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DOE-JIO 004

TRU WASTE MANAGEMENT PROGRAM COST/SCHEDULE OPTIMIZATION ANALYSIS

DEPARTMENT OF ENERGY

ROCKWELL INTERNATIONAL

WESTINGHOUSE

JOINT INTEGRATION OFFICE

ALBUQUERQUE, N.M.

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TRU WASTE MANAGEMENT PROGRAM
COST/SCHEDULE OPTIMIZATION ANALYSIS

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AS PART OF THE U.S. DEPARTMENT OF ENERGY
TRANSURANIC WASTE MANAGEMENT PROGRAM

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INTRODUCTION

The cost/schedule optimization task is a necessary function to ensure that program goals and plans are optimized from a cost and schedule aspect. Results of this study will offer DOE information with which it can establish, within institutional constraints, the most efficient program for the long-term management and disposal of contact handled (CH) defense transuranic (TRU) waste. To this end, a comprehensive review of program cost/schedule tradeoffs has been made, to identify any major cost saving opportunities that may be realized by modification of current program plans.

The result of this study is an information package from which the DOE can draw in order to make policy decisions. In this spirit, institutional concerns, per se, have not been allowed to foreclose promising options. However, institutional issues have been identified, where appropriate, as potential impediments to implementation of some alternatives.

Many of the alternatives investigated in this analysis represent substantial departures from present program plans, and therefore, in some cases, the information required to conduct a thorough evaluation of comparative costs is not available. In these cases, a "best estimate" has been used for purposes of determining if the alternative is promising, and in several cases, where initial estimates show promise of program improvements, a recommendation has been made to develop better data prior to making a final decision.

Several sites have expressed concern regarding the necessarily tentative nature of the waste generation projections used in this study and the potential impact of possible substantial revisions to this data in the future. Since the same projections are used to evaluate each alternative within any given scenario, revised projections would affect these alternatives proportionately. Therefore, such revisions might change the calculated cost differences but probably would not alter the conclusions drawn about the relative economics of various alternatives.

It should be noted that it was not the purpose of this study to determine an optimum transporter fleet size. Rather, the purpose was to perform trade-off or parameter studies to determine the relative economies of certain alternatives with "all else being equal." For this reason, some variables which can be assumed to affect all alternatives equally were held constant, and random variables (e.g., transit time variations and failures) were eliminated altogether. Therefore, any reference to fleet size in this report or its appendices should be used for comparative purposes only.

The Defense Transuranic Waste Management Program is evolving rapidly in response to system integration needs, and specific facility designs are changing as better information becomes available on waste characteristics, processing economies, WIPP requirements, and transportation economies. It was therefore necessary for this study to "freeze" facility designs and costs at mid-1985. Some designs and costs have subsequently been changed, especially the design of SRP waste treatment facilities, which are now being designed to allow Pu 238 waste shipments to WIPP. The numbers used in this study for scenario comparisons are those which were effective in mid-1985. In two cases we know of (SRP and Hanford waste processing design), the recommmendations of this study remain unchanged, although the magnitude of costs/savings have changed.

APPROACH

This task was completed in FY85 and involved extensive discussions with the major TRU waste generator and storage sites. Each site was visited twice and had three opportunities for review and comment on reports and strategies. Local area and field offices of the DOE also reviewed this document. All DOE offices and contractors involved were briefed as to the importance of the task, and great care was taken to make sure that the data used for analysis was the best available. Key milestones were:

- Review of strategy and pertinent facts with sites: completed 12/14/84.
- Incorporate comments, send informal strategy out for review to DOE and the sites, and incorporate comments: completed 2/12/85.
- Perform analyses and write up tentative conclusions: completed 4/1/85.
- Send draft report to DOE field and area offices and sites for review and then revisit sites. This was performed between 4/25/85 and 5/17/85.
- Incorporate site comments: completed 5/24/85.
- Brief DOE/AL and support Long Range Master Plan revisions/update: completed 6/24/85.
- Brief DOE headquarters: completed 6/28/85.

- o Revise codes and perform minor analyses if necessary. Incorporate comments and prepare a final version to be out for review by the sites: completed 8/7/85.
- o Final report out by the end of FY 85.

SCENARIOS TO BE ANALYZED

As previously stated, one of the ground rules of this study is that promising alternatives are not to be ruled out on institutional grounds only. It was decided that all promising scenarios would be explored, and that possible institutional limitations to implementation of these scenarios would be described.

In this study, each scenario was compared to the base case. The base case consists of current program plans, as follows:

- o Waste processing at INEL, Hanford, SRP, LANL and Rocky Flats, as required to meet WIPP acceptance criteria,
- o Transport of CH-TRU waste to WIPP in TRUPACT,
- o Shipment of drums in 6-Packs,
- o 25-year stored waste workoff,
- o WIPP operation 10/88, with all sites shipping to WIPP beginning 10/88, and
- o No processing at WIPP.

It became clear during the initial formulation of the strategy and the initial site visits that a virtually limitless number of possible alternative scenarios can be envisioned for purposes of cost/schedule optimization, and that it would be necessary to distill these possibilities into a manageable number of alternative scenarios. The resultant scenarios were described in the cost/schedule strategy and work plan document sent to the field for review in December, 1984. The final scenarios studied are:

1. Ship all difficult-to-certify waste from all sites to INEL for processing. Difficult-to-certify waste is defined as that waste which cannot be certified with QA/NDE/NDA.
2. Ship ORNL difficult-to-certify waste (if any) to SRP for processing; also analyze the possibility of shipping LANL Pu 238 waste to SRP for processing.
3. Ship difficult-to-certify waste to the WIPP site, where a processing facility would be built to handle this waste.

4. Determine the relative economies of shipping TRUPACT by truck versus by rail.

5. Analyze the cost impact of shipping individual drums versus six-packs to WIPP.

6. Analyze alternate sized TRUPACTs for transporting waste to WIPP.

7. Analyze the cost impact of various stored waste work-off periods (12, 18, 25 years)

8. Analyze alternate processing scenarios. It will be determined when processing facilities must be on line to keep WIPP operating at optimum capacity so that it can fulfill its mission. Such things as sunk costs, limitations on drum life, and gas generation will be taken into account. Also examined will be the extent to which capital expenses could be delayed until after a decision has been made as to whether WIPP has successfully demonstrated its mission.

9. Examine coding and labeling systems for the waste being shipped to the WIPP, to determine if there is any redundancy in this aspect of the program.

Each scenario was compared with the base case. No attempt was made to mix scenarios (for example, mix Scenarios 1 and 7 by using central processing and a 12-year stored waste work off). Once acceptable scenarios are identified, further optimization would likely be gained by such "scenario mixing", although some scenarios are mutually exclusive.

SUMMARY OF MAJOR FINDINGS

Scenario 1 (Central Processing at INEL):

Centralized processing at INEL holds promise for reducing system cost, with potential savings as much as $88 million, based on mid-1985 cost estimates (recent changes in SRP processing philosophy will probably reduce, but not eliminate, this potential savings). This option is particularly attractive for sites with small volumes of waste requiring new, expensive processing facilities. In addition to these small volume sites, there are several larger waste streams in the system which should be considered for central processing. Particular waste streams which should be considered in much more detail include:

- Rocky Flats HEPA filters and sludges,
- Hanford waste which must be shredded and grouted,
- SRP Pu 238 waste, and

o LANL Pu 238 waste.

There are, however, several technical and institutional uncertainties which could preclude parts of this option. The main technical undertainty is whether PREPP can process large volumes of SRP Pu238 waste, and an engineering feasibility study is necessary before pursuing this option. Some additional sampling of Hanford waste is required to determine its suitability for PREPP processing, and there is some concern regarding processing strategy at Hanford for oversize/overweight boxes, if WRAP design is changed. Continued high priority on PREPP is necessary to ensure that, if PREPP is used for central processing, it is reliable.

As new processing facilities are proposed (particularly at Rocky Flats), JIO should evaluate these costs against the alternative of central processing at INEL, to determine the most cost-effective alternative.

Institutional uncertainties include accepabilitity to the State of Idaho, transport of large quantities of uncertified Pu238 waste (including acceptability to "corridor" states), and additional NEPA documentation needs.

Scenario 2 (SRP Process ORNL Difficult-to-Certify and LANL Pu 238 Waste):

ORNL has not identified any significant quantity of waste which requires off-site processing. If LANL Pu 238 waste cannot be certified for WIPP using existing or committed LANL processing facilities, it would be cost-effective to ship this waste to SRP for processing. (Note that this scenario involves a very small amount of waste.)

Scenario 3 (Central Processing at WIPP):

Processing facilities which are already committed (especially INEL) have sufficient capacity to serve as central processing facilities. The additional capital needs for a processing facility at WIPP will more than offset any savings from transportation. Therefore, central processing at WIPP is not justified.

Scenario 4 (Rail vs. Truck TRUPACT Shipment)

Truck shipment of TRUPACT is less expensive than rail shipment of TRUPACT unless large discounts from rail tariff rates can be negotiated. Rail shipment (75% rail/25% truck) substantially increases the required TRUPACT fleet size compared to all-truck shipment.

Scenario 5 (6-Packs vs. Individual Drums)

It is more cost-effective to ship drums to WIPP in 6-packs than as individual drums.

Scenario 6 (TRUPACT Sizing)

The potential transportation savings from TRUPACT size redesign do not appear to warrant the offsetting costs of design and requalification, and no cost savings are likely from trying to further improve on TRUPACT geometry. However, this analysis is limited to the very specific question of TRUPACT internal dimensions and did not consider improvement questions such as those being pursued by the Value Analysis Team. These improvements appear to offer opportunities for significant savings.

Scenario 7 (Stored Waste Work-off Period)

Shorter stored waste work-off periods result in cost increases at WIPP, and cost savings at major processing sites. Additional transportation costs are incurred from shorter stored waste work-off periods, due to the need for a larger TRUPACT fleet. Analysis indicates that there is a net cost increase from work-off periods shorter than the base 25 year period. Additional costs are on the order of $22 million for an 18 year work-off, and $42 million for a 12 year work-off.

Scenario 8 (Alternative Processing Scenarios)

This scenario focuses on delaying construction and operation of WRAP and SRP facilities and operation of PREPP and concludes that these delays are possible, since SWEPP and generator sites can provide sufficient waste to keep up with WIPP demand until about 2004. To delay PREPP would probably result in lower system cost due to the economies of three shift operations. However, for institutional and technical reasons it is desirable to gain as much PREPP operating experience as soon as possible, particularly if PREPP is to be a central processing option (Scenario 1). Delay of other facilities would not result in any savings.

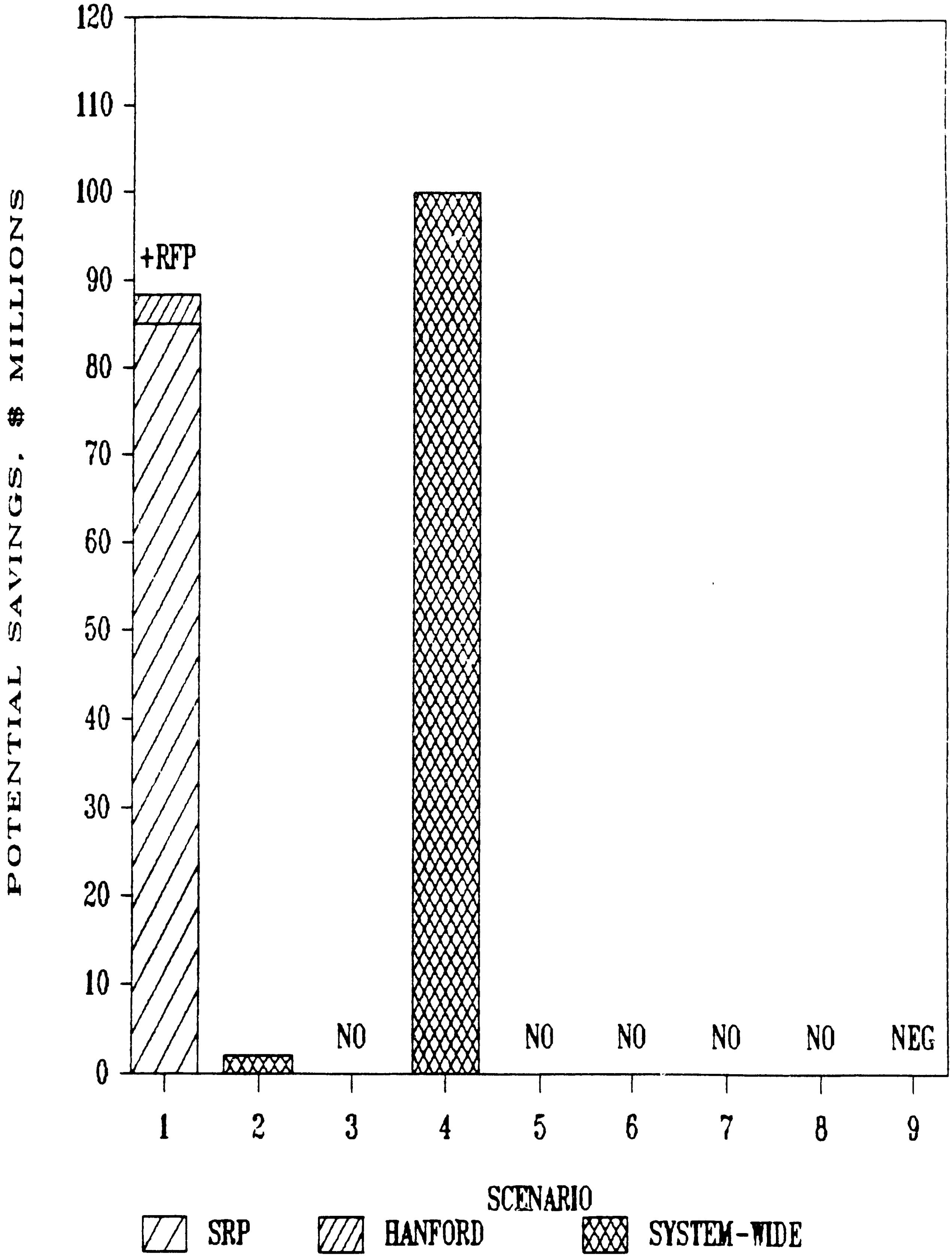
Scenario 9 (Coding and Labeling Systems)

Several sites expressed the opinion that some effort should be made to consolidate coding, labeling, and color-coding requirements, and that these requirements should be rigorously justified on the basis of real need. An admittedly perfunctory overview of the WIPP labeling requirements indicates the present requirements are justified and non-redundant. In any event, the cost impact of labeling requirements is small.

Figure 1 summarizes potential savings identified.

Figure 1

POTENTIAL SAVINGS FOR SCENARIOS



METHODOLOGY

Three computer models, previously developed by TWSO, were used to perform the analyses in this Cost/Schedule Optimization Study:

M-PLAN is a waste inventory build-up and work-off model, which tracks TRU waste inventory changes through waste generation, certification, storage, processing and disposal activities. M-PLAN takes as input existing storage site inventories, annual generation predictions, certification schedules, processing schedules, processing volume reduction factors, WIPP start date, WIPP duration, and WIPP work-off strategy (which sites have priority). From these inputs, M-PLAN calculates site inventories each year (both certified and uncertified) and annual shipments to WIPP from each storage and generator site. M-PLAN will also determine if a site does not process waste fast enough to meet WIPP receipt requirements.

TRUSIM is a transportation simulation model, which calculates transportation fleet requirements based on packaging characteristics and inventory work-off strategies. Since each site shipping waste to WIPP has different waste container characteristics, TRUSIM applies packaging efficiencies to each shipping site to account for the number of waste containers which can fit into a TRUPACT. TRUPACT useable volume can be set, as can the shipping mode (truck or rail) for each individual site. Travel times, site turnaround times, and frequency of maintenance can also be set. From these inputs, TRUSIM calculates the number of TRUPACTs required each year, the number of shipments from each site, and surge storage requirements at the sites, including WIPP.

TRUCOST is a data base management and spreadsheet model, which analyzes system-wide cost impacts of program alternatives. The TRUCOST data base includes the most recent budget projections from each storage and generating site facility, and facility-specific formulas have been developed to model relationships between cost and facility size. Also included are costs for transportation and WIPP, and these costs are modelled to change as the volume shipped and emplaced changes. By applying the facility, transportation, and WIPP formulas to inventory work-off scenarios, TRUCOST will calculate the new probable costs, by facility, by site, and system-wide.

All capital and operating projections and expenditures were reviewed using the Freiman Analysis of Systems Techniques (F.A.S.T.).

SCENARIO 1: Difficult-To-Certify Waste to INEL

For this scenario, difficult-to-certify waste is defined as that waste which cannot be certified by QA/NDE/NDA methods, whether stored or newly generated. This definition was determined to be appropriate based on the observation that most sites are either now, or soon will be, certifying the majority of their waste by these methods, and that mobile NDE/NDA has proven to be effective for those sites which do not have permanent facilities for this purpose.

There appear to be several institutional issues associated with this scenario:

- Acceptability to the State of Idaho of INEL accepting waste from sites not currently shipping to INEL,
- The acceptability of transporting difficult-to-certify waste, including institutional concerns of "corridor" states
- NEPA documentation for shipping this waste to INEL, and
- NEPA documentation for processing this waste at INEL.

Regarding the first institutional issue, INEL personnel have stated that they see no indication that the State of Idaho would raise serious objection at this time to the shipment of waste to INEL from sites not presently shipping to INEL, provided the purpose is processing and subsequent transfer to WIPP within a short time. The second institutional issue is primarily perceptual, since the waste shipments will all be required to meet applicable transportation regulations. Regarding the last two issues, additional NEPA documentation will probably be required in support of this scenario, since central processing of difficult-to-certify waste at INEL is not generally covered by existing NEPA documents.

Four technical issues have been identified relative to processing difficult-to-certify waste at INEL:

- By eliminating some processing facilities at other sites, this scenario may restrict system flexibility,
- PREPP may be required to operate beyond its planned operating period,
- If PREPP is the only facility in the defense TRU waste system which can process waste beyond NDA/NDE/QA, PREPP will approach its full 4-shift capacity, and
- Some waste may not be suitable for PREPP processing.

To counter the first concern, it is prudent to proceed with the PREPP facility in an expeditious fashion in order to obtain operating experience. PREPP operating experience may help define additional processing facility requirements. If PREPP operates well, other sites can consider shipping to INEL for processing. If PREPP operates poorly, other sites can employ lessons learned from PREPP in the design of their own waste processing facilities; or PREPP can be modified to correct deficiencies.

With regard to the second technical issue, some sites (e.g., Rocky Flats, Hanford) will continue to generate difficult-to-certify waste beyond the presently planned operating campaign of PREPP. The alternatives and cost sensitivities of constructing new facilities at that time or prolonging PREPP operation (beyond 2000) have not been considered in this analysis.

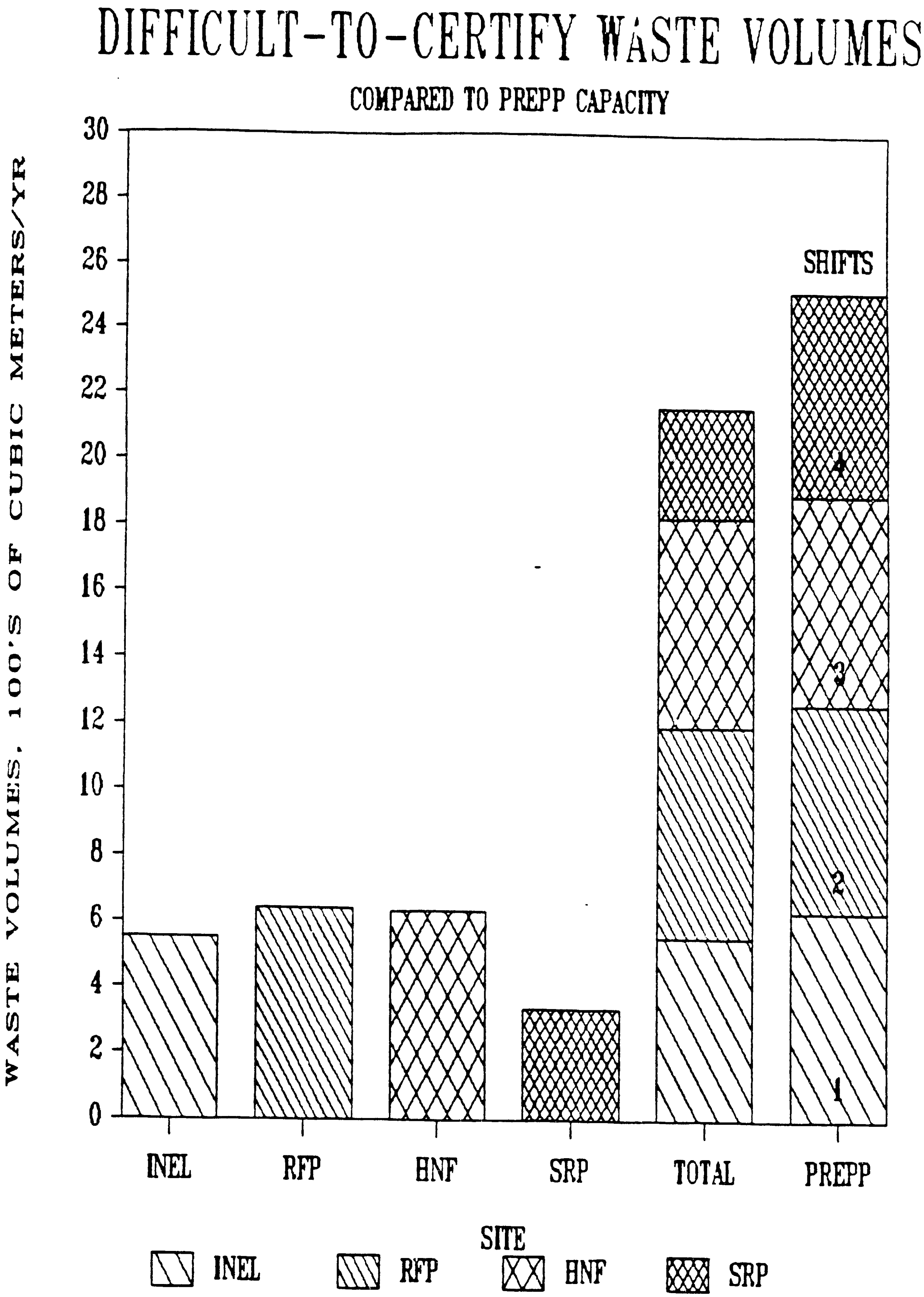
Calculations in Appendix A show that PREPP has sufficient capacity to serve as a central processing facility for difficult-to-certify waste, although this will require use of 3 or 4 shift operation. Figure 2 shows this graphically. These PREPP capabilities assume no unplanned unavailability of this facility, although margin is allowed for routine maintenance shutdowns.

During the site visits, the sites were asked to estimate quantities of difficult-to-certify waste which might reasonably be shipped to the INEL for processing and to identify any specific site concerns with such a plan. Based on these discussions, it was concluded that PREPP holds promise as a centralized processing facility for difficult-to-certify waste. It is important to demonstrate the PREPP facility with sample waste from the various sites that may participate. In any case, engineering work for site processing facilities should be continued as the capabilities and requirements are further established. The specific results of these site visits are as described in the following paragraphs.

LANL The difficult-to-certify waste at LANL consists primarily of overweight or oversized components, such as cemented pipes or oversized glove boxes, which cannot be shipped in any event. There are also about 600 drums of Pu 238 waste (the disposition of this waste is further discussed in Scenario 2). Based on a preliminary survey, LANL believes that almost all of the Pu 238 waste can be directly certified for shipment to WIPP without processing. Finally, there may be some small quantities of difficult-to-certify waste (mainly HEPA filters) which cannot be easily certified at LANL and could be shipped to INEL for processing.

LANL is planning, or has built, five separate facilities for processing and certifying TRU waste for shipment to the WIPP, and of these only the Waste Processing Facility is still in a sufficiently early stage of planning that it could be modified substantially to conform to this scenario. The Waste Processing Facility, which will cost approximately $4 million, will in large part process the corrugated metal pipes, which could not practically be shipped to Idaho in any event.

Figure 2


DIFFICULT-TO-CERTIFY WASTE VOLUMES
COMPARED TO PREPP CAPACITY
WASTE VOLUMES, 100'S OF CUBIC METERS/YR
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
SHIFTS
1
2
3
4
INEL
RFP
HNF
SRP
TOTAL
PREPP
SITE
INEL
RFP
HNF
SRP

It is concluded that, with the possible exception of some small amount of Pu 238 waste and other difficult-to-certify waste (mainly HEPA filters), there is no significant waste at LANL which qualifies for this scenario.

NTS NTS has had good success with mobile NDE/NDA, and NTS has not identified any waste which will be difficult to certify. Since the certification of NTS waste is not yet complete, there is a possibility that some difficult-to-certify waste may appear during the certification program, but at this point it is concluded that there is little or no waste at NTS which qualifies for this scenario.

Rocky Flats There are three difficult-to-certify waste streams at Rocky Flats: sludges, HEPA filters, and classified shapes. Rocky Flats is still developing certification systems for this waste, but should be certifying the majority of their waste by the end of 1985. However, the processes and facilities used to certify sludges and HEPA filters at RFP are pilot plants or prototype units and may not be adequate for long-term production scale operations. In that event, it may prove that processing the waste at INEL is more economic than expanding the facilities at RFP. Preliminary estimates of costs to ship difficult-to-certify RFP waste to INEL over 25 years versus expanding the RFP facilities are shown in Appendix B and show a cost advantage to RFP processing. However, RFP cost estimates for new facilities may be revised upward and may favor INEL processing.

Classified shapes must be re-configured prior to off-site shipment by routine transportation methods in any event, so this waste stream was not considered to be available for INEL processing.

As more information becomes available regarding cost of advance certification facilities at RFP these relative costs should be further examined prior to making any large capital investments in on-site waste processing at Rocky Flats.

ORNL ORNL has identified no difficult-to-certify waste. However, they have qualified this by pointing out that all stored waste will not be certified until FY86 and that some small amounts of difficult-to-certify waste may still be identified. In that event, it would be economically advantageous to have processing available at some other site.

ORNL has good waste characterization data, so processing at PREPP should be no problem. ORNL has had some difficulty segregating LLW from TRU on some high-neutron waste. WIPP has stated that, in the interest of conservatism, this waste will be accepted by WIPP provided that it is certified in all other respects. Of the non-Pu-238 TRU waste at Savannah River, approximately 90% is estimated to be easily certifiable in the Waste Certification Facility or segregated to LLW disposal.

SRP SRP has a relatively large quantity of Pu 238 waste. For this scenario, it has been assumed that INEL can process this Pu 238 waste. However, the technical basis for this assumption has not been rigorously examined. It is recommended that this scenario be examined carefully.

Assuming that Pu 238 waste can be processed at INEL and that the TRU Waste Processing Facility (TWPF) at SRP can be eliminated as a result of this scenario, the total savings as evaluated in Appendix C are $85 million. As discussed in the Introduction, this estimate is based on mid-1985 designs and cost estimates. More recent SRP processing strategies may substantially reduce the cost of SRP processing, and therefore the savings possible from this scenario. However, the recommendation that PREPP processing be further investigated remains valid. There are a number of other unresolved issues with regard to these potential savings; these are:

- An engineering evaluation is required to determine if Pu 238 waste can be processed in quantity at PREPP and to determine what additions are required to the PREPP facility (e.g., shielding, ventilation, etc.). The costs of such possible additions were not considered in the Appendix C evaluation.

- It should be determined what additional facilities might be required at SRP to prepare the Pu 238 waste for shipment to INEL in the absence of TWPF. Also, facility additions at SRP may be required to store newly generated waste before shipment to INEL.

- Further investigation into transportation requirements is required. Curie content, heat generation, and gas generation were examined and do not appear to be impediments.

- The possibility of sending certified Pu 238 waste directly from SRP to WIPP should be studied in depth. A preliminary investigation of the issues involved appeared to be positive.

Hanford Hanford has identified 6,000 m^3 of stored difficult-to-certify waste which may qualify for processing at INEL. An additional 30 m^3/yr of new waste will require processing. Hanford is planning, as part of its WRAP facilities, a shredder and grouter, and it is possible that the waste which requires shredding and grouting could alternatively be shipped to the INEL for treatment.

Appendix D details cost comparisons for shipping difficult-to-certify waste from Hanford to INEL versus processing it at WRAP. Recognizing that these cost estimates are based on very preliminary data, it appears that eliminating the shredder and grouter from the WRAP and sending some waste to INEL may result in some net cost savings. The upper bound of this cost savings is estimated to be on the order of $3.4 million ($17.4 million savings at WRAP, offset by $3.1 million in additional transportation costs and approximately $10.9 million additional costs at PREPP).

There are, however, a number of additional concerns relative to a decision to ship Hanford waste to INEL instead of constructing a shredder-grouter at the WRAP facility. These are as follows:

- Hanford now has 400 cubic meters of waste that is classified due to shape. An on-site shredder could be used to declassify this waste. INEL has stated that PREPP may be able to accept and declassify this waste, but transport would have to be by secure means which were not costed out in this study.
- Hanford will be generating 300 drums of waste per year which is classified by isotopic composition. It may be possible that this waste could be declassified by mixing with existing waste using a shredder-grouter. As with classified shapes, PREPP may be able to accept it, provided that secure transport costs are not prohibitive.
- Hanford waste is less well characterized than INEL waste. This might present a problem in accepting this waste for processing, although INEL has stated that PREPP can accept any CH waste meeting DOT criteria.

As a result of the last concern, it is important to complete PREPP as early as possible and to ship sample Hanford waste to INEL for examination to determine what technical problems might arise from putting it through the INEL facilities.

During final preparation of this report, Hanford raised some concerns regarding processing strategies for oversize and overweight boxes, which cannot be shipped as is. Prior to any final decision regarding WRAP, a strategy for these boxes should be considered.

SCENARIO 2: SRP Processes Difficult-To-Certify ORNL Waste and LANL Pu 238 Waste

The institutional issues identified for Scenario 1 also apply to this scenario; namely, acceptability to the State of South Carolina, the acceptability of shipping uncertified waste, and the need for additional NEPA documentation.

It should be noted that this scenario involves no more than a few hundred drums of waste. However, consideration of this scenario could avoid a significant future expense for a small quantity of waste.

LANL has about 600 drums of Pu 238 waste (the disposition of this waste and the LANL facilities is also discussed in Scenario 1). Based on a preliminary survey, LANL believes that almost all of the Pu 238 waste can be directly certified for shipment to WIPP without processing. The few (up to fifty) drums of difficult-to-certify Pu 238 waste could be sent to SRP (or elsewhere) on a case-by-case basis.

LANL has no plans for the disposition of these few drums. If LANL has to construct a processing facility for these few drums, it would be cost effective to ship the waste to SRP for processing (provided, of course, that the drums meet DOT regulations). The cost of shipping these drums to SRP is expected to be about $12,000 (see Appendix E). Operating costs at SRP were assumed to offset operating costs at LANL. If LANL must constrict additional facilities for these few drums, it would be more cost effective to ship the waste to SRP for processing.

The amount of difficult-to-certify waste at ORNL is expected to be small. Transportation and SRP processing costs are expected to be similarly small for this option. It is therefore important for both of these sites that the option for processing this difficult-to-certify waste at SRP, (or preferably INEL), be preserved.

SCENARIO 3: Central Processing at the WIPP Site

As noted in Appendix A, the volume of waste identified as potentially qualifying for central processing is about 2000 cubic meters per year, assuming a 10 year processing campaign period.

Institutional issues for this scenario include:

- o WIPP processing is not in the WIPP EIS.
- o Acceptability to the State of New Mexico and local communities of processing facilities at WIPP,
- o Acceptability of shipping large volumes of uncertified waste (this may require facilities to install drum vents for Pu238 waste at SRP),
- o Perception of a coupling (co-location) between a repository and processing facilities, at a time when DOE is exploring possibilities for a spent fuel repository.

A processing facility at WIPP would have to be built "from the ground up" expressly for this waste, and therefore would be much more expensive than the INEL option (Scenario 1). The INEL alternative is also probably much more institutionally acceptable.

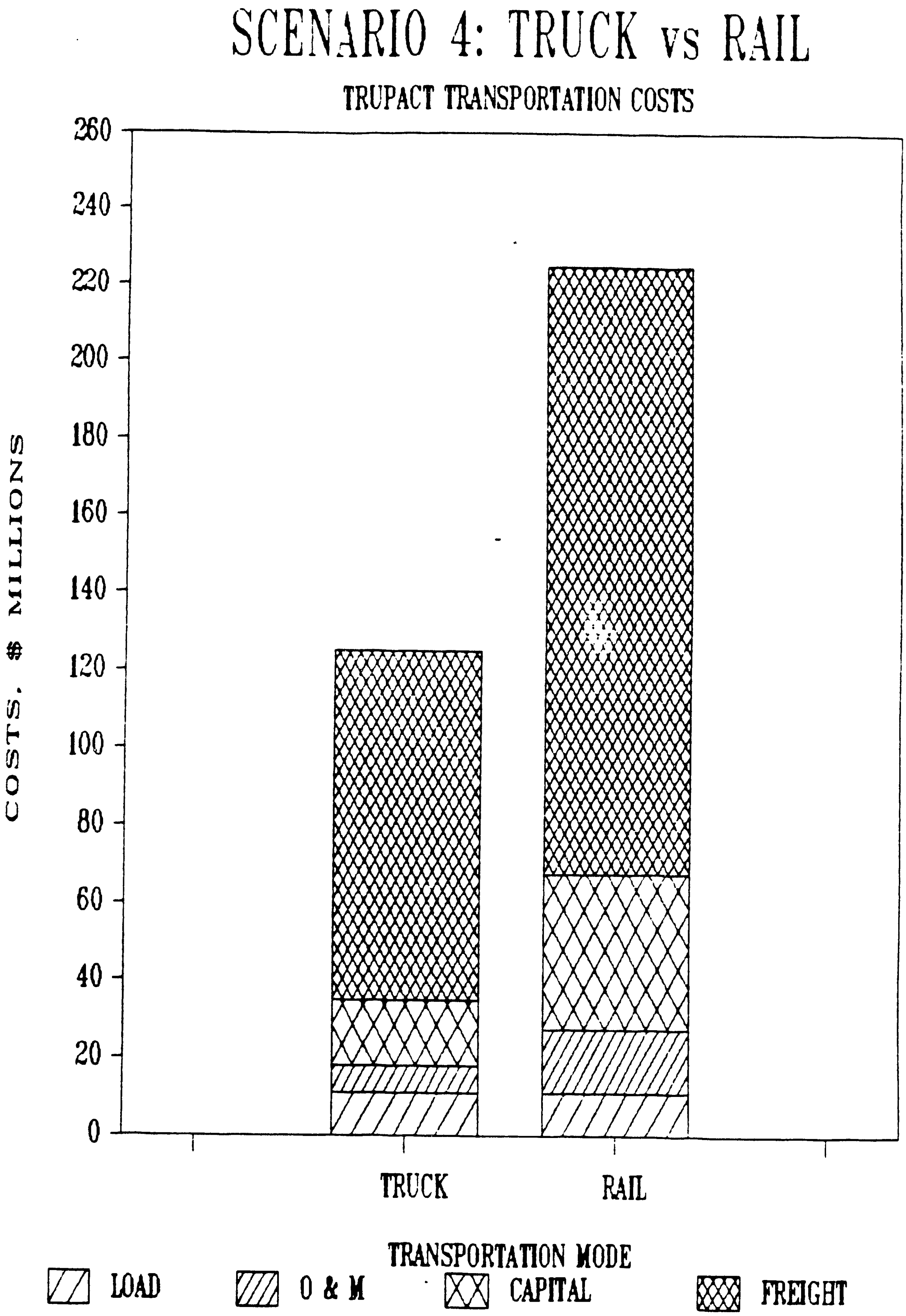
If a separate facility is required to process Pu 238 waste, the institutional and economic considerations favor building that facility at SRP.

In summary, a processing facility at WIPP for difficult-to-certify waste is not justified.

SCENARIO 4: Truck Versus Rail Shipment of TRUPACT

Appendix G concludes that truck shipment of TRUPACT is less expensive than rail shipment of TRUPACT, as shown in Figure 3 (this agrees with the findings of Reference 1). This is due primarily to much higher freight costs in the rail case and, to a lesser extent, a higher capital costs (larger fleet size) made necessary by longer rail travel times. Based on tariff rates, the freight cost of rail TRUPACT shipments, which is based on weight as well as mileage, is higher than that for truck shipments, which is based on mileage alone. Rail rates are thought to be more negotiable than truck rates so the cost advantage of truck shipment over rail shipment would be less than that calculated in Appendix G. However, to offset the higher capital cost, rail TRUPACT shipments would have to recieve negotiated discounts similar to those currently available for ATMX shipments (40% of tariff rates with free return). While some negotiated reduction in rates is anticipated, it is considered unlikely that the reduction will be sufficient to change the conclusion that truck transportation is cheaper than rail transportation for TRUPACTs.

Figure 3


SCENARIO 4: TRUCK vs RAIL
TRUPACT TRANSPORTATION COSTS
260
240
220
200
180
160
140
120
100
80
60
40
20
0
COSTS, $ MILLIONS
TRUCK
RAIL
TRANSPORTATION MODE
LOAD
O & M
CAPITAL
FREIGHT

It should also be noted that this truck/rail comparison considered the system as a whole. It is possible that an individual site has a different cost trade-off between transport modes because of local freight rate variations. Therefore, it is possible that an individual site might find it more economical to ship by rail than by truck, although the capital cost penalty associated with rail shipments must not be ignored in making such a determination. Also note that site-by-site selection of transport mode could complicate the determination of the optimum fleet size.

The analysis in Appendix G was performed in late 1984, and since that time some revised site waste characterization and cost data data has become available. The original study showed that the all-truck case would require 24 TRUPACTs, for a capital cost of $19.2 million and an operating (freight, O&M, loading) cost of $176.8 million, for a total transportation system cost of $196 million. This compared with a total system cost of $317 million for the 75/25 rail/truck mix. Revised site waste characterization data results in a slightly smaller (21) TRUPACT fleet for the truck-only case. Revised cost data (mainly reduction in loading and unloading cost estimates) results in a revised truck-only estimate of $125 million and a revised 75/25 rail/truck mix estimate of $225 million. These revisions in waste characterization and cost data are reflected in Figure 3 and do not change the conclusion that truck is cheaper than rail.

SCENARIO 5: Six-Packs Versus Individual Drums

Appendix G demonstrates that, because weight limitations dominate TRUPACT packing efficiencies at most sites, the transportation system cost savings from allowing shipment to WIPP of individual drums rather than six-packs is small (approximately $4 million, or 2% of total transportation system cost for the all-truck transportation mode). If six-packs were not required, the waste storage and generator sites would save the cost of six-pack frames and labor. Each shipping site was asked for estimates of this cost, but no site had made this calculation. INEL estimated the cost of fabricating a six-pack frame to be $1,000, but they added that this estimate is probably high, since it was based on a small number being fabricated. If it is assumed that mass-produced frames are available for $800 each, including installation, and that 60,000 frames are required, total site operating cost of using six-pack frames is $48 million.

WIPP estimates that operating costs for handling individual drums would increase by $64 million over the twenty-five year WIPP operating period, due to multiple shifts and larger waste handling crews required. In addition, WIPP personnel expressed concerns with regards to increased exposures at WIPP, and increased probability of an accident.

The net effect of savings from transportation and waste generator and storage sites, combined with additional WIPP costs, is an added cost of $12 million from allowing individual drums to be sent to WIPP.

SCENARIO 6: TRUPACT Sizing Analysis

This analysis is limited to the very specific question of TRUPACT internal dimensions and did not consider design improvement questions such as those considered by the Value Analysis Team. Instead, the results of this study provided input to the Value Analysis Study. The recommendations of the Value Analysis Task Force appear to offer an opportunity for significant savings which included revised sizing as well as payload modifications.

Appendix H is an analysis of alternative TRUPACT sizes, wherein the 50,000 lb. TRUPACT weight limit was maintained, but internal dimensions were varied, resulting in variation in TRUPACT payload and packing efficiency. Six TRUPACT designs were examined, including the present design, and it was concluded that, if a single design fleet is desired, the present design is very close to optimum. Up to $5 million (3% of total transportation system cost) could be saved in transport fleet and shipping costs by going to a wider, shorter design, but this savings could potentially be offset by the requirement for redesign, redocumentation, and by the schedule risk inherent in design changes.

If two TRUPACT designs are allowed, up to $11 million (7%) could be saved in transportation capital and shipping costs. Again, this savings would be offset by the cost of redesign and redocumentation, and possible inefficiencies in dispatching TRUPACTs under this scenario.

Theoretically, up to $35 million (21%) could be saved in transportation capital and shipping costs by using a complicated fleet of six different designs, optimized for each site's unique waste mix requirements. The impracticality of this approach is that design, qualification, and dispatching would be very complicated, and the transporta tion system would lose a substantial amount of versatility, since utilizing a uniquely designed TRUPACT for a site for which it was not designed would result in greater inefficiency.

In summary, the potential capital and shipping savings from TRUPACT size redesign does not appear to warrant the offsetting costs of design and redocumentation and no cost savings are likely from trying to further improve on TRUPACT geometry as long as geometry alone is the variable factor.

SCENARIO 7: 12, 18 and 25 Year Work-off Schedules

This scenario examines the cost impact associated with working off all stored waste in 12, 18 or 25 years. In each case it is assumed that newly-generated waste will continue to be received at the WIPP through 2013, so the total waste volume emplaced will not vary. Three categories of cost were considered: processing, transportation, and WIPP.

Processing costs do not change between the 18 and 25 year cases, since all sites currently plan to have all stored waste processed and available for shipment to the WIPP within the constraints of an 18 year work-off period. This is also true of the 12-year case, except for Hanford, which must accelerate processing to meet shipping requirements imposed by the 12 year case. Hanford could accelerate processing by adding a second WRAP shift, and meet the 12 year stored waste work-off. According to figures available on WRAP cost sensitivities, this would not result in any significant difference in WRAP costs.

Shorter work-off periods result in savings at INEL and LANL, due to the elimination of extended shipping, monitoring, and warehousing efforts after processing is complete. An 18 year work-off yields a $7 million savings; 12 year work-off saves $14 million from this effect.

Shorter work-off periods create the need for larger TRUPACT fleets, and hence increased transportation system cost. This effect is $3 million for the 18 year case and $7 million for the 12 year case.

WIPP operations are significantly increased by increasing throughput from the base case, resulting in an additional cost of $26 million for the 18 year case and $49 million for the 12 year case.

The net impact of these considerations is that an 18 year work-off increases system costs by $22 million; a 12 year work-off increases system costs by $42 million. Figure 4 shows these effects.

An institutional issue is that the State of Idaho favors a faster work-off.

SCENARIO 8: Processing Alternatives

This section of the report will determine to what extent there may be latitude in scheduling the construction and operation of TRU waste processing facilities at storage sites. This determination will not extend to newly generated waste certification facilities. It was assumed in this report that all newly generated waste will be certified as it is produced by the time the WIPP opens, although in fact, there may be some small streams of uncertified waste (for example, classified waste).

The TRU program could profit from levelization of funding requirements associated with delaying a facility. This of course depends on the specific facility and time frame being considered.

An additional benefit may be realized in delaying a facility due to maturation of TRU waste processing technology. Even if the technology does not advance, however, a site whose facilities are delayed will benefit from the experiences of a lead site (learning and technology transfer).

One institutional issue associated with this scenario is the acceptability of continued interim storage at a site or sites, if it is determined that delaying one or more facilities is desirable. In 1970 the AEC made a commitment to storage of TRU wastes, such that these wastes would be intact and readily retrievable for at least 20 years. The current base line processing plans call for these wastes to be processed by, at the latest, 2004. Thus, some of the oldest waste could be stored for as long as 34 years before being retrieved for processing. To delay any facilities would raise serious questions with regards to safety and ALARA considerations, due to potential container degradation and gas generation. Finally, to delay facilities could lead to the perception of slowing the momentum of the national program for TRU waste isolation.

Figure 4

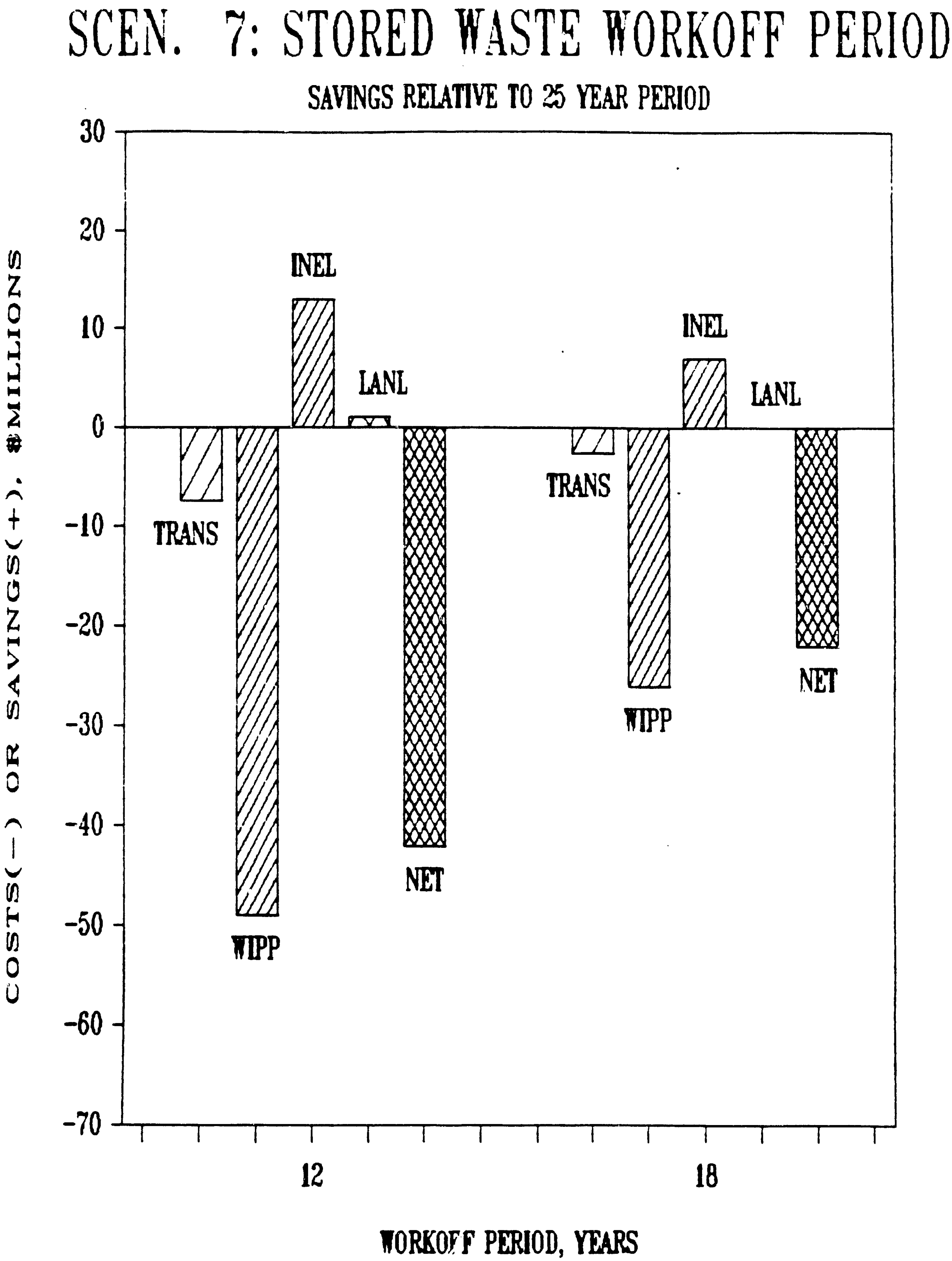

SCEN. 7: STORED WASTE WORKOFF PERIOD
SAVINGS RELATIVE TO 25 YEAR PERIOD
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
COSTS(-) OR SAVINGS(+), $MILLIONS
INEL
LANL
TRANS
WIPP
NET
INEL
LANL
TRANS
WIPP
NET
12
18
WORKOFF PERIOD, YEARS

Table 8-1 shows processing facilities that are planned at the storage sites. ORNL and NTS do not appear because no large scale processing facilities are planned at these two sites.

Table 8-1

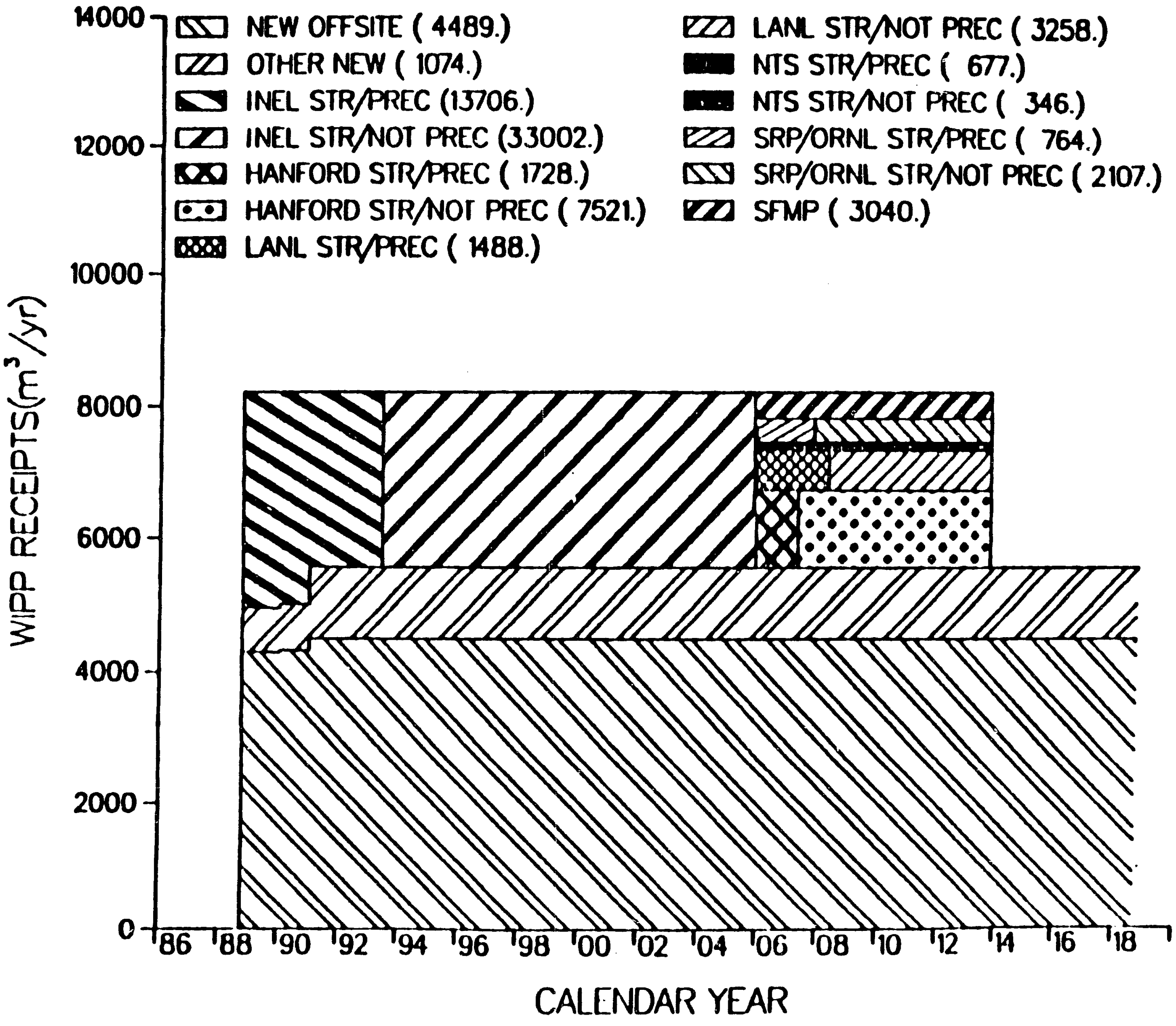
Site	Facility	Construction Begin	Construction Complete	Hot Operation Begin	Hot Operation Complete
INEL	SWEPP		9/84	10/85	99
	PREPP		9/85	10/86	99
HANF	WRAP	90	93	94	04
SRP	TWF	88	91	91	06
LANL	MISC	84	90		

LANL At LANL, the total design and construction costs are less than $8 million, so no major cost savings will be realized by delaying LANL projects. In addition, the timing of facility operations and construction and LANL are linked to the arragement of waste on the storage pads, so delaying one part of the LANL waste processing could have other impacts. Hence, LANL was not considered as a candidate for delay.

INEL In addition to NGW certification efforts, the SWEPP at INEL is the only processing facility which absolutely must come on line on schedule in order to support the WIPP. INEL plans a thirteen year work-off campaign for the SWEPP, processing about 8400 drums per year, plus other waste package types. The PREPP facility has been designed to process up to 9000 drums per year at full (three shift) capacity. However, it is currently estimated that only about 10% of the drums going through the SWEPP will require PREPP processing. Therefore, SWEPP operation, together with newly generated waste, can keep WIPP "fed" for a number of years, even without PREPP, WRAP, or TWPF. Referring to Figure 5, by October 1988 there will be 18,291 m^3 of pre-certified waste at all sites, available for shipment to WIPP. In addition, SWEPP will generate 29,745 m^3 (90% of 33,050) by 1998. To meet a steady-state receipt rate of slightly over 8,000 m^3/yr for a 25 year work-off, WIPP requires about 3,000 m^3/yr more than the newly generated waste rate. Hence, processed waste from Hanford, SRP, or PREPP would not be needed until about 2004 as a feed for WIPP.

Figure 5

WIPP Receipts by Site for INEL-First Case



The economics of operating PREPP generally favors three shift operation for a short duration over continuous but under-capacity (one shift) operation for 13 years. This characteristic, combined with the fact that PREPP output is not needed to supply WIPP for at least 10 years, would seem to promote the delayed startup of PREPP. However, there are problems with delaying PREPP. These problems include the following:

- o PREPP is nearly completed and the facility would have to be mothballed incurring additonal costs. Additionally, some redesign and replacement of equipment could also probably be required after such an extended mothballing.
- o PREPP is an integral part of the stated defense TRU waste management program.
- o PREPP could provide centralized processing for other sites (refer to Scenario 1). The technology and capability of PREPP should therefore be tested and proven as soon as possible to preclude a "log jam" type problem from affecting the strategy.
- o PREPP represents an important technology development activity in the incineration program. As such, PREPP will have wide impacts not only in the TRU program but also in the low level waste and commercial areas. Incinerator technology in the radioactive waste field has thus far been extremely disappointing. PREPP is an opportunity to gain valuable design and operating experience with radioactive waste incinerators.
- o INEL has begun to assemble and train a staff to operate PREPP. Delay of PREPP would necessitate layoffs.
- o As in Scenario 7, any delay in processing or shipping INEL stored waste could jeopardize the good working relationship with the state of Idaho.

Delayed operation of PREPP is therefore probably inadvisable.

Hanford Operation of WRAP could, according to the analysis above (i.e., considering only the requirements for supplying WIPP with waste), be delayed until about 2003, assuming a 10 year WRAP campaign is desired. That would mean delaying WRAP about 10 years. This only applies to those parts of WRAP not required for processing newly generated waste. If the shredder and grouter can be delayed in this way, about $17.4 million could be delayed 10 years, according to the analysis in Scenario 1. Note that WRAP delay does not save any money in constant-year dollars, since the facility must still be built.

As explained in Scenario 1, however, other uses for WRAP, including the shredder-grouter, argue against delaying its start. This is particularly true because it will be replacing the TRUSAF facility at Hanford, which is a stop-gap facility operating in a 40 year old building with high (about $250K/yr) maintenance costs. Furthermore, Hanford is concerned regarding container integrity if processing is significantly delayed.

SRP A similar conclusion applies to TWF at SRP: those portions of the facility which apply only to stored waste could be delayed about 10 years, but no net savings (in constant dollars) would result. Up to $70 million (the estimated cost of TWF in mid-1985) could be thus delayed.

In all cases the quantity of waste shipped to WIPP, and the annual rate, is the same, so transportation costs and WIPP costs do not change.

SCENARIO 9: Coding and Labeling

Based on discussions with generator and storage site personnel, a number of conclusions regarding coding and labeling requirements are apparent.

- A standardized coding and labeling system should be adopted as soon as possible. Recording redundant information should be avoided where possible.
- The technology for performing this coding and labeling (e.g., painting and labeling systems) should be developed at a single site.
- Cost and exposure impacts for labeling are generally only a small fraction of the overall program commitments.

It seems that these general objectives are being met with the present WIPP system.

References

1. Memo by Joseph N. Cook & Associates to ANL regarding transportation costs of TRU wastes, December 17, 1982.

Appendix A

Scenario 1: Waste Volume Impact fo Shipping Difficult-to-Certify Waste to PREPP

ASSUMPTIONS

Total Difficult-to-Certify Waste Volume Commitments

	Stored Waste Volume	New Waste Annual Volume	Total Annual Volume (1)
LANL	small	small	small
NTS	small	-	small
RFP	-	640 m^3	640 m^3/yr
ORNL	small	small	small
SRP	2981 m^3 (2)	37 m^3	335 m^3/yr
Hanford	6000 m^3	30 m^3	630 m^3/yr
Total (from sites other than INEL)			1605 m^3/yr
Total (from INEL site sources) (10% of 5508.3 m^3/yr(3))			551 m^3/yr
			2156 m^3/yr

PREPP Capacity

	Drums/yr	m^3/yr
1 shift	3K	630
2 shifts	6K	1260
3 shifts	9K	1890
4 shifts	12K	2520

CONCLUSIONS

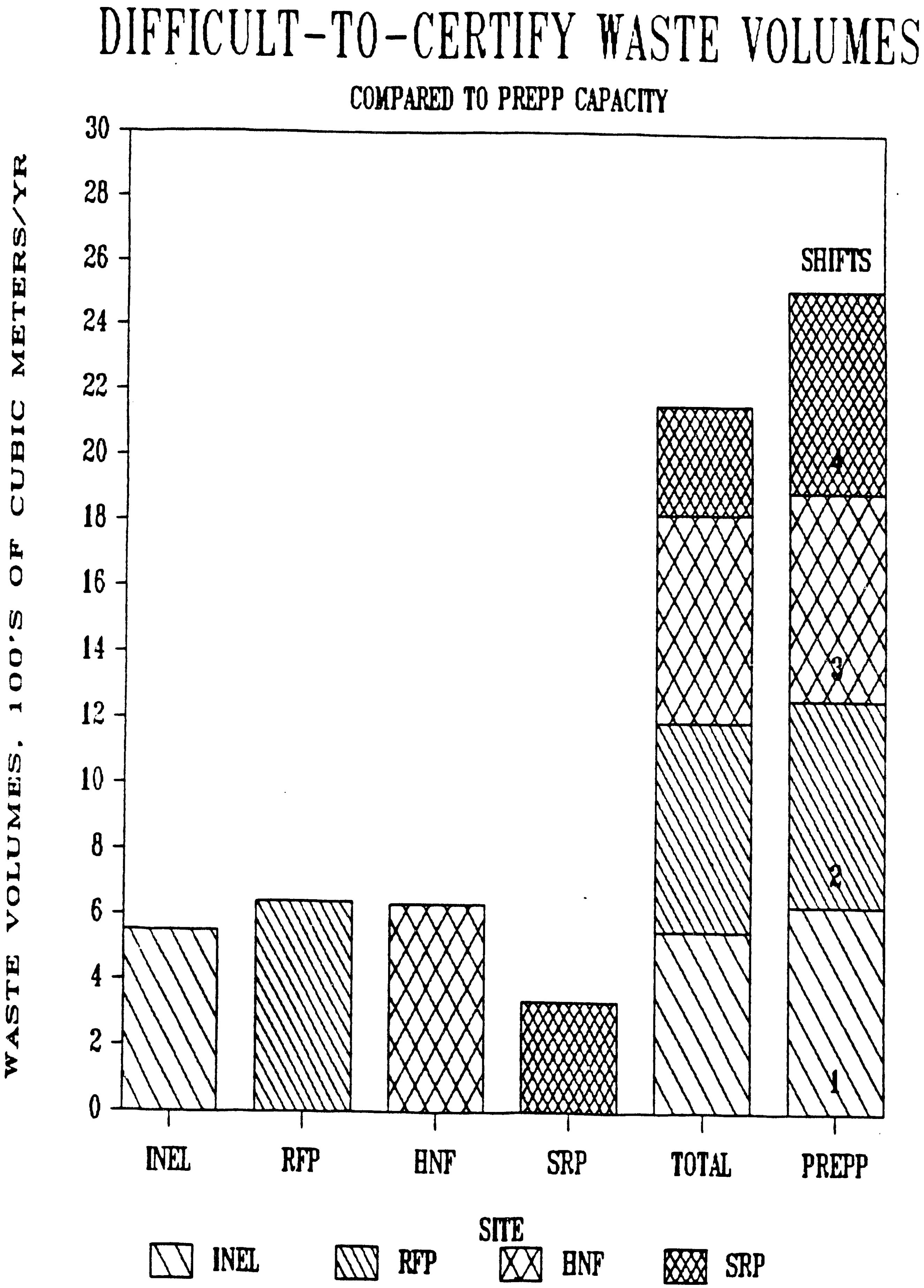
The expected throughput for PREPP, given that it is the central processing facility for difficult-to-certify waste from all sites, is 2156 m^3/yr as compared with a 4-shift operating capacity of 2520 m^3/yr. Figure A-1 shows this graphically.

(1) Assumes a 10 year PREPP campaign for stored waste, plus new waste.

(2) Refer to Appendix C.

(3) From Long-Range Master Plan - the total stored waste is 55083 m^3.

Figure A-1


DIFFICULT-TO-CERTIFY WASTE VOLUMES
COMPARED TO PREPP CAPACITY
WASTE VOLUMES, 100'S OF CUBIC METERS/YR
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
SHIFTS
4
3
2
1
INEL
RFP
HNF
SRP
TOTAL
PREPP
SITE
INEL
RFP
HNF
SRP

Appendix B

Scenario 1: Estimated Cost Impacts of Shipping Difficult-To-Certify Waste from Rocky Flats (RFP) to INEL

ASSUMPTIONS:

HEPA Filter Waste at RFP

- o Production Rate at RFP — approx. 400 m^3/yr
- o Certification Program Cost at RFP(1) (these are differential costs) — initial capital cost - $830K; annual O&M cost -$200K/yr

Sludges and/or Organics at RFP

- o Production Rate at RFP — approx. 40 m^3/mo; 240 m^3/yr
- o Certification Program Cost at RFP(1) — initial capital cost - $5,000K; annual O&M cost - $500K/yr (estimated at 10% of capital cost)

Transportation

o	TRUPACT	total volume	19.4 m^3/TRUPACT
		packing efficiency	x .414
		waste volume	8.03 m^3 of waste/TRUPACT
o	Trip duration (INEL to WIPP, one way including loading/unloading)		5.04 day/trip
o	Lifetime trip days/TRUPACT		365 days/yr
		program duration	x 25 yrs
		TRUPACT availability	x 0.8
			7300 trip days/TRUPACT
o	TRUPACT Costs		
	Capital Cost		$800K
	O&M Cost		+ $13K/yr (x 25 yr duration)
			$1125K/TRUPACT
o	Total Transportation Cost		
	INEL-WIPP trans. cost		$2300/trip
	Loading Cost(2)		$500/trip
	Total		$2800/trip

---

(1) These are costs provided by RFP.

(2) Only the loading cost at INEL was considered. The unloading cost will be assumed in the normal operating expenses of WIPP.

INEL Processing

- o HEPA filters and sludges/organics can be processed at INEL without major modifications
- o Volume reduction

HEPA filters	0.6
sludges/organics	none (1.0)

- o PREPP differential processing cost(3) — $\$1824/m^3$

HEPA filters ($400\ m^3$/yr)(25 yr) = $10Km^3$	\$18.2 M
Sludges/organics ($240\ m^3$/yr)(25 yrs) = 6 Km^3	\$10.9 M

COST IMPACT CALCULATION:

RFP Certification Program Differential Cost(1)

HEPA Filters:	Capital cost	\$830K
	O&M cost (\$200K/yr)(25 yr) =	+ \$5,000K
	Total cost	\$5.83 M
Sludges/organics:	Capital cost	\$5,000K
	O&M cost (\$500K/yr)(25 yr) =	+ \$12,500K
	Total cost	\$17.50 M

INEL PREPP Program Differential Cost

HEPA Filters	\$18.2 M
Sludges/organics	\$10.9 M

Differential Transportation Cost

It is assumed that the transportation costs from RFP to WIPP and from RFP to INEL are equal and offsetting. The only differential transportation cost is therefore from INEL to WIPP. The following calculations are for this leg of the transport.

---

(3) These incremental costs for PREPP are based on an incremental cost of \$383/drum which was in turn derived from:

Number of Shifts	Number of Drums Processed/yr	Annual Operating Cost
1 shift	3000 drums/yr	\$6.1 M
3 shift	9000 drums/yr	\$8.4 M

(1) These are costs provided by RFP.

Number of TRUPACT trips

HEPA Filters:	waste production		400 m^3/yr
	duration	x	25 yr
	volume reduction	x	.6
	TRUPACT waste volume	÷	8.03 m^3/TRUPACT
			747 TRUPACT trips
Sludge/organics:	waste production		240 m^3/yr
	duration	x	25 yr
	volume reduction	x	1.0
	TRUPACT waste volume	÷	8.03 m^3/TRUPACT
			747 TRUPACT trips

Additional TRUPACT Requirements

HEPA Filters:	number of trips		747 trips
	days/trip	x	5.04
	trip days/TRUPACT	÷	7300
			0.52 added TRUPACTs
Sludges/organics:	number of trips		747 trips
	days/trip	x	5.04
	trip days/TRUPACT	÷	7300
			0.52 added TRUPACTs

Additional Transportation Cost Requirements

HEPA Filters:	TRUPACT cost		0.52 added TRUPACTs
		x	$1125K/TRUPACT
			($0.585 M)
	Total transport cost		747 trips
		x	$2800/trip
			($2.092 M)
	Total		$2.677 M
Sludges/organics:	TRUPACT cost		0.52 added TRUPACTs
		x	$1125K/TRUPACT
			($0.585 M)
	Total transport cost		747 trips
		x	$2800/trip
			($2.092 M)
	Total		$2.677 M

CONCLUSION

HEPA Filter Differential Cost Savings	
RFP Differential cost saving	+ $5.8 M
INEL Differential cost	- $18.2 M
Added Transportation cost	- $2.7 M
Total Savings	- $15.1 M
Sludges/Organics Differential Costs Savings	
RFP Differential cost saving	+ $17.5 M
INEL Differential cost	- $10.9 M
Added Transportation cost	- $2.7 M
Total Savings	+ $3.9 M

Notes:

- These results are based on costs provided by the sites. RFP is currently evaluating waste processing facilities, and costs for HEPA filter and sludge certification may be revised upward. In that event, our conclusion could be reversed and could favor PREPP treatment.

Appendix C

Estimated Cost Impact of Processing SRP Waste at INEL.

These calculations were based on the SRP processing strategy which was effective in mid-1985. In late 1985, SRP revised their processing strategy to reduce capital cost and ship certified Pu238 waste to WIPP. These changes were not incorporated in this calculation. Indications are that, while the magnitude of the costs will change, the conclusion (that PREPP processing be examined as an alternative) will not change.

Assumptions:

- Pu 238 waste can be processed at INEL without major modifications;
- SRP new Pu 238 waste can be directly certified at the Waste Certification Facility;
- SRP facilities will eliminate all SRP Pu 238 waste from WIPP by putting residue into HLW;
- No net volume reduction or weight change as a result of INEL processing;
- INEL will not eliminate Pu 238 streams, but will make them acceptable for WIPP;
- Based on FY85 IDB numbers
- 10% of non-Pu 238 waste requires processing (369 m^3);
- 2612 m^3 of stored Pu 238 waste must be processed;
- 10 year stored waste processing campaign at INEL.

<u>Savings</u>

SRP facilities (TWPF):

- capital (post-1986)	$ 64.5 million
- operating	$ 64.5 million
total TWF savings	$129.0 million

Transportation:

369 m^3 non-Pu 238 waste SRP to WIPP, at 0.39 packing efficiency (7.566 m^3/trip).
= 49 trips x $5749/trip = $0.28 million (including loading).

Additional TRUPACTs: 4.9 trips/yr x 10 days = 49 trip-days per year, or .17 TRUPACTs at 0.8 availability.

.17 x $1.125 million = $.19 million capital and O&M.

Total transportation savings: $0.47 million.

Total SRP Savings $129 million

<u>Offsetting Costs</u>

Transportation:

Approximately 3000 m^3 shipped SRP to INEL to WIPP (all stored Pu 238 waste plus 10% of non-Pu 238 waste) thru FY88, at 0.39 packing efficiency equals 7.566 m^3 per trip or 397 trips.

$4021/trip SRP to INEL
$2300/trip INEL to WIPP
<u>$2407/trip</u> WIPP to SRP
$8728/trip x 397 trips = $3.47 million.

Additional 1191 loading/unloadings @ $500 each = $0.60 million.

Additional TRUPACT requirements:

15 days travel (3 days WIPP to SRP, 2 days loading, 3 days SRP to INEL, 4 days unload/load, 1 day to WIPP, 2 days unload) x 397 trips = 5955 trip-days Requires 2 TRUPACTs @ 0.8 availability.

capital cost	$1.6 million	
O&M	$0.26 million	($13,000 x 2 x 10 years)

Transportation of newly-generated-Pu 238 and 10% of non-Pu238 waste (certified at WCF) to WIPP = 7750 m^3 (310 m^3/yr x 25 years) = 1024 trips x ($5249 roundtrip freight and $500 loading) = $5.89 million.

Additional TRUPACTs: 1024 trips x 10 days (2 days loading at SRP, 3 days to WIPP, 2 days unloading, 3 days return) = 10240 trip-days or 410 trip-days/year for 25 years = 1.4 TRUPACTs @ 0.8 utilization.

capital cost	\$1.12 million
O&M	\$0.46 million

TOTAL TRANSPORTATION: <u>\$13.5 million</u>

Additional WIPP cost:	$3000\ m^3 \times 1200\ \$/m^3$ =	\$ 3.6 million
	+ $310\ m^3/yr \times 1200\ \$/m^3 \times 25\ yr$ =	<u>\$ 9.3 million</u>
	TOTAL	\$12.9 million

Processing at INEL @ \$1200/drum (PREPP and SWEPP) x $3000\ m^3 \div 0.21\ m^3$/drum = \$17.1 million

SAVINGS \$129 Million
TOTAL COSTS \$43.5 million
NET SAVINGS \$85 million

Appendix D

Scenario 1: Estimated cost impacts of shipping difficult-to-certify waste from Hanford to INEL.

ASSUMPTIONS

Hanford Production

- o Stored waste requiring processing (INEL) — 6000 m^{3} (1)
- o WRAP work-off period — 10 years

Transportation

- o Differential Transportation cost -

	Cost/Trip (1-way, truck)
Hanford - INEL	+ $1290
INEL - WIPP	+ $2300
Hanford - WIPP	- $3000
Cost differential	$590/trip

- o Loading-unloading cost -

  $500/loading-unloading
  x 2 loading-unloadings/additional trip
  $1000/additional trip

- o Additional TRUPACT requirements -

  Number of TRUPACT trips
  Waste amount — 6000 m^3
  TRUPACT waste volume(1) — ÷ 8.03 m^3/TRUPACT
  747 TRUPACT trips
  74.7 trips/year

  Trip requirements:

loading	2 days/trip
+ travel	4 days/trip
+ unloading	2 days/trip
	8 days/trip
x	74.7 trips/year
	597.6 days/year
÷	365 days/year
	1.64
÷	0.80 availability
	2.05 additional TRUPACTs

  Cost Requirements

TRUPACT Capital Cost	$800 K
TRUPACT O&M Cost	+ $13 K/yr (x 10 yr duration)
	$930 K/TRUPACT

(1) This number is from the trip notes. Not included is 5% of the newly generated waste (556 m^3/yr) from now until 2004 (19 years) or about 530 cubic meters.

- o Additional transportation cost:

Differential transport cost	$ 590/trip
Differential load-unload cost	+ $1000/trip
Differential trip cost	$1590/trip
Number of trips	x 747 trips
	$1.91 M

- o Additional TRUPACT requirement costs

TRUPACT cost	$930 K/TRUPACT
added TRUPACTs	x 2.05
	$1.91 M

Hanford WRAP Shredder-Grouter Cost Savings

o WRAP facility equipment cost	$13.3 million
Shredder-grouter portion of this cost (27%)[1] =	$ 3.6 million
o WRAP facility non-equipment capital cost	$36.2 million
Shredder-grouter portion of this cost (15%)[1] =	$ 5.4 million
o Other WRAP costs ($5.6 M/yr x 10 yr) =	$56.0 million
Shredder-grouter portion of this cost (15%)[1] =	$ 8.4 million

INEL Processing Costs

o PREPP incremental processing cost[(2)]	$1824/$m^3$
	x 6000 m^3
	$10.94 M

CONCLUSIONS

PREPP processing cost	- $10.94 M
Additional transportation cost	- $1.19 M
Additional TRUPACT requirement costs	- $1.91 M
WRAP capital cost savings ($3.6 + $5.4 M) =	+ $9.0 M
WRAP operating cost savings	+ $8.4 M
Total Savings	$3.4 M

(1) From trip notes.

(2) Refer to Appendix B.

Appendix E

Scenario 2: Costs of Shipping LANL Pu 238 Waste to SRP for Processing

ASSUMPTIONS:

LANL Pu 238 Waste

- o Number of Pu 238 drums — 600 drums
- o Number of difficult-to-certify Pu 238 drums (1 out of 12 drums) — 50 drums

Transportation Differential Cost

- o Added transport cost — Cost/Trip (Roundtrip, truck)
  - LANL - SRP: $6100
  - SRP - WIPP: + ------ (1)
  - LANL - WIPP: - $1800
  - $4300/trip (2)

- o Added TRUPACT trips
  - waste volume (50 drums x 0.21 m^3/drum) = 10.5 m^3
  - TRUPACT waste volume (see Appendix B) = ÷ 8.03 m^3/TRUPACT-trip
  - 1.31 (round to 2 TRUPACT trips)

Additional TRUPACT Requirements

o duration (additional travel days) for 1 trip	6 TRUPACT days/trip
o number of trips (or TRUPACTs)	x 2 trips
	÷ 365 days/yr
o lifetime	÷ 25 years
o availability	÷ 0.8
	0.0016 TRUPACT

TRUPACT Costs

o capital cost	$ 800 K
o O&M cost	$ 13 K/yr (x 25 yr duration)
	$1125 K/TRUPACT

Added Loading/Unloading Costs

- o 2 loading/unloadings @ $500/event — $1000

CONCLUSIONS: COST IMPACT CALCULATION

Added Transportation Costs (2 x $4300)	$8600
Added TRUPACT Costs (0.0016 x $1125 K)	+ $1850
Added Loading/unloading Cost (2 x $1000)	+ $2000
Total	$12.45 K

(1) SRP originally planned to process the Pu 238 waste in a way which removed it from the TRU waste management system (residue to HLW). Recent changes in SRP processing philosophy may change this assumption, but for this calculation it was assumed that SRP-WIPP transportation is not necessary.

(2) These estimates ignore some savings that may be gained by efficient TRUPACT dispatching (e.g., using an empty TRUPACT at SRP to ship waste to WIPP).

APPENDIX F

DELETED

APPENDIX G

TRUPACT LOADING AND EFFICIENCY ANALYSIS

1.0 INTRODUCTION

The size of the TRUPACT fleet required to support the WIPP depends, in part, on the packing efficiencies of the TRUPACT. Packing efficiencies may vary from site to site and from load to load, depending on package types and weights. This study examines issues concerning TRUPACT packing efficiencies and determines the likely packing efficiency of shipments from each major waste generator and storage site to WIPP. The resulting packing efficiencies provide inputs to the MPLAN/TRUSIM model, which calculates the required numbers of TRUPACTS for a particular reference TRU inventory workoff scenario. The TRUCOST model was used to compare costs of alternate packing scenarios.

Part One of this report, "Base Case Packing Efficiencies," summarizes the number, weight, and type of waste packages to be shipped to the Waste Isolation Pilot Plant from each of the major sites and explains the methods used to obtain "base case TRUPACT packing" efficiencies. In Part Two, "Packing Alternatives," various packing alternatives are examined to determine their effect on the transportation system. These alternatives include the following:

- Use of the TRUPACT efficient box (TEB)
- Use of loose drums instead of 6-packs
- Mixing package types
- Mixing packages of differing weights

The following assumptions were used in this study:

1. The TRUPACT payload is 17,000 lbs.
2. Weight and volume are the only limiting factors (Curie limits are not considered).
3. Only those packages listed in Table 1 are considered.
4. DOT 17C 55-gallon drums will be certified to carry PREPP end-product waste packages which will weigh about 1,100 to 1,500 lbs. each.
5. A twenty-five year waste workoff period, with no rampup period, was used in MPLAN/TRUSIM/TRUCOST runs.
6. No transportation costs are incurred after the year 2013.
7. Rocky Flats use TRUPACT efficient boxes for light waste.

2.0 SUMMARY OF FINDINGS

The results of this study show that, as a general rule, TRUPACT efficiency is only slightly affected, if at all, by loading strategies.

1. Weight limitations dominate all transportation scenarios. For example, the majority of shipments from RFP, INEL, Hanford, and LANL will be weight-limited, regardless of how packages are mixed.
2. A small (5%) exception to item #1 occurs at INEL for a very specific package mix (described in this report).
3. SRP and ORNL are volume-limited and ship primarily drums of the same approximate weight. Hence, there is no opportunity to improve efficiencies by mixing packages by type or by weight, although some savings (2% of total transportation system cost) are possible by using loose drums instead of 6-packs.
4. A "worst case" scenario for package availability for shipment (assuming that only packages in one specific range of weight are available to ship at any one time) results in no significant difference in site packing efficiencies. This is because, even at the light end of the weight spectrum, shipments are still close to being weight limited. Random package selection yields the same result.
5. As a consequence of item #4, a site may segregate heavy waste to await an alternate transportation system (e.g. TRUPACT Mod 1 or ATMX) and suffer no efficiency penalty if the alternative system is not subsequently available.
6. A transportation system cost savings of approximately 3% ($6.5 million) may be achieved by repacking the waste from some light drums at SRP and ORNL into Trupact Efficient Boxes. However, this savings may be offset by the cost of repacking and disposal cost of the empty drums.
7. There are no credible scenarios in which axle loading (balance) requirements create packing inefficiencies.

3.0 PART ONE: Base Case Packing Efficiencies

3.1 Packages

This section describes the number, weight, and type of waste packages to be shipped to WIPP from each major site (RFP, INEL, Hanford, LANL, SRP, ORNL) and determines "base case" packing efficiencies. "Base case" means that "typical" (average) container weights were used to determine packing efficiency. In Part Two, we will examine the impact of "worst case" weight and packing mix, mixing package types and the effect of TEB's.

Table 1 lists all packages considered acceptable by the WIPP, as well as the maximum number of each package type that will fit into a TRUPACT, and the best possible packing efficiency for each package type. Table 2 lists the maximum allowable average weight of each package type, based on the 17,000 lb. payload of the TRUPACT and based on maximum packing efficiency. For example, to place 54 loose drums in a TRUPACT, the maximum average weight of the drums must be no more than:

$$17{,}000/54 = 314.8 \text{ lbs/drum}$$

Efficiency, or packing efficiency, has been defined as the volume of the containers that can physically fit into the TRUPACT, divided by the TRUPACT working volume (19.4 cubic meters). Care must be taken with this concept in the case of overpacks. For example, the FRP overpack has a higher "efficiency" that the FRP box itself, since it has a higher volume than the FRP box, and only 2 of either box will fit into a TRUPACT. However, if the FRP overpack contains an FRP box, then the "true" efficiency of the two containers is equal.

3.2 Packing Efficiencies

Net packing efficiencies for each of the major sites (accounting for shipment of all WIPP-acceptable package types from that site) are given in Table 3. Breakdowns of IWOP data and explanations of how each value was calculated are given in tables 4 through 8. Packing efficiencies are given for both loose drums and "6 pack" conditions. If a site is weight limited at less than 36 drums per TRUPACT, then

TABLE 1

WASTE CONTAINERS AVAILABLE FOR TRANSPORT TO THE WIPP

TRUPACT CAVITY WORKING DIMENSIONS=226 X 68 X 77 (INCHES)

CONTAINER	VOLUME (FT^3)	VOLUME (M^3)	DIMINSIONS (INCHES)	# PER T/P (MAXIMUM)	MAXIMUM EFFICIEN
55 GAL DRUM	7.35	0.2083		54	0.5799
6 PACK	44.11	1.2500		6	0.3866
TP EFF BOX	81.1	2.2981	69 X 54 X 38.5	8	0.9477
OVERPACK FOR 6 DRUMS	83.8	2.3746	74.5 X 50.5 X 38.5	6	0.7344
REPLACEMENT FOR FRP BOX	112.0	3.1737	64 X 48 X 48	2	0.3272
OVERPACK FOR FRP BOX	148.5	4.2080	83 X 54 X 54	2	0.4338
MOUND BOX	317.3	8.9912	112 X 68 X 72	2	0.9269

TABLE 2

CONTAINER	MAXIMUM NUMBER PER TRUPACT	MAXIMUM AVERAGE WEIGHT PER PACKAGE FOR MAXIMUM EFFICIENCY (LBS)
55 GALLON DRUM	54	314.8
6-PACK OF DRUMS	6	2833.3 (PER 6-PACK)
6-PACK OF DRUMS	6	472.2 (PER DRUM)
TRUPACT EFFICIENT BOX	8	2125
OVERPACK FOR 6 DRUMS	6	2833.3
REPLACEMENT FOR FRP BOX	2	8500
OVERPACK FOR FRP BOX	2	8500
MOUND BOX	2	8500

TABLE 3

PACKING EFFICIENCIES

SITE	PACKING EFFICICIENCY LOOSE DRUMS	PACKING EFFICIENCY 6 PACKS
RFP	.600	.600
INEL	.340	.340
SRP	.580	.370
ORNL	.580	.39[illegible]
HANFORD	.198	.198
LANL	.370	.370

the 6-pack packing efficiency is equal to the loose drum packing efficiency. For example, if a site is limited at 21 drums per TRUPACT, then half the shipments would contain three 6-packs (18 drums) and half the shipments would contain four 6-packs. This assumes optimization of drum selection (based on weight), so that in this case, the three 6-pack shipments would consist of relatively heavy drums. It is interesting to note that only ORNL and SRP can improve their packing efficiencies if allowed to use loose drums. All other sites are weight limited at 36 drums per TRUPACT or less, and therefore cannot take advantage of the loose drum configuration. Except as noted in Tables 4 through 8, waste package type and weight distributions were taken from the site inventory work-off plans (IWOP's). For the Rocky Flats Plant, waste package information was obtained through telephone conversations with Charles E. Wickland.

3.3 Calculation Methodology

Except as noted in tables 4 through 8, the average weight per package values are calculated using the weight distributions given in the site IWOP's. The IWOP's give the number of each package type in the range 0 - 400, 400 -800 , 800 - 1500, and so on, up to 25,000 lbs. The following method was used to calculate the average weight per package type:

1. The midpoint of each range was multiplied by the number of packages in that range.
2. The results of step one were summed over all weight ranges.
3. This summation was divided by the total number of packages.

In the range 0 - 400 lbs, we choose to use the more conservative value of 300 lbs, rather than the actual midpoint of 200 lbs, since very few packages weigh 0 lbs. We feel that, because the weight distribution data is given in rather broad ranges, further detail in this area would be beneficial; however, collection of this data is outside the scope of this preliminary study, and the available data suffices at present for achieving the broad conclusions of this study.

Care must be taken when one calculates the site packing efficiency for a site with several types of packages. To emphasize this point, a hypothetical site packing efficiency caculation is presented here. If 500 cubic meters are available for shipment at a packing efficiency of 75%, and another 500 cubic meters are available for shipment at a packing efficiency of 25%, the resultant packing efficiency is not 0.5. The correct value is 0.375, and the correct calculation method is given in Appendix B. In all cases we have examined where sites were required to combine several packing efficiencies, the sites used the incorrect method, making earlier site estimates suspect.

3.4 Load Balance Analysis

Load balance requirements dictate that the center of gravity of a TRUPACT load be located at the geometric center of the TRUPACT.

In our analysis of load balance requirements, we determined the following:

1. Because shipments will generally be weight limited, there will be significant amounts of unused volume in a TRUPACT. Therefore, packages can be arranged in a way to satisfy the load balance requirements.
2. Using the physical model of the TRUPACT and waste packages, we found no credible mix of packages that could not be satisfactorily arranged.
3. Shipments of like packages can always be symmetrically arranged.

Table 4

HANFORD WASTE CHARACTERIZATION TOTAL VOLUME OF WASTE CHARACTERIZED= 834682 (FT^3)

23638 (M^3)

(REF: IWDP)

55 GALLON DRUMS	VOLUME OF WASTE (CUBIC FEET)	NUMBER OF DRUMS	WEIGHT DISTRIBUTION 400	800	1500	3000	5000
SOFT	167844	22866	19199	3430	237	0	
HARD	71128	9690	7376	1556	758		
PROCESSED	589829	80352	0	0	80352		
SPECIAL	5921	793	702	91			
TOTALS	834682	113701	27277	5077	81347	0	0

AVERAGE WT PER DRUM= 922

NUMBER OF DRUMS PER TRUPACT (WITH 6 PACK)= 18

NUMBER OF DRUMS PER TRUPACT (LOOSE DRUMS)= 18

DRUM PACKING EFFICIENCY= 0.190

SITE PACKING EFFICIENCY= 0.190

NOTES:

1. 46,989 CUBIC FEET DESIGNATED FOR SHIPMENT IN THE M III BIN WAS NOT INCLUDED IN THIS ANALYSIS.

2. 1350 CUBIC FEET OF WASTE DESIGNATED FOR SHIPMENT IN THE EBR II WAS ALSO NOT INCLUDED.

Table [illegible]

LANL WASTE CHARACTERIZATION

TOTAL VOLUME OF WASTE CHARACTERIZED= 589501 (FT^3)
16695 (M^3)

55 GALLON DRUMS	VOLUME OF WASTE (CUBIC FEET)	NUMBER OF DRUMS	WEIGHT DISTRIBUTION 400	800	1500	3000	5000
SOFT	69293	9440	9440				
HARD	84047	11450	11450				
PROCESSED	334689	45596		45596			
SPECIAL	12992	1770	1770				
TOTALS	501021 (See note 1)	68256	22660	45596	0	0	0

AVERAGE WT PER DRUM= 500 (See note 3)
DRUMS PER TRUPACT (6-PACK)= 34
DRUMS PER TRUPACT (LOOSE DRUMS)= 34
DRUM PACKING EFFICIENCY (6-PACKS)= 0.364
DRUM PACKING EFFICIENCY (LOOSE DRUMS)= 0.364

TRUPACT EFFICIENT BOX

60 BY 54 BY 38.5 INCH BOX	VOLUME OF WASTE (CUBIC FEET)	NUMBER OF BOXES	WEIGHT DISTRIBUTION 400	800	1500	3000	5000
	(SEE NOTE 2)						
HARD	10219	126				126	
PROCESSED	32035	395					
LARGE EQUIP	38766	478				233	245
SPECIAL	7461	92				92	
TOTALS	88480	1091	0	0	0	451	245

AVERAGE WT PER BOX= 4500
BOX PACKING EFFICIENCY= .440
SITE PACKING EFFICIENCY (6 PACKS)= 0.370
SITE PACKING EFFICIENCY (LOOSE DRUMS)= 0.370

NOTES:

1. THE NUMBER OF DRUMS, MULTIPLIED BY THE VOLUME OF A DRUM, DOES NOT CORRESPOND TO THE VOLUME OF WASTE SPECIFIED IN THE IWOP. WE ASSUMED THAT THE NUMBER OF DRUMS IS CORRECT, AND CALCULATED THE VOLUME OF WASTE, BASED ON THE NUMBER OF DRUMS.
2. THE NUMBER OF BOXES, MUTILPLIED BY THE VOLUME OF A BOX, DOES NOT CORRESPOND TO THE VOLUME OF WASTE SPECIFIED IN THE IWOP. AGAIN, WE ASSUMED THAT THE NUMBER OF BOXES WAS CORRECT, AND CALCULATED THE VOLUME OF WASTE BASED ON THE NUMBER OF BOXES.
3. LETTER DATED 3/13/84 FROM BRUCE T. REICH TO ED KERN (BOTH OF LANL) GIVES THE AVERAGE WEIGHT OF DRUMS TO BE 500 LBS. AND THE AVERAGE WEIGHT OF A BOX TO BE 4500 LBS. USING THE IWOP WEIGHT DISTRIBUTIONS AND THE MIDPOINT METHOD, OUR VALUES WOULD HAVE BEEN 501 LBS. AND 4001 LBS. FOR DRUMS AND BOXES, RESPECTIVELY.

ORNL WASTE CHARACTERIZATION ---------------------------

TOTAL VOLUME OF WASTE CHARACTERIZED= [illegible]
[illegible]

(REF: ORNL IWOP, AND IWOP SUMMARY REPT)

55 GALLON DRUMS	VOLUME OF WASTE (CUBIC FEET)	NUMBER OF DRUMS	WEIGHT DISTRIBUTION 400	800	1500	3000
ALL DRUMS	12482	1700	1700	0	0	
TOTALS	12482	1700	1700	0	0	

AVERAGE WT PER DRUM=	200	(ORNL IWOP STATES THAT ALL DRUMS WEIGH LESS THAN 200 LBS.)
DRUMS PER TRUPACT (6 PACK)=	36	
DRUMS PER TRUPACT (LOOSE DRUMS)=	54	
DRUM PACKING EFFICIENCY (6-PACKS) =	0.386	
DRUM PACKING EFFICIENCY (LOOSE DRUMS)=	0.579	

NOTES:

1. THESE NUMBERS DO NOT AGREE WITH THE ORNL IWOP, AND WERE OBTAINED THROUGH TELEPHONE CONVERSATIONS WITH DON BOX. HE INDICATED THAT THE IWOP NUMBERS WERE WRONG, POSSIBLY DUE TO A MISPRINT.

2. DON BOX ALSO INDICATED THAT SOME OF THESE DRUMS COULD BE DAMAGED AND WOULD THEN REQUIRE AN OVERPACK. HOWEVER, EVEN WITH AN OVERPACK, 36 DRUMS WILL FIT INTO A TRUPACT, AND THE NUMBER OF TRUPACT LOADS REQUIRED TO MOVE THE WASTE WILL NOT CHANGE.

3. MR. BOX ESTIMATED THAT, AT MOST, 5% OF THE DRUMS (85) ARE DAMAGED.

4. ORNL HAS ABOUT 300 30 GALLON DRUMS AND ABOUT 20 4 X 4 X 7 BOXES.

5. WHEN THE 4 X 4 X 7 BOXES ARE CONSIDERED, THE PACKING EFFICIENCY DECREASES BY ABOUT 1%.

INEL WASTE CHARACTERIZATION

TOTAL VOLUME OF WASTE CHARACTERIZED= 1443613 (FT^3)
40883 (M^3)

(REF: INEL IWOP, MARCH, 1984)

55 GALLON DRUMS	VOLUME OF WASTE (CUBIC FEET)	NUMBER OF DRUMS	WEIGHT DISTRIBUTION 400	800	1500	3000	5000
SOFT	35241	4001	3056	944	1		
HARD	90660	12351	11376	975			
PROCESSED	503502	69594	4465	29923	35206 (SEE NOTE 1)		
TOTALS	629403	85746	19697	31842	35207		

AVERAGE WT PER DRUM= 756
NUMBER OF DRUMS PER T/P (WITH 6 PACK)= 22
NUMBER OF DRUMS PER T/P (LOOSE DRUMS)= 22
DRUM PACKING EFFICIENCY= 0.241

OVERPACK FOR 6 DRUMS

74.5 BY 52.5 BY 38.5 INCH BOX	VOLUME OF WASTE (CUBIC FEET)	NUMBER OF BOXES	WEIGHT DISTRIBUTION 400	800	1500	3000	5000	7000
SOFT	161902	1932			56	1837	39	0
HARD	80448	960				576	335	49
PROCESSED								
TOTALS	242350	2892	0	0	56	2413	374	49

AVERAGE WT PER BOX= 2519
NUMBER OF BOXES PER TRUPACT= 6
BOX PACKING EFFICIENCY= 0.734

FRP OVERPACK

88 BY 54 BY 54 INCH BOX	VOLUME OF WASTE (CUBIC FEET)	NUMBER OF BOXES	WEIGHT DISTRIBUTION 400	800	1500	3000	5000	7000
SOFT	178479	1202			83	1099	18	2
HARD	321949	2168			137	1376	647	8
LARGE EQUIPMENT	66828	450				300	150	
PROCESSED	4604	31				1	23	7
TOTALS	571860	3851	0	0	220	2776	838	17

AVERAGE WT PER BOX= 2585
NUMBER OF BOXES PER TRUPACT= 2
BOX PACKING EFFICIENCY= 0.434

SITE PACKING EFFICIENCY (6-PACKS)= 0.339
SITE PACKING EFFICIENCY (LOOSE DRUMS)= 0.339

NOTES:

1. 15 DRUMS AT BETWEEN 12,000 AND 17,000 LBS IGNORED.
(SEE INEL IWOP, SECTION II, TABLE 11, PAGE 4.2)
2. 21,360 CUBIC FEET (605 CUBIC METERS) DESIGNATED FOR SHIPMENT BY THE M-III BIN WAS NOT CONSIDERED IN THIS ANALYSIS.

SRP WASTE CHARACTERIZATION

TOTAL VOLUME OF WASTE CHARACTERIZED= 456100 (FT^3)
12917 (M^3)

(REF: IWCP SUMMARY REPT, MAY, 1984)

55 GALLON DRUMS	VOLUME OF WASTE (CUBIC FEET)	NUMBER OF DRUMS	WEIGHT DISTRIBUTION 400	600	1500	3000	5000
SOFT	232000	18505	18505				
HARD	90100	12390	12390				
PROCESSED	134000	18375	17250	1125			
SPECIAL	0	0	0				
TOTALS	456100	49270	48145	1125	0	0	0

AVERAGE WT PER DRUM= 485
DRUMS PER TRUPACT (WITH 6 PACK)= 36
DRUMS PER TRUPACT (LOOSE DRUMS)= 42
SITE AND DRUM PACKING EFFICIENCY= 0.390

4.0 PART TWO: PACKAGING ALTERNATIVES

4.1 Mixing Package Types

Mixing package types (e.g., drums with boxes) does not generally offer any improvement in site packing efficiencies. Most sites are weight limited, and any volume optimization that mixing package types may offer is not available. At INEL, however, an improvement of about 5% may be attained by using the following mix:

1. Ship all 6-pack overpacks alone.
2. Ship two 6-packs of the heaviest drums with one FRP overpack as long as the FRP overpacks are available.
3. Ship the remaining (light) drums alone in 6-packs.

The small additional gain from this scenario is due to the fact that the FRP overpacks are relatively light (volume limited), and the drums are relatively heavy.

SRP has only 55-gallon drums and, therefore, cannot mix package types. ORNL has about 1,700 55-gallon drums and an insignificant number of FRP replacement boxes, so mixing package types is of no consequence.

4.2 Worst Case Weight Mix

All analyses in this report consider the average weight of packages in determining packing efficiencies. Realizing that sites do not always have the luxury of selecting an optimum mix of packages, we examined the "worst case" packing configuration. In this case, we assumed that each site would ship all of the packages in a single range of the IWOP weight distributions together. In other words, the site would ship only those packages that weigh between 0-400 lbs, and then only those packages that weight between 400-800 lbs. and so on, until all packages are shipped. These calculations were performed for both the loose drum and the 6-pack configurations. The result of this exercise showed little or no difference in site packing efficiencies due to these "worst-case" selections, with the exception of LANL, which will be discussed shortly. Since weight limitations are generally in effect, a typical site would ship light waste at a relatively good packing efficiency, followed by shipments of heavy waste at a relatively bad efficiency. The worst case efficiency generally differs from the original efficiency (calculated using average package weights) by only a fraction of a percent. An interesting consequence of this result is that a site may segregate heavy waste to await an alternative transportation system, (e.g. the TRUPACT mod 1 or the ATMX) and suffer no penalty if the system does not become available.

One exception to this result was seen at LANL, where a 4% loss in site efficiency could be seen if drums were shipped using the "worst case" method and the 6-pack configuration was used. Using the average weight method, LANL comes very close to the volume limit (six 6-packs) of the TRUPACT. Using the worst case method, LANL ships six 6-packs per TRUAPACT of light waste, and then drops off significantly with the heavier waste, for a substantial net efficiency loss. In this section, it was assumed that package types were not mixed. In addition to the worst case method, we also considered a random selection of packages, and the results were very similar (within one percent) to those obtained using the average weight method.

4.3 TRUPACT Efficient Box Analysis

In this section of the report, we examine the effect of loading waste into the TRUPACT Efficient Box (TEB). The TEB offers a packing efficiency of 95% if weight limitations do not come into play. If, however, the loading of a given package at a site is weight limited, the TEB provides no advantage.

To calculcate TEB efficiency values, the following rules were used:

1. If the density of the waste was low, the TEB was used to ship all waste of that package type.
2. If the density of the waste was high, only the amount of (light) waste that improved the packing efficiency was shipped in the TEB. The remainder was shipped "as is".

We assume that the old packages "go away", and we make no attempt to quantify the cost consequences of dealing with these packages. Further, we assumed that empty drums weigh 83 lbs. and that empty TEBs weigh 420 lbs.

It is interesting to note that five 55-gallon drums will fit into a TEB, and that eight TEBs will fit into a TRUPACT. This will result in 40 drums per TRUPACT (compared to 36 with 6-packs and 54 with loose drums), if weight limitations do not present a problem. We did not investigate overpacking drums into a TEB since this method would produce no benefit because of the weight limitations of the packages.

We found that LANL, Hanford and Rocky Flats could not improve their efficiencies by using the TEB (LANL and RFP currently plan to use the TEB for certain wastes, and they could not improve their efficiencies with more extensive use of the TEB). INEL could improve their net site packing efficiency by about 7% by repacking FRP overpacks into TEBs. This is probably not possible, however, because many of the FRP overpacks contain pieces of large equipment that would not fit into a TEB. ORNL and SRP could bring their packing efficiencies to 95% and 70%, respectively, by repacking their 55-gallon drums into TEBs.

5.0 TRUPACT REQUIREMENTS AND COST

Packing efficiencies, along with waste inventories to be shipped and assumptions regarding TRUPACT transportation, financial and maintenance terms, will determine the number of TRUPACT loads required for each site. The required number of TRUPACT loads will affect the TRUPACT fleet size. Therefore, varying the packing efficiencies will affect the following costs:

- TRUPACT capital cost
- Freight costs
- Site loading and unloading costs
- TRUPACT annual maintenance costs

Regardless of the method by which the waste is shipped, the WIPP will have to emplace the same amount of waste. WIPP cost sensitivity to the number and configuration of packages (i.e. loose drums vs. 6-packs or TRUPACT efficient boxes) emplaced is not considered.

The number of TRUPACTs, as well as the number of TRUPACT trips required for each packing efficiency, were determined with the help of the computer program TRUSIM, devleloped at LANL for TWSO. Cost impacts were determined by the computer program TRUCOST, developed by SMSC for TWSO.

Four TRUSIM/TRUCOST runs were made to determine costs and TRUPACT requirements for each of the following scenarios:

- All trucks using 6-packs for drums
- 25% truck, 75% rail, using 6-packs for drums
- 25/75% using loose drums
- All truck using TEB where efficient (ORM, SRP).

Results are shown in Table 9 and 10. As a broad conclusion, it may be observed that using 6-packs has relatively insignificant impact on system requirements. Likewise, selective use of the TEB on stored waste appears to be only marginally cost-effective, especially considering that repacking costs were not considered. The value of the TEB lies primarily in its use by RFP (which is volume limited) in packing NGW.

Table 9 Summary of Transportation Costs

(In Millions)

Packaging Mode	Transportation Mode: All Truck	Transportation Mode: 25% Truck, 75% Rail
6-pack	$196.	$317.
Loose Drums	($192.)	$310.
TEB (AT ORNL,SRP)	$188.	($304.)

Numbers in parenthesis indicate that no TRUSIM/TRUCOST run was made for this case. Approximate values are shown based on ratioing the the calculated values in the table. Any savings associated with an all truck fleet is due to the shorter truck travel and turnaround times, resulting in fewer TRUPACTs, and therefore the ratio of costs for the two 6-pack runs will apply to all other run combinations.

Table 10

Summary of TRUPACT Requirements

(Total Number Required)

Packaging Mode	Transportation Mode: All Truck	Transportation Mode: 25% Truck, 75% Rail
6-pack	24	57
Loose Drums	(23)	54
TEB (AT ORNL, SRP)	23	(55)

Appendix A: Rocky Flats Plant Packing Efficiency

RFP currently projects the following annual shipments to the WIPP.

Number of containers shipped per year	Package Type	Waste Density
1200	TEB	30 lbs. per cubic foot
2000	55 gal drum	70 lbs. per cubic foot

The following information about drums and TEB's is used :

Package	Volume	Empty Weight	Weight of Waste	Gross Weight
55-gallon Drum	7.35	83 lbs.	514 lbs.	597 lbs.
TEB	81.1	420 lbs	2433 lbs.	2853 lbs.

The volume is in cubic feet, and the weight of waste is calculated using the waste densities given above.

Using the TRUPACT payload of 17000 lbs, we now determine the maximum number of each container that can be placed in a TRUPACT.

$$\text{Max. Number of Drums} = \frac{17000}{597}$$

Max. Number of Drums = 28.5

$$\text{Max. Number of TEBs} = \frac{17000}{2853}$$

Max. Number of TEBs = 6

The packing efficiency for drums is then given by:

$$Peff = \frac{19.4}{28.5 \times .208}$$

$$Peff = .305$$

The packing efficiency for TEBs is given by:

$$Peff = \frac{19.4}{6 \times 2.298}$$

$$Peff = .706$$

The total volume of waste shipped by each container in a year is given by:

Volume (drums) = (2000 drums) x (.228 cubic meters per drum)

Volume (drums) = 420 cubic meters

Volume (TEBs) = (1200 TEBs) x (2.298) cubic meters per TEB)

Volume (TEBs) = 2758 cubic meters

The overall site packing efficiency is the given by:

$$Peff = \frac{(V1 + V2) \times P1 \times P2}{(V1 \times P2) + (V2 \times P1)}$$

$$Peff = \frac{(2433 + 420) \times .706 \times .305}{(2433 \times .305) + (420 \times .706)}$$

$$Peff = .6$$

Where P1 and P2 are the two values for packing efficiency calculated above, and V1 and V2 are the two volumes of waste shipped by each package type.

Appendix B: Combining Multiple Package Types

This appendix describes the correct method of calculating net packing efficiencies for a site with several types of packages. In the following example, the site has a volume V1 to be shipped in a package with efficiency P1, and a volume V2 to be shipped in a package with efficiency P2.

$$\text{Site Peff} = \frac{\text{TOTAL WASTE VOLUME}}{(\text{TRUPACT VOLUME}) * (\text{NUMBER OF TRUPACT SHIPMENTS})}$$

$$\text{TOTAL WASTE VOLUME} = V1+V2$$

$$\text{NUMBER OF TRUPACT SHIPMENTS} = \frac{\text{EFFECTIVE WASTE VOLUME}}{\text{TRUPACT VOLUME}}$$

$$\text{NUMBER OF TRUPACT SHIPMENTS} = \frac{\frac{V1}{P1} + \frac{V2}{P2}}{19.4}$$

$$\text{Site Peff} = \frac{V1 + V2}{(19.4) * \dfrac{\frac{V1}{P1} + \frac{V2}{P2}}{19.4}}$$

Which simplifies to:

$$\text{Peff} = \frac{(V1+V2)*P1*P2}{(V1*P2)+(V2*P1)}$$

P2=.75) the correct site packing efficiency is .375.

For combining three packing efficiencies the formula becomes:

$$Peff = \frac{(V1+V2+V3)*P1*P2*P3}{(V1*P2*P3)+(V2*P1*P3)+(V3*P1*P2)}$$

For combining four packing efficiencies the formula becomes:

$$Peff = \frac{(V1+V2+V3+V4)*P1*P2*P3*P4}{(V1*P2*P3*P4)+(V2*P1*P3*P4)+(V3*P1*P2*P4)+(V4*P1*P2*P3)}$$

APPENDIX H

ALTERNATE TRUPACT DESIGN STUDY

ANALYSIS OF ALTERNATIVE TRUPACT DESIGNS

1.0 Introduction

J. M. McGough, Jr., Director of the Waste Management and Transportation Development Division of DOE-AL, in his letter of December 4, 1984 (Reference 1), proposed two alternative TRUPACT designs ('A' and 'B'), both of which took advantage of an 8' 6" wide load, and asked for an analysis addressing the following points:

1. Which of the waste generating sites would require use of the 8' 0' wide TRUPACT because of state highway width limitations and no rail access?
2. Which of the waste generating sites would require use of rail only access because of state highway width limitations?
3. Which of the waste generating sites could utilize either TRUPACT 'A' or 'B' with no restrictions?
4. Based upon the data in items 1 through 3 above, provide a comparison of the following data for the current TRUPACT design, and for TRUPACTs 'A' and 'B' designs.
   - A. Projected yearly shipments to WIPP by rail and truck from each site.
   - B. Estimated shipping and operating costs for the above.
   - C. Number of TRUPACTs required for each design variation above.
5. Provide the same information in item 4 above assuming all states adopt the Federal width limit of 8' 6".

The S. M. Stoller Corporation was assigned Task 23 to assist in this evaluation. This report describes the methods used to conduct the analysis and presents the results obtained.

2.0 Assumptions

Following is a list of assumptions made in performing these analyses.

1. The base case (current) TRUPACT has a payload of 17,000 lbs. and a gross weight of 50,000 lbs. Payloads of alternate designs ("TRUPACT A" and "TRUPACT B") were calculated assuming constant wall thickness and density and constant clearances between the inner surfaces and the useable space envelope, as recommended by L. Romesberg (SNL). As a result, any change in outer surface dimension produces an equal change in the corresponding useable space dimension.

2. All states adopt the new 8' 6" maximum width. Section 2.1 describes the current regulatory status of the 8' 6" rule and concludes that all states will allow 8' 6" shipments of TRUPACT.

3. Inventory projections are from the Long-Range Master Plan

4. Weight distributions from the Inventory Work-Off Plans (IWOPs) were used, except for modifications at Hanford and INEL. Weight distributions at Hanford and INEL were modified from the IWOP data, based on discussions with people at these sites.

5. 25 year WIPP work-off plan (1988-2013)

6. Packing efficiencies were adjusted for changes in TRUPACT design at the six major sites (RFP, INEL, SRP, ORNL, LANL, Hanford) where waste characterization data is available. Waste characterization data was not available at smaller sites, but since the major sites represent 92% of the total waste to be shipped, omission of small sites does not change the conclusions.

7. The current TRUPACT Efficient Box design was used for all TRUPACT designs, although it is not quite as efficient for new TRUPACT designs. Since shipments continue to be largely weight limited, this assumption does not have a significant

impact on conclusions. Of course, were new TRUPACT designs to be implemented, the TEB design would have to be re-examined.

8. All drums are shipped in six-packs.

9. MPLAN, TRUISM, and TRUCOST computer programs were used (these are described in Section 5.1).

10. Costs were calculated only for truck transportation, since it had earlier been demonstrated that truck transportation is substantially cheaper than rail transportation for TRUPACTs (Reference 2).

11. Freight costs were calculated from the Tri-State Motor Transit Co. tariff document (Reference 9) assuming:

    - o two drivers for all trips (second driver costs 15¢/mile),
    - o no overweight charges, although the 50,000 lbs. gross weight of all TRUPACT designs exceeds the 48,000 lbs. cargo limit common to all the continental states (according to the Reference 9).
    - o discount of 5¢/mile for shipper-supplied trailer,
    - o all other items which could result in extra charges per Reference 9 do not apply (see Appendix B for a list of these items).

None of the freight cost assumptions significantly impact the comparative results of this analysis, since the charges would apply to all three designs. The total cost of each option would, of course, be impacted. Table 2-1 shows the resulting costs.

12. Capital cost of each TRUPACT is $800,000, regardless of design.

13. Each TRUPACT requires $13,000/year in operation and maintenance expenses.

14. Load/Unload cost = $2137 per event at every site.

15. Constant 1985 dollars.

16. Two base-design TRUPACTs exist.

TABLE 3-1

TRUCK TRANSPORTATION COSTS FOR TRUPACTS

BASED ON TRI-STATE TARIFF OCT 1984

SITE	1-WAY MILES	MILEAGE $/MILE	BASIC COST($)	NO. OF DRIVERS	2ND DR COST	TRAILER DISCOUNT	TOTAL 2-WAY COST($)
AFF	600	4.44	2664	2	100	-60	2704
ANL	1350	3.43	4630.5	2	405	-135	4900.5
MF	1400	3.43	4802	2	420	-140	5082
LLNL	1350	3.74	5049	2	405	-135	5319
HANF	1550	3.68	5704	2	465	-155	6014
[illegible]	1550	3.68	5704	2	465	-155	6014
INEL	1150	3.8	4370	2	345	-115	4600
LANL	300	5.7	1710	2	90	-30	1770
NTS	900	4	3600	2	270	-90	3780
ORNL	1300	3.44	4472	2	390	-130	4732
SRP	1450	3.42	4959	2	435	-145	5249
SPMP	1550	3.68	5704	2	465	-155	6014

2.1 Discussion of Width Limit Regulation

The Federal Highway Administration (FHWA), of the Department of Transportation (DOT), published 23 CFR 658, "Truck Size and Weight; Final Rule," in the Federal Register of June 5, 1984. This regulation defines the National Network of Highways consisting of the Interstate system and other qualifying Federal-Aid Primary System Highways. Appendix A to the regulation contains a detailed list of the highways composing the National Network on a state-by-state basis. All states are required to accept the new 102 inch width limit on the National Network. Quoting the regulation:

> "Section 658.15 Width.
>
> (a) No State shall impose a width limitation of more or less than 102 inches, or its approximate metric equivalent, 2.6 meters (102.36 inches) on a vehicle operating on the National Network, . . ."

In addition, the states are required to allow reasonable access to the National Network:

> "Section 658.19 Reasonable access.
>
> (a) All States must allow vehicles with dimensions authorized by the STAA (Surface Transportation Assistance Act of 1982) reasonable access between the National Network described in the regulation and terminals, and facilities for food, fuel, repairs, and rest."
>
> "Section 658.7 Applicability.
>
> Except as limited in Section 658.17(a) the provisions of this Part are applicable to the National Network and reasonable access thereto. However, nothing in this regulation shall be construed to prevent any State from applying any weight and size limits to other highways, except when such limits would deny reasonable access to the National Network."

All of the waste-generating sites, with two exceptions, either have immediate access to a National Network Highway or can reasonably be expected to have access under the reasonable access policies adopted in their respective states (The publication cited above contains a table listing such policies for all the states). The two exceptions are LANL and SRP. Neither has immediate access to a National Network Highway and their states, New Mexico and South Carolina, had not established their reasonable access provisions as of June 5, 1984. A telephone discussion with Mr. Hal Brown, Chief of Traffic Regulations in the Office of Traffic Operations, FWHA/DOT, on January 29, 1985 indicates that these two states still have not established their final reasonable access provisions and are currently operating on interim procedures. New Mexico is currently permitting access to delivery points within twenty miles of the

National Network. Since LANL is approximately twenty miles from the nearest National Network Highway, it is assumed that it will have access to the National Network under the interim procedures. South Carolina does not have a clearly stated interim procedure but is apparently pursuing a liberal interpretation of the reasonable access provision. Therefore it appears that SRP will also have access to the National Network under the interim procedures. These two states may ultimately adopt regulations somewhat more restrictive than the interim procedures. However, quoting from the background information published with the regulation:

> "Analysis of the comments has not revealed evidence that the States would not provide reasonable access. Eighteen States already offer virtually unlimited access, and many other States are in the process of considering liberal access policies. It is FHWA's intention to monitor the States' reasonable access policies and practices and reevaluate its position if necessary. Should FHWA determine that a State's position is unreasonable. and in violation of Section 412, it has the authority under Section 413 to seek injunctive relief."

On this basis, for the purposes of this study, it is assumed that all states effectively have adopted the new 102-inch width limit to a sufficient extent to permit all waste-generating sites to use the 102-inch wide TRUPACT without restriction. Since this analysis concludes that the TRUPACT A/B approach does not substantially improve the system, the width question is not critical to the results.

3.0 Description of TRUPACT Designs

Table 3-1 presents the geometric data for the three TRUPACT designs studied here. The dimensions of the base, or current, design were taken from references 6 and 7. The inside and outside dimensions refer to the respective physical wall surfaces. The useable space dimensions are slightly smaller than the inner surface dimensions to allow handling clearance during loading and dunnage space.

To generate alternate TRUPACT designs, it was assumed that the wall thicknesses and clearances indicated by differences in the base TRUPACT dimensions would be identical in all designs. The wall material density was assumed to be uniform and constant. The useable volume and wall material volume were calculated for each design, and the wall volume multiplied by the density gives the TRUPACT weight for each new design. The difference betwween the TRUPACT weight and gross loaded weight (50,000 lbs. in all cases) is the payload.

Both 'A' and 'B' designs reflect the six inch increase in overall width. The above assumptions result in a six inch increase in useable width, to 74 inches. This is the estimated length of a six-pack, so six-packs can be loaded sideways. A six-pack was estimated to be 50 inches wide. Therefore, the 'A' design was given a 200 inch useable length to accomdate four stacks of two six-packs each, for a total of eight. The 'B' design useable length of 250 inches will accommodate ten six-packs.

As shown in Table 3-1, the 'A' design is wider, which increases weight, and shorter, which descreases weight. The net effect is a decrease of 638 lbs. in TRUPACT weight and a corresponding increase in payload. Since the 'B' design is wider and longer, both of which increase the TRUPACT weight, the effects combine to reduce the payload to 13,493 lbs. While 'B' has the smaller payload, it has the larger useable volume. Therefore, the 'A' design will slightly benefit weight-limited sites. The 'B' design will significantly penalize weight-limited sites and significantly benefit volume-limited sites. While 'A' has a slightly smaller volume than the base case, it will benefit volume-limited sites to the extent that the space is more efficiently utilized.

Table 3-1

Description of TRUPACTs

TRUPACT Design	Dimensions, Inches									Useable VOL. M^3	Payload Lbs
	Useable			Inside			Outside				
	L	W	H	L	W	H	L	W	H		
Base	226	68	77	230	74	86	300	96	108	19.4	17,000
A, Wider Shorter	200	74	77	204	80	86	274	102	108	18.7	17,638
B, Wider Longer	250	74	77	254	80	86	324	102	108	23.3	13,493

Table 3-2 lists the waste containers available for shipment to WIPP, the maximum number of each container which can be packed in each TRUPACT, and the resultant maximum packing efficiencies.

Table 3-2

Waste Containers Available For Transport To The WIPP

	Container		Base TRUPACT		TRUPACT A		TRUPACT B	
	VOLUME FT^3	DIMENSIONS, INCHES L, W, H	MAX NUMB /TRUPACT	MAXIMUM EFF	MAX NUMB /TRUPACT	MAXIMUM EFF	MAX NUMB /TRUPACT	MAXIMUM EFF
Drums	7.35		54	0.579	48	0.534	60	0.534
Six-Pack	44.11	74, 50, 38.5	6	0.386	8	0.535	10	0.535
TP EFF Box	81.1	68, 54, 38.5	8	0.947	6	0.737	8	0.787
Overpack For 6 Drums	83.8	74.5, 50.5, 38.5	6	0.734	4	0.508	6	0.610
Replacement For FRP Box	112	84, 48, 48	2	0.327	2	0.339	2	0.271
Overpack For FRP Box	148.5	88, 54, 54	2	0.433	2	0.450	2	0.360
Mound Box	317.3	112, 68, 72	2	0.926	1	0.481	2	0.769

4.0 Site Packing Efficiencies

Table 4-1 presents the site packing efficiencies for the three TRUPACT designs compared in this study. The base case efficiencies were obtained from Reference 2. Packing efficiencies for the 'A' and 'B' designs were obtained from the base case numbers by adjusting for changes in TRUPACT design at the six sites (RFP, INEL, SRP, ORNL, LANL, Hanford) where waste characterization data is available. Since these sites represent 92% of the total waste to be shipped, omission of small sites does not change the conclusions.

The payload for each design is divided by the average weight per container at each site to obtain the maximum number of each type of container which can be loaded on a TRUPACT based on the weight limitation. If this number exceeds the maximum number of such containers which can physically be loaded into a TRUPACT based on volume limitation, then the volume-limited number is used. The total container volume divided by the TRUPACT volume gives the packing efficiency for that container type. Where a site uses several containers, the individual container efficiencies are combined as described in Reference 2 to obtain the site efficiency. Reference 2 gives a more detailed description of these calculations.

Examination of Table 4-1 shows that the 'A' design results in a slight increase in the packing efficiencies of the major sites. This is primarily due to the small increase in payload and the fact that most sites are weight-limited. The Oak Ridge site, which is volume-limited, benefits too, because, while the 'A' design has the smaller useable volume, that volume is optimized for the loading of six-packs, resulting in a more efficient use of the smaller volume.

The 'B' design results in reductions of packing efficiency at five of the six sites adjusted, because the much smaller payload results in those sites being severely weight-limited. The Oak Ridge site has an increased efficiency, because it is volume-limited and the 'B' design provides a somewhat larger useable volume.

Table 4-1

Site Packing Efficiencies

Site	TRUPACT Base	A	B
* Rocky Flats	.600	.634	.397
Argonne	.700	.700	.700
Mound	.680	.680	.680
Livermore	.392	.392	.392
Hanf Offsite	.392	.392	.392
* Idaho	.414	.413	.304
* Hanford Site	.386	.449	.275
* Los Alamos	.370	.404	.247
Nevada	.392	.392	.392
* Oak Ridge	.390	.535	.535
* Savannah Riv	.390	.485	.297
SFMP	.327	.327	.327

* Efficiencies for these sites were adjusted for changes in TRUPACT payload and volume. Others were assumed constant due to lack of waste characterization data. Adjusted cases account for 92% by volume of total waste.

5.0 Methodology and Summary of Results

This section describes the analysis methods and tools used to conduct this study and summarizes the results obtained.

5.1 Methodology

The program MPLAN (Reference 3) was used to calculate the annual waste shipped from each site to the WIPP. MPLAN takes as input the existing inventory at each storage site, inventory projections from each generating site, processing schedules and volume changes at processing sites, and WIPP receipt strategy. From these inputs, MPLAN calculates the annual quantity of waste to be shipped from each site to the WIPP.

The program TRUSIM (Reference 4) simulates the transportation system and calculates the required numbr of TRUPACTs and the number of shipments required from each site. TRUSIM utilizes as input the output from MPLAN: namely, the annual quantity of waste shipped from each site to the WIPP. TRUSIM uses the calculated site packaging efficiencies of the TRUPACT, and, combining this with the annual shipments from each site to the WIPP and the transportation and turnaround times, calculates the required number of TRUPACTs to meet transportation needs. TRUSIM will also calculate the required TRUPACT shipments each year from each site.

The program TRUCOST (Reference 5) was used to calculate the cost factors for the entire system. TRUCOST takes output from TRUSIM regarding the required number of TRUPACTs and TRUPACT trips, and also takes as input the estimated capital cost for TRUPACTs, operating and maintenance costs, and transportation costs from each site. From these inputs, TRUCOST calculates the total transportation costs each year.

A key assumption in performing this analysis is the packaging efficiency at each site. Packaging efficiencies are calculated by examining the waste mix at each site (mixes of container types and weight distributions), and calculating the optimum quantity of waste which can be emplaced in a given TRUPACT design, based on these waste characteristics. Packaging efficiencies are calculated by assuming that the site has

Table 5-1

Summary of Costs
& Required Numbers
of TRUPACTs

TRUPACT	Vol. M^3	Payload Lbs	Cost $Mil	TRUPACTs Req'd	Trips Req'd
Base	19.4	17,000	162	21	22618
A	18.7	17,638	160	20	22409
B	23.3	13,493	186	24	26347

Table 5-2

Breakdown of Costs ($ Millions)

Cost	Base	A	B
Capital	16.8	16.0	19.2
Operation & Maint.	6.8	6.5	7.8
Freight	90.2	89.5	102.2
(Un)Load	48.3	47.9	56.3
Total	162.1	159.9	185.5

relatively perfect access to the waste, in a way which allows mixing and matching to achieve optimum load configurations. As it turns out, this assumption is not particularly critical, since the majority of waste shipped to WIPP under all the scenarios examined is weight-limited. That is, optimum loading of the TRUPACT will in most cases not be an exercise in geometry, but a relatively simpler exercise in adding packages until the weight limit is met.

5.2 Results

Table 5-1 presents a summary of costs and the required numbers of TRUPACTs. Table 5-2 presents a breaksdown of the costs by category. Tables 5-3, 5-4, and 5-5 show projected yearly shipments to WIPP from each site for the three cases.

Shown in Table 5-1, the 'A' design represents a slight improvement over the base case. Only twenty TRUPACTs of the 'A' design are required, compared to twenty-one of the base design. A savings of about $2 million (about 1½%) is indicated. This slight improvement results from the slight increase in payload of the 'A' design, which benefits the weight-limited sites. Although the volume of the 'A' design is reduced slightly, the volume-limited sites benefit because of a more efficient use of the smaller volume.

The 'B' design has a much smaller payload and a somewhat larger and more efficient volume than the base case design. Because most of the sites are weight-limited, their packing efficiencies are reduced, and three more TRUPACTs are required. The Oak Ridge site, which is volume-limited, is the only site to benefit from the 'B' design, because of its larger volume. Even the formerly volume-limited SRP site becomes weight-limited because of the large payload reduction. The result is that the 'B' design increases system costs by $23 million (14%) over the base case.

In summary, only the 'A' design represents an improvement on the base case design, reducing total costs by less than 2%. This savings may be too small to justify a new TRUPACT design. However, this result does indicate a need for additional work to determine if there is a TRUPACT design which would result in more significant improvement over the base design, or if it is necessary to consider a mixed fleet of two TRUPACT designs in order to achieve a significantly higher system efficiency and lower cost.

TABLE 5.[illegible]
PROJECTED ANNUAL SHIPMENTS TO THE WIPP
USING THE BASE IMPACT

CAL YEAR	SITE: RFP	ARGN	MOUND	LLNL	HOS	INEL	HANF	LANL	NTS	ORNL	SRP	SEMF
1988	109	0	2	5	5	136	7	16	6	2	6	16
1989	329	1	3	16	15	464	52	66	1	4	36	3
1990	349	2	4	19	24	175	96	77	6	6	67	23
1991	343	1	1	21	60	181	78	71	3	6	69	19
1992	339	2	1	20	58	202	71	67	5	5	64	22
1993	322	1	1	20	57	214	74	71	5	5	64	24
1994	321	1	1	19	56	213	72	70	6	6	63	23
1995	323	2	1	19	56	215	73	71	5	5	64	24
1996	321	1	1	19	56	212	72	70	5	5	64	23
1997	325	2	1	19	55	216	72	72	5	6	63	24
1998	319	1	1	19	57	213	73	70	5	5	65	24
1999	323	1	1	19	55	213	72	70	5	5	63	23
2000	322	2	1	20	57	215	73	71	6	6	64	24
2001	321	1	1	19	55	212	72	71	5	5	64	23
2002	326	2	1	19	57	217	73	71	5	5	64	24
2003	322	1	1	17	56	214	73	71	5	6	64	23
2004	323	1	2	19	55	215	72	71	5	5	63	24
2005	320	2	1	19	57	212	72	70	6	5	65	23
2006	323	1	1	19	55	215	72	71	5	6	63	24
2007	324	1	1	19	57	214	73	71	5	5	65	24
2008	321	2	1	19	55	213	72	70	5	5	63	23
2009	324	1	1	19	57	216	73	72	5	6	64	24
2010	321	1	1	20	55	213	72	70	6	5	64	23
2011	324	1	1	18	56	215	72	71	5	5	63	24
2012	318	2	1	20	54	212	73	70	5	6	65	23
2013	290	1	1	17	50	203	67	65	5	5	57	23
TOTAL	8212	34	33	481	1332	5640	1822	1776	130	135	1576	577

TABLE 5-4
PROJECTED ANNUAL SHIPMENTS TO THE WIPP
USING TRUPACT A

CAL YEAR	SITE RFP	ARGN	MOUND	LLNL	HOS	INEL	HANF	LANL	NTS	ORNL	SRP	SEMI
1988	107	0	2	5	5	142	6	16	6	1	5	16
1989	333	1	3	17	16	401	51	62	2	4	30	7
1990	342	2	4	20	25	223	93	73	6	4	56	24
1991	337	1	1	21	61	206	74	73	4	4	58	[illegible]
1992	338	2	1	21	62	203	77	73	5	4	56	[illegible]
1993	337	1	1	21	62	208	75	63	5	5	59	[illegible]
1994	333	2	1	21	61	210	68	66	5	4	52	24
1995	330	1	1	22	62	220	72	69	6	4	55	[illegible]
1996	319	2	2	20	58	224	71	68	5	4	54	[illegible]
1997	327	1	1	20	60	230	71	70	6	5	54	[illegible]
1998	321	1	1	20	59	226	72	68	6	4	55	[illegible]
1999	323	2	1	20	59	228	70	68	5	4	54	[illegible]
2000	325	1	1	21	60	228	73	70	6	4	55	[illegible]
2001	324	2	1	20	59	227	71	68	5	4	55	[illegible]
2002	327	1	1	21	61	231	72	70	6	4	54	25
2003	322	2	1	20	59	227	71	68	5	4	55	[illegible]
2004	320	1	1	20	59	232	73	70	6	5	54	25
2005	320	2	2	21	60	224	71	68	5	4	55	[illegible]
2006	324	1	1	20	59	229	71	69	6	4	54	[illegible]
2007	326	2	1	20	60	228	72	69	5	4	56	[illegible]
2008	319	1	1	20	59	225	71	68	6	4	53	25
2009	320	1	1	21	60	223	73	70	5	4	55	26
2010	323	2	1	20	59	226	71	69	6	4	55	24
2011	320	1	1	20	60	232	72	70	5	5	55	26
2012	320	2	1	21	60	225	72	68	6	4	55	[illegible]
2013	303	1	1	19	55	191	61	61	4	3	49	21
TOTAL	8270	36	34	512	1420	5977	1794	1727	137	104	1348	611

TABLE 5-5
PROJECTED ANNUAL SHIPMENTS TO THE WIPP
USING TRUPACT B

SITE

CAL YEAR	RFP	ARGN	MOUND	INEL	HOS	THEL	HANF	LANL	NTS	ORNL	SRP	SLMP
1988	137	0	1	4	4	147	8	17	0	1	6	0
1989	427	1	3	14	13	522	67	84	3	2	40	8
1990	430	1	3	15	19	191	122	95	7	4	74	24
1991	433	1	1	18	50	205	95	82	3	3	73	17
1992	418	2	1	16	49	243	91	88	5	4	70	20
1993	415	1	1	17	48	249	94	91	4	3	72	20
1994	407	1	1	16	46	243	92	88	4	3	70	20
1995	418	1	0	16	49	250	94	91	5	4	71	20
1996	409	1	1	17	46	244	93	89	4	3	71	20
1997	416	1	1	16	48	250	93	91	5	4	71	20
1998	411	2	1	16	48	246	93	89	4	3	72	20
1999	416	1	1	16	47	249	93	90	4	3	70	20
2000	414	1	1	17	48	247	95	91	5	4	72	20
2001	410	1	1	16	47	246	92	89	4	3	71	20
2002	418	1	1	16	48	249	95	91	5	3	71	20
2003	410	1	1	16	47	246	92	89	4	3	71	20
2004	417	2	1	16	48	250	93	91	4	4	71	20
2005	410	1	0	16	47	245	94	89	5	3	72	20
2006	415	1	1	17	47	248	93	90	4	3	70	20
2007	412	1	1	16	48	247	94	90	5	4	72	20
2008	411	1	1	16	47	245	92	89	4	3	71	20
2009	419	1	1	16	49	251	95	91	4	3	71	20
2010	410	1	1	17	47	246	92	89	5	4	72	20
2011	417	2	1	16	47	250	94	91	4	3	70	20
2012	411	1	1	16	48	245	93	90	5	3	72	20
2013	385	1	1	15	44	218	84	81	4	3	65	17
TOTAL	10504	29	28	407	1129	6472	2333	2240	110	83	1751	486

6.0 Summary

This report has presented a comparison of two alternate TRUPACT designs, both 8' 6" wide, with the current eight-foot-wide design. This was done only for the assumption that all states adopt the new 8' 6" width limit, on the basis of federal regulations which essentially require adoption of the new limit. Since neither alternate design provided a significant improvement in efficiency over the current design, assumptions regarding the 8' 6" rule are not critical to the conclusions. Use of TRUPACT A decreased overall system costs by less than 2% compared to the current design, while TRUPACT B increases overall system costs by 14% compared to the current design.

These conclusions are based on assumptions which are favorable to new TRUPACT designs. For example, no cost was assumed for new design work and regulatory testing. All TRUPACT designs were assumed to cost $800,000 each, despite the substantially greater amount of materials required for the 'B' design. Hence, it is concluded that there is no substantive advantage to using the 'A' or 'B' designs.

It was clear from these results that additional analysis is necessary to determine if any single TRUPACT design can reduce the system cost significantly from the cost using the current TRUPACT, and what benefit can be obtained from a mixed fleet of two TRUPACT designs (one volume efficient and one weight efficient). This analysis is found in following sections of this report.

7.0 Need for Additional Analysis

As discussed in Section 5, the 'B' design TRUPACT has a lower overall system efficiency and increased cost relative to the base case design. 'A' design provides a small and probably insignificant savings relative to the base case design. This suggests that additional analysis is appropriate to achieve the objectives of the study; i.e., to determine if there is a single TRUPACT design which provides a significant improvement in efficiency and cost reduction relative to the current TRUPACT design. If such a TRUPACT design cannot be identified, it may be necessary to consider a mixed fleet consisting of two different TRUPACT designs.

Additional analysis was undertaken to define the optimal configuration for a TRUPACT fleet. Ultimately, six TRUPACT designs were considered individually and in pairs. The following sections discuss how this study was performed and its results.

8.0 Description of TRUPACT Designs for Optimization Study

The optimization portion of this study began with the three TRUPACT designs described in Section 3.0, plus three additional designs.

The only difference between 'A' and 'B' designs is their length, with 'A' being shorter than 'B' by the width of one six-pack. Since 'A' is more efficient than 'B', a 'C' design was identified as being one six-pack width shorter than 'A', in an attempt to better define the volume payload trade-off for the maximum permissible width.

Since the 'A', 'B' and 'C' designs are all wider than the base design, two designs were identified which are narrower than the base design. A seemingly logical choice for the width of a narrow TRUPACT design would be the width of a six-pack, so that the six-packs could be loaded lengthwise with high efficiency. However, this would exclude the drum overpack box and the FRP overpack box, since these are both wider than a six-pack. Therefore, the usable space width for the narrow designs was chosen as 54 inches, which is the width of the FRP overpack box. Note that this excludes the loading of the Mound box, which is 68 inches wide, but since there are very few such boxes it is assumed that the two existing base-design TRUPACTs would be availabe and capable of transporting the Mound boxes. The first narrow design was called 'D' and initially was given a usable length of three six-pack lengths. The other narrow design was called 'E' and was initially given a usable length of four six-pack lengths. Subsequent analysis indicated that the efficiency of these designs could be further improved by lengthening them very slightly to accomodate identical numbers of drum overpack boxes. Efficiency gained at INEL by being able to ship additonal drum overpack boxes more than offsets the slight loss of efficiency on the loading of six-packs from all the sites. This applies also to the 'A', 'B' and 'C' designs as well in various degrees. Since this requires the widening of the usable space in the 'A', 'B' and 'C' designs by ½ inch, it is assumed that the clearance (dunnage space) in the width dimension can be reduced by ½ inch, ¼ inch on each side, to avoid the necessity of exceeding the exterior width limit of 8½ feet. For uniformity this assumption was applied to all designs.

Since this is an optimization study, it was assumed that the TRUPACT efficient box (TEB) would be redesigned to make maximum use of the usable volume of each TRUPACT design where this is economically beneficial; i.e., where TEB loads are volume-limited. Therefore the design of the TEB was varied according to the design of the TRUPACT so that its volumetric loading efficiency is always 1.0.

In summary, each of the six designs was optimized on its own merits with respect to TEB design and accomodation of the various box containers. They were then compared individually and in pairs to identify the optimum fleet configuration. Note that the designs referred to as A, B, and C in the optimization study have slightly larger useable volume than designs A, B, and C in the original study.

Dimensions and other data for the TRUPACT designs used in the optimization study are summarized in Table 8-1. The outside, inside and usable heights were held constant for all designs.

Figure 8-1 is a plot of usable width versus usable length and shows how the five alternate designs bracket the base case design. A design similar to 'D' but shorter was not included as it would have been severely volume limited.

Figure 8-2 shows that these designs cover a wide range of the trade-off between payload and volume. It will be shown in Section 11, "Results of Optimization Study," that the designs chosen span the optimum point in the payload-volume trade-off.

Table 8-1

TRUPACT Designs for Optimization Study

GROSS WEIGHT = 50000 LBS

TRUPACT	DIMENSIONS, INCHES LENGTH	WIDTH	HEIGHT	VOLUME FT^3	WALLS VOLUME FT^3	WALLS WEIGHT LBS	WALLS DENSITY LBS/FT^3
BASE							
OUTSIDE	300	96	108	1800	952.9398	33000.00	34.62967
INSIDE	230	74	86	847.0601			
USEABLE	226	68	77	684.8099			
	USEABLE VOL M^3=			19.39121	PAYLOAD =16999.99	LBS	
A							
OUTSIDE	276	102	108	1759.5	939.3148	32528.17	34.62967
INSIDE	206	80	86	820.1851			
USEABLE	202	74.5	77	670.5862			
	USEABLE VOL M^3=			18.98870	PAYLOAD =17471.83	LBS	
B							
OUTSIDE	324	102	108	2065.5	1054.203	36506.73	34.62967
INSIDE	254	80	86	1011.296			
USEABLE	250	74	77	824.3634			
	USEABLE VOL M^3=			23.34315	PAYLOAD =13493.26	LBS	
C							
OUTSIDE	225.5	102	108	1437.562	818.4421	28342.38	34.62967
INSIDE	155.5	80	86	619.1203			
USEABLE	151.5	74.5	77	502.9396			
	USEABLE VOL M^3=			14.24153	PAYLOAD =21657.61	LBS	
D							
OUTSIDE	297.5	81.5	108	1515.390	841.7115	29148.20	34.62967
INSIDE	227.5	59.5	86	673.6791			
USEABLE	223.5	54	77	537.7968			
	USEABLE VOL M^3=			15.22856	PAYLOAD =20851.79	LBS	
E							
OUTSIDE	372	81.5	108	1894.875	1000.584	34649.92	34.62967
INSIDE	302	59.5	86	894.2905			
USEABLE	298	54	77	717.0625			
	USEABLE VOL M^3=			20.30475	PAYLOAD =15350.07	LBS	

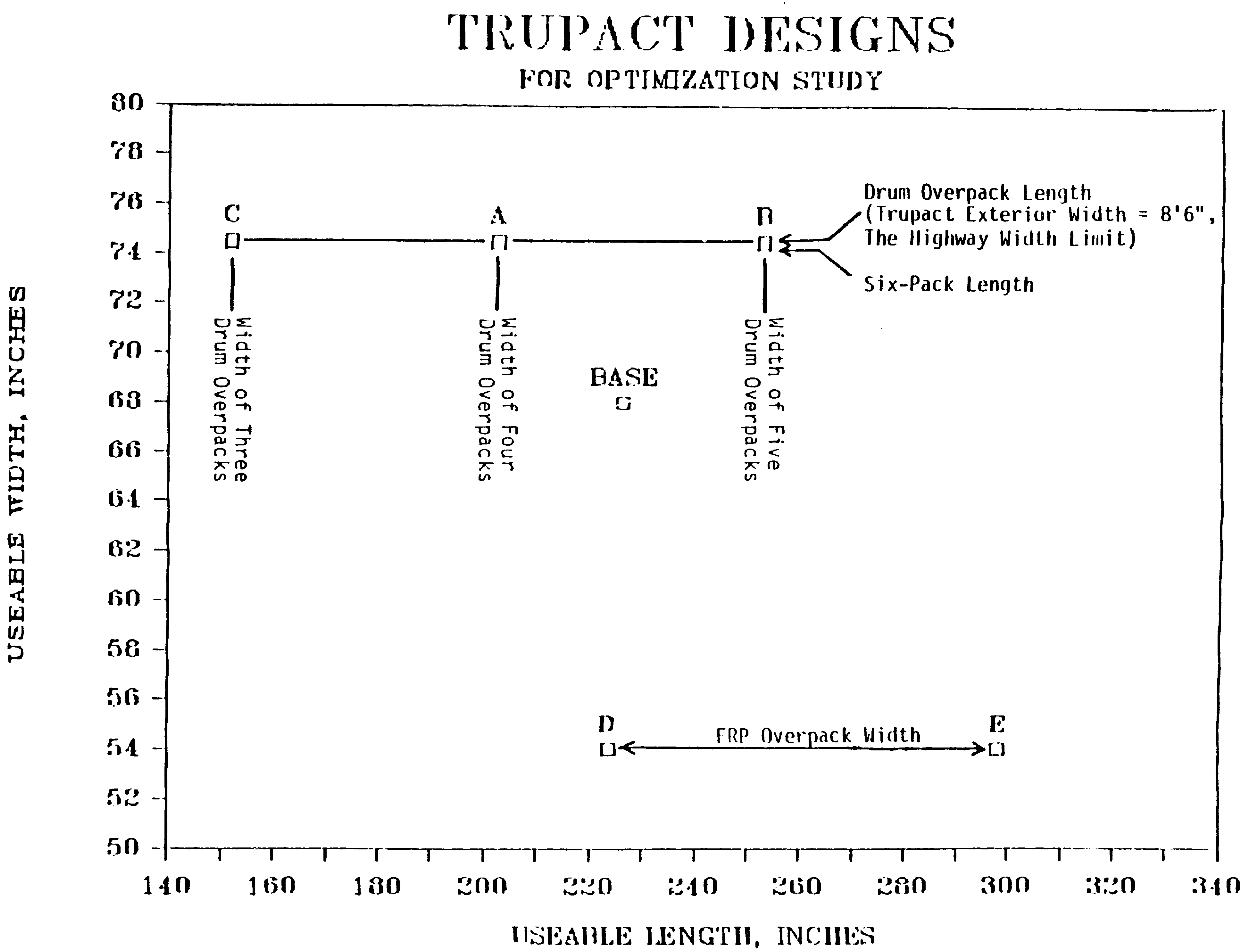
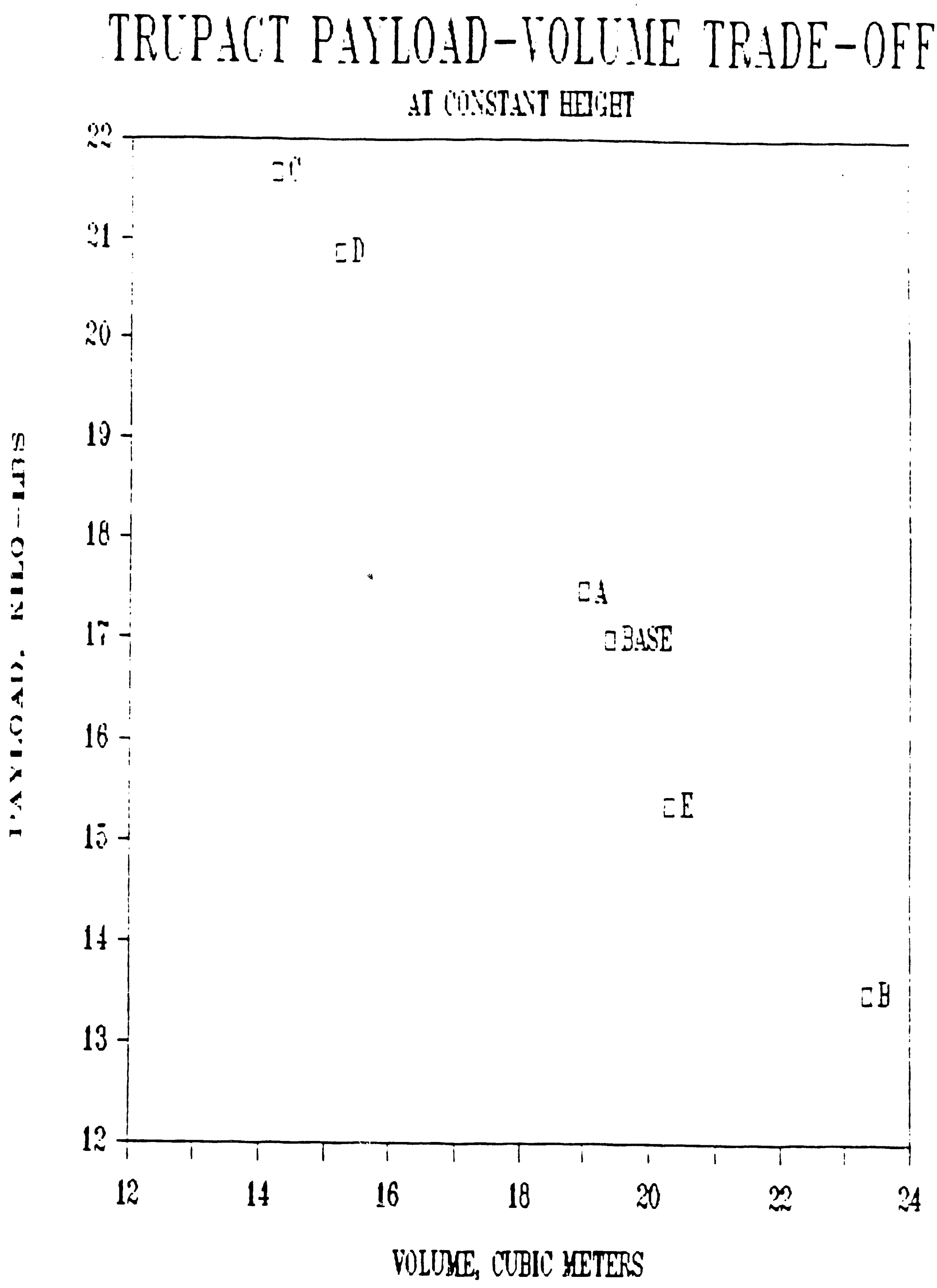

TRUPACT DESIGNS
FOR OPTIMIZATION STUDY
USEABLE WIDTH, INCHES
USEABLE LENGTH, INCHES
C
A
B
Drum Overpack Length
(Trupact Exterior Width = 8'6",
The Highway Width Limit)
Six-Pack Length
Width of Three Drum Overpacks
Width of Four Drum Overpacks
Width of Five Drum Overpacks
BASE
D
E
FRP Overpack Width
80
78
76
74
72
70
68
66
64
62
60
58
56
54
52
50
140
160
180
200
220
240
260
280
300
320
340

Figure 8-1



TRUPACT PAYLOAD-VOLUME TRADE-OFF
AT CONSTANT HEIGHT
PAYLOAD, KILO-LBS
VOLUME, CUBIC METERS
12
13
14
15
16
17
18
19
20
21
22
24
C
D
A
BASE
E
B

Figure 8-2

9.0 Optimization Study Methodology

Consideration of a mixed fleet made it necessary to abandon TRUSIM and TRUCOST as the calculation method for the optimization study. TRUSIM and TRUCOST are based on the assumption of a single TRUPACT design serving all waste-generating sites. Since these programs were obtained as a software package, we cannot examine or reprogram their coding. Therefore, the simulation of a mixed fleet would have to be done through modifications to the input data. It was not clear how this could be done in a meaningful way. Therefore, a new calculation method was programmed on an IBM/PC using LOTUS software. For ease of reference this program has been named COMPACT, from "COMpare truPACTs". It's name is also generally descriptive of its nature. This program generally uses hand-calculation methods, but incorporates several key relationships derived from the TRUSIM/TRUCOST output for the three TRUPACT cases of Section 5.2, in effect calibrating it to these cases. COMPACT is described in detail in Appendix A. Its ease of use and speed of operation permits consideration of many TRUPACT designs in a timely and cost-effective way.

10.0 Results of Optimization Study

The first step in the optimization study was to consider each of the six TRUPACT designs individually, since it is desirable to have a single-design fleet if possible.

Figure 10-1 shows a plot of the estimated total number of TRUPACT trips for the system using each of the six TRUPACT designs versus their respective volumes. This figure shows that the designs selected span the optimum point in the payload volume trade-off mentioned in Section 8. Note that it is not feasible to include intervening points since it is not meaningful to size TRUPACT designs for other than integer numbers of containers.

Table 10-1 tabulates the results for these six designs showing estimates of the number of TRUPACTs required, the number of trips and the total system cost. Table 10-2 shows a breakdown of the estimated costs for these six cases.

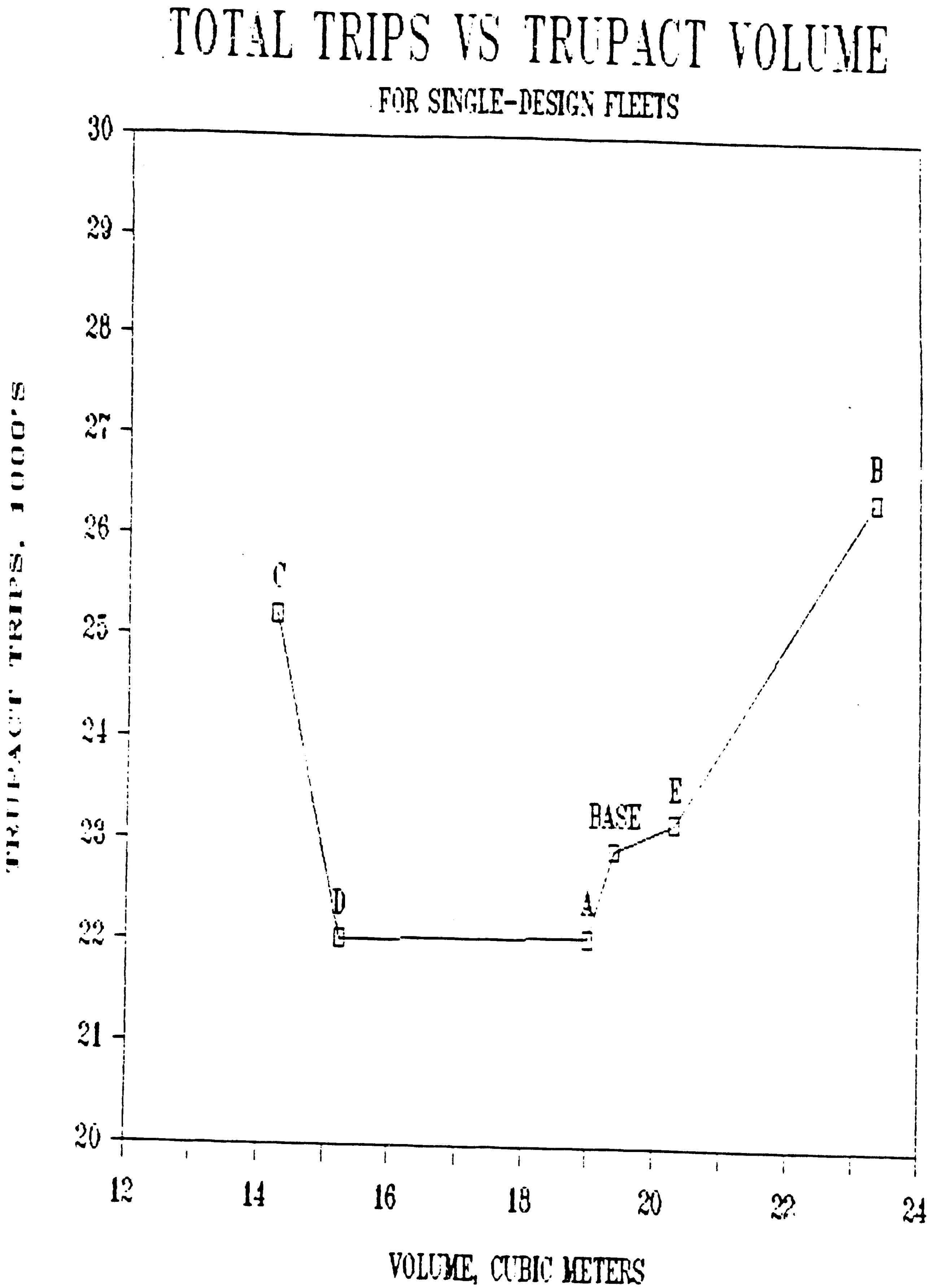
As shown in Table 10-1, the 'A' and 'D' designs are estimated to provide a small savings in cost over the base design. However, these small saving may not justify the change in design since they may be somewhat offset by the testing and qualification costs of the new design, a cost factor not considered in this study. As a result, a study of the mixed fleet concept was undertaken to determine if there exists a combination of two of the above designs which provides significantly greater savings in total system cost.

Figure 10-2 shows the result of the mixed fleet portion of the study. The number of TRUPACTs required, the number of trips, and the total system cost were estimated for each combination of two of the six designs. The table represents these results combined with the results of the study of individual designs discussed previously. The entries on the diagonal represent those individual cases while the entries off the diagonal represent the combinations. For example, the entries in the lower left hand box are the results for a combination of the 'B' design and the 'C' design.

Examination of Figure 10-2 shows the following:

- o If it is desired that the present base design be used as one of the two TRUPACT designs, then there are five possible combinations, indicated in the boxes outlined by the double lines in Figure 10-2. The best combination is the base design with design 'D', which results in a savings of about

Figure 10-1



TOTAL TRIPS VS TRUPACT VOLUME
FOR SINGLE-DESIGN FLEETS
TRUPACT TRIPS, 1000'S
30
29
28
27
26
25
24
23
22
21
20
C
D
A
BASE
E
B
12
14
16
18
20
22
24
VOLUME, CUBIC METERS

Table 10-1

Results Of Optimization Study For Individual TRUPACT Designs

TRUPACT	Volume m^3	Payload Lbs.	TRUPACTs Required	Total Trips	Cost $Million
C	14.2	21,658	23	25213	184.9
D	15.2	20,852	20	22024	160.4
A	19.0	17,472	20	22050	157.5
Base	19.4	17,000	21	22917	162.8
E	20.3	15,350	21	23190	164.1
B	23.3	13,493	24	26402	185.9

Table 10-2

Breakdown Of Costs For Individual TRUPACT Designs

($Millions)

Cost	C	D	A	BASE	E	B
Capital	18.4	16.0	16.0	15.2*	16.8	19.2
O&M	7.5	6.5	6.5	6.8	6.8	7.8
Load	53.9	47.1	47.1	49.0	49.6	56.4
Freight	105.4	90.8	87.9	91.8	90.9	102.5
TOTAL	184.9	160.4	157.5	162.8	164.1	185.9

Figure 10-2

RESULTS OF OPTIMIZATION STUDY

TRUPACT DESIGN (rows) × TRUPACT DESIGN (columns)

TRUPACT DESIGN	C	D	A	BASE	E	B
C	25319 23 185.4					
D	22003 20 160.3	22063 20 160.6				
A	21136 19 151.3	20770 19 149.5	22050 20 157.5			
BASE	21628 20 154.6*	21288 19 151.8*	21989 20 155.5*	22917 21 162.8*		
E	20610 19 147.9	20164 18 144.5	21000 19 149.1	21793 20 154.0*	23198 21 164.1	
B	21298 19 152.2	20895 19 150.2	21531 20 155.8	22404 20 157.7*	22842 21 161.3	26402 24 185.9

LEGEND

Total Trips → XXXXX YY ← No. TRUPACTS

$MIL ← Total Cost $Millions

* Cost reduced by $1.6 million, the capital cost of two existing base design TRUPACTS

$11 million (7%) relative to the base design alone. Since neither of these designs exceeds 8 feet in width, the state width limitations would not be an issue for this fleet configuration.

- For the combinations which do not include the base design TRUPACT, the fact that two base design TRUPACTs will be built was initially ignored. If such a fleet configuration were eventually selected, the decision would have to be made on whether to include the two base-design TRUPACTs. Since their inclusion would result in a fleet of three different TRUPACT designs, it may result in unacceptable queuing and scheduling complications at WIPP. This question is of more than academic interest, because the results of this study indicate that the least costly fleet configuration consists of the 'D' and 'E' designs, which are the two narrow designs. Since neither of these designs can accomodate the Mound box the two base-design TRUPACTs would have to be included. The other combinations could transport all of the waste without the help of the base design TRUPACTs, although their inclusion would be acceptable and would reduce the capital cost of the fleet.

- The 'D' and 'E' combination results in a savings of $18 million (11%) as compared to the base design alone. If this combination is found to be undesirable, there are four combinations which result in a savings of $13-15 million relative to the base design alone. These are 'D' combined with 'A' or 'B', and 'E' combined with 'A' or 'C'. Note that each of these combinations contains one narrow-design TRUPACT and one wide-design TRUPACT. The above five combinations are the only ones resulting in a significant savings relative to the combination of the base and 'D' designs discussed previously.

To put all these results in better perspective, an additional hypothetical case was considered. In this case it was assumed that TRUPACTs of all six designs in various numbers were all available at the WIPP, so that every load of waste could be transported in the TRUPACT which most economically can perform the task. It was found that eighteen TRUPACTs would be required resulting in 19,300 trips and a total system cost of $128 million. Considering that this ultimate fleet would save only $35 million (21%) relative to the base-design TRUPACT alone, it is not surprising that the best combination of two TRUPACTs could save only $18 million, and that the best single TRUPACT results in a possibly insignificant savings of about $5 million. It is also apparent that the required number of TRUPACTs and the total number of trips required are relatively insensitive to fleet design selected.

12.0 References

1. Ltr. J. M. McGough to L. J. Smith, December 4, 1984, DOE/AL/WMTDD/JM McGough/DOCIDO202C/TWSO/LJ Smith/12/04/84.

2. "TRUPACT Loading and Efficiency Analysis," M. H. Raudenbush and R. W. Wolaver, The S. M. Stoller Corp., September 28, 1984.

3. "Documentation of the Program 'MPLAN'," The S. M. Stoller Corp., January 10, 1984.

4. Q-4/83-574, "Systems Modeling and Performance Measures Study Phase II Final Report," E.A. Kern, Los Alamos National Laboratory, Draft Report, October 1983.

5. TRUCOST documentation being prepared.

6. "Evaluation of Alternatives for a Second-Generation Transportation System for Department of Energy Transuranic Waste," EG&G Idaho, Inc., January, 1984.

7. SPE 953109, "Design Specification - TRUPACT-I Semitrailer," Issue B, December 1, 1983.

8. Memo by Joseph N. Cook & Associates to ANL regarding transportation costs of TRU wastes, December 17, 1982.

9. ICC TSMT 4007-A, Tri-State Motor Transit Co. truck tariff document, issued September 10, 1984, effective October 15, 1984.

11.0 Summary of Optimization Study

In addition to the present base TRUPACT design, five alternative designs were considered, ranging from short and wide (C) through short and narrow (D), long and wide (B), and long and narrow (E). A is a slight variation of the base.

Considering only single-design fleets, very little improvement can be made on the base design. Designs A and D showed slight improvements, but probably not sufficient to justify redesign and requalification.

Were it desired to add a second design to a smaller base-design fleet, D would be the best choice, since it is optimized for weight-restricted loads. This would result in two less TRUPACTs being built and a savings of about $11 million (7%), not counting redesign and qualification costs and dispatching inefficiences from having two designs.

The lowest cost fleet configuration identified would consist of ten TRUPACTs of the D design and six of the E design, plus the two base TRUPACTs already planned. This would result in a savings of $18 million (11%), not counting for redesign and qualification costs and dispatching inefficiencies from having three designs. To put these results in perspective, it was calculated that a hypothetical "ideal" fleet including all six designs would provide a savings of $35 million (21%), again ignoring redesign, requalification, and dispatching inefficiencies.

APPENDIX A

Methodology of Optimization Calculations in Program COMPACT

This appendix describes the calculation method used to search for the optimum configuration of the TRUPACT fleet. Assumptions, inputs, calculations and results have been mixed together in the order of logic flow of the program in order to present it clearly.

1. It is assumed that all TRUPACTS when loaded will have a gross weight of 50,000 lbs.

2. It is assumed that the base case TRUPACT has an empty weight of 33,000 lbs. and a payload of 17,000 lbs.

3. For the base TRUPACT outside, inside and usable space dimensions (length, width, and height) are taken from references 6 and 7. The wall thickness in each section is the difference between outside and inside dimensions. The clearance between the TRUPACT inner wall and the load is the difference between the inside dimension and the usable space dimension. Initially, these clearances and wall thicknesses were assumed to be constant for all TRUPACT designs. Later it was assumed that the width clearance could be reduced by ½ inch (from 6 inches to 5½ inches, total) since a significant economic advantage is gained thereby.

4. For the base case, the outside, inside and usable space volumes are calculated from the dimensions. The difference between the outside and inside volume is the wall volume, which is then divided into the weight of the walls, i.e., TRUPACT empty weight, to determine the wall density for the base case. This density is assumed to be uniform and constant for all TRUPACT designs.

5. The usable space dimensions for a new TRUPACT design are program inputs. The inside and outside dimensions are calculated using the clearances and wall thicknesses determined in Step 3. The outside, inside, usable space and wall volumes are determined as in Step 4. The wall volume times the density of the walls as determined in Step 4 gives the wall weight; that is, the new TRUPACT

empty weight. The difference between this number and the gross weight is the payload of the new TRUPACT.

6. The results of Steps 1 through 5 are summarized in Table A-1 for the base TRUPACT and TRUPACT 'A' comparison.

7. Additional program inputs required at this time are the volumes of individual waste containers and the maximum number of such containers which can be physically placed in each TRUPACT design as shown in Table A-2. The maximum efficiency numbers shown for each container type is the volume of all such containers which can be put in a given TRUPACT divided by the volume of the TRUPACT. It is the maximum efficiency attainable for a given container and TRUPACT combination and applies to volume-limited loads. Weight-limited loads will have fewer TRUPACTS per load, on average, and a lower efficiency.

8. The total waste volumes for each site is taken from the long-range master plan, and is distributed among container types according to the Inventory Work Off Plan (IWOP) data. The average weight for each type of container at each site is also taken from the IWOP data. This data is summarized in the third and fourth columns of Table A-3.

9. The TRUPACT payload is divided by the average weight for each container type to determine the maximum number of such containers which can be put in a given TRUPACT based on weight limitations. If this number is larger than the number of such containers which can be put in such a TRUPACT based on volume limitations as given in Table A-2, then the volume limited number is used. These results are shown in column five of Table A-3. An integer indicates the volume limitation while a real number indicates weight limitation. The container efficiencies shown in column six are the total volume of such containers divided by the TRUPACT volume. Combining these container volumes by the methods of reference 2 gives the site packing efficiency shown in column seven.

10. The number of TRUPACT trips required to ship the total waste for a given container type is then estimated by dividing the total volume of such waste by the volume of the containers of that type which can be put in a single TRUPACT and rounding to the nearest integer.

11. The entries for the site labelled "other" are exceptions to the above. The outputs of the TRUCOST runs for the 'A', 'B' and base cases described in the text were tabulated for the sites not listed specifically in Table A-3. The total number of trips required from each of these other sites seems to vary roughly in inverse proportion with the TRUPACT volume indicating that these sites are volume limited. The entry in the waste volume column for the 'other' sites is the product of trips times volume for the base case. Dividing this number by the volume of a TRUPACT gives the estimated number of TRUPACT trips required from the other sites and approximates the numbers generated by the TRUCOST runs. The volume entry for the other site is not a true volume and is not included in the the total system volume, but the number of trips calculated for the other sites is included in the total number of TRUPACT trips required for the system.

12. The overall average packing efficiency for the system is determined from the individual site packing efficiencies in the same way that the site efficiencies are calculated from the individual container efficiencies. This number is useful primarily as a check on the total number of TRUPACT trips required for the system. The total system volume divided by the TRUPACT volume and the system average packing efficiency plus other site trips should equal the total of the TRUPACT trips calculated for the individual sites.

13. It is assumed that each TRUPACT can make 1100 roundtrips during the twenty-five year span of the project. This was the average number derived from the TRUSIM/TRUCOST outputs for the base, 'A', and 'B' designs and did not vary much from case to case. For comparison an estimate was made of the maximum number of trips a TRUPACT could make assuming no idle time. The travel times for each site used as input to TRUSIM were combined with the number of trips calculated for each site which was output by TRUSIM. This gave a weighted average travel time for the average TRUPACT trip. Adding the two day turn-around time at each end of the trip gave the total time required for a single trip. From this it was calculated that an average TRUPACT could make fifty-five trips per year assuming no idle time. The average of 1100 TRUPACT trips calculated by TRUSIM for the three cases analyzed is equivalent to forty-four trips per year. Thus it appears that TRUSIM has determined that each TRUPACT has about 20% idle time composed of maintenance and queue time.

Since there was very little variance among the three cases this number is assumed constant for all cases. Dividing the total number of TRUPACT trips required for the system by 1100 and rounding to the nearest integer gives the estimated number of TRUPACTs required.

14. The following assumptions are made for the cost calculations:

- The capital cost of each TRUPACT is $800,000 regardless of design;

- Each TRUPACT requires $13,000 a year in operation and maintenance expenses over the twenty-five year period for a total of $325,000;

- The TRUPACT loading cost at each site is $2,137 per event;

- The transportation cost for a roundtrip to each site is as described in Assumption 10 of Section 2.0.

All cost factors are then totaled to get the total estimated cost to the system of using the given TRUPACT design.

15. For mixed-fleet optimization cases the various TRUPACT designs are considered in pairs. Total shipping costs are calculated for each TRUPACT carrying each type of waste container from each waste-generating site. Then it is determined which of the two TRUPACT designs is the most efficient for shipping each type of waste container from each site. The number of trips and transportation cost for the more economical TRUPACT is used in each case. It is assumed that, when a shipment of a particular type of waste container is required, the TRUPACT which most economically carries that type of container will be available in the queue at WIPP.

16. Table A-4 illustrates the results of the cost calculations and the optimization selection process for the combination of base case and 'A' design TRUPACTs.

Table A-4

Cost Calculations & Fleet Selection
TRUPACTs Base & 'A'

	BASE			TRUPACT 'A'			Fleet Selection		
	TRIPS	COST/TRIP	TRANS $K	TRIPS	COST/TRIP	TRANS $K	TP	TRIPS	TRANS $K
.FP, 6PK	2214	2784	10895	2154	2784	10600	A	2154	10600
TEB	6300		30922	6162		30323	A	6162	30323
NEL,6PK	2622	4600	17664	2551	4600	17186	A	2551	17186
DOPK	654		4406	566		3813	A	566	3813
FOPK	2613		17604	2613		17604	EITHER	2613	17604
HANFORD	2090	6014	17036	1884	6014	15356	A	1884	15356
ANL,6PK	1642	1770	6415	1598	1770	6243	A	1598	6243
TEB	224		910	227		887	BASE	224	875
ORNL	145	4732	996	109	4732	749	A	109	749
RP	1723	5249	12726	1438	5249	10621	A	1438	10621
THER	2690	5746	21205	2748	5746	21662	BASE	2690	21205
SYSTEM	22917		140849 K$	22050		135044 K$		21989	134575
TRUPACTS	21*			20				20*	(BASE=3-5)
OSTS ($ Millions)									
CAP + O&M	22.0			22.5				20.9	
TRANS	140.8			135.0				134.6	
OTAL	162.8			157.5				155.5	

* Two base design TRUPACTs assumed to be available.

Table A-1

Dimensions and Payload Calculations for
Base TRUPACT and TRUPACT "A"

GROSS WEIGHT = 50000 LBS

TRUPACT	DIMENSIONS, INCHES LENGTH	WIDTH	HEIGHT	VOLUME FT^3	WALLS VOLUME FT^3	WALLS WEIGHT LBS	WALLS DENSITY LBS/FT^3
BASE							
OUTSIDE	300	96	108	1800	952.9398	33000.00	34.62[illegible]
INSIDE	230	74	86	847.0601			
USEABLE	226	68	77	684.5009			
	USEABLE VOL M^3=			19.39121	PAYLOAD =16999.99	LBS	
A							
OUTSIDE	276	102	108	1759.5	939.3148	32528.17	34.62[illegible]
INSIDE	206	80	86	820.1851			
USEABLE	202	74.5	77	670.5862			
	USEABLE VOL M^3=			18.98870	PAYLOAD =17471.82	LBS	

Table A-2

Waste Container Comparison
Base TRUPACT and TRUPACT "A"

CONTAINR	VOLUME FT^3	DIMENSIONS, INCHES L, W, H	BASE TRUPACT CASE 1 MAX NUMB /TRUPACT	BASE TRUPACT CASE 1 MAXIMUM EFF	TRUPACT A CASE 2 MAX NUMB /TRUPACT	TRUPACT A CASE 2 MAXIMUM EFF
DRUMS	7.35		54	0.579584	48	0.526104
SIX-PACK	44.11	74, 50, 38.5	6	0.386477	[illegible]	[illegible]6226
TEBCASE1	85.60011	68, 56.5, 38.5	8	1	0	0
DRUMOPAK	83.82327	74.5, 50.5, 38.5	6	0.734431	8	1
REFRFBOX	112	84, 48, 48	2	0.327102	2	0.334036
FRFOPAK	148.5	66, 54, 54	2	0.433702	2	0.442876
MOUNDBOX	317.3333	112, 68, 72	2	0.926790	1	0.473317
TEBCASE2	62.43634	74, 50, 38.5	0	0	8	0.963454

Table A-3

Calculation of Packing Efficiencies and
Number of TRUPACT Trips
for Base TRUPACT

WASTE VOL PER LRMP, SPLIT PER IWOP DATA

SITE	CONTR	WASTE M3	AVERAGE LBS/CON	#CONS /TP	CONTR PEFF	SITE PEFF	TRUPACT TRIPS
RFP	SIX-PACK	13124	3583	4.745951	0.305700	0.605734	[illegible]
	TEB	86876	2983	5.689424	0.711178		[illegible]
	TOTAL	100000					[illegible]
INEL	SIX-PACK	15969	3486	4.876649	0.314119	0.413849	[illegible]
	DRUMOPAK	9311	2519	6	0.734431		[illegible]
	FREOPAK	21972	2595	3	0.433702		[illegible]
	TOTAL	47252		-			[illegible]
HANFORD	SIX-PACK	15666	2625	6	0.386477	0.386477	[illegible]
LANL	SIX-PACK	11624	3000	5.666666	0.365006	0.377684	[illegible]
	TEB	2053	4500	3.777777	0.472222		[illegible]
	TOTAL	13677					[illegible]
ORNL	SIX-PACK	1090	1200	6	0.386477	0.386477	[illegible]
SRP	SIX-PACK	12915	2430	6	0.386477	0.386477	[illegible]
OTHER	TRIPS+VOL	52172					[illegible]
SYSTEM		190600				0.485976	[illegible]

Appendix B

Assumptions for Truck Cost Calculation

Item and Page numbers refer to Tri-State Motor Transit Co. truck tariff, ICC TSMT 4007-A, issued September 10, 1984; Effective October 15, 1984.

Not Required or No Charge Considered

Item	Page	Description
30	5	Decontamination of Carrier's Equipment
35	5	State Inspections
45	6	Special Equipment
60	7	Trailer set out charges
65	7	Secutiry Inspections (jacking of cab)
500	12	Detention of Vehicles (excess loading/unloading time)
520	13	Special Equipment
570	15	Impracticable Operation
578	16	Loading/Unloading, excess labor or equipment
670	17	Over Dimension Freight
675	22-24A	Overweight Shipments (all states greater than 48 Klbs.), charge varies by state
677	24A	Special Services - Escort Vehicles and/or Flagmen
740	25	Special Permits for radioactive shipments through state, county, city or other mun. ($25 + costs)/permit
750	25	Pick-up and Deliver under Labor Disturbance Conditions
810 thru 810-6	26 thru 28	Protective Services
820	29	Reconsignment or Diversion
830	30	Redelivery
848	30	Released value (Declared value greater than $1 million) 3¢/$100 excess value
860	30	Returned, Undelivered Shipment
900	31	Stopping in Transit to Partially Load or Unload
910	32	Storage
985	32	Vehicle furnished but not used
990	33	Weighing and Weights (by request)

Required or Charge Considered

315	11	Allowance for shipper-furnished trailer, 5¢/mile
530	15	Expedited Service - Second Driver, 15¢/mile, $60 minimum
3000	47	Mileage Commodity rates apply to these shipments

END

DATE FILMED

12/05/91