EVALUATION OF THE

DUANE ARNOLD NUCLEAR STATION

to demonstrate conformance to the

DESIGN OBJECTIVES OF 10 CFR 50
APPENDIX I

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1.0 SUMMARY

In compliance with Appendix I to 10 CFR 50 a cost-benefit analysis has been performed on the liquid and gaseous radwaste systems at the Duane Arnold Energy Center. The analysis of the liquid systems is contained in Section 2; that for the gas systems in Section 3.

For the liquid systems it has been shown that:

1) The Base Case equipment (that originally installed) results in releases which meet all of the requirements of Paragraph II A of Appendix I.

2) Not only are there no additional augments of reasonably demonstrated technology which could be added to the system with a favorable cost-benefit ratio, but there are some components already installed which are not cost-beneficial.

3) A truly cost-beneficial configuration fails to provide releases low enough to permit meeting all of the requirements of Paragraph II A of Appendix I.

4) The Compliance Case (see Figure 2-3), which represents the configuration now being used at the plant, meets all the requirements of Paragraph II A of Appendix I.

Similarly for the gaseous system it has been shown that:

1) The Base Case equipment (that presently installed) results in releases which meet all of the requirements of Paragraphs II B & C of Appendix I. This Base Case is used to demonstrate compliance with Appendix I.

2) Not only are there no additional augments of reasonably demonstrated technology which could be added to the system with a favorable cost-benefit ratio, but there are some components already installed which are not cost-beneficial.

3) A truly cost-beneficial configuration fails but just barely to provide releases low enough to permit meeting all of the requirements of Paragraphs II B & C of Appendix I.

Since it has been demonstrated that for both the liquid and gaseous radwaste systems of DAEC:

1) the individual dose requirements of Appendix I are met;
2) there are no additional augments of reasonably demonstrated technology which could be added to the systems to provide additional population dose reductions at costs less than \$1,000/man-rem;

therefore the design of the radwaste systems at Duane Arnold meets the As Low As Reasonably Achievable (ALARA) requirements of Appendix I to 10 CFR Part 50.

measure and until establishment and adoption of better values (or other appropriate criteria), the values $1000 per total body man-rem and $1000 per man-thyroid-rem (or such lesser values as may be demonstrated to be suitable in a particular case) shall be used in this cost-benefit analysis."

This Section 2.0 and the subsequent Section 3.0 are provided to show whether Duane Arnold does indeed meet the requirements of Paragraphs II A, B, and C of Appendix I as well as those of Paragraph II D, that is, to show that there are no augments of (reasonably demonstrated technology) which can be added to the system and result in a favorable cost-benefit ratio.

In carrying out the calculations described herein use has been made, to the greatest extent possible, of the Regulatory Guides which the NRC Staff has issued to provide guidance in the implementation of Appendix I. Except where specifically noted the equations, methods, and suggested parameters of these guides have been used throughout. Specifically the Regulatory Guides which were used in the development of this section (and Section 3.0) are:

1.109 Calculation of Annual Average Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Implementing Appendix I
Issue Date: March, 1976

1.CC Calculation of Releases of Radioactive Materials in Liquid and Gaseous Effluents from BWR
Issue Date: Reissued as Reg Guide 1.112 in April, 1976

1.110 Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors
Issue Date: March, 1976

1.111 Methods of Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Reactors
Issue Date: March, 1976.

2.0 LIQUID RADWASTE SYSTEMS

2.1 Introduction

On April 30, 1975 the Nuclear Regulatory Commission issued its Final Opinion in the matter of the Rule Making Hearings (RM-50-2) on "numerical Guides for Design Objectives and limiting Conditions for Operation to meet the Criterion 'As Low As Practicable' for Radioactive material in Light-Water-Cooled Nuclear Power Reactor Effluents." This opinion provides in part that:

"The Applicant shall provide reasonable assurance that the following design objectives will be met.

II A. "The calculated annual total quantity of all radioactive material above background[1] to be released from each light-water-cooled nuclear power reactor to unrestricted areas will not result in an estimated annual dose or dose commitment from liquid effluents for any individual in an unrestricted area from all pathways of exposure in excess of 3 millirems to the total body or 10 millirems to any organ.

B. 1. "The calculated annual total quantity of all radioactive material above background to be released from each light-water-cooled nuclear power reactor to the atmosphere will not result in an estimated annual air dose from gaseous effluents at any location near ground level which could be occupied by individuals in unrestricted areas in excess of 10 millirads for gamma radiation or 20 millirads for beta radiation.

2. "Notwithstanding the guidance of paragraph B.1:

(a) The Commission may specify, as guidance on design objectives, a lower quantity of radioactive material above background to be released to the atmosphere if it appears that the use of the

[1] Here and elsewhere in the Appendix background means radioactive materials in the environment and in the effluents from light-water-cooled power reactors not generated in, or attributable to, the reactors of which specific account is required in determining design objectives.

design objectives in paragraph B.1 is likely to result in an estimated annual external dose from gaseous effluents to any individual in an unrestricted area in excess of 5 millirems to the total body; and

(b) "Design objectives based upon a higher quantity of radioactive material above background to be released to the atmosphere than the quantity specified in paragraph B.1 will be deemed to meet the requirements for keeping levels of radioactive material in gaseous effluents as low as practicable if the applicant provides reasonable assurance that the proposed higher quantity will not result in an estimated annual external dose from gaseous effluents to any individual in unrestricted areas in excess of 5 millirems to the total body or 15 millirems to the skin.

C. "The calculated annual total quantity of all radioactive iodine and radioactive material in particulate form above background to be released from each light-water-cooled nuclear power reactor in effluents to the atmosphere will not result in an estimated annual dose or dose commitment from such radioactive iodine and radioactive material in particulate form for any individual in an unrestricted area from all pathways of exposure in excess of 15 millirems to any organ.

D. "In addition to the provisions of paragraphs A, B, and C above, the applicant shall include in the radwaste system all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, can for a favorable cost-benefit ratio effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor. As an interim

2.2 Description of Base Case Equipment

The waste systems which have been used at Duane Arnold have been described in some detail in the Safety Analysis Report and in the Final Environmental Statement. For an orderly presentation of this discussion, however, a brief and simplified description of the waste treatment systems which have been used for handling the liquid wastes from Duane Arnold is included herein.

Liquid wastes from any BWR come from a variety of sources which have a considerable disparity in chemical and radio-chemical composition and concentration. Normally these wastes are collected and treated separately. The liquid wastes fall into the following categories:

1) High Purity
2) Low Purity
3) Chemical
4) Detergent.

High-purity wastes generally have low solids content, low conductivity, and variable radioactivity. They come from equipment drain sumps and from the backwash and resin transfer water used to change out the condensate demineralizers. Liquid wastes collected in the turbine building equipment drains may sometimes be included with the high-purity waste stream; more frequently they are returned directly to the main condenser hotwell. Reuse of processed high-purity waste is highly desirable.

Low-purity wastes have moderate conductivity and solids content. They come from building floor sumps and are generally high-purity wastes which have become contaminated by dirt, grease, etc. When processed this stream may or may not be reused depending on the water balance in the plant and the quality of the product.

The chemical wastes, which come from laboratory drains, contain higher solids, and relatively higher radioactivity, should be segregated from the other waste streams, although they have sometimes been combined with the low-purity wastes for treatment. If treated separately it is likely that the product would be discarded rather than reused.

Detergent wastes come from the laundry (if provided) and from personnel and equipment decontamination. They are very low in radioactivity content and the detergent content makes their processing difficult.

The liquid radwaste system installed at Duane Arnold is shown in a very simplified schematic way in Figure 2-1. The High Purity (low conductivity) waste is collected in a 10,000-gal Waste Collection Tank. This waste receives one stage of mixed bed ion exchange and it is reused to the greatest extent possible, normally more than 99%.

The Low Purity (high conductivity) waste is collected in another 10,000-gal Collection Tank. This waste is also purified by one stage of ion exchange. It too is reused to the greatest extent possible.

The chemical waste is collected in a 4000-gal tank and has been evaporated in a 2-gpm evaporator. The evaporator has been giving trouble so as one of the alternates (see Section 2.3) the effect of treating this waste by ion exchange is shown.

There is no on-site laundry.

2.3 Description of Alternative Systems Considered

In order to carry out the sequential cost-benefit analysis required by paragraph II D of Appendix I, it is necessary to consider additions (or subtractions) to the Base Case systems. The liquid treatment alternates which were considered in this study are listed in Table 2-1.

2.4 Source Terms

The liquid emission source terms for the Base Case, and for all of the alternatives considered were calculated using the BWR-GALE code and the parameters outlined in Reg Guide 1.CC. The detailed inputs for each of these cases and the resulting source term outputs are described in this section.

2.4.1 Basic Inputs to GALE Code

There are certain fundamental input terms which describe the subject reactor, which are common to all cases, and which are specific to the particular reactor. These common input terms for Duane Arnold are given in Table 2-2.

2.4.2 Base Case Input Terms and Resulting Releases

The input terms required to describe the Base Case liquid radwaste treatments (outlined in Section 2.2) are shown in Table 2-3. The resulting liquid releases by isotope are shown in Table 2-4.

2.4.3 Inputs of Alternative Cases and Resulting Releases

Similarly the input terms required to describe each alternate case are shown in Table 2-5. For the alternates the resulting source terms represent the differences between the Base Case release and the release of the alternate. Thus in the case of an additional augment, the difference will be positive, representing a reduction in release. In the case of the elimination of an augment, the difference will be negative, representing an increase in release. These differences for the alternate cases described in Table 2-1 are shown in Table 2-6.

2.4.4 Inputs for Cost-Beneficial Case

The indicated cost-beneficial equipment for the various waste systems is shown in Paragraph 2.9.2. Since the cost-beneficial case involves the removal of some equipment pieces which were included in the base case, it is necessary to run the individual doses for the cost-beneficial case to determine whether or not the cost-beneficial case is able to meet the requirements of Paragraph II A of Appendix I. The cost-beneficial case is shown on Figure 2-2. The GALE inputs for this cost-beneficial case are shown in Table 2-7 and the resulting liquid releases are shown in Table 2-8.

2.4.5 Compliance Case

As indicated in Section 2.9.3 it was necessary to set up a Compliance Case which is intermediate between the Base Case and the Cost-Beneficial Case. The GALE inputs for this case are shown in Table 2-9 and the resulting liquid releases in Table 2-10. This Compliance Case represents the configuration which is actually being used at Duane Arnold today. The calculations were made as though the chemical waste were a separate stream. It actually is combined with the Low Purity Waste for treatment.

2.5 Environmental Inputs

In order to convert the releases described in Section 2.4 into either individual or population doses it is necessary to develop a considerable amount of information which describes the pathways at and near the site by which radioactivity released in liquid effluents might make its way back to individuals. In this section there are described the parameters which were used in making dose calculations to individuals and to populations. Extensive use has been made of the parameters outlined in Reg Guide 1.109, but these have been supplemented, particularly in the case of population doses, with site specific information. In the calculation of population doses considerable reliance has been placed on the selection of clearly conservative assumptions.

2.5.1 Characteristics of Individuals and Populations

In the calculation of doses to individuals and populations exposed to liquid discharges from Duane Arnold, the usage factors given in Reg Guide 1.109 have been assumed. These usage factor values are given in Table 2-11.

2.5.2 Mixing Ratios

For all calculations, the mixing ratios used to determine concentrations of isotopes at the point of exposure have been conservatively estimated. For calculations of doses to individuals, the mixing ratio was assumed to be 0.2 (at edge of initial mixing zone) for all pathways except potable water, for which a mixing ratio of 0.1 was used.

For all population dose pathways the 4000 gpm cooling tower blowdown was assumed to be fully mixed with the average flow of the Cedar River (3065 cfs) giving a mixing ratio of 0.003.

2.5.3 Water Use

The major downstream water use of the Cedar River is at the City of Cedar Rapids 8 miles from the site. The City does not, except under most unusual circumstances, take river water directly for domestic use. The Cedar Rapids water supply comes from shallow wells near the river. It was assumed that one half the recharge water for these wells comes from the river. No credit was taken for removal of radionuclides by the soil between the river and the well. Neither was credit taken for removal of radioactivity by the water treatment plant. Thus the resulting calculated population dose is quite conservative. The total 1980 population at risk was taken as 150,000, something in excess of the City's population, to allow for other minor uses along the banks of the river and for the export outside the City of soft drinks from a bottling plant in Cedar Rapids.

2.5.4 Recreation

The very conservative assumption was made that twice the population of Cedar Rapids, 200,000 people, spent RG 1.109 hours along, on, and in the Cedar River.

2.5.5 Aquatic Foods

The Cedar River is not productive of Aquatic foods. There are no shellfish to speak of and only about 7,500 lb/year (3,500 kg/year) of fish are taken.

2.5.6 Other Pathways

No other pathways which would be likely to produce 10% of the dose calculated by those pathways described above were identified for the liquid discharges for Duane Arnold.

2.6 Individual Doses

Individual doses for the various Cases described in Section 2.4 are discussed in this Section.

2.6.1 With Base Case

The liquid releases described in Paragraph 2.4.2 were combined with the parameters outlined in Paragraph 2.5.1 and the individual doses were calculated using the methods outlined in RG 1.109. These results are summarized in Table 2-12. It can be seen that these meet the requirements of Paragraph II A of Appendix I.

2.6.2 With Cost-Beneficial Case

The liquid releases described in Paragraph 2.4.4 were treated in a similar manner and the results are summarized in Table 2-13. It can be seen that the doses which result from the Cost-Beneficial Base Case liquid releases do not meet the requirements of Paragraph II A of Appendix I.

2.6.3 With Compliance Case

The liquid releases described in Paragraph 2.4.5 were also treated in a similar manner and the results are summarized in Table 2-14. It can be seen that the doses which result from the Compliance Case liquid releases meet all the requirements of Paragraph II A of Appendix I.

2.7 Population Doses

Five liquid pathways have been evaluated in determining population doses from liquid discharges. They are:

a) consumption of potable water
b) consumption of fresh water fish;
c) exposure from shoreline residues;
d) swimming;
e) boating.

The second of these is dependent not on population but rather on the fish catches outlined in Paragraph 2.5.5. The first and the last three are dependent on water use and recreational pressure as outlined in Paragraphs 2.5.3 & 2.5.4. Population doses have been evaluated for the Base Case described in Section 2.2 and the change in population dose for each of the alternatives described in Section 2.3 have also been calculated.

2.7.1 Base Case

The population doses resulting from the liquid releases from the Base Case described in Section 2.2 and Paragraph 2.4.2 are shown in Table 2-15. It is clear from the very small total shown in that table that the Base Case treatments have undoubtedly already gone beyond the point of cost-effectiveness. This point will be examined in more detail in section 2.9.

2.7.2 Change in Population Doses for Alternates Considered

Although there appears to be an almost a priori case that the liquid augments already added to Duane Arnold have gone beyond the point of cost effectiveness, to prove the point conclusively and to respond fully to the requirements of Paragraph II D of Appendix I requires that a series of augments (or subments) be hypothetically applied to the Base Case and a cost-benefit analysis be performed on these changes. To this end the alternates described in Section 2.3 were developed, the changes in the liquid releases were determined (see Paragraph 2.4.3), and the changes in population dose resulting therefrom were calculated. The results of these calculations are shown in Table 2-16.

2.7.3 Compliance Case

The population doses resulting from the liquid releases from the Compliance Case (See Paragraphs 2.4.5 and 2.9.3) are shown in Table 2-17.

2.8 Cost Changes Associated with Alternates

2.8.1 Methodology

For each of the alternate cases listed in Table 2-1 estimates have been made of the capital and operating costs associated with the described change. The capital costs have been annualized and added to the annual operating costs to arrive at a total annual cost. For additional augments the resulting costs are additional costs to be compared to the savings in environmental cost which result from population dose reductions. For the instances in which an equipment sequence is removed (either actually or hypothetically), the resulting costs are cost savings to be compared to increases in environmental cost which result from environmental dose increases. In either case the test is whether or not the quotient of

$$\frac{\text{annual cost in dollars}}{\text{annual change in dose in man-rem}}$$

in greater than $1000.

To the greatest extent possible the cost estimates used herein are based on Regulatory Guide 1.110. Only where necessary (and where indicated) have other sources of cost data and other methods of cost estimating been used.

2.8.2 Cost of Alternates

The resulting cost increases (or savings) for the alternate cases listed in Table 2-1 are shown in Table 2-18. A detailed backup for these values is given in Appendix A. This appendix also includes the backup for gaseous alternates (see paragraph 3.8.2).

2.9 Cost-Benefit Ratios

By combining the costs associated with the various alternates considered (given in Section 2.8) with the changes in population doses (given in Section 2.7) one obtains the cost per man-rem change in dose for each.

2.9.1 Alternate Cases

The cost-benefit ratios for the alternate cases listed in Table 2-1 are shown in Table 2-19. It can be seen that there is no additional augment which is justified by cost-benefit and, indeed, some of the equipment pieces which have been included in the design are not cost-beneficial.

2.9.2 Indicated Cost-Beneficial Configuration

Base solely on the criterion of cost-benefit the liquid radwaste systems for Duane Arnold should have been those indicated in Table 2-20. This cost beneficial system is shown schematically on Figure 2-2. Cost-beneficiality is a necessary condition for selection of radwaste equipment, but lack of same is not a sufficient condition for the removal of equipment. It must also be shown that, were the non-beneficial equipment removed, the resulting individual doses would still meet the requirements of Paragraph II A of Appendix I. To make this determination a new set of GALE inputs and resulting liquid releases were prepared (See Paragraph 2.4.4).

2.9.3 Compliance Case

As indicated in Paragraph 2.6.2 the Cost-Beneficial Case fails to meet the requirements of Paragraph II A of Appendix I. Therefore the configuration outlined in Figure 2-3 was established as the case by which compliance with Appendix I is shown. This configuration also happens to be that which is prevently in use at Duane Arnold.

2.10 Appendix I Compliance

For the Compliance Case equipment, discussed in sections 2.4.5 and Figure 2-3 it has been shown herein that:

1) the individual dose requirements of Paragraph II A of Appendix I are met;
2) there are no additional augments of reasonably demonstrated technology which could be added to the systems to provide additional population dose reductions at costs less than $1,000/man-rem.

Therefore, the design of the liquid radwaste system at Duane Arnold meets the As Low As Reasonably Achievable (ALARA) requirements of Appendix I to 10 CFR Part 50.

3.0 Gaseous Radwaste Systems

3.1 Introduction

The requirements of Appendix I to 10 CFR Part 50 were outlined in Section 2.1; likewise the Regulatory Guides which were used to make the necessary calculations were described. These comments, which were directed toward the liquid radwaste systems, apply equally to the gaseous systems.

3.2 Description of Base Case Equipment

The waste systems used at Duane Arnold have been described in some detail in the Safety Analysis Report and in the Final Environmental Statement. For an orderly presentation of this discussion, however, a brief and simplified description of the base case waste treatment systems used for handling the gaseous wastes from Duane Arnold is included herein.

The major gaseous waste stream from BWR as they were originally designed, as Duane Arnold was, is the exhaust from the steam jet air ejector which removes non-condensibles from the condenser. It was this stream, which discharged up to 0.1 curie/sec of noble gas activity, which led to the pressure to reduce emissions from light water reactors and resulted in the promulgation by the then AEC of proposed changes to 10 CFR Part 50 (Appendix I) the effect of which is to limit total body doses from LWR to individuals in unrestricted areas to about 5 mrem/year. All BWR today are being designed to provide considerably further treatment for this air ejector off-gas.

At Duane Arnold the air ejector off gas is now put through a catalytic recombiner (to convert the contained hydrogen to water), condenser, drier, and then through massive beds of charcoal which serve to hold up the noble gases, krypton and xenon, for periods of from hours to days allowing all of the shorter lived noble gases to decay prior to release to the atmosphere. This also effectively removes the iodine isotopes from this stream.

In addition to releases of radioactivity from the condenser off gas all BWR can be expected to experience small releases from the following sources:

1) with the discharge from the turbine gland seal system,
2) from leaks of steam or water into the reactor building ventilation system,
3) from leaks of liquid and particularly of steam into the turbine building ventilation system,
4) from leakage into the radwaste building ventilation system, and
5) with the discharge of the mechanical vacuum pump system which is used for the removal of non-condensibles from the main condenser during startups before steam is available with which to operate the steam jet air ejector.

The systems used for handling gaseous waste at Duane Arnold are shown schematically in Figure 3-1. This system is the Base Case used for this cost-benefit analysis.

3.3 Description of Alternative Systems Considered

In order to carry out the sequential cost-benefit analysis required by paragraph II D of Appendix I, it is necessary to consider additions (or subtractions) to the Base Case systems. The gaseous treatment alternates which were considered in this study are listed in Table 3-1.

3.4 Source Terms

The gaseous emission source terms for the Base Case and for all of the alternatives considered were calculated using the BWR-GALE code and the parameters outlined in Reg Guide 1.CC. The detailed inputs for each of these cases and theresulting source term outputs are described in this section.

3.4.1 Basic Inputs to GALE Code

There are certain fundamental input terms which describe the subject reactor and which are common to all cases and which are specific to the particular reactor. These common input terms for Duane Arnold were given in Table 2.2 for liquid releases and are also used for gaseous releases.

3.4.2 Base Case Input Terms and Resulting Releases

The input terms required to describe the Base Case gaseous radwaste treatments (outlined in paragraph 3.2) are shown in Table 3-2. The resulting gaseous releases by isotope for the Base Case are shown in Table 3-3. Note that there are two gaseous release points and that it is necessary to specify the release terms for each.

3.4.3 Inputs of Alternative Cases and Resulting Releases

Similarly the input terms required to describe each alternate case are shown in Table 3-4. For the alternates the resulting source terms represent the differences between the Base Case release and the release of the alternate. Thus in the case of additional augments, the difference will be positive, representing a reduction in release. In the case of the elimination of an augment, the difference will be negative, representing an increase in release. These differences for the alternate cases described in Table 3-1 are shown in Table 3-5.

3.4.4 Inputs for Cost-Beneficial Base

The indicated cost-beneficial equipment for the various waste systems is shown in Paragraph 3.9.2. Since the cost-beneficial case would involve the removal of some equipment pieces which were included in the base case, it is necessary to run the individual doses for the cost-beneficial case to determine whether it meets the requirements of Paragraphs II B & C of Appendix I. The cost-beneficial case is shown schematically on Figure 3-2. The GALE inputs for this cost-beneficial case are shown in Table 3-6 and the resulting gaseous releases are shown in Table 3-7.

3.5 Environmental Inputs

In order to convert the releases described in Section 3.4 into either individual or population doses it is necessary to develop a considerable amount of information which describes the pathways at and near the site by which radioactivity released in gaseous effluents might make its way back to individuals. In this section there are described the parameters which were used in making dose calculations to individuals and to populations. Extensive use has been made of the parameters outlined in Reg Guide 1.109, but these have been supplemented, particularly in the case of population doses, with site specific information. In the calculation of population doses considerable reliance has been placed on the selection of clearly conservative assumptions.

3.5.1 Characteristics of Maximum Individual

In the calculation of doses to individuals maximumly exposed to the gaseous discharges from Duane Arnold the usage factors given in Table A-2 of Reg Guide 1.109 have been assumed. Doses to individuals have been calculated at three points:

a) Residence 1610 meters NNW

b) Residence 2650 meters WNW (real cow)

c) Residence 3000 meters NE (real cow)

3.5.2 Atmospheric Dispersion

One of the most important factors governing potential doses to individuals and to populations from the release of gaseous radionuclides from nuclear reactors is the atmospheric dispersion available at the site.

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The meteorology of the site has been studied in detail as discussed in Chapter 2 of the Environmental Report. These meteorological data have been evaluated using the techniques outlined in Regulatory Guide 1.111. The resulting values of dispersion (X/Q in sec/m^3), depleted dispersion (X/Q' in sec/m^3), and specific deposition (d in 1/m^2) are shown in Table 3-8 for releases from the stack and in Table 3-9 for releases from the building. It is necessary to treat these two release sources separately since the former is elevated release whereas the latter is essentially a ground release. In both cases data are given for the grazing season as well as the annual averages.

As explained in Paragraph 3.5.4 the agricultural yields of the two counties nearest the site were used to characterize the entire 50-mile area. Since the assumption was made that these crops were grown evenly over the entire area, it was then possible to areal-average the meteorological parameters and arrive at a single set of values which characterizes the entire 7854 square miles within 50 miles of the site. The determination of this set of values is shown on Table 3-10.

3.5.3 Population Data

Current and future population data have been discussed previously in the Environmental Report (See Section 2). However, to have the data used available for review in this section there are presented in Table 3-11 two sets of population data. They are data provided by the Applicant for the years 1980 and 2010. The data are in each case given by sector and distance.

In making the population doses discussed herein the following age distribution was assumed:

Adult	66%
Teen	14%
Children	20%.

3.5.4 Agricultural Products

The area within 50 miles of Duane Arnold produces a large amount of a variety of foods. Crop data given in the Environmental Report for Linn & Benton Counties were used to determine yields per square mile. These same yields were then ascribed to the entire 7854 square miles within 50 miles of the site. Milk production was obtained from the number of dairy cattle for the entire area. Vegetables and fruits were classified as follows:

a) Leafy Grown in open, exterior surface eater
b) Exposed Grown in open, exterior surface not eaten
c) Root Grown under the surface.

The crop data obtained are summarized in Table 3-12. This table also includes for convenience all of the other input parameters used in making the population dose calculations. These are:

a) crop yield kg/m^2

b) deposition modifier

c) food preparation modifier

d) time between harvest and consumption

e) meteorological dispersion factors.

The deposition and food preparation modifiers are not included in Reg Guide 1.109. They were obtained from the HERMES report* and are believed by the Applicant to be appropriate for use.

Note that the population dose calculations have been based on crops, not on population. In every instance the crop yield is sufficient to feed many more people than actually live in the 50-mile area. Technically in making the cost-benefit analysis pursuant to Paragraph II D of Appendix I, it is necessary only to consider the dose to actual inhabitants of the 50-mile area. The Applicant believes, however, that the project should account for the entire population dose produced within the fifty miles, whether or not the food consumption takes place within that area. Therefore the population doses from the food paths are considerably overstated, at least in a technical Appendix I sense.

3.5.5 Other Pathways

No other pathways which might increase the calculated population doses by as much as 10% were found.

*HEDL-TME-71-168, HERMES--Digital Computer Code for Estimating Regional Radiological Effects from the Nuclear Power Industry, J E Fletcher, et atl, December 1971.

3.6 Individual Doses

Individual doses for the various Cases described in Section 3.4 are discussed in this Section.

3.6.1 With Base Case

The gaseous releases described in Paragraph 3.4.2 were combined with the parameters outlined in Paragraph 3.5.1 and the individual doses were calculated using the methods of Reg Guide 1.109. The results of those calculations are summarized in Table 3-13. It can be seen that the Base Case gaseous releases meet all of the requirements of Paragraphs II B & C of Appendix I.

3.6.2 With Cost-Beneficial Case

The gaseous releases described in Paragraph 3.4.4 were treated in a similar manner and the results are summarized in Table 3-14. It can be seen that the doses which result from the case meet the requirements of Paragraphs II B and C of Appendix I although the infant doses via milk push the limit closely. This implies that all of the non-cost beneficial equipment already included in Duane Arnold could be dispensed with. However, the equipment is already in place and it has been decided to continue using it notwithstanding its non-essentiality. Therefore, to demonstrate compliance with Appendix I the Base Case is used.

3.7 Population Doses

Three major food pathways:

a) fruits & vegetables

b) milk

c) meat

and three population-oriented pathways:

a) noble gas immension

b) ground plane deposition

c) inhalation

have been evaluated in determing population doses from gaseous discharges. The first three depend on the crop production described in Paragraph 3.5.4, the last three on the populations described in Paragraph 3.5.3. Population doses have been calculated for the Base Case described in Section 3.2 and the changes in population dose for each of the alternatives described in Section 3.3 have also been calculated.

3.7.1 Base Case

The population doses resulting from the gaseous releases from the Base Case described in Section 3.2 and Paragraph 3.4.2 are shown in Table 3-15. It appears from the total shown in that table that the Base Case treatments may have already passed the point of cost-effectiveness. This point will be examined in more detail in section 3.9.

3.7.2 Change in Population Doses for Alternates Considered

Although there appears to be a reasonable chance that the gaseous augments already included in Duane Arnold may have passed the point of cost effectiveness, to prove the point conclusively and to respond fully to the requirements of Paragraph II D of Appendix I requires that a series of augments (or subments) be hypothetically applied to the Base Case and a cost-benefit analysis be performed on these changes. To this end the alternates described in Section 3.3 were developed, the changes in the gaseous releases were determined (see Paragraph 3.4.3), and the changes in population dose resulting therefrom were calculated. The results of these calculations are shown in Table 3-16.

3.8 Cost Changes Associated with Alternates

3.8.1 Methodology

For each of the alternate cases listed in Table 3-1 . estimates have been made of the capital and operating costs associated with the described change. The capital costs have been annualized and added to the annual operating costs to arrive at a total annual cost. For additional augments the resulting costs are additional costs to be compared to the savings in environmental cost which result from population dose reductions. For the instances in which an equipment sequence is removed (either actually or hypothetically), the resulting costs are cost savings to be compared to increases in environmental cost which result from environmental dose increases. In either case the test is whether or not the quotient of

$$\frac{\text{annual cost in dollars}}{\text{annual change in dose in man-rem}}$$

is greater than $1000.

To the greatest extent possible the cost estimates used herein are based on Regulatory Guide 1.110. Only where necessary (and where indicated) have other sources of cost data and other methods of cost estimating been used.

3.8.2 Cost of Alternates

The resulting cost increases (or savings) for the alternate cases listed in Table 3-1 are shown in Table 3-17. A detailed backup for these values is given in Appendix A.

3.9 Cost Benefit Ratios

By combining the costs associated with the various alternates considered (given in Section 3.8) with the changes in population doses (given in Section 3.7) one obtains the cost per man-rem change in dose for each.

3.9.1 Alternate Cases

The cost-benefit ratios for the alternate cases listed in Table 3-1 are shown in Table 3-18. The values given are based on the population values. It can be seen that there is no additional augment which is justified by cost-benefit and, indeed, there are two augments which have been included in the design which are not cost-beneficial.

3.9.2 Indicated Cost-Beneficial Configuration

Based solely on the criterion of cost-benefit the gaseous radwaste systems for Duane Arnold should be those shown in Table 3-19. As indicated earlier even though this system is cost-beneficial, and it does just meet the individual dose requirements, it has been decided to use the Base Case for demonstrating compliance with Appendix I.

3.10 Appendix I Compliance

For the Base Case equipment, discussed in sections 3.2 and 3.9 and shown schematically on Figure 3-1 it has been shown herein that:

1) the individual dose requirements of Paragraphs II B & C are met;
2) there are no additional augments of reasonably demonstrated technology which could be added to the systems to provide additional population dose reductions at costs less than $1,000/man-rem.

Therefore the design of the gaseous radwaste system at Duane Arnold meets the As Low As Reasonably Achievable (ALARA) requirements of Appendix I to 10 CFR Part 50.

Figure 2-1

Liquid Waste Treatment Schematic—Base Case

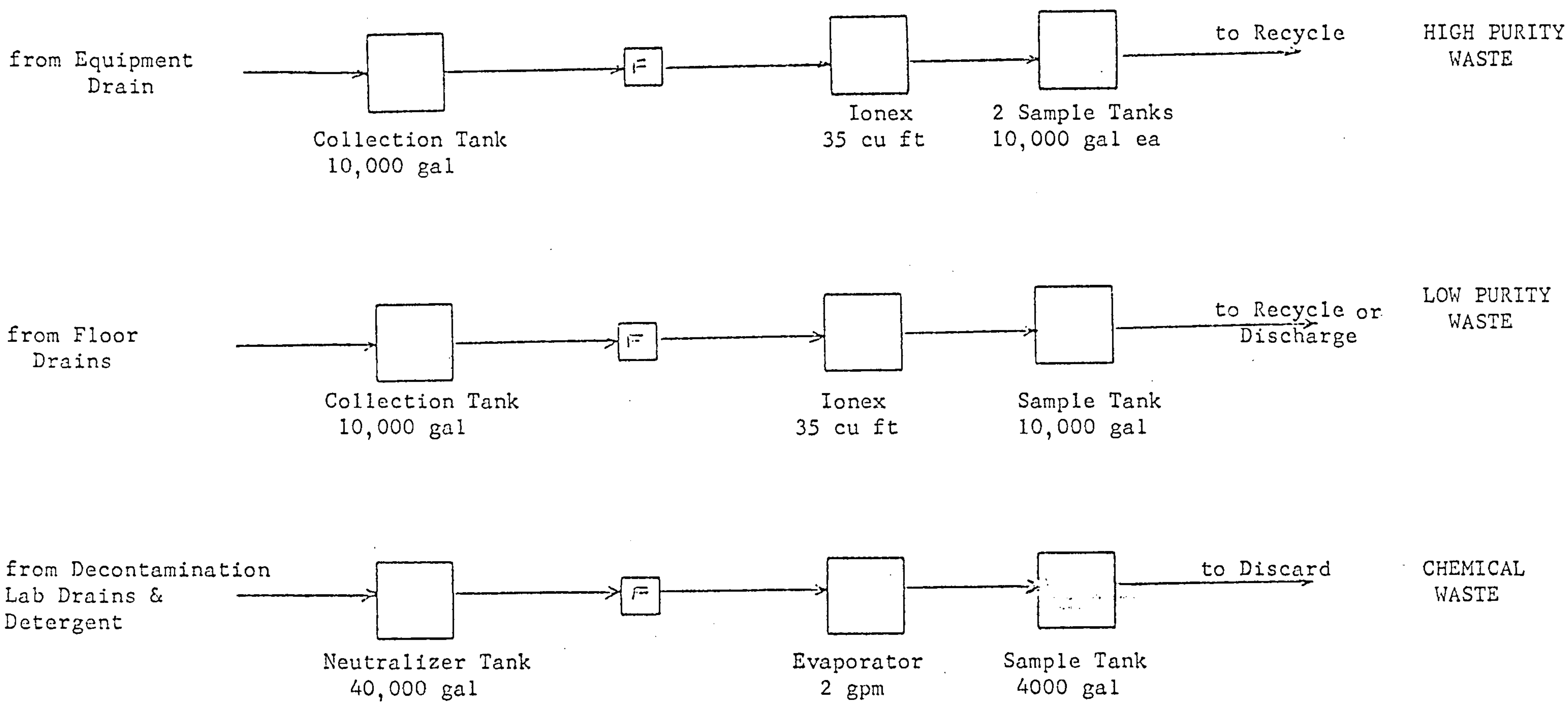
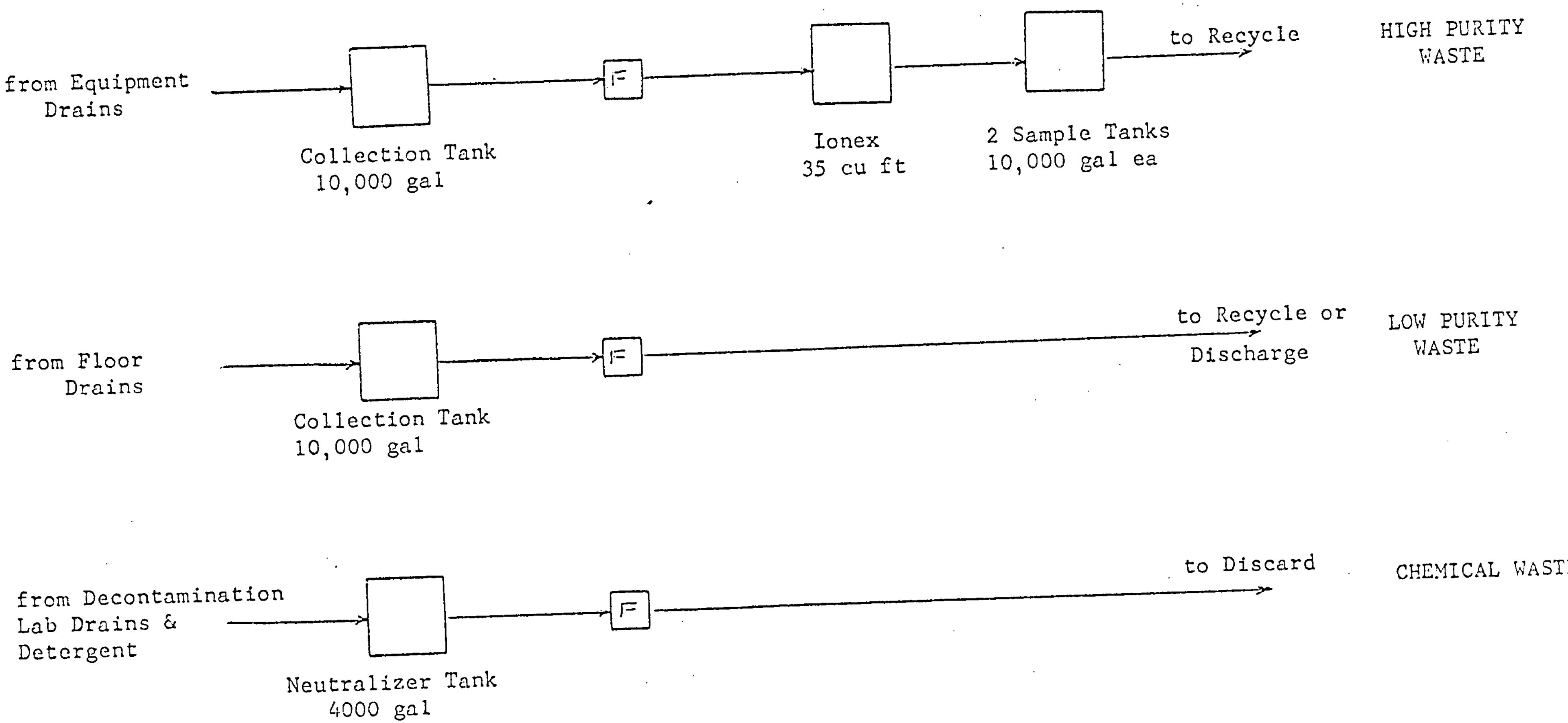


Figure 2-2

Liquid Waste Treatment Schematic—Cost-Beneficial Case

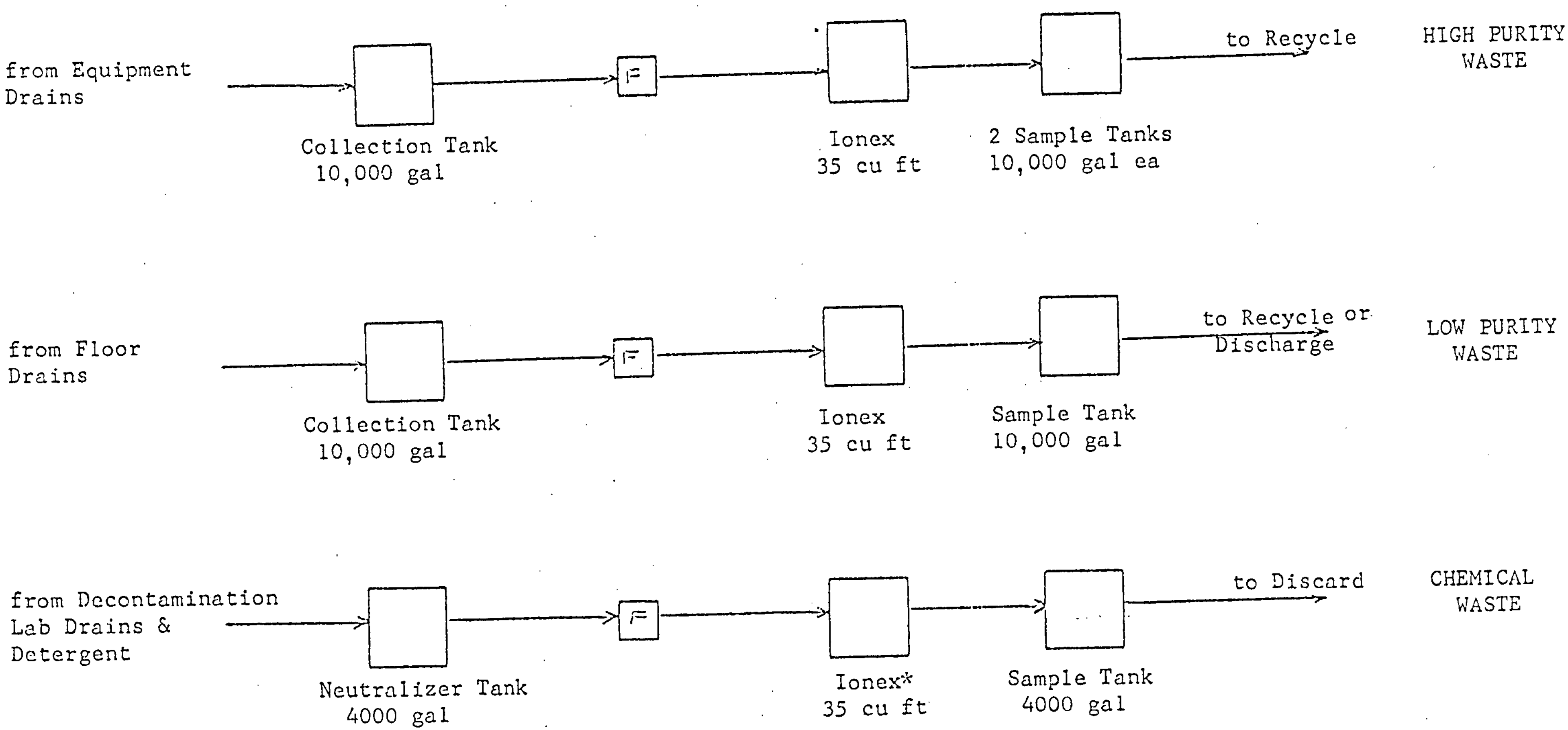


Duane ld

May, 1976

Figure 2-3

Liquid Waste Treatment Schematic—Compliance Case



* Same equipment as Low Purity Waste

Table 2-1

Liquid Treatment Alternates

Run Designation[a]	Waste System Affected	Description of Alternate
	Alternates to Base Case	
A-2	High Purity	Add Cation Bed
A-3	" "	Discard without treatment
B-2	Low Purity	Add Cation Bed
B-3	" "	Discard without treatment
C-1	Chemical Waste	Remove Evaporator (discard w/o treatment)
C-2	" "	Use mixed bed ion ex vice evaporator

a Corresponds to identifying number on GALE code inputs and outputs as well as on LIP inputs and outputs.

Table 2-2

GALE Input Terms Common to All Cases

Card No.	Spaces	Entry	Item	Units
1	33-60	DUANE ARNOLD	Reactor Name	
2	73-80	1658	Maximum Thermal Power	mwt
3	73-80	7.147	Steam Flow	10^6 lb/hour
4	73-80	0.289	Mass Reactor Water	10^6 lb
5	73-80	0.07	Cleanup Flow	10^6 lb/hour
6	73-80	0	Cond Demin Regeneration Time	days
7	73-80	1.0	Fraction Feedwater to Demin	
8	73-80	4	Effective Dilution Flow	10^3 gpm
21	73-80	7.147	Gland Seal Steam Flow	10^3 lb/hour
22	73-80	9.64E-03	Mass Steam in Reactor	10^6 lb
23	73-80	0.029	Gland Seal Holdup Time	hr
24	73-80	0.5	Holdup Time before AOG	hr

Table 2-3

GALE Input Terms for Base Case—Liquids

Card No.	Spaces	Entry	Item	Units
9	18-41	HIGH PURITY WASTE	Waste Stream	
	42-49	2.49E+04	Volume	gal/day
	57-61	0.14	Fraction PCA	
10	21-28	1E+02	I dF	
	34-41	1E+01	Cs dF	
	47-54	1E+02	Other dF	
11	29-33	0.16	Collection Time	days
	48-53	0.03	Process Time	days
	72-77	0.01	Fraction Discharged	
12	18-41	LOW PURITY WASTE	Waste Stream	
	42-49	5700	Volume	gal/day
	57-61	0.13	Fraction PCA	
13	21-28	1E+02	I dF	
	34-41	2E 00	Cs dF	
	47-54	1E+02	Other dF	
14	29-33	0.7	Collection Time	days
	48-53	0.03	Process Time	days
	72-77	0.1	Fraction Discharged	
15	18-41	CHEMICAL WASTE	Waste Stream	
	42-49	600	Volume	gal/day
	57-61	0.02	Fraction PCA	
16	21-28	1E+03	I dF	
	34-41	1E+04	Cs dF	
	47-54	1E+04	Other dF	
17	29-33	2.7	Collection Time	days
	48-53	0.6	Process Time	days
	72-77	1	Fraction Discharged	
18	73-80	0	volume	gal/day
19	21-28	1	I dF	
	34-41	1	Cs dF	
	47-54	1	Other dF	
20	29-33	0	Collection Time	days
	48-53	0	Process Time	days
	72-77	0	Fraction Discharged	
36	73-80	0	No On-site Laundry	

TABLE 2-4

LIQUID RELEASES -- BASE CASE
(CURIES/YEAR)

ISOTOPE	RELEASE	ISOTOPE	RELEASE
H----3	2.00E+01	RU-103	4.80E-05
NA--24	1.50E-02	RU-105	1.80E-03
P---32	4.70E-04	RH103M	4.50E-05
CR--51	1.20E-02	RH105M	1.80E-03
MN--54	1.40E-04	RH-105	2.70E-04
MN--56	2.90E-02	TE129M	9.60E-05
FE--55	2.40E-03	TE-129	5.60E-05
FE--59	7.20E-05	TE131M	2.00E-04
CO--58	4.80E-04	TE-131	3.60E-05
CO--60	9.60E-04	TE-132	2.20E-05
NI--65	1.70E-04	I--131	1.30E-02
CU--64	4.80E-02	I--132	1.80E-02
ZN--65	4.80E-04	I--133	4.10E-02
ZN-69M	3.30E-03	I--134	1.30E-02
ZN--69	3.10E-03	I--135	2.70E-02
BR--83	1.90E-03	CS-134	2.70E-03
BR--84	3.60E-04	CS-136	1.70E-03
RB--89	1.30E-03	CS-137	6.30E-03
SR--89	2.40E-04	CS-138	1.50E-02
SR--90	1.40E-05	BA137M	5.90E-03
SR--91	5.70E-03	BA-139	3.00E-03
SR--92	6.10E-03	BA-140	9.50E-04
Y--91M	3.30E-03	BA-141	1.80E-04
Y---91	1.20E-04	BA-142	2.20E-05
Y---92	9.20E-03	LA-140	1.10E-04
Y---93	5.90E-03	LA-141	5.90E-04
ZR--95	1.70E-05	LA-142	1.90E-03
NB--95	1.70E-05	CE-141	7.60E-05
NB--98	6.10E-04	CE-143	6.10E-05
MO--99	4.40E-03	PR-143	9.60E-05
TC-99M	2.40E-02	W--187	5.80E-04
TC-101	7.70E-04	NP-239	1.50E-02
TC-104	1.40E-03	OTHERS	6.70E-05

Table 2-5

GALE Input Terms for Alternate

Run Designation	Purpose	Card Changes Required: Card No.	Lines	Entry
A-2	Add cation bed ahead of mixed bed on high purity waste	10	21-28	1E+02
			34-41	1E+02
			47-54	1E+03
A-3	Discard high purity waste w/o treatment	10	21-28	1
			34-41	1
			47-54	1
		11	72-77	1
B-2	Add cation bed ahead of mixed bed on low purity waste	13	21-28	1E+02
			34-41	1E+02
			47-54	1E+03
B-3	Discard low purity waste w/o treatment	13	21-28	1
			34-41	1
			47-54	1
		14	72-77	1
C-1	Remove evaporator from chemical waste	16	21-28	1
			34-41	1
			47-54	1
C-2	Treat chemical waste through mixed bed	16	21-28	1E+02
			34-41	2E 00
			47-54	1E+02

TABLE 2-6

REDUCTIONS IN LIQUID RELEASES FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

ISOTOPE	CASE A-2	CASE A-3	CASE B-2
NA--24	3.02E-03	-3.35E+01	4.87E-03
P---32	7.88E-05	-8.76E-01	1.66E-04
CR--51	1.98E-03	-2.20E+01	4.18E-03
MN--54	2.38E-05	-2.65E-01	5.07E-05
MN--56	8.60E-03	-9.55E+01	6.42E-03
FE--55	3.97E-04	-4.41E+00	8.44E-04
FE--59	1.19E-05	-1.32E-01	2.52E-05
CO--58	7.94E-05	-8.82E-01	1.68E-04
CO--60	1.59E-04	-1.77E+00	3.37E-04
NI--63	0.	-4.42E-03	0.
NI--65	5.13E-05	-5.70E-01	3.82E-05
CU--64	9.81E-03	-1.09E+02	1.51E-02
ZN--65	7.95E-05	-8.83E-01	1.68E-04
ZN-69M	6.61E-04	-7.34E+00	1.04E-03
ZN--69	5.49E-04	-6.10E+00	1.07E-03
BR--83	0.	-6.26E+00	0.
BR--84	0.	-1.41E+00	0.
RB--89	1.95E-04	-2.17E-01	5.17E-04
SR--89	4.01E-05	-4.44E-01	8.52E-05
SR--90	2.38E-06	-2.65E-02	8.29E-06
SR--91	1.22E-03	-1.36E+01	1.74E-03
SR--92	1.78E-03	-1.98E+01	1.36E-03
Y---90	0.	-7.45E-04	0.
Y--91M	6.35E-04	-7.06E+00	1.06E-03
Y---91	1.72E-05	-1.91E-01	4.30E-05
Y---92	2.14E-03	-2.38E+01	2.58E-03
Y---93	1.24E-03	-1.38E+01	1.79E-03
ZR--95	2.78E-06	-3.09E-02	9.64E-06
ZR--97	0.	-1.90E-02	0.
NB-95M	0.	-1.24E-05	0.
NB--95	2.78E-06	-3.09E-02	9.66E-06
NB-97M	0.	-1.82E-02	0.
NB--97	0.	-1.43E-02	0.
NB--98	2.07E-04	-2.30E+00	1.05E-04
MO--99	7.64E-04	-8.49E+00	1.52E-03
TC-99M	5.50E-03	-6.11E+01	6.99E-03
TC-101	2.66E-04	-2.96E+00	1.30E-04
TC-104	4.94E-04	-5.49E+00	2.40E-04
RU-103	7.93E-06	-8.81E-02	1.67E-05
RU-105	4.71E-04	-5.23E+00	4.71E-04

CASE A-2 ADD CATION BED AHEAD OF MIXED BED ON HIGH PURITY WASTE
CASE A-3 DISCARD HIGH PURITY WASTE WITHOUT TREATMENT
CASE B-2 ADD CATION BED AHEAD OF MIXED BED ON LOW PURITY WASTE

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

REDUCTIONS IN LIQUID RELEASES FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

ISOTOPE	CASE A-2	CASE A-3	CASE B-2
RU-106	0.	-1.32E-02	0.
RH103M	6.35E-06	-7.06E-02	1.67E-05
RH105M	4.73E-04	-5.25E+00	4.72E-04
RH-105	2.75E-05	-3.05E-01	1.11E-04
RH-106	0.	-1.32E-02	0.
AG110M	0.	-4.41E-03	0.
AG-110	0.	-5.74E-04	0.
TE129M	1.58E-05	-1.76E-01	3.35E-05
TE-129	7.59E-06	-8.43E-02	2.14E-05
TE131M	3.64E-05	-4.05E-01	6.70E-05
TE-131	6.31E-06	-7.01E-02	1.21E-05
TE-132	3.84E-06	-4.27E-02	7.71E-06
I--131	0.	-2.34E+01	0.
I--132	0.	-6.05E+01	0.
I--133	0.	-6.55E+01	0.
I--134	0.	-4.80E+01	0.
I--135	0.	-6.92E+01	0.
CS-134	1.19E-04	-1.32E-01	1.36E-03
CS-136	7.87E-05	-8.73E-02	8.97E-04
CS-137	2.78E-04	-3.09E-01	3.22E-03
CS-138	2.29E-03	-2.54E+00	6.09E-03
BA137M	2.60E-04	-2.89E-01	3.01E-03
BA-139	9.81E-04	-1.09E+01	5.56E-04
BA-140	1.57E-04	-1.75E+00	3.30E-04
BA-141	6.17E-05	-6.86E-01	3.00E-05
BA-142	1.28E-05	-8.61E-02	3.76E-06
LA-140	7.00E-06	-7.78E-02	4.73E-05
LA-141	1.61E-04	-1.79E+00	1.41E-04
LA-142	6.28E-04	-6.98E+00	3.69E-04
CE-141	1.23E-05	-1.37E-01	2.68E-05
CE-143	1.10E-05	-1.22E-01	2.05E-05
CE-144	0.	-1.32E-02	0.
PR-143	1.58E-05	-1.76E-01	3.35E-05
PR-144	0.	-1.32E-02	0.
ND-147	0.	-1.31E-02	0.
W--187	1.07E-04	-1.19E+00	1.90E-04
NP-239	2.66E-03	-2.95E+01	5.22E-03
TOTAL	4.89E-02	-8.05E+02	7.55E-02

CASE A-2 ADD CATION BED AHEAD OF MIXED BED ON HIGH PURITY WASTE
CASE A-3 DISCARD HIGH PURITY WASTE WITHOUT TREATMENT
CASE B-2 ADD CATION BED AHEAD OF MIXED BED ON LOW PURITY WASTE

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

TABLE 2-6

REDUCTIONS IN LIQUID RELEASES FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

ISOTOPE	CASE B-3	CASE C-1	CASE C-2
NA--24	-5.41E+00	-2.12E-02	-2.10E-04
P---32	-1.84E-01	-2.76E-03	-2.73E-05
CR--51	-4.63E+00	-7.23E-02	-7.16E-04
MN--54	-5.62E-02	-9.08E-04	-8.99E-06
MN--56	-7.12E+00	-7.67E-04	-7.59E-06
FE--55	-9.37E-01	-1.52E-02	-1.50E-04
FE--59	-2.80E-02	-4.42E-04	-4.38E-06
CO--58	-1.87E-01	-2.98E-03	-2.95E-05
CO--60	-3.75E-01	-6.07E-03	-6.01E-05
NI--63	-9.38E-04	-1.66E-05	0.
NI--65	-4.24E-02	-4.43E-06	-4.39E-08
CU--64	-1.68E+01	-5.46E-02	-5.40E-04
ZN--65	-1.87E-01	-3.02E-03	-2.99E-05
ZN-69M	-1.16E+00	-4.13E-03	-4.09E-05
ZN--69	-1.19E+00	-4.44E-03	-4.40E-05
BR--83	-4.50E-01	-3.74E-05	-3.37E-07
BR--84	-6.87E-02	-4.90E-12	-4.42E-14
RB--89	-1.01E-02	-4.01E-21	-2.00E-21
SR--89	-9.39E-02	-1.49E-03	-1.48E-05
SR--90	-5.62E-03	-9.12E-05	-9.03E-07
SR--91	-1.93E+00	-4.30E-03	-4.26E-05
SR--92	-1.51E+00	-1.95E-04	-1.93E-06
Y---90	-5.23E-04	-3.57E-05	0.
Y--91M	-1.18E+00	-2.78E-03	-2.75E-05
Y---91	-4.77E-02	-9.48E-04	-9.38E-06
Y---92	-2.87E+00	-1.70E-03	-1.68E-05
Y---93	-1.99E+00	-4.79E-03	-4.74E-05
ZR--95	-6.53E-03	-1.04E-04	-1.03E-06
ZR--97	-3.16E-03	-1.93E-05	0.
NB-95M	0.	0.	0.
NB--95	-6.55E-03	-1.06E-04	-1.05E-06
NB-97M	-3.03E-03	-1.85E-05	0.
NB--97	-3.23E-03	-1.90E-05	0.
NB--98	-1.17E-01	-7.02E-09	-6.95E-11
MO--99	-1.69E+00	-1.88E-02	-1.86E-04
TC-99M	-7.76E+00	-2.46E-02	-2.43E-04
TC-101	-1.44E-01	-1.36E-21	-1.35E-23
TC-104	-2.67E-01	-2.10E-17	-2.08E-19
RU-103	-1.86E-02	-2.94E-04	-2.91E-06
RU-105	-5.23E-01	-2.80E-04	-2.77E-06

CASE B-3 DISCARD LOW PURITY WASTE WITHOUT TREATMENT
CASE C-1 REMOVE EVAPORATOR FROM CHEM WASTE
CASE C-2 MIXED BED IONEX ON CHEMICAL WASTE

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

TABLE 2-6

REDUCTIONS IN LIQUID RELEASES FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

ISOTOPE	CASE B-3	CASE C-1	CASE C-2
RU-106	-2.81E-03	-4.95E-05	0.
RH103M	-1.86E-02	-2.94E-04	-2.91E-06
RH105M	-5.23E-01	-2.81E-04	-2.78E-06
RH-105	-1.23E-01	-1.53E-03	-1.52E-05
RH-106	-2.81E-03	-4.95E-05	0.
AG110M	-9.37E-04	-1.65E-05	0.
AG-110	-1.22E-04	0.	0.
TE129M	-3.72E-02	-5.84E-04	-5.78E-06
TE-129	-2.38E-02	-3.74E-04	-3.70E-06
TE131M	-7.44E-02	-5.50E-04	-5.44E-06
TE-131	-1.35E-02	-1.00E-04	-9.90E-07
TE-132	-8.56E-03	-1.01E-04	-1.00E-06
I--131	-4.87E+00	-6.91E-02	-6.23E-04
I--132	-4.26E+00	-3.95E-04	-3.65E-06
I--133	-1.49E+01	-8.22E-02	-7.41E-04
I--134	-2.45E+00	-2.15E-07	-1.93E-09
I--135	-8.45E+00	-1.04E-02	-9.36E-05
CS-134	-2.67E-02	-4.55E-04	-2.28E-04
CS-136	-1.74E-02	-2.73E-04	-1.36E-04
CS-137	-6.24E-02	-1.06E-03	-5.32E-04
CS-138	-1.18E-01	-1.11E-11	-5.53E-12
BA137M	-5.83E-02	-9.95E-04	-4.97E-04
BA-139	-6.17E-01	-2.72E-06	-2.69E-08
BA-140	-3.67E-01	-5.46E-03	-5.40E-05
BA-141	-3.33E-02	-2.63E-18	-2.60E-20
BA-142	-4.18E-03	0.	0.
LA-140	-5.26E-02	-3.00E-03	-2.97E-05
LA-141	-1.57E-01	-6.19E-05	-6.13E-07
LA-142	-4.10E-01	-3.49E-06	-3.48E-08
CE-141	-2.98E-02	-4.81E-04	-4.76E-06
CE-143	-2.28E-02	-1.80E-04	-1.78E-06
CE-144	-2.81E-03	-4.95E-05	0.
PR-143	-3.72E-02	-5.75E-04	-5.69E-06
PR-144	-2.81E-03	-4.95E-05	0.
ND-147	-2.74E-03	-4.44E-05	0.
W--187	-2.11E-01	-1.31E-03	-1.30E-05
NP-239	-5.79E+00	-6.06E-02	-6.00E-04
TOTAL	-1.03E+02	-4.90E-01	-6.07E-03

CASE B-3 DISCARD LOW PURITY WASTE WITHOUT TREATMENT
CASE C-1 REMOVE EVAPORATOR FROM CHEM WASTE
CASE C-2 MIXED BED IONEX ON CHEMICAL WASTE

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

Table 2-7

GALE Input Terms for Cost-Beneficial Case—Liquids

Card No.	Spaces	Entry	Item	Units
9	18-41	HIGH PURITY WASTE	Waste Stream	
	42-49	2.49E+04	Volume	gal/day
	57-61	0.14	Fraction PCA	
10	21-28	1E+02	I dF	
	34-41	1E+01	Cs dF	
	47-54	1E+02	Other dF	
11	29-33	0.16	Collection Time	days
	48-53	0.03	Process Time	days
	72-77	0.01	Fraction Discharged	
12	18-41	LOW PURITY WASTE	Waste Stream	
	42-49	5700	Volume	gal/day
	57-61	0.13	Fraction PCA	
13	21-28	1	I dF	
	34-41	1	Cs dF	
	47-54	1	Other dF	
14	29-33	0.7	Collection Time	days
	48-53	0.03	Process Time	days
	72-77	0.1	Fraction Discharged	
15	18-41	CHEMICAL WASTE	Waste Stream	
	42-49	600	Volume	gal/day
	57-61	0.02	Fraction PCA	
16	21-28	1	I dF	
	34-41	1	Cs dF	
	47-54	1	Other dF	
17	29-33	2.7	Collection Time	days
	48-53	0.6	Process Time	days
	72-77	1	Fraction Discharged	
18	73-80	0	volume	gal/day
19	21-28	1	I dF	
	34-41	1	Cs dF	
	47-54	1	Other dF	
20	29-33	0	Collection Time	days
	48-53	0	Process Time	days
	72-77	0	Fraction Discharged	
36	73-80	0	No On-site Laundry	

TABLE 2-8

LIQUID RELEASES -- COST-BENEFICIAL CASE
(CURIES/YEAR)

ISOTOPE	RELEASE	ISOTOPE	RELEASE
H----3	2.00E+01	RU-105	5.40E-02
NA--24	5.70E-01	RU-106	3.30E-04
P---32	2.20E-02	RH103M	2.20E-03
CR--51	5.50E-01	RH105M	5.40E-02
MN--54	6.70E-03	RH-105	1.40E-02
MN--56	7.30E-01	RH-106	3.30E-04
FE--55	1.10E-01	AG110M	1.10E-04
FE--59	3.30E-03	AG-110	1.40E-05
CO--58	2.20E-02	TE129M	4.40E-03
CO--60	4.40E-02	TE-129	2.80E-03
NI--63	1.10E-04	TE131M	8.10E-03
NI--65	4.40E-03	TE-131	1.50E-03
CU--64	1.80E+00	TE-132	9.80E-04
ZN--65	2.20E-02	I--131	5.70E-01
ZN-69M	1.20E-01	I--132	4.40E-01
ZN--69	1.30E-01	I--133	1.60E+00
BR--83	4.60E-02	I--134	2.50E-01
BR--84	7.10E-03	I--135	8.70E-01
RB--89	1.30E-03	CS-134	3.40E-03
SR--89	1.10E-02	CS-136	2.20E-03
SR--90	6.70E-04	CS-137	8.10E-03
SR--91	2.00E-01	CS-138	1.50E-02
SR--92	1.60E-01	BA137M	7.50E-03
Y---90	8.90E-05	BA-139	6.40E-02
Y--91M	1.20E-01	BA-140	4.30E-02
Y---91	5.80E-03	BA-141	3.50E-03
Y---92	3.00E-01	BA-142	4.30E-04
Y---93	2.10E-01	LA-140	8.40E-03
ZR--95	7.70E-04	LA-141	1.60E-02
ZR--97	3.40E-04	LA-142	4.20E-02
NB--95	7.80E-04	CE-141	3.50E-03
NB-97M	3.20E-04	CE-143	2.50E-03
NB--97	3.40E-04	CE-144	3.30E-04
NB--98	1.20E-02	PR-143	4.40E-03
MO--99	1.90E-01	PR-144	3.30E-04
TC-99M	5.20E-01	ND-147	3.20E-04
TC-101	1.50E-02	W--187	2.30E-02
TC-104	2.80E-02	NP-239	6.50E-01
RU-103	2.20E-03	OTHERS	9.54E-07

Table 2-9

GALE Input Terms for Compliance Case--Liquids

Card No.	Spaces	Entry	Item	Units
9	18-41	HIGH PURITY WASTE	Waste Stream	
	42-49	2.49E+04	Volume	gal/day
	57-61	0.14	Fraction PCA	
10	21-28	1E+02	I dF	
	34-41	1E+01	Cs dF	
	47-54	1E+02	Other dF	
11	29-33	0.16	Collection Time	days
	48-53	0.03	Process Time	days
	72-77	0.01	Fraction Discharged	
12	18-41	LOW PURITY WASTE	Waste Stream	
	42-49	5700	Volume	gal/day
	57-61	0.13	Fraction PCA	
13	21-28	1E+02	I dF	
	34-41	2E 00	Cs dF	
	47-54	1E+02	Other dF	
14	29-33	0.7	Collection Time	days
	48-53	0.03	Process Time	days
	72-77	0.1	Fraction Discharged	
15	18-41	CHEMICAL WASTE	Waste Stream	
	42-49	600	Volume	gal/day
	57-61	0.02	Fraction PCA	
16	21-28	1E+02	I dF	
	34-41	2E 00	Cs dF	
	47-54	1E+02	Other dF	
17	29-33	2.7	Collection Time	days
	48-53	0.6	Process Time	days
	72-77		Fraction Discharged	
18	18-41	REGENERANT WASTE	Waste Stream	
	73-80	0	volume	gal/day
19	21-28	1	I dF	
	34-41	1	Cs dF	
	47-54	1	Other dF	
20	29-33	0	Collection Time	days
	48-53	0	Process Time	days
	72-77	0	Fraction Discharged	
36	73-80	0	No On-site Laundry	

TABLE 2-10

LIQUID RELEASES -- COMPLIANCE CASE (CURIES/YEAR)

ISOTOPE	RELEASE	ISOTOPE	RELEASE
H----3	2.00E+01	RU-103	5.20E-05
NA--24	1.50E-02	RU-105	1.80E-03
P---32	5.10E-04	RH103M	4.90E-05
CR--51	1.30E-02	RH105M	1.80E-03
MN--54	1.60E-04	RH-105	2.90E-04
MN--56	2.90E-02	TE129M	1.00E-04
FE--55	2.60E-03	TE-129	6.20E-05
FE--59	7.80E-05	TE131M	2.10E-04
CO--58	5.20E-04	TE-131	3.70E-05
CO--60	1.10E-03	TE-132	2.40E-05
NI--65	1.70E-04	I--131	1.40E-02
CU--64	4.90E-02	I--132	1.80E-02
ZN--65	5.30E-04	I--133	4.20E-02
ZN-69M	3.30E-03	I--134	1.20E-02
ZN--69	3.20E-03	I--135	2.70E-02
BR--83	1.90E-03	CS-134	3.00E-03
BR--84	3.60E-04	CS-136	2.00E-03
RB--89	1.30E-03	CS-137	7.10E-03
SR--89	2.70E-04	CS-138	1.50E-02
SR--90	1.60E-05	BA137M	6.60E-03
SR--91	5.70E-03	BA-139	2.90E-03
SR--92	6.00E-03	BA-140	1.00E-03
Y--91M	3.30E-03	BA-141	1.80E-04
Y---91	1.30E-04	BA-142	2.20E-05
Y---92	9.10E-03	LA-140	1.60E-04
Y---93	5.90E-03	LA-141	5.80E-04
ZR--95	1.80E-05	LA-142	1.90E-03
NB--95	1.80E-05	CE-141	3.30E-05
NB--98	6.00E-04	CE-143	6.30E-05
MO--99	4.70E-03	PR-143	1.00E-04
TC-99M	2.40E-02	W--187	5.90E-04
TC-101	7.60E-04	NP-239	1.60E-02
TC-104	1.40E-03	OTHERS	7.20E-05

(I--131 through I--135: 0.11 curie)

total release = H^3 + (all other)
= 20.0 + 0.39

total Iodines released only = 0.113

Table 2-11

Consumption Rates and Occupation Times
Used to Calculate Doses from Liquid Effluents

Pathway	Units	Adults	Teenagers	Children	Infants
To Maximum Individual					
Potable Water	liter/yr	730	510	510	510
Fresh Water Fish	kg/yr	21.	16.	6.9	0.
River Shoreline	hr/yr	12.	67.	14.	0.
Swimming	hr/yr	52.	52.	29.	0.
Boating	hr/yr	52.	52.	29.	0.
To Population					
Potable Water	liter/yr	370	260	260	260
Fresh Water Fish	kg/yr	6.9	5.2	2.2	0.
River Shoreline	hr/yr	8.3	47.	8.5	0.
Swimming	hr/yr	9.0	50.	9.0	0.
Boating	hr/yr	9.0	50.	9.0	0.

TABLE 2 MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO LIQUID RELEASES (MREM)

BASE CASE

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
POTABLE WATER	4.38E-03	1.79E-02	6.16E-02	1.43E-02	1.32E-02	1.35E-02	0.	1.63E-02
FRESH WATER FISH	5.29E+00	1.49E+00	2.59E-01	4.18E-01	1.36E-01	5.97E-01	0.	1.04E+00
RIVER SHORELINE DEPOSITS	8.39E-04	8.39E-04	8.39E-04	8.39E-04	8.39E-04	8.39E-04	9.81E-04	8.39E-04
SWIMMING	8.54E-04	8.54E-04	8.54E-04	8.54E-04	8.54E-04	8.54E-04	1.16E-03	8.54E-04
BOATING	4.27E-04	4.27E-04	4.27E-04	4.27E-04	4.27E-04	4.27E-04	5.78E-04	4.27E-04
TOTAL ADULTS	5.30E+00	1.51E+00	3.23E-01	4.34E-01	1.51E-01	6.13E-01	2.72E-03	1.06E+00
TEENAGERS								
POTABLE WATER	4.03E-03	1.18E-02	4.69E-02	1.00E-02	7.62E-03	7.53E-03	0.	8.95E-03
FRESH WATER FISH	4.21E+00	1.41E+00	2.37E-01	3.19E-01	1.55E-01	4.53E-01	0.	6.17E-01
RIVER SHORELINE DEPOSITS	4.68E-03	4.68E-03	4.68E-03	4.68E-03	4.68E-03	4.68E-03	5.48E-03	4.68E-03
SWIMMING	8.54E-04	8.54E-04	8.54E-04	8.54E-04	8.54E-04	8.54E-04	1.16E-03	8.54E-04
BOATING	4.27E-04	4.27E-04	4.27E-04	4.27E-04	4.27E-04	4.27E-04	5.78E-04	4.27E-04
TOTAL TEENAGERS	4.22E+00	1.43E+00	2.90E-01	3.35E-01	1.69E-01	4.66E-01	7.22E-03	6.32E-01
CHILDREN								
POTABLE WATER	1.06E-02	2.30E-02	1.09E-01	1.00E-02	1.43E-02	1.37E-02	0.	1.52E-02
FRESH WATER FISH	2.40E+00	1.13E+00	2.56E-01	1.37E-01	1.20E-01	1.95E-01	0.	2.45E-01
RIVER SHORELINE DEPOSITS	9.79E-04	9.79E-04	9.79E-04	9.79E-04	9.79E-04	9.79E-04	1.14E-03	9.79E-04
SWIMMING	4.76E-04	4.76E-04	4.76E-04	4.76E-04	4.76E-04	4.76E-04	6.45E-04	4.76E-04
BOATING	2.38E-04	2.38E-04	2.38E-04	2.38E-04	2.38E-04	2.38E-04	3.22E-04	2.38E-04
TOTAL CHILDREN	2.41E+00	1.15E+00	3.67E-01	1.49E-01	1.36E-01	2.10E-01	2.11E-03	2.62E-01
INFANTS								
POTABLE WATER	2.14E-02	4.26E-02	2.51E-01	1.00E-02	2.25E-02	2.04E-02	0.	2.21E-02
TOTAL INFANTS	2.14E-02	4.26E-02	2.51E-01	1.00E-02	2.25E-02	2.04E-02	0.	2.21E-02

TABLE 2-13 MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO LIQUID RELEASES (MREM)

COST-BENEFICIAL CASE

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
POTABLE WATER	6.38E-02	4.28E-02	2.17E+00	2.84E-02	2.92E-02	6.25E-02	0.	3.30E-02
FRESH WATER FISH	2.15E+02	1.55E+01	1.09E+01	9.28E-01	3.78E-01	2.63E+01	0.	9.63E+00
RIVER SHORELINE DEPOSITS	8.89E-03	8.89E-03	8.89E-03	8.89E-03	8.89E-03	8.89E-03	1.05E-02	8.89E-03
SWIMMING	2.29E-02	2.29E-02	2.29E-02	2.29E-02	2.29E-02	2.29E-02	3.10E-02	2.29E-02
BOATING	1.15E-02	1.15E-02	1.15E-02	1.15E-02	1.15E-02	1.15E-02	1.55E-02	1.15E-02
TOTAL ADULTS	2.15E+02	1.56E+01	1.31E+01	1.00E+00	4.50E-01	2.64E+01	5.70E-02	9.71E+00
TEENAGERS								
POTABLE WATER	5.79E-02	3.11E-02	1.76E+00	1.98E-02	1.89E-02	3.82E-02	0.	2.34E-02
FRESH WATER FISH	1.64E+02	1.22E+01	9.99E+00	7.07E-01	3.53E-01	2.00E+01	0.	7.13E+00
RIVER SHORELINE DEPOSITS	4.96E-02	4.96E-02	4.96E-02	4.96E-02	4.96E-02	4.96E-02	5.85E-02	4.96E-02
SWIMMING	2.29E-02	2.29E-02	2.29E-02	2.29E-02	2.29E-02	2.29E-02	3.10E-02	2.29E-02
BOATING	1.15E-02	1.15E-02	1.15E-02	1.15E-02	1.15E-02	1.15E-02	1.55E-02	1.15E-02
TOTAL TEENAGERS	1.64E+02	1.23E+01	1.18E+01	8.11E-01	4.56E-01	2.01E+01	1.05E-01	7.24E+00
CHILDREN								
POTABLE WATER	1.21E-01	5.07E-02	4.22E+00	1.98E-02	2.57E-02	4.42E-02	0.	4.19E-02
FRESH WATER FISH	7.15E+01	5.94E+00	1.08E+01	3.05E-01	2.20E-01	8.62E+00	0.	3.08E+00
RIVER SHORELINE DEPOSITS	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.04E-02	1.22E-02	1.04E-02
SWIMMING	1.28E-02	1.28E-02	1.28E-02	1.28E-02	1.28E-02	1.28E-02	1.73E-02	1.28E-02
BOATING	6.40E-03	6.40E-03	6.40E-03	6.40E-03	6.40E-03	6.40E-03	8.64E-03	6.40E-03
TOTAL CHILDREN	7.17E+01	6.02E+00	1.50E+01	3.54E-01	2.75E-01	8.69E+00	3.81E-02	3.15E+00
INFANTS								
POTABLE WATER	2.18E-01	9.31E-02	1.02E+01	1.98E-02	3.43E-02	5.12E-02	0.	6.49E-02
TOTAL INFANTS	2.18E-01	9.31E-02	1.02E+01	1.98E-02	3.43E-02	5.12E-02	0.	6.49E-02

TABLE 2-14 MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO LIQUID RELEASES (MREM)

COMPLIANCE CASE

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
POTABLE WATER	4.91E-03	1.86E-02	6.54E-02	1.46E-02	1.33E-02	1.36E-02	0.	1.67E-02
FRESH WATER FISH	5.77E+00	1.66E+00	2.75E-01	4.70E-01	1.53E-01	6.46E-01	0.	1.16E+00
RIVER SHORELINE DEPOSITS	9.45E-04	9.45E-04	9.45E-04	9.45E-04	9.45E-04	9.45E-04	1.11E-03	9.45E-04
SWIMMING	8.57E-04	8.57E-04	8.57E-04	8.57E-04	8.57E-04	8.57E-04	1.16E-03	8.57E-04
BOATING	4.28E-04	4.28E-04	4.28E-04	4.28E-04	4.28E-04	4.28E-04	5.80E-04	4.28E-04
TOTAL ADULTS	5.78E+00	1.68E+00	3.43E-01	4.87E-01	1.69E-01	6.62E-01	2.85E-03	1.18E+00
TEENAGERS								
POTABLE WATER	4.52E-03	1.24E-02	5.00E-02	1.02E-02	7.72E-03	7.60E-03	0.	9.21E-03
FRESH WATER FISH	4.59E+00	1.58E+00	2.51E-01	3.58E-01	1.73E-01	4.90E-01	0.	6.87E-01
RIVER SHORELINE DEPOSITS	5.28E-03	5.28E-03	5.28E-03	5.28E-03	5.28E-03	5.28E-03	6.17E-03	5.28E-03
SWIMMING	8.57E-04	8.57E-04	8.57E-04	8.57E-04	8.57E-04	8.57E-04	1.16E-03	8.57E-04
BOATING	4.28E-04	4.28E-04	4.28E-04	4.28E-04	4.28E-04	4.28E-04	5.80E-04	4.28E-04
TOTAL TEENAGERS	4.60E+00	1.60E+00	3.08E-01	3.75E-01	1.87E-01	5.04E-01	7.91E-03	7.03E-01
CHILDREN								
POTABLE WATER	1.19E-02	2.42E-02	1.16E-01	1.02E-02	1.45E-02	1.38E-02	0.	1.55E-02
FRESH WATER FISH	2.64E+00	1.26E+00	2.72E-01	1.54E-01	1.34E-01	2.11E-01	0.	2.73E-01
RIVER SHORELINE DEPOSITS	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.29E-03	1.10E-03
SWIMMING	4.78E-04	4.78E-04	4.78E-04	4.78E-04	4.78E-04	4.78E-04	6.46E-04	4.78E-04
BOATING	2.39E-04	2.39E-04	2.39E-04	2.39E-04	2.39E-04	2.39E-04	3.23E-04	2.39E-04
TOTAL CHILDREN	2.65E+00	1.29E+00	3.90E-01	1.66E-01	1.50E-01	2.27E-01	2.26E-03	2.90E-01
INFANTS								
POTABLE WATER	2.40E-02	4.53E-02	2.69E-01	1.02E-02	2.28E-02	2.05E-02	0.	2.24E-02
TOTAL INFANTS	2.40E-02	4.53E-02	2.69E-01	1.02E-02	2.28E-02	2.05E-02	0.	2.24E-02

TABLE 2-15 POPULATION DOSES FROM LIQUID RELEASES

BASE CASE

1980 POPULATION

PATHWAY	THYROID MAN-REM/YR	TOTAL BODY MAN-REM/YR	TOTAL MAN-REM/YR
POTABLE WATER	9.99E-02	6.77E-02	1.68E-01
FRESH WATER FISH	2.50E-04	2.26E-03	2.51E-03
RIVER SHORELINE DEPOSITS	2.89E-03	2.89E-03	5.77E-03
SWIMMING	3.63E-05	3.63E-05	7.27E-05
BOATING	1.82E-05	1.82E-05	3.63E-05
TOTAL	1.03E-01	7.29E-02	1.76E-01

2010 POPULATION

PATHWAY	THYROID MAN-REM/YR	TOTAL BODY MAN-REM/YR	TOTAL MAN-REM/YR
POTABLE WATER	1.53E-01	1.04E-01	2.57E-01
FRESH WATER FISH	2.50E-04	2.26E-03	2.51E-03
RIVER SHORELINE DEPOSITS	4.47E-03	4.47E-03	8.95E-03
SWIMMING	5.45E-05	5.45E-05	1.09E-04
BOATING	2.72E-05	2.72E-05	5.45E-05
TOTAL	1.58E-01	1.11E-01	2.69E-01

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Table

Population Dose Reductions from Liquid Alternates

Case	Description	Thyroid MTR/year	Total Body man-rem/yr	Total man-rem/yr
	High Purity Waste			
A-2	Add cation bed	2.31E-04	1.13E-03	1.36E-03
A-3	Discard without treatment	-8.61E+01	-5.08E 00	-9.12E+01
	Low Purity Waste			
B-2	Add cation bed	1.43E-03	9.88E-03	1.13E-02
B-3	Discard without treatment	-1.79E+01	-1.05E 00	-1.90E+01
	Chemical Waste			
C-1	Remove evaporator (discard w/o treatment)	-2.54E-01	-1.67E-02	-2.71E-01
C-2	Use mixed bed ionex vice evaporator	-2.48E-03	-1.62E-03	-4.10E-03

Note: negative values are increases in dose.

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15.13.33

TABLE 2-17 POPULATION DOSES FROM LIQUID RELEASES

COMPLIANCE CASE

1980 POPULATION

PATHWAY	THYROID MAN-REM/YR	TOTAL BODY MAN-REM/YR	TOTAL MAN-REM/YR
POTABLE WATER	1.03E-01	6.94E-02	1.73E-01
FRESH WATER FISH	2.69E-04	2.53E-03	2.80E-03
RIVER SHORELINE DEPOSITS	3.25E-03	3.25E-03	6.50E-03
SWIMMING	3.64E-05	3.64E-05	7.29E-05
BOATING	1.82E-05	1.82E-05	3.64E-05
TOTAL	1.07E-01	7.53E-02	1.82E-01

2010 POPULATION

PATHWAY	THYROID MAN-REM/YR	TOTAL BODY MAN-REM/YR	TOTAL MAN-REM/YR
POTABLE WATER	1.59E-01	1.06E-01	2.65E-01
FRESH WATER FISH	2.69E-04	2.53E-03	2.80E-03
RIVER SHORELINE DEPOSITS	5.04E-03	5.04E-03	1.01E-02
SWIMMING	5.46E-05	5.46E-05	1.09E-04
BOATING	2.73E-05	2.73E-05	5.46E-05
TOTAL	1.64E-01	1.14E-01	2.78E-01

R703E40 R704E4F

Table 2-18

Annual Cost of Liquid Alternates

Case Designation	Description	Δ Cost, \$/year[a]
	High Purity Waste	
A-2	Add cation bed	45,600
A-3	Discard without treatment	(45,600)
	Low Purity Waste	
B-2	Add cation bed	89,200
B-3	Discard without treatment	(89,200)
	Chemical Waste	
C-1	Remove evaporator (discard w/o treatment)	(>50,000)
C-2	Use mixed bed ionex vice evaporation	(30,400)

Note: values in ( ) are cost savings

a See Appendix A for details on cost estimating

Table 2-19

Cost-Benefit Ratios for Alternate Cases

Case	Purpose	Annual Δ Doses from Base man-rem	Annual Δ Doses from Prev Case man-rem	Annual Δ Costs from Base man-rem	Annual Δ Costs from Prev Case man-rem	Cost-Benefit Ratios from Base $/man-rem	Cost-Benefit Ratios from Prev Case $/man-rem
	High Purity Waste						
A-2	Add cation bed	1.36E-03	-	45,600	-	3.3E+06	-
A-3	Discard w/o treatmt	-9.12E+01[c]	-	-45,600[d]	-	5.0E+02	-
	Low Purity Waste						
B-2	Add cation bed	1.13E-02	-	89,200	-	7.9E+06	-
B-3	Discard w/o treatmt	-1.90E+01	-	-89,200	-	4.7E+03	
	Chemical Waste						
C-1	Remove evaporator	-2.71E-01	-	->50,000	-	>1.8E+05	
C-2	Use mixed bed	-4.10E-03	-	-30,400	-	7.4E+06	-

a From Table 2-16

b From Table 2-18

c Negative changes are increases in dose

d Negative costs are decreases in costs

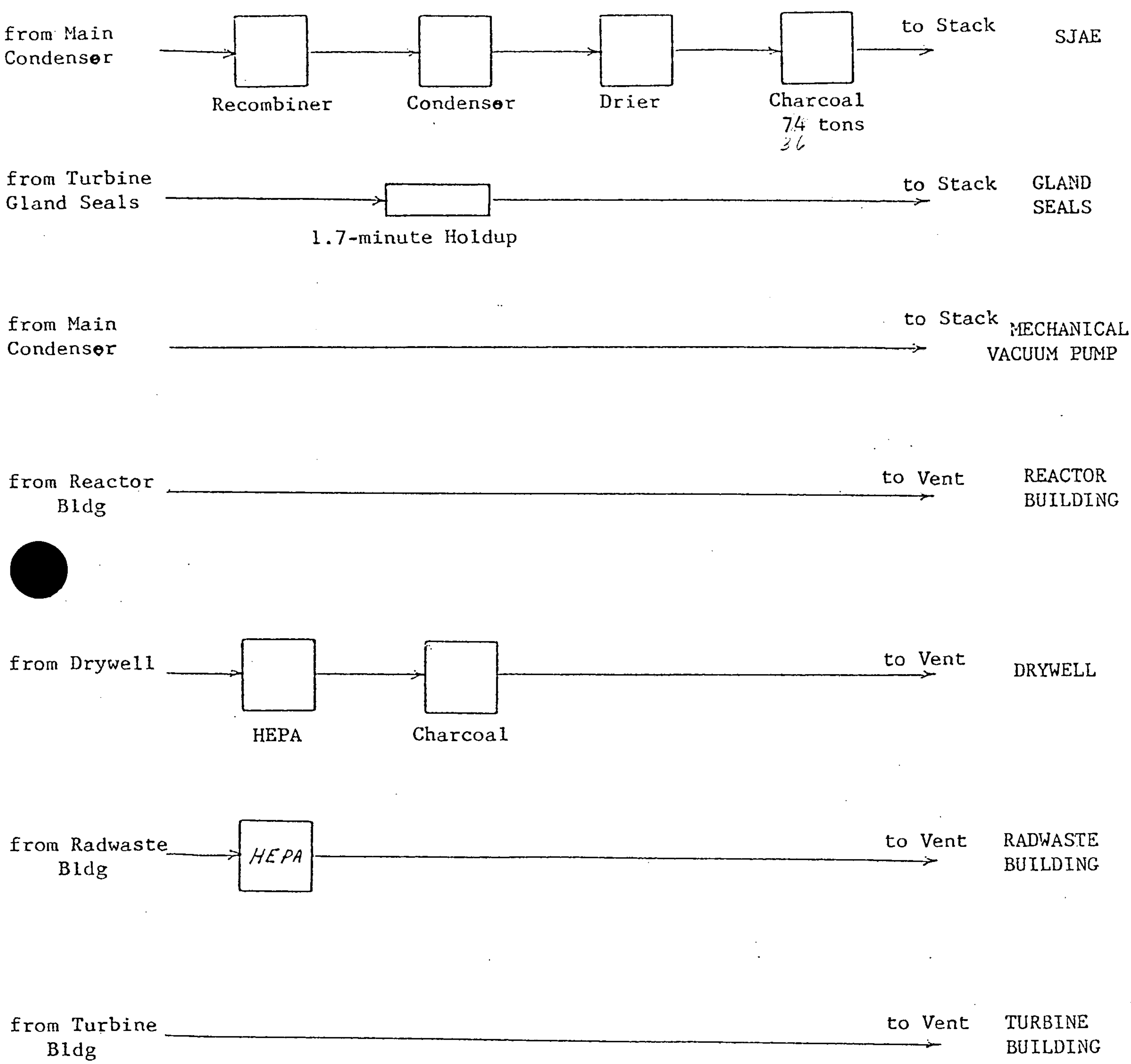
Table 2-20

Cost-Beneficial Radwaste System

Waste System	Cost-Beneficial Treatment
High Purity	One mixed bed ion exchanger
Low Purity	Discard without treatment
Miscellaneous Chemical	Discard without treatment

Figure 3-1

Gaseous Waste Schematic—Base Case[a]



a The Base Case is the Compliance Case

Figure 3-2

Gaseous Waste Schematic—Cost-Beneficial Case

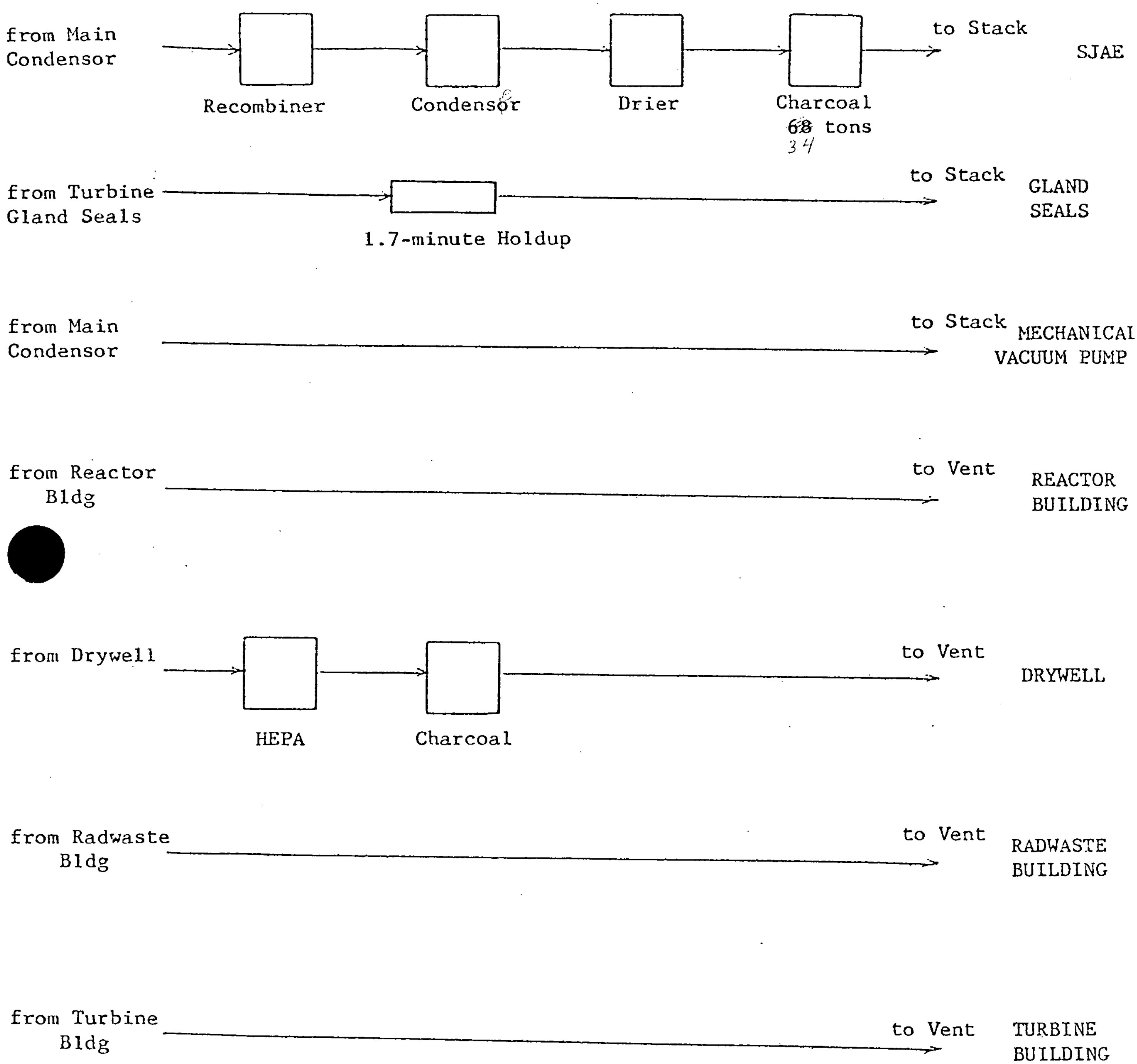


Table 3-1

Gaseous Treatment Alternates

Run Designation[a]	Waste System Affected	Description of Alternate
D-1	Gland Seal	Double holdup time
D-2	" "	Add charcoal & HEPA
E-1	Steam Jet Air Ejector	Operate at 0 F dewpoint
E-2	"	Add 2 more beds
E-3	"	Subtract 2 beds
F-2	Drywell	Remove charcoal
F-3	"	Remove HEPA & charcoal
G-1	Turbine Bldg	Add HEPA
G-2	"	Add HEPA & charcoal
G-3	"	Add clean steam 2 1/2 valves
H-1	Reactor (Aux) Bldg	Add HEPA
H-3	"	Add HEPA & charcoal
I-1	Radwaste Bldg	Add charcoal
I-2	"	Remove HEPA

Table 3-2

GALE Input Terms for Base Case—Gases

Card No.	Spaces	Entry	Item	Units
21	73-80	7.147	gland seal steam	10^3 lb/hr
22	73-80	9.64E-03	mass steam in reactor	10^6 lb/hr
23	73-80	0.029	gland seal holdup time	hour
24	73-80	0.5	SJAE holdup	hour
25	43-45	yes	Drywell vented through charcoal	
	52-54	yes	Drywell vented through HEPA	
26	43-45	Blank	turbine, no charcoal	
	52-54	Blank	no HEPA	
	68-70	Blank	no clean steam	
27	73-80	1	no HEPA or charcoal on gland seal	
28	73-80	0	charcoal delay on SJAE	
	43-45	Blank	no charcoal Reactor Bldg	
	52-54	Blank	no HEPA	
30	43-45	Blank	no charcoal Radwaste Bldg	
	52-54	yes	HEPA	
31	80	1	charcoal delay system	
32	73-80	18.5	Kr coef	
33	73-80	330	Xe coef	
34	73-80	2	No. of cond shells	
35	73-80	74	mass of charcoal	10^3 lb

TABLE 3-3

GASEOUS RELEASES -- BASE CASE
(CURIES/YEAR)

RELEASE FROM

ISOTOPE	STACK	PLANT VENT	TOTAL
H----3	1.05E+01	1.05E+01	2.10E+01
C---14	9.50E+00	0.	9.50E+00
AR--41	0.	2.50E+01	2.50E+01
CR--51	0.	1.34E-02	1.34E-02
MN--54	0.	3.93E-03	3.93E-03
FE--59	0.	1.05E-03	1.05E-03
CO--58	0.	1.25E-03	1.25E-03
CO--60	0.	1.30E-02	1.30E-02
ZN--65	0.	2.24E-03	2.24E-03
KR-83M	4.90E+01	0.	4.90E+01
KR-85M	2.34E+03	7.40E+01	2.42E+03
KR--85	1.40E+02	0.	1.40E+02
KR--87	1.56E+02	1.36E+02	2.92E+02
KR--88	1.65E+03	2.36E+02	1.89E+03
KR--89	6.40E+02	0.	6.40E+02
SR--89	0.	6.10E-03	6.10E-03
SR--90	0.	2.80E-05	2.30E-05
ZR--95	0.	5.05E-04	5.05E-04
SB-124	0.	5.02E-04	5.02E-04
XE131M	4.80E+01	0.	4.80E+01
XE133M	3.50E+01	0.	3.50E+01
XE-133	1.24E+04	3.92E+02	1.28E+04
XE135M	1.80E+01	7.42E+02	7.60E+02
XE-135	5.10E+02	7.43E+02	1.25E+03
XE-137	7.80E+02	0.	7.80E+02
XE-138	5.90E+02	1.41E+03	2.00E+03
I--131	5.20E-02	4.27E-01	4.79E-01
I--133	8.80E-02	1.69E+00	1.78E+00
CS-134	3.00E-06	4.39E-03	4.39E-03
CS-136	2.00E-06	3.58E-04	3.59E-04
CS-137	1.00E-05	6.25E-03	6.25E-03
BA-140	1.10E-05	1.14E-02	1.14E-02
CE-141	0.	7.27E-04	7.27E-04

GALE Inputs for Alternates Considered

Run Designation	Purpose	Card Changes Required: Card No.	Lines	Entry
D-1	Double Gland Seal Holdup Time	23	73-80	0.058
D-2	Add Charcoal (& HEPA) filter to Gland Seal Exhaust	27	73-80	0.1
E-1	Operate SJAE AOG at OF Dew Point	32 33	73-80 73-80	25 440
E-2	Add Two more Charcoal Beds to AOG	35	73-80	80
E-3	Subtract two Charcoal Beds from AOG	35	73-80	68
F-2	Remove Charcoal from Drywell	25	43-45	Blank
F-3	Remove Both HEPA & Charcoal from Drywell	25	43-45 52-54	Blank Blank
G-1	Add HEPA to Turbine Bldg Vent	26	52-54	Yes
G-2	Add HEPA & Charcoal to Turb Bldg Vent	26	43-45 52-54	Yes Yes
G-3	Add Clean Steam to Valves	26	68-70	Yes
H-1	Add HEPA to Reactor (Aux) Bldg	29	52-54	Yes
H-3	Add HEPA & Charcoal to Reactor Bldg	29	43-45 52-54	Yes Yes
I-1	Add Charcoal to Radwaste Bldg	30	43-45	Yes
I-2	Remove HEPA from Radwaste Bldg	30	52-54	Blank

TABLE 3-5

REDUCTIONS IN GASEOUS RELEASES RESULTING FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

STACK

ISOTOPE	CASE D-1	CASE D-2	CASE E-1	CASE E-2	CASE E-3
KR-83M	1.00E+00	0.	2.20E+01	1.00E+01	-1.80E+01
KR-85M	0.	0.	1.46E+03	5.00E+02	-6.00E+02
KR--87	0.	0.	6.00E+00	4.00E+00	-6.00E+00
KR--88	0.	0.	1.19E+03	5.00E+02	-6.00E+02
KR--89	2.00E+02	0.	0.	0.	0.
XE131M	0.	0.	1.10E+01	3.00E+00	-4.00E+00
XE133M	0.	0.	2.50E+01	1.00E+01	-1.30E+01
XE-133	0.	0.	4.40E+03	1.30E+03	-2.00E+03
XE135M	2.00E+00	0.	0.	0.	0.
XE-137	2.10E+02	0.	0.	0.	0.
XE-138	4.00E+01	0.	0.	0.	0.
I--131	0.	1.98E-02	0.	0.	0.
I--133	0.	7.92E-02	0.	0.	0.
TOTAL	4.53E+02	9.90E-02	7.11E+03	2.33E+03	-3.24E+03

CASE D-1 DOUBLE GLAND SEAL HOLDUP TIME
CASE D-2 ADD HEPA AND CHARCOAL TO GLAND SEAL EXHAUST
CASE E-1 OPERATE SJAE AOG AT 0F DEW POINT
CASE E-2 ADD TWO MORE CHARCOAL BEDS TO AOG
CASE E-3 REMOVE TWO CHARCOAL BEDS FROM AOG

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

TABLE 3-5

REDUCTIONS IN GASEOUS RELEASES RESULTING FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

PLANT VENT

ISOTOPE	CASE D-1	CASE D-2	CASE E-1	CASE E-2	CASE E-3
CR--51	0.	0.	0.	0.	0.
MN--54	0.	0.	0.	0.	0.
FE--59	0.	0.	0.	0.	0.
CO--58	0.	0.	0.	0.	0.
CO--60	0.	0.	0.	0.	0.
ZN--65	0.	0.	0.	0.	0.
KR-85M	0.	0.	0.	0.	0.
KR--87	0.	0.	0.	0.	0.
KR--88	0.	0.	0.	0.	0.
SR--89	0.	0.	0.	0.	0.
SR--90	0.	0.	0.	0.	0.
ZR--95	0.	0.	0.	0.	0.
SB-124	0.	0.	0.	0.	0.
XE-133	0.	0.	0.	0.	0.
XE135M	0.	0.	0.	0.	0.
XE-135	0.	0.	0.	0.	0.
XE-138	0.	0.	0.	0.	0.
I--131	0.	0.	0.	0.	0.
I--133	0.	0.	0.	0.	0.
CS-134	0.	0.	0.	0.	0.
CS-136	0.	0.	0.	0.	0.
CS-137	0.	0.	0.	0.	0.
BA-140	0.	0.	0.	0.	0.
CE-141	0.	0.	0.	0.	0.
TOTAL	0.	0.	0.	0.	0.

CASE D-1 DOUBLE GLAND SEAL HOLDUP TIME
CASE D-2 ADD HEPA AND CHARCOAL TO GLAND SEAL EXHAUST
CASE E-1 OPERATE SJAE AOG AT 0F DEW POINT
CASE E-2 ADD TWO MORE CHARCOAL BEDS TO AOG
CASE E-3 REMOVE TWO CHARCOAL BEDS FROM AOG

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

TABLE 3-5

REDUCTIONS IN GASEOUS RELEASES RESULTING FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

STACK

ISOTOPE	CASE F-2	CASE F-3	CASE G-1	CASE G-2	CASE G-3
KR-83M	0.	0.	0.	0.	0.
KR-85M	0.	0.	0.	0.	0.
KR--87	0.	0.	0.	0.	0.
KR--88	0.	0.	0.	0.	0.
KR--89	0.	0.	0.	0.	0.
XE131M	0.	0.	0.	0.	0.
XE133M	0.	0.	0.	0.	0.
XE-133	0.	0.	0.	0.	0.
XE135M	0.	0.	0.	0.	0.
XE-137	0.	0.	0.	0.	0.
XE-138	0.	0.	0.	0.	0.
I--131	0.	0.	0.	0.	0.
I--133	0.	0.	0.	0.	0.
TOTAL	0.	0.	0.	0.	0.

CASE F-2 REMOVE CHARCOAL FROM DRY WELL VENT
CASE F-3 REMOVE HEPA AND CHARCOAL FROM DRY WELL VENT
CASE G-1 ADD HEPA TO TURBINE BUILDING VENT
CASE G-2 ADD HEPA AND CHARCOAL TO TURBINE BUILDING VENT
CASE G-3 ADD CLEAN STEAM TO VALVES

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

TABLE 3-5

REDUCTIONS IN GASEOUS RELEASES RESULTING FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

PLANT VENT

ISOTOPE	CASE F-2	CASE F-3	CASE G-1	CASE G-2	CASE G-3
CR--51	0.	-2.97E-04	1.29E-02	1.29E-02	1.04E-02
MN--54	0.	-2.97E-03	5.94E-04	5.94E-04	4.80E-04
FE--59	0.	-3.96E-04	4.95E-04	4.95E-04	4.00E-04
CO--58	0.	-5.94E-04	5.94E-04	5.94E-04	4.80E-04
CO--60	0.	-9.90E-03	1.98E-03	1.98E-03	1.60E-03
ZN--65	0.	-1.93E-03	1.98E-04	1.98E-04	1.60E-04
KR-85M	0.	0.	0.	0.	5.40E+01
KR--87	0.	0.	0.	0.	1.04E+02
KR--88	0.	0.	0.	0.	1.84E+02
SR--89	0.	-8.91E-05	5.94E-03	5.94E-03	4.80E-03
SR--90	0.	-4.95E-06	1.98E-05	1.98E-05	1.60E-05
ZR--95	0.	-3.96E-04	9.90E-05	9.90E-05	8.00E-05
SB-124	0.	-1.98E-04	2.97E-04	2.97E-04	2.40E-04
XE-133	0.	0.	0.	0.	2.00E+02
XE135M	0.	0.	0.	0.	5.20E+02
XE-135	0.	0.	0.	0.	5.00E+02
XE-138	0.	0.	0.	0.	1.11E+03
I--131	-1.53E-01	-1.53E-01	0.	1.71E-01	1.52E-01
I--133	-6.12E-01	-6.12E-01	0.	6.84E-01	6.10E-01
CS-134	0.	-3.96E-03	2.97E-04	2.97E-04	2.40E-04
CS-136	0.	-2.97E-04	4.95E-05	4.95E-05	4.00E-05
CS-137	0.	-5.45E-03	5.94E-04	5.94E-04	4.80E-04
BA-140	0.	-3.96E-04	1.09E-02	1.09E-02	8.80E-03
CE-141	0.	-9.90E-05	5.94E-04	5.94E-04	4.80E-04
TOTAL	-7.65E-01	-7.92E-01	3.55E-02	8.91E-01	2.67E+03

CASE F-2 REMOVE CHARCOAL FROM DRY WELL VENT
CASE F-3 REMOVE HEPA AND CHARCOAL FROM DRY WELL VENT
CASE G-1 ADD HEPA TO TURBINE BUILDING VENT
CASE G-2 ADD HEPA AND CHARCOAL TO TURBINE BUILDING VENT
CASE G-3 ADD CLEAN STEAM TO VALVES

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

REDUCTIONS IN GASEOUS RELEASES RESULTING FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

STACK

ISOTOPE	CASE H-1	CASE H-3	CASE I-1	CASE I-2
KR-83M	0.	0.	0.	0.
KR-85M	0.	0.	0.	0.
KR--87	0.	0.	0.	0.
KR--88	0.	0.	0.	0.
KR--89	0.	0.	0.	0.
XE131M	0.	0.	0.	0.
XE133M	0.	0.	0.	0.
XE-133	0.	0.	0.	0.
XE135M	0.	0.	0.	0.
XE-137	0.	0.	0.	0.
XE-138	0.	0.	0.	0.
I--131	0.	0.	0.	0.
I--133	0.	0.	0.	0.
TOTAL	0.	0.	0.	0.

CASE H-1 ADD HEPA TO REACTOR (AUX) BUILDING
CASE H-3 ADD HEPA AND CHARCOAL TO REACTOR (AUX) BUILDING
CASE I-1 ADD CHARCOAL TO RADWASTE
CASE I-2 REMOVE HEPA FROM RADWASTE

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

REDUCTIONS IN GASEOUS RELEASES RESULTING FROM ALTERNATE TREATMENTS
(CURIES/YEAR)

PLANT VENT

ISOTOPE	CASE H-1	CASE H-3	CASE I-1	CASE I-2
CR--51	2.97E-04	2.97E-04	0.	-8.91E-03
MN--54	2.97E-03	2.97E-03	0.	-2.97E-02
FE--59	3.96E-04	3.96E-04	0.	-1.48E-02
CO--58	5.94E-04	5.94E-04	0.	-4.45E-03
CO--60	9.90E-03	9.90E-03	0.	-8.91E-02
ZN--65	1.98E-03	1.98E-03	0.	-1.49E-03
KR-85M	0.	0.	0.	0.
KR--87	0.	0.	0.	0.
KR--88	0.	0.	0.	0.
SR--89	8.91E-05	8.91E-05	0.	-4.45E-04
SR--90	4.95E-06	4.95E-06	0.	-2.97E-04
ZR--95	3.96E-04	3.96E-04	0.	-4.95E-05
SB-124	1.98E-04	1.98E-04	0.	-4.95E-05
XE-133	0.	0.	0.	0.
XE135M	0.	0.	0.	0.
XE-135	0.	0.	0.	0.
XE-138	0.	0.	0.	0.
I--131	0.	1.53E-01	4.50E-02	0.
I--133	0.	6.12E-01	1.62E-01	0.
CS-134	3.96E-03	3.96E-03	0.	-4.45E-03
CS-136	2.97E-04	2.97E-04	0.	-4.45E-04
CS-137	5.45E-03	5.45E-03	0.	-8.91E-03
BA-140	3.96E-04	3.96E-04	0.	-9.90E-05
CE-141	9.90E-05	9.90E-05	0.	-2.57E-03
TOTAL	2.70E-02	7.92E-01	2.07E-01	-1.66E-01

CASE H-1 ADD HEPA TO REACTOR (AUX) BUILDING
CASE H-3 ADD HEPA AND CHARCOAL TO REACTOR (AUX) BUILDING
CASE I-1 ADD CHARCOAL TO RADWASTE
CASE I-2 REMOVE HEPA FROM RADWASTE

NOTE -- NEGATIVE VALUES REPRESENT INCREASED RELEASES

Duane Arnold

May, 1976
Revised July, 1976

Table 3-6

GALE Input Terms for Cost-Beneficial Case--Gases

Card No.	Spaces	Entry	Item	Units
21	73-80	7.147	gland seal steam	10^3 lb/hr
22	73-80	9.64E-03	mass steam in reactor	10^6 lb/hr
23	73-80	0.029	gland seal holdup time	hour
24	73-80	0.5	SJAE holdup	hour
25	43-45	yes	Drywell vented through charcoal	
	52-54	yes	Drywell vented through HEPA	
26	43-45	Blank	turbine, no charcoal	
	52-54	Blank	no HEPA	
	68-70	Blank	no clean steam	
27	73-80	1	no HEPA on charcoal on gland seal	
28	73-80	0	charcoal delay on SJAE	
[illegible]	43-45	Blank	no charcoal Reactor Bldg	
	52-54	Blank	no HEPA	
30	43-45	Blank	no charcoal Radwaste Bldg	
	52-54	Blank	no HEPA	
31	80	1	charcoal delay system	
32	73-80	18.5	Kr coef	
33	73-80	330	Xe coef	
34	73-80	2	No. of cond shells	
35	73-80	68	mass of charcoal	10^3 lb

TABLE 3-7

GASEOUS RELEASES -- COST-BENEFICIAL CASE (CURIES/YEAR)

RELEASE FROM

ISOTOPE	STACK	PLANT VENT	TOTAL
H----3	1.05E+01	1.05E+01	2.10E+01
C---14	9.50E+00	0.	9.50E+00
AR--41	0.	2.50E+01	2.50E+01
CR--51	0.	2.23E-02	2.23E-02
MN--54	0.	3.36E-02	3.36E-02
FE--59	0.	1.59E-02	1.59E-02
CO--58	0.	5.71E-03	5.71E-03
CO--60	0.	1.02E-01	1.02E-01
ZN--65	0.	3.72E-03	3.72E-03
KR-83M	6.70E+01	0.	6.70E+01
KR-85M	2.94E+03	7.40E+01	3.02E+03
KR--85	1.40E+02	0.	1.40E+02
KR--87	1.62E+02	1.36E+02	2.98E+02
KR--88	2.25E+03	2.36E+02	2.49E+03
KR--89	6.40E+02	0.	6.40E+02
SR--89	0.	6.54E-03	6.54E-03
SR--90	0.	3.25E-04	3.25E-04
ZR--95	0.	5.54E-04	5.54E-04
SB-124	0.	5.52E-04	5.52E-04
XE131M	5.20E+01	0.	5.20E+01
XE133M	4.80E+01	0.	4.80E+01
XE-133	1.44E+04	3.92E+02	1.48E+04
XE135M	1.80E+01	7.42E+02	7.60E+02
XE-135	5.10E+02	7.43E+02	1.25E+03
XE-137	7.80E+02	0.	7.80E+02
XE-138	5.90E+02	1.41E+03	2.00E+03
I--131	5.20E-02	4.27E-01	4.79E-01
I--133	8.80E-02	1.69E+00	1.78E+00
CS-134	3.00E-06	8.84E-03	8.84E-03
CS-136	2.00E-06	8.03E-04	8.05E-04
CS-137	1.00E-05	1.52E-02	1.52E-02
BA-140	1.10E-05	1.15E-02	1.15E-02
CE-141	0.	3.30E-03	3.30E-03

A[illegible]HERIC DISPERSION FACTORS FOR-DUANE ARNOLD [illegible]-STACK SEASON-GRAZING REQ-DX-1 3[illegible]

RUN TYPE- X/Q SEC/M3 DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
	1	1.5	2.5	3.5	4.5	7.5	15	25	35	45
N	4.35E-07	3.09E-07	1.65E-07	1.13E-07	1.21E-07	6.25E-08	2.01E-08	1.08E-08	7.19E-09	5.30E-09
NNE	3.23E-07	1.15E-07	9.47E-08	7.16E-08	5.69E-08	4.15E-08	1.35E-08	7.23E-09	4.84E-09	3.58E-09
NE	2.05E-07	9.79E-08	6.75E-08	5.32E-08	3.88E-08	3.26E-08	1.04E-08	5.48E-09	3.66E-09	2.70E-09
ENE	1.04E-07	1.50E-07	7.15E-08	4.46E-08	3.31E-08	2.07E-08	7.32E-09	4.15E-09	2.84E-09	2.13E-09
E	2.45E-07	1.38E-07	9.06E-08	5.61E-08	4.14E-08	2.08E-08	7.33E-09	4.16E-09	2.85E-09	2.14E-09
ESE	1.17E-07	7.58E-08	7.02E-08	4.37E-08	3.30E-08	2.32E-08	8.46E-09	4.86E-09	3.34E-09	2.52E-09
SE	2.11E-07	9.26E-08	5.80E-08	3.89E-08	2.95E-08	2.51E-08	8.93E-09	5.10E-09	3.49E-09	2.62E-09
SSE	2.18E-07	7.82E-08	5.06E-08	3.49E-08	2.79E-08	2.76E-08	1.00E-08	5.83E-09	4.02E-09	3.03E-09
S	1.25E-07	5.96E-08	3.78E-08	2.68E-08	2.74E-08	1.94E-08	7.14E-09	4.19E-09	2.90E-09	2.19E-09
SSW	5.88E-08	5.43E-08	3.58E-08	2.51E-08	2.65E-08	2.15E-08	7.30E-09	4.03E-09	2.73E-09	2.03E-09
SW	3.03E-08	5.63E-08	4.14E-08	3.16E-08	2.37E-08	2.07E-08	7.11E-09	3.97E-09	2.69E-09	2.00E-09
WSW	3.29E-08	6.54E-08	4.24E-08	3.14E-08	2.46E-08	2.09E-08	7.01E-09	3.85E-09	2.60E-09	1.92E-09
W	4.94E-08	7.41E-08	4.53E-08	4.77E-08	3.35E-08	1.48E-08	4.78E-09	2.58E-09	1.72E-09	1.26E-09
WNW	7.00E-08	1.17E-07	8.78E-08	5.29E-08	4.23E-08	3.00E-08	9.51E-09	5.02E-09	3.34E-09	2.45E-09
NW	1.56E-07	2.49E-07	1.28E-07	7.64E-08	6.55E-08	3.93E-08	1.23E-08	6.46E-09	4.28E-09	3.14E-09
NNW	3.55E-07	2.59E-07	1.31E-07	8.21E-08	6.02E-08	5.72E-08	1.78E-08	9.25E-09	6.14E-09	4.52E-09

RUN TYPE- DEPLETED X/Q SEC/M3 DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	4.28E-07	2.96E-07	1.57E-07	1.07E-07	1.14E-07	5.67E-08	1.67E-08	8.03E-09	4.91E-09	3.38E-09
NNE	3.17E-07	1.09E-07	8.95E-08	6.72E-08	5.32E-08	3.76E-08	1.12E-08	5.47E-09	3.34E-09	2.31E-09
NE	2.02E-07	9.31E-08	6.35E-08	4.97E-08	3.60E-08	2.92E-08	8.30E-09	3.81E-09	2.26E-09	1.53E-09
ENE	1.02E-07	1.43E-07	6.78E-08	4.21E-08	3.11E-08	1.92E-08	6.53E-09	3.52E-09	2.31E-09	1.68E-09
E	2.40E-07	1.32E-07	8.60E-08	5.31E-08	3.91E-08	1.94E-08	6.64E-09	3.64E-09	2.41E-09	1.76E-09
ESE	1.15E-07	7.25E-08	6.62E-08	4.11E-08	3.09E-08	2.15E-08	7.40E-09	3.97E-09	2.58E-09	1.86E-09
SE	2.08E-07	8.83E-08	5.51E-08	3.67E-08	2.77E-08	2.35E-08	8.13E-09	4.49E-09	2.99E-09	2.18E-09
SSE	2.15E-07	7.47E-08	4.79E-08	3.27E-08	2.59E-08	2.56E-08	9.09E-09	5.14E-09	3.45E-09	2.54E-09
S	1.23E-07	5.71E-08	3.60E-08	2.52E-08	2.56E-08	1.82E-08	6.66E-09	3.89E-09	2.67E-09	1.99E-09
SSW	5.78E-08	5.24E-08	3.42E-08	2.36E-08	2.46E-08	1.97E-08	6.40E-09	3.35E-09	2.17E-09	1.55E-09
SW	2.98E-08	5.47E-08	3.95E-08	2.97E-08	2.21E-08	1.90E-08	6.32E-09	3.40E-09	2.24E-09	1.62E-09
WSW	3.24E-08	6.31E-08	4.04E-08	2.95E-08	2.29E-08	1.90E-08	6.07E-09	3.14E-09	2.02E-09	1.44E-09
W	4.85E-08	7.12E-08	4.28E-08	4.40E-08	3.07E-08	1.33E-08	4.16E-09	2.17E-09	1.40E-09	1.00E-09
WNW	6.88E-08	1.12E-07	8.27E-08	4.93E-08	3.91E-08	2.66E-08	7.60E-09	3.51E-09	2.09E-09	1.41E-09
NW	1.53E-07	2.38E-07	1.21E-07	7.13E-08	6.05E-08	3.49E-08	9.80E-09	4.48E-09	2.65E-09	1.76E-09
NNW	3.47E-07	2.48E-07	1.24E-07	7.75E-08	5.65E-08	5.00E-08	1.37E-08	6.06E-09	3.51E-09	2.32E-09

RUN TYPE- DEPOSITION D/Q M-2 DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	3.18E-08	6.59E-09	2.07E-09	9.78E-10	6.02E-10	2.39E-10	6.47E-11	3.19E-11	2.06E-11	1.37E-11
NNE	2.70E-08	4.54E-09	1.57E-09	7.47E-10	4.60E-10	1.68E-10	4.32E-11	2.08E-11	1.33E-11	8.83E-12
NE	1.88E-08	3.15E-09	1.03E-09	4.85E-10	2.97E-10	1.38E-10	4.02E-11	1.72E-11	9.89E-12	6.19E-12
ENE	9.31E-09	2.09E-09	6.07E-10	2.77E-10	1.69E-10	5.55E-11	1.28E-11	6.06E-12	4.05E-12	2.90E-12
E	1.25E-08	2.80E-09	8.41E-10	3.81E-10	2.30E-10	7.60E-11	1.74E-11	7.87E-12	5.04E-12	3.55E-12
ESE	8.86E-09	2.07E-09	7.08E-10	3.22E-10	1.95E-10	6.52E-11	1.53E-11	7.24E-12	4.74E-12	3.26E-12
SE	1.54E-08	3.13E-09	1.02E-09	4.81E-10	2.95E-10	9.74E-11	2.21E-11	9.93E-12	6.35E-12	4.47E-12
SSE	1.99E-08	3.51E-09	1.20E-09	5.81E-10	3.58E-10	1.20E-10	2.71E-11	1.21E-11	7.64E-12	5.33E-12
S	1.06E-08	2.12E-09	7.34E-10	3.42E-10	2.27E-10	7.67E-11	1.72E-11	7.40E-12	4.50E-12	3.19E-12
SSW	4.65E-09	1.34E-09	4.89E-10	2.46E-10	1.59E-10	5.24E-11	1.17E-11	5.40E-12	3.65E-12	2.63E-12
SW	2.55E-09	1.23E-09	4.79E-10	2.47E-10	1.54E-10	5.12E-11	1.09E-11	4.65E-12	3.02E-12	2.18E-12
WSW	3.34E-09	1.23E-09	4.53E-10	2.30E-10	1.44E-10	4.81E-11	1.06E-11	4.81E-12	3.24E-12	2.31E-12
W	4.41E-09	1.55E-09	5.57E-10	2.94E-10	1.79E-10	5.68E-11	1.22E-11	5.17E-12	3.26E-12	2.31E-12
[illegible]	[illegible]	2.32E-09	8.46E-10	3.98E-10	2.47E-10	1.23E-10	3.62E-11	1.49E-11	8.37E-12	5.12E-12

Duane Arnold

Atmospheric Dispers[illegible] Factors for Stack

ATM[illegible]RIC DISPERSION FACTORS FOR-DUANE ARNOLD VE[illegible]ACK SEASON-ANNUAL REQ-DX-2 3YR

RUN TYPE- X/Q SEC/M3

DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	2.99E-07	2.78E-07	1.48E-07	1.01E-07	1.04E-07	5.08E-08	1.59E-08	8.39E-09	5.56E-09	4.06E-09
NNE	2.25E-07	9.84E-08	8.51E-08	6.39E-08	5.02E-08	3.44E-08	1.09E-08	5.80E-09	3.86E-09	2.84E-09
NE	1.60E-07	8.54E-08	6.30E-08	5.01E-08	3.64E-08	2.88E-08	9.08E-09	4.77E-09	3.17E-09	2.33E-09
ENE	9.00E-08	1.40E-07	6.66E-08	4.13E-08	3.04E-08	1.84E-08	6.42E-09	3.61E-09	2.46E-09	1.84E-09
E	2.19E-07	1.51E-07	9.50E-08	5.75E-08	4.18E-08	2.01E-08	6.90E-09	3.85E-09	2.61E-09	1.95E-09
ESE	1.10E-07	1.07E-07	9.39E-08	5.61E-08	4.08E-08	2.46E-08	8.44E-09	4.69E-09	3.18E-09	2.37E-09
SE	1.52E-07	1.23E-07	7.45E-08	4.80E-08	3.54E-08	2.49E-08	8.32E-09	4.59E-09	3.09E-09	2.29E-09
SSE	2.04E-07	1.05E-07	6.94E-08	4.70E-08	3.69E-08	3.04E-08	1.04E-08	5.81E-09	3.94E-09	2.93E-09
S	8.87E-08	7.16E-08	4.71E-08	3.28E-08	3.20E-08	1.99E-08	6.92E-09	3.92E-09	2.67E-09	1.99E-09
SSW	4.04E-08	6.66E-08	4.35E-08	2.95E-08	2.88E-08	1.95E-08	6.40E-09	3.47E-09	2.32E-09	1.70E-09
SW	2.16E-08	6.74E-08	4.75E-08	3.47E-08	2.54E-08	1.79E-08	5.73E-09	3.07E-09	2.04E-09	1.49E-09
WSW	2.08E-08	7.58E-08	4.75E-08	3.34E-08	2.53E-08	1.70E-08	5.33E-09	2.81E-09	1.86E-09	1.35E-09
W	3.31E-08	9.49E-08	5.64E-08	5.40E-08	3.71E-08	1.54E-08	4.76E-09	2.50E-09	1.63E-09	1.18E-09
WNW	5.64E-08	1.41E-07	9.87E-08	5.78E-08	4.42E-08	2.58E-08	7.78E-09	4.00E-09	2.61E-09	1.89E-09
NW	1.12E-07	2.33E-07	1.17E-07	6.89E-08	5.71E-08	3.17E-08	9.73E-09	5.04E-09	3.31E-09	2.41E-09
NNW	2.24E-07	2.40E-07	1.19E-07	7.29E-08	5.26E-08	4.26E-08	1.29E-08	6.61E-09	4.35E-09	3.17E-09

RUN TYPE- DEPLETED X/Q SEC/M3

DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	2.94E-07	2.67E-07	1.41E-07	9.47E-08	9.64E-08	4.56E-08	1.31E-08	6.18E-09	3.75E-09	2.56E-09
NNE	2.21E-07	9.41E-08	8.06E-08	6.00E-08	4.68E-08	3.09E-08	9.03E-09	4.33E-09	2.65E-09	1.82E-09
NE	1.58E-07	8.17E-08	5.96E-08	4.71E-08	3.40E-08	2.58E-08	7.26E-09	3.32E-09	1.96E-09	1.32E-09
ENE	8.87E-08	1.34E-07	6.32E-08	3.90E-08	2.86E-08	1.71E-08	5.70E-09	3.04E-09	1.99E-09	1.43E-09
E	2.14E-07	1.45E-07	8.96E-08	5.40E-08	3.91E-08	1.86E-08	6.16E-09	3.31E-09	2.17E-09	1.57E-09
ESE	1.08E-07	1.02E-07	8.81E-08	5.24E-08	3.78E-08	2.24E-08	7.22E-09	3.73E-09	2.38E-09	1.69E-09
SE	1.50E-07	1.18E-07	7.04E-08	4.49E-08	3.28E-06	2.27E-08	7.34E-09	3.90E-09	2.55E-09	1.83E-09
SSE	2.01E-07	1.01E-07	6.58E-08	4.40E-08	3.41E-08	2.76E-08	9.16E-09	4.98E-09	3.29E-09	2.39E-09
S	8.74E-08	6.92E-08	4.49E-08	3.09E-08	2.96E-08	1.83E-08	6.29E-09	3.55E-09	2.40E-09	1.76E-09
SSW	3.97E-08	6.46E-08	4.15E-08	2.77E-08	2.64E-08	1.74E-08	5.45E-09	2.80E-09	1.79E-09	1.27E-09
SW	2.12E-08	6.55E-08	4.52E-08	3.23E-08	2.34E-08	1.59E-08	4.90E-09	2.52E-09	1.62E-09	1.15E-09
WSW	2.05E-08	7.34E-08	4.50E-08	3.10E-08	2.31E-08	1.48E-08	4.40E-09	2.19E-09	1.37E-09	9.61E-10
W	3.25E-08	9.14E-08	5.31E-08	4.89E-08	3.32E-08	1.35E-08	3.99E-09	2.01E-09	1.27E-09	8.95E-10
WNW	5.55E-08	1.35E-07	9.22E-08	5.31E-08	4.00E-08	2.21E-08	5.99E-09	2.71E-09	1.59E-09	1.06E-09
NW	1.10E-07	2.23E-07	1.10E-07	6.40E-08	5.22E-08	2.77E-08	7.64E-09	3.46E-09	2.04E-09	1.36E-09
NNW	2.19E-07	2.30E-07	1.12E-07	6.85E-08	4.90E-08	3.66E-08	9.75E-09	4.27E-09	2.46E-09	1.62E-09

RUN TYPE- DEPOSITION D/Q M-2

DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	2.20E-08	5.59E-09	1.78E-09	8.52E-10	5.28E-10	2.07E-10	5.52E-11	2.68E-11	1.72E-11	1.14E-11
NNE	1.83E-08	3.47E-09	1.24E-09	5.96E-10	3.68E-10	1.36E-10	3.50E-11	1.68E-11	1.07E-11	7.14E-12
NE	1.34E-08	2.52E-09	8.44E-10	4.02E-10	2.47E-10	1.22E-10	3.63E-11	1.53E-11	8.71E-12	5.41E-12
ENE	7.17E-09	1.78E-09	5.22E-10	2.39E-10	1.46E-10	4.78E-11	1.10E-11	5.20E-12	3.51E-12	2.53E-12
E	1.54E-08	2.87E-09	8.80E-10	4.00E-10	2.42E-10	7.88E-11	1.77E-11	7.95E-12	5.13E-12	3.64E-12
ESE	9.33E-09	2.86E-09	1.02E-09	4.65E-10	2.82E-10	9.46E-11	2.22E-11	1.04E-11	6.80E-12	4.64E-12
SE	1.25E-08	3.85E-09	1.31E-09	6.31E-10	3.90E-10	1.27E-10	2.78E-11	1.21E-11	7.61E-12	5.32E-12
SSE	1.72E-08	4.33E-09	1.57E-09	7.81E-10	4.87E-10	1.63E-10	3.55E-11	1.51E-11	9.30E-12	6.43E-12
S	7.53E-09	2.30E-09	8.47E-10	4.27E-10	2.75E-10	9.20E-11	1.99E-11	8.21E-12	4.88E-12	3.41E-12
SSW	3.35E-09	1.63E-09	6.23E-10	3.18E-10	2.09E-10	6.74E-11	1.44E-11	6.17E-12	3.92E-12	2.72E-12
SW	1.85E-09	1.55E-09	6.18E-10	3.22E-10	2.01E-10	6.63E-11	1.36E-11	5.57E-12	3.39E-12	2.33E-12
WSW	2.06E-09	1.56E-09	5.97E-10	3.09E-10	1.94E-10	6.34E-11	1.33E-11	5.51E-12	3.41E-12	2.32E-12
W	3.33E-09	2.01E-09	7.44E-10	4.01E-10	2.44E-10	7.65E-11	1.60E-11	6.51E-12	3.92E-12	2.69E-12
WNW				[illegible]	2.51E-10	1.44E-10	3.81E-11	1.52E-11	8.55E-12	5.22E-12
NW								[illegible]	[illegible]	[illegible]

Table 3-9

Duane Arnold — Atmospheric Dispersion Factors for Reactor Bldg Vent

ATM[illegible]IC DISPERSION FACTORS FOR-DUANE ARNOLD VE[illegible]ACTOR BUILDING SEASON-GRAZING REQ-DX-3 3YR [illegible]SPLT

RUN TYPE- X/Q SEC/M3 — DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	2.19E-06	2.39E-06	1.06E-06	7.29E-07	9.00E-07	3.87E-07	1.14E-07	5.73E-08	3.78E-08	2.78E-08
NNE	1.53E-06	6.10E-07	4.91E-07	4.13E-07	3.67E-07	2.79E-07	8.36E-08	4.23E-08	2.81E-08	2.07E-08
NE	8.84E-07	4.88E-07	3.35E-07	3.40E-07	2.56E-07	2.09E-07	6.23E-08	3.13E-08	2.08E-08	1.53E-08
ENE	6.25E-07	1.12E-06	4.91E-07	2.97E-07	2.15E-07	1.19E-07	3.70E-08	1.91E-08	1.27E-08	9.44E-09
E	1.20E-06	7.96E-07	4.82E-07	2.70E-07	1.85E-07	7.81E-08	2.39E-08	1.23E-08	8.17E-09	6.03E-09
ESE	6.97E-07	4.07E-07	3.29E-07	1.85E-07	1.28E-07	6.20E-08	1.85E-08	9.36E-09	6.18E-09	4.53E-09
SE	1.09E-06	4.81E-07	2.22E-07	1.30E-07	9.31E-08	6.53E-08	1.96E-08	1.00E-08	6.59E-09	4.83E-09
SSE	1.13E-06	3.48E-07	1.70E-07	1.02E-07	7.59E-08	6.29E-08	1.91E-08	9.79E-09	6.46E-09	4.73E-09
S	6.36E-07	2.92E-07	1.46E-07	9.25E-08	9.40E-08	5.84E-08	1.81E-08	9.42E-09	6.25E-09	4.59E-09
SSW	4.73E-07	3.68E-07	2.01E-07	1.35E-07	1.79E-07	1.42E-07	4.27E-08	2.17E-08	1.44E-08	1.06E-08
SW	3.40E-07	4.59E-07	2.82E-07	2.27E-07	1.78E-07	2.49E-07	7.80E-08	4.05E-08	2.71E-08	2.01E-08
WSW	3.84E-07	4.09E-07	2.14E-07	1.70E-07	1.64E-07	3.29E-07	1.05E-07	5.46E-08	3.67E-08	2.74E-08
W	5.04E-07	6.24E-07	3.28E-07	6.76E-07	4.85E-07	2.23E-07	7.23E-08	3.83E-08	2.57E-08	1.92E-08
WNW	6.60E-07	8.50E-07	5.93E-07	3.64E-07	3.43E-07	2.29E-07	6.78E-08	3.40E-08	2.25E-08	1.65E-08
NW	1.02E-06	1.99E-06	9.40E-07	5.52E-07	5.14E-07	2.54E-07	7.45E-08	3.73E-08	2.46E-08	1.80E-08
NNW	2.27E-06	2.48E-06	1.07E-06	6.42E-07	4.67E-07	3.49E-07	1.02E-07	5.10E-08	3.36E-08	2.47E-08

RUN TYPE- DEPLETED X/Q SEC/M3 — DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	2.05E-06	2.30E-06	1.02E-06	7.01E-07	7.52E-07	2.64E-07	6.62E-08	2.80E-08	1.61E-08	1.06E-08
NNE	1.44E-06	5.82E-07	4.71E-07	3.99E-07	3.51E-07	1.94E-07	4.97E-08	2.12E-08	1.22E-08	8.08E-09
NE	8.32E-07	4.62E-07	3.20E-07	3.28E-07	2.45E-07	1.33E-07	3.34E-08	1.41E-08	8.14E-09	5.39E-09
ENE	5.90E-07	1.06E-06	4.66E-07	2.82E-07	2.02E-07	9.44E-08	2.54E-08	1.10E-08	6.39E-09	4.24E-09
E	1.13E-06	7.55E-07	4.37E-07	2.43E-07	1.65E-07	6.34E-08	1.69E-08	7.34E-09	4.23E-09	2.80E-09
ESE	6.53E-07	3.81E-07	2.96E-07	1.66E-07	1.13E-07	4.49E-08	1.15E-08	4.93E-09	2.83E-09	1.86E-09
SE	1.02E-06	4.52E-07	2.08E-07	1.22E-07	8.66E-08	5.16E-08	1.35E-08	5.82E-09	3.34E-09	2.20E-09
SSE	1.06E-06	3.27E-07	1.60E-07	9.48E-08	7.02E-08	5.04E-08	1.33E-08	5.81E-09	3.34E-09	2.19E-09
S	5.95E-07	2.78E-07	1.39E-07	8.74E-08	8.82E-08	5.05E-08	1.38E-08	6.21E-09	3.64E-09	2.43E-09
SSW	4.41E-07	3.53E-07	1.92E-07	1.29E-07	1.71E-07	1.07E-07	2.78E-08	1.19E-08	6.86E-09	4.54E-09
SW	3.19E-07	4.42E-07	2.71E-07	2.19E-07	1.71E-07	2.01E-07	5.48E-08	2.40E-08	1.39E-08	9.28E-09
WSW	3.63E-07	3.90E-07	2.03E-07	1.62E-07	1.57E-07	2.62E-07	7.22E-08	3.17E-08	1.84E-08	1.23E-08
W	4.76E-07	5.98E-07	3.13E-07	6.32E-07	4.49E-07	1.91E-07	5.43E-08	2.43E-08	1.42E-08	9.48E-09
WNW	6.22E-07	8.06E-07	5.64E-07	3.47E-07	3.20E-07	1.48E-07	3.70E-08	1.56E-08	8.99E-09	5.93E-09
NW	9.74E-07	1.92E-06	8.99E-07	5.28E-07	4.54E-07	1.63E-07	4.05E-08	1.71E-08	9.78E-09	6.44E-09
NNW	2.15E-06	2.40E-06	1.04E-06	6.23E-07	4.49E-07	2.10E-07	5.12E-08	2.15E-08	1.24E-08	8.14E-09

RUN TYPE- DEPOSITION D/Q M-2 — DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	7.58E-08	8.27E-09	2.24E-09	1.09E-09	1.11E-09	4.54E-10	9.82E-11	3.63E-11	1.84E-11	1.14E-11
NNE	6.00E-08	5.23E-09	1.53E-09	7.17E-10	4.86E-10	2.75E-10	6.01E-11	2.22E-11	1.13E-11	6.97E-12
NE	3.54E-08	3.50E-09	9.93E-10	4.98E-10	3.15E-10	1.73E-10	3.62E-11	1.33E-11	6.77E-12	4.19E-12
ENE	2.57E-08	2.90E-09	7.91E-10	3.89E-10	2.51E-10	1.15E-10	2.79E-11	1.05E-11	5.44E-12	3.32E-12
E	4.27E-08	3.11E-09	9.34E-10	4.64E-10	2.96E-10	1.14E-10	2.77E-11	1.05E-11	5.46E-12	3.34E-12
ESE	2.81E-08	3.00E-09	9.35E-10	4.52E-10	2.82E-10	1.12E-10	2.44E-11	9.04E-12	4.62E-12	2.85E-12
SE	4.22E-08	4.20E-09	1.16E-09	5.25E-10	3.12E-10	1.55E-10	3.64E-11	1.38E-11	7.21E-12	4.44E-12
SSE	4.53E-08	4.24E-09	1.24E-09	5.66E-10	3.42E-10	1.63E-10	3.84E-11	1.46E-11	7.65E-12	4.71E-12
S	2.49E-08	2.62E-09	7.68E-10	3.54E-10	2.13E-10	1.11E-10	2.98E-11	1.16E-11	6.26E-12	3.32E-12
SSW	1.74E-08	2.21E-09	6.57E-10	3.04E-10	1.89E-10	1.43E-10	3.46E-11	1.30E-11	6.58E-12	4.07E-12
SW	1.40E-08	2.36E-09	7.20E-10	3.34E-10	2.02E-10	1.70E-10	4.52E-11	1.71E-11	8.85E-12	5.32E-12
WSW	1.51E-08	2.23E-09	6.62E-10	3.06E-10	1.84E-10	1.45E-10	3.70E-11	1.39E-11	7.19E-12	4.34E-12
W	1.73E-08	2.60E-09	7.53E-10	4.95E-10	3.43E-10	1.53E-10	4.18E-11	1.59E-11	8.33E-12	5.00E-12
[illegible]	[illegible]	[illegible]	1.06E-09	4.89E-10	3.57E-10	1.82E-10	3.84E-11	1.42E-11	7.18E-12	4.45E-12

ATM[illegible]RIC DISPERSION FACTORS FOR-DUANE ARNOLD V[illegible]ACTOR BUILDING SEASON-ANNUAL REQ-DX-4 3YR [illegible] SPLT

RUN TYPE- X/Q SEC/M3 DISTAN[illegible]METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	1.74E-06	2.12E-06	9.19E-07	6.20E-07	7.44E-07	3.17E-07	9.29E-08	4.66E-08	3.07E-08	2.25E-08
NNE	1.16E-06	5.33E-07	4.12E-07	3.41E-07	3.00E-07	2.21E-07	6.62E-08	3.34E-08	2.21E-08	1.63E-08
NE	7.84E-07	4.59E-07	3.06E-07	3.02E-07	2.25E-07	1.75E-07	5.22E-08	2.62E-08	1.74E-08	1.23E-08
ENE	5.44E-07	1.02E-06	4.17E-07	2.44E-07	1.73E-07	8.95E-08	2.73E-08	1.40E-08	9.28E-09	6.85E-09
E	1.28E-06	8.77E-07	4.86E-07	2.67E-07	1.81E-07	7.42E-08	2.23E-08	1.14E-08	7.54E-09	5.54E-09
ESE	9.79E-07	5.60E-07	3.90E-07	2.10E-07	1.41E-07	6.18E-08	1.80E-08	8.98E-09	5.87E-09	4.27E-09
SE	1.27E-06	7.06E-07	3.08E-07	1.74E-07	1.21E-07	7.09E-08	2.06E-08	1.03E-08	6.73E-09	4.87E-09
SSE	1.40E-06	4.84E-07	2.21E-07	1.28E-07	9.27E-08	6.31E-08	1.84E-08	9.27E-09	6.04E-09	4.37E-09
S	7.47E-07	3.80E-07	1.80E-07	1.10E-07	1.04E-07	5.63E-08	1.68E-08	8.57E-09	5.61E-09	4.08E-09
SSW	5.05E-07	3.95E-07	1.98E-07	1.26E-07	1.49E-07	1.09E-07	3.23E-08	1.63E-08	1.08E-08	7.91E-09
SW	4.09E-07	5.07E-07	2.72E-07	1.98E-07	1.48E-07	1.69E-07	5.21E-08	2.68E-08	1.78E-08	1.32E-08
WSW	3.40E-07	4.47E-07	2.11E-07	1.51E-07	1.32E-07	2.04E-07	6.40E-08	3.31E-08	2.21E-08	1.64E-08
W	4.75E-07	6.17E-07	2.96E-07	4.67E-07	3.29E-07	1.46E-07	4.62E-08	2.42E-08	1.62E-08	1.20E-08
WNW	7.46E-07	8.58E-07	5.10E-07	2.98E-07	2.60E-07	1.58E-07	4.61E-08	2.30E-08	1.51E-08	1.10E-08
NW	9.54E-07	1.62E-06	7.25E-07	4.16E-07	3.72E-07	1.77E-07	5.16E-08	2.57E-08	1.69E-08	1.23E-08
NNW	1.77E-06	2.24E-06	9.34E-07	5.49E-07	3.92E-07	2.68E-07	7.77E-08	3.87E-08	2.54E-08	1.86E-08

RUN TYPE- DEPLETED X/Q SEC/M3 DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	1.62E-06	2.04E-06	8.82E-07	5.93E-07	6.15E-07	2.13E-07	5.33E-08	2.25E-08	1.29E-08	8.48E-09
NNE	1.08E-06	5.08E-07	3.93E-07	3.27E-07	2.86E-07	1.52E-07	3.88E-08	1.65E-08	9.49E-09	6.27E-09
NE	7.36E-07	4.36E-07	[illegible]E-07	2.90E-07	2.14E-07	1.10E-07	2.76E-08	1.16E-08	6.71E-09	4.44E-09
ENE	5.12E-07	9.56E-07	[illegible]E-07	2.29E-07	1.60E-07	6.94E-08	1.83E-08	7.92E-09	4.56E-09	3.02E-09
E	1.20E-06	8.26E-07	4.33E-07	2.35E-07	1.57E-07	5.87E-08	1.54E-08	6.64E-09	3.81E-09	2.51E-09
ESE	9.03E-07	5.22E-07	3.40E-07	1.81E-07	1.19E-07	4.23E-08	1.05E-08	4.43E-09	2.52E-09	1.65E-09
SE	1.17E-06	6.60E-07	2.86E-07	1.61E-07	1.11E-07	5.38E-08	1.35E-08	5.77E-09	3.28E-09	2.13E-09
SSE	1.28E-06	4.51E-07	2.04E-07	1.17E-07	8.36E-08	4.78E-08	1.22E-08	5.21E-09	2.96E-09	1.93E-09
S	6.86E-07	3.59E-07	1.69E-07	1.02E-07	9.50E-08	4.69E-08	1.24E-08	5.44E-09	3.15E-09	2.08E-09
SSW	4.65E-07	3.76E-07	1.87E-07	1.19E-07	1.41E-07	8.09E-08	2.07E-08	8.85E-09	5.08E-09	3.34E-09
SW	3.77E-07	4.83E-07	2.57E-07	1.86E-07	1.39E-07	1.34E-07	3.60E-08	1.57E-08	9.07E-09	6.01E-09
WSW	3.16E-07	4.24E-07	1.97E-07	1.40E-07	1.23E-07	1.60E-07	4.34E-08	1.89E-08	1.10E-08	7.31E-09
W	4.43E-07	5.85E-07	2.78E-07	4.27E-07	2.98E-07	1.22E-07	3.40E-08	1.51E-08	8.78E-09	5.84E-09
WNW	6.89E-07	8.04E-07	4.73E-07	2.76E-07	2.36E-07	1.01E-07	2.49E-08	1.04E-08	5.97E-09	3.91E-09
NW	8.99E-07	1.54E-06	6.83E-07	3.91E-07	3.23E-07	1.13E-07	2.78E-08	1.17E-08	6.67E-09	4.37E-09
NNW	1.67E-06	2.16E-06	9.01E-07	5.29E-07	3.75E-07	1.60E-07	3.88E-08	1.62E-08	9.30E-09	6.10E-09

RUN TYPE- DEPOSITION D/Q M-2 DISTANCE (METERS)

IN DIRECTION SECTOR	1609	2413	4022	5631	7240	12067	24135	40225	56315	72405
N	6.09E-08	7.50E-09	2.03E-09	9.87E-10	9.99E-10	4.05E-10	8.71E-11	3.22E-11	1.64E-11	1.01E-11
NNE	4.52E-08	4.30E-09	1.27E-09	6.00E-10	4.12E-10	2.32E-10	5.04E-11	1.86E-11	9.47E-12	5.84E-12
NE	3.00E-08	3.11E-09	8.88E-10	4.52E-10	2.89E-10	1.60E-10	3.33E-11	1.23E-11	6.22E-12	3.86E-12
ENE	2.15E-08	2.55E-09	7.03E-10	3.51E-10	2.30E-10	1.06E-10	2.53E-11	9.51E-12	4.92E-12	3.01E-12
E	4.51E-08	3.43E-09	1.06E-09	5.28E-10	3.38E-10	1.30E-10	3.11E-11	1.17E-11	6.08E-12	3.72E-12
ESE	3.47E-08	4.18E-09	1.35E-09	6.59E-10	4.13E-10	1.62E-10	3.46E-11	1.28E-11	6.52E-12	4.03E-12
SE	4.75E-08	5.70E-09	1.58E-09	7.13E-10	4.24E-10	2.13E-10	4.91E-11	1.84E-11	9.57E-12	5.93E-12
SSE	5.37E-08	5.93E-09	1.75E-09	8.04E-10	4.85E-10	2.20E-10	5.01E-11	1.89E-11	9.84E-12	6.06E-12
S	2.61E-08	3.40E-09	1.01E-09	4.69E-10	2.85E-10	1.38E-10	3.53E-11	1.36E-11	7.24E-12	4.41E-12
SSW	1.76E-08	2.69E-09	8.03E-10	3.73E-10	2.29E-10	1.43E-10	3.36E-11	1.25E-11	6.45E-12	3.94E-12
SW	1.57E-08	3.22E-09	9.88E-10	4.58E-10	2.76E-10	1.63E-10	4.04E-11	1.52E-11	7.88E-12	4.77E-12
WSW	1.36E-08	2.73E-09	8.16E-10	3.78E-10	2.27E-10	1.31E-10	3.14E-11	1.18E-11	6.07E-12	3.69E-12
W	1.71E-08	3.07E-09	8.93E-10	5.30E-10	3.47E-10	1.40E-10	3.58E-11	1.35E-11	7.08E-12	4.23E-12
WNW	2.78E-08	4.78E-09	1.40E-09	6.32E-10	4.31E-10	1.93E-10	4.03E-11	1.48E-11	7.53E-12	4.67E-12

Table 3-10

Determination of Meteorological Parameters
for All Food Pathways (Grazing Season Values)

Direction	Distance	Sector Fraction	Stack X/Q sec/m^3	Stack Specific Deposition 1/m^2	Vent X/Q sec/m^3	Vent Specific Depositio 1/m^2
N	1-5	0.01	1.65E-07	2.07E-09	1.06E-06	2.24E-09
	5-10	0.03	6.25E-08	2.39E-10	3.87E-07	4.54E-10
	10-20	0.12	2.01E-08	6.47E-11	1.14E-07	9.82E-11
	20-30	0.20	1.08E-08	3.19E-11	5.73E-08	3.63E-11
	30-40	0.28	7.19E-09	2.06E-11	3.78E-08	1.84E-11
	40-50	0.36	5.30E-09	1.37E-11	2.78E-08	1.14E-11
	Total		1.20E-08	5.27E-11	6.79E-08	6.43E-11
NNE	1-5	0.01	9.47E-08	1.57E-09	4.91E-07	1.53E-09
	5-10	0.03	4.15E-08	1.68E-10	2.79E-07	2.75E-10
	10-20	0.12	1.35E-08	4.32E-11	8.36E-08	6.01E-11
	20-30	0.20	7.23E-09	2.08E-11	4.23E-08	2.22E-11
	30-40	0.28	4.84E-09	1.33E-11	2.81E-08	1.13E-11
	40-50	0.36	3.58E-09	8.88E-12	2.07E-08	6.97E-12
	Total		7.90E-09	3.70E-11	4.71E-08	4.09E-11
NE	1-5	0.01	6.75E-08	1.03E-09	3.35E-07	9.93E-10
	5-10	0.03	3.26E-08	1.38E-10	2.09E-07	1.73E-10
	10-20	0.12	1.04E-08	4.02E-11	6.23E-08	3.62E-11
	20-30	0.20	5.48E-09	1.72E-11	3.13E-08	1.33E-11
	30-40	0.28	3.66E-09	9.89E-12	2.08E-08	6.77E-12
	40-50	0.36	2.70E-09	6.19E-12	1.53E-08	4.19E-12
	Total		5.99E-09	2.77E-11	3.47E-08	2.55E-11
ENE	1-5	0.01	7.15E-08	6.07E-10	4.91E-07	7.91E-10
	5-10	0.03	2.07E-08	5.55E-11	1.19E-07	1.15E-10
	10-20	0.02	7.32E-09	1.28E-11	3.70E-08	2.79E-11
	20-30	0.20	4.15E-09	6.06E-12	1.91E-08	1.05E-11
	30-40	0.28	2.84E-09	4.05E-12	1.27E-08	5.44E-12
	40-50	0.36	2.13E-09	2.90E-12	9.44E-09	3.32E-12
	Total		4.61E-09	1.27E-11	2.37E-08	1.95E-11
E	1-5	0.01	9.06E-08	8.41E-10	4.82E-07	9.34E-10
	5-10	0.03	2.08E-08	7.60E-11	7.81E-08	1.14E-10
	10-20	0.12	7.33E-09	1.74E-11	2.39E-08	2.77E-11
	20-30	0.20	4.16E-09	7.87E-12	1.23E-08	1.05E-11
	30-40	0.28	2.85E-09	5.04E-12	8.17E-09	5.46E-12
	40-50	0.36	3.14E-09	3.55E-12	6.03E-09	3.34E-12
	Total		4.81E-09	1.70E-11	1.69E-08	2.09E-11

Table 3-10

Determination of Meteorological Parameters
for All Food Pathways (Grazing Season Values)

Direction	Distance	Sector Fraction	Stack X/Q sec/m^3	Stack Specific Deposition 1/m^2	Vent X/Q sec/m^3	Vent Specific Depositi 1/m^2
ESE	1-5	0.01	7.02E-08	7.08E-10	3.29E-07	9.35E-10
	5-10	0.03	2.32E-08	6.52E-11	6.20E-08	1.12E-10
	10-20	0.12	8.46E-09	1.53E-11	1.85E-08	2.44E-11
	20-30	0.20	4.86E-09	7.24E-12	9.36E-09	9.04E-12
	30-40	0.28	3.34E-09	4.74E-12	6.18E-09	4.62E-12
	40-50	0.36	2.52E-09	3.26E-12	4.53E-09	2.85E-12
	Total		5.23E-09	1.48E-11	1.26E-08	1.98E-11
SE	1-5	0.01	5.80E-08	1.02E-09	2.22E-07	1.16E-09
	5-10	0.03	2.51E-08	9.74E-11	6.53E-08	1.55E-10
	10-20	0.12	8.93E-09	2.21E-11	1.96E-08	3.64E-11
	20-30	0.20	5.10E-09	9.93E-12	1.00E-08	1.38E-11
	30-40	0.28	3.49E-09	6.35E-12	6.59E-09	7.21E-12
	40-50	0.36	2.62E-09	4.47E-12	4.83E-09	4.44E-12
	Total		5.43E-09	2.11E-11	1.21E-08	2.70E-11
SSE	1-5	0.01	5.06E-08	1.20E-09	1.70E-07	1.24E-09
	5-10	0.03	2.76E-08	1.20E-10	6.29E-08	1.63E-10
	10-20	0.12	1.00E-08	2.71E-11	1.91E-08	3.84E-11
	20-30	0.20	5.83E-09	1.21E-11	9.79E-09	1.46E-11
	30-40	0.28	4.02E-09	7.64E-12	6.46E-09	7.65E-12
	40-50	0.36	3.03E-09	5.38E-12	4.73E-09	4.71E-12
	Total		5.92E-09	2.53E-11	1.13E-08	2.87E-11
S	1-5	0.01	3.78E-08	7.34E-10	1.46E-07	7.68E-10
	5-10	0.03	1.94E-08	7.67E-11	5.84E-08	1.11E-10
	10-20	0.12	7.14E-09	1.72E-11	1.81E-08	2.98E-11
	20-30	0.20	4.19E-09	7.40E-12	9.42E-09	1.16E-11
	30-40	0.28	2.90E-09	4.50E-12	6.25E-09	6.26E-12
	40-50	0.36	2.19E-09	3.19E-12	4.59E-09	3.82E-12
	Total		4.26E-09	1.56E-11	1.07E-08	2.00E-11
SSW	1-5	0.01	3.58E-08	4.89E-10	2.01E-07	6.57E-10
	5-10	0.03	2.15E-08	5.24E-11	1.42E-07	1.43E-10
	10-20	0.02	7.30E-09	1.17E-11	4.27E-08	3.46E-11
	20-30	0.20	4.03E-09	5.40E-12	2.17E-08	1.30E-11
	30-40	0.28	2.73E-09	3.65E-12	1.44E-08	6.68E-12
	40-50	0.36	2.03E-09	2.63E-12	1.06E-08	4.07E-12
	Total		4.18E-09	1.09E-11	2.36E-08	2.09E-11

Table 3-10

Determination of Meteorological Parameters for All Food Pathways (Grazing Season Values)

Direction	Distance	Sector Fraction	Stack X/Q sec/m^3	Stack Specific Deposition 1/m^2	Vent X/Q sec/m^3	Vent Specific Deposition 1/m^2
SW	1-5	0.01	4.14E-08	4.79E-10	2.82E-07	7.20E-10
	5-10	0.03	2.07E-08	5.12E-11	2.49E-07	1.70E-10
	10-20	0.12	7.11E-09	1.09E-11	7.80E-08	4.52E-11
	20-30	0.20	3.97E-09	4.65E-12	4.05E-08	1.71E-11
	30-40	0.25	2.69E-09	3.02E-12	2.71E-08	8.85E-12
	40-50	0.36	2.00E-09	2.18E-12	2.01E-08	5.32E-12
	Total		4.16E-09	1.02E-11	4.26E-08	2.55E-11
WSW	1-5	0.01	4.24E-08	4.53E-10	2.14E-07	6.62E-10
	5-10	0.03	2.09E-08	4.81E-11	3.29E-07	1.45E-10
	10-20	0.12	7.01E-09	1.06E-11	1.05E-07	3.70E-11
	20-30	0.20	3.85E-09	4.81E-12	5.46E-08	1.39E-11
	30-40	0.28	2.60E-09	3.24E-12	3.67E-08	7.19E-12
	40-50	0.36	1.92E-09	2.31E-12	2.74E-08	4.34E-12
	Total		4.08E-09	9.96E-12	5.57E-08	2.18E-11
W	1-5	0.01	4.53E-08	5.57E-10	3.28E-07	7.53E-10
	5-10	0.03	1.48E-08	5.68E-11	2.23E-07	1.53E-10
	10-20	0.12	4.78E-09	1.22E-11	7.23E-08	4.18E-11
	20-30	0.20	2.58E-09	5.17E-12	3.83E-08	1.59E-11
	30-40	0.28	1.72E-09	3.26E-12	2.57E-08	8.33E-12
	40-50	0.36	1.26E-09	2.31E-12	1.92E-08	5.00E-12
	Total		2.92E-09	1.15E-11	4.04E-08	2.44E-11
WNW	1-5	0.01	8.78E-08	8.46E-10	5.93E-07	1.06E-09
	5-10	0.03	3.00E-08	1.23E-10	2.29E-07	1.82E-10
	10-20	0.12	9.51E-09	3.62E-11	6.78E-08	3.84E-11
	20-30	0.20	5.02E-09	1.49E-11	3.40E-08	1.42E-11
	30-40	0.28	3.34E-09	8.37E-12	2.25E-08	7.18E-12
	40-50	0.36	2.45E-09	5.12E-12	1.65E-08	4.45E-12
	Total		5.74E-09	2.37E-11	4.00E-08	2.71E-11
NW	1-5	0.01	1.28E-07	1.11E-09	9.40E-07	1.15E-09
	5-10	0.03	3.93E-08	1.70E-10	2.54E-07	2.30E-10
	10-20	0.12	1.23E-08	5.17E-11	7.45E-08	4.84E-11
	20-30	0.20	6.46E-09	2.16E-11	3.73E-08	1.78E-11
	30-40	0.28	4.28E-09	1.23E-11	2.46E-08	9.05E-12
	40-50	0.36	3.14E-09	7.50E-12	1.80E-08	5.60E-12
	Total		7.56E-09	3.29E-11	4.68E-08	3.23E-11
NNW	1-5	0.01	1.31E-07	1.17E-09	1.07E-06	1.48E-09
	5-10	0.03	5.72E-08	2.44E-10	3.49E-07	3.37E-10
	10-20	0.12	1.78E-08	7.64E-11	1.02E-07	6.95E-11
	20-30	0.20	9.25E-09	3.01E-11	5.10E-08	2.55E-11
	30-40	0.28	6.14E-09	1.62E-11	3.36E-08	1.30E-11
	40-50	0.36	4.52E-09	9.75E-12	2.47E-08	8.04E-12
	Total		1.04E-08	4.23E-11	6.19E-08	4.49E-11
Overall Total			5.94E-09	2.28E-11	3.43E-08	2.90E-11

Table 3-11

1980 Population

MILES FROM PLANT SITE

DIRECTION	0-1	1-2	2-3	3-4	4-5	5-10
N	0	5	38	61	55	2017
NNE	0	17	33	49	44	326
NE	0	17	33	44	44	317
ENE	0	17	38	55	55	734
E	0	22	72	44	73	492
ESE	0	17	30	61	100	11077
SE	0	55	76	85	126	43896
SSE	0	28	114	30	102	33118
S	0	22	22	38	18	1681
SSW	0	11	268	204	22	1015
SW	3	11	22	28	28	343
WSW	4	16	16	22	106	317
W	3	22	33	47	386	524
WNW	1	22	22	28	45	317
NW	5	6	38	28	23	327
NNW	2	0	1	22	28	985
TOTALS	18	285	858	846	1253	97486
CUMULATIVE TOTALS	18	303	1161	2007	3260	100749

Table 3-11 (cont)

DIRECTION	MILES FROM PLANT SITE 10-20	20-30	30-40	40-50	TOTALS
N	1395	3072	2052	12412	21109
NNE	1626	2438	7050	6454	18037
NE	1856	1803	4375	7613	16104
ENE	3510	2257	6822	7929	21418
E	3320	6338	3469	4519	18348
ESE	15801	3115	8026	4870	43097
SE	49755	7113	13602	7599	122308
SSE	19340	3563	47239	5475	109009
S	2495	3605	4451	5729	18061
SSW	1228	2509	5046	4398	14700
SW	1528	3259	3090	3068	11380
WSW	1205	4060	2523	5900	14169
W	882	2064	1957	5724	11641
WNW	5417	2002	5244	14274	27371
NW	1944	3804	26935	91937	125046
NNW	1670	7390	3902	13982	27980
TOTALS	112971	58392	145783	201882	619778
CUMULATIVE TOTALS	213720	272113	417896	619778	619778

Table 3-11 (cont)

MILES FROM PLANT SITE

DIRECTION	0-1	1-2	2-3	3-4	4-5	5-10
N	0	5	55	90	80	2625
NNE	0	25	50	70	65	450
NE	0	25	50	65	65	450
ENE	0	25	55	80	80	1040
E	0	30	105	65	135	880
ESE	0	25	80	160	265	32500
SE	0	80	200	250	300	77605
SSE	0	40	255	80	300	69600
S	0	30	30	55	30	6500
SSW	0	15	400	295	30	1465
SW	5	15	30	40	40	480
WSW	5	20	20	30	180	450
W	5	30	50	80	650	735
WNW	5	30	30	40	90	450
NW	5	10	55	40	35	455
NNW	5	0	5	30	40	1410
TOTALS	30	405	1470	1470	2385	197095
CUMULATIVE TOTALS	30	435	1905	3375	5760	202855

Table 3-11 (cont)

MILES FROM PLANT SITE

DIRECTION	10-20	20-30	30-40	40-50	TOTALS
N	1536	6464	4740	9280	24875
NNE	2562	4437	6048	9119	22826
NE	3588	2410	7355	8958	22966
ENE	6356	4214	7071	8179	27100
E	9124	6018	6788	7400	30545
ESE	39905	6599	20352	7404	107290
SE	70686	7180	33916	7408	197625
SSE	37721	6549	24759	7027	146331
S	4756	5918	15603	6646	39568
SSW	3243	5103	9593	4947	25091
SW	1730	4288	3584	3248	13460
WSW	2363	3328	3205	4803	14404
W	2996	2368	2826	6358	16098
WNW	2512	2791	13670	49028	68646
NW	2028	3214	24514	91698	122054
NNW	1782	4839	14627	50489	73227
TOTALS	192888	75720	198651	281992	952106
CUMULATIVE TOTALS	395743	471463	670114	952106	952106

Table 3-12

Input Parameters for Gaseous Food Pathways
(for all food grown within 50 miles)

Parameter		Exposed Vegetables—corn and grain	Milk	Meat	Fresh Vegetables[a]
Total yield	kg/yr	4.7E+09		4.4E+03	3.1E+07
	li/yr		4.8E+08		
Specific yield	kg/m^2	0.55	-	-	2.0
Absorption modifier		0.5	1.0	1.0	1.0
Preparation modifier		0.4[b]	1.0	1.0	0.4
Time to consumption	days	14	4	20	1
Meteorological Parameters:					
Stack X/Q	sec/m^3		5.94E-09		
di	$1/m^2$		2.28E-11		
Vent X/Q	sec/m^3		3.43E-08		
di	$1/m^2$		2.90E-11		

[a] In this predominantly rural community allowance is made for the total 50-mile population obtaining about 1/4 of its fruit, vegetables, and grain from home gardens (50 kg)—for conservatism all of this is taken as fresh although some would be preserved. 1980 total population of 620,000 was used in this calculation.

[b] By using this preparation modifier this corn is treated as though it were for direct human consumption. Actually most is used for animal feed and as such will show up in the meat pathway. Since this is calculated separately and thus may in effect be counted twice, this factor is used in lieu of a transfer coefficient between feed and animal. Since much shorter consumption times are used than are actually the case, the calculation should result in a conservative answer.

TABLE 3-13

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

BASE CASE -- RESIDENCE 1609 METERS NNW

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
NOBLE GAS IMMERSION (GAMMA)	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	2.14E+00	1.84E+00
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.30E+00	0.
GROUND PLANE DEPOSITION	4.47E-01	4.47E-01	4.47E-01	4.47E-01	4.47E-01	4.47E-01	5.16E-01	4.47E-01
INHALATION	1.04E-02	2.23E-02	1.13E+00	1.69E-02	1.50E-02	4.67E-03	0.	1.04E-02
STORED FRUITS AND VEGETABLES	2.49E-01	8.47E-02	2.24E-01	4.51E-02	3.04E-02	1.43E-01	0.	7.43E-02
FRESH FRUITS AND VEGETABLES	5.53E-02	2.42E-02	4.24E+00	2.88E-02	3.77E-03	3.03E-02	0.	1.71E-02
TOTAL ADULTS	2.60E+00	2.42E+00	7.88E+00	2.38E+00	2.34E+00	2.46E+00	3.96E+00	2.39E+00
TEENAGERS								
NOBLE GAS IMMERSION (GAMMA)	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	2.14E+00	1.84E+00
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.30E+00	0.
GROUND PLANE DEPOSITION	4.47E-01	4.47E-01	4.47E-01	4.47E-01	4.47E-01	4.47E-01	5.16E-01	4.47E-01
INHALATION	6.95E-03	1.68E-02	9.72E-01	1.18E-02	1.42E-02	3.06E-03	0.	7.51E-03
STORED FRUITS AND VEGETABLES	2.81E-01	1.33E-01	3.18E-01	5.47E-02	8.10E-02	1.82E-01	0.	8.83E-02
FRESH FRUITS AND VEGETABLES	4.20E-02	2.09E-02	3.27E+00	1.89E-02	5.44E-03	2.00E-02	0.	1.31E-02
TOTAL TEENAGERS	2.62E+00	2.46E+00	6.85E+00	2.37E+00	2.39E+00	2.49E+00	3.96E+00	2.40E+00
CHILDREN								
NOBLE GAS IMMERSION (GAMMA)	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	2.14E+00	1.84E+00
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.30E+00	0.
GROUND PLANE DEPOSITION	4.47E-01	4.47E-01	4.47E-01	4.47E-01	4.47E-01	4.47E-01	5.16E-01	4.47E-01
INHALATION	7.30E-03	1.25E-02	1.35E+00	6.25E-03	1.31E-02	2.39E-03	0.	6.22E-03
STORED FRUITS AND VEGETABLES	6.70E-01	2.47E-01	6.45E-01	4.51E-02	1.07E-01	2.15E-01	0.	1.45E-01
FRESH FRUITS AND VEGETABLES	7.62E-02	2.81E-02	4.92E+00	1.17E-02	5.35E-03	1.58E-02	0.	1.92E-02
TOTAL CHILDREN	3.04E+00	2.57E+00	9.20E+00	2.35E+00	2.41E+00	2.52E+00	3.96E+00	2.46E+00
INFANTS								
NOBLE GAS IMMERSION (GAMMA)	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	1.84E+00	2.14E+00	1.84E+00
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.30E+00	0.
GROUND PLANE DEPOSITION	4.47E-01	4.47E-01	4.47E-01	4.47E-01	4.47E-01	4.47E-01	5.16E-01	4.47E-01
INHALATION	9.41E-03	1.51E-02	2.32E+00	4.40E-03	1.97E-02	2.26E-03	0.	6.53E-03
TOTAL INFANTS	2.30E+00	2.30E+00	4.61E+00	2.29E+00	2.31E+00	2.29E+00	3.96E+00	2.29E+00

Doses above are based upon semi-infinite plume model for gamma dose. Use of the finite plume model for the stack release point increases the noble gas immersion gamma and total doses for each organ by 0.21 mrem/year.

TABLE 3-13

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

BASE CASE -- RESIDENCE 2650 METERS WNW

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
NOBLE GAS IMMERSION (GAMMA)	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.69E-01	4.03E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	2.84E-01	0.
GROUND PLANE DEPOSITION	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.69E-01	1.47E-01
INHALATION	2.89E-03	6.04E-03	2.27E-01	4.15E-03	3.12E-03	1.03E-03	0.	2.96E-03
STORED FRUITS AND VEGETABLES	6.85E-02	2.05E-02	4.96E-02	1.23E-02	9.21E-03	3.28E-02	0.	1.84E-02
FRESH FRUITS AND VEGETABLES	1.40E-02	5.40E-03	8.87E-01	6.37E-03	1.14E-03	6.74E-03	0.	3.94E-03
MEAT (CONTAMINATED FORAGE)	6.80E-03	2.10E-03	5.37E-02	1.76E-03	1.31E-03	2.50E-03	0.	1.87E-03
MEAT (CONTAMINATED FEED)	6.22E-03	1.54E-03	1.25E-03	1.35E-03	1.27E-07	1.69E-03	0.	1.48E-03
COWS MILK (CONTAMIN FORAGE)	1.40E-02	1.10E-02	1.50E+00	1.12E-02	1.90E-03	3.59E-03	0.	7.59E-03
COWS MILK (CONTAMIN FEED)	8.04E-03	3.63E-03	1.63E-03	2.20E-03	1.63E-03	1.64E-03	0.	2.99E-03
TOTAL ADULTS	6.70E-01	6.00E-01	3.27E+00	5.89E-01	5.70E-01	6.00E-01	9.22E-01	5.89E-01
TEENAGERS								
NOBLE GAS IMMERSION (GAMMA)	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.69E-01	4.03E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	2.84E-01	0.
GROUND PLANE DEPOSITION	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.69E-01	1.47E-01
INHALATION	1.78E-03	4.47E-03	1.96E-01	2.90E-03	2.94E-03	6.91E-04	0.	2.12E-03
STORED FRUITS AND VEGETABLES	6.75E-02	3.22E-02	7.12E-02	1.49E-02	2.15E-02	4.28E-02	0.	2.31E-02
FRESH FRUITS AND VEGETABLES	9.70E-03	4.65E-03	6.83E-01	4.18E-03	1.44E-03	4.52E-03	0.	3.05E-03
MEAT (CONTAMINATED FORAGE)	1.58E-03	1.61E-03	3.71E-02	1.04E-03	1.02E-03	1.61E-03	0.	1.31E-03
MEAT (CONTAMINATED FEED)	1.10E-03	1.19E-03	9.67E-04	7.97E-04	9.87E-04	1.19E-03	0.	1.08E-03
COWS MILK (CONTAMIN FORAGE)	1.53E-02	1.86E-02	2.26E+00	1.45E-02	3.32E-03	5.06E-03	0.	1.05E-02
COWS MILK (CONTAMIN FEED)	4.80E-03	6.06E-03	2.69E-03	2.83E-03	2.79E-03	2.63E-03	0.	3.87E-03
TOTAL TEENAGERS	6.52E-01	6.19E-01	3.80E+00	5.91E-01	5.84E-01	6.09E-01	9.22E-01	5.95E-01

Doses above are based upon semi-infinite plume model for gamma dose. Use of the finite plume model for the stack release point increases the noble gas immersion gamma and total doses for each organ by 0.06 mrem/year.

TABLE 3-13

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

BASE CASE -- RESIDENCE 2650 METERS WNW

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
CHILDREN								
NOBLE GAS IMMERSION (GAMMA)	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.69E-01	4.03E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	2.84E-01	0.
GROUND PLANE DEPOSITION	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.69E-01	1.47E-01
INHALATION	1.73E-03	3.17E-03	2.72E-01	1.54E-03	2.74E-03	5.92E-04	0.	1.64E-03
STORED FRUITS AND VEGETABLES	1.62E-01	6.27E-02	1.46E-01	1.23E-02	3.36E-02	5.64E-02	0.	4.19E-02
FRESH FRUITS AND VEGETABLES	1.77E-02	6.42E-03	1.03E+00	2.59E-03	1.69E-03	3.89E-03	0.	4.60E-03
MEAT (CONTAMINATED FORAGE)	2.92E-03	2.58E-03	5.63E-02	6.57E-04	1.87E-03	2.17E-03	0.	2.16E-03
MEAT (CONTAMINATED FEED)	2.06E-03	2.08E-03	1.61E-03	5.03E-04	1.83E-03	1.93E-03	0.	1.90E-03
COWS MILK (CONTAMIN FORAGE)	3.67E-02	3.30E-02	4.49E+00	1.19E-02	7.17E-03	7.93E-03	0.	1.87E-02
COWS MILK (CONTAMIN FEED)	1.15E-02	1.17E-02	6.40E-03	2.34E-03	6.37E-03	5.93E-03	0.	6.87E-03
TOTAL CHILDREN	7.85E-01	6.72E-01	6.55E+00	5.82E-01	6.05E-01	6.29E-01	9.22E-01	6.28E-01
INFANTS								
NOBLE GAS IMMERSION (GAMMA)	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.03E-01	4.69E-01	4.03E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	2.84E-01	0.
GROUND PLANE DEPOSITION	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.47E-01	1.69E-01	1.47E-01
INHALATION	2.15E-03	3.56E-03	4.66E-01	1.08E-03	4.07E-03	5.92E-04	0.	1.65E-03
COWS MILK (CONTAMIN FORAGE)	7.69E-02	7.65E-02	1.08E+01	1.19E-02	1.55E-02	1.44E-02	0.	3.42E-02
COWS MILK (CONTAMIN FEED)	2.41E-02	2.59E-02	1.37E-02	2.34E-03	1.36E-02	1.23E-02	0.	1.32E-02
TOTAL INFANTS	6.53E-01	6.56E-01	1.18E+01	5.65E-01	5.83E-01	5.77E-01	9.22E-01	5.99E-01

Doses above are based upon semi-infinite plume model for gamma dose. Use of the finite plume model for the stack release point increases the noble gas immersion gamma and total doses for each organ by 0.06 mrem/year.

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

BASE CASE -- RESIDENCE 3000 METERS NE

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
NOBLE GAS IMMERSION (GAMMA)	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.43E-01	2.09E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.47E-01	0.
GROUND PLANE DEPOSITION	7.95E-02	7.95E-02	7.95E-02	7.95E-02	7.95E-02	7.95E-02	9.16E-02	7.95E-02
INHALATION	1.53E-03	3.16E-03	1.14E-01	2.13E-03	1.59E-03	5.30E-04	0.	1.55E-03
STORED FRUITS AND VEGETABLES	6.65E-02	1.81E-02	4.65E-02	1.04E-02	7.50E-03	3.07E-02	0.	1.63E-02
FRESH FRUITS AND VEGETABLES	1.45E-02	5.00E-03	8.55E-01	5.96E-03	9.29E-04	6.50E-03	0.	3.66E-03
MEAT (CONTAMINATED FORAGE)	5.69E-03	1.81E-03	5.17E-02	1.49E-03	1.06E-03	2.19E-03	0.	1.59E-03
MEAT (CONTAMINATED FEED)	5.06E-03	1.28E-03	1.00E-03	1.10E-03	1.02E-03	1.42E-03	0.	1.22E-03
COWS MILK (CONTAMIN FORAGE)	1.28E-02	1.03E-02	1.44E+00	1.05E-02	1.58E-03	3.27E-03	0.	7.01E-03
COWS MILK (CONTAMIN FEED)	6.75E-03	3.21E-03	1.34E-03	1.86E-03	1.33E-03	1.35E-03	0.	2.61E-03
TOTAL ADULTS	4.01E-01	3.31E-01	2.80E+00	3.22E-01	3.04E-01	3.34E-01	4.82E-01	3.22E-01
TEENAGERS								
NOBLE GAS IMMERSION (GAMMA)	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.43E-01	2.09E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.47E-01	0.
GROUND PLANE DEPOSITION	7.95E-02	7.95E-02	7.95E-02	7.95E-02	7.95E-02	7.95E-02	9.16E-02	7.95E-02
INHALATION	9.19E-04	2.33E-03	9.85E-02	1.49E-03	1.50E-03	3.58E-04	0.	1.11E-03
STORED FRUITS AND VEGETABLES	7.43E-02	2.85E-02	6.67E-02	1.26E-02	1.84E-02	3.98E-02	0.	2.03E-02
FRESH FRUITS AND VEGETABLES	1.09E-02	4.32E-03	6.59E-01	3.91E-03	1.23E-03	4.33E-03	0.	2.84E-03
MEAT (CONTAMINATED FORAGE)	1.44E-03	1.38E-03	3.56E-02	8.82E-04	8.29E-04	1.39E-03	0.	1.11E-03
MEAT (CONTAMINATED FEED)	9.23E-04	9.88E-04	7.79E-04	6.49E-04	7.97E-04	9.87E-04	0.	8.85E-04
COWS MILK (CONTAMIN FORAGE)	1.51E-02	1.74E-02	2.18E+00	1.36E-02	2.79E-03	4.55E-03	0.	9.65E-03
COWS MILK (CONTAMIN FEED)	4.32E-03	5.37E-03	2.21E-03	2.40E-03	2.29E-03	2.16E-03	0.	3.32E-03
TOTAL TEENAGERS	3.96E-01	3.49E-01	3.33E+00	3.24E-01	3.16E-01	3.42E-01	4.82E-01	3.28E-01

TABLE 3-13

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

BASE CASE -- RESIDENCE 3000 METERS NE

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
CHILDREN								
NOBLE GAS IMMERSION (GAMMA)	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.43E-01	2.09E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.47E-01	0.
GROUND PLANE DEPOSITION	7.95E-02	7.95E-02	7.95E-02	7.95E-02	7.95E-02	7.95E-02	9.16E-02	7.95E-02
INHALATION	8.93E-04	1.65E-03	1.37E-01	7.89E-04	1.41E-03	3.13E-04	0.	8.62E-04
STORED FRUITS AND VEGETABLES	1.79E-01	5.48E-02	1.36E-01	1.04E-02	2.75E-02	5.00E-02	0.	3.61E-02
FRESH FRUITS AND VEGETABLES	1.99E-02	5.91E-03	9.90E-01	2.42E-03	1.38E-03	3.58E-03	0.	4.27E-03
MEAT (CONTAMINATED FORAGE)	2.66E-03	2.19E-03	5.41E-02	5.57E-04	1.51E-03	1.80E-03	0.	1.80E-03
MEAT (CONTAMINATED FEED)	1.72E-03	1.71E-03	1.46E-03	4.09E-04	1.43E-03	1.57E-03	0.	1.55E-03
COWS MILK (CONTAMIN FORAGE)	3.61E-02	3.06E-02	4.33E+00	1.12E-02	5.96E-03	6.78E-03	0.	1.71E-02
COWS MILK (CONTAMIN FEED)	1.03E-02	1.03E-02	5.25E-03	1.98E-03	5.21E-03	4.80E-03	0.	5.69E-03
TOTAL CHILDREN	5.39E-01	3.96E-01	5.94E+00	3.16E-01	3.33E-01	3.57E-01	4.82E-01	3.56E-01
INFANTS								
NOBLE GAS IMMERSION (GAMMA)	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.09E-01	2.43E-01	2.09E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.47E-01	0.
GROUND PLANE DEPOSITION	7.95E-02	7.95E-02	7.95E-02	7.95E-02	7.95E-02	7.95E-02	9.16E-02	7.95E-02
INHALATION	1.11E-03	1.84E-03	2.35E-01	5.55E-04	2.09E-03	3.17E-04	0.	8.63E-04
COWS MILK (CONTAMIN FORAGE)	7.57E-02	7.11E-02	1.05E+01	1.12E-02	1.30E-02	1.20E-02	0.	3.12E-02
COWS MILK (CONTAMIN FEED)	2.16E-02	2.27E-02	1.13E-02	1.98E-03	1.12E-02	9.91E-03	0.	1.08E-02
TOTAL INFANTS	3.87E-01	3.84E-01	1.10E+01	3.02E-01	3.15E-01	3.11E-01	4.82E-01	3.31E-01

TABLE 3-14

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

COST-BENEFICIAL CASE -- RESIDENCE 1609 METERS NNW

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
NOBLE GAS IMMERSION (GAMMA)	1.91E+00	1.91E+00	1.91E+00	1.91E+00	1.91E+00	1.91E+00	2.22E+00	1.91E+00
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.32E+00	0.
GROUND PLANE DEPOSITION	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.57E+00	1.35E+00
INHALATION	1.43E-02	6.93E-02	1.13E+00	1.73E-02	8.10E-02	8.18E-03	0.	1.18E-02
STORED FRUITS AND VEGETABLES	4.02E-01	1.70E-01	2.24E-01	7.04E-02	3.86E-02	1.09E+00	0.	1.70E-01
FRESH FRUITS AND VEGETABLES	7.48E-02	3.54E-02	4.24E+00	3.21E-02	4.91E-03	1.50E-01	0.	2.94E-02
TOTAL ADULTS	3.75E+00	3.53E+00	8.85E+00	3.38E+00	3.38E+00	4.51E+00	5.11E+00	3.47E+00
TEENAGERS								
NOBLE GAS IMMERSION (GAMMA)	1.91E+00	1.91E+00	1.91E+00	1.91E+00	1.91E+00	1.91E+00	2.22E+00	1.91E+00
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.32E+00	0.
GROUND PLANE DEPOSITION	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.57E+00	1.35E+00
INHALATION	7.85E-03	4.97E-02	9.72E-01	1.21E-02	7.85E-02	5.17E-03	0.	8.09E-03
STORED FRUITS AND VEGETABLES	5.34E-01	2.65E-01	3.18E-01	8.53E-02	4.40E-01	1.36E+00	0.	2.07E-01
FRESH FRUITS AND VEGETABLES	5.93E-02	3.02E-02	3.27E+00	2.10E-02	2.95E-02	1.00E-01	0.	2.13E-02
TOTAL TEENAGERS	3.86E+00	3.60E+00	7.82E+00	3.38E+00	3.81E+00	4.73E+00	5.11E+00	3.50E+00
CHILDREN								
NOBLE GAS IMMERSION (GAMMA)	1.91E+00	1.91E+00	1.91E+00	1.91E+00	1.91E+00	1.91E+00	2.22E+00	1.91E+00
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.32E+00	0.
GROUND PLANE DEPOSITION	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.57E+00	1.35E+00
INHALATION	8.66E-03	3.05E-02	1.35E+00	6.40E-03	7.09E-02	3.38E-03	0.	6.53E-03
STORED FRUITS AND VEGETABLES	1.09E+00	4.61E-01	6.45E-01	7.04E-02	1.28E-01	1.26E+00	0.	2.99E-01
FRESH FRUITS AND VEGETABLES	9.79E-02	3.92E-02	4.92E+00	1.30E-02	6.52E-03	6.89E-02	0.	2.71E-02
TOTAL CHILDREN	4.46E+00	3.79E+00	1.02E+01	3.35E+00	3.47E+00	4.59E+00	5.11E+00	3.59E+00
INFANTS								
NOBLE GAS IMMERSION (GAMMA)	1.91E+00	1.91E+00	1.91E+00	1.91E+00	1.91E+00	1.91E+00	2.22E+00	1.91E+00
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.32E+00	0.
GROUND PLANE DEPOSITION	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.35E+00	1.57E+00	1.35E+00
INHALATION	1.14E-02	2.87E-02	2.32E+00	4.50E-03	1.05E-01	2.92E-03	0.	6.76E-03
TOTAL INFANTS	3.27E+00	3.29E+00	5.58E+00	3.26E+00	3.36E+00	3.26E+00	5.11E+00	3.27E+00

Doses above are based upon semi-infinite plume model for gamma dose. Use of finite plume model for the stack release point increases the noble gas immersion gamma and total doses for each organ by 0.24 mrem/year.

TABLE 3-14

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

COST-BENEFICIAL CASE -- RESIDENCE 2650 METERS WNW

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
NOBLE GAS IMMERSION (GAMMA)	4.32E-01	4.32E-01	4.32E-01	4.32E-01	4.32E-01	4.32E-01	5.02E-01	4.32E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	2.96E-01	0.
GROUND PLANE DEPOSITION	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.97E-01	4.26E-01
INHALATION	3.66E-03	1.54E-02	2.27E-01	4.23E-03	1.60E-02	1.72E-03	0.	3.30E-03
STORED FRUITS AND VEGETABLES	1.00E-01	3.81E-02	4.96E-02	1.75E-02	1.09E-02	2.29E-01	0.	3.82E-02
FRESH FRUITS AND VEGETABLES	1.80E-02	7.71E-03	8.87E-01	7.04E-03	1.38E-03	3.14E-02	0.	6.47E-03
MEAT (CONTAMINATED FORAGE)	7.52E-03	3.45E-03	5.37E-02	2.03E-03	1.48E-03	8.55E-03	0.	3.09E-03
MEAT (CONTAMINATED FEED)	6.50E-03	2.03E-03	1.25E-03	1.47E-03	1.31E-03	3.99E-03	0.	1.98E-03
COWS MILK (CONTAMIN FORAGE)	1.80E-02	1.69E-02	1.50E+00	1.32E-02	2.52E-03	5.09E-03	0.	1.20E-02
COWS MILK (CONTAMIN FEED)	9.91E-03	6.30E-03	1.63E-03	3.12E-03	1.91E-03	2.26E-03	0.	4.97E-03
TOTAL ADULTS	1.02E+00	9.48E-01	3.58E+00	9.07E-01	8.93E-01	1.14E+00	1.29E+00	9.28E-01
TEENAGERS								
NOBLE GAS IMMERSION (GAMMA)	4.32E-01	4.32E-01	4.32E-01	4.32E-01	4.32E-01	4.32E-01	5.02E-01	4.32E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	2.96E-01	0.
GROUND PLANE DEPOSITION	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.97E-01	4.26E-01
INHALATION	1.95E-03	1.10E-02	1.96E-01	2.96E-03	1.55E-02	1.10E-03	0.	2.29E-03
STORED FRUITS AND VEGETABLES	1.20E-01	5.96E-02	7.12E-02	2.12E-02	9.56E-02	2.87E-01	0.	4.77E-02
FRESH FRUITS AND VEGETABLES	1.33E-02	6.59E-03	6.83E-01	4.62E-03	6.42E-03	2.12E-02	0.	4.75E-03
MEAT (CONTAMINATED FORAGE)	2.11E-03	2.57E-03	3.71E-02	1.20E-03	1.16E-03	4.71E-03	0.	2.07E-03
MEAT (CONTAMINATED FEED)	1.32E-03	1.55E-03	9.67E-04	8.68E-04	1.03E-03	2.33E-03	0.	1.40E-03
COWS MILK (CONTAMIN FORAGE)	2.22E-02	2.85E-02	2.26E+00	1.71E-02	4.55E-03	6.77E-03	0.	1.48E-02
COWS MILK (CONTAMIN FEED)	8.00E-03	1.06E-02	2.69E-03	4.02E-03	3.34E-03	3.33E-03	0.	5.84E-03
TOTAL TEENAGERS	1.03E+00	9.78E-01	4.11E+00	9.10E-01	9.86E-01	1.18E+00	1.29E+00	9.37E-01

Doses above are based upon semi-infinite plume model for gamma dose. Use of the finite plume model for the stack release point increases the noble gas immersion gamma and total doses for each organ by 0.08 mrem/year.

TABLE 3-14

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

COST-BENEFICIAL CASE -- RESIDENCE 2650 METERS WNW

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
CHILDREN								
NOBLE GAS IMMERSION (GAMMA)	4.32E-01	4.32E-01	4.32E-01	4.32E-01	4.32E-01	4.32E-01	5.02E-01	4.32E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	2.96E-01	0.
GROUND PLANE DEPOSITION	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.97E-01	4.26E-01
INHALATION	2.00E-03	6.74E-03	2.72E-01	1.56E-03	1.40E-02	7.86E-04	0.	1.73E-03
STORED FRUITS AND VEGETABLES	2.48E-01	1.07E-01	1.46E-01	1.75E-02	3.82E-02	2.72E-01	0.	7.37E-02
FRESH FRUITS AND VEGETABLES	2.21E-02	8.72E-03	1.03E+00	2.86E-03	1.93E-03	1.49E-02	0.	6.24E-03
MEAT (CONTAMINATED FORAGE)	3.68E-03	3.62E-03	5.63E-02	7.57E-04	1.98E-03	3.93E-03	0.	3.04E-03
MEAT (CONTAMINATED FEED)	2.39E-03	2.50E-03	1.81E-03	5.48E-04	1.87E-03	2.56E-03	0.	2.28E-03
COWS MILK (CONTAMIN FORAGE)	5.19E-02	4.93E-02	4.49E+00	1.41E-02	8.99E-03	9.22E-03	0.	2.24E-02
COWS MILK (CONTAMIN FEED)	1.86E-02	1.92E-02	6.40E-03	3.32E-03	7.20E-03	6.45E-03	0.	8.52E-03
TOTAL CHILDREN	1.21E+00	1.06E+00	6.86E+00	8.99E-01	9.32E-01	1.17E+00	1.29E+00	9.76E-01
INFANTS								
NOBLE GAS IMMERSION (GAMMA)	4.32E-01	4.32E-01	4.32E-01	4.32E-01	4.32E-01	4.32E-01	5.02E-01	4.32E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	2.96E-01	0.
GROUND PLANE DEPOSITION	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.26E-01	4.97E-01	4.26E-01
INHALATION	2.54E-03	6.26E-03	4.66E-01	1.10E-03	2.07E-02	7.21E-04	0.	1.72E-03
COWS MILK (CONTAMIN FORAGE)	1.08E-01	1.14E-01	1.08E+01	1.41E-02	1.99E-02	1.56E-02	0.	3.80E-02
COWS MILK (CONTAMIN FEED)	3.84E-02	4.31E-02	1.37E-02	3.32E-03	1.57E-02	1.28E-02	0.	1.49E-02
TOTAL INFANTS	1.01E+00	1.02E+00	1.21E+01	8.77E-01	9.14E-01	8.87E-01	1.29E+00	9.13E-01

Doses above are based upon semi-infinite plume model for gamma dose. Use of the finite plume model for the stack release point increases the noble gas immersion gamma and total doses for each organ by 0.08 mrem/year.

TABLE 3-14

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

COST-BENEFICIAL CASE -- RESIDENCE 3000 METERS NE

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
ADULTS								
NOBLE GAS IMMERSION (GAMMA)	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.62E-01	2.26E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.54E-01	0.
GROUND PLANE DEPOSITION	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.56E-01	2.19E-01
INHALATION	1.92E-03	7.91E-03	1.14E-01	2.17E-03	8.15E-03	8.78E-04	0.	1.73E-03
STORED FRUITS AND VEGETABLES	9.62E-02	3.45E-02	4.65E-02	1.53E-02	9.09E-03	2.14E-01	0.	3.49E-02
FRESH FRUITS AND VEGETABLES	1.82E-02	7.17E-03	8.55E-01	6.59E-03	1.15E-03	2.96E-02	0.	6.02E-03
MEAT (CONTAMINATED FORAGE)	6.36E-03	3.07E-03	5.17E-02	1.74E-03	1.22E-03	7.85E-03	0.	2.73E-03
MEAT (CONTAMINATED FEED)	3.33E-03	1.73E-03	1.00E-03	1.21E-03	1.06E-03	3.57E-03	0.	1.69E-03
COWS MILK (CONTAMIN FORAGE)	1.66E-02	1.58E-02	1.44E+00	1.24E-02	2.17E-03	4.68E-03	0.	1.11E-02
COWS MILK (CONTAMIN FEED)	8.50E-03	5.71E-03	1.34E-03	2.72E-03	1.59E-03	1.93E-03	0.	4.47E-03
TOTAL ADULTS	5.98E-01	5.21E-01	2.95E+00	4.87E-01	4.69E-01	7.08E-01	6.72E-01	5.08E-01
TEENAGERS								
NOBLE GAS IMMERSION (GAMMA)	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.62E-01	2.26E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.54E-01	0.
GROUND PLANE DEPOSITION	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.56E-01	2.19E-01
INHALATION	1.01E-03	5.67E-03	9.85E-02	1.52E-03	7.88E-03	5.67E-04	0.	1.20E-03
STORED FRUITS AND VEGETABLES	1.23E-01	5.42E-02	6.67E-02	1.85E-02	8.77E-02	2.68E-01	0.	4.33E-02
FRESH FRUITS AND VEGETABLES	1.43E-02	6.13E-03	6.59E-01	4.32E-03	5.89E-03	1.99E-02	0.	4.42E-03
MEAT (CONTAMINATED FORAGE)	1.94E-03	2.28E-03	3.56E-02	1.03E-03	9.58E-04	4.29E-03	0.	1.82E-03
MEAT (CONTAMINATED FEED)	1.13E-03	1.32E-03	7.79E-04	7.15E-04	8.37E-04	2.06E-03	0.	1.18E-03
COWS MILK (CONTAMIN FORAGE)	2.15E-02	2.66E-02	2.18E+00	1.60E-02	3.95E-03	6.15E-03	0.	1.37E-02
COWS MILK (CONTAMIN FEED)	7.32E-03	9.58E-03	2.21E-03	3.52E-03	2.82E-03	2.81E-03	0.	5.16E-03
TOTAL TEENAGERS	6.15E-01	5.51E-01	3.49E+00	4.91E-01	5.55E-01	7.49E-01	6.72E-01	5.16E-01

TABLE 3-14

MAXIMUM INDIVIDUAL DOSES FROM EXPOSURE TO GASEOUS RELEASES (MREM)

COST-BENEFICIAL CASE -- RESIDENCE 3000 METERS NE

PATHWAY/AGE GROUP	BONE	LIVER	THYROID	KIDNEY	LUNG	GI-LLI	SKIN	TOTAL BODY
CHILDREN								
NOBLE GAS IMMERSION (GAMMA)	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.62E-01	2.26E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.54E-01	0.
GROUND PLANE DEPOSITION	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.56E-01	2.19E-01
INHALATION	1.03E-03	3.47E-03	1.37E-01	8.04E-04	7.14E-03	4.11E-04	0.	9.10E-04
STORED FRUITS AND VEGETABLES	2.60E-01	9.61E-02	1.36E-01	1.53E-02	3.17E-02	2.52E-01	0.	6.59E-02
FRESH FRUITS AND VEGETABLES	2.41E-02	8.05E-03	9.90E-01	2.68E-03	1.60E-03	1.39E-02	0.	5.81E-03
MEAT (CONTAMINATED FORAGE)	3.37E-03	3.16E-03	5.41E-02	6.50E-04	1.62E-03	3.45E-03	0.	2.62E-03
MEAT (CONTAMINATED FEED)	2.03E-03	2.11E-03	1.46E-03	4.51E-04	1.52E-03	2.17E-03	0.	1.90E-03
COWS MILK (CONTAMIN FORAGE)	5.03E-02	4.58E-02	4.33E+00	1.32E-02	7.66E-03	7.99E-03	0.	2.05E-02
COWS MILK (CONTAMIN FEED)	1.69E-02	1.72E-02	5.25E-03	2.90E-03	5.99E-03	5.29E-03	0.	7.23E-03
TOTAL CHILDREN	8.03E-01	6.21E-01	6.10E+00	4.81E-01	5.02E-01	7.30E-01	6.72E-01	5.50E-01
INFANTS								
NOBLE GAS IMMERSION (GAMMA)	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.62E-01	2.26E-01
NOBLE GAS IMMERSION (BETA)	0.	0.	0.	0.	0.	0.	1.54E-01	0.
GROUND PLANE DEPOSITION	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.19E-01	2.56E-01	2.19E-01
INHALATION	1.31E-03	3.21E-03	2.35E-01	5.66E-04	1.05E-02	3.82E-04	0.	8.98E-04
COWS MILK (CONTAMIN FORAGE)	1.04E-01	1.06E-01	1.05E+01	1.32E-02	1.71E-02	1.32E-02	0.	3.47E-02
COWS MILK (CONTAMIN FEED)	3.50E-02	3.88E-02	1.13E-02	2.90E-03	1.31E-02	1.04E-02	0.	1.24E-02
TOTAL INFANTS	5.85E-01	5.93E-01	1.12E+01	4.62E-01	4.86E-01	4.69E-01	6.72E-01	4.93E-01

Table 3-15

Base Case Population Doses from Gaseous Effluents

Pathway	Population Doses Thyroid MTR/year	 Total Body man-rem/yr	 Total man-rem/yr
Via Food Chains:			
Fruits & Vegetables	4.17E+01	2.46E 00	4.42E+01
Milk	2.72E+01	4.99E-01	2.77E+01
Meat	2.99E 00	6.70E-01	3.66E 00
Total Food Paths	7.19E+01	3.66E 00	7.55E+01
Via 1980 Population[a]			
Noble Gas Immersion	3.78E 00	3.78E 00	7.56E 00
Ground Plane Deposition	6.97E-01	6.97E-01	1.39E 00
Inhalation	4.11E 00	7.73E-02	4.19E 00
Total Population Paths	8.58E 00	4.55E 00	1.31E+01
Total 1980 Population Dose	8.05E+01	8.21E 00	8.86E+01
Via 2020 Population[b]			
Noble Gas Immersion	6.93E 00	6.93E 00	1.39E+01
Ground Plane Deposition	1.31E 00	1.31E 00	2.62E 00
Inhalation	6.98E 00	1.38E-01	7.12E 00
Total Population Paths	1.52E+01	8.37E 00	2.36E+01
Total Food Paths	7.19E+01	3.66E 00	7.55E+01
Total 2020 Population Dose	8.71E+01	1.20E+01	9.91E+01

a See Table 3-11, pages 1 & 2

b See Table 3-11, pages 3 & 4

R503ERS	R501ERW	R502ERX
5/17/76	5/17/76	5/17/76
23.31.29	26.36.30	23.38.41

Table 3-16

Population Dose Reduction with Gaseous Alternates

Case	Description	1980 Population Thyroid man-rem	1980 Population Total Body man-rem	Food Pathways Thyroid man-rem	Food Pathways Total Body man-rem	Total man-rem
	Gland Seal					
D-1	Double holdup time	6.66E-03	7.06E-03	0	2.80E-03	1.65E-02
D-2	Add HEPA & charcoal	6.37E-02	2.42E-04	2.28E 00	4.64E-03	2.35E 00
	SJAE					
E-1	Operate at 0 F	1.47E 00	1.49E 00	0	1.37E-06	2.96E 00
E-2	Add 2 more beds	5.97E-01	6.04E-01	0	5.78E-07	1.20E 00
E-3	Remove 2 beds	-1.27E-01	-7.36E-01	0	-6.93E-07	-1.46E 00
	Drywell					
F-2	Remove charcoal	-1.44E 00	-3.97E-03	-2.24E+01	-4.56E-02	-2.39E+01
F-3	Remove HEPA & charcoal	-1.66E 00	-2.27E-01	-2.24E+01	-2.41E-01	-2.45E+01
	Turbine Bldg					
G-1	Add HEPA	3.97E-02	3.99E-02	1.96E-06	2.41E-02	1.04E-01
G-2	Add HEPA & charcoal	1.64E 00	4.43E-02	2.51E+01	7.50E-02	2.69E+01
G-3	Add clean steam	2.76E 00	1.36E 00	2.23E+01	6.47E-02	2.65E+01
	Auxiliary Bldg					
H-1	Add HEPA	2.22E-01	2.23E-01	1.02E-06	1.80E-01	6.25E-01
H-3	Add HEPA & charcoal	1.66E 00	2.27E-01	2.24E+01	2.26E-01	2.45E+01
	Radwaste Bldg					
I-1	Add charcoal	4.01E-01	1.12E-03	6.60E 00	1.34E-02	7.02E 00
I-2	Remove HEPA	-1.53E 00	-1.53E 00	-5.63E-07	-3.80E-01	-3.44E 00
				R537EHK 5/18/76 15.08.07	R536EHI 5/18/76 14.41.43	R561EMH 5/18/76 17.25.16

Negative values are Dose Increase

Table 3-17

Cost of Alternates

Designation	Purpose	Annual Δ Cost[a] $
	Gland Seal	
D-1	Double holdup time	6,400
D-2	Add HEPA & charcoal	14,600
	SJAE	
E-1	Operate at 0 F dewpoint	155,300
E-2	Add 2 more beds	45,800
E-3	Remove 2 beds	(45,800)
	Drywell	
F-2	Remove charcoal	(9,300)
F-3	Remove HEPA & charcoal	(18,100)
	Turbine Bldg	
G-1	Add HEPA	59,400
G-2	Add HEPA & charcoal	120,700
G-3	Add clean steam	195,800
	Auxiliary Bldg	
H-1	Add HEPA	76,200
H-3	Add HEPA & charcoal	153,100
	Radwaste Bldg	
I-1	Add charcoal	18,100
I-2	Remove HEPA	(17,300)

Values in ( ) are cost savings

[a] See Apendix A for details of cost estimating

Table 3-18

Cost-Benefit Ratios for Alternate Cases

Case	Purpose	Annual Δ Doses from Base man-rem[a]	Annual Δ Doses from Prev Case man-rem	Annual Δ Costs from Base dollars[b]	Annual Δ Costs from Prev Case dollars	Cost-Benefit Ratios from Base $/man-rem	Cost-Benefit Ratios from Prev Case $/man-rem
	Gland Seal						
D-1	Double holdup time	1.65E-02	-	>5,000	-	>3.0E+05	-
D-2	Add HEPA & charcoal	2.35E 00	-	14,600	-	6.2E+03	-
	SJAE						
E-1	Operate at 0 F dewpont	2.96E 00	-	155,300	-	5.2E+04	-
E-2	Add 2 more beds	1.20E 00	-	45,800	-	3.8E+04	-
E-3	Remove 2 beds	-1.46E 00[c]	-	-45,800[d]	-	3.1E+04	-
	Drywell						
F-2	Remove charcoal	-2.39E+01	-	-9,300	-	3.9E+02	-
F-3	Remove HEPA & charcoal	-2.45E+01	6.00E-01	-18,100	-8,800	7.4E+02	1.5E+04
	Turbine Bldg						
G-1	Add HEPA	1.04E-01	-	59,400	-	5.7E+05	-
G-2	Add HEPA & charcoal	2.69E+01	2.68E+01	120,700	61,300	4.5E+03	2.2E+03
G-3	Add clean steam	2.65E+01	-	>150,000	-	>5.7E+03	-
	Auxiliary Bldg						
H-1	Add HEPA	6.25E-01	-	76,200	-	1.2E+05	-
H-3	Add HEPA & charcoal	2.45E+01	2.39E+01	153,100	76,900	6.2E+03	3.2E+03
	Radwaste Bldg						
I-1	Add charcoal	7.02E 00	-	18,100	-	2.6E+03	-
I-2	Remove HEPA	-3.44E 00	-	-17,300	-	5.0E+03	-

a From Table 3- 16

b From Table 3- 17

c Negative dose changes are increases in dose

d Negative costs are decreases in costs

Duane Arnold

May, 1976

Revised July, 1976

Table 3- 19

Indicated Cost-Beneficial Treatment

System	Indicated Treatment
SJAE	Operate as at present with at least two fewer beds
Gland Seal	Present design
Drywell	Present Design
Turbine Bldg	Discard without treatment--Present Design
Auxiliary (Reactor) Bldg	Discard without treatment--Present Design
Radwaste Bldg	Remove HEPA and discard w/o treatment

DUANE ARNOLD NUCLEAR STATION

IOWA ELECTRIC LIGHT AND POWER COMPANY

Appendix 10.7-A

COST ESTIMATING METHODOLOGY AND DETAIL COST ESTIMATES

prepared by
Nuclear Safety Associates
Bethesda, Maryland

June 1976

Appendix 10.7-A

Reactor: Duane Arnold

INDEX

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Cost Estimating Methodology	10.7-A1
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Summary of Augment Costs	10.7-A5

DETAIL COST ESTIMATES

Case	Description	
A-2	Add demineralizer to high purity waste	10.7-A6
A-3	Delete demineralizer from high purity waste	10.7-A9
B-2	Add demineralizer to low purity waste	10.7-A12
B-3	Delete demineralizer from low purity waste	10.7-A15
C-1	Remove evaporator from chem waste	10.7-A18
C-2	Add demineralizer to chem waste treatment	10.7-A22
D-1	Double gland seal exhaust holdup time	10.7-A25
D-2	Add HEPA/Charcoal to gland seal exhaust	10.7-A28
E-1	Add OF dewpoint dryer to AOG	10.7-A30
E-2	Add two more charcoal beds to AOG	10.7-A32
E-3	Delete two charcoal beds from AOG	10.7-A34
F-1	Remove charcoal from Drywell purge	10.7-A36
F-2	Remove HEPA/Charcoal from Drywell purge	10.7-A40
G-1	Add HEPA to Turbine Bldg. vent	10.7-A44
G-2	Add HEPA/Charcoal to Turbine Bldg vent	10.7-A48
G-3	Add clean steam to valves larger than 2 1/2"	10.7-A53
H-1	Add HEPA to Reactor Bldg vent	10.7-A58
H-2	Add HEPA/Charcoal to Reactor Bldg vent	10.7-A62
I-1	Add charcoal to Radwaste Bldg vent	10.7-A66
I-2	Remove HEPA from Radwaste Bldg vent	10.7-A70

Cost Estimating Methodology

The methods used in estimating the cost of the augments are outlined in the following paragraphs.

(1) General Bases

The cost estimates for the augments were prepared using wherever possible the cost bases and data presented in NRC Regulatory Guide 1.110.*

(2) Direct Installed Costs

In most of the augment cases studied for this application there were Regulatory Guide 1.110 unit cost values which could be applied, with appropriate adjustments for size or capacity, to the augments considered. In many of the cases the unit values were used directly as outlined in the Regulatory Guide for the basic augment process systems. Support facilities such as building space, piping systems, electrical system and the like were then applied at approximately the same percentage or at the same unit costs as stated in Regulatory Guide 1.110 cases.

In some of the augments studied the equipment sizes or capacities were not sufficiently close to the Regulatory Guide 1.110 typical equipment to use the Regulatory Guide cost numbers directly. In these cases the estimated costs of equipment were obtained from curves or graphs which were constructed by using various Regulatory Guide 1.110 equipment cost/capacities as specific curve points. In other cases where only

*All references herein to "Regulatory Guide" or "Reg Guide" refer to the United States Nuclear Regulatory Commission Regulatory Guide No. 1.110 dated March 1976 titled Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors one Regulatory Guide 1.110 cost value was shown, estimated costs for the new equipment sizes were obtained by use of an exponential cost/size relationship (such as the "0.6 power curve") which engineering data or literature indicates to be appropriate for the type of equipment under consideration; these curves were projected using the Regulatory Guide 1.110 value as the base point.

In a few cases where there was either no Regulatory Guide 1.110 data available or no actual construction cost data at hand the costs were derived in a standard estimating manner using equipment costs obtained from equipment manufacturers or reliable engineering literature.

In the above cases the same approximate cost relationships of support facilities such as building space assignment, piping systems, electrical systems, etc., as were used in the Regulatory Guide were then applied to arrive at the total estimated direct installed cost.

The detail estimate sheet for each case shows the cost bases used for estimating the cost of the case.

(3) Operating and Maintenance Costs

The annual operating and maintenance costs for the various augments were derived using Regulatory Guide 1.110 outlined costs for like equipment or systems. The same approximate equipment labor attention ranges were used as outlined in the Regulatory Guide. The amounts of the various maintenance materials, utilities and services were estimated using the augment requirements; the unit costs used for these are similar to those outlined in the Regulatory Guide.

(4) Cost Multipliers and Factors

The multipliers and factors used to obtain the total capital cost of each augment, the annualized cost of capital and the appropriate geographical labor multiplier are shown on page 10.7-A4.

(5) Cost Presentation

Direct cost totals are rounded to the nearest whole number; operating and maintenance costs are rounded to the nearest tenth. All costs are expressed in year 1975 dollars.

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Cost Multipliers and Factors

Indirect Cost Factor

This is a one-unit site; per Regulatory Guide 1.110 page 14 the Indirect Cost Factor is 1.75. The estimated installed direct cost of the augment is multiplied by this factor to obtain the total capital cost.

Capital Recovery Factor

Iowa Electric Light and Power Co. advises that the capital recovery factor to be used for this nuclear facility is 17.97%.

Labor Cost Correction Factor

This facility is constructed in FPC Geographic Region IV Per Regulatory Guide 1.110 page 13 the labor correction factor for this area is 1.4.

Reactor: Duane Arnold

Summary of Augment Costs
(1975 $1000)

Augment Case	Description	Inst Direct Cost	Total Capital Cost	Annual Fixed Charge @17.97%	Oper-ating	Mainte-nance	Total Annual Cost
A-2	Add demineralizer to high purity waste	88	154	27.7	12.9	5.0	45.6
A-3	Delete demineralizer from high purity waste	88	154	27.7	12.9	5.0	45.6
B-2	Add demineralizer to low purity waste	88	154	27.7	56.5	5.0	89.2
B-3	Delete demineralizer from low purity waste	88	154	27.7	56.5	5.0	89.2
C-1	Remove evaporator from chem waste	462	808	145.2	16.0	12.4	173.6
C-2	Add demineralizer to chem waste treatment	69	121	21.7	3.7	5.0	30.4
D-1	Double gland seal exhaust holdup time	19	33	5.9	neg	0.5	6.4
D-2	Add HEPA/charcoal to gland seal exhaust	28	49	8.8	3.8	2.0	14.6
E-1	Add 0 F dewpoint dryer to AOG	464	812	145.9	3.3	6.1	155.3
E-2	Add two more charcoal beds to AOG	146	255	45.8	neg	neg	45.8
E-3	Delete two charcoal beds from AOG	146	255	45.8	neg	neg	45.8
F-1	Remove charcoal from Drywell purge	28	49	8.8	0.2	0.3	9.3
F-2	Remove HEPA/charcoal from Drywell purge	55	96	17.2	0.5	0.4	18.1
G-1	Add HEPA to Turbine Bldg. vent	154	269	48.3	5.9	5.2	59.4
G-2	Add HEPA/Charcoal to Turbine Bldg. vent	285	499	89.7	10.0	21.0	120.7

(continued next page)

Reactor: Duane Arnold

Summary of Augment Costs
(1975 $1000)

Augment Case	Description	Inst Direct Cost	Total Capital Cost	Annual Fixed Charge @17.97%	Operating	Maintenance	Total Annual Cost
G-3	Add clean steam to valves larger than 2½"	551	964	173.2	6.6	16.0	195.8
H-1	Add HEPA to Reactor Bldg. vent	201	352	63.2	6.7	6.3	76.2
H-2	Add HEPA/charcoal to Reactor Bldg. vent	371	649	116.6	11.3	25.2	153.1
I-1	Add charcoal to Radwaste Bldg. vent	38	66	11.9	2.6	3.6	18.1
I-2	Remove HEPA from Radwaste Bldg. vent	42	73	13.1	3.0	1.2	17.3

Reactor Duane Arnold   Case A-2

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM

FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment delete demineralizer from high purity waste treatment

DIRECT COST (1975 $1000)

	ITEM	LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	23	28	35 ft^3, SS, ASME VIII, 150 psi, with resin
2.	BUILDING ASSIGNMENT	9	5	14	
3.	ASSOCIATED PIPING SYSTEMS	9	6	15	
4.	INSTRUMENTATION AND CONTROLS	4	6	10	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS		2	2	
	SUBTOTAL x 1.4 labor multiplier**	27 38	42 -	69* 80	with labor factor = 1.0 includes labor multiplier
7.	CONTINGENCY	4	4	8	
8.	TOTAL DIRECT COSTS	42	46	88	

*cost data per page 10.7-A7

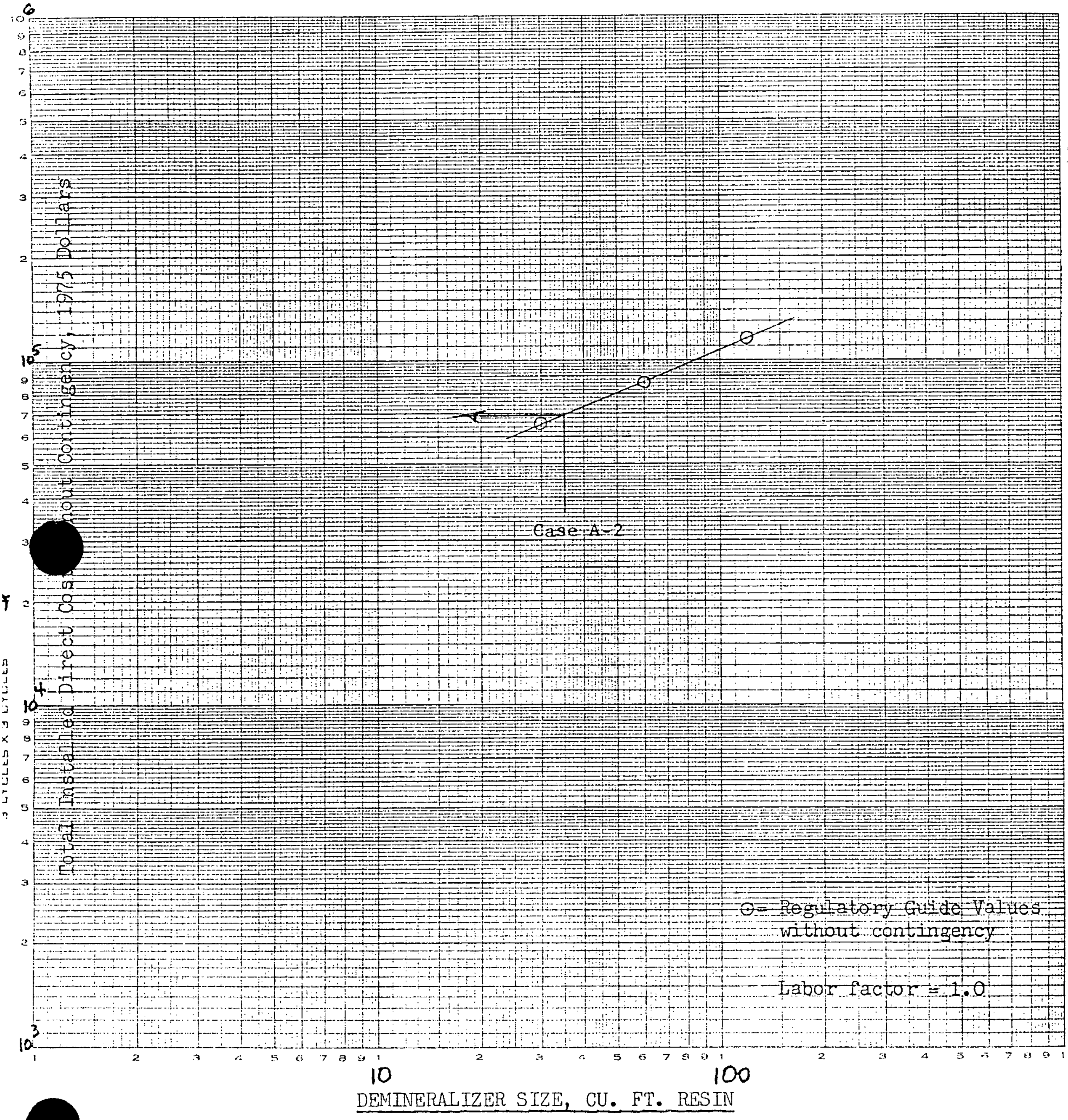
**for FPC Geographical Region IV per Regulatory Guide 1.110 p 13

Estimated Installed Direct Costs for Process Demineralizers

Per Regulatory Guide 1.110 Values Without Contingency

Reactor: Duane Arnold

Case: A-2



Reference: Regulatory Guide 1.110 dated 3/76 pp 64-68
Assign same labor/equipment/support-facility distribution as per Regulatory Guide 1.110 approximate values.

Reactor Duane Arnold

Case A-2

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment ~~delete demineralizer from high purity waste~~ treatment

COST (1975 $1000)

	ITEM	LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			6.5	7.7×10^6 gpy 30 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			5.0	70 ft^3/yr @ $75/$ft^3$
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			1.4	70 ft^3/yr @ 20/ft^3
5.	TOTAL O AND M ANNUAL COST			17.9	*

*cost bases per Reg Guide 1.110 p 71 approximate values

5/76

12.9
5.0
17.9

10.7-A8

76-3c

Reactor Duane Arnold   Case A-3

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment delete demineralizer from high purity waste treatment

DIRECT COST (1975 $1000)

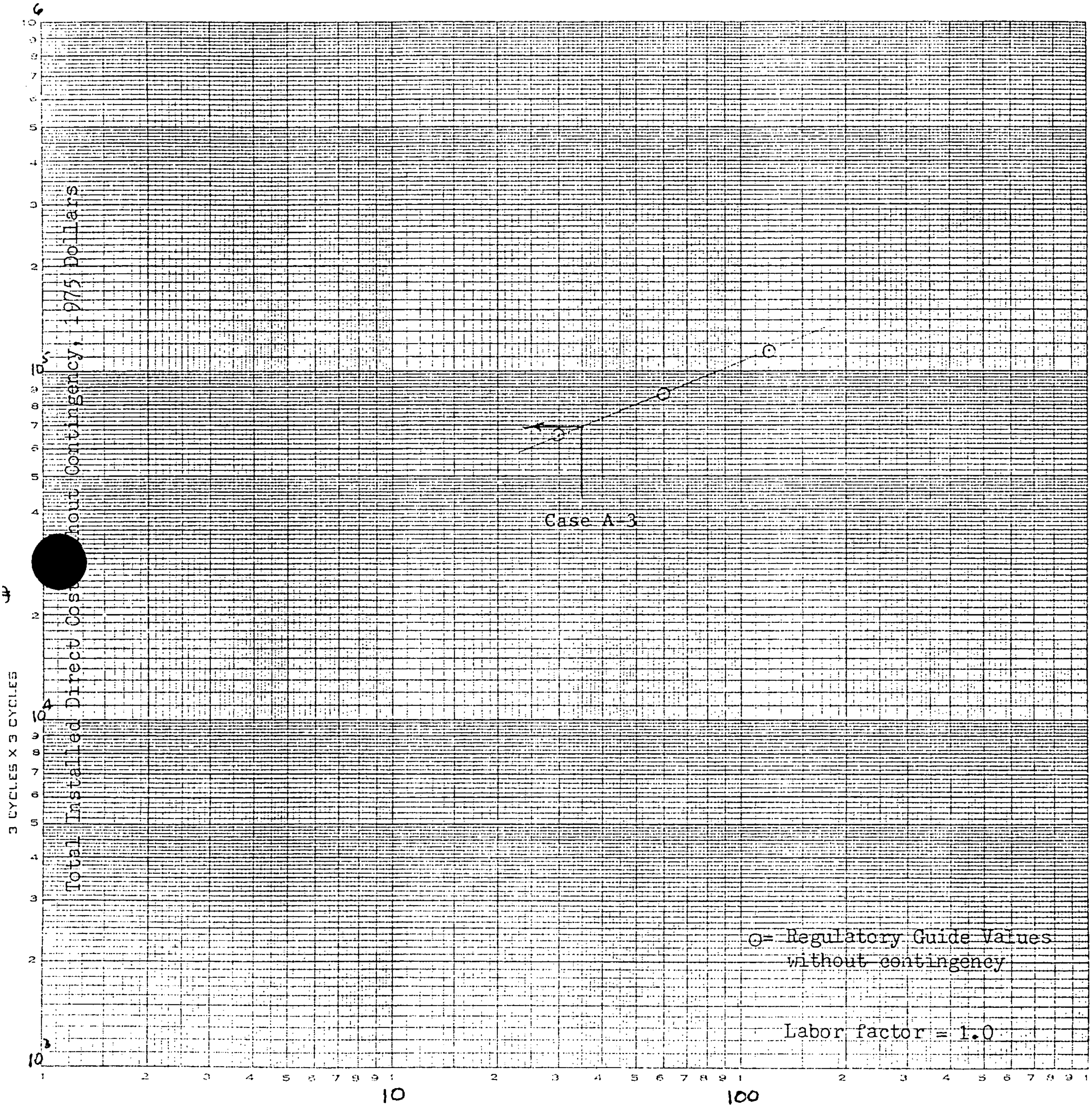
	ITEM	LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	23	28	35 ft^3, SS, ASME VIII, 150 psi, with resin
2.	BUILDING ASSIGNMENT	9	5	14	
3.	ASSOCIATED PIPING SYSTEMS	9	6	15	
4.	INSTRUMENTATION AND CONTROLS	4	6	10	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS		2	2	
	SUBTOTAL	27	42	69*	with labor factor = 1.0
	x 1.4 labor multiplier**	38	-	80	includes labor multiplier
7.	CONTINGENCY	4	4	8	
8.	TOTAL DIRECT COSTS	42	46	88	

*cost data per page 10.7-A10
**for FPC Geographical Region IV per Regulatory Guide 1.110 p 13

Estimated Installed Direct Costs for Process Demineralizers
Per Regulatory Guide 1.110 Values Without Contingency

Reactor: Duane Arnold

Case: A-3



DEMINERALIZER SIZE, CU. FT. RESIN

Reference: Regulatory Guide 1.110 dated 3/76 pp 64-68
Assign same labor/equipment/support-facility distribution as per Regulatory Guide 1.110 approximate values.

5/76

Reactor Duane Arnold Case A-3

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment delete demineralizer from high purity waste treatment

COST (1975 $1000)

	ITEM	LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			6.5	7.7×10^6 gpy 30 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			5.0	70 ft^3/yr @ $75/$ft^3$
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			1.4	70 ft^3/yr @ $20/$ft^3$
5.	TOTAL O AND M ANNUAL COST			17.9	*

*cost bases per Regulatory Guide 1.110 p 70 approximate values

5/76

12.9
5.0
17.9

10.7-A11

Reactor Duane Arnold   Case B-2

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM

FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

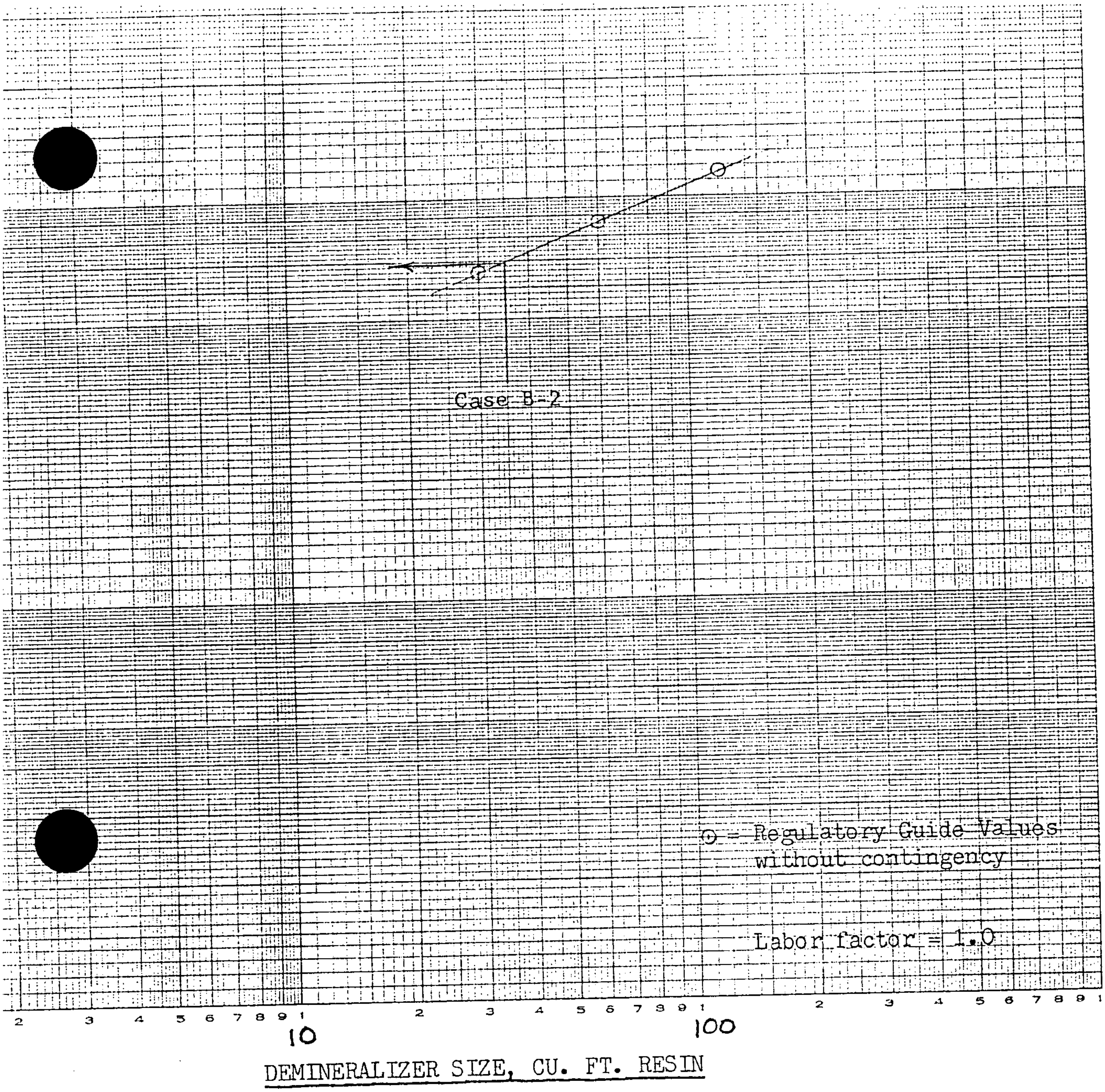
Description of Augment add demineralizer to low purity waste treatment

DIRECT COST (1975 $1000)

	ITEM	LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	23	28	35 ft^3, 55, ASME VIII, 150 psi, with resin
2.	BUILDING ASSIGNMENT	9	5	14	
3.	ASSOCIATED PIPING SYSTEMS	9	6	15	
4.	INSTRUMENTATION AND CONTROLS	4	6	10	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS		2	2	
	SUBTOTAL x 1.4 labor multiplier**	27 38	42 -	69* 80	with labor factor = 1.0 includes labor multiplier
7.	CONTINGENCY	4	4	8	
8.	TOTAL DIRECT COSTS	42	46	88	

*cost data per page 10.7-A13

**for FPC Geographical Region IV per Regulatory Guide 1.110 p 13



Reference: Regulatory Guide 1.110 dated 3/76 pp 64-68
Assign same labor/equipment/support-facility distribution as per Regulatory Guide 1.110 approximate values.

Reactor Duane Arnold Case B-2

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment add demineralizer to low purity waste treatment

COST (1975 $1000)

	ITEM	LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	1.7×10^6 gpy 15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			42.0	560 ft^3/yr @ $75/$ft^3$
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			11.2	560 ft^3/yr @ $20/$ft^3$
5.	TOTAL O AND M ANNUAL COST			61.5	*

*cost bases per Regulatory Guide 1.110 p 72 approximate values

5/76

56.5
5.0
61.5

10.7-A14

76-3a

Reactor Duane Arnold Case B-3

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM

FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment delete demineralizer from low purity waste treatment

DIRECT COST (1975 $1000)

	ITEM	LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5	23	28	35 ft^3, 55, ASME VIII, 150 psi, with resin
2.	BUILDING ASSIGNMENT	9	5	14	
3.	ASSOCIATED PIPING SYSTEMS	9	6	15	
4.	INSTRUMENTATION AND CONTROLS	4	6	10	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS		2	2	
	SUBTOTAL	27	42	69*	with labor factor = 1.0
	x 1.4 labor multiplier**	38	-	80	includes labor multiplier
7.	CONTINGENCY	4	4	8	
8.	TOTAL DIRECT COSTS	42	46	88	

*cost data per page 10.7-A16

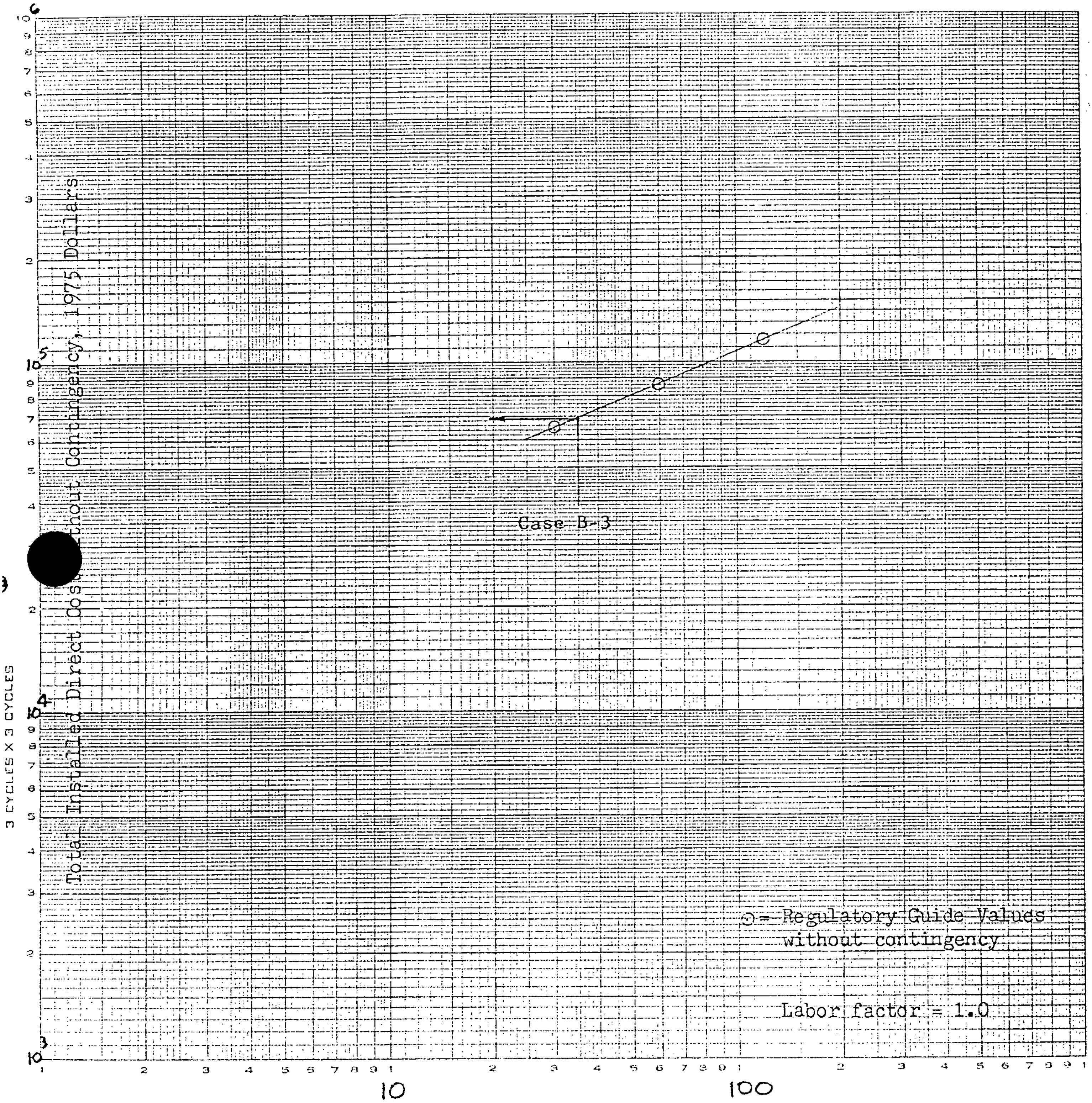
**for FPC Geographical Region IV per Regulatory Guide 1.110 p 13

Estimated Installed Direct Costs for Process Demineralizers

Per Regulatory Guide 1.110 Values Without Contingency

Reactor: Duane Arnold

Case: B-3



Reference: Regulatory Guide 1.110 dated 3/76 pp 64-68
Assign same labor/equipment/support-facility distribution as per Regulatory Guide 1.110 approximate values.

Reactor Duane Arnold   Case B-3

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment delete demineralizer from low purity waste treatment

COST (1975 $1000)

	ITEM	LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			3.3	1.7×10^6 gpy 15 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			42.0	560 ft^3/yr @ $75/$ft^3$
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			11.2	560 ft^3/yr @ $20/$ft^3$
5.	TOTAL O AND M ANNUAL COST			61.5	*

*cost bases per Regulatory Guide 1.110 p 72 approximate values

5/76

56.5
5.0
61.5

10.7-A17

Reactor Duane Arnold   Case C-1

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment remove evaporator (5 gpm) from chem waste

DIRECT COST (1975 $1000)

	ITEM	LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	25	165	190	
2.	BUILDING ASSIGNMENT	45	25	70	
3.	ASSOCIATED PIPING SYSTEMS	30	20	50	
4.	INSTRUMENTATION AND CONTROLS	7	8	15	
5.	ELECTRICAL SERVICE	18	12	30	
6.	SPARE PARTS		15	15	
	SUBTOTAL x 1.4 labor multiplier**	125 = 175	245 -	370* 420	with labor factor = 1.0 includes labor multiplier
7.	CONTINGENCY	17	25	42	
8.	TOTAL DIRECT COSTS	192	270	462	

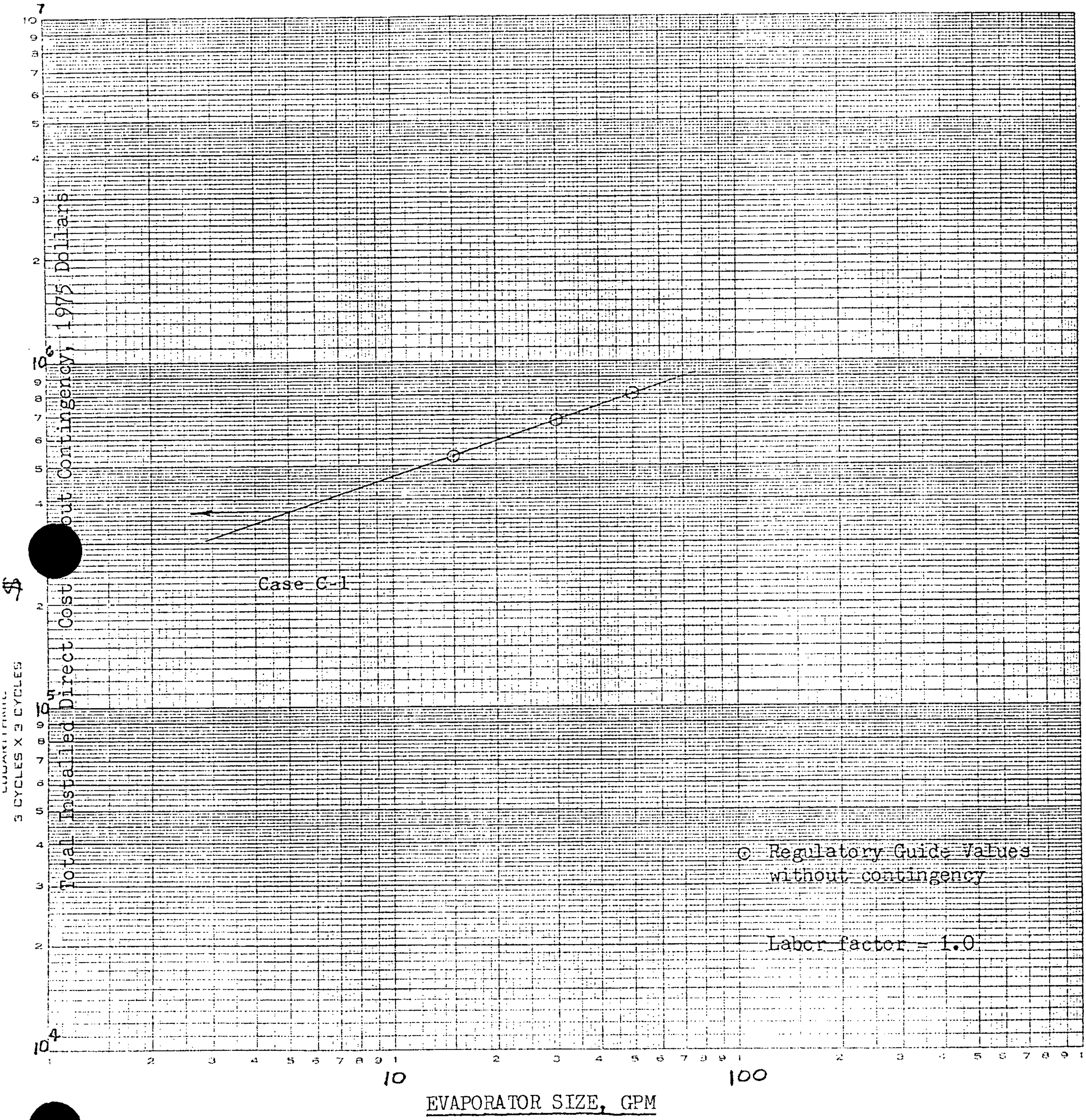
*cost data per page 10.7-A19
**for FPC Geographical Region IV per Regulatory Guide 1.110 p 13

Estimated Installed Direct Costs for Process Evaporators

Per Regulatory Guide 1.110 Values Without Contingency

Reactor: Duane Arnold

Case C-1



Reference: Regulatory Guide 1.110 dated 3/76 pp 57-59
Assign same labor/equipment/support-facility distribution as per Regulatory Guide 1.110 approximate values.

Reactor Duane Arnold　　　　　　Case C-1

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment remove evaporator (5 gpm) from chem waste

COST (1975 $1000)

	ITEM	LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			2.2	
2.	MAINTENANCE MATERIAL AND LABOR			12.4	
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			-	
4.	UTILITIES AND SERVICES				
	Waste Disposal			4.9	
	Water			3.3	
	Steam			5.6	
	Electricity				
	Building Services				
	Other				
5.	TOTAL O AND M ANNUAL COST			28.4	*

*per detail calculation sheet page 10.7-A21

5/76

16.0
12.4
28.4

Reactor Duane Arnold

Case C-1

EVAPORATOR SYSTEMS
ESTIMATED ANNUAL OPERATING AND MAINTENANCE COSTS
Detail Calculation Sheet

Description of Augment remove evaporator (5 gpm) from chem waste

I. COST BASES (per Reg Guide 1.110 dated 3/76, pp 60-63 approximate values)

1. OPERATING LABOR, SUPERVISORY AND OVERHEAD
   a) chem waste volume: 600 gpd x 310 days/yr = 186×10^3 gpy
   b) Use 1 hr labor per 1000 gal waste handled (approx Reg Guide basis).

2. MAINTENANCE MATERIAL AND LABOR
   a) Use 7-1/2 % of estimated equipment cost

3. CONSUMABLES, CHEMICALS & SUPPLIES

4. UTILITIES & SERVICES
   a) Waste disposal: clean waste; use 100:1 feed/conc ratio
   dirty waste; use 50:1 feed/conc ratio
   disposal cost = $\$20/ft^3$ concentrate
   b) Water: Use 4 gal cooling water per lb steam used (= about 30 F rise)
   Use water cost = $0.30/1000 gal
   c) Steam: Use 10 lb steam per gal waste processed x 1.5 for heat losses, start-up, idling time allowances, etc.
   Use steam cost @ $\$2/10^3$ lbs

II. CALCULATIONS FOR ESTIMATE SHEET (per above bases)

1. OPERATING LABOR, SUPERVISORY AND OVERHEAD
   b) Operating labor hours: 186 hours @ $12/hr = $ 2,232 /yr

2. MAINTENANCE MATERIAL AND LABOR
   a) 7 1/2% x $ 165,000 = $ 12,375 /yr

3. CONSUMABLES, CHEMICALS & SUPPLIES[b]

4. UTILITIES & SERVICES
   a) Waste generated @ 100:1 ratio = 1,860 gal/yr ÷ 7.5 = 248 ft^3/y
   @ $\$20/ft^3$ disposal = $ 4,960 /yr.
   b) Cooling water @ 4 gal/lb of steam used = 4 x 2790 x 10^3 lb steam/yr
   = 11,160 x 10^3 gal water/year @ $\$0.30/10^3$ gal = $ 3,348 /yr
   c) Steam = 15 x 186 x 10^3 gal waste/yr
   = 2790 x 10^3 lb steam/yr @ $\$2/10^3$ lb = $ 5,580 /yr

III. NOTES

concentrate solidification chemicals are in item 4.
dollars = year 1975.

Reactor Duane Arnold   Case C-2

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment add demineralizer (20 ft^3) to chem waste

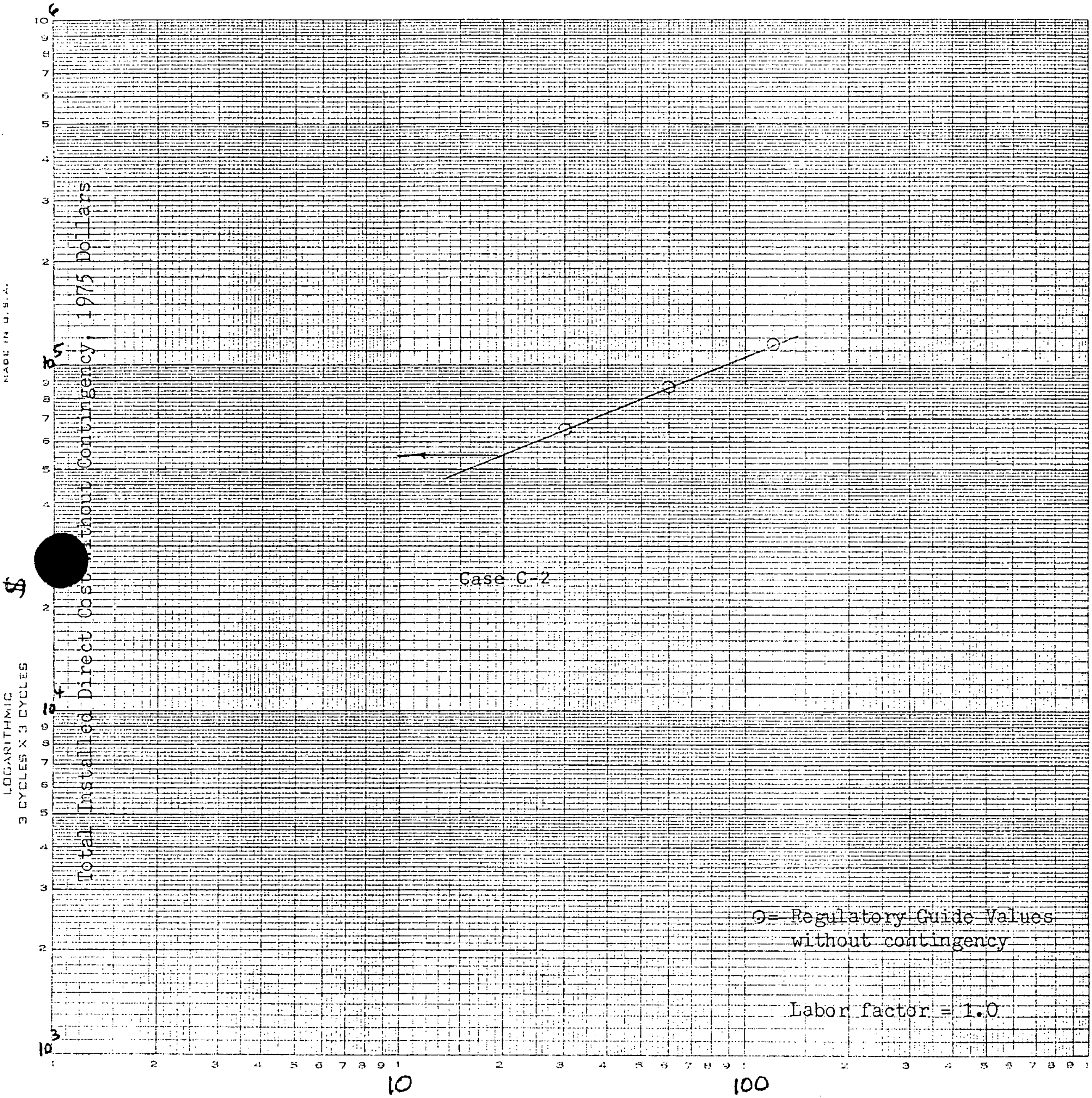
DIRECT COST (1975 $1000)

	ITEM	LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	3	22	25	20 ft^3, 55, ASME VIII, 150 psi, with resin
2.	BUILDING ASSIGNMENT	7	3	10	
3.	ASSOCIATED PIPING SYSTEMS	6	4	10	
4.	INSTRUMENTATION AND CONTROLS	4	4	8	
5.	ELECTRICAL SERVICE			neg	
6.	SPARE PARTS		2	2	
	SUBTOTAL x 1.4 labor multiplier**	20 = 28	35 -	55* 63	with labor factor = 1.0 includes labor multiplier
7.	CONTINGENCY	3	3	6	
8.	TOTAL DIRECT COSTS	31	38	69	

*cost bases per page 10.7-A23
**for FPC Geographical Region IV per Regulatory Guide 1.110 p 13

Estimated Installed Direct Costs for Process Demineralizers
Per Regulatory Guide 1.110 Values Without Contingency

Reactor: Duane Arnold   Case C-2



Reference: Regulatory Guide 1.110 dated 3/76 pp 64-68
Assign same labor/equipment/support-facility distribution as per Regulatory Guide 1.110 approximate values.

Reactor Duane Arnold Case C-2

ANNUAL OPERATING AND MAINTENANCE COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment add demineralizer (20 ft^3) to chem waste

COST (1975 $1000)

	ITEM	LABOR	OTHER	TOTAL	BASIS FOR COST ESTIMATE
1.	OPERATING LABOR, SUPERVISION, AND OVERHEAD			1.8	10 min/shift
2.	MAINTENANCE MATERIAL AND LABOR			5.0	allowance
3.	CONSUMABLES, CHEMICALS, AND SUPPLIES			1.5	20 ft^3/yr @ $75/$ft^3$
4.	UTILITIES AND SERVICES Waste Disposal Water Steam Electricity Building Services Other			0.4	20 ft^3/yr @ $20/$ft^3$
5.	TOTAL O AND M ANNUAL COST			8.7	*

*cost bases per Regulatory Guide 1.110 p 71 approximate values

5/76

3.7
5.0
8.7

Reactor Duane Arnold

Case D-1

TOTAL DIRECT COST ESTIMATE SHEET OF RADWASTE TREATMENT SYSTEM
FOR LIGHT-WATER-COOLED NUCLEAR REACTORS

Description of Augment Double gland seal holdup time

DIRECT COST (1975 $1000)

	ITEM	LABOR	EQUIPMENT/MATERIALS	TOTAL	BASIS FOR COST ESTIMATE
1.	PROCESS EQUIPMENT	5.7	2.9	8.6	replace present 8" holdup pipe section with new 12" pipe section
2.	BUILDING ASSIGNMENT			-	use existing space
3.	ASSOCIATED PIPING SYSTEMS	4.5	.5	5.0	decontamination & removal of present pipe section
4.	INSTRUMENTATION AND CONTROLS				
5.	ELECTRICAL SERVICE				
6.	SPARE PARTS				
	SUBTOTAL	10.2	3.4	13.6*	with labor factor = 1.0
	x 1.4 labor multiplier**	14	-	17.4	includes labor multiplier
7.	CONTINGENCY	1.3	0.3	1.6	
8.	TOTAL DIRECT COSTS	15.3	3.7	19	

*per detail calculation sheet page 10.7-A26
**for FPC Geographical Region IV per Regulatory Guide 1.110 p 13

5/76

Reactor Duane Arnold

Case D-1

Description of Augment double gland seal exhuast holdup time*

TOTAL DIRECT COST
Detail Calculation Sheet

Item	Direct Installed Cost ($ 1975)
1. Remove present holdup pipe (90 lin ft 8" pipe)	Allow $5,000 for cleaning, decontamination and preparation for torch work and removal of present 90 lin ft of 8" holdup pipe. (assign approximately $500 material, $4,500 labor)
2. Install new holdup pipe, consisting of 90 lin ft 12" pipe, in same building space	90 lin ft 12" pipe @ $8/dia inch/ft** = 90 ft x $96/ft = $8640 (assign approximately $2,900 material, $5,700 labor)
3. sum of the above = Case D-1	item 1 $ 5,000 item 2 8,640 Case D-1 = total = $13,640**

Notes:

*present design basis: 2 minutes holdup for approximately 15 scfm design flow

**cost bases per Reg Guide 1.110 p 55 approximate values.
Labor factor = 1.0

Cases D, E, F, G,
H, and I deal with
airborne effluent
and are not included
in this copy.