION DATE: 9/30/85

STAFF YEARS OF EFFORT (Round to nearest tenth of a year)	FY 1984	FY 1985	FY	FY	FY
Direct Scientific/Technical	0.1	1.6			
Other Direct (Clerical)	0.0	0.3			
TOTAL DIRECT STAFF YEARS	0.1	1.9			
COST PROPOSAL					
Direct Salaries	5.7	106.4			
Material and Services (Excluding ADP)	1.8	15.3			
ADP Support	0.0	20.0			
Subcontracts	0.0	0.0			
Travel Expenses (Foreign / Domestic)	1.9	4.0			
Indirect Labor Costs	5.6	109.3			
Other (Specify)					
General and Administrative (%)					
TOTAL OPERATING COST	15.0	255.0			
CAPITAL EQUIPMENT FIN CHARGED					
TOTAL PROJECT COST	15.0	255.0			

MONTHLY FORECAST EXPENSE — 1985

OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH
21	21	21	21	21	21
APRIL	**MAY**	**JUNE**	**JULY**	**AUGUST**	**SEPTEMBER**
21	21	21	21	21	24

NRC FORM 189
(2-81)

U.S. NUCLEAR REGULATORY COMMISSION

FIN NUMBER

DATE

PROJECT AND BUDGET PROPOSAL FOR NRC WORK

PROJECT TITLE

DOE PROPOSING ORGANIZATION

FORECAST MILESTONE CHART Schedule to Start - △ - Complete (Shown in Quarter) and,
PROVIDE ESTIMATED DOLLAR COST FOR EACH TASK FOR EACH FISCAL YEAR

TASK		FY 1984				FY 1985				FY				FY				FY			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1. Familiarization with nonpower reactors	SCHEDULE					△															
	COST	15 k				10 k															
2. Calculations of maximum and limiting Radiological Consequences	SCHEDULE					△															
	COST					75 k															
3. Calculation of Explosive or Incendiary devices required for maximum and limiting release	SCHEDULE						△														
	COST					75 k															
4. Calculations of explosives for Part 20 and 100 releases	SCHEDULE						△														
	COST					15 k															
5. Effect of unauthorized control manipulation	SCHEDULE							△													
	COST					35 k															
6. Effect of mitigating systems	SCHEDULE							△													
	COST					35 k															
7. Program Plan for FY 1986	SCHEDULE							△													
	COST					10 k															
	SCHEDULE																				
	COST																				
	SCHEDULE																				
	COST																				
	SCHEDULE																				
	COST																				
TOTAL ESTIMATED PROJECT COST		15 k				255 k															

APPROVAL AUTHORITY-SIGNATURE

John R. Hulcal

DATE

10/2/84

1. Objective of Proposed Work

a. Background

In 1979, the Los Alamos Scientific Laboratory conducted a study of the consequences of sabotage of nonpower reactors (NPRs). It was concluded that, within the constraints of this study, only one NPR had any potential for the release of significant amounts of fission product materials in the event of sabotage. Because of terrorist activities in other parts of the world, concerns of the ACRS about manipulation of reactor control systems, and concerns of a public interest group about the effects of incendiary devices on reactor components, this information should be supplemented with further technical information.

b. Objective

The objective of this work is to provide the NRC with technical information on the effects of malicious manipulation of reactor controls and of the use of incendiary devices on NPRs to assure a margin of public safety.

2. Summary of Prior Efforts

None

3. Work to be Performed and Expected Results

During the period from FY 1984 to 1986 Los Alamos will perform the following tasks.

a. Work Required

Task No. 1

Existing information in available sources, such as the NRC docket files, augmented by site-specific information provided by NRC staff and site visits should be reviewed to (a) familiarize task personnel

with characteristics peculiar to each reactor and (b) obtain information necessary to aid in the calculation of the radiological consequences for three of the NPRs listed in Table I.

Within 1 month after initiation of task orders, Los Alamos shall provide a detailed work plan that identifies study milestones and their projected dates of accomplishment. Upon NRC review and approval of this plan, it will become the operating schedule for the overall task. The work plan is Appendix A to this proposal.

Task No. 2

Mathematical models or other appropriate methods will be developed and/or used to perform the following.

a. Calculate the radiological release resulting from a total core meltdown, partial core meltdown, core disintegration and/or crushing, or other means that could damage severely the fuel in the reactor core. Because the key consideration is the fission product release associated with such incidents, the effects of using low-enriched uranium vs high-enriched uranium on the fission product release will be evaluated,

TABLE I

LIST OF REACTORS

Licensee	Docket No.	Power Level	Reactor Type
National Bureau of Standards	50-184	20 MW	Tank
University of Missouri	50-186	10 MW	Tank
Georgia Institute of Technology	50-160	5 MW	Tank
Massachusetts Institute of Technology	50-20	5 MW	Tank
Union Carbide	50-54	5 MW	Pool
Rhode Island Atomic Energy Commission	50-193	2 MW	Pool
State University of New York	50-57	2 MW	Pool
University of Michigan	50-2	2 MW	Pool
University of Virginia	50-62	2 MW	Pool

b. Determine, as a function of distance from the reactor, the total radiation dose (rem) to the whole body and the radiation dose (rem) to the thyroid from iodine exposure and identify any facility for which these could exceed 10 CFR 20 and 10 CFR 100 standards

c. Determine the characteristics of the event that would limit it to less than Parts 20 and 100 standards.

Certain other parameters and assumptions should be considered when performing this task. These include and are limited to the following except as may be approved by the NMSS Project Manager (PM) in the future.

a. The models or methods used to calculate the damage and the release shall assume that the reactor has been operating at the maximum power level authorized by the NRC license and that equilibrium of fission products was attained before the incident. This also will be evaluated if significant damage to the core or subsequent release is calculated to occur after a period of reactor shutdown.

b. The study for facility shall be terminated and the basis for the conclusion documented in those cases in which the fission product inventory of the NPR is determined to be insufficient to create a risk to the public health and safety or those in which the fuel configuration or composition and/or the reactor construction or other factors is such as to limit the fuel damage and fission product release to a level that is insufficient to create a risk to the public health and safety.

c. No assumptions are made regarding the saboteurs' capabilities nor is any design-basis threat associated with this task.

d. For base-line considerations, it should be assumed that all reactor safety features fail upon initiation of the incident.

e. The mean meteorological conditions at the site and the surrounding area should be considered when calculating the atmospheric dispersion of a release.

Task No. 3

After Tasks 1 and 2 have been accomplished, mathematical models or other appropriate methods will be developed to calculate the amount of explosives and the amount of incendiary material needed to cause

the placement of explosives and incendiary devices at the reactor facility boundary and attached to reactor components.

Certain parameters and assumptions should be considered in those calculations. These include, and are limited to, the following except as may be approved by the NMSS project monitor (PM) in the future.

a. The type of explosives and incendiary devices used to cause an event are assumed to be easily obtainable.
b. Two opposing conditions will be considered in performing Task 3.
    1. Safeguards credit will be given for all physical barriers interposed between the explosives/incendiaries and the reactor fuel.
    2. The adversary will have access to all reactor components in carrying out the sabotage event.

Task No. 4

Upon completion of Task No. 3, for those cases in which the fission product release and estimated doses exceed 10 CFR 20 and 10 CFR 100 standards, calculate the amount of explosives and the amount of incendiary material needed to cause the release. The calculations shall be made for placement of explosives and incendiary devices attached to reactor components and outside the structure containing the reactor. The parameters and assumptions employed in Task No. 3 will be used in this task.

Task No. 5

Upon completion of Task No. 3, reactor control systems and fuels shall be reviewed and evaluated to determine whether an unauthorized manipulation of such controls could cause any detrimental effects that may be identified in Task No. 2. Only credible scenarios and analytical assumptions shall be used, and these shall be reviewed and approved by the NMSS PM before the analyses are made.

Task No. 6

Upon completion of Task No. 3, calculate the mitigating effects of full and partial operation of existing safety features associated with the operation of the reactor. (These features are ignored in Task 3 to

determine maximum consequences.) Identify additional safety measures and modifications as well as administrative procedures and practices that could be adopted and determine the degree to which these additional considerations would mitigate the consequences. Exclude specific safeguards measures from consideration in this task.

Task 7: Program Plan and Schedule for the Remaining Reactors

A detailed plan for applying the tools developed in Tasks 2 through 6 to the remaining five reactors in Table I will be formulated. This plan will attempt completion at the remaining reactors in as short a time as possible during FY 1986. This plan will be submitted to NRC for approval.

b. Meetings and Travel

Site visits for two analysts to the three reactors will be required. Three meetings with NRC sponsors in Washington, DC, for two people also will be required in FY 1985.

c. NRC Furnished Materials

NRC will furnish only reactor documentation that cannot be obtained by Los Alamos.

4. Description of Follow-On Efforts

Upon completion of the analysis in Tasks 1 through 6 a program plan and cost estimate for completion of the remaining five reactors in Table I will be submitted to NRC for the follow-on efforts.

5. Relationship to Other Projects

None

6. Reporting Schedule

Monthly letter status reports and a final report will be provided. All reports will be submitted to the NRC technical monitor. A distribution

list for the final report should be provided by the NRC technical monitor. For any reports that will not be submitted according to the contract schedule, a written reason for the delay will be submitted to the technical monitor by the original scheduled date.

a. Monthly Letter Status Report

Los Alamos will submit a letter status report each month that summarizes the work performed during the previous month, personnel time expenditures during the previous month, and costs generated against the work effort. Any changes to cost projections or schedules will be indicated. The letter report will arrive at the NRC by the 20th of each month. In all monthly reports there will be a breakdown of (1) manpower costs; (2) costs incurred for direct salaries, material and services, ADP support, subcontracts, travel, general, and administrative and other related items; and (3) current obligation status information for the project.

The report shall be distributed as follows.

Donald M. Carlson, SG, NMSS - one copy

Office of the Director, NMSS (Attn: Program Support) - one copy

b. Inter m Reports

A draft interim report shall be furnished to the NMSS PM upon completion of each major task (that is, Tasks No. 2, 3, 4, and 5). After review by appropriate NRC personnel, the PM will provide comments or the draft report to Los Alamos National Laboratory within 60 days of receipt of each report. A revised interim report shall be submitted if deemed necessary by the NMSS PM.

c. Final Report

Los Alamos shall furnish two copies of a draft final report to the NMSS PM by June 30, 1986. The format of these documents shall be as specified for formal technical reports in NRC Manual Chapter 1102 and will provide

1. the on-site and off-site fission product release and dosage calculations associated with a total loss of coolant,
2. the quantities of explosives and incendiary material or a description of acts necessary to cause a limiting case incident,
3. the placement of explosives and incendiary materials in relation to the reactor,
4. a description of unauthorized manipulation of reactor controls and fuel to cause a limiting case incident,
5. the resulting consequences, and
6. appropriate alternative measures that can be implemented to mitigate a significant event (for example, reactor facility modifications, administrative procedures, and so on).

After review by appropriate NRC personnel, the PM will provide comments on the draft report to Los Alamos within 60 days of receipt of the report.

The performing organization shall revise the draft report based on the PM's comments and submit one camera-ready copy of the final report to the Document Management Branch, Technical Information and Document Control, NRC, to be published as a NUREG/CR series report, and a duplicate to the NMSS PM.

All draft reports, as well as final reports, shall be screened for Classified Information and appropriately marked in accordance with "NRC Classification Guide for Information Dealing with the Release and Dispersion of Radioactive Material (NRC-RDRM-1)," dated September 1982, and NRC Manual Chapter 1102.

7. Subcontractor Information

None

8. New Capital Equipment Required

None

9. Special Facilities Required

None

10. Conflict of Interest Information

None

APPENDIX A
WORK PLAN

I. INTRODUCTION

Because of the developmental nature of this study, Los Alamos will approach this work in two phases. The first phase, to be completed in FY 1985, will develop the methodology and apply it to three reactors, which hereafter are referred to as lead reactors (LRs). After this phase of work, a detailed plan for completing the remaining five reactors will be formulated based on the data gained in the LR phase.

In the LR phase (FY 1985), three representative nonpower reactors (NPRs) will be fully analyzed by October 1, 1985. These reactors are the NBS reactor, the largest NPR representing tank reactors; the University of Missouri reactor, the largest enclosed pool reactor; and the Union Carbide reactor, the largest open pool type reactor. Based on the results of these three calculations, a better estimate of the time and cost required to perform the remaining calculations can be made for FY 1986.

II. TASK BREAKDOWN FOR LEAD REACTOR PHASE (FY 1985)

Task 1. Collection of Information and Familiarization With It

This task will be initiated immediately and will continue as required to gain a familiarity with the three LRs. Information available at Los Alamos will be supplemented by docket information from NRC and with site visits when sufficient familiarity is gained to make the visit meaningful.

Task 2. Calculation of Maximum Radiological Release

a. Develop core inventory analyses and apply them to the three LRs for an operating history of the maximum authorized power level long enough to achieve equilibrium fission product levels. Both high- and low-enrichment fuels will be considered.

b. Use a Master Logic Diagram (MLD) to identify potential physical modes of core disruption or other radionuclide sources for each LR.

c. The maximum extent of core damage for each mode identified in the previous step and the fission product release associated with this damage will be determined using available methods. If no methods exist for a given requirement, an approximate and conservative analytical tool will be developed based on the best current knowledge.

d. The effects of physical decontamination factors on the radionuclide transport will be calculated using currently accepted methods and site-specific information for each LR.

e. The whole body radiation dose and thyroid dose from iodine will be calculated in rem using currently accepted methods for the potential releases identified for each LR. Mean meteorological conditions at each LR will be assumed.

f. This study will be terminated for those sites with no identified sequence leading to at least a 10 CFR Part 20 release.

g. For those LRs that have sequences exceeding 10 CFR 20 or 10 CFR 100 releases, the extent of core damage leading to these releases will be calculated by scaling of results from previous calculations in Task 2.d.

h. All results from the foregoing calculations will be documented and submitted to NRC as an interim technical report.

Task 3. Determination of Sources of Damage

a. For each damage mode capable of resulting in at least a 10 CFR Part 20 or 100 release, the credible sources of such damage (for example, explosives or incediary devices) will be identified.

b. Using explosive yield, structural response, and other analyses, the amount and placement of damage sources resulting in the maximum release will be determined assuming no mitigating system functions and assuming that the adversary has direct access to all reactor components.

c. The calculations of Task 3 will be repeated allowing safeguards credit for any physical barriers blocking direct access to the reactor fuel.

d. The results of this task will be reported in an interim report to the NRC.

Task 4. Scaling of Damage Sources to 10 CFR 20 and 10 CFR 100

a. The results of Task 3 will be scaled to determine the damage sources leading to 10 CFR 20 and 10 CFR 100 releases.

b. The results of this task will be reported along with Task 3 in an interim report to the NRC.

Task 5. Determination of Misoperation Scenerios

a. Using LR system descriptions, damage modes from Task 2, and damage sources from Task 3, a system logic model (fault-tree) approach will be used to determine sabotage scenarios resulting from unauthorized operation of reactor controls, systems, or fuels.

b. The results of this task will be documented in an interim report for the NRC.

Task 6. Mitigating Systems Effects

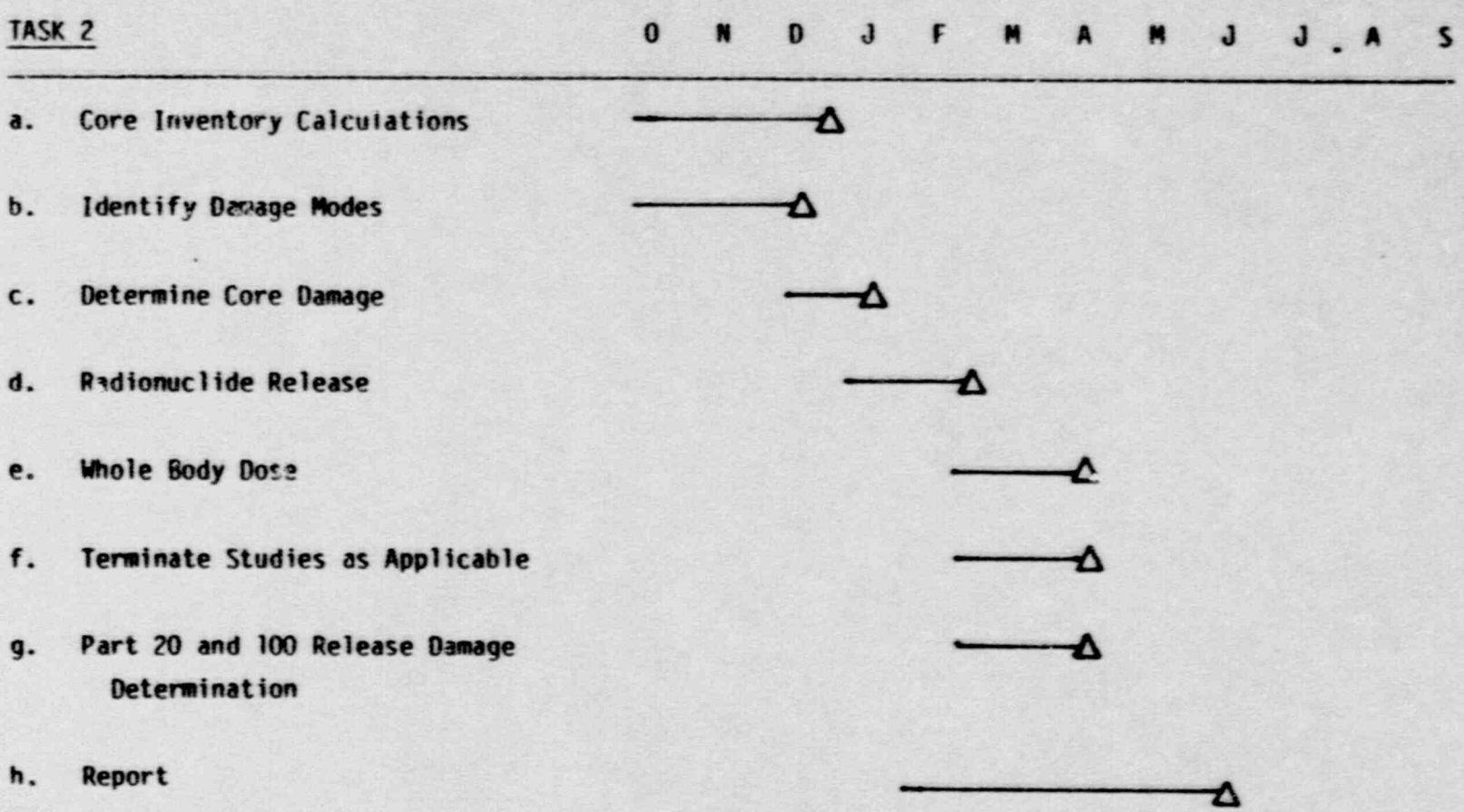
a. Using the sabotage scenarios developed in Task 5, the effect of mitigating systems on radionuclide release will be included using system logic models (fault trees) to determine the effects of both full and partial operation of mitigating systems.

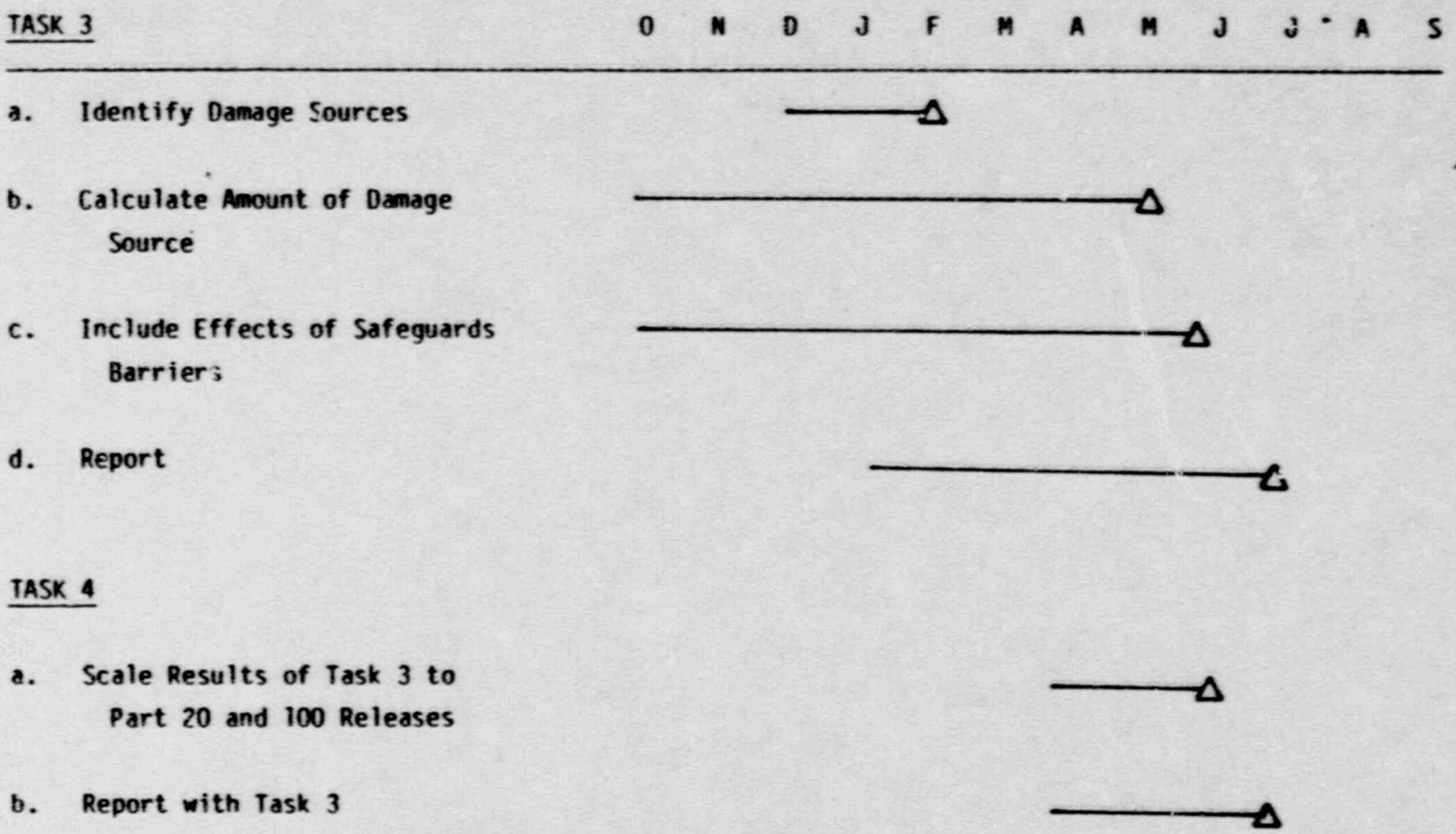
b. Using the insights of Task 6.a, above, identify additional or modified safety features or administrative practices that could be adopted.

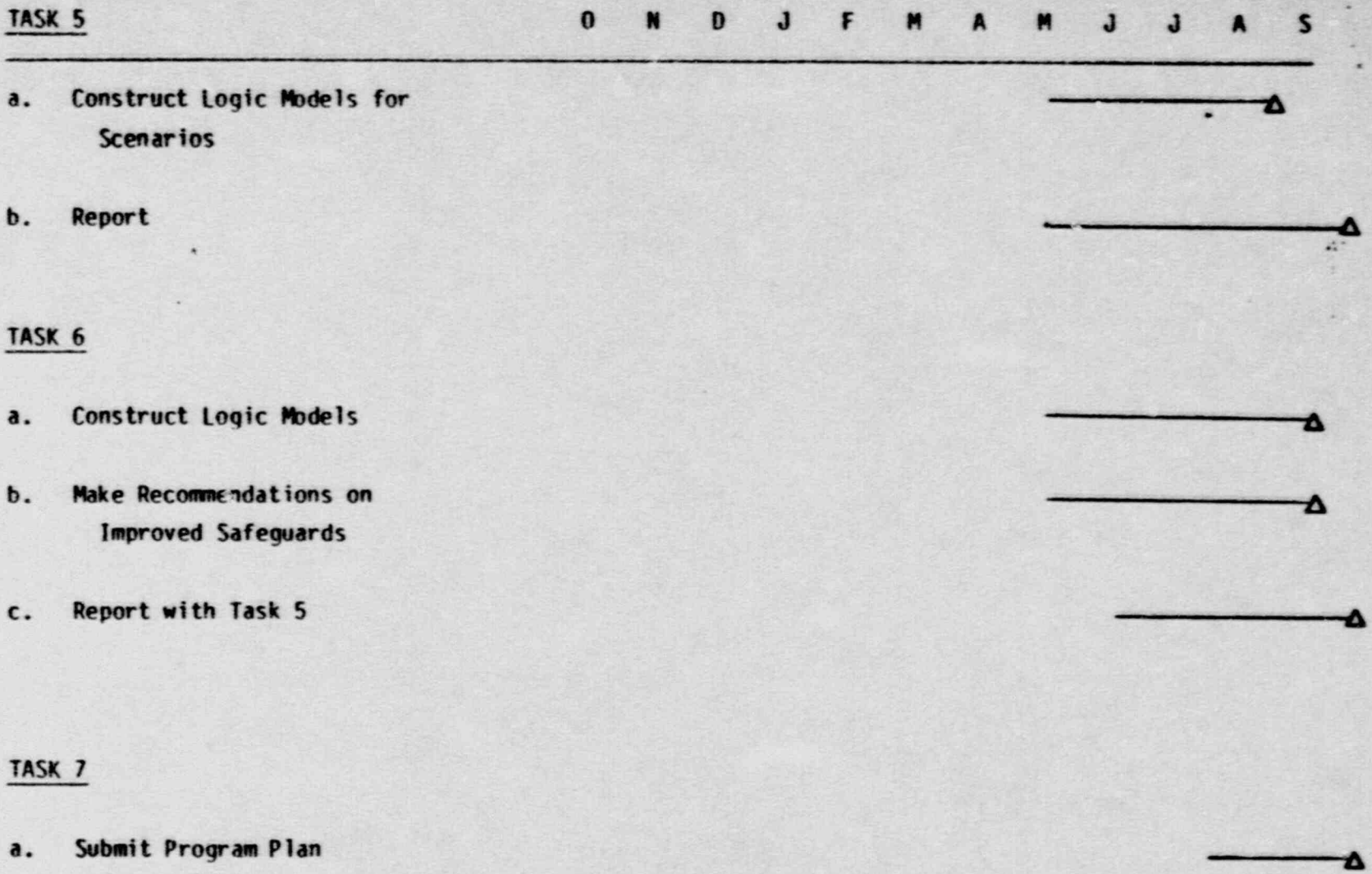
C. The results of this task will be documented in an interim report for the NRC.

Task 7. Program Plan for FY 1986

Upon the conclusion of the LR analyses, a detailed plan for completing the remaining five nonpower reactors in FY 1986 will be formulated and submitted to the NRC.


TASK 2
O N D J F M A M J J A S
a. Core Inventory Calculations
b. Identify Damage Modes
c. Determine Core Damage
d. Radionuclide Release
e. Whole Body Dose
f. Terminate Studies as Applicable
g. Part 20 and 100 Release Damage Determination
h. Report


TASK 3
O N D J F M A M J J A S
a. Identify Damage Sources
b. Calculate Amount of Damage Source
c. Include Effects of Safeguards Barriers
d. Report
TASK 4
a. Scale Results of Task 3 to Part 20 and 100 Releases
b. Report with Task 3


TASK 5
O N D J F M A M J J A S
a. Construct Logic Models for Scenarios
b. Report
TASK 6
a. Construct Logic Models
b. Make Recommendations on Improved Safeguards
c. Report with Task 5
TASK 7
a. Submit Program Plan for FY 1986