SEP 10 1996

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

1. EDT 608745

2. To: (Receiving Organization) HLW/LLW Programs	3. From: (Originating Organization) Process Design 73520	4. Related EDT No.: NA
5. Proj./Prog./Dept./Div.: TWRS Disposal Program	6. Design Authority/Design Agent/Cog. Engr.: J. D. Galbraith, 376-7929	7. Purchase Order No.: NA
8. Originator Remarks: The document provides identification of waste transfer routes for high-level waste and low-activity waste staging in support of Phase I Privatization. The recommended alternative has been approved by DOE-RL		9. Equip./Component No.: NA
The document title has been changed since release for review.		10. System/Bldg./Facility: NA
		12. Major Assm. Dwg. No.: NA
11. Receiver Remarks: 11A. Design Baseline Document? ☐ Yes ☒ No		13. Permit/Permit Application No.: NA
		14. Required Response Date: NA

15. DATA TRANSMITTED									
(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Approval Design- nator	(G) Reason for Trans- mittal	(H) Orig- inator Dispo- sition	(I) Receiv- er Dispo- sition	
1	WHC-SD-WM-TI-750		0	Decision Document for Phase I Privatization Transfer System Needs	NA	1			

16. KEY					
Approval Designator (F)		Reason for Transmittal (G)		Disposition (H) & (I)	
E, S, Q, D or N/A (see WHC-CM-3-5, Sec.12.7)		1. Approval	4. Review	1. Approved	4. Reviewed no/comment
		2. Release	5. Post-Review	2. Approved w/comment	5. Reviewed w/comment
		3. Information	6. Dist. (Receipt Acknow. Required)	3. Disapproved w/comment	6. Receipt acknowledged

17. SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)									
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date	(M) MSIN	(G) Reason	(H) Disp.	(J) Name	(K) Signature
3	6	Design Authority: R. L. Schlosser/R. W. Reed		R1-56/S5-07					
		Design Agent							
1	1	Cog.Eng. J.D. Galbraith		8/15/96	45-49				
1	1	Cog. Mgr. J.S. Garfield		8/15/96	45-49				
		QA							
		Safety							
		Env.							

18. J.D. Galbraith Signature of EDT Originator 8/14/96	19. K. A. Gaeper Authorized Representative for Receiving Organization 8/14/96	20. J.S. Garfield Design Authority/ Cognizant Manager 8/15/96	21. DOE APPROVAL (if required) Ctrl. No. ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
---	--	--	---

Decision Document for Phase I Privatization Transfer System Needs

J. D. Galbraith

Westinghouse Hanford Company, Richland, WA 99352

T. B. Salzano and J. R. Nicholson

ICF Kaiser Hanford Company, Richland, WA 99352

U.S. Department of Energy Contract DE-AC06-87RL10930

EDT/ECN: 608745

UC: 721

Org Code: 73520

Charge Code: D6129

B&R Code: EW3130010

Total Pages: 365

Key Words: decision, privatization

Abstract: This decision document provides input for the Phase I Privatization waste staging plans for the High-Level Waste (HLW) and Low-Level Waste (LLW) Disposal Programs. This AGA report evaluates what infrastructure upgrades to existing 200 East waste transfer systems are necessary for delivery of HLW and LLW streams to the Phase I Privatization vendor. The AGA identifies the transfer routing alternatives for supernatant waste transfers from the 241-AN, 241-AW, and 241-AP Tank Farms to the 241-AP-102 tank and/or the 241-AP-104 tank. These two tanks have been targeted as the initial LLW feed staging tanks. In addition, this report addresses the transfer of slurry waste from the 241-AY and 241-AZ Tank Farms to the Phase I Privatization vendor's facilities for HLW immobilization.

TRADEMARK DISCLAIMER. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Printed in the United States of America. To obtain copies of this document, contact: WHC/BCS Document Control Services, P.O. Box 1970, Mailstop H6-08, Richland WA 99352, Phone (509) 372-2420; Fax (509) 376-4989.

Release Approval

Date

T. B. Salzano 9-10-96

Release Stamp

Approved for Public Release

**DECISION DOCUMENT FOR PHASE I
PRIVATIZATION TRANSFER
SYSTEM NEEDS**

May 1996

J. D. Galbraith
Westinghouse Hanford Company
Richland, Washington

T. B. Salzano
J. R. Nicholson
ICF Kaiser Hanford Company
Richland, Washington

Prepared for
U.S. Department of Energy
Richland, Washington

This page intentionally left blank.

CONTENTS

1.0	DECISION ANALYSIS SUMMARY	1
1.1	STATEMENT OF DECISION	1
1.2	DATE OF SELECTION	1
1.3	DECISION MAKER	2
1.4	DECISION ACTION OFFICER	2
1.5	ALTERNATIVE SELECTED	3
1.6	DECISION ISSUES	4
1.6.1	Function and Requirements	4
1.6.2	Open Issues	4
1.6.3	Function and Requirements Open Issues	6
1.6.4	Scope	8
1.7	DESCRIPTION OF OPTIONS CONSIDERED	8
1.7.1	Low-Level Waste Options	8
1.7.2	High-Level Waste Options	11
1.8	DECISION CRITERIA	16
1.8.1	Hydraulic Performance	16
1.8.2	Cost	19
1.8.3	Schedule	19
1.8.4	Flexibility	19
1.9	OPTIONS EVALUATION	20
2.0	PROBLEM STATEMENT	29
3.0	CONSTRAINTS AND ASSUMPTIONS	31
3.1	CONSTRAINTS	31
3.2	ASSUMPTIONS	31
4.0	ANALYSIS OF OPTIONS	33
4.1	GENERATION OF OPTIONS	33
4.2	SCREENING OF OPTIONS	34
4.3	ANALYSIS OF LOW-LEVEL WASTE OPTIONS	34
4.4	ANALYSIS OF HIGH-LEVEL WASTE OPTIONS	35
5.0	FINDINGS	37
6.0	REFERENCES	39

APPENDIXES

A - CALCULATIONS	A-1
B - JUMPER MANIFOLD DESIGN	B-1
C - COST ESTIMATES	C-1
D - DESIGN PRESSURE RATING UPGRADE	D-1

LIST OF FIGURES

1-1. Low-Level Waste Option 1: "Do Nothing."	9
1-2. Low-Level Waste Option 2: "New 7.6-cm (3-in.) Line, 241-AN-B to 241-AX-B."	10
1-3. Low-Level Waste Option 3: "New SN-650 Valve Pit."	12
1-4. Low-Level Waste Option 4: "New 7.6-cm (3-in.) Line and Valve Pit."	13
1-5. High-Level Waste Option 1: "Do Nothing."	14
1-6. High-Level Waste Option 2: "New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A" and "New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B."	15
1-7. High-Level Waste Option 3: "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"	17
1-8. High-Level Waste Option 4: "New 7.6-cm (3-in.) Route, 241-AZ to Vendor" and "New 7.6-cm (3-in.) Route, 241-AY to Vendor."	18

LIST OF TABLES

1-1. Matrix of Low-Level Waste Options by Decision Criteria	21
1-2. Matrix of High-Level Waste Options (241-AZ Tank Farm) by Decision Criteria . . .	23
1-3. Matrix of High-Level Waste Options (241-AY Tank Farm) by Decision Criteria . . .	25
1-4. Option Cost Breakdown between Project W-314 and the Privatization Infrastructure Project	27
1-5. Matrix of Low-Level Waste and High-Level Waste Options by Combined Cost (\$ million)	28

LIST OF TERMS

AGA	Alternative Generation and Analysis
DOE-RL	U.S. Department of Energy-Richland Operations Office
DST	Double-shell tank
FY	Fiscal year
HLW	High-level waste
LLW	Low-level waste
NDE	Nondestructive examination
NGTP	New Generation Transfer Pump
PIP	Privatization Infrastructure Project
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company

This page intentionally left blank.

1.3 DECISION MAKER

The decision makers are Gary A. Meyer and John E. Truax. Mr. Meyer is the manager of Retrieval Programs for Westinghouse Hanford Company (WHC), and Mr. Truax is the manager of WHC's Tank Farm Transition Projects.

1.4 DECISION ACTION OFFICER

The decision action officer is John S. Garfield. Mr. Garfield is the manager of the Process Design Group within WHC's Disposal Engineering.

1.5 ALTERNATIVE SELECTED

The preferred waste transfer system upgrade will be Option LLW 4 and HLW 3 (see Figures 1-4 and 1-7). The combination of these options meets the hydraulic performance, schedule performance, and cost criteria.

The options selected are integrated with current plans by Project W-314 to upgrade waste transfer systems in the northern quadrant of the A Farm Complex. The remainder of transfer system upgrades are focused on providing new transfer lines to 241-AP-102 and 241-AP-104 tanks; the selected LLW intermediate waste staging tanks. The upgrades are targeted to modify line SN-650 by adding a new valve pit and providing three 7.6-cm (3-in) waste transfer lines. Two of the lines will be routed to 241-AP-102 and 241-AP-104 tanks for LLW staging and the third line will be routed to the HLW vendors processing facility. (NOTE: The evaluation for the HLW feed line assumed a scope of routing the line to the vendor HLW processing facility. The DOE is not committed to installing the HLW feed line to the vendors location unless negotiations with vendor stipulates otherwise. For follow-on project scoping evaluations the HLW line will be terminated outside the 241-AP tank farm East fence line.)

The selection of the LLW intermediate waste staging tanks was based on location, current use of tanks, waste type, and cost to upgrade the tanks to support intermediate feed staging. Other tanks that were considered for possible use were eliminated due in part to the cost for systems that would be required to retrieve and transfer their current inventory. Selecting 241-AP-102 and 241-AP-104 tanks also minimizes waste transfer distances and the number of process pits that need to be accessed during the transfer of waste to the vendors feed staging tanks, 241-AP-106 or 241-AP-108.

Responsible Decision Maker:

J. E. Truax, WHC/Deputy Director,
Tank Farm Transition Projects

8/29/96
Date

DOE Concurrence:

W. J. Taylor, DOE/Director
Waste Disposal Division

8/28/96
Date

J. K. McClusky, DOE/Director,
Waste Storage Division

8/28/96
Date

Action Officer:

J. S. Garfield, WHC/Manager, Tank
Waste Remediation System Disposal
Process Design

8/28/96
Date

1.6 DECISION ISSUES

1.6.1 Function and Requirements

The Phase I privatization transfer system is considered to be part of the Retrieve Double-Shell Tank (DST) Waste function 4.2.2.2 (WHC 1996a). The waste retrieval system includes demonstration of technologies for Phase I HLW pretreatment processing for privatization and transfer of HLW and LLW to the Phase I processing facilities.

The requirements of the Phase I privatization transfer system identified in Function 4.2.2.2, Paragraph 3.2.3.18.1 are as follows:

- Interfacing waste sources shall be categorized according to the Waste Reactivity Group Compatibility Matrix and the potential chemical compatibility hazards identified before acceptance into a DST.
- Interfacing waste sources shall ensure that the criticality prevention limits are met before initiating waste transfers.
- The sum of the receiving tank waste and the source waste heat generation rate shall be less than or equal to the Operating Specification Document limit for the receiving tank in order for the transfer to take place.
- The waste solutions shall be transferred at a maximum waste temperature of 82 °C (180 °F), if collected in the 241-AP DST Farm.
- The specific gravity of the solution must be less than 1.41 SpG. If the SpG is > 1.41, then a detailed technical evaluation of potential for flammable gas accumulation in the commingled waste shall be performed.
- Following a waste transfer through a transfer pipeline, the waste generator shall flush the transfer pipeline with a volume of water that is equal to the transfer pipeline volume.
- Waste provided to the transfer managed tank waste system shall comply with the following parameters: Calculated Reynolds number for the waste transfer shall be $\geq 20,000$, volume percent shall be ≤ 30 percent solids.

1.6.2 Open Issues

A viscosity of 10 cP was used as a basis for this analysis. However, the design range of the LLW and HLW viscosities varies from 1 to 94 cP (DOE 1995). If the Waste

Pumpability Rule (Fowler 1995) must be met and a higher viscosity is required, the upgrades to the existing transfer system would be more extensive than that presented in this analysis, or dilution of the waste would be required to meet the current transfer system design limits. This is because the head and pressure requirements for a system will increase by the square of the increase in the viscosity of the waste if the Reynolds number is constant.

The hydraulic performance of several of the options are limited by the design pressure of the existing transfer lines. It has been suggested that the existing transfer lines could be re-rated to new pressure and temperature design limits to allow their use at the higher operating conditions required for transferring the LLW and HLW. The minimum requirements to re-rate a transfer line are as follows (ASME 1993):

- Survey the existing piping to establish current conditions including thickness, layout, supports, and any other design factors.
- Review documentation for examination that was performed during initial fabrication and determine adequacy to the new design ratings.
- Perform design analysis of existing system to the new design conditions.
- Perform hydrostatic leak test based on the new design conditions.

Determining the physical condition of the existing transfer lines would be the limiting factor on re-rating the lines. Methodologies that are judged to be currently available for examination of encased underground piping was investigated by the Hanford onsite Architectural Engineer (see Appendix D). A number of contacts were made with offsite vendors to determine methodologies used at chemical processing facilities.

The findings of the investigation are as follows:

"Considering the transfer systems continuing failure from 1980, only a 100% examination of the pipeline to verify existing wall thickness would be acceptable to validate re-rating. The risk would not be acceptable to only perform a partial examination (approximately 33% of SN-213/200, based on 100 foot entry from each end of line). At the current time no system has been found that can traverse 100% of the lines length to determine remaining pipe wall thickness and attempting to re-rate the system is not recommended. If 100% of the transfer system were to be examined, the probability of increasing the design pressure is very low due to expected corrosion to be detected given past history on pipeline failures."

1.6.3 Function and Requirements Open Issues

- **Emergency Tank Waste Transfer Procedure Issue (WHC 1996a, Table 1, Appendix G, Page G-13)**

In the event of a catastrophic failure the Hanford Site operating procedures require a method for transferring the contents a leaking tank. In such an event the privatization contractor will transfer the contents to a DST. However, the procedures needed to enable such a transfer have not been determined.

Resolution:

This study has determined that the existing 200E Area waste transfer system is capable of supporting the emergency pumping operation. The privatization contractor will be required to develop a specific procedure with protocols for initiating the transfer.

Since the waste residing in the privatization contractor's tank will be conditioned and compliant with the transfer system design requirements, the transfer can be accomplished. Receipt of the waste into another DST will be based on Waste Compatibility Rules.

- **HLW PHYSICAL INTERFACE ISSUE (WHC 1996a, Table 1, Appendix G, Page G-16)**

What is the most sensible place to tie the privatization contractor into the service?

Resolution:

This study had determined the interface point to be the "new valve pit" located with the existing SN-650 line. The valve pit will either be located within the 241-AP tank farm, adjacent to the 241-AP-102 tank, or outside the 241-AP tank farm. The privatization contractor's HLW transfer line will be routed east of this location for tie-in to the privatization contractor's HLW processing facility. This line will be sloped to the processing facility to assure that no drain back to this new valve pit occurs.

- **LAW FEED PHYSICAL INTERFACE LOCATIONS ISSUE (WHC 1996a, Table 1, Appendix G, Page G-22)**

What is the most sensible place to tie the privatization contractor's into the service?

Resolution:

This study has determined that connection to the existing waste transfer system will be at the central pump pit on the privatization contractor's LLW waste feed staging tank (241-AP-106 or 241-AP-108). Using this location will allow the privatization contractor to access the 200E Area waste transfer system by the 241-AP tank farm valve pit. The transfer system provides the required capabilities to receive waste from the 241-AP-102 and 241-AP-104 LLW intermediate waste staging tanks.

- **STRONTIUM/TRU/ENTRAINED SOLIDS PHYSICAL INTERFACE ISSUE (WHC 1996a, Table 1, Appendix G, page G-38)**

The physical location of the interface and details of the interface need to be determined whether it shall be at the privatization contractor's property line or at a location closer to the tank farms (making the contractor responsible for the transfer line).

Resolution:

It has been concluded that the interface point for return of strontium/TRU/entrained solids to be by the privatization contractor's LLW waste feed staging tank central pump pit, (i.e., tanks 241-AP-106 and 241-AP-108). The privatization contractor will be responsible for the waste transfer line from their facilities to the LLW waste feed staging tank central pump pit and any jumpers needed within the pump pit. DOE will provide the necessary jumpers and routing from the central pump pit to the AP tank farm valve pit and the remainder of the DST transfer system. Transfer protocol and procedures must be developed to ensure compatibility with the receiving DST. This interface point will provide connection to the existing 200E Area waste transfer system.

- **WASTE PUMPABILITY CRITERIA ISSUE (WHC 1996a, Table 1, Appendix G, Page G-44)**

The physical and chemical properties may differ from source to source depending on the individual waste source that the managed transfer tank waste system will interface with.

Resolution:

The movement of tank waste through the combination of existing and upgraded waste transfer systems, as identified in this study, will be achievable. Each waste source will have to be sampled and analyzed to verify specific waste characteristics; e.g., viscosity, SpG, wt% solids, and thixotropic behavior. The results of the analysis will be used to specify the extent of waste conditioning required before initiating the waste transfer. All wastes will meet the limits on characteristics imposed by the transfer system design limits.

1.6.4 Scope

The objective of the Phase I Privatization is to deliver a LLW and HLW feed to the Phase I private contractors for vitrification. This report addresses the transfer of supernatant waste from the 241-AN Tank Farm to the 241-AP-102 and/or the 241-AP-104 Tanks. These two tanks have been designated as the Intermediate LLW Feed Staging Tanks. In addition, this report addresses the transfer of slurry waste from the 241-AY and 241-AZ Tank Farms to the Phase I vendor facilities for HLW immobilization.

The results of this AGA will provide input to the revised Phase I LLW and HLW Feed Staging Plans.

1.7 DESCRIPTION OF OPTIONS CONSIDERED**1.7.1 Low-Level Waste Options**

The primary feed for the Phase I LLW immobilization considered in this AGA is the supernate contained in the 241-AN Tank Farm. There are four main option routings for the transfer of LLW from the 241-AN Tank Farm to the feed staging tanks in the 241-AP Tank Farm.

LLW Option 1 is the "Do Nothing" option. This option utilizes the existing waste transfer system routing with no upgrades. The option is illustrated in Figure 1-1.

LLW Option 2 is the "New 7.6-cm (3-in.) Line, 241-AN to 241-AX-B" option. This option would require a new 7.6-cm (3-in.) routing from the 241-AN-B Valve Pit (VP) to the 241-AX-B VP. This would allow the LLW to be transferred in 7.6-cm (3-in.) transfer lines from the source tank to the intermediate feed staging tanks. Project W-314 is planning to add a new 7.6-cm (3-in.) transfer route from the 241-AN Tank Farm to the 241-AX Valve Pits (WHC 1996b). The option is illustrated in Figure 1-2.

WHC-SD-WM-TI-750
Revision 0

Figure 1-1. Low-Level Waste Option 1: "Do Nothing."

CHS/PS: WML/RT

WHC-SD-WM-TI-750
Revision 0

Figure 1-2. Low-Level Waste Option 2: "New 7.6-cm (3-in.) Line,
241-AN-B to 241-AX-B."

LLW Option 3 is the "New SN-650 Valve Pit" Option. This option would utilize the existing 5.1-cm (2-in.) and 7.6-cm (3-in.) transfer system. However, instead of transferring through the 241-AW Tank Farm, the waste would transfer through the 7.6-cm (3-in.) SN-650 line at the 241-A-B VP. This option would require adding a new valve pit and transfer line at the 241-AP Tank Farm to allow LLW transfers to either of the intermediate feed staging tanks. The option is illustrated in Figure 1-3.

LLW Option 4 is the "New 7.6-cm (3-in.) Line and Valve Pit" option. This option is a combination of Options 2 and 3. This option would add a 7.6-cm (3-in.) transfer line from the 241-AN-B VP to the 241-AX-B VP, and add a new valve pit and transfer lines on the 7.6-cm (3-in.) SN-650 line to allow for transfers to either intermediate feed staging tank. The option is illustrated in Figure 1-4.

1.7.2 High-Level Waste Options

The neutralized current acid waste (NCAW) sludges contained in tanks 241-AZ-101 and 241-AZ-102 and the high-heat sludge in tank 241-AY-102 (including retrieved solids from tank 241-C-106) are candidate feeds for the Phase I HLW vitrification (Manuel 1996). There are four optional routings for the transfer of HLW to the vendor. (Note: for the purpose of this evaluation the HLW feed line is analyzed to the vendors proposed HLW processing facility. The interface/tie-in point for the tank farm operating contractor and the HLW vendor have not been negotiated at this time.)

HLW Option 1 is the "Do Nothing" option. From the 241-AZ Tank Farm this option uses the existing waste transfer system routing with no upgrades except the addition of a new HLW feed line from the 241-AP Tank Farm to the vendor's processing facility. From the 241-AY Tank Farm the "Do Nothing" option uses the existing 5.1-cm (2-in.) slurry lines to route waste back to tank 241-AZ-101. The waste would be staged in the 241-AZ-101 Tank and then routed to the vendor's processing facility using the selected HLW staging plan. The option is illustrated in Figure 1-5.

HLW Option 2 is the "New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A" option for the 241-AZ Tank Farm transfers and the "New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B" option for the 241-AY Tank Farm transfers. From the 241-AZ Tank Farm this option would require the upgrade of the 5.1-cm (2-in.) SL-501 and 5.1-cm (2-in.) SL-500 transfer lines to 7.6-cm (3-in.). From the 241-AY Tank Farm this option would require the upgrade of the 5.1-cm (2-in.) SL-502 line to 7.6-cm (3-in.). Project W-314 is planning to replace the 5.1-cm (2-in.) SL-502 line with a new 5.1-cm (2-in.) transfer line (WHC 1996b). The option is illustrated in Figure 1-6.

Figure 1-3. Low-Level Waste Option 3: "New SN-650 Valve Pit."

WHC-SD-WM-TI-750
Revision 0

Figure 1-4. Low-Level Waste Option 4: "New 7.6-cm (3-in.) Line and Valve Pit."

Figure 1-5. High-Level Waste Option 1: "Do Nothing."

Figure 1-6. High-Level Waste Option 2: "New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A" and "New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B."

HLW Option 3 is the "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit" option. This option would replace/upgrade the existing 5.1-cm (2-in.) transfer lines to 7.6-cm (3-in.) as in Option 2, however, the line from 241-AZ would tie in to the 241-AX-B VP. The waste would then be transferred through the 7.6-cm (3-in.) SN-200/213 replacement line (WHC 1996b) and then through the 7.6-cm (3-in.) SN-650 line at the 241-A-B VP. This option would require adding a new valve pit and transfer line at the 241-AP Tank Farm to transfer waste to the vendor(s). The option is illustrated in Figure 1-7.

HLW Option 4 is the New 7.6-cm (3-in.) Route, 241-AZ to Vendor option for the 241-AZ Tank Farm transfers and the New 7.6-cm (3-in.) Route, 241-AY to Vendor option for the 241-AY Tank Farm transfers. This option would upgrade the existing 5.1-cm (2-in.) transfer lines to 7.6-cm (3-in.) as in Option 2, and add a new 7.6-cm (3-in.) transfer line from the 241-A-A VP to the vendor's processing facility. The option is illustrated in Figure 1-8.

1.8 DECISION CRITERIA

Decision criteria are used to evaluate the options. The decision criteria were specified in the decision plan and were chosen in relation to the Phase I Privatization mission fulfillment. The criteria of Operability and Maintainability were specified in the decision plan, but will not be used in the decision criteria. None of the options differ in these two criteria. The criteria are described in the following sections.

1.8.1 Hydraulic Performance

The primary factors in the hydraulic performance criteria are the Reynolds number and the required pump head and pressure. An analysis was done on each waste routing option to develop the system head curve for each of the options generated (see Appendix A). The requirement to upgrade the existing transfer pump will be addressed for each option.

The Waste Pumpability Rule requires that the Reynolds number be above 20,000 for non-routine transfers (Fowler 1995). For the waste properties used in this AGA that would require a minimum velocity of 1.7 m/sec (5.6 ft/sec) in a 7.6-cm (3-in.) transfer line and around 2.6 m/sec (8.5 ft/sec) in a 2-in. transfer line.

The main limitation of the existing transfer lines is the design pressure. For each of the options, except the 241-AY Tank Farm "Do Nothing" option and HLW Option 3, the lowest design pressure was 1.6 MPa (230 psi), equivalent to approximately 107 m (350 ft) of head.

WHC-SD-WM-TI-750
Revision 0

Figure 1-7. High-Level Waste Option 3: "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"

Figure 1-8. High-Level Waste Option 4: "New 7.6-cm (3-in.) Route, 241-AZ to Vendor" and "New 7.6-cm (3-in.) Route, 241-AY to Vendor."

CHPT12: HML-AL74

1.8.2 Cost

The cost criteria of each option will be the total project cost. Each viable option would have relatively the same life-cycle cost and, therefore, only initial project cost will be considered. The cost of the jumper manifolds in each of the main process pits is included. A recent life-cycle cost analysis was done that showed that the use of a jumper manifold system was cost effective (WHC 1995).

1.8.3 Schedule

The options should minimize schedule impacts with the 242-A Evaporator. This criterion deals with the use of the 241-AW-B VP and the 241-AW-02A Pump Pit, in addition to the use of common transfer lines. It is assumed that each option would incorporate a jumper manifold design in the main A-Farm Complex process pits. These jumper manifolds are needed to minimize the set-up time for the transfers by eliminating pit entries for routing changes. The design of a jumper manifold system in each of the process pits is discussed in Appendix B.

The HLW preliminary schedule assumes that there will be two batch transfers of HLW feed per fiscal year (FY) (Manuel 1996). This will have no impact in the screening of the options. In addition, the private contractors must provide 30 to 90 days notice in advance of the ready-for-feed date. The Management and Integration contractor must begin delivery of feed no earlier than the ready-for-feed date and complete delivery no later than 60 days after the ready-for-feed date. This requirement will not vary among the options, and, therefore, have no impact in the decision criteria.

The design and construction time for the different upgrades will be addressed. The LLW and HLW transfers to the vendor(s) are scheduled to begin in FY 2002.

A nodal analysis will be provided in the next revision of the revised *Low-Level Waste Feed Staging Plan* (Certa to be released). The analysis will quantify the schedule criteria and determine the benefits of the evaluated options.

1.8.4 Flexibility

Waste transfer flexibility will be a key operational value. Each option will be evaluated based on supporting sequential LLW and HLW transfers, concurrent 242-A Evaporator operation, routine waste management operations, and return of separated waste from the privatization contractor(s).

1.9 OPTIONS EVALUATION

The analysis of the options have been summarized in a tabular form in Tables 1-1, 1-2, and 1-3. In addition, Table 1-4 shows the cost breakdown of the options between Project W-314 and the Privatization Infrastructure Project (PIP), and Table 1-5 shows the combined cost of the options. The cost estimates for each option are provided in Appendix C.

LLW Option 4, the "New 7.6-cm (3-in.) Line and Valve Pit," is the only LLW option to satisfy all of the decision criteria. LLW Option 2 satisfied the hydraulic performance criteria and was lower in cost, but it causes possible schedule impacts with the 242-A Evaporator operation and HLW staging of waste. A nodal analysis in the revised Phase I privatization LLW staging plan will quantify the schedule criteria and determine if the benefits of Option 4 are cost effective. Options 1 and 3 do not satisfy the hydraulic performance criteria.

HLW Option 3, the "New 7.6-cm (3-in) Lines to 241-AX-B and New SN-650 Valve Pit" is the only HLW option to satisfy the hydraulic performance criteria. However, Option 3 will not meet the hydraulic performance criteria if the 7.6-cm (3-in.) SN-200/213 line is not upgraded due to the existing line's design pressure limit of 1.6 Mpa (230 psi). No other option satisfied the hydraulic performance criteria except Option 1 for the 241-AY Tank Farm transfers. However, Option 1 requires a double transfer and staging of the waste in the 241-AZ-101 tank. This would create additional scheduling problems. A nodal analysis in the next revision of the revised LLW Feed Staging Plan (Certa to be released) will quantify the schedule criteria for the combined LLW and HLW options.

WHC-SD-WM-TI-750
Revision 0

Table 1-1. Matrix of Low-Level Waste Options by Decision Criteria.

Decision Criteria	Option					
	Option 1 "Do Nothing"	Option 2 "New 7.6-cm (3-in.) Line, 241-AN-B to 241-AX-B"	Option 3 "New SN-650 Valve Pit"	Option 4 "New 7.6-cm (3-in.) Line and Valve Pit"		
Design Data						
Routing Length	1090 m (3570 ft)		1090 m (3570 ft)		1020 m (3340 ft)	1020 m (3340 ft)
Line Size(s)	5.1 cm and 7.6 cm (2 in. and 3 in.)		7.6 cm (3 in.)		5.1 cm and 7.6 cm (2 in. and 3 in.)	7.6 cm (3 in.)
Design Pressure	1.6 MPa (230 psi)		1.6 MPa (230 psi)		1.6 MPa (230 psi)	1.6 MPa (230 psi)
Hydraulic Performance ^d (SpG = 1.5, viscosity = 10 cP)						
Flow Rate - L/min (gal/min)	490 (130)	320 (85)	490 (130)	490 (130)	340 (90)	490 (130)
Reynolds No. ^a	20,000	13,500	20,000	20,000	14,000	20,000
Velocity	1.7 m/s (5.6 ft/s)	1.2 m/s (3.8 ft/s)	1.7 m/s (5.6 ft/s)	1.7 m/s (5.6 ft/s)	1.2 m/s (3.9 ft/s)	1.7 m/s (5.6 ft/s)
Pump Head	200 m (660 ft)	110 m (350 ft)	100 m (320 ft)	190 m (630 ft)	110 m (350 ft)	90 m (300 ft)
Line Pressure	3.0 MPa (430 psi)	1.6 MPa (230 psi)	1.5 MPa (210 psi)	2.8 MPa (410 psi)	1.6 MPa (230 psi)	1.3 MPa (190 psi)
Cost (\$ million) ^e						
Line Upgrade	N/A ^b	\$0	\$6.5	N/A ^b	\$3.1	\$9.6
Jumper Manifold	--	\$6.8	\$6.8	--	\$6.8	\$6.8
Pump Upgrade ^c	--	\$1.8	\$1.8	--	\$1.8	\$1.8
Total Cost	--	\$8.6	\$15.1	--	\$11.7	\$18.2
Schedule	PROS: <ul style="list-style-type: none">• No design and Construction upgrades CONS: <ul style="list-style-type: none">• Possible schedule impacts with Evaporator• Possible impacts to feed delivery to vendor		CONS: <ul style="list-style-type: none">• Possible schedule impacts with Evaporator• Design and Construction of the upgrades needed by FY 2002		PROS: <ul style="list-style-type: none">• No schedule impacts with Evaporator• Avoids "bottlenecks in 241-AW and 241-AP Valve Pits (VP) CONS: <ul style="list-style-type: none">• Design and Construction of the upgrades needed by FY 2002	
					PROS: <ul style="list-style-type: none">• No schedule impacts with Evaporator• Avoids "bottlenecks in 241-AW and 241-AP Valve Pits (VP) CONS: <ul style="list-style-type: none">• Design and Construction of the upgrades needed by FY 2002	

WHC-SD-WM-TI-750
Revision 0

Table 1-1. Matrix of Low-Level Waste Options by Decision Criteria.

Decision Criteria	Option			
	Option 1 "Do Nothing"	Option 2 "New 7.6-cm (3-in.) Line, 241-AN-B to 241-AX-B"	Option 3 "New SN-650 Valve Pit"	Option 4 "New 7.6-cm (3-in.) Line and Valve Pit"
Flexibility	CONS: <ul style="list-style-type: none"> Routes waste through the 241-AW-B VP and the 241-AW-02A Pump Pit (PP) 	CONS: <ul style="list-style-type: none"> Routes waste through the 241-AW-B VP and the 241-AW-02A PP 	PROS: <ul style="list-style-type: none"> Supports concurrent Evaporator operation 	PROS: <ul style="list-style-type: none"> Supports concurrent Evaporator operation

^aThe Waste Pumpability Rule requires that the Reynolds Number be $\geq 20,000$ for non-routine transfers.

^bThe head and pressure requirements for this option are unacceptable.

^cThe pump upgrade cost is based on the initial cost of the New Generation Transfer Pump and does not include removal/disposal of the existing transfer pump or electrical upgrades. Also, this is the cost for all seven pumps in the 241-AN Tank Farm.

^dThe shaded cells show the hydraulic performance of the option with the design pressure limitation.

^eTable 1-4 shows the cost breakdowns between Project W-314 and the Privatization Infrastructure Project, and Table 1-5 shows a combined cost matrix for the options.

WHC-SD-WM-TI-750
Revision 0

Table 1-2. Matrix of High-Level Waste Options
(241-AZ Tank Farm) by Decision Criteria.

Decision Criteria	Option							
	Option 1 "Do Nothing"	Option 2 "New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A"		Option 3 "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"		Option 4 "New 7.6-cm (3-in.) Route, 241-AZ to Vendor"		
Design Data								
Routing Length	1830 m (6000 ft)		1830 m (6000 ft)		1670 m (5480 ft)		1670 m (5470 ft)	
Line Size(s)	5.1 cm (2 in.) and 7.6 cm (3 in.)		7.6 cm (3 in.)		7.6 cm (3 in.)		7.6 cm (3 in.)	
Design Pressure	1.6 MPa (230 psi)		1.6 MPa (230 psi)		2.8 MPa (400 psi)	1.6 MPa (230 psi)	1.6 MPa (230 psi)	
Hydraulic Performance ^a (SpG = 1.5, viscosity = 10 cP)								
Flow Rate L/min (gal/min)	490 (130)	320 (85)	90 (130)	420 (110)	490 (130)	450 (115)	490 (130)	450 (115)
Reynolds No. ^a	20,000	13,000	20,000	17,000	20,000	18,000	20,000	18,000
Velocity	1.7 m/s (5.6 ft/s)	1.1 m/s (3.6 ft/s)	1.7 m/s (5.6 ft/s)	1.5 m/s (4.6 ft/s)	1.7 m/s (5.6 ft/s)	1.5 m/s (4.9 ft/s)	1.7 m/s (5.6 ft/s)	1.5 m/s (5.0 ft/s)
Pump Head	220 m (720 ft)	110 m (350 ft)	145 m (475 ft)	110 m (350 ft)	130 m (435 ft)	110 m (350 ft)	130 m (425 ft)	110 m (350 ft)
Line Pressure	3.2 MPa (470 psi)	1.6 MPa (230 psi)	2.1 MPa (310 psi)	1.6 MPa (230 psi)	1.9 MPa (280 psi)	1.6 MPa (230 psi)	1.9 MPa (275 psi)	1.6 MPa (230 psi)
Cost ^b (\$ million) ^f								
Line Upgrade	N/A ^c	\$0	\$4.2+	\$4.2	\$10.3	\$8.8	\$7.8+	\$7.8
Jumper Manifold	—	\$6.8	\$6.8	\$6.8	\$6.8	\$6.8	\$6.8	\$6.8
Pump Upgrade ^d	--	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Total Cost	--	\$6.8	\$11.0	\$11.0	\$17.1	\$15.6	\$14.6	\$14.6
Schedule	PROS: • No design and Construction upgrades	PROS: • Possible schedule impacts with Evaporator	PROS: • Possible schedule impacts with Evaporator	PROS: • No schedule impacts with Evaporator	PROS: • No schedule impacts with Evaporator	PROS: • No schedule impacts with Evaporator	PROS: • No schedule impacts with Evaporator	PROS: • No schedule impacts with Evaporator
	CONS: • Possible schedule impacts with Evaporator • Possible impacts to feed delivery to vendor							

Table 1-2. Matrix of High-Level Waste Options
(241-AZ Tank Farm) by Decision Criteria.

Decision Criteria	Option			
	Option 1 "Do Nothing"	Option 2 "New 7.6-cm (3-in.) Line, 241-AZ to 241-AX-A"	Option 3 "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"	Option 4 "New 7.6-cm (3-in.) Route, 241-AZ, to Vendor"
Flexibility	CONS: <ul style="list-style-type: none"> Routes waste through the AW-02A Pump Pit (PP) Utilizes transfer lines with Clean-out Boxes (COBs) 	PROS: <ul style="list-style-type: none"> Accommodates change to TWRS Treatment Complex 	PROS: <ul style="list-style-type: none"> Supports concurrent Evaporator operation CONS: <ul style="list-style-type: none"> Shares transfer lines with LLW transfers 	PROS: <ul style="list-style-type: none"> Supports concurrent Evaporator operation Allows for simultaneous HLW and LLW transfers Accommodate change to TWRS Treatment Complex

^aThe Waste Pumpability Rule requires that the Reynolds Number be $\geq 20,000$.

^bThe "+" symbol indicates an unknown amount for design pressure upgrade analysis including NDE.

^cThe head and pressure requirements for this option are unacceptable.

^dThe pump upgrade is required on each of these options. However, it is assumed that Project W-211 will be installing the New Generation Transfer Pump in tanks 241-AZ-101 and 241-AZ-102.

^eThe shaded cells show the hydraulic performance of the option with the existing design pressure limitation.

^fTable 1-4 shows the cost breakdowns between Project W-314 and the Privatization Infrastructure Project, and Table 1-5 shows a combined cost matrix for the options.

Table 1-3. Matrix of High-Level Waste Options
(241-AY Tank Farm) by Decision Criteria.

Decision Criteria	Option						
	Option 1 "Do Nothing" (to 241-AZ-101)	Option 2 "New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B"	Option 3 "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"		Option 4 "New 7.6-cm (3-in.) Route, 241-AY to Vendor"		
Design Data							
Routing Length	280 m (920 ft)	1700 m (5580 ft)	1530 m (5020 ft)		1540 m (5050 ft)		
Line Size(s)	5.1 cm (2 in.)	7.6 cm (3 in.)	7.6 cm (3 in.)		7.6 cm (3 in.)		
Design Pressure	2.6 MPa (375 psi)	1.6 MPa (230 psi)	2.8 MPa (400 psi)	1.6 MPa (230 psi)	1.6 MPa (230 psi)		
Hydraulic Performance ^f (SpG = 1.5, viscosity = 10 cP)							
Flow Rate - L/min (gal/min)	340 (90)	490 (130)	435 (115)	490 (130)	470 (125)	490 (130)	470 (125)
Reynolds No. ^a	20,000	20,000	17,500	20,000	19,000	20,000	19,000
Velocity	2.6 m/s (8.6 ft/s)	1.7 m/s (5.6 ft/s)	1.5 m/s (4.9 ft/s)	1.7 m/s (5.6 ft/s)	1.6 m/s (5.3 ft/s)	1.7 m/s (5.6 ft/s)	1.6 m/s (5.3 ft/s)
Pump Head	90 m (300 ft)	135 m (440 ft)	110 m (350 ft)	115 m (385 ft)	110 m (350 ft)	120 m (390 ft)	110 m (350 ft)
Line Pressure	1.3 MPa (190 psi)	1.4 MPa (200 psi)	2.0 MPa (290 psi)	1.7 MPa (250 psi)	1.6 MPa (230 psi)	1.7 MPa (250 psi)	1.6 MPa (230 psi)
Cost ^b (\$ million) ^g							
Line Upgrade	\$0	\$1.9+	\$1.9	\$0+ ^d	\$0 ^d	\$1.9+	\$1.9 ^d
Jumper Manifold ^d	--	--	--	--	--	--	--
Pump Upgrade ^e	Not Required	\$0	\$0	\$0	\$0	\$0	\$0
Total Cost ^d	\$0	\$1.9+	\$1.9	\$0+	\$0	\$1.9+	\$1.9
Schedule	PROS: ● No design and Construction upgrades	PROS: ● Possible schedule impacts with Evaporator	PROS: ● No schedule impacts with Evaporator	PROS: ● No schedule impacts with Evaporator	PROS: ● No schedule impacts with Evaporator		
	CONS: ● Requires a double transfer to send waste to the vendor(s) ● Possible impacts on feed delivery to vendor	CONS: ● Design and Construction of the upgrades needed by FY 2002	CONS: ● Design and Construction of the upgrades needed by FY 2002	CONS: ● Design and Construction of the upgrades needed by FY 2002	CONS: ● Design and Construction of the upgrades needed by FY 2002		

Table 1-3. Matrix of High-Level Waste Options
(241-AY Tank Farm) by Decision Criteria.

Decision Criteria	Option			
	Option 1 "Do Nothing" (to 241-AZ-101)	Option 2 "New 7.6-cm (3-in.) Line, 241-AY to 241-AX-B"	Option 3 "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"	Option 4 "New 7.6-cm (3-in.) Route, 241-AY to Vendor"
Flexibility	Depends on HLW staging plan selection	PROS: <ul style="list-style-type: none"> Accommodates change to TWRS Treatment Complex 	PROS: <ul style="list-style-type: none"> Supports concurrent Evaporator operation CONS: <ul style="list-style-type: none"> Shares transfer lines with LLW transfers 	PROS: <ul style="list-style-type: none"> Supports concurrent Evaporator operation Accommodate change to TWRS Treatment Complex Allows for simultaneous HLW and LLW transfers

^aThe Waste Pumpability Rule requires that the Reynolds Number be $\geq 20,000$ for non-routine transfers.

^bThe "+" symbol indicates an unknown amount for design pressure upgrade analysis including NDE.

^cThe head and pressure requirements for this option are unacceptable.

^dThe cost that are covered in the corresponding AZ-Farm options are not included.

^eThe pump upgrade is required on each option unless mentioned otherwise. However, it is assumed that Project W-211 will be installing the New Generation Transfer Pump in tank 241-AY-102.

^fThe shaded cells show the hydraulic performance of the option with the existing design pressure limitation.

^gTable 1-4 shows the cost breakdowns between Project W-314 and the Privatization Infrastructure Project, and Table 1-5 shows a combined cost matrix for the options.

Table 1-4. Option Cost Breakdown between Project W-314
and the Privatization Infrastructure Project.

Description of upgrade	PIP cost (\$ million)	W-314 cost (\$ million)	Option utilizing upgrade							
			Low-level waste				High-level waste			
			1	2	3	4	1	2	3	4
New 3-in. SN from AN-B Valve Pit (VP) to AZ-02A Pump Pit (PP)	-	3.2		✓		✓				
New 3-in. SN from AZ-02A PP to AX-B VP	-	3.3		✓		✓			✓	
New SN-650 valve pit and 3-in. lines to 241-AP-102 and 241-AP-104	3.1	-			✓	✓				
Valve manifolds	-	6.8	✓	✓	✓	✓	✓	✓	✓	✓
Pump upgrade	1.8	-	✓	✓	✓	✓				
Replacement of 2-in. SL-502	-	1.4						✓	✓	✓
Upgrade SL-502 replacement to 3-in. (Delta)	0.5	-						✓	✓	✓
New 3-in. SN from AZ-01A PP to AZ-02A PP	0.9							✓	✓	✓
New 3-in. SN from AZ-02A PP to AX-A VP	3.3							✓		✓
New 3-in. SN from A-A VP to Vendor	3.6	-								✓
New 3-in. SN from new SN-650 valve pit*	1.5	-							✓	
Replacement of 3-in. SN-200/213	-	1.5							✓	
Replacement of 3-in. SN-216	-	11.0	W-314 Scope Only							
Replacement of 2-in. SL-504	-	0.7	W-314 Scope Only							
Total Stand-Alone Cost (\$ million)			8.6	15.1	11.7	18.2	6.8	12.9	15.9	16.5

PIP = Privatization Infrastructure Project

*Cost estimate covers installation of line from SN-650 valve pit to vendor High-level waste processing facility. The U.S. Department of Energy is not committed to providing the entire line at this time.

Table 1-5. Matrix of Low-Level Waste and High-Level Waste Options
by Combined Cost (\$ million).

High-Level Waste Option	Low-Level Waste Option			
	1	2	3	4
1 (W-314 \$) (PIP \$)	\$8.6 (\$6.8) (\$1.8)	\$15.1 (\$13.3) (\$1.8)	\$11.7 (\$6.8) (\$4.9)	\$18.2 (\$13.3) (\$4.9)
2 (W-314 \$) (PIP \$)	\$14.7 (\$8.2) (\$6.5)	\$21.2 (\$14.7) (\$6.5)	\$17.8 (\$8.2) (\$9.6)	\$24.3 (\$14.7) (\$9.6)
3 (W-314 \$) (PIP \$)	\$17.7 (\$13.0) (\$4.7)	\$20.9 (\$16.2) (\$4.7)	\$20.8 (\$9.7) (\$11.1)	\$24.0 (\$16.2) (\$7.8)
4 (W-314 \$) (PIP \$)	\$18.3 (\$8.2) (\$10.1)	\$24.8 (\$14.7) (\$10.1)	\$21.4 (\$8.2) (\$13.2)	\$27.9 (\$14.7) (\$13.2)

Shaded options do not meet the current hydraulic performance criteria, therefore the alternative/option is not considered.

2.0 PROBLEM STATEMENT

The U.S. Department of Energy, Richland Operations Office, is pursuing a new business strategy for remediation of Hanford Site tank waste. This strategy, commonly called privatization, involves hiring private contractors to perform specific functions on a pay-for-product basis. During Phase I, the technical, regulatory, and financial viability of the privatization concept will be demonstrated by processing a portion of the waste stored in the DST system. The Phase I Privatization mission will include supernatant pretreatment, LLW immobilization, and an optional HLW immobilization.

This AGA Report was prepared to determine the best waste transfer routing option. DST supernate and pretreated solids would be provided to the vendor(s) for processing.

This page intentionally left blank.

3.0 CONSTRAINTS AND ASSUMPTIONS

3.1 CONSTRAINTS

Constraints are requirements that are imposed by an external organization. The design, operation and maintenance of the Phase I privatization transfer system are affected by state and federal regulations, agreements, DOE Orders, and WHC requirements. In addition, there are guidelines and specifications that set forth engineering requirements deemed necessary for safe design and construction of the transfer system. The requirements and guidelines presented in these orders, regulations, codes, and agreements must be followed when designing and installing a transfer system. The format below establishes a hierarchy into the listed documents to be used during definitive the design stage of the transfer system:

DOE Order 6430.1A, *General Design Criteria*

DOE Order 5820.2A, *Radioactive Waste Management*

WAC 173-303-640, *Dangerous Waste Regulations, Tank Systems*

WHC-IP-1043, *WHC Occupational ALARA Program*

WHC-SD-GN-DGS-30011, *Radiological Design Guide*

WHC-CM-4-46, *Safety Classification of Structures, Systems, and Components*

WHC-SD-GN-DGS-30008, *Design Loads for New Underground DSTs and Associated Underground Process Piping*

ASME B31.3, *Chemical Plant and Petroleum Refinery Piping*.

3.2 ASSUMPTIONS

The following assumptions have been made in the analysis of the Phase I privatization transfer system:

- The waste fluid has a 1.5 SpG and a viscosity of 10 cP. The 1.5 SpG is the worst case value for the waste to be transferred. The issue of viscosity was discussed previously in Section 1.6.2. (Note: Current operations require a SpG of ≤ 1.41 , see Section 1.6.1. The use of 1.5 SpG was used to provide a more conservative head loss evaluation.)

- The HLW will be staged in the vendor(s) processing plant per interface description 20: High-Level Waste Feed (DOE 1995).
- The vendor's facility is located at the coordinates N40500 and W44500.
- LLW intermediate feed staging will occur in 241-AP-102 and 241-AP-104 tanks.
- Vendor(s) LLW feed staging tanks will be in 241-AP-106 and 241-AP-108, per Interface Description 20: Waste Feed Tanks (DOE 1995).
- The evaluation has assumed that Project W-314, *Tank Farm Restoration and Safe Operations*, will upgrade the current master pump shutdown system (MPS). The MPS is an integral subsystem of the waste transfer system and therefore the functionality and reliability of the system can affect the efficient operation of waste transfers. Therefore this evaluation has assumed that the MPS is upgraded/restored by Project W-314 to a highly reliable system.

4.0 ANALYSIS OF OPTIONS

This section documents the methodology used to generate the options and documents any options that were screened. In addition, this section determines how well an option satisfies each selection criteria.

4.1 GENERATION OF OPTIONS

The option routings for transferring the LLW and HLW to the vendor(s) were developed by informal brainstorming. The only initial criteria used in the generation of the options was to avoid routing through the 242-A Evaporator. A description of each of the options is provided in Section 1.7.

The LLW Options considered by this study include the following:

- Option 1: "Do Nothing"
- Option 2: "New 7.6-cm (3-in.) Line, 241-AN to AX-B"
- Option 3: "New SN-650 Valve Pit"
- Option 4: "New 7.6-cm (3-in.) Route and Valve Pit."

The HLW Options (241-AZ Tank Farm) considered by this study include the following:

- Option 1: "Do Nothing"
- Option 2: "New 7.6-cm (3-in.) Line, 241-AZ to AX-A"
- Option 3: "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"
- Option 4: "New 7.6-cm (3-in.) Route, 241-AZ to Vendor."

The HLW Options (241-AY-Tank Farm) considered by this study include the following:

- Option 1: "Do Nothing"
- Option 2: "New 7.6-cm (3-in.) Line, 241-AY to AX-B"
- Option 3: "New 7.6-cm (3-in.) Lines to 241-AX-B and New SN-650 Valve Pit"
- Option 4: "New 7.6-cm (3-in.) Route, 241-AY to Vendor."

4.2 SCREENING OF OPTIONS

The options generated could be initially screened against the requirement that the Reynolds number be $\geq 20,000$ (Fowler 1995). That would screen out LLW Options 1 and 3, and HLW Options 1, 2, and 4 for the 241-AZ Tank Farm and HLW Options 2 and 4 for the 241-AY Tank Farm. However, this requirement applies to non-routine transfers and does not have to be complied to if technical evaluation can show that plugging of the line will not occur at Reynolds numbers below this value. Therefore, each option is evaluated against the decision criteria and no options are screened.

4.3 ANALYSIS OF LOW-LEVEL WASTE OPTIONS

This section determines how well each LLW option satisfies the decision criterion. In absence of a tangible means of comparison, engineering judgement has been used in determining how well a criteria has been met by the options. The results of this analysis are summarized in Table 1-1. The next revision of the revised LLW Feed Staging Plan (Certa to be released) will analyze the combined LLW and HLW options against the schedule criteria.

Option 1 is not capable of meeting the hydraulic performance requirements. The head and pressure requirements to meet the Waste Pumpability Rule are beyond the capabilities of the existing transfer system. If the system was operated at its design pressure limit of 1.6 MPa (230 psi), the Reynolds number would be 13,500 and the velocity of the waste would be just over 1.1 m/sec (3.5 ft/sec). In addition, Option 1 does not eliminate the possibility of schedule conflicts with the 242-A Evaporator since common lines and pits are utilized. Finally, Option 1 does not provide the flexibility to support concurrent operation of the Evaporator or the HLW transfers. The total cost of Option 1 is \$8.6 million.

Option 2 is capable of meeting the hydraulic performance requirements, however, the schedule and flexibility concerns from Option 1 still exist. The total cost of Option 2 is \$15.1 million.

Option 3 eliminates the schedule and flexibility concerns of Option 1, however, the hydraulic performance requirements can not be met. The head and pressure requirements to meet the Waste Pumpability Rule are beyond the capabilities of the existing portions of this transfer system. If the system was operated at its design pressure limit of 1.6 MPa (230 psi), the Reynolds number would be 14,000 and the velocity of the waste would be just under 1.2 m/sec (4.0 ft/sec). The total cost of Option 3 is \$11.7 million.

Option 4 is a combination of Options 2 and 3. This system is capable of meeting the hydraulic performance requirements as well as eliminating possible schedule conflicts with the Evaporator. In addition, Option 4 supports concurrent operation of the Evaporator and the HLW transfers. This is accomplished by not utilizing the 241-AW Tank Farm valve pits

and by not using common transfer lines. The only concern with this option is that the required upgrades would need to be complete by FY 2002. The total cost of Option 4 is \$18.2 million.

4.4 ANALYSIS OF HIGH-LEVEL WASTE OPTIONS

This section determines how well each HLW option satisfies the decision criterion. In absence of a tangible means of comparison, engineering judgement has been used in determining how well a criterion has been met by the options. The results of this analysis are summarized in Table 1-2 and Table 1-3. The next revision of the revised LLW Feed Staging Plan (Certa to be released) will analyze the combined LLW and HLW options against the schedule criteria.

For the 241-AZ Tank Farm transfers, Option 1 is not capable of meeting the hydraulic performance requirements. The head and pressure requirements to meet the Waste Pumpability Rule are beyond the capabilities of the existing transfer system. If the system was operated at its design pressure limit of 1.6 MPa (230 psi), the Reynolds number would be 13,000 and the velocity of the waste would be just over 1.1 m/sec (3.5 ft/sec). In addition, Option 1 does not eliminate the possibility of schedule conflicts with the 242-A Evaporator and LLW transfers since common lines and pits are utilized. Also, Option 1 does not provide the flexibility to support concurrent operation of the Evaporator or the LLW transfers. The total cost of Option 1 is \$6.8 million.

For the 241-AY Tank Farm transfers, Option 1 is capable of meeting the hydraulic performance requirements, however, this option adds additional scheduling concerns. The waste would be transferred to the 241-AZ-101 Tank, after the original contents have been transferred to the vendor, and staged there before continuing the transfer to the vendor(s). The other concerns with this option will depend on the option selected for the transfer from the 241-AZ Tank Farm. There would be no additional cost associated with this option.

Option 2 is short of meeting the hydraulic performance requirements. The main driver is the design pressure of the existing portions of this transfer system. If the design pressure of the transfer lines could be increased from 1.6 MPa (230 psi) to 2.1 MPa (310 psi), the hydraulic performance requirements could be met. The analysis required to increase the design pressure limit would require some nondestructive examination (NDE) of the existing lines. However, if the system was operated at its design pressure limit, the Reynolds number would be 17,000 and the velocity of the waste would be just over 1.4 m/sec (4.5 ft/sec) for transfers from the 241-AZ Tank Farm. The Reynolds number and velocity for transfer from the 241-AY Tank Farm would be 17,500 and just under 1.5 m/sec (5.0 ft/sec), respectively. In addition, Option 2 does not eliminate the possibility of schedule conflicts with the 242-A Evaporator since common lines and pits are utilized. Also, Option 2 does not provide the flexibility to support concurrent operation of the Evaporator or the LLW transfers. The total cost of Option 2 is \$12.9 million.

Option 3 is capable of meeting the hydraulic performance requirements as well as eliminating possible schedule conflicts with the Evaporator. This is accomplished by not utilizing the 241-AW Tank Farm valve pits and by not utilizing common transfer lines. However, this alternative does share common transfer lines with the LLW transfers and does require that the SN-200/213 transfer line be replaced. The replacing of the SN-200/213 line makes the design pressure limit of the system 2.8 MPa (400 psi) instead of the 1.6 MPa (230 psi) for the existing transfer line. If the system was operated at its design pressure limit of 1.6 MPa (230 psi), the Reynolds number would be 18,000 and the velocity of the waste would be just under 1.5 m/sec (5.0 ft/sec) for transfers from the 241-AZ Tank Farm. The Reynolds number and velocity for transfer from the 241-AY Tank Farm would be 19,000 and just under 1.7 m/sec (5.5 ft/sec), respectively. The total cost of Option 3 is \$15.9 million.

Option 4 is short of meeting the hydraulic performance requirements. The main driver is the design pressure of the existing portions of this transfer system. If the design pressure of the transfer lines could be increased from 1.6 MPa (230 psi) to 1.9 MPa (280 psi), the hydraulic performance requirements could be met. However, if the system was operated at a design pressure limit, the Reynolds number would be 18,000 and the velocity of the waste would be 1.5 m/sec (5.0 ft/sec) for transfers from the 241-AZ Tank Farm. The Reynolds number and velocity for transfer from the 241-AY Tank Farm would be 19,000 and just under 1.7 m/sec (5.5 ft/sec), respectively. However, Option 4 supports concurrent operation of the Evaporator and the LLW transfers. This is accomplished by not utilizing the 241-AW Tank Farm valve pits and by not using common transfer lines. Another concern with the Option is that the required upgrades would need to be complete by FY 2002. The total cost of Option 4 is \$16.5 million.

5.0 FINDINGS

The decision process used to recommend the preferred options was to minimize the possible bad consequences. The findings of this AGA report are to be analyzed further in the next revision of the revised LLW Feed Staging Plan (Certa to be released). A nodal analysis will provide the decision makers with the cost benefits of the combined LLW and HLW options based on scheduling and sequencing requirements. The findings presented in this section are based primarily on meeting the hydraulic performance requirements.

For the LLW transfer system, Options 2 and 4 were capable of meeting the hydraulic performance criteria. Option 4 is capable of eliminating the schedule concerns with the Evaporator by avoiding the 241-AW and 241-AP valve pits. For the HLW transfer system, only Option 3 meets the hydraulic performance criteria.

The combined cost of LLW Option 2 and HLW Option 3 would be \$24.0 million. This includes \$8.3 million of LLW Option 2, \$8.9 million for the additional HLW Option 3 upgrades, and \$6.8 million for the jumper manifold system. Of the total cost, \$16.2 million of this scope was included in the Project W-314 scope (WHC 1996b). This would leave a total project cost of \$7.8 million for the PIP (see Table 1-4).

The combined cost of LLW Option 4 and HLW Option 3 would be \$24.0 million. This includes \$11.4 million of LLW Option 4, \$5.8 million for the additional HLW Option 3 upgrades, and \$6.8 million for the jumper manifold system. Of the total cost, \$16.2 million of this scope was included in the Project W-314 scope (WHC 1996b). This would leave a total project cost of \$7.8 million for the PIP (see Table 1-4).

Since the combined cost of the options that meet the hydraulic performance requirements are no different, LLW Option 4 and HLW Option 3 are the recommended options. If the decision makers want to operate the LLW and/or HLW transfer systems at a reduced hydraulic performance, the results of the nodal analysis in the revised waste staging plan can be used to show the cost versus performance trade-offs of the options based on scheduling and sequencing requirements.

Based on hydraulic performance calculations performed for this study it has been concluded that the system will also support return of separated waste (^{90}Sr /TRU/entrained solids) from the vendor(s). The interface point of connect by the vendor(s) will be the vendor(s) LLW waste feed staging (241-AP-106 and 241-AP-108) tank. This connection will provide access to the existing 200 East Area waste transfer system.

This page intentionally left blank.

6.0 REFERENCES

- ASME B31.3, 1993 Edition, *Chemical Plant and Petroleum Refinery Piping*, American Society of Mechanical Engineers.
- Brantley, W. M., 1996, *Functional Design Criteria for Project W-058, Replacement of the Cross-Site Transfer System*, WHC-SD-W058-FDC-001, Rev. 4, Westinghouse Hanford Company, Richland, Washington.
- Certa, P. J., 1996, *Preliminary Low-Level Waste Feed Staging Plan*, WHC-SD-WM-RPT-210, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- Certa, P. J., to be released, *Low-Level Waste Feed Staging Plan*, WHC-SD-WM-RPT-224, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- DOE, 1988, *Radioactive Waste Management*, DOE Order 5820.2A, U.S. Department of Energy, Washington, D.C.
- DOE, 1989, *General Design Criteria*, DOE Order 6430.1A, U.S. Department of Energy, Washington, D.C.
- DOE, 1995, *1995, TWRS Privatization Requests for Proposals - Draft*, Solicitation Number DE-RP06-96RL13308, U.S. Department of Energy, Richland Operations, Richland, Washington.
- Fowler, K. D., 1995, *Tank Farm Waste Transfer Compatibility Program*, WHC-SD-WM-OCD-015, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
- Manuel, A. F., 1996, *Phase I High-Level Waste Pretreatment and Feed Staging Plan*, WHC-SD-WM-ES-370, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
- WAC 173-303-640, 1990, "Dangerous Waste Regulations, Tank Systems," *Washington Administrative Code*, as amended.
- WHC, 1992, *Safety Classification of Structures, Systems, and Components*, WHC-CM-4-46,
- WHC, 1993, *Design Loads for New Underground DSTs and Associated Underground Process Piping*, WHC-SD-GN-DGS-30008, Westinghouse Hanford Company, Richland, Washington.

WHC, 1994, *Radiological Design Guide*, WHC-SD-GN-DGS-30011, Westinghouse Hanford Company, Richland, Washington.

WHC, 1995a, *AW Jumper Manifold Upgrade, Project W-454 Conceptual Design Letter Report*, WHC-SD-W454-CDLR-001, Rev. 0 Draft, Westinghouse Hanford Company, Richland, Washington.

WHC, 1995b, *WHC Occupational ALARA Program*, WHC-IP-1043, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996a, *Tank Waste Remediation System Functions and Requirements Document*, WHC-SD-WM-FRD-020, Rev. A Draft, Westinghouse Hanford Company, Richland, Washington.

WHC, 1996b, *Tank Farm Restoration and Safe Operations, Project W-314 Conceptual Design Report*, WHC-SD-W314-CDR-001, Rev. 0 Draft, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

CALCULATIONS

This page intentionally left blank.

ICF Kaiser Hanford	CALCULATION IDENTIFICATION AND INDEX	Page 1 of 1
		Date 5/9/96

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline Piping, 27 WO/Job No. E44810 Calculation No. E44810-2701

Project No. & Name Phase I Privatization Transfer System Needs

Calculation Item Head Loss Calculation for HLW Feed from 241-AY Tanks (Alternative 1)

These calculations apply to:

Dwg. No. Rev. No.

Dwg. No. Rev. No.

Other (Study, CDR) Rev. No.

The status of these calculations is:

☐ Preliminary Calculations

☒ Final Calculations

☐ Check Calculations (On Calculation Dated)

☐ Void Calculation (Reason Voided)

Incorporated in Final Drawings? ☐ Yes ☐ No

This calculation verified by independent "check" calculations? ☐ Yes ☐ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	<i>J. H. S. / 5-9-96</i>		
Checked by	<i>J. H. S. / 5-9-96</i>		
Approved by			
Checked Against Approved Vendor Data			

INDEX	
Design Analysis Page No.	Description
1	1.0 Objective
1	2.0 Design Inputs: Given Data, Assumptions, References, Method
1	3.0 Conclusion
2-7	4.0 AY-Farm HLW Transfer Head Losses
-	Attachment A - Transfer Lines

ICF Kaiser Hanford

Calc. No. E44810-2701

Revision 0

Page No. 1 of 7

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/8/96

By: T.B. Salzano

Feed from 241-AY Tanks (Alternative 1)

Checked: 5/22/96

By: T.B. Salzano

Location: 200 East

Revised:

By:

1.0 OBJECTIVE

Determine the pump head requirements to transfer high-level waste (HLW) from the 241-AY-102 Tank to the 241-AZ-101 Tank. This analysis is in support of the Alternative Generation Analysis for the Phase I Transfer System Needs, WHC-SD-WM-TI-750 and corresponds to HLW Alternative 1 for the 241-AY Tank Farm.

2.0 DESIGN INPUTS

2.1 Given Data Absolute Viscosity: 10 cp Specific Gravity: 1.5 (Ref. 2)

Pipe Selection: 2" Schedule 40

Inside Diameter: ID = 2.067

2.2 Assumptions

1. The sending and receiving tanks are at atmospheric pressure.
2. The head loss (including elevation and line loss) from the centerline of the discharge pump to the nozzle of the first transfer line is 50 feet.
3. Purex Connectors were assumed to have losses equal to a 90° miter bend.
4. Pipeline friction factors are based on clean commercial steel pipe.
5. The pit head losses for the AX valve pits and the AZ pump pit are based on 10 feet of pipe, four 90° LR elbows, two three-way ball valves, and four Purex Connectors. The two AY process pits are assumed to have 10 ft jumpers with two 90° LR elbows, one three-way ball valve, and two Purex Connectors.

2.3 References

1. Galbraith, J.D., March 4, 1996, *Letter of Instruction for FY1996 Transfer System Needs for Low-Level Waste and High-Level Waste Staging - Phase I Privatization*, Internal Memo 73520-96-011, Westinghouse Hanford Company, Richland, Washington.
2. Koberg, J.T., March 5, 1996, *Statement of Work for Phase I Privatization Transfer System Needs*, Interoffice Memo W-314-005, ICF Kaiser Hanford Company, Richland, Washington.
3. Manuel, A.F., February 5, 1996, *Phase I High-Level Waste Pretreatment and Feed Staging Plan*, WHC-SD-WM-ES-370, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
4. Fowler, K.D., April 24, 1995, *Tank Farm Waste Compatibility Program*, WHC-SD-WM-OCD-015, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
5. "Flow of Fluids Through Valves, Fittings, and Pipe", Crane, Technical Paper No. 410, 1991. Fitting Resistance Coefficients, K: "K" factor table, Page A-26 to A-29
Friction factors: Fittings, f_f , Page A-26; Pipe, f_{pipe} , Page A-25

2.4 Method

The method used for the determination of the pressure loss in the piping system is based upon the Darcy-Weisbach formula. Pressure losses in fittings are determined using experimental resistance coefficients (K) along with friction factors. The losses of all the fittings, valves, and pipe are totaled and using the Bernoulli Theorem, the pressure loss of the system can be determined. The computer program Mathcad, Version 4.0, is used.

3.0 CONCLUSION

See Body of Calculation

ICF Kaiser Hanford

Calc. No. E44810-2701

DESIGN ANALYSIS

Revision 0

Page No. 2 of 7

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/8/96

Feed from 241-AY Tanks (Alternative 1)

Checked: *5/12/96*

Location: 200 East

Revised:

By: T.B. Salzano

By: *not*

By:

4.0 AY-FARM HLW TRANSFER HEAD LOSSES

The head loss for transfers from the 241-AY-102 Tank will be calculated. The analysis will be based on a flow rate of 90 gpm to maintain a minimum Reynolds Number of 20,000 (Ref. 4).

4.1 Constant Data

Volumetric Flow Rate, $Q_{90} = 90 \cdot \frac{\text{gal}}{\text{min}}$

$$q = \frac{Q_{90} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}} \quad q = 0.20 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Pipe Diameter,

2 inch pipe $d_{2in} = 2.067 \cdot \text{in}$

$$D_{2in} = \frac{d_{2in}}{12 \cdot \frac{\text{in}}{\text{ft}}} \quad D_{2in} = 0.17 \cdot \text{ft}$$

Area of Flow,

2 inch pipe $A_{2in} = \frac{\pi D_{2in}^2}{4}$

$$A_{2in} = 0.02 \cdot \text{ft}^2$$

Velocity of Flow,

2 inch pipe $v_{2in} = \frac{q}{A_{2in}}$

$$v_{2in} = 8.6 \cdot \frac{\text{ft}}{\text{sec}}$$

Density of Liquid, $\text{SpG} = 1.5$ (Ref. 2)

$$\rho = \text{SpG} \cdot 62.371 \cdot \frac{\text{lb}}{\text{ft}^3} \quad \rho = 93.6 \cdot \frac{\text{lb}}{\text{ft}^3}$$

(62.371 lb/cu. ft is the density of water at 60°F, Ref. 4, Page A-6)

Absolute Viscosity, $\mu = 10 \cdot \text{cp}$ (Ref. 2)

$$\mu_e = \mu \cdot (6.72 \cdot 10^{-4}) \cdot \frac{\text{ft} \cdot \text{sec}}{\text{cp}} \quad \mu_e = 0.007 \cdot \frac{\text{lb}}{\text{ft} \cdot \text{sec}}$$

Reynolds Number,

2 inch pipe $\text{Re}_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e}$

$$\text{Re}_{2in} = 20635$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe $f_{2in} = 0.028$ $f_{T2in} = 0.019$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2701

Revision 0

Page No. 3 of 7

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 1)

Location: 200 East

WO/Job No. E44810

Date: 5/8/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *NDP*

By:

4.2 PROCESS PIT HEAD LOSSES

The HLW transfer route from 241-AY-102 will pass through six process pits: The 241-AY-02A Pump Pit (PP), the 241-AY-02D Sluice Pit (SP), the 241-AX-B Valve Pit (VP), the 241-AX-A VP, the 241-AZ-02A PP, and the 241-AZ-01A PP (See Attachment A).

4.2.1 AY-Farm Process Pits

The AY-Farm pump pit and sluice pit are assumed to have 2-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain two 90 degree LR elbows, one three-way ball valve, and two Purex Connectors.

10.0 ft - 2" Pipe Length: $L_1 = 10 \text{ ft}$

$$K_1 = f \cdot 2 \text{ in} \cdot \frac{L_1}{D_{2 \text{ in}}} \quad K_1 = 1.6$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f \cdot T_{2 \text{ in}}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f \cdot T_{2 \text{ in}}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f \cdot T_{2 \text{ in}}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit: } h_{\text{ay_pit}} = \frac{v_{2 \text{ in}}^2}{2 \cdot g} \sum_{i=1}^4 K_i$$

$$h_{\text{ay_pit}} = 6.4 \cdot \text{ft}$$

Head Loss for both AY-Farm pits:

$$h_{\text{ay102_pits}} = 2 \cdot h_{\text{ay_pit}}$$

$$h_{\text{ay102_pits}} = 12.8 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2701

Revision 0

Page No. 4 of 7

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 1)

Location: 200 East

WO/Job No. E44810

Date: 5/8/96

Checked: *5/22/96*

Revised:

By: T.B. Salzano

By: *~00*

By:

4.2.2 Remaining Process Pits

The remaining four process pits have jumper manifolds and are assumed to have 2-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain four 90 degree LR elbows, two three-way ball valves, and four Purex Connectors.

10.0 ft - 2" Pipe Length: $L_1 = 10 \text{ ft}$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.6$$

4 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{2in}) \cdot 4 \quad K_2 = 4.6$$

4 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f_{2in}) \cdot 4 \quad K_3 = 1.1$$

2 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{2in}) \cdot 2 \quad K_4 = 2.3$$

Head Loss for each pit:
$$h_{\text{pits}} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pits}} = 11 \cdot \text{ft}$$

Head Loss for four remaining pits:

$$h_{\text{valve_pits}} = 4 \cdot h_{\text{pits}}$$

$$h_{\text{valve_pits}} = 43.9 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2701

Revision 0

Page No. 5 of 7

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 1)

Location: 200 East

WO/Job No. E44810

Date: 5/8/96

Checked: 5/27/96

Revised:

By: T.B. Salzano

By: *WLB*

By:

4.3 TRANSFER LINE HEAD LOSSES

The HLW transfers from the 241-AY-102 will pass through five transfer lines: 2"SL-503, 2"SL-502, 2"SL-110, 2"SL-500, and 2"SL-501 to the 241-AZ-101 Tank (See Attachment A).

4.3.1 2"SL-503 (AY-02A PP to AY-02D SP)11' - 2" Pipe Length: $L_1 = 11\text{-ft}$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.8$$

2 - 36" Radius Bends (r/d=18):

$$K_2 = (46 f_{T2in}) \cdot 2 \quad K_2 = 1.7$$

Elevation at Start of Transfer (pit exit nozzle):

$$z_{start} = 675.0\text{-ft}$$

(See Assumption 2)

Head Loss:

$$h_{sl_503} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sl_503} = 4\text{-ft}$$

4.3.2 2"SL-502 (AY-02D SP to AX-B VP)235' - 2" Pipe Length: $L_1 = 235\text{-ft}$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 38.2$$

5 - 36" Radius Bends (r/d=18):

$$K_2 = (46 f_{T2in}) \cdot 5 \quad K_2 = 4.4$$

1 - Clean-Out Boxes (COB) (assume Tee - thru):

$$K_3 = (20 f_{T2in}) \cdot 1 \quad K_3 = 0.4$$

Head Loss:

$$h_{sl_502} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^3 K_i$$

$$h_{sl_502} = 49\text{-ft}$$

ICF Kaiser Hanford

DESIGN ANALYSIS

Calc. No. E44810-2701

Revision 0

Page No. 6 of 7

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 1)

Location: 200 East

WO/Job No. E44810

Date: 5/8/96

Checked: 5/27/96

Revised:

By: T.B. Salzano

By: *T.B. Salzano*

By:

4.3.3 2"SL-110 (AX-A VP to AX-B VP)

5.5' - 2" Pipe Length: $L_1 = 5.5 \text{ ft}$

$$K_1 = f_{2in} \frac{L_1}{D_{2in}} \quad K_1 = 0.9$$

4 - 36" Radius Bends (r/d=18):

$$K_2 = (46 \cdot f_{T2in}) \cdot 4 \quad K_2 = 3.5$$

Head Loss:

$$h_{sl_110} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sl_110} = 5 \cdot \text{ft}$$

4.3.4 2"SL-500 (AZ-02A PP to AX-A VP)

530' - 2" Pipe Length: $L_1 = 530 \text{ ft}$

$$K_1 = f_{2in} \frac{L_1}{D_{2in}} \quad K_1 = 86.2$$

14 - 36" Radius Bends (r/d=18):

$$K_2 = (46 \cdot f_{T2in}) \cdot 14 \quad K_2 = 12.2$$

5 - Clean-Out Boxes (COB) (assume Tee - thru):

$$K_3 = (20 \cdot f_{T2in}) \cdot 5 \quad K_3 = 1.9$$

Head Loss:

$$h_{sl_500} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^3 K_i$$

$$h_{sl_500} = 115 \cdot \text{ft}$$

4.3.5 2"SL-501 (AZ-01A PP to AZ-02A PP)

140' - 2" Pipe Length: $L_1 = 140 \text{ ft}$

$$K_1 = f_{2in} \frac{L_1}{D_{2in}} \quad K_1 = 22.8$$

4 - 36" Radius Bends (r/d=18):

$$K_2 = (46 \cdot f_{T2in}) \cdot 4 \quad K_2 = 3.5$$

Elevation at End of Transfer:

$$z_{end} = 668.4 \text{ ft}$$

Head Loss:

$$h_{sl_501} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sl_501} = 30 \cdot \text{ft}$$

A-9

ICF Kaiser Hanford

Calc. No. E44810-2701

Revision 0

Page No. 7 of 7

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/8/96

By: T.B. Salzano

Feed from 241-AY Tanks (Alternative 1)

Checked: *5/27/96*By: *~TBS*

Location: 200 East

Revised:

By:

4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 1Process Pit Losses:

$$h_1 := h_{\text{ay102_pits}} + h_{\text{valve_pits}} \quad h_1 = 57 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := h_{\text{sl_503}} + h_{\text{sl_502}} + h_{\text{sl_110}} + h_{\text{sl_500}} + h_{\text{sl_501}}$$

$$h_2 = 204 \cdot \text{ft}$$

Elevation Change (w/ 50 ft suction lift):

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 43.4 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss:

$$i = 1, 2, 3$$

$$\text{TDH}_{90_alt1} := \sum_i h_i \quad \text{TDH}_{90_alt1} = 304 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{90_alt1} := \frac{\text{TDH}_{90_alt1} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{90_alt1} = 198 \cdot \frac{\text{lb}}{\text{in}^2}$$

The lowest design pressure in the system is 375 psi. Therefore, the above operating point is acceptable.

HLW ALTERNATIVE 1 "DO NOTHING"

2" SL-503,504,505

(AY-FARM)

241-AY-01A
PUMP PIT

241-AY-02A
PUMP PIT

NOTE: ALL NOZZLES AT EL 675 UNLESS OTHERWISE NOTED

REFERENCES:

H-2-70764
H-2-64313
H-2-64314
B-131-C1

SUMMARY:

	SL-503	SL-504	SL-505
LENGTH	11 FT	116 FT	18 FT
3'R BENDS	2	4	2

DESIGN:

PRESSURE 400 PSIG
TEMP 200 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *[Signature]* 4/5/96

2" SL-502

241-AX-B
VALVE PIT

REFERENCES:

H-2-69245
H-2-70763
H-2-70764
H-2-70780
B-131-C1

SUMMARY:

LENGTH	234.7 FT
3'R BENDS	5
COBs	1
REDUCERS	1

DESIGN:

PRESSURE	400 PSIG
TEMP	200 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John Nicholas* 4/5/96

2" SL-500

REFERENCES:

H-2-70765
H-2-70763
B-131-C1

SUMMARY:

LENGTH 529.3 FT
3'R BENDS 14
COBs 5

DESIGN:

PRESSURE 400 PSIG
TEMP 340 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John V. Salzano* 4/5/96

2" SL-501
(AZ-FARM)

241-AZ-01A
PUMP PIT

95'

241-AZ-02A
PUMP PIT

REFERENCES:

H-2-70765
H-2-68304
B-131-C1

SUMMARY:

LENGTH 137.8 FT
3'R BENDS 4

DESIGN:

PRESSURE 400 PSIG
TEMP 200 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: Joel Nicholas 4/5/96

ICF Kaiser Hanford	CALCULATION IDENTIFICATION AND INDEX	Page 1 of 1
		Date 5/9/96

This sheet shows the status and description of the attached Design Analysis sheets.

Discipline Piping, 27 WO/Job No. E44810 Calculation No. E44810-2702

Project No. & Name Phase I Privatization Transfer System Needs

Calculation Item Head Loss Calculation for HLW Feed from 241-AY Tanks (Alternative 2)

These calculations apply to:

Dwg. No. Rev. No.

Dwg. No. Rev. No.

Other (Study, CDR) Rev. No.

The status of these calculations is:

☐ Preliminary Calculations

☒ Final Calculations

☐ Check Calculations (On Calculation Dated)

☐ Void Calculation (Reason Voided)

Incorporated in Final Drawings? ☐ Yes ☐ No

This calculation verified by independent "check" calculations? ☐ Yes ☐ No

Original and Revised Calculation Approvals:

	Rev. 0 Signature/Date	Rev. 1 Signature/Date	Rev. 2 Signature/Date
Originator	<i>J. H. Smith</i> / 5-9-96		
Checked by	<i>J. H. Smith</i> / 5-9-96		
Approved by			
Checked Against Approved Vendor Data			

<u>INDEX</u>	
Design Analysis Page No.	Description
1	1.0 Objective
1	2.0 Design Inputs: Given Data, Assumptions, References, Method
1	3.0 Conclusion
2-9	4.0 AY-Farm HLW Transfer Head Losses
10-25	5.0 System Curve Development
26-28	6.0 System Curve
-	Attachment A - Transfer Lines

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 1 of 28

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: *5/29/96*

Revised:

By: T.B. Salzano

By: *WDA*

By:

1.0 OBJECTIVE

Determine the pump head requirements to transfer high-level waste (HLW) from the 241-AY-102 Tank to one of the Phase I Privatization Vendors. This calculation will develop the system curve for transfers from the 241-AY-102 to the vendor including the upgrade of the 2-in. transfer lines. This system corresponds to HLW Alternative 2.

2.0 DESIGN INPUTS

2.1 Given Data	Absolute Viscosity: 10 cp	Specific Gravity: 1.5	(Ref. 2)
	Pipe Selection: 2" Schedule 40	3" Schedule 40	
	Inside Diameter: ID = 2.067	ID = 3.068	

2.2 Assumptions

1. The sending and receiving tanks are at atmospheric pressure.
2. The head loss (including elevation and line loss) from the centerline of the discharge pump to the nozzle of the first transfer line is 50 feet.
3. Purex Connectors were assumed to have losses equal to a 90° miter bend.
4. Pipeline friction factors are based on clean commercial steel pipe.
5. The pit head losses are based on 10 feet of pipe, four 90° LR elbows, two three-way ball valves, and four Purex Connectors. The two AY process pits are assumed to have 10 ft jumpers with two 90° LR elbows, one three-way ball valve, and two Purex Connectors.
6. The ending elevation of the system at the vendor(s) facility is 670.0 feet (Ref. 3).

2.3 References

1. Galbraith, J.D., March 4, 1996, *Letter of Instruction for FY1996 Transfer System Needs for Low-Level Waste and High-Level Waste Staging - Phase I Privatization*, Internal Memo 73520-96-011, Westinghouse Hanford Company, Richland, Washington.
2. Koberg, J.T., March 5, 1996, *Statement of Work for Phase I Privatization Transfer System Needs*, Interoffice Memo W-314-005, ICF Kaiser Hanford Company, Richland, Washington.
3. Manuel, A.F., February 5, 1996, *Phase I High-Level Waste Pretreatment and Feed Staging Plan*, WHC-SD-WM-ES-370, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
4. Fowler, K.D., April 24, 1995, *Tank Farm Waste Compatibility Program*, WHC-SD-WM-OCD-015, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
5. "Flow of Fluids Through Valves, Fittings, and Pipe", Crane, Technical Paper No. 410, 1991. Fitting Resistance Coefficients, K: "K" factor table, Page A-26 to A-29
Friction factors: Fittings, f_T , Page A-26; Pipe, f_{pipe} , Page A-25

2.4 Method

The method used for the determination of the pressure loss in the piping system is based upon the Darcy-Weisbach formula. Pressure losses in fittings are determined using experimental resistance coefficients (K) along with friction factors. The losses of all the fittings, valves, and pipe are totaled and using the Bernoulli Theorem, the pressure loss of the system can be determined. The computer program Mathcad, Version 4.0, is used.

3.0 CONCLUSION

See Body of Calculation

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 2 of 28

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/23/96

Location: 200 East

Revised:

By: T.B. Salzano

By: NDA

By:

4.0 AY-FARM HLW TRANSFER HEAD LOSSES

The head losses for transfers from the 241-AY-102 Tank will be calculated. The first analysis will be based on a flow rate of 140 gpm to maintain a minimum Reynolds number of 20,000 (Ref. 4).

4.1 Constant Data

Volumetric Flow Rate,

$$Q_{140} = 140 \frac{\text{gal}}{\text{min}}$$

$$q = \frac{Q_{140} \cdot 0.13368 \frac{\text{ft}^3}{\text{gal}}}{60 \frac{\text{sec}}{\text{min}}} \quad q = 0.31 \frac{\text{ft}^3}{\text{sec}}$$

Pipe Diameter,

2 inch pipe

$$d_{2in} = 2.067 \text{ in}$$

$$D_{2in} = \frac{d_{2in}}{12 \frac{\text{in}}{\text{ft}}}$$

$$D_{2in} = 0.17 \text{ ft}$$

3 inch pipe

$$d_{3in} = 3.068 \text{ in}$$

$$D_{3in} = \frac{d_{3in}}{12 \frac{\text{in}}{\text{ft}}}$$

$$D_{3in} = 0.26 \text{ ft}$$

Area of Flow,

2 inch pipe

$$A_{2in} = \frac{\pi D_{2in}^2}{4}$$

$$A_{2in} = 0.02 \text{ ft}^2$$

3 inch pipe

$$A_{3in} = \frac{\pi D_{3in}^2}{4}$$

$$A_{3in} = 0.05 \text{ ft}^2$$

Velocity of Flow,

2 inch pipe

$$v_{2in} = \frac{q}{A_{2in}}$$

$$v_{2in} = 13.4 \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3in} = \frac{q}{A_{3in}}$$

$$v_{3in} = 6.1 \frac{\text{ft}}{\text{sec}}$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 3 of 28

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/27/96

Revised:

By: T.B. Salzano

By: NDA

By:

Density of Liquid,

$$\text{SpG} := 1.5$$

(Ref. 2)

$$\rho = \text{SpG} \cdot 62.371 \cdot \frac{\text{lb}}{\text{ft}^3} \quad \rho = 93.6 \cdot \frac{\text{lb}}{\text{ft}^3}$$

(62.371 lb/cu. ft is the density of water at 60°F, Ref. 4, Page A-6)

Absolute Viscosity,

$$\mu := 10 \text{ cp}$$

(Ref. 2)

$$\mu_e = \mu \cdot (6.72 \cdot 10^{-4}) \cdot \frac{\text{lb}}{\text{ft} \cdot \text{sec}} \quad \mu_e = 0.007 \cdot \frac{\text{lb}}{\text{ft} \cdot \text{sec}}$$

Reynolds Number,

$$\text{2 inch pipe} \quad \text{Re}_{2\text{in}} := \frac{D_{2\text{in}} \cdot v_{2\text{in}} \cdot \rho}{\mu_e} \quad \text{Re}_{2\text{in}} = 32100$$

$$\text{3 inch pipe} \quad \text{Re}_{3\text{in}} := \frac{D_{3\text{in}} \cdot v_{3\text{in}} \cdot \rho}{\mu_e} \quad \text{Re}_{3\text{in}} = 21626$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

$$\text{2 inch pipe} \quad f_{2\text{in}} := 0.026$$

$$f_{T2\text{in}} := 0.019$$

$$\text{3 inch pipe} \quad f_{3\text{in}} := 0.027$$

$$f_{T3\text{in}} := 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 4 of 28

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

By: T.B. Salzano

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/29/96

By: WDA

Location: 200 East

Revised:

By:

4.2 PROCESS PIT HEAD LOSSES

The HLW Alternative 2 transfer route from 241-AY-102 will pass through nine process pits: The 241-AY-02A Pump Pit (PP), the 241-AY-02D Sluice Pit (SP), the 241-AX-B Valve Pit (VP), the 241-AX-A VP, the 241-A-A VP, the 241-AW-A VP, the 241-AW-02A PP, the 241-AP VP, and the 241-AP-08A PP.

4.2.1 AY-Farm Process Pits

The AY-Farm pump pit and sluic pit are assumed to have 2-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain two 90 degree LR elbows, one three-way ball valve, and two Purex Connectors.

10.0 ft - 2" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.5$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f_{2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{2in}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit: } h_{\text{pit}_2in} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_2in} = 15.2 \cdot \text{ft}$$

Head Loss for both AY-Farm pits:

$$h_{\text{ay_pits}} = 2 \cdot h_{\text{pit}_2in}$$

$$h_{\text{ay_pits}} = 30.4 \cdot \text{ft}$$

ICF Kaiser Hanford

DESIGN ANALYSIS

Calc. No. E44810-2702

Revision 0

Page No. 5 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/27/96

Revised:

By: T.B. Salzano

By: NDA

By:

4.2.2 Remaining Process Pits

The remaining seven process pits are assumed to have 3-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain four 90 degree elbows, two three-way ball valves, and four Purex Connectors.

10.0 ft - 3" Pipe Length: $L_1 := 10\text{-ft}$

$$K_1 := f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.1$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 := (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 := (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 := (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

Head Loss for each pit: $h_{\text{pit}_3in} := \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$

$$h_{\text{pit}_3in} = 4.9 \cdot \text{ft}$$

Head Loss for all seven remaining pits:

$$h_{\text{valve_pits}} := 7 \cdot h_{\text{pit}_3in}$$

$$h_{\text{valve_pits}} = 34.3 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 6 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *~DA*

By:

4.3 TRANSFER LINE HEAD LOSSES

The HLW transfers from the 241-AY-102 will pass through nine transfer lines: 2"SL-503, new 3"SL-502, 3"SN-210, 3"SN-201/214, 3"SN-220, 3"SN-267, 3"SN-610, 3"SN-618, and a new 3" SN line to the Phase 1 vendor (See Attachment A).

4.3.1 2"SL-503 (AY-02A PP to AY-02D SP)11' - 2" Pipe Length:

$$L_1 = 11 \text{ ft}$$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.7$$

2 - 36" Radius Bends (r/d=18):

$$K_2 = (46 f_{12in}) \cdot 2 \quad K_2 = 1.7$$

Elevation at Start of Transfer (pit exit nozzle):

$$z_{start} = 675.0 \text{ ft}$$

(See Assumption 2)

Head Loss:

$$h_{sl_503} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sl_503} = 9 \text{ ft}$$

4.3.2 NEW 3"SL-502 (AY-02D SP to AX-B VP)235' - 3" Pipe Length:

$$L_1 = 235 \text{ ft}$$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 24.8$$

5 - 36" Radius Bends (r/d=12):

$$K_2 = (34 f_{12in}) \cdot 5 \quad K_2 = 3.1$$

Head Loss:

$$h_{new_sl_502} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{new_sl_502} = 16 \text{ ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 7 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *not*

By:

4.3.3 3"SN-210 (AX-B VP to AX-A VP)6' - 3" Pipe Length:

$$L_1 = 6 \text{ ft}$$

$$K_1 = f_{3in} \frac{L_1}{D_{3in}}$$

$$K_1 = 0.6$$

4 - 36" Radius Bends (r/d=12):

$$K_2 = (34 f_{T3in}) \cdot 4$$

$$K_2 = 2.4$$

Head Loss:

$$h_{sn_210} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_210} = 2 \cdot \text{ft}$$

4.3.4 3" SN-201/214 (AX-A VP to A-A VP)650' - 3" Pipe Length:

$$L_1 = 650 \cdot \text{ft}$$

$$K_1 = f_{3in} \frac{L_1}{D_{3in}}$$

$$K_1 = 68.6$$

17 - 36" Radius Bends (r/d=12):

$$K_2 = (34 f_{T3in}) \cdot 17$$

$$K_2 = 10.4$$

Head Loss:

$$h_{sn_201_214} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_201_214} = 45 \cdot \text{ft}$$

4.3.5 3" SN-220 (A-A VP to AW-A VP)577' - 3" Pipe Length:

$$L_1 = 577 \cdot \text{ft}$$

$$K_1 = f_{3in} \frac{L_1}{D_{3in}}$$

$$K_1 = 60.9$$

12 - 36" Radius Bends (r/d=12):

$$K_2 = (34 f_{T3in}) \cdot 12$$

$$K_2 = 7.3$$

Head Loss:

$$h_{sn_220} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_220} = 39 \cdot \text{ft}$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 8 of 28

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/21/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *NDH*

By:

4.3.6 3" SN-267 (AW-A VP to AW-02A PP)106' - 3" Pipe Length: $L_1 = 106\text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 11.2$$

5 - 36" Radius Bends (r/d=12):

$$K_2 = (34 \cdot f_{T3in}) \cdot 5 \quad K_2 = 3.1$$

Head Loss:

$$h_{sn_267} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_267} = 8 \cdot \text{ft}$$

4.3.7 3" SN-610 (AW-02A PP to AP VP)750' - 3" Pipe Length: $L_1 = 750\text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 79.2$$

17 - 36" Radius Bends (r/d=12):

$$K_2 = (34 \cdot f_{T3in}) \cdot 17 \quad K_2 = 10.4$$

Head Loss:

$$h_{sn_610} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_610} = 51 \cdot \text{ft}$$

4.3.8 3" SN-618 (AP VP to AP-08A PP)425' - 3" Pipe Length: $L_1 = 425\text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 44.9$$

8 - 36" Radius Bends (r/d=12):

$$K_2 = (34 \cdot f_{T3in}) \cdot 8 \quad K_2 = 4.9$$

Head Loss:

$$h_{sn_618} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_618} = 29 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 9 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/14/96

Revised:

By: T.B. Salzano

By: NDA

By:

4.3.9 NEW 3" SN LINE (AP-08A PP to VENDOR)

The length and number of bends for this new line are from the analysis done in support of the Feed Staging Plan (Ref. 2).

2820' - 3" Pipe Length: $L_1 = 2820 \text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 297.8$$

50 - 36" Radius Bends (r/d=12):

$$K_2 = (34 f_{13in}) \cdot 50 \quad K_2 = 30.6$$

Elevation at End of Transfer:

$$z_{\text{end}} = 670.0 \text{ ft}$$

(Assumption 5)

Head Loss:

$$h_{\text{sn_vendor}} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{\text{sn_vendor}} = 188 \text{ ft}$$

4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2Process Pit Losses:

$$h_1 = h_{\text{ay_pits}} + h_{\text{valve_pits}} \quad h_1 = 65 \text{ ft}$$

Transfer Path Losses:

$$h_2 = h_{\text{sl_503}} + h_{\text{new_sl_502}} + h_{\text{sn_210}} + h_{\text{sn_201_214}} + h_{\text{sn_220}} + h_{\text{sn_267}} + h_{\text{sn_610}} + h_{\text{sn_618}} + h_{\text{sn_vendor}}$$

$$h_2 = 388 \text{ ft}$$

Elevation Change:

$$h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}}$$

$$h_3 = 45 \text{ ft}$$

(Assumption 2)

Total Head Loss:

$$i = 1, 2, 3$$

$$\text{TDH}_{140_alt2} = \sum_i h_i$$

$$\text{TDH}_{140_alt2} = 498 \text{ ft}$$

Pressure Drop:

$$\Delta P_{140_alt2} = \frac{\text{TDH}_{140_alt2} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}}$$

$$\Delta P_{140_alt2} = 324 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 10 of 28

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

By: T.B. Salzano

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/29/96

By: *NDA*

Location: 200 East

Revised:

By:

5.0 SYSTEM CURVE DEVELOPMENT

A system-head curve is a graphical representation of the relationship between flow and hydraulic losses in a given piping system. The system curve can be used with a pump characteristic curve to develop the operating point of the system. For this system, the friction losses at flow rates of 140 (previously calculated), 120, 100, 80, and 60 gpm will be used to develop the system-head curve.

5.1 120 GPM: 241-AY**5.1.1 Constant Data**

Volumetric Flow Rate,

$$Q_{120} = 120 \frac{\text{gal}}{\text{min}}$$

$$q = \frac{Q_{120} \cdot 0.13368 \frac{\text{ft}^3}{\text{gal}}}{60 \frac{\text{sec}}{\text{min}}} \quad q = 0.27 \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

2 inch pipe

$$v_{2in} = \frac{q}{A_{2in}}$$

$$v_{2in} = 11.5 \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3in} = \frac{q}{A_{3in}}$$

$$v_{3in} = 5.2 \frac{\text{ft}}{\text{sec}}$$

Reynolds Number,

2 inch pipe

$$Re_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e}$$

$$Re_{2in} = 27514$$

3 inch pipe

$$Re_{3in} = \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e}$$

$$Re_{3in} = 18537$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe

$$f_{2in} = 0.026$$

$$f_{T2in} = 0.019$$

3 inch pipe

$$f_{3in} = 0.0275$$

$$f_{T3in} = 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 11 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: *5/24/96*

Revised:

By: T.B. Salzano

By: *MDA*

By:

5.1.2.1 AY-Farm Process Pits10.0 ft - 2" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{2in} \frac{L_1}{D_{2in}} \quad K_1 = 1.5$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 f_{T2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 f_{T2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 f_{T2in}) \cdot 1 \quad K_4 = 1.1$$

Head Loss for each pit:
$$h_{\text{pit_2in}} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit_2in}} = 11.2 \cdot \text{ft}$$

Head Loss for both AY-Farm pits:

$$h_{\text{ay_pits}} = 2 \cdot h_{\text{pit_2in}}$$

$$h_{\text{ay_pits}} = 22.3 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 12 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *NSA*

By:

5.1.2.2 Remaining Process Pits10.0 ft - 3" Pipe Length: $L_1 = 10\text{ ft}$

$$K_1 = f_{3in} \frac{L_1}{D_{3in}} \quad K_1 = 1.1$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pit}_3in} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_3in} = 3.6 \cdot \text{ft}$$

Head Loss for all seven remaining pits:

$$h_{\text{valve}_pits} = 7 \cdot h_{\text{pit}_3in}$$

$$h_{\text{valve}_pits} = 25.3 \cdot \text{ft}$$

5.1.3 TRANSFER LINE HEAD LOSSES2" Pipe Length:

$$L_{2in} = 11 \cdot \text{ft}$$

$$K_1 = f_{2in} \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.7$$

2" Pipe - 36" Radius Bends (r/d=18):

$$N_{2in_bends} = 2$$

$$K_2 = (46 f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 1.7$$

ICF Kaiser Hanford

Calc. No. E44810-2702

DESIGN ANALYSIS

Revision 0

Page No. 13 of 28

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/22/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *MSA*

By:

3" Pipe Length:

$$L_{3in} := 235 \cdot \text{ft} + 6 \cdot \text{ft} + 650 \cdot \text{ft} + 577 \cdot \text{ft} + 106 \cdot \text{ft} + 750 \cdot \text{ft} + 425 \cdot \text{ft} + 2820 \cdot \text{ft}$$

$$K_3 := f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_3 = 599$$

3" Pipe - 36" Radius Bends (r/d=12):

$$N_{3in_bends} := 5 + 4 + 17 + 12 + 5 + 17 + 8 + 50$$

$$K_4 := (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_4 = 72.2$$

5.1.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2Process Pit Losses:

$$h_1 := h_{ay_pits} + h_{valve_pits} \quad h_1 = 48 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{2in}^2}{2 \cdot g} \sum_{i=1}^2 K_i + \frac{v_{3in}^2}{2 \cdot g} \sum_{i=3}^4 K_i \quad h_2 = 290 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{end} - z_{start} \quad h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$TDH_{120_alt2} := \sum_i h_i \quad TDH_{120_alt2} = 382 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{120_alt2} := \frac{TDH_{120_alt2} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{120_alt2} = 249 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 14 of 28

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/24/96

By: T.B. Salzano

Location: 200 East

Revised:

By: *vda***5.2 100 GPM: 241-AY****5.2.1 Constant Data**

Volumetric Flow Rate,

$$Q_{100} = 100 \cdot \frac{\text{gal}}{\text{min}}$$

$$Q_{100} = 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}$$

$$q = \frac{60 \cdot \frac{\text{sec}}{\text{min}}}{60} \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$q = 0.22 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

2 inch pipe

$$v_{2in} = \frac{q}{A_{2in}}$$

$$v_{2in} = 9.6 \cdot \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3in} = \frac{q}{A_{3in}}$$

$$v_{3in} = 4.3 \cdot \frac{\text{ft}}{\text{sec}}$$

Reynolds Number,

2 inch pipe

$$Re_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e}$$

$$Re_{2in} = 22928$$

3 inch pipe

$$Re_{3in} = \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e}$$

$$Re_{3in} = 15447$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe

$$f_{2in} = 0.027$$

$$f_{T2in} = 0.019$$

3 inch pipe

$$f_{3in} = 0.029$$

$$f_{T3in} = 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 15 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *TBS*

By:

5.2.2 PROCESS PIT HEAD LOSSES**5.2.2.1 AY-Farm Process Pits**10.0 ft - 2" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 := f_{2in} \frac{L_1}{D_{2in}} \quad K_1 = 1.6$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 := (60 f_{T2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 := (14 f_{T2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 := (60 f_{T2in}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit: } h_{\text{pit_2in}} := \frac{v_{2in}^2}{2 \cdot g} \sum_{i=1}^4 K_i$$

$$h_{\text{pit_2in}} = 7.8 \cdot \text{ft}$$

Head Loss for both AY-Farm pits:

$$h_{\text{ay_pits}} := 2 \cdot h_{\text{pit_2in}}$$

$$h_{\text{ay_pits}} = 15.7 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 16 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: *SP/9/96*

Revised:

By: T.B. Salzano

By: *NDP*

By:

5.2.2.2 Remaining Process Pits10.0 ft - 3" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.1$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pit}_3in} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_3in} = 2.5 \cdot \text{ft}$$

Head Loss for all seven remaining pits:

$$h_{\text{valve}_pits} = 7 \cdot h_{\text{pit}_3in}$$

$$h_{\text{valve}_pits} = 17.7 \cdot \text{ft}$$

5.2.3 TRANSFER LINE HEAD LOSSES2" Pipe Length:

$$L_{2in} = 11 \cdot \text{ft}$$

$$K_1 = f_{2in} \cdot \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.7$$

2" Pipe - 36" Radius Bends (r/d=18):

$$N_{2in_bends} = 2$$

$$K_2 = (46 \cdot f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 1.7$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 17 of 28

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

Feed from 241-AY Tanks (Alternative 2)

Checked: *5/29/96*

By: T.B. Salzano

Location: 200 East

Revised:

By: *NDH*

By:

3" Pipe Length:

$$L_{3in} := 235 \cdot \text{ft} + 6 \cdot \text{ft} + 650 \cdot \text{ft} + 577 \cdot \text{ft} + 106 \cdot \text{ft} + 750 \cdot \text{ft} + 425 \cdot \text{ft} + 2820 \cdot \text{ft}$$

$$K_3 := f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_3 = 631.7$$

3" Pipe - 36" Radius Bends (r/d=12):

$$N_{3in_bends} := 5 + 4 + 17 + 12 + 5 + 17 + 8 + 50$$

$$K_4 := (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_4 = 72.2$$

5.2.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2**Process Pit Losses:**

$$h_1 := h_{ay_pits} + h_{valve_pits} \quad h_1 = 33 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i + \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=3}^4 K_i \quad h_2 = 211 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{end} - z_{start} \quad h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, \dots, 3$

$$TDH_{100_alt2} := \sum_i h_i \quad TDH_{100_alt2} = 289 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{100_alt2} = \frac{TDH_{100_alt2} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{100_alt2} = 188 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 18 of 28

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: *5/29/96*

Revised:

By: T.B. Salzano

By: *WDA*

By:

5.3 80 GPM: 241-AY**5.3.1 Constant Data**

Volumetric Flow Rate,

$$Q_{80} := 80 \cdot \frac{\text{gal}}{\text{min}}$$

$$q := \frac{Q_{80} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q = 0.18 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

2 inch pipe

$$v_{2in} := \frac{q}{A_{2in}}$$

$$v_{2in} = 7.6 \cdot \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3in} := \frac{q}{A_{3in}}$$

$$v_{3in} = 3.5 \cdot \frac{\text{ft}}{\text{sec}}$$

Reynolds Number,

2 inch pipe

$$Re_{2in} := \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e}$$

$$Re_{2in} = 18343$$

3 inch pipe

$$Re_{3in} := \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e}$$

$$Re_{3in} = 12358$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe

$$f_{2in} := 0.028$$

$$f_{T2in} := 0.019$$

3 inch pipe

$$f_{3in} := 0.03$$

$$f_{T3in} := 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 19 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *NDT*

By:

5.3.2 PROCESS PIT HEAD LOSSES**5.3.2.1 AY-Farm Process Pits**10.0 ft - 2" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.6$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (50 \cdot f_{T2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (50 \cdot f_{T2in}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit: } h_{\text{pit_2in}} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit_2in}} = 5.1 \cdot \text{ft}$$

Head Loss for both AY-Farm pits:

$$h_{\text{ay_pits}} = 2 \cdot h_{\text{pit_2in}}$$

$$h_{\text{ay_pits}} = 10.1 \cdot \text{ft}$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 20 of 28

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *NOA*

By:

5.3.2.2 Remaining Process Pits10.0 ft - 3" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{3in} \frac{L_1}{D_{3in}} \quad K_1 = 1.2$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pit}_3in} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_3in} = 1.6 \cdot \text{ft}$$

Head Loss for all seven remaining pits:

$$h_{\text{valve}_pits} = 7 \cdot h_{\text{pit}_3in}$$

$$h_{\text{valve}_pits} = 11.4 \cdot \text{ft}$$

5.3.3 TRANSFER LINE HEAD LOSSES2" Pipe Length:

$$L_{2in} = 11\text{-ft}$$

$$K_1 = f_{2in} \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.8$$

2" Pipe - 36" Radius Bends (r/d=18):

$$N_{2in_bends} = 2$$

$$K_2 = (46 f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 1.7$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 21 of 28

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: *5/27/96*

Revised:

By: T.B. Salzano

By: *NDA*

By:

3" Pipe Length:

$$L_{3in} := 235 \cdot \text{ft} + 6 \cdot \text{ft} + 650 \cdot \text{ft} + 577 \cdot \text{ft} + 106 \cdot \text{ft} + 750 \cdot \text{ft} + 425 \cdot \text{ft} + 2820 \cdot \text{ft}$$

$$K_3 := f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_3 = 653.5$$

3" Pipe - 36" Radius Bends (r/d=12):

$$N_{3in_bends} := 5 + 4 + 17 + 12 + 5 + 17 + 8 + 50$$

$$K_4 := (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_4 = 72.2$$

5.3.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2**Process Pit Losses:**

$$h_1 := h_{ay_pits} + h_{valve_pits} \quad h_1 = 21 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i + \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=3}^4 K_i \quad h_2 = 139 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{end} - z_{start} \quad h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$TDH_{80_alt2} := \sum_i h_i \quad TDH_{80_alt2} = 206 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{80_alt2} := \frac{TDH_{80_alt2} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{80_alt2} = 134 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 22 of 28

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/29/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *NDA*

By:

5.4 60 GPM: 241-AY**5.4.1 Constant Data**

Volumetric Flow Rate, $Q_{60} := 60 \cdot \frac{\text{gal}}{\text{min}}$

$$Q_{60} = 0.13368 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$q := \frac{Q_{60} \cdot \frac{\text{sec}}{\text{min}}}{60} = 0.13 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

2 inch pipe $v_{2in} := \frac{q}{A_{2in}}$ $v_{2in} = 5.7 \cdot \frac{\text{ft}}{\text{sec}}$

3 inch pipe $v_{3in} := \frac{q}{A_{3in}}$ $v_{3in} = 2.6 \cdot \frac{\text{ft}}{\text{sec}}$

Reynolds Number,

2 inch pipe $Re_{2in} := \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e}$ $Re_{2in} = 13757$

3 inch pipe $Re_{3in} := \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e}$ $Re_{3in} = 9268$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe $f_{2in} := 0.03$ $f_{T2in} := 0.019$

3 inch pipe $f_{3in} := 0.032$ $f_{T3in} := 0.018$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 23 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: *5/24/96*

Revised:

By: T.B. Salzano

By: *ndt*

By:

5.4.2 PROCESS PIT HEAD LOSSES**5.4.2.1 AY-Farm Process Pits**10.0 ft - 2" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{2in} \frac{L_1}{D_{2in}} \quad K_1 = 1.7$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T2in}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit: } h_{\text{pit_2in}} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit_2in}} = 2.9 \cdot \text{ft}$$

Head Loss for both AY-Farm pits:

$$h_{\text{ay_pits}} = 2 \cdot h_{\text{pit_2in}}$$

$$h_{\text{ay_pits}} = 5.8 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2702

Revision 0

Page No. 24 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/24/96

Revised:

By: T.B. Salzano

By: NDA

By:

5.4.2.2 Remaining Process Pits10.0 ft - 3" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.3$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pit}_3in} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_3in} = 0.9 \cdot \text{ft}$$

Head Loss for all seven remaining pits:

$$h_{\text{valve}_pits} = 7 \cdot h_{\text{pit}_3in}$$

$$h_{\text{valve}_pits} = 6.4 \cdot \text{ft}$$

5.4.3 TRANSFER LINE HEAD LOSSES2" Pipe Length:

$$L_{2in} = 11 \cdot \text{ft}$$

$$K_1 = f_{2in} \cdot \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.9$$

2" Pipe - 36" Radius Bends (r/d=18):

$$N_{2in_bends} = 2$$

$$K_2 = (46 \cdot f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 1.7$$

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 25 of 28

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *NDA*

By:

3" Pipe Length:

$$L_{3in} := 235 \cdot \text{ft} + 6 \cdot \text{ft} + 650 \cdot \text{ft} + 577 \cdot \text{ft} + 106 \cdot \text{ft} + 750 \cdot \text{ft} + 425 \cdot \text{ft} + 2820 \cdot \text{ft}$$

$$K_3 := f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_3 = 697$$

3" Pipe - 36" Radius Bends (r/d=12):

$$N_{3in_bends} := 5 + 4 + 17 + 12 + 5 + 17 + 8 + 50$$

$$K_4 := (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_4 = 72.2$$

5.4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 2Process Pit Losses:

$$h_1 := h_{ay_pits} + h_{valve_pits} \quad h_1 = 12 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i + \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=3}^4 K_i \quad h_2 = 83 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{end} - z_{start} \quad h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$TDH_{60_alt2} := \sum_i h_i \quad TDH_{60_alt2} = 140 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{60_alt2} := \frac{TDH_{60_alt2} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{60_alt2} = 91 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

Calc. No. E44810-2702

DESIGN ANALYSIS

Revision 0

Page No. 26 of 28

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/29/96

Location: 200 East

Revised:

By: T.B. Salzano

By: NDA

By:

6.0 SYSTEM CURVE

The system curve can now be generated. The curve will be used to determine different possible operating points for the system. A pump could then be selected to meet the needed operating requirements. The main operating points to be considered are at a Reynolds number of 20,000 and at the design pressure limit of the system.

6.1 SYSTEM CURVE DATA: 241-AY

The system curve for the 241-AY-102 Tank transfers to the vendor's processing facility can now be generated.

Flow Rate:Total Head:

$$Q := \begin{bmatrix} Q_{60} \\ Q_{80} \\ Q_{100} \\ Q_{120} \\ Q_{140} \end{bmatrix}$$

$$TDH_{ay_alt2} := \begin{bmatrix} TDH_{60_alt2} \\ TDH_{80_alt2} \\ TDH_{100_alt2} \\ TDH_{120_alt2} \\ TDH_{140_alt2} \end{bmatrix}$$

ICF Kaiser Hanford

DESIGN ANALYSIS

Calc. No. E44810-2702

Revision 0

Page No. 27 of 28

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 2)

Location: 200 East

WO/Job No. E44810

Date: 5/9/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *nda*

By:

6.2 SYSTEM CURVE

$i = 0.4$

HLW Transfers from 241-AY-102 to the Vendor (Alternative 2)

ICF Kaiser Hanford

Calc. No. E44810-2702

Revision 0

Page No. 28 of 28

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/9/96

Feed from 241-AY Tanks (Alternative 2)

Checked: 5/19/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *NOT*

By:

6.3 SPECIFIC OPERATING POINTS**6.3.1 Operating Point at Reynolds Number > 20,000: 241-AY ALTERNATIVE 2**

This operating point occurs at a flow rate of 130 gpm. From the above graph,

$$Q_{Re} = 130 \text{ gpm}$$

$$TDH_{Re} = 440 \text{ ft}$$

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

Velocity:

$$q_{Re} = \frac{Q_{Re} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{Re} = 0.29 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{Re_3in} = \frac{q_{Re}}{A_{3in}}$$

$$v_{Re_3in} = 5.6 \cdot \frac{\text{ft}}{\text{sec}}$$

Pressure Drop:

$$\Delta P_{Re} = \frac{TDH_{Re} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}}$$

$$\Delta P_{Re} = 286 \cdot \frac{\text{lb}}{\text{in}^2}$$

6.3.2 Operating Point at Lowest Pipeline Design Pressure: 241-AY ALTERNATIVE 2

The lowest design pressure is 230 psi (See Attachment A). This is equivalent to the following Head:

$$\Delta P_{DP} = 230 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$TDH_{DP} = \frac{\Delta P_{DP} \cdot 144 \cdot \frac{\text{in}^2}{\text{ft}^2}}{\rho}$$

$$TDH_{DP} = 354 \text{ ft}$$

From the above graph,

$$Q_{DP} = 113 \text{ gpm}$$

Therefore, the velocity in the 3 inch lines is as follows.

Velocity:

$$q_{DP} = \frac{Q_{DP} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{DP} = 0.25 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{DP_3in} = \frac{q_{DP}}{A_{3in}} \quad A-44$$

$$v_{DP_3in} = 4.9 \cdot \frac{\text{ft}}{\text{sec}}$$

HLW ALTERNATIVE 2

"NEW 3" LINE, AZ TO AX-A", AND
"NEW 3" LINE, AY TO AX-B"

2" SL-503,504,505

(AY-FARM)

NOTE: ALL NOZZLES AT EL 675 UNLESS OTHERWISE NOTED

REFERENCES:

H-2-70764
H-2-64313
H-2-64314
B-131-C1

SUMMARY:

	SL-503	SL-504	SL-505
LENGTH	11 FT	116 FT	18 FT
3'R BENDS	2	4	2

DESIGN:

PRESSURE 400 PSIG
TEMP 200 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John N. Wilson* 4/5/96

2" SL-502

241-AX-B
VALVE PIT

REFERENCES:

H-2-69245
H-2-70763
H-2-70764
H-2-70780
B-131-C1

SUMMARY:

LENGTH	234.7 FT
3'R BENDS	5
COBs	1
REDUCERS	1

DESIGN:

PRESSURE	400 PSIG
TEMP	200 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John H. H. 4/5/96*

3" SN-201/214

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John W. Salzano* 4/5/96

3" SN-220 REFERENCES:

H-2-69188
H-2-69184
H-2-69183
H-2-70398-2
H-2-70399
H-2-70401
B-120-C1

SUMMARY:

LENGTH 576.8 FT
3'R BENDS 12

DESIGN:

PRESSURE 230 PSIG
TEMP 330 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *Jack W. Salzano 4/5/96*

3" SN-267

(AW-FARM)

REFERENCES:

H-2-70399
H-2-70401
H-2-70404
B-120-C7

SUMMARY:

LENGTH 106.1 FT
3'R BENDS 5

DESIGN:

PRESSURE 275 PSIG
TEMP 340 °F

241-AW-A
VALVE PIT

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John N. Salzano* 4/5/96

3" SN-618

(AP-FARM)

REFERENCES:

H-2-90547
H-2-90548
H-2-90560
B-340-C7

SUMMARY:

LENGTH 425.4 FT
3'R BENDS 8

DESIGN:

PRESSURE 400 PSIG
TEMP 340 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *Jack Wilson* 4/5/96

ICF Kaiser Hanford		CALCULATION IDENTIFICATION AND INDEX		Page 1 of 1 Date 5/10/96	
This sheet shows the status and description of the attached Design Analysis sheets.					
Discipline Piping, 27		WO/Job No. E44810		Calculation No. E44810-2703	
Project No. & Name Phase I Privatization Transfer System Needs					
Calculation Item Head Loss Calculation for HLW Feed from 241-AY Tanks (Alternatives 3 and 4)					
These calculations apply to:					
Dwg. No.		Rev. No.			
Dwg. No.		Rev. No.			
Other (Study, CDR)				Rev. No.	
The status of these calculations is:					
☐ Preliminary Calculations					
☒ Final Calculations					
☐ Check Calculations (On Calculation Dated)					
☐ Void Calculation (Reason Voided)					
Incorporated in Final Drawings?		☐ Yes		☐ No	
This calculation verified by independent "check" calculations?		☐ Yes		☐ No	
Original and Revised Calculation Approvals:					
Rev. 0 Signature/Date		Rev. 1 Signature/Date		Rev. 2 Signature/Date	
Originator		[Signature] / 5-10-96			
Checked by		[Signature] / 5-24-96			
Approved by					
Checked Against Approved Vendor Data					
<div style="text-align: center;"><u>INDEX</u></div>					
Design Analysis Page No.		Description			
1		1.0 Objective			
1		2.0 Design Inputs: Given Data, Assumptions, References, Method			
1		3.0 Conclusion			
2-10		4.0 AY-Farm HLW Transfer Head Losses			
11-27		5.0 System Curve Development			
27-30		6.0 System Curve			
-		Attachment A - Transfer Lines			

ICF Kaiser Hanford

Calc. No. E44810-2703

Revision 0

Page No. 1 of 30

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: *5/1/96*

Location: 200 East

Revised:

By: T.B. Salzano

By: *DA*

By:

1.0 OBJECTIVE

Determine the pump head requirements to transfer high-level waste (HLW) from the AY-Farm to one of the Phase I Privatization Vendors. This calculation will develop the system curve for transfers from the 241-AY-102 to the vendor via transfer line SN-650 including upgrade of SL-502 to 3-inch. In addition, the system curve including a new transfer line parallel to SN-650 to the vendor will be developed. These two systems correspond to HLW Alternatives 3 and 4, respectively.

2.0 DESIGN INPUTS

2.1 Given Data Absolute Viscosity: 10 cp Specific Gravity: 1.5 (Ref. 2)

Pipe Selection: 2" Schedule 40 3" Schedule 40

Inside Diameter: ID = 2.067 ID = 3.068

2.2 Assumptions

1. The sending and receiving tanks are at atmospheric pressure.
2. The head loss (including elevation and line loss) from the centerline of the discharge pump to the nozzle of the first transfer line is 50 feet.
3. Purex Connectors were assumed to have losses equal to a 90° miter bend.
4. Pipeline friction factors are based on clean commercial steel pipe.
5. The pit head losses are based on 10 feet of pipe, four 90° LR elbows, two three-way ball valves, and four Purex Connectors. The two AY process pits are assumed to have 10 ft jumpers with two 90° LR elbows, one three-way ball valve, and two Purex Connectors.
6. The ending elevation of the system at the vendor(s) facility is 670.0 feet (Ref. 3).

2.3 References

1. Galbraith, J.D., March 4, 1996, *Letter of Instruction for FY1996 Transfer System Needs for Low-Level Waste and High-Level Waste Staging - Phase I Privatization*, Internal Memo 73520-96-011, Westinghouse Hanford Company, Richland, Washington.
2. Koberg, J.T., March 5, 1996, *Statement of Work for Phase I Privatization Transfer System Needs*, Interoffice Memo W-314-005, ICF Kaiser Hanford Company, Richland, Washington.
3. Manuel, A.F., February 5, 1996, *Phase I High-Level Waste Pretreatment and Feed Staging Plan*, WHC-SD-WM-ES-370, Rev. 0, Westinghouse Hanford Company, Richland, Washington.
4. Fowler, K.D., April 24, 1995, *Tank Farm Waste Compatibility Program*, WHC-SD-WM-OCD-015, Rev. 1, Westinghouse Hanford Company, Richland, Washington.
5. "Flow of Fluids Through Valves, Fittings, and Pipe", Crane, Technical Paper No. 410, 1991. Fitting Resistance Coefficients, K: "K" factor table, Page A-26 to A-29
Friction factors: Fittings, f_f , Page A-26; Pipe, f_{pipe} , Page A-25

2.4 Method

The method used for the determination of the pressure loss in the piping system is based upon the Darcy-Weisbach formula. Pressure losses in fittings are determined using experimental resistance coefficients (K) along with friction factors. The losses of all the fittings, valves, and pipe are totaled and using the Bernoulli Theorem, the pressure loss of the system can be determined. The computer program Mathcad, Version 4.0, is used.

3.0 CONCLUSION

See Body of Calculation

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 2 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *not*

By:

4.0 AY-FARM HLW TRANSFER HEAD LOSSES

The head losses for transfers from the 241-AY-102 Tank will be calculated. The first analysis will be based on a flow rate of 140 gpm to maintain a minimum Reynolds number of 20,000 (Ref. 4).

4.1 Constant Data

Volumetric Flow Rate,

$$Q_{140} := 140 \frac{\text{gal}}{\text{min}}$$

$$q := \frac{Q_{140} \cdot 0.13368 \frac{\text{ft}^3}{\text{gal}}}{60 \frac{\text{sec}}{\text{min}}}$$

$$q = 0.31 \frac{\text{ft}^3}{\text{sec}}$$

Pipe Diameter,

2 inch pipe

$$d_{2\text{in}} := 2.067 \cdot \text{in}$$

$$D_{2\text{in}} := \frac{d_{2\text{in}}}{12 \frac{\text{in}}{\text{ft}}}$$

$$D_{2\text{in}} = 0.17 \cdot \text{ft}$$

3 inch pipe

$$d_{3\text{in}} := 3.068 \cdot \text{in}$$

$$D_{3\text{in}} := \frac{d_{3\text{in}}}{12 \frac{\text{in}}{\text{ft}}}$$

$$D_{3\text{in}} = 0.26 \cdot \text{ft}$$

Area of Flow,

2 inch pipe

$$A_{2\text{in}} := \frac{\pi D_{2\text{in}}^2}{4}$$

$$A_{2\text{in}} = 0.02 \cdot \text{ft}^2$$

3 inch pipe

$$A_{3\text{in}} := \frac{\pi D_{3\text{in}}^2}{4}$$

$$A_{3\text{in}} = 0.05 \cdot \text{ft}^2$$

Velocity of Flow,

2 inch pipe

$$v_{2\text{in}} := \frac{q}{A_{2\text{in}}}$$

$$v_{2\text{in}} = 13.4 \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3\text{in}} := \frac{q}{A_{3\text{in}}}$$

$$v_{3\text{in}} = 6.1 \frac{\text{ft}}{\text{sec}}$$

ICF Kaiser Hanford

Calc. No. E44810-2703

DESIGN ANALYSIS

Revision 0

Page No. 3 of 30

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/23/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *ndr*

By:

Density of Liquid,

SpG = 1.5

(Ref. 2)

$$\rho = \text{SpG} \cdot 62.371 \cdot \frac{\text{lb}}{\text{ft}^3}$$

$$\rho = 93.6 \cdot \frac{\text{lb}}{\text{ft}^3}$$

(62.371 lb/cu. ft is the density of water at 60°F, Ref. 4, Page A-6)

Absolute Viscosity,

 $\mu = 10 \text{ cp}$

(Ref. 2)

$$\mu_e = \mu \cdot (6.72 \cdot 10^{-4}) \cdot \frac{\frac{\text{lb}}{\text{ft} \cdot \text{sec}}}{\text{cp}}$$

$$\mu_e = 0.007 \cdot \frac{\text{lb}}{\text{ft} \cdot \text{sec}}$$

Reynolds Number,

2 inch pipe

$$\text{Re}_{2\text{in}} = \frac{D_{2\text{in}} \cdot v_{2\text{in}} \cdot \rho}{\mu_e}$$

 $\text{Re}_{2\text{in}} = 32100$ 3 inch pipe

$$\text{Re}_{3\text{in}} = \frac{D_{3\text{in}} \cdot v_{3\text{in}} \cdot \rho}{\mu_e}$$

 $\text{Re}_{3\text{in}} = 21626$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe $f_{2\text{in}} = 0.026$ $f_{T2\text{in}} = 0.019$ 3 inch pipe $f_{3\text{in}} = 0.027$ $f_{T3\text{in}} = 0.018$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 4 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/21/96

Revised:

By: T.B. Salzano

By: *MDA*

By:

4.2 PROCESS PIT HEAD LOSSES

The HLW Alternative 3 transfer route from 241-AY-102 will pass through five process pits: The 241-AY-02A Pump Pit (PP), the 241-AY-02D Sluice Pit (SP), the 241-AX-B Valve Pit (VP), the 241-A-B VP, and the new SN-650 VP. The Alternative 4 transfer route will pass through five process pits: The 241-AY-02A PP, the 241-AY-02D SP, the 241-AX-B VP, the 241-AX-A VP, and the 241-A-A VP (See Attachment A).

4.2.1 AY-Farm Process Pits

The two AY-Farm process pits are assumed to have 2-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain two 90 degree LR elbows, one three-way ball valve, and two Purex Connectors.

10.0 ft - 2" Pipe Length: $L_1 = 10 \text{ ft}$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.5$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f_{2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{2in}) \cdot 1 \quad K_4 = 1.1$$

Head Loss for each pit: $h_{\text{pit_2in}} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$

$$h_{\text{pit_2in}} = 15.2 \text{ ft}$$

Head Loss for both AY-Farm pits:

$$h_{\text{pump_pits}} = 2 \cdot h_{\text{pit_2in}}$$

$$h_{\text{pump_pits}} = 30.4 \text{ ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 5 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/27/96

Revised:

By: T.B. Salzano

By: *TS*

By:

4.2.2 Valve Pits

The three valve pits for Alternative 3 and Alternative 4 are assumed to have 3-inch jumpers that are 10 feet in length. In addition, each jumper is assumed to contain four 90 degree LR elbows, two three-way ball valves, and four Purex Connectors.

10.0 ft - 3" Pipe Length: $L_1 := 10\text{-ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.1$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

Head Loss for each pit: $h_{\text{pit}_3in} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$

$$h_{\text{pit}_3in} = 4.9 \cdot \text{ft}$$

Head Loss for all six remaining pits:

$$h_{\text{valve_pits_alt3}} := 3 \cdot h_{\text{pit}_3in} \quad h_{\text{valve_pits_alt3}} = 14.7 \cdot \text{ft}$$

$$h_{\text{valve_pits_alt4}} := 3 \cdot h_{\text{pit}_3in} \quad h_{\text{valve_pits_alt4}} = 14.7 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 6 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *WDA*

By:

4.3 TRANSFER LINE HEAD LOSSES

The HLW Alternative 3 transfers from the 241-AY-102 will pass through five transfer lines: 2"SL-503 New 3"SL-502, 3"SN-200/213, 3"SN-650, and a new 3" SN line from the new VP to the Phase 1 vendor. The HLW Alternative 4 transfers will pass through five transfer lines: 2"SL-503, New 3"SL-502, 3"SN-210, 3"SN-201/214, and a new 3" SN line from the A-A VP to the Phase 1 vendor (See Attachment A).

4.3.1 2"SL-503 (AY-02A PP to AY-02D SP)11' - 2" Pipe Length:

$$L_1 = 11 \text{ ft}$$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.7$$

2 - 36" Radius Bends (r/d=18):

$$K_2 = (46 f_{T2in}) \cdot 2 \quad K_2 = 1.7$$

Elevation at Start of Transfer (pit exit nozzle):

$$z_{start} = 675.0 \text{ ft}$$

(See Assumption 2)

Head Loss:

$$h_{sl_503} = \frac{v_{2in}^2}{2 \cdot g} \sum_{i=1}^2 K_i$$

$$h_{sl_503} = 9 \text{ ft}$$

4.3.2 NEW 3"SL-502 (AY-02D SP to AX-B VP)235' - 3" Pipe Length:

$$L_1 = 235 \text{ ft}$$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 24.8$$

5 - 36" Radius Bends (r/d=12):

$$K_2 = (34 f_{T3in}) \cdot 5 \quad K_2 = 3.1$$

Head Loss:

$$h_{new_sl_502} = \frac{v_{3in}^2}{2 \cdot g} \sum_{i=1}^2 K_i$$

$$h_{new_sl_502} = 16 \text{ ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 7 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: *5/29/96*

Revised:

By: T.B. Salzano

By: *MDA*

By:

4.3.3 3" SN-200/213 (AX-B VP to A-B VP)618' - 3" Pipe Length: $L_1 = 618 \text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 65.3$$

15 - 36" Radius Bends (r/d=12):

$$K_2 = (34 \cdot f_{T3in}) \cdot 15 \quad K_2 = 9.2$$

2 - 36" Radius 45 Bends (r/d=12):

$$K_3 = [(.5 - 1) \cdot (.25 \cdot \pi \cdot f_{T3in} \cdot 12 + .5 \cdot (34 \cdot f_{T3in})) + 34 \cdot f_{T3in}] \cdot 2$$

$$K_3 = 0.7$$

Head Loss:

$$h_{sn_200_213} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^3 K_i$$

$$h_{sn_200_213} = 43 \cdot \text{ft}$$

4.3.4 3" SN-650 MODIFIED (A-B VP to New VP)

It is assumed that the modified SN-650 to the new valve pit will be the same length and include the same number of bends as the existing SN-650.

1334' - 3" Pipe Length: $L_1 = 1334 \text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 140.9$$

25 - 36" Radius Bends (r/d=12):

$$K_2 = (34 \cdot f_{T3in}) \cdot 25 \quad K_2 = 15.3$$

Head Loss:

$$h_{sn_650} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_650} = 90 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 8 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/24/96

Revised:

By: T.B. Salzano

By: *WDA*

By:

4.3.5 NEW 3" SN Line (New VP to Vendor)

The length of this line is based on the location of the vendor's facility provided in Ref. 3.

2820' - 3" Pipe Length: $L_1 := 2820 \cdot \text{ft}$

$$K_1 := f_{3\text{in}} \frac{L_1}{D_{3\text{in}}} \quad K_1 = 297.8$$

50 - 36" Radius Bends (r/d=12):

$$K_2 := (34 \cdot f_{T3\text{in}}) \cdot 50 \quad K_2 = 30.6$$

Elevation at End of Transfer:

$$z_{\text{end}} := 670.0 \cdot \text{ft}$$

(Assumption 6)

Head Loss:

$$h_{\text{sn_vp_vendor}} := \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{\text{sn_vp_vendor}} = 188 \cdot \text{ft}$$

4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3Process Pit Losses:

$$h_1 := h_{\text{pump_pits}} + h_{\text{valve_pits_alt3}} \quad h_1 = 45 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := h_{\text{sl_503}} + h_{\text{new_sl_502}} + h_{\text{sn_200_213}} + h_{\text{sn_650}} + h_{\text{sn_vp_vendor}}$$

$$h_2 = 347 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}}$$

$$h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, 3$

$$\text{TDH}_{140_alt3} := \sum_i h_i \quad \text{TDH}_{140_alt3} = 437 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{140_alt3} := \frac{\text{TDH}_{140_alt3} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{140_alt3} = 284 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 9 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *ND*

By:

4.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4

Alternative 4 requires a new 3-inch transfer line from the A-A VP to the vendor. If this new line is used instead of the SN-650 modifications the HLW transfer would have the following head requirements.

4.5.1 3" SN-210 (AX-B VP to AX-A VP)6' - 3" Pipe Length: $L_1 = 6\text{-ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 0.6$$

4 - 36" Radius Bends (r/d=12):

$$K_2 = (34 \cdot f_{T3in}) \cdot 4 \quad K_2 = 2.4$$

Head Loss:

$$h_{sn_210} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_210} = 2\text{-ft}$$

4.5.2 3" SN-201/214 (AX-A VP to A-A VP)650' - 3" Pipe Length: $L_1 = 650\text{-ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 68.6$$

17 - 36" Radius Bends (r/d=12):

$$K_2 = (34 \cdot f_{T3in}) \cdot 17 \quad K_2 = 10.4$$

Head Loss:

$$h_{sn_201_214} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i$$

$$h_{sn_201_214} = 45\text{-ft}$$

ICF Kaiser Hanford
DESIGN ANALYSIS

Calc. No. E44810-2703

Revision 0

Page No. 10 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/21/96

Revised:

By: T.B. Salzano

By: *WBS*

By:

4.5.3 NEW 3" SN parallel to SN-650 (A-A PP to Vendor)

The length of this line is based on the location of the vendor's facility provided in Ref. 3.

4150' - 3" Pipe Length: $L_1 = 4150 \text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 438.3$$

72 - 36" Radius Bends (r/d=12):

$$K_2 = (34 \cdot f_{T3in}) \cdot 72 \quad K_2 = 44.1$$

Head Loss:

$$h_{sn_aa_vendor} = \frac{v_{3in}^2}{2 \cdot g} \sum_{i=1}^2 K_i$$

$$h_{sn_aa_vendor} = 277 \text{ ft}$$

4.5.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4
Process Pit Losses:

$$h_1 = h_{\text{pump_pits}} + h_{\text{valve_pits_alt4}} \quad h_1 = 45 \text{ ft}$$

Transfer Path Losses:

$$h_2 = h_{sl_503} + h_{new_sl_502} + h_{sn_210} + h_{sn_201_214} + h_{sn_aa_vendor}$$

$$h_2 = 349 \text{ ft}$$

Elevation Change:

$$h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45 \text{ ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$TDH_{140_alt4} = \sum_i h_i \quad TDH_{140_alt4} = 439 \text{ ft}$$

Pressure Drop:

$$\Delta P_{140_alt4} = \frac{TDH_{140_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{140_alt4} = 285 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

Calc. No. E44810-2703

Revision 0

Page No. 11 of 30

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *WBT*

By:

5.0 SYSTEM CURVE DEVELOPMENT

A system-head curve is a graphical representation of the relationship between flow and hydraulic losses in a given piping system. The system curve can be used with a pump characteristic curve to develop the operating point of the system. For this system, the friction losses at flow rates of 140 (previously calculated), 120, 100, 80, and 60 gpm will be used to develop the system-head curve.

5.1 120 GPM: 241-AY
5.1.1 Constant Data

Volumetric Flow Rate,

$$Q_{120} = 120 \frac{\text{gal}}{\text{min}}$$

$$Q_{120} = 0.13368 \frac{\text{ft}^3}{\text{sec}}$$

$$q = \frac{0.13368 \frac{\text{ft}^3}{\text{sec}}}{60 \frac{\text{sec}}{\text{min}}} = 0.27 \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

2 inch pipe

$$v_{2in} = \frac{q}{A_{2in}}$$

$$v_{2in} = 11.5 \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3in} = \frac{q}{A_{3in}}$$

$$v_{3in} = 5.2 \frac{\text{ft}}{\text{sec}}$$

Reynolds Number,

2 inch pipe

$$Re_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e}$$

$$Re_{2in} = 27514$$

3 inch pipe

$$Re_{3in} = \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e}$$

$$Re_{3in} = 18537$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe

$$f_{2in} = 0.026$$

$$f_{T2in} = 0.019$$

3 inch pipe

$$f_{3in} = 0.0275$$

$$f_{T3in} = 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 12 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *WDA*

By:

5.1.2.1 AY-Farm Process Pits10.0 ft - 2" Pipe Length: $L_1 := 10\text{-ft}$

$$K_1 := f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.5$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 := (60 \cdot f_{T2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 := (14 \cdot f_{T2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 := (60 \cdot f_{T2in}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit: } h_{\text{pit}_2in} := \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_2in} = 11.2 \cdot \text{ft}$$

Head Loss for both AY-Farm pits:

$$h_{\text{pump}_pits} := 2 \cdot h_{\text{pit}_2in}$$

$$h_{\text{pump}_pits} = 22.3 \cdot \text{ft}$$

ICF Kaiser Hanford

DESIGN ANALYSIS

Calc. No. E44810-2703

Revision 0

Page No. 13 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: *5/24/96*

Revised:

By: T.B. Salzano

By: *WBS*

By:

5.1.2.2 Valve Pits

10.0 ft - 3" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{3in} \frac{L_1}{D_{3in}} \quad K_1 = 1.1$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pit}_3in} := \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_3in} = 3.6 \cdot \text{ft}$$

Head Loss for all six remaining pits:

$$h_{\text{valve_pits_alt3}} := 3 \cdot h_{\text{pit}_3in}$$

$$h_{\text{valve_pits_alt3}} = 10.8 \cdot \text{ft}$$

$$h_{\text{valve_pits_alt4}} := 3 \cdot h_{\text{pit}_3in}$$

$$h_{\text{valve_pits_alt4}} = 10.8 \cdot \text{ft}$$

5.1.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length (Alternative 3 and 4):

$$L_{2in} := 11\text{-ft}$$

$$K_1 = f_{2in} \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.7$$

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3 and 4):

$$N_{2in_bends} := 2$$

$$K_2 = (46 \cdot f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 1.7$$

3" Pipe Length (Alternative 3):

$$L_{3in} := 235\text{-ft} + 618\text{-ft} + 1334\text{-ft} + 2820\text{-ft}$$

$$K_3 = f_{3in} \frac{L_{3in}}{D_{3in}} \quad K_3 = 538.6$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 14 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/24/96

Revised:

By: T.B. Salzano

By: *MD*

By:

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

$$N_{3in_bends} = 5 + 15 + 25 + 50$$

$$K_4 = (34 f_{T3in}) \cdot N_{3in_bends} \quad K_4 = 58.1$$

3" Pipe - 36" Radius 45 Bends (r/d=12) (Alternative 3):

$$N_{3in_45s} = 2$$

$$K_5 = [(0.5 - 1) \cdot [0.25 \pi f_{T3in} \cdot 12 + 0.5 \cdot (34 f_{T3in})] + 34 f_{T3in}] \cdot N_{3in_45s} \quad K_5 = 0.7$$

3" Pipe Length (Alternative 4):

$$L_{3in} = 235 \text{ ft} + 6 \text{ ft} + 650 \text{ ft} + 4150 \text{ ft}$$

$$K_6 = f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_6 = 542.2$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

$$N_{3in_bends} = 5 + 4 + 17 + 72$$

$$K_7 = (34 f_{T3in}) \cdot N_{3in_bends} \quad K_7 = 60$$

5.1.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3Process Pit Losses:

$$h_1 = h_{\text{pump_pits}} + h_{\text{valve_pits_alt3}} \quad h_1 = 33 \text{ ft}$$

Transfer Path Losses:

$$h_2 = \frac{v_{2in}^2}{2 \cdot g} \sum_{i=1}^2 K_i + \frac{v_{3in}^2}{2 \cdot g} \sum_{i=3}^5 K_i \quad h_2 = 259 \text{ ft}$$

Elevation Change:

$$h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45 \text{ ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, \dots, 3$

$$TDH_{120_alt3} = \sum_i h_i \quad TDH_{120_alt3} = 337 \text{ ft}$$

Pressure Drop:

$$\Delta P_{120_alt3} = \frac{TDH_{120_alt3} \cdot \rho}{144 \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{120_alt3} = 219 \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 15 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *WDS*

By:

5.1.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4Process Pit Losses:

$$h_1 := h_{\text{pump_pits}} + h_{\text{valve_pits_alt4}} \quad h_1 = 33 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 = \frac{v_{2\text{in}}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i + \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=6}^7 K_i \quad h_2 = 261 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, 3$

$$\text{TDH}_{120_alt4} := \sum_i h_i \quad \text{TDH}_{120_alt4} = 339 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{120_alt4} := \frac{\text{TDH}_{120_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{120_alt4} = 220 \cdot \frac{\text{lb}}{\text{in}^2}$$

5.2 100 GPM: 241-AY**5.2.1 Constant Data**

Volumetric Flow Rate,

$$Q_{100} := 100 \cdot \frac{\text{gal}}{\text{min}}$$

$$q := \frac{Q_{100} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}} \quad q = 0.22 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

$$\text{2 inch pipe} \quad v_{2\text{in}} := \frac{q}{A_{2\text{in}}} \quad v_{2\text{in}} = 9.6 \cdot \frac{\text{ft}}{\text{sec}}$$

$$\text{3 inch pipe} \quad v_{3\text{in}} := \frac{q}{A_{3\text{in}}} \quad v_{3\text{in}} = 4.3 \cdot \frac{\text{ft}}{\text{sec}}$$

ICF Kaiser Hanford

Calc. No. E44810-2703

Revision 0

Page No. 16 of 30

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/24/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *DA*

By:

Reynolds Number,

$$\text{2 inch pipe} \quad Re_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e} \quad Re_{2in} = 22928$$

$$\text{3 inch pipe} \quad Re_{3in} = \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e} \quad Re_{3in} = 15447$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

$$\text{2 inch pipe} \quad f_{2in} = 0.027 \quad f'_{T2in} = 0.019$$

$$\text{3 inch pipe} \quad f_{3in} = 0.029 \quad f'_{T3in} = 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

5.2.2 PROCESS PIT HEAD LOSSES**5.2.2.1 AY-Farm Process Pits**10.0 ft - 2" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.6$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T2in}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit: } h_{pit_2in} = \frac{v_{2in}^2}{2g} \cdot \sum_{i=1}^4 K_i \quad h_{pit_2in} = 7.8 \cdot ft$$

Head Loss for both AY-Farm pits:

$$h_{pump_pits} = 2 \cdot h_{pit_2in} \quad h_{pump_pits} = 15.7 \cdot ft$$

ICF Kaiser Hanford

DESIGN ANALYSIS

Calc. No. E44810-2703

Revision 0

Page No. 17 of 30

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/29/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *~ Det*

By:

5.2.2.2 Valve Pits

10.0 ft - 3" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.1$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pit}_3in} := \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_3in} = 2.5 \cdot \text{ft}$$

Head Loss for all six remaining pits:

$$h_{\text{valve_pits_alt3}} = 3 \cdot h_{\text{pit}_3in} \quad h_{\text{valve_pits_alt3}} = 7.6 \cdot \text{ft}$$

$$h_{\text{valve_pits_alt4}} = 3 \cdot h_{\text{pit}_3in} \quad h_{\text{valve_pits_alt4}} = 7.6 \cdot \text{ft}$$

5.2.3 TRANSFER LINE HEAD LOSSES

2" Pipe Length (Alternative 3 and 4):

$$L_{2in} = 11 \cdot \text{ft}$$

$$K_1 = f_{2in} \cdot \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.7$$

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3 and 4):

$$N_{2in_bends} = 2$$

$$K_2 = (46 \cdot f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 1.7$$

3" Pipe Length (Alternative 3):

$$L_{3in} = 235 \cdot \text{ft} + 618 \cdot \text{ft} + 1334 \cdot \text{ft} + 2820 \cdot \text{ft}$$

$$K_3 = f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_3 = 567.9$$

ICF Kaiser Hanford

Calc. No. E44810-2703

Revision 0

Page No. 18 of 30

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 1 and 2)

Checked: 5/24/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *WDA*

By:

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

$$N_{3in_bends} = 5 + 15 + 25 + 50$$

$$K_4 = (34 f_{T3in}) \cdot N_{3in_bends} \quad K_4 = 58.1$$

3" Pipe - 36" Radius 45 Bends (r/d=12) (Alternative 3):

$$N_{3in_45s} = 2$$

$$K_5 = [(0.5 - 1) \cdot [0.25 \pi f_{T3in} \cdot 12 + 0.5 \cdot (34 f_{T3in})] + 34 f_{T3in}] \cdot N_{3in_45s} \quad K_5 = 0.7$$

3" Pipe Length (Alternative 4):

$$L_{3in} = 235 \text{ ft} + 6 \text{ ft} + 650 \text{ ft} + 4150 \text{ ft}$$

$$K_6 = f_{3in} \frac{L_{3in}}{D_{3in}} \quad K_6 = 571.8$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

$$N_{3in_bends} = 5 + 4 + 17 + 72$$

$$K_7 = (34 f_{T3in}) \cdot N_{3in_bends} \quad K_7 = 60$$

5.2.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3**Process Pit Losses:**

$$h_1 = h_{\text{pump_pits}} + h_{\text{valve_pits_alt3}} \quad h_1 = 23 \text{ ft}$$

Transfer Path Losses:

$$h_2 = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i + \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=3}^5 K_i \quad h_2 = 188 \text{ ft}$$

Elevation Change:

$$h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45 \text{ ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$TDH_{100_alt3} = \sum_i h_i \quad TDH_{100_alt3} = 257 \text{ ft}$$

Pressure Drop:

$$\Delta P_{100_alt3} = \frac{TDH_{100_alt3} \cdot \rho}{144 \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{100_alt3} = 167 \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

Calc. No. E44810-2703

Revision 0

Page No. 19 of 30

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

By: T.B. Salzano

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/27/96

By: NDA

Location: 200 East

Revised:

By:

5.2.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4Process Pit Losses:

$$h_1 = h_{\text{pump_pits}} + h_{\text{valve_pits_alt4}} \quad h_1 = 23 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 = \frac{v_{2\text{in}}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i + \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=6}^7 K_i \quad h_2 = 190 \cdot \text{ft}$$

Elevation Change:

$$h_3 = 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$\text{TDH}_{100_alt4} = \sum_i h_i \quad \text{TDH}_{100_alt4} = 258 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{100_alt4} = \frac{\text{TDH}_{100_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{100_alt4} = 168 \cdot \frac{\text{lb}}{\text{in}^2}$$

5.3 80 GPM: 241-AY**5.3.1 Constant Data**

Volumetric Flow Rate,

$$Q_{80} = 80 \cdot \frac{\text{gal}}{\text{min}}$$

$$q = \frac{Q_{80} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q = 0.18 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

2 inch pipe

$$v_{2\text{in}} = \frac{q}{A_{2\text{in}}}$$

$$v_{2\text{in}} = 7.6 \cdot \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3\text{in}} = \frac{q}{A_{3\text{in}}}$$

$$v_{3\text{in}} = 3.5 \cdot \frac{\text{ft}}{\text{sec}}$$

ICF Kaiser Hanford

Calc. No. E44810-2703

Revision 0

Page No. 20 of 30

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

By: T.B. Salzano

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/24/96

By: NDA

Location: 200 East

Revised:

By:

Reynolds Number,

$$\text{2 inch pipe} \quad Re_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e} \quad Re_{2in} = 18343$$

$$\text{3 inch pipe} \quad Re_{3in} = \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e} \quad Re_{3in} = 12358$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

$$\text{2 inch pipe} \quad f_{2in} = 0.028 \quad f_{T2in} = 0.019$$

$$\text{3 inch pipe} \quad f_{3in} = 0.03 \quad f_{T3in} = 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

5.3.2 PROCESS PIT HEAD LOSSES**5.3.2.1 AY-Farm Process Pits**10.0 ft - 2" Pipe Length: $L_1 = 10 \text{ ft}$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.6$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T2in}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit:} \quad h_{pit_2in} = \frac{v_{2in}^2}{2g} \cdot \sum_{i=1}^4 K_i \quad h_{pit_2in} = 5.1 \text{ ft}$$

Head Loss for both AY-Farm pits:

$$h_{pump_pits} = 2 \cdot h_{pit_2in} \quad h_{pump_pits} = 10.1 \text{ ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 21 of 30

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/24/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *ms*

By:

5.3.2.2 Valve Pits10.0 ft - 3" Pipe Length: $L_1 := 10\text{-ft}$

$$K_1 := f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.2$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 := (60 f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 := (14 f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 := (60 f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pit}_3in} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_3in} = 1.6 \cdot \text{ft}$$

Head Loss for all six remaining pits:

$$h_{\text{valve_pits_alt3}} := 3 \cdot h_{\text{pit}_3in} \quad h_{\text{valve_pits_alt3}} = 4.9 \cdot \text{ft}$$

$$h_{\text{valve_pits_alt4}} := 3 \cdot h_{\text{pit}_3in} \quad h_{\text{valve_pits_alt4}} = 4.9 \cdot \text{ft}$$

5.3.3 TRANSFER LINE HEAD LOSSES2" Pipe Length (Alternative 3 and 4):

$$L_{2in} := 11 \cdot \text{ft}$$

$$K_1 := f_{2in} \cdot \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.8$$

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3 and 4):

$$N_{2in_bends} := 2$$

$$K_2 := (46 f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 1.7$$

3" Pipe Length (Alternative 3):

$$L_{3in} := 235\text{-ft} + 618\text{-ft} + 1334\text{-ft} + 2820\text{-ft}$$

$$K_3 := f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_3 = 587.5$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 22 of 30

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/14/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *nda*

By:

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

$$N_{3in_bends} := 5 + 15 + 25 + 50$$

$$K_4 := (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_4 = 58.1$$

3" Pipe - 36" Radius 45 Bends (r/d=12) (Alternative 3):

$$N_{3in_45s} := 2$$

$$K_5 := \left[(.5 - 1) \cdot \left[.25 \cdot \pi \cdot f_{T3in} \cdot 12 + .5 \cdot (34 \cdot f_{T3in}) \right] - 34 \cdot f_{T3in} \right] \cdot N_{3in_45s} \quad K_5 = 0.7$$

3" Pipe Length (Alternative 4):

$$L_{3in} := 235 \text{ ft} + 6 \text{ ft} + 650 \text{ ft} + 4150 \text{ ft}$$

$$K_6 := f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_6 = 591.5$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

$$N_{3in_bends} := 5 + 4 + 17 + 72$$

$$K_7 := (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_7 = 60$$

5.3.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3**Process Pit Losses:**

$$h_1 := h_{\text{pump_pits}} + h_{\text{valve_pits_alt3}} \quad h_1 = 15 \text{ ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i + \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=3}^5 K_i \quad h_2 = 124 \text{ ft}$$

Elevation Change:

$$h_3 := 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45 \text{ ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$TDH_{80_alt3} := \sum_i h_i \quad TDH_{80_alt3} = 184 \text{ ft}$$

Pressure Drop:

$$\Delta P_{80_alt3} := \frac{TDH_{80_alt3} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{80_alt3} = 120 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 23 of 30

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/29/96

Location: 200 East

Revised:

By: T.B. Salzano

By: ~~ND~~

By:

5.3.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4Process Pit Losses:

$$h_1 = h_{\text{pump_pits}} + h_{\text{valve_pits_alt4}}$$

$$h_1 = 15 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 = \frac{v_{2\text{in}}^2}{2 \cdot g} \sum_{i=1}^2 K_i + \frac{v_{3\text{in}}^2}{2 \cdot g} \sum_{i=6}^7 K_i$$

$$h_2 = 125 \cdot \text{ft}$$

Elevation Change:

$$h_3 = 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}}$$

$$h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss:

$$i = 1, 2, 3$$

$$\text{TDH}_{80_alt4} = \sum_i h_i$$

$$\text{TDH}_{80_alt4} = 185 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{80_alt4} = \frac{\text{TDH}_{80_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}}$$

$$\Delta P_{80_alt4} = 120 \cdot \frac{\text{lb}}{\text{in}^2}$$

5.4 60 GPM: 241-AY**5.4.1 Constant Data**

Volumetric Flow Rate,

$$Q_{60} = 60 \cdot \frac{\text{gal}}{\text{min}}$$

$$q = \frac{Q_{60} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q = 0.13 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

$$\text{2 inch pipe} \quad v_{2\text{in}} = \frac{q}{A_{2\text{in}}}$$

$$v_{2\text{in}} = 5.7 \cdot \frac{\text{ft}}{\text{sec}}$$

$$\text{3 inch pipe} \quad v_{3\text{in}} = \frac{q}{A_{3\text{in}}}$$

$$v_{3\text{in}} = 2.6 \cdot \frac{\text{ft}}{\text{sec}}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 24 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *~ D.A.*

By:

Reynolds Number,

$$\text{2 inch pipe} \quad Re_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e} \quad Re_{2in} = 13757$$

$$\text{3 inch pipe} \quad Re_{3in} = \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e} \quad Re_{3in} = 9268$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

$$\text{2 inch pipe} \quad f_{2in} = 0.03 \quad f_{T2in} = 0.019$$

$$\text{3 inch pipe} \quad f_{3in} = 0.032 \quad f_{T3in} = 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

5.4.2 PROCESS PIT HEAD LOSSES**5.4.2.1 AY-Farm Process Pits**

$$\text{10.0 ft - 2" Pipe Length: } L_1 = 10 \text{ ft}$$

$$K_1 = f_{2in} \cdot \frac{L_1}{D_{2in}} \quad K_1 = 1.7$$

2 - 2" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T2in}) \cdot 2 \quad K_2 = 2.3$$

2 - 2" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T2in}) \cdot 2 \quad K_3 = 0.5$$

1 - 2" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T2in}) \cdot 1 \quad K_4 = 1.1$$

$$\text{Head Loss for each pit: } h_{pit_2in} = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i \quad h_{pit_2in} = 2.9 \text{ ft}$$

Head Loss for both AY-Farm pits:

$$h_{pump_pits} = 2 \cdot h_{pit_2in} \quad h_{pump_pits} = 5.8 \text{ ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 25 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/28/96

Revised:

By: T.B. Salzano

By: *W.D.P.*

By:

5.4.2.2 Valve Pits10.0 ft - 3" Pipe Length: $L_1 := 10\text{-ft}$

$$K_1 := f_{3in} \frac{L_1}{D_{3in}} \quad K_1 = 1.3$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 := (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 := (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1.0$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 := (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pit}_3in} := \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pit}_3in} = 0.9 \cdot \text{ft}$$

Head Loss for all six remaining pits:

$$h_{\text{valve_pits_alt3}} := 3 \cdot h_{\text{pit}_3in} \quad h_{\text{valve_pits_alt3}} = 2.8 \cdot \text{ft}$$

$$h_{\text{valve_pits_alt4}} := 3 \cdot h_{\text{pit}_3in} \quad h_{\text{valve_pits_alt4}} = 2.8 \cdot \text{ft}$$

5.4.3 TRANSFER LINE HEAD LOSSES2" Pipe Length (Alternative 3 and 4):

$$L_{2in} := 11\text{-ft}$$

$$K_1 := f_{2in} \frac{L_{2in}}{D_{2in}} \quad K_1 = 1.9$$

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3 and 4):

$$N_{2in_bends} := 2$$

$$K_2 := (46 \cdot f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 1.7$$

3" Pipe Length (Alternative 3):

$$L_{3in} := 235\text{-ft} + 618\text{-ft} + 1334\text{-ft} + 2820\text{-ft}$$

$$K_3 := f_{3in} \frac{L_{3in}}{D_{3in}} \quad K_3 = 626.7$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 26 of 30

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 1 and 2)

Checked: 5/29/96

Location: 200 East

Revised:

By: T.B. Salzano

By: NDA

By:

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

$$N_{3in_bends} = 5 + 15 + 25 + 50$$

$$K_4 = (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_4 = 58.1$$

3" Pipe - 36" Radius 45 Bends (r/d=12) (Alternative 3):

$$N_{3in_45s} = 2$$

$$K_5 = [(5 - 1) \cdot [0.25 \cdot \pi \cdot f_{T3in} \cdot 12 + 0.5 \cdot (34 \cdot f_{T3in})] + 34 \cdot f_{T3in}] \cdot N_{3in_45s} \quad K_5 = 0.7$$

3" Pipe Length (Alternative 4):

$$L_{3in} = 235 \text{ ft} + 6 \text{ ft} + 650 \text{ ft} + 4150 \text{ ft}$$

$$K_6 = f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_6 = 630.9$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

$$N_{3in_bends} = 5 + 4 + 17 + 72$$

$$K_7 = (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_7 = 60$$

5.4.4 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 3Process Pit Losses:

$$h_1 = h_{\text{pump_pits}} + h_{\text{valve_pits_alt3}} \quad h_1 = 9 \text{ ft}$$

Transfer Path Losses:

$$h_2 = \frac{v_{2in}^2}{2 \cdot g} \cdot \sum_{i=1}^2 K_i + \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=3}^5 K_i \quad h_2 = 74 \text{ ft}$$

Elevation Change:

$$h_3 = 50 \text{ ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45 \text{ ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$TDH_{60_alt3} = \sum_i h_i \quad TDH_{60_alt3} = 128 \text{ ft}$$

Pressure Drop:

$$\Delta P_{60_alt3} = \frac{TDH_{60_alt3} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{60_alt3} = 83 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

DESIGN ANALYSIS

Calc. No. E44810-2703

Revision 0

Page No. 27 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *TD*

By:

5.4.5 TOTAL HEAD LOSS: 241-AY ALTERNATIVE 4

Process Pit Losses:

$$h_1 = h_{\text{pump_pits}} + h_{\text{valve_pits_alt4}} \quad h_1 = 9 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 = \frac{v_{2\text{in}}^2}{2 \cdot g} \sum_{i=1}^2 K_i + \frac{v_{3\text{in}}^2}{2 \cdot g} \sum_{i=6}^7 K_i \quad h_2 = 75 \cdot \text{ft}$$

Elevation Change:

$$h_3 = 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 45 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$\text{TDH}_{60_alt4} = \sum_i h_i \quad \text{TDH}_{60_alt4} = 128 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{60_alt4} = \frac{\text{TDH}_{60_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{60_alt4} = 83 \cdot \frac{\text{lb}}{\text{in}^2}$$

6.0 SYSTEM CURVE

The system curve can now be generated. The curve will be used to determine different possible operating points for the system. A pump could then be selected to meet the needed operating requirements. The main operating points to be considered are at a Reynolds number of 20,000 and at the design pressure limit of the system.

6.1 SYSTEM CURVE DATA: 241-AY

The system curve for the 241-AY-102 Tank transfers to the vendor's processing facility can now be generated.

Flow Rate:

Total Head:

$$Q = \begin{bmatrix} Q_{60} \\ Q_{80} \\ Q_{100} \\ Q_{120} \\ Q_{140} \end{bmatrix}$$

$$\text{TDH}_{ay_alt3} = \begin{bmatrix} \text{TDH}_{60_alt3} \\ \text{TDH}_{80_alt3} \\ \text{TDH}_{100_alt3} \\ \text{TDH}_{120_alt3} \\ \text{TDH}_{140_alt3} \end{bmatrix}$$

$$\text{TDH}_{ay_alt4} = \begin{bmatrix} \text{TDH}_{60_alt4} \\ \text{TDH}_{80_alt4} \\ \text{TDH}_{100_alt4} \\ \text{TDH}_{120_alt4} \\ \text{TDH}_{140_alt4} \end{bmatrix}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2703

Revision 0

Page No. 28 of 30

Client: WHC

Subject: Head Loss Calculations for HLW

Feed from 241-AY Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/29/96

Revised:

By: T.B. Salzano

By: *DA*

By:

6.2 SYSTEM CURVE

$$i = 0.4$$

HLW Transfers from 241-AY-102 to the Vendor (Alternative 3 and 4)

ICF Kaiser Hanford

Calc. No. E44810-2703

Revision 0

Page No. 29 of 30

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/24/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *WDA*

By:

6.3 SPECIFIC OPERATING POINTS

6.3.1 Operating Point at Reynolds Number > 20,000: 241-AY ALTERNATIVE 3

This operating point occurs at a flow rate of 130 gpm. From the above graph,

$$Q_{Re} = 130 \text{ gpm}$$

$$TDH_{Re} = 385 \text{ ft}$$

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

Velocity:

$$q_{Re} = \frac{Q_{Re} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{Re} = 0.29 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{Re_3in} = \frac{q_{Re}}{A_{3in}}$$

$$v_{Re_3in} = 5.6 \cdot \frac{\text{ft}}{\text{sec}}$$

Pressure Drop:

$$\Delta P_{Re} = \frac{TDH_{Re} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}}$$

$$\Delta P_{Re} = 250 \cdot \frac{\text{lb}}{\text{in}^2}$$

6.3.2 Operating Point at Lowest Pipeline Design Pressure: 241-AY ALTERNATIVE 3

The lowest design pressure is 230 psi (See Attachment A). This is equivalent to the following Head:

$$\Delta P_{DP} = 230 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$TDH_{DP} = \frac{\Delta P_{DP} \cdot 144 \cdot \frac{\text{in}^2}{\text{ft}^2}}{\rho}$$

$$TDH_{DP} = 354 \text{ ft}$$

From the above graph,

$$Q_{DP} = 123 \text{ gpm}$$

Therefore, the velocity in the 3 inch lines is as follows.

Velocity:

$$q_{DP} = \frac{Q_{DP} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{DP} = 0.27 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{DP_3in} = \frac{q_{DP}}{A_{3in}}$$

$$v_{DP_3in} = 5.3 \cdot \frac{\text{ft}}{\text{sec}}$$

ICF Kaiser Hanford

Calc. No. E44810-2703

Revision 0

Page No. 30 of 30

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for HLW

Date: 5/1/96

Feed from 241-AY Tanks (Alternative 3 and 4)

Checked: 5/27/96

Location: 200 East

Revised:

By: T.B. Salzano

By: *~Dd*

By:

6.3.3 Operating Point at Reynolds Number > 20,000: 241-AY ALTERNATIVE 4

This operating point occurs at a flow rate of 130 gpm. From the above graph,

$$Q_{Re} = 130 \text{ gpm}$$

$$TDH_{Re} = 390 \text{ ft}$$

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

Velocity:

$$q_{Re} = \frac{Q_{Re} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{Re} = 0.29 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{Re_3in} = \frac{q_{Re}}{A_{3in}}$$

$$v_{Re_3in} = 5.6 \cdot \frac{\text{ft}}{\text{sec}}$$

Pressure Drop:

$$\Delta P_{Re} = \frac{TDH_{Re} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}}$$

$$\Delta P_{Re} = 253 \cdot \frac{\text{lb}}{\text{in}^2}$$

6.3.4 Operating Point at Lowest Pipeline Design Pressure: 241-AY ALTERNATIVE 4

The lowest design pressure is 230 psi (See Attachment A). This is equivalent to the following Head:

$$\Delta P_{DP} = 230 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$TDH_{DP} = \frac{\Delta P_{DP} \cdot 144 \cdot \frac{\text{in}^2}{\text{ft}^2}}{\rho}$$

$$TDH_{DP} = 354 \cdot \text{ft}$$

From the above graph,

$$Q_{DP} = 122 \text{ gpm}$$

Therefore, the velocity in the 3 inch lines is as follows.

Velocity:

$$q_{DP} = \frac{Q_{DP} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{DP} = 0.27 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{DP_3in} = \frac{q_{DP}}{A_{3in}}$$

$$v_{DP_3in} = 5.3 \cdot \frac{\text{ft}}{\text{sec}}$$

add

HLW ALTERNATIVE 3

"NEW 3" LINES TO AX-B AND NEW
SN-650 VALVE PIT"

~172

HLW ALTERNATIVE 4

"NEW 3" LINES TO AX VALVE PITS
AND A-A TO VENDOR"

2" SL-503,504,505

(AY-FARM)

NOTE: ALL NOZZLES AT EL 675 UNLESS OTHERWISE NOTED

REFERENCES:

H-2-70764
H-2-64313
H-2-64314
B-131-C1

SUMMARY:

	SL-503	SL-504	SL-505
LENGTH	11 FT	116 FT	18 FT
3'R BENDS	2	4	2

DESIGN:

PRESSURE 400 PSIG
TEMP 200 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John N. Salzano* 4/5/96

2" SL-502

241-AX-B
VALVE PIT

REFERENCES:

H-2-69245
H-2-70763
H-2-70764
H-2-70780
B-131-C1

SUMMARY:

LENGTH	234.7 FT
3'R BENDS	5
COBs	1
REDUCERS	1

DESIGN:

PRESSURE	400 PSIG
TEMP	200 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *[Signature]* 4/5/96

3" SN-200/213

REFERENCES:

H-2-69244
H-2-69241
H-2-69240
H-2-69184
H-2-70397
H-2-69188
B-102-C1

SUMMARY:

LENGTH	617.8 FT
3'R BENDS	15
45 3'R	2

DESIGN:

PRESSURE	230 PSIG
TEMP	330 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: John N. Salzano 4/5/96

3" SN-201/214

REFERENCES:

H-2-69244
H-2-69241
H-2-69240
H-2-69184
H-2-70397
H-2-69188
B-102-C1

SUMMARY:

LENGTH 648.1 FT
3'R BENDS 17

DESIGN:

PRESSURE 230 PSIG
TEMP 330 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John N. Salzano* 4/5/96

3" SN-650

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John N. Salzano* 4/5/96

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 15 of 31

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for LLW

Date: 5/1/96

By: T.B. Salzano

Feed from 241-AN Tanks (Alternative 3 and 4)

Checked: 5/23/96

By: *WBS*

Location: 200 East

Revised:

By:

5.1.4 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 3Process Pit Losses:

$$h_1 := h_{\text{pump_pit}} + h_{\text{valve_pits}} \quad h_1 = 27 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{2\text{in}}^2}{2 \cdot g} \cdot \sum_{i=1}^3 K_i + \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=4}^6 K_i \quad h_2 = 456 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 58.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, \dots, 3$

$$\text{TDH}_{120_alt3} := \sum_i h_i \quad \text{TDH}_{120_alt3} = 542 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{120_alt3} = \frac{\text{TDH}_{120_alt3} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{120_alt3} = 352 \cdot \frac{\text{lb}}{\text{in}^2}$$

5.1.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 4Process Pit Losses:

$$h_1 := h_{\text{pump_pit}} + h_{\text{valve_pits}} \quad h_1 = 27 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=6}^8 K_i \quad h_2 = 173 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 58.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, \dots, 3$

$$\text{TDH}_{120_alt4} := \sum_i h_i \quad \text{TDH}_{120_alt4} = 259 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{120_alt4} = \frac{\text{TDH}_{120_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{120_alt4} = 168 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2708

Revision 0

Page No. 16 of 31

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *SD*

By:

5.2 100 GPM: 241-AN**5.2.1 Constant Data**

Volumetric Flow Rate,

$$Q_{100} := 100 \cdot \frac{\text{gal}}{\text{min}}$$

$$q := \frac{Q_{100} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q = 0.22 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

2 inch pipe

$$v_{2in} := \frac{q}{A_{2in}}$$

$$v_{2in} = 9.6 \cdot \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3in} := \frac{q}{A_{3in}}$$

$$v_{3in} = 4.3 \cdot \frac{\text{ft}}{\text{sec}}$$

Reynolds Number,

2 inch pipe

$$Re_{2in} := \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e}$$

$$Re_{2in} = 22928$$

3 inch pipe

$$Re_{3in} := \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e}$$

$$Re_{3in} = 15447$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe

$$f_{2in} := 0.027$$

$$f_{T2in} := 0.019$$

3 inch pipe

$$f_{3in} := 0.029$$

$$f_{T3in} := 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2708

Revision 0

Page No. 17 of 31

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *ndp*

By:

5.2.2 PROCESS PIT HEAD LOSSES**5.2.2.1 AN-Farm Pump Pit**10.0 ft - 3" Pipe Length: $L_1 = 10\text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.1$$

2 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 2 \quad K_2 = 2.2$$

2 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 2 \quad K_3 = 0.5$$

1 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 1 \quad K_4 = 1.1$$

Head Loss for pump pit:

$$h_{\text{pump pit}} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pump pit}} = 1.4 \text{ ft}$$

5.2.2.2 Valve Pits10.0 ft - 3" Pipe Length: $L_1 = 10\text{ ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.1$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pits}} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i \quad h_{\text{pits}} = 2.5 \text{ ft}$$

Head Loss for all seven valve pits:

$$h_{\text{valve pits}} = 7 \cdot h_{\text{pits}} \quad h_{\text{valve pits}} = 17.7 \text{ ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2708

Revision 0

Page No. 18 of 31

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *NDI*

By:

5.2.3 TRANSFER LINE HEAD LOSSES2" Pipe Length (Alternative 3):

$$L_{2in} := 389\text{-ft} + 530\text{-ft}$$

$$K_1 = f_{2in} \frac{L_{2in}}{D_{2in}} \quad K_1 = 144.1$$

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3):

$$N_{2in_bends} := 9 + 14$$

$$K_2 = (46 f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 20.1$$

Clean-Out Boxes (COB) (assume Tee - thru) (Alternative 3):

$$N_{COB} := 3 + 5$$

$$K_3 = (20 f_{T2in}) \cdot N_{COB} \quad K_3 = 3$$

3" Pipe Length (Alternative 3):

$$L_{3in} := 222\text{-ft} + 7\text{-ft} + 6\text{-ft} + 618\text{-ft} + 1334\text{-ft} + 235\text{-ft}$$

$$K_4 = f_{3in} \frac{L_{3in}}{D_{3in}} \quad K_4 = 274.7$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

$$N_{3in_bends} := 5 + 4 + 4 + 15 + 25 + 5$$

$$K_5 = (34 f_{T3in}) \cdot N_{3in_bends} \quad K_5 = 35.5$$

3" Pipe - 36" Radius 45 Bends (r/d=12):

$$K_6 := \left[(.5 - 1) \cdot \left[.25 \cdot \pi \cdot f_{T3in} \cdot 12 + .5 \cdot (34 \cdot f_{T3in}) \right] + 34 \cdot f_{T3in} \right] \cdot 2$$

$$K_6 = 0.7$$

3" Pipe Length (Alternative 4):

$$L_{3in} := 222\text{-ft} + 7\text{-ft} + 389\text{-ft} + 530\text{-ft} + 6\text{-ft} + 618\text{-ft} + 1334\text{-ft} + 235\text{-ft}$$

$$K_7 = f_{3in} \frac{L_{3in}}{D_{3in}} \quad K_7 = 379$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

$$N_{3in_bends} := 5 + 4 + 9 + 14 + 4 + 15 + 25 + 5$$

$$K_8 = (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_8 = 49.6$$

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 19 of 31

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/2/96

Revised:

By: T.B. Salzano

By: *NDT*

By:

5.2.4 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 3Process Pit Losses:

$$h_1 = h_{\text{pump_pit}} + h_{\text{valve_pits}} \quad h_1 = 19 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v^2}{2 \cdot g} \sum_{i=1}^3 K_i + \frac{v^2}{2 \cdot g} \sum_{i=4}^6 K_i \quad h_2 = 329 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 58.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, 3$

$$\text{TDH}_{100_alt3} := \sum_i h_i \quad \text{TDH}_{100_alt3} = 407 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{100_alt3} := \frac{\text{TDH}_{100_alt3} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{100_alt3} = 264 \cdot \frac{\text{lb}}{\text{in}^2}$$

5.2.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 4Process Pit Losses:

$$h_1 = h_{\text{pump_pit}} + h_{\text{valve_pits}} \quad h_1 = 19 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v^2}{2 \cdot g} \sum_{i=6}^8 K_i \quad h_2 = 126 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 58.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, 3$

$$\text{TDH}_{100_alt4} := \sum_i h_i \quad \text{TDH}_{100_alt4} = 204 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{100_alt4} := \frac{\text{TDH}_{100_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{100_alt4} = 132 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 20 of 31

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/22/96

Revised:

By: T.B. Salzano

By: *ND*

By:

5.3 80 GPM: 241-AN**5.3.1 Constant Data**

Volumetric Flow Rate,

$$Q_{80} = 80 \frac{\text{gal}}{\text{min}}$$

$$q = \frac{Q_{80} \cdot 0.13368 \frac{\text{ft}^3}{\text{gal}}}{60 \frac{\text{sec}}{\text{min}}}$$

$$q = 0.18 \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

2 inch pipe

$$v_{2in} = \frac{q}{A_{2in}}$$

$$v_{2in} = 7.6 \frac{\text{ft}}{\text{sec}}$$

3 inch pipe

$$v_{3in} = \frac{q}{A_{3in}}$$

$$v_{3in} = 3.5 \frac{\text{ft}}{\text{sec}}$$

Reynolds Number,

2 inch pipe

$$Re_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e}$$

$$Re_{2in} = 18343$$

3 inch pipe

$$Re_{3in} = \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e}$$

$$Re_{3in} = 12358$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

2 inch pipe

$$f_{2in} = 0.028$$

$$f_{T2in} = 0.019$$

3 inch pipe

$$f_{3in} = 0.03$$

$$f_{T3in} = 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 21 of 31

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *~D~*

By:

5.3.2 PROCESS PIT HEAD LOSSES**5.3.2.1 AN-Farm Pump Pit**10.0 ft - 3" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.2$$

2 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 2 \quad K_2 = 2.2$$

2 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 2 \quad K_3 = 0.5$$

1 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 1 \quad K_4 = 1.1$$

Head Loss for pump pit:

$$h_{\text{pump_pit}} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pump_pit}} = 0.9 \cdot \text{ft}$$

5.3.2.2 Valve Pits10.0 ft - 3" Pipe Length: $L_1 = 10\text{-ft}$

$$K_1 = f_{3in} \cdot \frac{L_1}{D_{3in}} \quad K_1 = 1.2$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3in}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3in}) \cdot 4 \quad K_3 = 1$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3in}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pits}} = \frac{v_{3in}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i \quad h_{\text{pits}} = 1.6 \cdot \text{ft}$$

Head Loss for all seven valve pits:

$$h_{\text{valve_pits}} = 7 \cdot h_{\text{pits}} \quad h_{\text{valve_pits}} = 11.4 \cdot \text{ft}$$

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 22 of 31

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for LLW

Date: 5/1/96

By: T.B. Salzano

Feed from 241-AN Tanks (Alternative 3 and 4)

Checked: 5/23/96

By: NDA

Location: 200 East

Revised:

By:

5.3.3 TRANSFER LINE HEAD LOSSES2" Pipe Length (Alternative 3):

$$L_{2in} = 389\text{ ft} + 530\text{ ft}$$

$$K_1 = f_{2in} \frac{L_{2in}}{D_{2in}} \quad K_1 = 149.4$$

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3):

$$N_{2in_bends} = 9 + 14$$

$$K_2 = (46 f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 20.1$$

Clean-Out Boxes (COB) (assume Tee - thru) (Alternative 3):

$$N_{COB} = 3 + 5$$

$$K_3 = (20 f_{T2in}) \cdot N_{COB} \quad K_3 = 3$$

3" Pipe Length (Alternative 3):

$$L_{3in} = 222\text{ ft} + 7\text{ ft} + 6\text{ ft} + 618\text{ ft} + 1334\text{ ft} + 235\text{ ft}$$

$$K_4 = f_{3in} \frac{L_{3in}}{D_{3in}} \quad K_4 = 284.2$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

$$N_{3in_bends} = 5 + 4 + 4 + 15 - 25 + 5$$

$$K_5 = (34 f_{T3in}) \cdot N_{3in_bends} \quad K_5 = 35.5$$

3" Pipe - 36" Radius 45 Bends (r/d=12):

$$K_6 = [(0.5 - 1) \cdot (.25 \pi f_{T3in} \cdot 12 + .5 (34 f_{T3in})) + 34 f_{T3in}] \cdot 2$$

$$K_6 = 0.7$$

3" Pipe Length (Alternative 4):

$$L_{3in} = 222\text{ ft} + 7\text{ ft} + 389\text{ ft} + 530\text{ ft} + 6\text{ ft} + 618\text{ ft} + 1334\text{ ft} + 235\text{ ft}$$

$$K_7 = f_{3in} \frac{L_{3in}}{D_{3in}} \quad K_7 = 392$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

$$N_{3in_bends} = 5 + 4 + 9 + 14 + 4 + 15 + 25 + 5$$

$$K_8 = (34 f_{T3in}) \cdot N_{3in_bends} \quad K_8 = 49.6$$

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 23 of 31

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for LLW

Date: 5/1/96

By: T.B. Salzano

Feed from 241-AN Tanks (Alternative 3 and 4)

Checked: 5/23/96

By: *NDA*

Location: 200 East

Revised:

By:

5.3.4 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 3Process Pit Losses:

$$h_1 := h_{\text{pump_pit}} + h_{\text{valve_pits}} \quad h_1 = 12 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{2in}^2}{2 \cdot g} \sum_{i=1}^3 K_i + \frac{v_{3in}^2}{2 \cdot g} \sum_{i=4}^6 K_i \quad h_2 = 217 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 58.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, 3$

$$\text{TDH}_{80_alt3} := \sum_i h_i \quad \text{TDH}_{80_alt3} = 288 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{80_alt3} := \frac{\text{TDH}_{80_alt3} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{80_alt3} = 187 \cdot \frac{\text{lb}}{\text{in}^2}$$

5.3.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 4Process Pit Losses:

$$h_1 := h_{\text{pump_pit}} + h_{\text{valve_pits}} \quad h_1 = 12 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{3in}^2}{2 \cdot g} \sum_{i=6}^8 K_i \quad h_2 = 83 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 58.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i := 1, 2, 3$

$$\text{TDH}_{80_alt4} := \sum_i h_i \quad \text{TDH}_{80_alt4} = 154 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{80_alt4} := \frac{\text{TDH}_{80_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{80_alt4} = 100 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2708

Revision 0

Page No. 24 of 31

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/22/96

Revised:

By: T.B. Salzano

By: *rvb*

By:

5.4 60 GPM: 241-AN**5.4.1 Constant Data**

Volumetric Flow Rate,

$$Q_{60} = 60 \frac{\text{gal}}{\text{min}}$$

$$q = \frac{Q_{60} \cdot 0.13368 \frac{\text{ft}^3}{\text{gal}}}{60 \frac{\text{sec}}{\text{min}}} \quad q = 0.13 \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

$$\text{2 inch pipe} \quad v_{2in} = \frac{q}{A_{2in}} \quad v_{2in} = 5.7 \frac{\text{ft}}{\text{sec}}$$

$$\text{3 inch pipe} \quad v_{3in} = \frac{q}{A_{3in}} \quad v_{3in} = 2.6 \frac{\text{ft}}{\text{sec}}$$

Reynolds Number,

$$\text{2 inch pipe} \quad Re_{2in} = \frac{D_{2in} \cdot v_{2in} \cdot \rho}{\mu_e} \quad Re_{2in} = 13757$$

$$\text{3 inch pipe} \quad Re_{3in} = \frac{D_{3in} \cdot v_{3in} \cdot \rho}{\mu_e} \quad Re_{3in} = 9268$$

Friction Factor (Ref. Crane, Page A-25 and A-26),

$$\text{2 inch pipe} \quad f_{2in} = 0.03 \quad f_{T2in} = 0.019$$

$$\text{3 inch pipe} \quad f_{3in} = 0.032 \quad f_{T3in} = 0.018$$

Bernoulli's Theorem,

$$z_1 + \frac{144 \cdot P_1}{\rho_1} + \frac{v_1^2}{2g} = z_2 + \frac{144 \cdot P_2}{\rho_2} + \frac{v_2^2}{2g} + h_L$$

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 25 of 31

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for LLW

Date: 5/1/96

Feed from 241-AN Tanks (Alternative 3 and 4)

Checked: 5/23/96

Location: 200 East

Revised:

By: T.B. Salzano

By: NDA

By:

5.4.2 PROCESS PIT HEAD LOSSES**5.4.2.1 AN-Farm Pump Pit**10.0 ft - 3" Pipe Length: $L_1 = 10 \cdot \text{ft}$

$$K_1 = f_{3\text{in}} \cdot \frac{L_1}{D_{3\text{in}}} \quad K_1 = 1.3$$

2 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3\text{in}}) \cdot 2 \quad K_2 = 2.2$$

2 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3\text{in}}) \cdot 2 \quad K_3 = 0.5$$

1 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3\text{in}}) \cdot 1 \quad K_4 = 1.1$$

Head Loss for pump pit:

$$h_{\text{pump_pit}} = \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i$$

$$h_{\text{pump_pit}} = 0.5 \cdot \text{ft}$$

5.4.2.2 Valve Pits10.0 ft - 3" Pipe Length: $L_1 = 10 \cdot \text{ft}$

$$K_1 = f_{3\text{in}} \cdot \frac{L_1}{D_{3\text{in}}} \quad K_1 = 1.3$$

4 - 3" Connectors (assume 90 Mitre Bend):

$$K_2 = (60 \cdot f_{T3\text{in}}) \cdot 4 \quad K_2 = 4.3$$

4 - 3" Long Radius Elbow:

$$K_3 = (14 \cdot f_{T3\text{in}}) \cdot 4 \quad K_3 = 1$$

2 - 3" 3-Way Ball Valve (assume 90 Mitre Bend):

$$K_4 = (60 \cdot f_{T3\text{in}}) \cdot 2 \quad K_4 = 2.2$$

$$\text{Head Loss for each pit: } h_{\text{pits}} = \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=1}^4 K_i \quad h_{\text{pits}} = 0.9 \cdot \text{ft}$$

Head Loss for all seven valve pits:

$$h_{\text{valve_pits}} = 7 \cdot h_{\text{pits}} \quad h_{\text{valve_pits}} = 6.4 \cdot \text{ft}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2708

Revision 0

Page No. 26 of 31

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *nda*

By:

5.4.3 TRANSFER LINE HEAD LOSSES**2" Pipe Length (Alternative 3):**

$$L_{2in} = 389 \text{ ft} + 530 \text{ ft}$$

$$K_1 = f_{2in} \cdot \frac{L_{2in}}{D_{2in}} \quad K_1 = 160.1$$

2" Pipe - 36" Radius Bends (r/d=18) (Alternative 3):

$$N_{2in_bends} = 9 + 14$$

$$K_2 = (46 \cdot f_{T2in}) \cdot N_{2in_bends} \quad K_2 = 20.1$$

Clean-Out Boxes (COB) (assume Tee - thru) (Alternative 3):

$$N_{COB} = 3 + 5$$

$$K_3 = (20 \cdot f_{T2in}) \cdot N_{COB} \quad K_3 = 3$$

3" Pipe Length (Alternative 3):

$$L_{3in} = 222 \text{ ft} + 7 \text{ ft} + 6 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 235 \text{ ft}$$

$$K_4 = f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_4 = 303.1$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 3):

$$N_{3in_bends} = 5 + 4 + 4 + 15 + 25 + 5$$

$$K_5 = (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_5 = 35.5$$

3" Pipe - 36" Radius 45 Bends (r/d=12):

$$K_6 = [(1.5 - 1) \cdot (.25 \cdot \pi \cdot f_{T3in} \cdot 12 - .5 \cdot (34 \cdot f_{T3in})) + 34 \cdot f_{T3in}] \cdot 2$$

$$K_6 = 0.7$$

3" Pipe Length (Alternative 4):

$$L_{3in} = 222 \text{ ft} + 7 \text{ ft} + 389 \text{ ft} + 530 \text{ ft} + 6 \text{ ft} + 618 \text{ ft} + 1334 \text{ ft} + 235 \text{ ft}$$

$$K_7 = f_{3in} \cdot \frac{L_{3in}}{D_{3in}} \quad K_7 = 418.2$$

3" Pipe - 36" Radius Bends (r/d=12) (Alternative 4):

$$N_{3in_bends} = 5 + 4 + 9 + 14 + 4 + 15 + 25 + 5$$

$$K_8 = (34 \cdot f_{T3in}) \cdot N_{3in_bends} \quad K_8 = 49.6$$

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 27 of 31

DESIGN ANALYSIS

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: NDA

By:

5.4.4 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 3Process Pit Losses:

$$h_1 := h_{\text{pump_pit}} + h_{\text{valve_pits}} \quad h_1 = 7 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{2\text{in}}^2}{2 \cdot g} \cdot \sum_{i=1}^3 K_i + \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=4}^6 K_i \quad h_2 = 129 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 58.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, \dots, 3$

$$\text{TDH}_{60_alt3} := \sum_i h_i \quad \text{TDH}_{60_alt3} = 195 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{60_alt3} := \frac{\text{TDH}_{60_alt3} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{60_alt3} = 127 \cdot \frac{\text{lb}}{\text{in}^2}$$

5.4.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 4Process Pit Losses:

$$h_1 := h_{\text{pump_pit}} + h_{\text{valve_pits}} \quad h_1 = 7 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{3\text{in}}^2}{2 \cdot g} \cdot \sum_{i=6}^8 K_i \quad h_2 = 49 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 58.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, \dots, 3$

$$\text{TDH}_{60_alt4} := \sum_i h_i \quad \text{TDH}_{60_alt4} = 115 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{60_alt4} := \frac{\text{TDH}_{60_alt4} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{60_alt4} = 75 \cdot \frac{\text{lb}}{\text{in}^2}$$

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2708

Revision 0

Page No. 28 of 31

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/2/96

Revised:

By: T.B. Salzano

By: *nd#*

By:

6.0 SYSTEM CURVE

The system curve can now be generated. The curve will be used to determine different possible operating points for the system. A pump could then be selected to meet the needed operating requirements. The main operating points to be considered are at a Reynolds number of 20,000 and at the design pressure limit of the system.

6.1 SYSTEM CURVE DATA: 241-AN

The system curve for the 241-AN-104 Tank transfers to the 241-AP-102 Feed Staging Tank can now be generated.

Flow Rate:

$$Q := \begin{bmatrix} Q_{60} \\ Q_{80} \\ Q_{100} \\ Q_{120} \\ Q_{140} \end{bmatrix}$$

Total Head:

$$TDH_{an_alt3} = \begin{bmatrix} TDH_{60_alt3} \\ TDH_{80_alt3} \\ TDH_{100_alt3} \\ TDH_{120_alt3} \\ TDH_{140_alt3} \end{bmatrix} \quad TDH_{an_alt4} = \begin{bmatrix} TDH_{60_alt4} \\ TDH_{80_alt4} \\ TDH_{100_alt4} \\ TDH_{120_alt4} \\ TDH_{140_alt4} \end{bmatrix}$$

ICF Kaiser Hanford

DESIGN ANALYSIS

Calc. No. E44810-2708

Revision 0

Page No. 29 of 31

Client: WHC

Subject: Head Loss Calculations for LLW

Feed from 241-AN Tanks (Alternative 3 and 4)

Location: 200 East

WO/Job No. E44810

Date: 5/1/96

Checked: 5/23/96

Revised:

By: T.B. Salzano

By: *WJA*

By:

6.2 SYSTEM CURVE

$i = 0.4$

LLW Transfers from 241-AN-104 to 241-AP-104 (Alternative 3 and 4)

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 30 of 31

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for LLW

Date: 5/1/96

Feed from 241-AN Tanks (Alternative 3 and 4)

Checked: *5/2/96*

Location: 200 East

Revised:

By: T.B. Salzano

By: *WTD*

By:

6.3 SPECIFIC POINTS**6.3.1 Operating Point at Reynolds Number > 20,000: 241-AN ALTERNATIVE 3**

This operating point occurs at a flow rate of 130 gpm. From the above graph,

$$Q_{Re} = 130 \text{ gpm}$$

$$TDH_{Re} = 630 \text{ ft}$$

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

Velocity:

$$q_{Re} = \frac{Q_{Re} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{Re} = 0.29 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{Re_3in} = \frac{q_{Re}}{A_{3in}}$$

$$v_{Re_3in} = 5.6 \cdot \frac{\text{ft}}{\text{sec}}$$

Pressure Drop:

$$\Delta P_{Re} = \frac{TDH_{Re} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}}$$

$$\Delta P_{Re} = 409 \cdot \frac{\text{lb}}{\text{in}^2}$$

6.3.2 Operating Point at Lowest Pipeline Design Pressure: 241-AN ALTERNATIVE 3

The lowest design pressure is 230 psi (See Attachment A). This is equivalent to the following

Head:

$$\Delta P_{DP} = 230 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$TDH_{DP} = \frac{\Delta P_{DP} \cdot 144 \cdot \frac{\text{in}^2}{\text{ft}^2}}{\rho}$$

$$TDH_{DP} = 354 \cdot \text{ft}$$

From the above graph,

$$Q_{DP} = 91 \text{ gpm}$$

Therefore, the velocity in the 3 inch lines is as follows.

Velocity:

$$q_{DP} = \frac{Q_{DP} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{DP} = 0.2 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{DP_3in} = \frac{q_{DP}}{A_{3in}}$$

$$v_{DP_3in} = 3.9 \cdot \frac{\text{ft}}{\text{sec}}$$

ICF Kaiser Hanford

Calc. No. E44810-2708

Revision 0

Page No. 31 of 31

DESIGN ANALYSIS

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for LLW

Date: 5/1/96

By: T.B. Salzano

Feed from 241-AN Tanks (Alternative 3 and 4)

Checked: 5/23/96

By: NDA

Location: 200 East

Revised:

By:

6.3.3 Operating Point at Reynolds Number > 20,000: 241-AN ALTERNATIVE 4

This operating point occurs at a flow rate of 130 gpm. From the above graph,

$$Q_{Re} = 130 \text{ gpm}$$

$$TDH_{Re} = 295 \text{ ft}$$

Therefore, the pressure drop and velocity in the 3 inch lines are as follows.

Velocity:

$$q_{Re} = \frac{Q_{Re} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}}$$

$$q_{Re} = 0.29 \cdot \frac{\text{ft}^3}{\text{sec}}$$

$$v_{Re_3in} = \frac{q_{Re}}{A_{3in}}$$

$$v_{Re_3in} = 5.6 \cdot \frac{\text{ft}}{\text{sec}}$$

Pressure Drop:

$$\Delta P_{Re} = \frac{TDH_{Re} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}}$$

$$\Delta P_{Re} = 192 \cdot \frac{\text{lb}}{\text{in}^2}$$

6.3.4 Operating Point at Lowest Pipeline Design Pressure: 241-AN ALTERNATIVE 4

The lowest design pressure is 230 psi (See Attachment A). The operating point of this system at the minimum Reynolds of 20,000 is below this design pressure requirement.

LLW ALTERNATIVE 3"NEW SN-650 VALVE PIT"

LLW ALTERNATIVE 4
"NEW 3" LINE AND VALVE PIT"

3" SN-264

(AN-FARM)

241-AN-04A
PUMP PIT

241-AN-A
VALVE PIT

126'

26.5'

EL 666.2

25.3'

REFERENCES:

H-2-71986
H-2-71987
H-2-71989
H-2-71994
H-2-71998
B-130-C7

SUMMARY:

LENGTH 221.4 FT
3'R BENDS 5

DESIGN:

PRESSURE 275 PSIG
TEMP 340 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John W. DeLoach* 9/5/96

2" SL-160

REFERENCES:

H-2-71989
H-2-71986
H-2-71987
H-2-70765
B-130-C7

SUMMARY:

LENGTH 388.6 FT
3'R BENDS 9
COBs 3

DESIGN:

PRESSURE 400 PSIG
TEMP 340 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *[Signature]*

2" SL-500

REFERENCES:

H-2-70765
H-2-70763
B-131-C1

SUMMARY:

LENGTH 529.3 FT
3'R BENDS 14
COBs 5

DESIGN:

PRESSURE 400 PSIG
TEMP 340 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: *John V. Salzano* 4/5/96

3" SN-200/213

REFERENCES:

H-2-69244
H-2-69241
H-2-69240
H-2-69184
H-2-70397
H-2-69188
B-102-C1

SUMMARY:

LENGTH	617.8 FT
3'R BENDS	15
45 3'R	2

DESIGN:

PRESSURE	230 PSIG
TEMP	330 °F

PREPARED BY: T.B. SALZANO 4/5/96

CHECKED BY: John V. Salzano 4/15/96

3" SN-650

This page intentionally left blank.

APPENDIX B

JUMPER MANIFOLD DESIGN

This page intentionally left blank.

APPENDIX B

JUMPER MANIFOLD DESIGN

B1.0 INTRODUCTION

The increase in the number of transfers to support Phase I privatization, 242-A Evaporator campaigns, and tank farm operations will require the elimination of the jumper changes to configure a new transfer route. Under the current operational mode, each time a different waste transfer route is required, valve pit cover blocks are removed, an individual jumper is physically disconnected, a different jumper is installed and the desired waste transfer piping configuration is obtained. The cover blocks are then reinstalled and operations proceed. This method of aligning waste transfer piping requires entry into the valve pits exposing workers to high radiation levels and is very expensive.

To support the schedule and flexibility requirements needed for the Phase I privatization transfer system, valve manifolds designs have been provided. These designs support the recommended low-level waste and high-level waste options. Installation of jumper manifolds will benefit regular double-shell tanks (DSTs) waste transfer operations, current and future evaporator campaigns and future waste management and retrieval operations.

B2.0 JUMPER MANIFOLDS

Jumper manifold designs are provided to support waste transfer operations in the following process pits: The 241-AN-A Valve Pit (VP), the 241-AN-B VP, the 241-AZ-02A Pump Pit, the 241-AX-A VP, the 241-AX-B VP, the 241-A-A VP, and the 241-A-B VP. Project W-454 is currently responsible for providing jumper manifolds for the 241-AW-A VP and 241-AW-B VP. The manifolds are constructed of stainless steel valves and piping to facilitate decontamination and to ensure long-term reliability. The manifolds provide all necessary waste routing configurations by manual operation of valve handles that would extend through the pit cover blocks. The seven jumper manifold designs are shown in Figures B2-1 through B2-7. Figure B2-8 shows an isometric of the 241-AN-A VP manifold.

The jumper manifold designs provide the following:

- Two-valve isolation from piping outside the desired flow path.
- Avoid trapping of liquids.
- The ability to cross-connect the slurry and supernate transfer piping lines.
- The ability to flush all flow paths.

New cover blocks would be required on each of the process pits. The new cover blocks will accept the valve operating extension handles.

B3.0 COST

The cost estimate for each of the jumper manifold designs include the cost for decontamination, removal and disposal of the existing pit jumpers, and new cover blocks. The total estimated cost for the seven jumper manifolds is \$6.8 million. The detail cost estimate is provided in Appendix C. Table B3-1 shows the cost of the jumper manifolds per process pit.

Table B3-1. Jumper Manifold Cost per Process Pit.

Process pit	Cost estimate (\$ million)
241-AN-A Valve Pit (VP)	\$1.08
241-AN-B VP	\$1.08
241-AZ-02A Pump Pit	\$0.62
241-AX-A VP	\$0.96
241-AX-B VP	\$0.96
241-A-A VP	\$1.07
241-A-B VP	\$1.04
Total	\$6.81

Figure B2-1. 241-AN-A Valve Pit Arrangement.

NORTH
→

[illegible]

Figure B2-2. 241-AN-B
Valve Pit Arrangement.

LEGEND

- EXISTING TRANSFER PIPING
- NEW TRANSFER PIPING OR JUMPER COMPONENT
- PUREX REMOTE HORIZONTAL CONNECTOR
- PUREX REMOTE VERTICAL CONNECTOR
- PUREX REMOTE HORIZONTAL NOZZLE W/ KICK PLATE
- PUREX REMOTE VERTICAL NOZZLE W/ KICK PLATE
- BALL VALVE
- BALL VALVE 3-WAY
- REDUCER
- ENCASUREMENT

241-AN-B
VALVE PIT ARRANGEMENT

B-7/B-8

DESIGNED: D.O. DOUGHERTY CHECKED: [blank] DATE: [blank]		U.S. DEPARTMENT OF ENERGY HIGH-LEVEL OPERATIONS OFFICE ICF Kaiser, Hanford Company 241-AN-B VALVE PIT ARRANGEMENT	
PROJECT: [blank] DRAWING NO.: [blank]		SCALE: 3/4" = 1'-0" SHEET: 1 OF 1	

Figure B2-3. Piping Arrangement
241-AZ-02A Pump Pit.

B-9/B-10

PLAN (SHOWN WITH COVER BLOCKS REMOVED)

SCALE: 3/4\"=1'-0"

NOTE:
FOR EXISTING PIPING SEE DRAWING W-2-64-353
AND W-2-10725

PROJECT	U.S. DEPARTMENT OF ENERGY
CLIENT	Kaiser Engineers, Inc.
DESIGN	ENGINEERS
DATE	241-AZ-02A PUMP PIT
REVISION	ARRANGEMENT
NO.	FIGURE B2-3.0
BY	W. J. WOOD
CHECKED	W. J. WOOD
DATE	11/11/77
SCALE	1\"=1'-0"

2 PLOT SCALE: 1/16\"=1'-0"

KEMCAD

Figure B2-4. 241-AX-A
Valve Pit Arrangement.

LEGEND

- EXISTING TRANSFER PIPING
NEW TRANSFER PIPING OR JUMPER COMPONENT
- PURGE REMOTE HORIZONTAL CONNECTOR
PURGE REMOTE VERTICAL CONNECTOR
PURGE REMOTE HORIZONTAL NOZZLE
PURGE REMOTE VERTICAL NOZZLE
W/ KICK PLATE
BALL VALVE
BALL VALVE 3-WAY
REDUCER
ENGAGEMENT

241-AX-A
VALVE PIT ARRANGEMENT

B-11/B-12

U.S. DEPARTMENT OF ENERGY		PROJECT NUMBER	
NUCLEAR REGULATORY COMMISSION		DATE	
INTEGRAL BRIDGE COMPANY		DRAWING NUMBER	
241-AX-A		REVISION	
VALVE PIT ARRANGEMENT		SCALE	
FIGURE B2-4.10		SHEET NO.	
F		TOTAL SHEETS	
3/4" = 1'-0"		PROJECT NUMBER	
2		SHEET NO.	
PLOT SCALE 1:116		DATE	
2		TOTAL SHEETS	
KENDAO		PROJECT NUMBER	

1

2

3

4

5

6

7

8

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

25

26

27

28

29

30

31

32

33

34

35

36

37

38

39

40

Figure B2-5. 241-AX-B
Valve Pit Arrangement.

LEGEND

- EXISTING TRANSFER PIPING
- - - NEW TRANSFER PIPING OR JUMPER COMPONENT
- PUREX REMOTE HORIZONTAL CONNECTOR
- PUREX REMOTE VERTICAL CONNECTOR
- PUREX REMOTE HORIZONTAL NOZZLE W/ KICK PLATE
- PUREX REMOTE VERTICAL NOZZLE W/ KICK PLATE
- BALL VALVE
- BALL VALVE 3-WAY
- REDUCER
- ENCASEMENT

241-AX-B
VALVE PIT ARRANGEMENT

B-13/B-14

PRELIMINARY	
U.S. DEPARTMENT OF ENERGY HIGHLAND OPERATIONS OFFICE ICF Kaiser, Hanford, Company	
241-AX-B VALVE PIT ARRANGEMENT	
TANK FARM RESTORATION AND SAFE OPERATIONS	
FIGURE B2-5.0	FIGURE B2-5.0
3/4" x 11-0"	3/4" x 11-0"
1	1

WHC-SD-WM-TI-750
Revision 0

Figure B2-6. 241-A-A
Valve Pit Arrangement.

LEGEND

- EXISTING TRANSFER PIPING
- NEW TRANSFER PIPING OR JUMPER COMPONENT
- PURGE REMOTE HORIZONTAL CONNECTOR
- PURGE REMOTE VERTICAL CONNECTOR
- PURGE REMOTE HORIZONTAL NOZZLE
- PURGE REMOTE VERTICAL NOZZLE
- W/ KICK PLATE
- BALL VALVE
- BALL VALVE 3-WAY
- REDUCER
- ENCLOSURE

B-15/B-16

241-A-A
VALVE PIT ARRANGEMENT

U.S. DEPARTMENT OF ENERGY FOR NUCLEAR WASTE MANAGEMENT	
241-A-A VALVE PIT ARRANGEMENT	
FIGURE B2-6.10	
2. PLOT SCALE: 1"=1' K&C/O	

WHC-SD-WM-TI-750
Revision 0

Revision 0

Figure B2-7. 241-A-B Valve Pit Arrangement.

EXISTING TRANSFER PIPING

NEW TRANSFER PIPING OR JUMPER COMPONENT

PUREX REMOTE HORIZONTAL CONNECTOR

PUREX REMOTE VERTICAL CONNECTOR

PUREX REMOTE HORIZONTAL NOZZLE

PURDY REMOTE VERTICAL NOZZLE

ALL VALVE JET

Figure 8

© 2004 Blackwell Publishing Ltd *Journal of Internal Medicine* 255: 105–112

B-17/B-18

241-A-B
VALVE PIT ARRANGEMENT

[illegible]

Figure B2-8. 241-AN-A
Valve Pit Isometric.

B-19/B-20

Designer: D.O. DOUGHERTY Date: 10/1/80 Project: 241-AN-A Title: VALVE PIT ISOMETRIC		PRELIMINARY
U.S. DEPARTMENT OF ENERGY RICHMOND OPERATIONS OFFICE 101 KAISER HANFORD COMPANY		
241-AN-A VALVE PIT ISOMETRIC		
TANK FARM RESTORATION AND SAFE OPERATIONS		
FIGURE B2-8		

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA5/P4W000
FILE NO. Z394SAA5

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 5
DOE_R07 - ONSITE INDIRECT COSTS BY WBS

PAGE 7 OF 7
DATE 04/21/96 14:19:51
BY BAL

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	CONTRACT ADMINISTRATION % TOTAL	BID PACK PREP.	OTHER INDIRECTS	TOTAL INDIRECTS
=====	=====	=====	=====	=====	=====	=====
110100	TITLE I, II & III	500000	0.00	0	0	0
310100	GENERAL REQUIREMENTS	50000	0.00	0	0	0
310101	TRENCH EXCAVATION	465819	0.00	0	0	0
310201	CORE DRILL	93214	0.00	0	0	0
310301	SHOP FAB PIPE	110754	0.00	0	0	0
310302	FIELD INSTALL PIPE	215747	0.00	0	0	0
310401	CATHODIC PROTECTION	121462	0.00	0	0	0
401000	PROJECT MANAGEMENT	130000	0.00	0	0	0
501000	OPC ACTIVITIES	400000	0.00	0	0	0

PROJECT TOTAL		2,086,996		0	0	0

C-24

WHC-SD-WM-JT-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA6/P4W000
FILE NO. Z394SAA6

** TEST - INTERACTIVE ESTIMATING **
PHASE 1 PRIVATIZATION ALTERNATIVES
STUDY - OPTION 6
DOE_R01 - PROJECT COST SUMMARY

PAGE 1 OF 7
DATE 04/21/96 14:41:24
BY BAL

COST CODE	DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY % TOTAL	TOTAL DOLLARS
000	ENGINEERING	390,000	35	530,000
060	PROJECT MANAGEMENT (ADJUSTED TO MEET DOE 5100.4)	100,000 10,000	35	140,000 20,000 30,000
TOTAL DESIGN & MANAGEMENT		500,000	40	700,000
460	IMPROVEMENTS TO LAND	1,010,000	35	1,360,000
700	SPECIAL EQUIP/PROCESS SYSTEMS (ADJUSTED TO MEET DOE 5100.4)	50,000 40,000	35	70,000 70,000
TOTAL CONSTRUCTION		1,100,000	36	1,500,000
TOTAL ESTIMATED CONSTRUCTION COST (TECC)		1,600,000	38	2,200,000
900	OTHER PROJECT COSTS (ADJUSTED TO MEET DOE 5100.4)	320,000 20,000	35	430,000 30,000
TOTAL OTHER PROJECT COSTS (OPC)		300,000	33	400,000
TOTAL PROJECT COST		1,900,000	37	2,600,000

C-25

WHC-SD-WM-TT-750
Revision 0

TYPE OF ESTIMATE	STUDY	APRIL 21, 1996	REMARKS:
ARCHITECT ENGINEER			CHECK
OPERATING CONTRACTOR			

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. 2394SAA6/P4W000
FILE NO. 2394SAA6

** TEST - INTERACTIVE ESTIMATING **
PHASE 1 PRIVATIZATION ALTERNATIVES
STUDY - OPTION 6
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

PAGE 2 OF 7
DATE 04/21/96 14:41:34
BY BAL

WBS DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
110100 TITLE I, II & III	390000	0	390000	0.00	0	390000	526500
SUBTOTAL 1 TITLE I, II & III DESIGN	390000	0	390000	0.00	0	390000	526500
310100 GENERAL REQUIREMENTS	10000	0	10000	0.00	0	3500	13500
310101 HAND EXCAV TRENCH	57739	0	57739	0.00	0	35	77948
310301 PIPE INSTALL	85303	0	85303	0.00	0	35	115159
310302 VALVE PIT TIE-IN	38607	0	38607	0.00	0	35	52119
310401 CATHODIC PROTECTION	51395	0	51395	0.00	0	35	69383
SUBTOTAL 31 ONSITE E/C	243044	0	243044	0.00	0	85065	328109
320101 MACH EXCAV TRENCH	82377	31884	114261	0.00	0	35	154252
320102 HAND EXCAV TRENCH	73873	21866	95739	0.00	0	35	129248
320301 FAB & INSTALL PIPE	469255	138899	608154	0.00	0	35	821009
SUBTOTAL 32 FP CONSTRUCTION	625505	192649	818154	0.00	0	35	1104509
SUBTOTAL 3 CONSTRUCTION	868549	192649	1061198	0.00	0	35	1432618
401000 PROJECT MANAGEMENT	100000	0	100000	0.00	0	35	135000
SUBTOTAL 4 WMC PROJECT MANAGEMENT	100000	0	100000	0.00	0	35	135000
501000 OPC ACTIVITIES	320000	0	320000	0.00	0	35	432000
SUBTOTAL 5 OPC ACTIVITIES	320000	0	320000	0.00	0	35	432000
PROJECT TOTAL	1,678,549	192,649	1,871,198	0.00	0	35	2,526,118

C-26

WMC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA6/P4W000
FILE NO. Z394SAA6

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 4
DOE_R03 - ESTIMATE BASIS SHEET

PAGE 3 OF 7
DATE 04/09/96 11:51:54
BY BAL

1. DOCUMENTS AND DRAWINGS

DOCUMENTS: DSI FROM T. SALZANO REQUESTING ESTIMATES FOR PHASE I PRIVATIZATION ALTERNATIVES DATED 3/20/96.

DRAWINGS: ATTACHMENT A, B & C TO DSI.

2. LABOR RATES

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEH FINANCE (EFFECTIVE 3-08-96). SEE ALSO THE FY 1996 PLANNING RATES B (REPORT BGHB7012).

B.) BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, TRAVEL, DEPARTMENTAL OVERHEADS AND G&A/SWS.

SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

3. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (BGHB) LOCATED ON HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK. THE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "ON&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEH SUMMARY REPORT DOE_R07, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL)

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "ON&P/B&I" COLUMN OF THE ESTIMATE DETAIL:
LABOR - 30% MATERIAL - 30% EQUIPMENT USAGE - 0% EQUIPMENT - 0% SUBCONTRACTS - 10%

4. ESCALATION

ESCALATION PERCENTAGES WERE CALCULATED FROM THE JANUARY 1996 UPDATE OF THE ECONOMIC ESCALATION PRICE CHANGE INDICES FOR DOE CONSTRUCTION PROJECTS AS PUBLISHED BY THE "OFFICE OF INFRASTRUCTURE ACQUISITION" FM-50.

5. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (N), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE 1-11, DATED 10-31-84.

6. REMARKS

A.) ESTIMATE IS IN FY 96 DOLLARS. NO ESCALATION WAS APPLIED AS A SCHEDULE FOR THIS WORK IS UNKNOWN.

B.) WORK IS ASSUMED TO BE ALL VALVE PIT TIE-INS PER DESIGN AND NO BURNOUT WAS APPLIED AS RADIOLOGICAL CONDITIONS WERE UNKNOWN.

C.) 150 FEET OF LINE WAS INSTALLED BY THE ONSITE E/C AND REMAINING 2850 FEET BY FIXED PRICE CONTRACTOR.

D.) THE FIXED PRICE CONTRACTOR WILL SUPPLY ONSITE E/C WITH MATERIAL REQUIRED TO COMPLETE PIPE RUN INSIDE THE FARM.

E.) ASSUME THAT LAST 1000 FEET OF PIPE RUN IS TO BE BERNED AND REMAINING 1850 FEET (TOWARDS FARM) TO BE EXCAVATED.

F.) 89 CY OF EXCAVATED EARTH IN FARM WILL BE SPREAD ABOUT THE FARM.

G.) INSTALL 3"/6" ENCASED LINE FROM 241-A-8 VALVE PIT TO THE VENDOR.

C-27

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA6/P4W000
FILE NO. Z394SAA6

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 2
DOE_R04 - COST CODE ACCOUNT SUMMARY

PAGE 4 OF 7
DATE 04/21/96 14:41:45
BY BAL

COST CODE/UBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
000	ENGINEERING							
110100	TITLE I, II & III	390000	0	390000	0.00	0	390000 35	136500 526500
	TOTAL 000 ENGINEERING	390000	0	390000	0.00	0	390000 35	136500 526500
060	PROJECT MANAGEMENT							
401000	PROJECT MANAGEMENT	100000	0	100000	0.00	0	100000 35	35000 135000
	TOTAL 060 PROJECT MANAGEMENT	100000	0	100000	0.00	0	100000 35	35000 135000
460	IMPROVEMENTS TO LAND							
310100	GENERAL REQUIREMENTS	10000	0	10000	0.00	0	10000 35	3500 13500
310101	HAND EXCAV TRENCH	57739	0	57739	0.00	0	57739 35	20209 77948
310301	PIPE INSTALL	85303	0	85303	0.00	0	85303 35	29856 115159
310302	VALVE PIT TIE-IN	38607	0	38607	0.00	0	38607 35	13512 52119
320101	HAND EXCAV TRENCH	82377	31884	114261	0.00	0	114261 35	39991 154252
320102	HAND EXCAV TRENCH	73873	21866	95739	0.00	0	95739 35	33509 129248
320301	FAB & INSTALL PIPE	469255	158899	628154	0.00	0	628154 35	212854 821009
	TOTAL 460 IMPROVEMENTS TO LAND	817154	192649	1009803	0.00	0	1009803 35	353431 1363235
700	SPECIAL EQUIP/PROCESS SYSTEMS							
310401	CATHODIC PROTECTION	51395	0	51395	0.00	0	51395 35	17988 69383
	TOTAL 700 SPECIAL EQUIP/PROCESS SYSTEM	51395	0	51395	0.00	0	51395 35	17988 69383
900	OTHER PROJECT COSTS							
501000	OPC ACTIVITIES	320000	0	320000	0.00	0	320000 35	112000 432000
	TOTAL 900 OTHER PROJECT COSTS	320000	0	320000	0.00	0	320000 35	112000 432000
PROJECT TOTAL		1,678,549	192,649	1,871,198	0.00	0	1,871,198 35	654,919 2,526,118

C-28

WHS-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA6/P4W000
FILE NO. Z394SAA6

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 6
DOE_R05 - ESTIMATE SUMMARY BY CSI DIVISION

PAGE 5 OF 7
DATE 04/21/96 14:41:55
BY BAL

CSI DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
ENGINEERING							
00 TECHNICAL SERVICES	390000	0	390000	0.00	0	390000	526500
TOTAL ENGINEERING	390,000	0	390,000	0.00	0	390,000	526,500
CONSTRUCTION							
01 GENERAL REQUIRMENTS	10000	0	10000	0.00	0	10000	13500
02 SITEWORK	213989	53750	267739	0.00	0	267739	361448
15 MECHANICAL	593165	138899	732064	0.00	0	732064	988287
16 ELECTRICAL	51395	0	51395	0.00	0	51395	69383
99 WMC LABOR	420000	0	420000	0.00	0	420000	567000
TOTAL CONSTRUCTION	1,288,549	192,649	1,481,198	0.00	0	1,481,198	1,999,618
PROJECT TOTAL	1,678,549	192,649	1,871,198	0.00	0	1,871,198	2,526,118

C-29

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA6/P4W000
FILE NO. Z394SAA6

•• IEST - INTERACTIVE ESTIMATING ••
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 6
DOE_R06 - CONTINGENCY ANALYSIS BASIS SHEET

PAGE 6 OF 7
DATE 04/19/96 17:20:08
BY BAL

REFERENCE: ESTIMATE BASIS SHEET
COST CODE ACCOUNT SUMMARY

PAGE 3 OF 7
PAGE 4 OF 7

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

000 ENGINEERING

110100 TITLE I, II & III DESIGN

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR DESIGN AND A DETAILED PLANNING EFFORT HAS NOT BEEN PERFORMED TO IDENTIFY ALL DISCIPLINE INVOLVED.

060 PROJECT MANAGEMENT

401000 PROJECT MANAGEMENT

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR WMC PROJECT MANAGEMENT AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

460 IMPROVEMENTS TO LAND

310100 GENERAL REQUIREMENTS

310101 HAND EXCAV TRENCH

310301 PIPE INSTALL

310302 VALVE PIT TIE-IN

320101 MACH EXCAV TRENCH

320102 HAND EXCAV TRENCH

320301 FAB & INSTALL PIPE

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

700 SPECIAL EQUIP/PROCESS SYSTEMS

310401 CATHODIC PROTECTION

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

900 OTHER PROJECT COSTS

501000 OPC ACTIVITIES

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR WMC OPC ACTIVITIES AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

C-30

T

WHS-SD-WM-TL-750
Revision 0

ICF KAISER HANFORD
 WESTINGHOUSE HANFORD COMPANY
 JOB NO. Z394SAA6/P4W000
 FILE NO. Z394SAA6

** TEST - INTERACTIVE ESTIMATING **
 PHASE I PRIVATIZATION ALTERNATIVES
 STUDY - OPTION 6
 DOE_R07 - ONSITE INDIRECT COSTS BY WBS

PAGE 7 OF 7
 DATE 04/21/96 14:42:04
 BY BAL

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	CONTRACT X	ADMINISTRATION TOTAL	BID PACK PREP.	OTHER INDIRECTS	TOTAL INDIRECTS
*****	*****	*****	*****	*****	*****	*****	*****
110100	TITLE I, II & III	390000	0.00	0	0	0	0
310100	GENERAL REQUIREMENTS	10000	0.00	0	0	0	0
310101	HAND EXCAV TRENCH	57739	0.00	0	0	0	0
310301	PIPE INSTALL	85303	0.00	0	0	0	0
310302	VALVE PIT TIE-IN	38607	0.00	0	0	0	0
310401	CATHODIC PROTECTION	51395	0.00	0	0	0	0
320101	MACH EXCAV TRENCH	82377	29.60	24384	7500	0	31884
320102	HAND EXCAV TRENCH	73873	29.60	21866	0	0	21866
320301	FAB & INSTALL PIPE	469255	29.60	138899	0	0	138899
401000	PROJECT MANAGEMENT	100000	0.00	0	0	0	0
501000	OPC ACTIVITIES	320000	0.00	0	0	0	0

PROJECT TOTAL		1,678,549		185,149	7,500	0	192,649

C-31

WHC-SD-WM-TI-750
 Revision 0

KAISER ENGINEERS HANFORD
J.R. NICHOLSON
JOB NO. Z397SAA2

** TEST - INTERACTIVE ESTIMATING **
PHASE I - PRIVATIZATION STUDY
S T U D Y
DOE_R01 - PROJECT COST SUMMARY

PAGE 1 OF 10
DATE 04/26/96
BY TLW

COST CODE	DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY %	TOTAL	TOTAL DOLLARS
010	ENGINEERING - TITLE 1, II & III	2,860,000	35	1,000,000	3,860,000
060	PROJECT MANAGEMENT (ADJUSTED TO MEET DOE 5100.4)	730,000 10,000	35	260,000 40,000	990,000 50,000
TOTAL DESIGN AND MANAGEMENT		3,600,000	35	1,300,000	4,900,000
700	SPECIAL EQUIP/PROCESS SYSTEMS	5,900,000	35	2,060,000	7,960,000
810	DENOLITION (ADJUSTED TO MEET DOE 5100.4)	190,000 10,000	35	70,000 (30,000)	260,000 (20,000)
TOTAL CONSTRUCTION COST		6,100,000	35	2,100,000	8,200,000
TOTAL ESTIMATED CONSTRUCTION COST (TECC)		9,700,000	35	3,400,000	13,100,000
900	OTHER PROJECT COST (ADJUSTED TO MEET DOE 5100.4)	2,300,000	35	810,000 (10,000)	3,110,000 (10,000)
TOTAL OTHER PROJECT COSTS (OPC)		2,300,000		800,000	3,100,000
TOTAL PROJECT COST (TPC)		12,000,000	35	4,200,000	16,200,000

TYPE OF
ESTIMATE
ARCHITECT
ENGINEER
OPERATING
CONTRACTOR

STUDY

REMARKS:

CHECK

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

C-32

WQC-SD-WM-TL-730
Revision 0

KAISER ENGINEERS HANFORD
J.R. NICHOLSON
JOB NO. 2397SAA2

** TEST - INTERACTIVE ESTIMATING **
PHASE I - PRIVATIZATION STUDY
S T U D Y
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

PAGE 2 OF 10
DATE 04/26/96 07:53:33
BY TLW

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
1A01	PM & INTEGRATION	730000	0	730000	0.00	0	730000	985500
	SUBTOTAL 1A PROJECT MGMT. & INTEGRATION	730000	0	730000	0.00	0	730000	985500
	SUBTOTAL 1 PROJECT MANAGEMENT	730000	0	730000	0.00	0	730000	985500
2B01	TITLE 1, II, III & CM	2860000	0	2860000	0.00	0	2860000	3861000
	SUBTOTAL 2B TITLE 1, II, III & CM	2860000	0	2860000	0.00	0	2860000	3861000
	SUBTOTAL 2 TITLE 1, II, III & CM	2860000	0	2860000	0.00	0	2860000	3861000
4B00	OTHER PROJECT COSTS	2300000	0	2300000	0.00	0	2300000	3105000
	SUBTOTAL 4 OTHER PROJECT COSTS	2300000	0	2300000	0.00	0	2300000	3105000
5A4I	GENERAL REQUIREMENTS	55506	0	55506	0.00	0	55506	74933
5A4J	SITE WORK	51342	0	51342	0.00	0	51342	69313
5A4K	VALVE PIT 241-AN-A	339749	0	339749	0.00	0	339749	458662
	SUBTOTAL 5A4 CONSTRUCTION FORCES	446597	0	446597	0.00	0	446597	602908
	SUBTOTAL 5A 241-AN-A VALVE PIT	446597	0	446597	0.00	0	446597	602908
5B4I	GENERAL REQUIREMENTS	55506	0	55506	0.00	0	55506	74933
5B4J	SITE WORK	51342	0	51342	0.00	0	51342	69313
5B4K	VALVE PIT 241-AN-B	339749	0	339749	0.00	0	339749	458662
	SUBTOTAL 5B4 CONSTRUCTION FORCES	446597	0	446597	0.00	0	446597	602908
	SUBTOTAL 5B 241-AN-B VALVE PIT	446597	0	446597	0.00	0	446597	602908
	SUBTOTAL 5 DOUBLE SHELL TANKS	893194	0	893194	0.00	0	893194	1205816
6C4A	PIPING GENERAL REQUIREMENTS	237890	0	237890	0.00	0	237890	321153
6C4B	PIPING 241-AN-B TO 241-AX-A	2083276	0	2083276	0.00	0	2083276	3892423

C-33

T

WHS-SD-WM-TI-750
Revision 0

KAISER ENGINEERS HANFORD
J. R. NICHOLSON
JOB NO. 2397SAA2

** TEST - INTERACTIVE ESTIMATING **
PHASE I - PRIVATIZATION STUDY
S T U D Y
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

PAGE 3 OF 10
DATE 04/26/96 07:53:33
BY TLW

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
6C4C	VALVE PIT 241-A-A	400504	0	400504	0.00	0	35	540681
6C4D	VALVE PIT 241-A-B	390789	0	390789	0.00	0	35	527565
6C4E	VALVE PIT 241-AX-A	359358	0	359358	0.00	0	35	485134
6C4F	VALVE PIT 241-AX-B	362319	0	362319	0.00	0	35	489131
6C4G	241-AW-02A PUMP PIT	329712	0	329712	0.00	0	35	445112
6C4H	241-AZ-02A PUMP PIT	232276	0	232276	0.00	0	35	313574
SUBTOTAL 6C4	CONSTRUCTION FORCES	5196124	0	5196124	0.00	0	35	7014773
SUBTOTAL 6	INTERFARM SUPPORT SYSTEMS	5196124	0	5196124	0.00	0	35	7014773
PROJECT TOTAL		11,979,318	0	11,979,318	0.00	0	35	16,172,089

C-34

PHC-SD-WM-TJ-750
Revision 0

KAISER ENGINEERS HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. 23979SAA2
FILE NO. 23979SAA2

** TEST - INTERACTIVE ESTIMATING **
PHASE I - PRIVATIZATION STUDY
S T U D Y
DOE_R03 - ESTIMATE BASIS SHEET

PAGE 4 OF 10
DATE 4/26/96
BY: TLW

1. DOCUMENTS AND DRAWINGS

DOCUMENTS: W-314 COST ESTIMATE, DATED 3/20/96, SKETCHES AND WRITTEN DIRECTIONS DATED 3/25/96.

2. MATERIAL PRICES

UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL. VENDOR INFORMATION WAS OBTAINED FOR THE FOLLOWING ITEMS:
CAMERON PRODUCTS - PIT COATING
QSCS - TYPE A BURIAL BOXES
QBECHTEL - WOODEN BURIAL BOXES
AIR CONTROL, QINC. - QNEPA FILTER HOUSINGS
UNIT PROCESS CO. - ISOLATION BUTTERFLY VALVES
ELECTRICAL RESOURCES - DATA BASE

3. LABOR RATES

A.) QICF-QKH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEH FINANCE (EFFECTIVE 03-18-96). SEE ALSO THE QFY 1996 PLANNING RATES * (REPORT QBGNB7012).
B.) BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, DEPARTMENTAL OVERHEADS, G&A AND QSMS, AND TRAVEL.
* SEE HANFORD SOFT REPORTING, QFDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.
C.) WHC HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGNB2001).

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ON SITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE QCF-QKH ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (BGNB) LOCATED ON HANFORD SOFT REPORTING. QFDS BUDGET GUIDELINE HANDBOOK. THE PERCENTAGE APPLIED TO ON SITE CONSTRUCTION FORCES LABOR. FOR THIS PROJECT, IS 52% FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "ONAP/R&I" COLUMN OF THE ESTIMATE DETAIL.
B.) ON SITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEH SUMMARY REPORT DOE_R07, INCLUDED WITH THIS ESTIMATE, (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL).

5. ESCALATION

ESCALATION PERCENTAGES WERE CALCULATED FROM THE JANUARY, 1996 UPDATE OF THE ECONOMIC ESCALATION PRICE CHANGE INDICES FOR DOE CONSTRUCTION PROJECTS AS PUBLISHED BY THE "OFFICE OF INFRASTRUCTURE ACQUISITION" FM-50.
***** ESCALATION IS NOT INCLUDED IN THIS COST ESTIMATE.

6. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (N), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (QAPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE 1-11, DATED 10-31-84.

C35

WHC-SD-WM-TI-750
Revision 0

KAISER ENGINEERS HANFORD
JOB NO. Z3975AA2
FILE NO. Z3975AA2
** TEST - INTERACTIVE ESTIMATING **
PHASE I - PRIVATIZATION STUDY
S T U D Y
DOE-A03 - ESTIMATE BASIS SHEET
BY: TLW
DATE 4/26/96
PAGE 5 OF 10

7. REMARKS:
=====
1. METHOD OF PERFORMANCE:
A. DESIGN BY ON SITE A/E.
B. CONSTRUCTION INSIDE OF THE TANK FARM FENCES IS BY THE ON SITE CONSTRUCTION FORCES.
C. CONSTRUCTION OUTSIDE OF THE TANK FARM FENCES IS BY FIXED PRICE CONTRACT.
D. PROJECT MANAGEMENT IS BY THE OPERATING CONTRACTOR.
E. OTHER PROJECT COSTS IS PERFORMED BY THE OPERATING CONTRACTOR.
2. BURNOUT IS NOT INCLUDED AS FURNACE OR REWORK IS NOT A REQUIREMENT.
3. CRANE ALLOWANCES ARE FOR 18EA 30T GROVE.
4. NEW JUMPER ALLOWANCES ARE BASED UPON SKETCHES. BURIAL FOR EXISTING JUMPERS IS BASED UPON THE LISTS PROVIDED BY THE ENGINEER.
5. NEW COVER BLOCK COSTS ARE BASED UPON PROJECT W-151, TANK 101-AZ WASTE RETRIEVAL SYSTEM.
6. PROJECTS W-211 AND W-030 "LESSONS LEARNED" WERE INCORPORATED INTO THE COST ESTIMATE FOR JUMPERS AND EXCAVATION.
7. THIS COST ESTIMATE DOES NOT INCLUDE MASK WORK ON ALL FIELD WELDS (PER 1/31/96 MEETING).
8. SEALING OF PITS IS INCLUDED FOR THOSE THAT WERE OPENED.
9. FRESH AIR SUPPORT IS SHOWN SEPARATELY FROM MASK WORK.
10. TRANSFER PIPING BETWEEN TANK FARMS IS BASED UPON THE WORK BEING PERFORMED BY CONSTRUCTION FORCES.
11. THE EXISTING PIPING IS ABANDONED IN PLACE.
12. COVER BLOCK BURIAL INCLUDES WRAPPING IN PLASTIC, IN ONE PIECE, AND TRANSPORTATION TO THE BURIAL GROUNDS. IT WAS ASSUMED THAT BURIAL IN BOXES IS NOT NECESSARY.
13. ASBESTOS ABATEMENT ON PIPING TIE-INS IS ASSUMED TO NOT BE A PROBLEM.
14. REMOVAL OF EXISTING PIPING, UNDERGROUND UTILITIES, ETC. FOR USE OF PIPE AND CONDUIT INSTALLATION IS NOT INCLUDED IN THE COST ESTIMATE.
15. JUMPER CUTUP WILL BE PERFORMED BY USING AN EXISTING ON SITE MECHANICAL SHEAR.
16. SPECIAL WORK PROCEDURE (SWP) MAKEUP FOR THIS ESTIMATE HAS BEEN APPLIED AT 40%. THIS IS USED TO COMPENSATE FOR PRODUCTIVITY LOSS DUE TO WORKING IN THE TANK FARM. PRODUCTIVITY IS LOST FOR SAFETY MEETINGS, PRE JOB REVIEW, DRESS, SURVEY OUT, TRANSPORT TO AND FROM FARM, AND LOADING OF TOOLS FOR TRANSPORT. ALONG WITH THESE ACTIVITIES, THERE ARE OTHER DELAYS THAT ARE NOT ACCOUNTED FOR BY THIS PERCENTAGE: LATE ARRIVALS OF MP/IS AND OPERATORS, ACCESS THROUGH THE GYMAN SYSTEMS, LARGE CREW (CHANGE TRAILER LIMITATIONS), CONFLICTS WITH WMC OPERATIONS, INITIAL PRE JOB BRIEFINGS WHICH CAN TAKE UP TO ONE HOUR, REASSIGNMENT OF PERSONNEL WHICH WILL CAUSE A REVIEW OF INITIAL PRE JOB BRIEFING AND QUESTIONS, LACK OF TRANSPORTATION, CHANGES IN FARM CONDITIONS, SAFETY CONCERNS AND WEATHER. THESE DELAYS OR IMPACTS HAVE BEEN ADDRESSED THROUGH CONTINGENCY APPLICATION.
16. ASSUME ALL WORK WILL BE DONE DURING THE NORMAL WORK DAY, 7:30AM-4:30PM, THERE ARE NO ALLOWANCES MADE FOR SHIFT WORK OR OVERTIME.
17. WORK SCOPE INCLUDES: 1.) A NEW 3" S.S. TRANSFER LINE ENCASED IN 6" C.S. PIPE, APPROXIMATELY 700' LONG, FROM 241-AN-B TO 241-AX-A; 2.) VALVE MANIFOLDS IN 241-AN-A, 241-AN-B, 241-AX-A, 241-AX-B AND 241-AX-02A. THESE VALVE MANIFOLDS ARE SIMILAR TO THOSE FOUND IN PROJECT W-314. IT SHOULD BE NOTED THAT SOME EXISTING MANIFOLDS ARE REUSED. SEE ESTIMATE DETAILS FOR QUANTITIES.

C-36

KAISER ENGINEERS HANFORD
J.R. NICHOLSON
JOB NO. 2397SAA2

** TEST - INTERACTIVE ESTIMATING **
PHASE I - PRIVATIZATION STUDY
S T U D Y
DOE_R04 - COST CODE ACCOUNT SUMMARY

PAGE 6 OF 10
DATE 04/26/96 07:53:50
BY TLW

COST CODE/WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
010	ENGINEERING - TITLE I, II & III							
2801	TITLE I, II, III & CM	2860000	0	2860000	0.00	0	2860000	35
	TOTAL 010 ENGINEERING - TITLE I, II &	2860000	0	2860000	0.00	0	2860000	35
060	PROJECT MANAGEMENT							
1A01	PM & INTEGRATION	730000	0	730000	0.00	0	730000	35
	TOTAL 060 PROJECT MANAGEMENT	730000	0	730000	0.00	0	730000	35
700	SPECIAL EQUIP/PROCESS SYSTEMS							
5A4I	GENERAL REQUIREMENTS	28249	0	28249	0.00	0	28249	35
5A4J	SITE WORK	51342	0	51342	0.00	0	51342	35
5A4K	VALVE PIT 241-AW-A	339749	0	339749	0.00	0	339749	35
5B4I	GENERAL REQUIREMENTS	28249	0	28249	0.00	0	28249	35
5B4J	SITE WORK	51342	0	51342	0.00	0	51342	35
5B4K	VALVE PIT 241-AW-B	339749	0	339749	0.00	0	339749	35
6C4A	PIPING GENERAL REQUIREMENTS	237890	0	237890	0.00	0	237890	35
6C4B	PIPING 241-AW-B TO 241-AX-A	2883276	0	2883276	0.00	0	2883276	35
6C4C	VALVE PIT 241-A-A	373247	0	373247	0.00	0	373247	35
6C4D	VALVE PIT 241-A-B	363532	0	363532	0.00	0	363532	35
6C4E	VALVE PIT 241-AX-A	332101	0	332101	0.00	0	332101	35
6C4F	VALVE PIT 241-AX-B	335062	0	335062	0.00	0	335062	35
6C4G	241-AW-02A PUMP PIT	302455	0	302455	0.00	0	302455	35
6C4H	241-AZ-02A PUMP PIT	231453	0	231453	0.00	0	231453	35
	TOTAL 700 SPECIAL EQUIP/PROCESS SYSTEM	5897696	0	5897696	0.00	0	5897696	35
810	DEMOLITION							
5A4I	GENERAL REQUIREMENTS	27257	0	27257	0.00	0	27257	35
5B4I	GENERAL REQUIREMENTS	27257	0	27257	0.00	0	27257	35
6C4C	VALVE PIT 241-A-A	27257	0	27257	0.00	0	27257	35
6C4D	VALVE PIT 241-A-B	27257	0	27257	0.00	0	27257	35

WHC-SD-WM-TL-750
Revision 0

PAGE 7 OF 10
DATE 04/26/96 07:53:50
BY ILW

** TEST - INTERACTIVE ESTIMATING **
PHASE I - PRIVATIZATION STUDY
S T U D Y
DOE_R04 - COST CODE ACCOUNT SUMMARY

KAISER ENGINEERS HANFORD
J.R. NICHOLSON
JOB NO. 23975AA2

COST
CODE/URS
DESCRIPTION

ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	SUB TOTAL	CONTINGENCY %	TOTAL DOLLARS
27257	0	27257	0.00	0	35	36797
27257	0	27257	0.00	0	35	36797
27257	0	27257	0.00	0	35	36797
823	0	823	0.00	0	35	1111
191622	0	191622	0.00	0	35	258690

TOTAL 810 DEMOLITION

900 OTHER PROJECT COSTS

4800 OTHER PROJECT COSTS

TOTAL 900 OTHER PROJECT COSTS

PROJECT TOTAL

11,979,318 0 11,979,318 0.00 0 11,979,318 35 4,192,771 16,172,089

KAISER ENGINEERS HANFORD
J.R. NICHOLSON
JOB NO. Z397SAA2

** TEST - INTERACTIVE ESTIMATING **
PHASE 1 - PRIVATIZATION STUDY
S T U D Y
DOE_R05 - ESTIMATE SUMMARY BY CSI DIVISION

PAGE 8 OF 10
DATE 04/26/96 07:54:17
BY TLW

CSI	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
=====								
CONSTRUCTION								
00	TECHNICAL SERVICES	2300000	0	2300000	0.00	0	2300000	3105000
01	GENERAL REQUIREMENTS	5104943	0	5104943	0.00	0	5104943	6891675
02	SITEWORK	1883695	0	1883695	0.00	0	1883695	2542992
03	CONCRETE	181643	0	181643	0.00	0	181643	245217
06	WOOD AND PLASTICS	41864	0	41864	0.00	0	41864	56517
07	MOISTURE AND THERMAL	96608	0	96608	0.00	0	96608	130424
15	MECHANICAL	2035622	0	2035622	0.00	0	2035622	2748091
16	ELECTRICAL	334943	0	334943	0.00	0	334943	452173
TOTAL CONSTRUCTION								
		11,979,318	0	11,979,318	0.00	0	11,979,318	16,172,089
=====								
PROJECT TOTAL								
		11,979,318	0	11,979,318	0.00	0	11,979,318	16,172,089

C-39

WHC-SD-WM-TI-750
Revision 0

WESTINGHOUSE HANFORD COMPANY
KAISER ENGINEERS HANFORD
JOB NO. Z397SAZ
FILE # Z397SAZ

** TEST - INTERACTIVE ESTIMATING **
PHASE I - PRIVATIZATION STUDY
S T U D Y
DOE-R06 - CONTINGENCY ANALYSIS BASIS SHEET

PAGE 9 OF 10
DATE 04/26/96
BY T.L. WALDO

REFERENCE: ESTIMATE BASIS SHEET
COST CODE ACCOUNT SUMMARY

PAGE 3 OF 8
PAGE 1 OF 8

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 5-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A CONCEPTUAL ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 15 TO 40%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

ENGINEERING

010 TITLE I, II & III

A 35% CONTINGENCY WAS APPLIED DUE TO UNCERTAINTIES FROM P11 RADIOLOGICAL CONDITIONS; CHANGES IN TECHNOLOGY OVER THE LIFE OF THE PROJECT; UTILIZATION OF UNPROVEN EQUIPMENT TO BE INSTALLED BY OTHER PROJECTS, (E.G. W-211, W-320); TANK WASTE CHARACTERIZATION (I.E. DOME LOADING, TANK TEMPERATURES, CHEMICAL AND PHYSICAL PROPERTIES, OPERATING CONDITIONS ETC.).

CONSTRUCTION

700 SPECIAL EQUIP/PROCESS SYSTEMS 35%

THE PERCENTAGES NOTED REFLECT UNCERTAINTIES IN: RADIOLOGICAL CONDITION AT THE PUMP AND VALVE PITS AND DURING EXCAVATION; CONGESTION OF EXISTING PIPING, ELECTRICAL LINES, ETC. AND THE ASSOCIATED DIFFICULTIES IN WORKING AROUND THESE; AVAILABILITY AND RELIABILITY OF EQUIPMENT FROM OTHER PROJECTS; WEATHER; REQUIREMENT FOR MOCK-UP TESTING, SPECIAL TOOLS AND TEMPORARY SHIELDING; AVAILABILITY OF ESSENTIAL SUPPORT PERSONNEL, SUCH AS WELDS, CURRENT PROCEDURES THAT ARE IN EFFECT NOW BUT MAY BE DIFFERENT AT THE TIME OF CONSTRUCTION;

810 DEMOLITION

35%

THE TYPES OF BURIED MATERIAL FOR LLW, RADIOLOGICAL MIXED WASTE AND TRU IS AN ESTIMATING ALLOWANCE. OTHER TYPES (I.E. HAZARDOUS WASTE) WERE NOT ADDRESSED IN THE CDR.

900 OTHER PROJECT COSTS

35%

A CONTINGENCY OF 35% WAS APPLIED TO ALLOW FOR COST GROWTH DUE TO SCHEDULE SLIPPAGE OR EXTENSION; ACCEPTABILITY OF GRADED APPROACH TO OPERATIONAL READINESS REVIEW; AND ADDITIONAL TECHNICAL SUPPORT FOR STARTUP TESTING.

AVERAGE CONSTRUCTION CONTINGENCY 35%

AVERAGE PROJECT CONTINGENCY 35%

C-40

KAISER ENGINEERS HANFORD
J.R. NICHOLSON
JOB NO. 2397SAA2

** TEST - INTERACTIVE ESTIMATING **
PHASE 1 - PRIVATIZATION STUDY
S T U D Y
DOE_R07 - ONSITE INDIRECT COSTS BY WBS

PAGE 10 OF 10
DATE 04/26/96 07:54:25
BY TLW

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	CONTRACT ADMINISTRATION % TOTAL	BID PACK PREP.	OTHER INDIRECTS	TOTAL INDIRECTS
*****	*****	*****	*****	*****	*****	*****
1A01	PM & INTEGRATION	730000	0.00	0	0	0
2B01	TITLE I, II, III & CM	2860000	0.00	0	0	0
4B00	OTHER PROJECT COSTS	2300000	0.00	0	0	0
5A41	GENERAL REQUIREMENTS	55506	0.00	0	0	0
5A4J	SITE WORK	51342	0.00	0	0	0
5A4K	VALVE PIT 241-AN-A	339749	0.00	0	0	0
5B41	GENERAL REQUIREMENTS	55506	0.00	0	0	0
5B4J	SITE WORK	51342	0.00	0	0	0
5B4K	VALVE PIT 241-AN-B	339749	0.00	0	0	0
6C4A	PIPING GENERAL REQUIREMENTS	237890	0.00	0	0	0
6C4B	PIPING 241-AN-B TO 241-AX-A	2883276	0.00	0	0	0
6C4C	VALVE PIT 241-A-A	400504	0.00	0	0	0
6C4D	VALVE PIT 241-A-B	390789	0.00	0	0	0
6C4E	VALVE PIT 241-AX-A	359358	0.00	0	0	0
6C4F	VALVE PIT 241-AX-B	362319	0.00	0	0	0
6C4G	241-AN-02A PUMP PIT	329712	0.00	0	0	0
6C4H	241-AZ-02A PUMP PIT	232276	0.00	0	0	0
PROJECT TOTAL		11,979,318	0	0	0	0

C41

WHS-SD-WM-TL-70
Revision 0

This page intentionally left blank.

APPENDIX D

DESIGN PRESSURE RATING UPGRADE

This page intentionally left blank.

DON'T SAY IT --- Write It!

DATE: 9/9/96

TO: John Koberg

G3-12

FROM: J.R. Nicholson

G3-12

Telephone: 372-1656

cc: J. Galbraith H5-49

SUBJECT: DESIGN PRESSURE RATING UP-GRADE FOR SN-213/200

The existing 3" SN-213/200 transfer line has been investigated to determine if a methodology is available to re-rate the design pressure of 230 psig to 400 psig to enhance the transfer systems hydraulic performance.

The 3" SN-213/200 is approximately 620 feet long with 15-90° 3 ft radius bends and 2-45° 3 ft radius bends. This line along with SN-216 are potential candidates for increasing their design pressure to 400 psig.

The pipe lines referenced above have been subjected to transfers from B Plant to the 241-AY-101 double shell tank and piping failures have occurred from 1980 to 1995, refer to Figure 1 for route failure locations and SD-RE-TI-148 (Metallurgical Analysis of Leak Failure of 241-A-B Valve Pit Jumper, 1985) for documented analysis of jumper failure.

Two methods have been researched and are available to examine the 3"-SN-213/200 pipe line to investigate corrosion/erosion to aid in determining the remaining strength of these areas and what is the pressure containing capability of the remaining pipe metal in terms of its ability to operate safely at the maximum allowable operating pressure of the transfer system.

CCTV EXAMINATION SYSTEM

The CCTV examination consists of a laser-ring followed by a camera pushed into the transfer pipe for approximately 100 feet using a push pole. Entry is through the wall nozzle in the valve pit at either end of the line. The laser-ring illuminates a circumferential circle on the internal surface of the pipe. These circles, which take the form of the pipe contour are compared with a standard pipe contour to measure corrosion or scaling of the pipe material. While the laser-ring paints a contour, the camera provides a direct view of the internal surface condition. The product of the exam is the information gained by direct viewing of the laser-ring and the internal surface of the pipe wall through the monitor in the field. Video tape of both the direct viewing and the laser-ring information is available for further examination and evaluation to determine the probability of significant piping material degradation. The evaluation is qualitative and the system is currently available on site. The estimated cost for the CCTV examination is \$61,000 (see attachment) for an examination of 100 feet from one end of the line. If entry from both ends of the transfer pipe is performed, the cost is estimated to be \$110,000.

EDDY CURRENT SYSTEM

D-3

The Eddy Current instrument with remote field option is used for a broad range of tubing and piping applications on the petroleum, chemical and power generation industries. The probe is hand feed and pushed thru a wall nozzle in the valve pits at either end of the transfer line and power and signal data connected to equipment adjacent to the point of entry of the probe. A vector analysis of the data is used to estimate pitting depth, length and general wall thinning. A local vendor representing ZETEL estimated 50 - 100 feet entry maximum from each end of the 620 feet line. The estimated costs for the Eddy Current examination will be very similar to the CCTV system and are assumed the same.

Cleanliness of the line to be examined is also a critical factor for both methods. The CCTV examination may mask the pitting corrosion if sludge exists in the bottom of the pipe. If sludge buildup is present, the Eddy Current system will not function properly and therefore the sludge will have to be removed. Present knowledge of the transfer lines does not quantify the amount of sludge that is present. Past experience during performance of transfer line "hot tie-ins", has identified sludge being present in some of the lines.

Considering the transfer systems continuing failure from 1980, only a 100% examination of the pipeline to verify existing wall thickness would be acceptable to validate re-rating. The risk would not be acceptable to only perform a partial examination (approximately 33% of SN-213/200, based on 100 foot entry from each end of line). At the current time no system has been found that can traverse 100% of the lines length to determine remaining pipe wall thickness and attempting to re-rate the system is not recommended. If 100% of the transfer system were to be examined, the probability of increasing the design pressure is very low due to expected corrosion to be detected given past history on pipeline failures.

Attachments: Figure 1-Recent Failure Locations In B-Plant/200 East Area Lines
Estimated Cost For CCTV Pipeline Examination

FIGURE 1
RECENT FAILURE LOCATIONS IN B-PLANT/200 EAST AREA LINES
D-5

WHC-SD-WM-TI-750
Revision 0

ESTIMATED COST FOR CCTV PIPELINE EXAMINATION

SMET/RAVENCRAFT	
Equipment and hardware for mock-up & exam	\$20,000
Labor to procure test equip., mock-up, & follow exam (Operators - 5 ea. for 5 days)	\$12,000
Disposal costs	\$10,000
Work Package	
Writer (1 ea. for 4 days)	4 days
RWP (1 ea. for 1 day)	1 day
Safety (1 ea. for 1 day)	1 day
HPT (1 ea. for 1 day)	1 day
Q.A. (1 ea. for 1/2 day)	1/2 day
Field Work	
Riggers (3 ea. for 2 days)	6 days
Crane Operator (1 ea. for 2 days)	2 days
HPT (3 ea. for 2 days)	6 days
Q.A. (1 ea. for 1 day)	1 day
Electrician (1 ea. for 1/2 day)	1/2 day
Sniffer (1 ea. for 1 day)	1 day
Operators (3 ea. for 2 days)	6 days
Tent - Iron worker (1 ea. for 1 day)	1 day
Riggers (3 ea. for 1 day)	3 days
Operators (2 ea. for 2 days)	4 days
Totals	\$5,000 38 days or \$19,000
Estimated Cost	\$61,000

DISTRIBUTION SHEET

To Distribution	From Process Design 73520	Page 1 of 1
		Date 9/10/96
Project Title/Work Order Decision Document for Phase I Privatization Transfer System Needs, WHC-SD-WM-TI-750, Revision 0		EDT No. 608745
		ECN No.

Name	MSIN	Text With All Attach.	Text Only	Attach./ Appendix Only	EDT/ECN Only
DOE Reading Room	H2-53	X			
Central Files (2)	A3-88	X			
<u>Westinghouse Hanford Company</u>					
J. N. Apple	G3-21			X*	
K. A. Boes	R3-25	X			
V. C. Boyles	R1-43	X			
P. J. Certa	H5-61	X			
R. U. Elwell	S7-12			X*	
P. Felise	B4-55			X*	
J. D. Galbraith	H5-49	X			
K. A. Gasper	G3-21			X*	
J. S. Garfield	H5-49			X*	
W. H. Grams	H5-61			X*	
R. W. Jacobson	R1-09	X			
E. J. Kosiancic	H5-61			X*	
A. F. Manuel	H5-49	X			
R. P. Marshall	H5-61	X			
D. W. Reberger	S5-13	X			
R. L. Schlosser	R1-56	X			
D. J. Washenfelder	H5-27			X*	
<u>ICF Kaiser Hanford Company</u>					
S. K. Baker	H5-49	X			
J. R. Nicholson	G3-12			X*	
T. B. Salzano	G3-12	X			

*These employees will receive the main document plus Appendix B, C, and D only. Appendix A consists of 250 pages of calculations.

APPENDIX C

COST ESTIMATES

This page intentionally left blank.

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA3/P4W000
FILE NO. Z394SAA3

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 3
DOE_R01 - PROJECT COST SUMMARY

PAGE 1 OF 7
DATE 04/19/96 17:39:12
BY BAL

COST CODE	DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY %	TOTAL	TOTAL DOLLARS
000	ENGINEERING	750,000	35	260,000	1,010,000
060	PROJECT MANAGEMENT (ADJUSTED TO MEET DOE 5100.4)	190,000	35	70,000	260,000
		-40,000		-30,000	-70,000
TOTAL DESIGN & MANAGEMENT		900,000	33	300,000	1,200,000
460	IMPROVEMENTS TO LAND	1,100,000	35	380,000	1,480,000
700	SPECIAL EQUIP/PROCESS SYSTEMS (ADJUSTED TO MEET DOE 5100.4)	500,000	35	180,000	680,000
				40,000	40,000
TOTAL CONSTRUCTION		1,600,000	38	600,000	2,200,000
TOTAL ESTIMATED CONSTRUCTION COST (TECC)		2,500,000	36	900,000	3,400,000
900	OTHER PROJECT COSTS (ADJUSTED TO MEET DOE 5100.4)	610,000	35	210,000	820,000
		-10,000		-10,000	-20,000
TOTAL OTHER PROJECT COSTS (OPC)		600,000	33	200,000	800,000
TOTAL PROJECT COST		3,100,000	35	1,100,000	4,200,000

C-3

WHS-SD-MM-TT-750
Revision 0-

TYPE OF
ESTIMATE STUDY APRIL 21, 1996

ARCHITECT
ENGINEER

OPERATING
CONTRACTOR

REMARKS:

CHECK

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA3/P4W000
FILE NO. Z394SAA3

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 3
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

PAGE 2 OF 7
DATE 04/19/96 17:39:21
BY BAL

WBS DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
110100 TITLE I, II & III	750000	0	750000	0.00	0	750000 35	262500 1012500
SUBTOTAL 1 TITLE I, II & III DESIGN	750000	0	750000	0.00	0	750000 35	262500 1012500
310100 GENERAL REQUIREMENTS	82202	0	82202	0.00	0	82202 35	28771 110973
310101 EXCAV FROM AX TO AZ PITS	701138	0	701138	0.00	0	701138 35	245398 946536
310201 SHOP FAB PIPING	181634	0	181634	0.00	0	181634 35	63572 245206
310202 FIELD INSTALL PIPING	338146	0	338146	0.00	0	338146 35	118351 456497
310301 CORE DRILL & TIE IN	58011	0	58011	0.00	0	58011 35	20304 78315
310401 CATHODIC PROTECTION	239559	0	239559	0.00	0	239559 35	83846 323405
SUBTOTAL 31 ONSITE E/C	1600690	0	1600690	0.00	0	1600690 35	560242 2160932
401000 PROJECT MANAGEMENT	190000	0	190000	0.00	0	190000 35	66500 256500
SUBTOTAL 4 WNC PROJECT MANAGEMENT	190000	0	190000	0.00	0	190000 35	66500 256500
501000 OPC ACTIVITIES	610000	0	610000	0.00	0	610000 35	213500 823500
SUBTOTAL 5 OPC ACTIVITIES	610000	0	610000	0.00	0	610000 35	213500 823500
PROJECT TOTAL	3,150,690	0	3,150,690	0.00	0	3,150,690 35	1,102,742 4,253,432

C-4

T

WHC-SD-WM-TT-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. 2394SAA3/P4W000
FILE NO. 2394SAA3

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 3
DOE_R03 - ESTIMATE BASIS SHEET

PAGE 3 OF 7
DATE 04/18/96 11:48:14
BY BAL

1. DOCUMENTS AND DRAWINGS

DOCUMENTS: DSI FROM T. SALZANO REQUESTING ESTIMATES FOR PHASE I PRIVATIZATION ALTERNATIVES DATED 3/20/96.

DRAWINGS: ATTACHMENT B TO DSI.

2. LABOR RATES

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEN FINANCE (EFFECTIVE 3-08-96). SEE ALSO THE FY 1996 PLANNING RATES * (REPORT BGHB7012).

B.) BASE CRAFT RATES ARE AS ISSUED BY KEN FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, TRAVEL, DEPARTMENTAL OVERHEADS AND G&A/S&S.
* SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

3. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (BGHB) LOCATED ON HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK. THE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEN SUMMARY REPORT DOE_R07, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY MANLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL)

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL:
LABOR - 0% MATERIAL - 0% EQUIPMENT USAGE - 0% EQUIPMENT - 0% SUBCONTRACTS - 0%

4. ESCALATION

ESCALATION PERCENTAGES WERE CALCULATED FROM THE JANUARY 1996 UPDATE OF THE ECONOMIC ESCALATION PRICE CHANGE INDICES FOR DOE CONSTRUCTION PROJECTS AS PUBLISHED BY THE "OFFICE OF INFRASTRUCTURE ACQUISITION" FM-50.

5. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (M), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE 1-11, DATED 10-31-84.

6. REMARKS

A.) ESTIMATE IS FOR CONSTRUCTION ONLY. DOES NOT INCLUDE DESIGN COSTS.

B.) ESTIMATE IS IN FY 96 DOLLARS. NO ESCALATION WAS APPLIED AS A SCHEDULE FOR THIS WORK IS UNKNOWN.

C.) WORK IS ASSUMED TO BE ALL VALVE PIT TIE-INS PER DESIGN AND NO BURNOUT WAS APPLIED AS RADIOLOGICAL CONDITIONS WERE UNKNOWN.

D.) ALL WORK WAS ASSUMED TO BE DONE BY THE ONSITE E/C.

E.) ESTIMATE FOR \$1,500 WAS DERIVED USING THE EXISTING ESTIMATE FROM PROJECT W-314.

F.) NEW 3/6" ENCASED LINE FROM 241-AZ-01A TO 241-AZ-02A AND 241-AZ-02A TO 241-AX-A.

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA3/P44000
FILE NO. Z394SAA3

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 3
DOE_R04 - COST CODE ACCOUNT SUMMARY

PAGE 4 OF 7
DATE 04/19/96 17:39:29
BY BAL

COST CODE/WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
000	ENGINEERING							
110100	TITLE I, II & III	750000	0	750000	0.00	0	750000 35	262500 1012500
TOTAL 000	ENGINEERING	750000	0	750000	0.00	0	750000 35	262500 1012500
060	PROJECT MANAGEMENT							
401000	PROJECT MANAGEMENT	190000	0	190000	0.00	0	190000 35	66500 256500
TOTAL 060	PROJECT MANAGEMENT	190000	0	190000	0.00	0	190000 35	66500 256500
460	IMPROVEMENTS TO LAND							
310101	EXCAV FROM AX TO AZ PITS	701138	0	701138	0.00	0	701138 35	245398 946536
310202	FIELD INSTALL PIPING	338146	0	338146	0.00	0	338146 35	118351 456497
310301	CORE DRILL & TIE IN	58011	0	58011	0.00	0	58011 35	20304 78315
TOTAL 460	IMPROVEMENTS TO LAND	1097295	0	1097295	0.00	0	1097295 35	384053 1481348
700	SPECIAL EQUIP/PROCESS SYSTEMS							
310100	GENERAL REQUIREMENTS	82202	0	82202	0.00	0	82202 35	28771 110973
310201	SHOP FAB PIPING	181634	0	181634	0.00	0	181634 35	63572 245206
310401	CATHODIC PROTECTION	239559	0	239559	0.00	0	239559 35	83846 323405
TOTAL 700	SPECIAL EQUIP/PROCESS SYSTEM	503395	0	503395	0.00	0	503395 35	176189 679584
900	OTHER PROJECT COSTS							
501000	OPC ACTIVITIES	610000	0	610000	0.00	0	610000 35	213500 823500
TOTAL 900	OTHER PROJECT COSTS	610000	0	610000	0.00	0	610000 35	213500 823500
PROJECT TOTAL		3,150,690	0	3,150,690	0.00	0	3,150,690 35	1,102,742 4,253,432

WHS-SD-WM-TI-750
Revision 0

C-6

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. 23942AAS/744000
FILE NO. 23942AAS

** TEST - INTERACTIVE ESTIMATING **
PHASE 1 - EVALUATION OF ALTERNATIVES
BY: BAL
DOE_R05 - ESTIMATE SUMMARY BY CSI DIVISION

PAGE 5 OF 7
DATE 04/21/96 13:17:17
BY BAL

CSI DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION %	SUB TOTAL	CONTINGENCY %	TOTAL DOORS
ENGINEERING							
00 TECHNICAL SERVICES	750000	0	750000	0.00	0	0	750000
TOTAL ENGINEERING	750,000	0	750,000	0.00	0	0	750,000
CONSTRUCTION							
01 GENERAL REQUIREMENTS	82202	0	82202	0.00	0	35	110973
02 SITEWORK	701138	0	701138	0.00	0	35	946536
15 MECHANICAL	577791	0	577791	0.00	0	35	757106
16 ELECTRICAL	239559	0	239559	0.00	0	35	312405
99 WMC LABOR	800000	0	800000	0.00	0	35	1080000
TOTAL CONSTRUCTION	2,400,690	0	2,400,690	0.00	0	840,242	3,240,932
PROJECT TOTAL	3,150,690	0	3,150,690	0.00	0	840,242	3,990,932

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. 2394SAA3/P4W000
FILE NO. 2394SAA3

•• TEST - INTERACTIVE ESTIMATING ••
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 3
DOE_R06 - CONTINGENCY ANALYSIS BASIS SHEET

PAGE 6 OF 7
DATE 04/19/96 17:20:08
BY BAL

REFERENCE: ESTIMATE BASIS SHEET
COST CODE ACCOUNT SUMMARY

PAGE 3 OF 7
PAGE 4 OF 7

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

000 ENGINEERING

110100 TITLE I, II & III DESIGN

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR DESIGN AND A DETAILED PLANNING EFFORT HAS NOT BEEN PERFORMED TO IDENTIFY ALL DISCIPLINE INVOLVED.

060 PROJECT MANAGEMENT

401000 PROJECT MANAGEMENT

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR WMC PROJECT MANAGEMENT AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

460 IMPROVEMENTS TO LAND

310101 EXCAV FROM AX TO AZ PITS
310202 FIELD INSTALL PIPING
310301 CORE DRILL & TIE IN

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

700 SPECIAL EQUIP/PROCESS SYSTEMS

310100 GENERAL REQUIREMENTS
310201 SHOP FAB PIPING
310401 CATHODIC PROTECTION

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

900 OTHER PROJECT COSTS

501000 OPC ACTIVITIES

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR WMC OPC ACTIVITIES AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

C-8

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA3/P4W000
FILE NO. Z394SAA3

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 3
DOE_R07 - ONSITE INDIRECT COSTS BY WBS

PAGE 7 OF 7
DATE 04/19/96 17:39:52
BY BAL

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	CONTRACT ADMINISTRATION % TOTAL	BID PACK PREP.	OTHER INDIRECTS	TOTAL INDIRECTS
=====	=====	=====	=====	=====	=====	=====
110100	TITLE I, II & III	750000	0.00	0	0	0
310100	GENERAL REQUIREMENTS	82202	0.00	0	0	0
310101	EXCAV FROM AX TO AZ PITS	701138	0.00	0	0	0
310201	SHOP FAB PIPING	181634	0.00	0	0	0
310202	FIELD INSTALL PIPING	338146	0.00	0	0	0
310301	CORE DRILL & TIE IN	58011	0.00	0	0	0
310401	CATHODIC PROTECTION	239559	0.00	0	0	0
401000	PROJECT MANAGEMENT	190000	0.00	0	0	0
501000	OPC ACTIVITIES	610000	0.00	0	0	0
=====						
PROJECT TOTAL		3,150,690	0	0	0	0

C-9

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA1/P4W000
FILE NO. Z394SAA1

** IEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 1
DOE_R01 - PROJECT COST SUMMARY

PAGE 1 OF 8
DATE 04/19/96 17:33:42
BY BAL

COST CODE	DESCRIPTION	ESCALATED TOTAL COST	CONTINGENCY % TOTAL	TOTAL DOLLARS
000	ENGINEERING	540.000	35	190.000
060	PROJECT MANAGEMENT (ADJUSTED TO MEET DOE 5100.4)	140.000 20.000	35	50.000 -40.000
TOTAL DESIGN & MANAGEMENT		700.000	29	200.000
460	IMPROVEMENTS TO LAND	940.000	35	330.000
700	SPECIAL EQUIP/PROCESS SYSTEMS	190.000	35	70.000
810	DEMOLITION (ADJUSTED TO MEET DOE 5100.4)	20.000 50.000	35	10.000 -10.000
TOTAL CONSTRUCTION		1,200.000	33	400.000
TOTAL ESTIMATED CONSTRUCTION COST (TECC)		1,900.000	32	600.000
900	OTHER PROJECT COSTS (ADJUSTED TO MEET DOE 5100.4)	440.000 -40.000	35	150.000 50.000
TOTAL OTHER PROJECT COSTS (OPC)		400.000	50	200.000
TOTAL PROJECT COST		2,300.000	35	800.000

TYPE OF ESTIMATE STUDY APRIL 21, 1996

ARCHITECT
ENGINEER
OPERATING
CONTRACTOR

REMARKS:

CHECK

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

W/C-SD-WM-TT-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA1/P4W000
FILE NO. Z394SAA1

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 1
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

PAGE 2 OF 8
DATE 04/19/96 17:33:51
BY BAL

WBS DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
110100 TITLE 1, 11 & III DESIGN	540000	0	540000	0.00	0	540000 35	189000 729000
SUBTOTAL 11 TITLE 1, 11 & III	540000	0	540000	0.00	0	540000 35	189000 729000
310100 GENERAL REQUIREMENTS	60000	0	60000	0.00	0	60000 35	21000 81000
310101 TRENCH	242153	0	242153	0.00	0	242153 35	84754 326907
310102 VALVE PIT - SITEWORK	58537	0	58537	0.00	0	58537 35	20488 79025
310201 VALVE PIT - ERECTION	135616	0	135616	0.00	0	135616 35	47466 183082
310202 JUMPER	58903	0	58903	0.00	0	58903 35	20616 79519
310301 3/6" ENCASED PIPE	381280	0	381280	0.00	0	381280 35	133448 514728
310302 RISER TIE-INS	26248	0	26248	0.00	0	26248 35	9187 35435
310401 CATHODIC PROTECTION	114615	0	114615	0.00	0	114615 35	40115 154730
310402 LEAK DETECTION	76935	0	76935	0.00	0	76935 35	26927 103862
SUBTOTAL 31 ONSITE E/C	1154287	0	1154287	0.00	0	1154287 35	404001 1558288
401000 PROJECT MANAGEMENT	140000	0	140000	0.00	0	140000 35	49000 189000
SUBTOTAL 40 WMC PROJECT MANAGEMENT	140000	0	140000	0.00	0	140000 35	49000 189000
501000 OPC ACTIVITIES	440000	0	440000	0.00	0	440000 35	154000 594000
SUBTOTAL 50 OPC ACTIVITIES	440000	0	440000	0.00	0	440000 35	154000 594000
PROJECT TOTAL	2,274,287	0	2,274,287	0.00	0	2,274,287 35	796,001 3,070,288

C-11

WMC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z3945AA1/P4W000
FILE NO. Z3945AA1

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 1
DOE_R03 - ESTIMATE BASIS SHEET

PAGE 3 OF 8
DATE 04/09/96 11:44:28
BY BAL

1. DOCUMENTS AND DRAWINGS

DOCUMENTS: DSI FROM T. SALZANO REQUESTING ESTIMATES FOR PHASE I PRIVATIZATION ALTERNATIVES DATED 3/20/96.

DRAWINGS: ATTACHMENT A, B & C TO DSI.

2. MATERIAL PRICES

UNIT COSTS REPRESENT CURRENT PRICES FOR SPECIFIED MATERIAL. VENDOR INFORMATION WAS OBTAINED FOR THE FOLLOWING ITEMS:

3. LABOR RATES

- A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEH FINANCE (EFFECTIVE 3-08-96). SEE ALSO THE FY 1996 PLANNING RATES * (REPORT BGHB7012).
- B.) WHC HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB2001).
- C.) TRM HOURLY RATES ARE BASED UPON THE FY 1996 PLANNING RATES * (REPORT BGHB7008).
- D.) BASE CRAFT RATES ARE AS ISSUED BY KEH FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, TRAVEL, DEPARTMENTAL OVERHEADS AND G&A/S&S.
- * SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

4. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

- A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (BGHB) LOCATED ON HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK. THE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

5. ESCALATION

ESCALATION PERCENTAGES WERE CALCULATED FROM THE JANUARY 1996 UPDATE OF THE ECONOMIC ESCALATION PRICE CHANGE INDICES FOR DOE CONSTRUCTION PROJECTS AS PUBLISHED BY THE "OFFICE OF INFRASTRUCTURE ACQUISITION" FM-50.

6. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (H), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE 1-11, DATED 10-31-84.

7. REMARKS

- A.) ESTIMATE IS IN FY 96 DOLLARS. NO ESCALATION WAS APPLIED AS A SCHEDULE FOR THIS WORK IS UNKNOWN.
- B.) TIE-INS TO THE TANKS WERE ASSUMED TO BE HOT TIE-INS PER DESIGN HOWEVER NO BURNDOUT WAS APPLIED AS RADIOLOGICAL CONDITIONS WERE UNKNOWN.
- C.) ALL WORK WAS ASSUMED TO BE DONE BY THE ONSITE E/C.
- D.) THIS WORK IS FOR TIE IN TO SN 650. PROVIDE NEW VALVE PIT, NEW 3"/6" ENCASED PIPING TO TANKS AP-102 AND AP-104 AND VALVE PIT DRAIN TO TANK AP-102.

C-12

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA1/P4W000
FILE NO. Z394SAA1

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 1
DOE_R04 - COST CODE ACCOUNT SUMMARY

PAGE 4 OF 8
DATE 04/19/96 17:34:01
BY BAL

COST CODE/WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
000	ENGINEERING							
110100	TITLE I, II & III DESIGN	540000	0	540000	0.00	0	35	189000
TOTAL 000	ENGINEERING	540000	0	540000	0.00	0	35	189000
060	PROJECT MANAGEMENT							
401000	PROJECT MANAGEMENT	140000	0	140000	0.00	0	35	49000
TOTAL 060	PROJECT MANAGEMENT	140000	0	140000	0.00	0	35	49000
460	IMPROVEMENTS TO LAND							
310100	GENERAL REQUIREMENTS	60000	0	60000	0.00	0	35	21000
310101	TRENCH	242153	0	242153	0.00	0	35	84754
310102	VALVE PIT	58537	0	58537	0.00	0	35	20488
310201	VALVE PIT	135616	0	135616	0.00	0	35	47466
310202	JUMPER	58903	0	58903	0.00	0	35	20616
310301	3/6" ENCASED PIPE	362981	0	362981	0.00	0	35	127043
310302	RISER TIE-INS	26248	0	26248	0.00	0	35	9187
TOTAL 460	IMPROVEMENTS TO LAND	944438	0	944438	0.00	0	35	330554
700	SPECIAL EQUIP/PROCESS SYSTEMS							
310401	CATHODIC PROTECTION	114615	0	114615	0.00	0	35	40115
310402	LEAK DETECTION	76935	0	76935	0.00	0	35	26927
TOTAL 700	SPECIAL EQUIP/PROCESS SYSTEM	191550	0	191550	0.00	0	35	67042
810	DEMOLITION							
310301	3/6" ENCASED PIPE	18299	0	18299	0.00	0	35	6405
TOTAL 810	DEMOLITION	18299	0	18299	0.00	0	35	6405

WHS-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA1/P4W000
FILE NO. Z394SAA1

** IEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 1
DOE_R04 - COST CODE ACCOUNT SUMMARY

PAGE 5 OF 8
DATE 04/19/96 17:34:01
BY BAL

COST CODE/WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
900	OTHER PROJECT COSTS							
501000	OPC ACTIVITIES	440000	0	440000	0.00	0	35	594000
TOTAL 900	OTHER PROJECT COSTS	440000	0	440000	0.00	0	35	594000
<hr/>								
PROJECT TOTAL		2,274,287	0	2,274,287	0.00	0	35	3,070,288

C-14

WHS-SD-WM-TL-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA1/P4W000
FILE NO. Z394SAA1

** IEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 1
DOE_R05 - ESTIMATE SUMMARY BY CSI DIVISION

PAGE 6 OF 8
DATE 04/21/96 12:08:19
BY BAL

CSI	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
ENGINEERING								
00	TECHNICAL SERVICES	540000	0	540000	0.00	0	540000	0
	TOTAL ENGINEERING	540,000	0	540,000	0.00	0	540,000	0
CONSTRUCTION								
01	GENERAL REQUIRMENTS	60000	0	60000	0.00	0	60000	35
02	SITWORK	300690	0	300690	0.00	0	300690	35
03	CONCRETE	135616	0	135616	0.00	0	135616	35
15	MECHANICAL	466431	0	466431	0.00	0	466431	35
16	ELECTRICAL	191550	0	191550	0.00	0	191550	35
99	WHC SUPPORT PERSONNEL	580000	0	580000	0.00	0	580000	35
	TOTAL CONSTRUCTION	1,734,287	0	1,734,287	0.00	0	1,734,287	35
								607,001
								2,341,288

	PROJECT TOTAL	2,274,287	0	2,274,287	0.00	0	2,274,287	27
								607,001
								2,881,288

C-15

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z3945AA1/P4W000
FILE NO. Z3945AA1

•• IEST - INTERACTIVE ESTIMATING ••
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 1
DOE_R06 - CONTINGENCY ANALYSIS BASIS SHEET

PAGE 7 OF 8
DATE 04/19/96 17:20:08
BY BAL

REFERENCE: ESTIMATE BASIS SHEET
COST CODE ACCOUNT SUMMARY

PAGE 3 OF 8
PAGE 4 & 5 OF 8

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

000 ENGINEERING

110100 TITLE I, II & III DESIGN

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR DESIGN AND A DETAILED PLANNING EFFORT HAS NOT BEEN PERFORMED TO IDENTIFY ALL DISCIPLINE INVOLVED.

060 PROJECT MANAGEMENT

401000 PROJECT MANAGEMENT

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR WMC PROJECT MANAGEMENT AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

460 IMPROVEMENTS TO LAND

310100 GENERAL REQUIREMENTS

310101 TRENCH

310102 VALVE PIT

310201 VALVE PIT

310202 JUMPER

310301 3/6" ENCASED PIPE

310302 RISER TIE-INS

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

700 SPECIAL EQUIP/PROCESS SYSTEMS

310401 CATHODIC PROTECTION

310402 LEAK DETECTION

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

810 DEMOLITION

310301 3/6" ENCASED PIPE

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

900 OTHER PROJECT COSTS

501000 OPC ACTIVITIES

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR WMC OPC ACTIVITIES AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

C-16

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA1/P4W000
FILE NO. Z394SAA1

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 1
DOE_R07 - ONSITE INDIRECT COSTS BY WBS

PAGE 8 OF 8
DATE 04/19/96 17:34:26
BY BAL

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	CONTRACT ADMINISTRATION %	TOTAL	BID PACK PREP.	OTHER INDIRECTS	TOTAL INDIRECTS
110100	TITLE I, II & III DESIGN	540000	0.00	0	0	0	0
310100	GENERAL REQUIREMENTS	60000	0.00	0	0	0	0
310101	TRENCH	242153	0.00	0	0	0	0
310102	VALVE PIT	58537	0.00	0	0	0	0
310201	VALVE PIT	135616	0.00	0	0	0	0
310202	JUMPER	58903	0.00	0	0	0	0
310301	3/6" ENCASED PIPE	381280	0.00	0	0	0	0
310302	RISE R TIE-IMS	26248	0.00	0	0	0	0
310401	CATHODIC PROTECTION	114615	0.00	0	0	0	0
310402	LEAK DETECTION	76935	0.00	0	0	0	0
401000	PROJECT MANAGEMENT	140000	0.00	0	0	0	0
501000	OPC ACTIVITIES	440000	0.00	0	0	0	0
PROJECT TOTAL		2,274,287		0	0	0	0

C-17

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAA5/P4W000
FILE NO. Z394SAA5

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 5
DOE_R01 - PROJECT COST SUMMARY

PAGE 1 OF 7
DATE 04/21/96 14:19:08
BY BAL

COST CODE =====	DESCRIPTION =====	ESCALATED TOTAL COST =====	CONTINGENCY		TOTAL DOLLARS =====
			% =====	TOTAL =====	
000	ENGINEERING	500,000	35	180,000	680,000
060	PROJECT MANAGEMENT (ADJUSTED TO MEET DOE 5100.4)	130,000 -30,000	35	50,000 -30,000	180,000 40,000
TOTAL DESIGN & MANAGEMENT		600,000	33	200,000	800,000
460	IMPROVEMENTS TO LAND	820,000	35	290,000	1,110,000
700	SPECIAL EQUIP/PROCESS SYSTEMS (ADJUSTED TO MEET DOE 5100.4)	230,000 50,000	35	80,000 30,000	310,000 80,000
TOTAL CONSTRUCTION		1,100,000	36	400,000	1,500,000
TOTAL ESTIMATED CONSTRUCTION COST (TECC)		1,700,000	35	600,000	2,300,000
900	OTHER PROJECT COSTS (ADJUSTED TO MEET DOE 5100.4)	400,000	35	140,000 -40,000	540,000 -40,000
TOTAL OTHER PROJECT COSTS (OPC)		400,000	25	100,000	500,000
TOTAL PROJECT COST		2,100,000	33	700,000	2,800,000

C-18

TYPE OF ESTIMATE	STUDY	APRIL 21, 1996	REMARKS:
ARCHITECT ENGINEER			CHECK
OPERATING CONTRACTOR			

(ROUNDED/ADJUSTED TO THE NEAREST " 10,000 / 100,000 " - PERCENTAGES NOT RECALCULATED TO REFLECT ROUNDING)

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAAS/P4W000
FILE NO. Z394SAAS

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 5
DOE_R02 - WORK BREAKDOWN STRUCTURE SUMMARY

PAGE 2 OF 7
DATE 04/21/96 14:19:18
BY BAL

WBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
110100	TITLE I, II & III	500000	0	500000	0.00	0	500000 35 175000	675000
	SUBTOTAL 1 TITLE I, II & III DESIGN	500000	0	500000	0.00	0	500000 35 175000	675000
310100	GENERAL REQUIREMENTS	50000	0	50000	0.00	0	50000 35 17500	67500
310101	TRENCH EXCAVATION	465819	0	465819	0.00	0	465819 35 163037	628856
310201	CORE DRILL	93214	0	93214	0.00	0	93214 35 32625	125839
310301	SHOP FAB PIPE	110754	0	110754	0.00	0	110754 35 38764	149518
310302	FIELD INSTALL PIPE	215747	0	215747	0.00	0	215747 35 75511	291258
310401	CATHODIC PROTECTION	121462	0	121462	0.00	0	121462 35 42512	163974
	SUBTOTAL 31 ONSITE E/C	1056996	0	1056996	0.00	0	1056996 35 369949	1426945
	SUBTOTAL 3 CONSTRUCTION	1056996	0	1056996	0.00	0	1056996 35 369949	1426945
401000	PROJECT MANAGEMENT	130000	0	130000	0.00	0	130000 35 45500	175500
	SUBTOTAL 4 WMC PROJECT MANAGEMENT	130000	0	130000	0.00	0	130000 35 45500	175500
501000	OPC ACTIVITIES	400000	0	400000	0.00	0	400000 35 140000	540000
	SUBTOTAL 5 OPC ACTIVITIES	400000	0	400000	0.00	0	400000 35 140000	540000
PROJECT TOTAL		2,086,996	0	2,086,996	0.00	0	2,086,996 35 730,449	2,817,445

319

WMC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAAS/P4W000
FILE NO. Z394SAAS

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 5
DOE_R03 - ESTIMATE BASIS SHEET

PAGE 3 OF 7
DATE 04/01/96 11:53:08
BY BAL

1. DOCUMENTS AND DRAWINGS

DOCUMENTS: DSI FROM T. SALZANO REQUESTING ESTIMATES FOR PHASE I PRIVATIZATION ALTERNATIVES DATED 3/20/96.

DRAWINGS: ATTACHMENT A, B & C TO DSI.

2. LABOR RATES

A.) ICF-KH HOURLY RATES ARE BASED ON THE 1996 FISCAL YEAR BUDGET LIQUIDATION RATES AS ISSUED BY KEN FINANCE (EFFECTIVE 3-08-96). SEE ALSO THE FY 1996 PLANNING RATES * (REPORT BGHB7012).

B.) BASE CRAFT RATES ARE AS ISSUED BY KEN FINANCE (EFFECTIVE 10-01-95). RATES INCLUDE FRINGE BENEFITS, LABOR INSURANCE, TAXES, TRAVEL, DEPARTMENTAL OVERHEADS AND G&A/SWS.

* SEE HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK, SECTION 2 - COMPANY INFORMATION, FY 1996 PLANNING RATES.

3. GENERAL REQUIREMENTS/TECHNICAL SERVICES/OVERHEADS

A.) ONSITE CONSTRUCTION FORCES GENERAL REQUIREMENTS AND TECHNICAL SERVICES COSTS ARE INCLUDED AS A COMPOSITE PERCENTAGE BASED ON THE ICF-KH ESTIMATING FACTORS FOUND IN SECTION 2 OF THE BUDGET GUIDELINE HANDBOOK (BGHB) LOCATED ON HANFORD SOFT REPORTING, FDS BUDGET GUIDELINE HANDBOOK. THE PERCENTAGE APPLIED TO ONSITE CONSTRUCTION FORCES LABOR, FOR THIS PROJECT, IS 52% FOR SHOP WORK AND FIELD WORK, WHICH IS REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL.

B.) ONSITE CONTRACT ADMINISTRATION AND CONSTRUCTION MANAGEMENT COSTS, ASSOCIATED WITH THE OVERALL MANAGEMENT OF THE FIXED PRICE CONTRACTS, ARE INCLUDED AS A COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE (FOR BID PACKAGE PREP) BASED ON THE ESTIMATING FACTOR/BILLING SCHEDULE. THE TOTAL COMPOSITE PERCENTAGE AND LUMP SUM ALLOWANCE ARE APPLIED AGAINST THE TOTAL FIXED PRICE CONTRACT AMOUNT WHICH IS REFLECTED ON THE KEN SUMMARY REPORT DOE R07, INCLUDED WITH THIS ESTIMATE. (FINAL ESTIMATES MAY BE PARTIALLY UNLOADED AND INCLUDED WITHIN THE ESTIMATE DETAIL)

C.) FIXED PRICE CONTRACTOR OVERHEAD, PROFIT, BOND AND INSURANCE COSTS HAVE BEEN APPLIED AT THE FOLLOWING PERCENTAGES AND ARE REFLECTED IN THE "OH&P/B&I" COLUMN OF THE ESTIMATE DETAIL:

LABOR - 0% MATERIAL - 0% EQUIPMENT USAGE - 0% EQUIPMENT - 0% SUBCONTRACTS - 0%

4. ESCALATION

ESCALATION PERCENTAGES WERE CALCULATED FROM THE JANUARY 1996 UPDATE OF THE ECONOMIC ESCALATION PRICE CHANGE INDICES FOR DOE CONSTRUCTION PROJECTS AS PUBLISHED BY THE "OFFICE OF INFRASTRUCTURE ACQUISITION" FM-50.

5. ROUNDING

U.S. DEPARTMENT OF ENERGY - DOE ORDER 5100.4 PAGE 1-32 SUBPARAGRAPH (N), REQUIRES ROUNDING OF ALL GENERAL PLANT PROJECTS (GPP'S) AND LINE ITEM (LI) COST ESTIMATES. REFERENCE: DOE 5100.4, FIGURE 1-11, DATED 10-31-84.

6. REMARKS

A.) ESTIMATE IS FOR CONSTRUCTION ONLY. DOES NOT INCLUDE DESIGN COSTS.

B.) ESTIMATE IS IN FY 96 DOLLARS. NO ESCALATION WAS APPLIED AS A SCHEDULE FOR THIS WORK IS UNKNOWN.

C.) WORK IS ASSUMED TO BE ALL VALVE PIT TIE-INS PER DESIGN AND NO BURNOUT WAS APPLIED AS RADIOLOGICAL CONDITIONS WERE UNKNOWN.

D.) ALL WORK WAS ASSUMED TO BE DONE BY THE ONSITE E/C.

E.) ESTIMATE FOR SL-502 WAS DERIVED USING THE EXISTING ESTIMATE FROM PROJECT W-314.

F.) MODIFY THE W-314 ESTIMATE FOR REPLACEMENT OF 2" SL-504 AND 2" SL-502 AND INCREASE TO 3"/6" ENCASED PIPE.

C-20

WHC-SD-WM-TL-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAAS/P4W000
FILE NO. Z394SAAS

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 5
DOE_R04 - COST CODE ACCOUNT SUMMARY

PAGE 4 OF 7
DATE 04/21/96 14:19:32
BY BAL

COST CODE/VBS	DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
000 ENGINEERING								
110100	TITLE I, II & III	500000	0	500000	0.00	0	500000 35	675000
TOTAL 000 ENGINEERING		500000	0	500000	0.00	0	500000 35	675000
060 PROJECT MANAGEMENT								
401000	PROJECT MANAGEMENT	130000	0	130000	0.00	0	130000 35	175500
TOTAL 060 PROJECT MANAGEMENT		130000	0	130000	0.00	0	130000 35	175500
460 IMPROVEMENTS TO LAND								
310100	GENERAL REQUIREMENTS	50000	0	50000	0.00	0	50000 35	67500
310101	TRENCH EXCAVATION	465819	0	465819	0.00	0	465819 35	628856
310201	CORE DRILL	93214	0	93214	0.00	0	93214 35	125839
310302	FIELD INSTALL PIPE	215747	0	215747	0.00	0	215747 35	291258
TOTAL 460 IMPROVEMENTS TO LAND		824780	0	824780	0.00	0	824780 35	1113453
700 SPECIAL EQUIP/PROCESS SYSTEMS								
310301	SHOP FAB PIPE	110754	0	110754	0.00	0	110754 35	149518
310401	CATHODIC PROTECTION	121462	0	121462	0.00	0	121462 35	163974
TOTAL 700 SPECIAL EQUIP/PROCESS SYSTEM		232216	0	232216	0.00	0	232216 35	313492
900 OTHER PROJECT COSTS								
501000	OPC ACTIVITIES	400000	0	400000	0.00	0	400000 35	540000
TOTAL 900 OTHER PROJECT COSTS		400000	0	400000	0.00	0	400000 35	540000
=====								
PROJECT TOTAL		2,086,996	0	2,086,996	0.00	0	2,086,996 35	2,817,445

C-21

WHC-SD-WM-TI-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. 2394SAA5/P4W000
FILE NO. 2394SAA5

** TEST - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 5
DOE_R05 - ESTIMATE SUMMARY BY CSI DIVISION

PAGE 5 OF 7
DATE 04/21/96 14:19:42
BY BAL

CSI DESCRIPTION	ESTIMATE SUBTOTAL	ONSITE INDIRECTS	SUB TOTAL	ESCALATION % TOTAL	SUB TOTAL	CONTINGENCY % TOTAL	TOTAL DOLLARS
ENGINEERING							
00 TECHNICAL SERVICES	500000	0	500000	0.00	0	35	675000
TOTAL ENGINEERING	500,000	0	500,000	0.00	0	35	675,000
CONSTRUCTION							
01 GENERAL REQUIREMENTS	50000	0	50000	0.00	0	35	67500
02 SITEWORK	465819	0	465819	0.00	0	35	628856
15 MECHANICAL	419715	0	419715	0.00	0	35	566615
16 ELECTRICAL	121462	0	121462	0.00	0	35	163974
99 WHC LABOR	530000	0	530000	0.00	0	35	715500
TOTAL CONSTRUCTION	1,586,996	0	1,586,996	0.00	0	35	2,142,445
PROJECT TOTAL							
	2,086,996	0	2,086,996	0.00	0	35	2,817,445

C-22

T

WHC-SD-WM-ET-750
Revision 0

ICF KAISER HANFORD
WESTINGHOUSE HANFORD COMPANY
JOB NO. Z394SAAS/P4W000
FILE NO. Z394SAAS

DOE - INTERACTIVE ESTIMATING **
PHASE I PRIVATIZATION ALTERNATIVES
STUDY - OPTION 5
DOE_R06 - CONTINGENCY ANALYSIS BASIS SHEET

PAGE 6 OF 7
DATE 04/19/96 17:20:08
BY BAL

REFERENCE: ESTIMATE BASIS SHEET
COST CODE ACCOUNT SUMMARY

PAGE 3 OF 7
PAGE 4 OF 7

THE U.S. DEPARTMENT OF ENERGY - RICHLAND ORDER 5700.3 "COST ESTIMATING, ANALYSIS AND STANDARDIZATION" DATED 3-27-85, PROVIDES GUIDELINES FOR ESTIMATE CONTINGENCIES. THE GUIDELINE FOR A STUDY ESTIMATE SHOULD HAVE AN OVERALL RANGE OF 20 TO 50%.

CONTINGENCY IS EVALUATED AT THE THIRD COST CODE LEVEL AND SUMMARIZED AT THE PRIMARY AND SECONDARY COST CODE LEVEL OF THE DETAILED COST ESTIMATE.

000 ENGINEERING

110100 TITLE I, II & III DESIGN

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR DESIGN AND A DETAILED PLANNING EFFORT HAS NOT BEEN PERFORMED TO IDENTIFY ALL DISCIPLINE INVOLVED.

060 PROJECT MANAGEMENT

401000 PROJECT MANAGEMENT

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR WMC PROJECT MANAGEMENT AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

460 IMPROVEMENTS TO LAND

310100 GENERAL REQUIREMENTS

310101 TRENCH EXCAVATION

310201 CORE DRILL

310302 FIELD INSTALL PIPE

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

700 SPECIAL EQUIP/PROCESS SYSTEMS

310301 SHOP FAB PIPE

310401 CATHODIC PROTECTION

A 35% CONTINGENCY WAS APPLIED TO CONSTRUCTION AS LIMITED DESIGN MEDIA WAS SUPPLIED TO ESTIMATING AND DUE TO UNKNOWN/UNFORESEEN CONDITIONS IN TANK FARMS THAT COULD IMPACT THE COST OF CONSTRUCTION.

900 OTHER PROJECT COSTS

501000 OPC ACTIVITIES

A 35% CONTINGENCY WAS APPLIED AS A PERCENTAGE OF DIRECT CONSTRUCTION WAS USED TO GENERATE THE COST FOR WMC OPC ACTIVITIES AND A DETAILED PLANNING EFFORT NEEDS TO BE PERFORMED TO DETERMINE THE NUMBER OF SUPPORT PERSONNEL.

C-23

WMC-SD-WM-TI-750
Revision 0

ICF Kaiser Hanford**DESIGN ANALYSIS**

Calc. No. E44810-2707

Revision 0

Page No. 20 of 31

Client: WHC

WO/Job No. E44810

Subject: Head Loss Calculations for LLW

Date: 5/1/96

Feed from 241-AN Tanks (Alternative 1 and 2)

Checked: *ST/23/46*

Location: 200 East

Revised:

By: T.B. Salzano

By: *ndt*

By:

5.2.5 TOTAL HEAD LOSS: 241-AN ALTERNATIVE 2Process Pit Losses:

$$h_1 := h_{\text{pump_pits}} + h_{\text{valve_pits}} \quad h_1 = 24 \cdot \text{ft}$$

Transfer Path Losses:

$$h_2 := \frac{v_{3\text{in}}^2}{2 \cdot g} \sum_{i=6}^8 K_i \quad h_2 = 134 \cdot \text{ft}$$

Elevation Change:

$$h_3 := 50 \cdot \text{ft} + z_{\text{end}} - z_{\text{start}} \quad h_3 = 60.9 \cdot \text{ft} \quad (\text{Assumption 2})$$

Total Head Loss: $i = 1, 2, 3$

$$\text{TDH}_{100_alt2} := \sum_i h_i \quad \text{TDH}_{100_alt2} = 220 \cdot \text{ft}$$

Pressure Drop:

$$\Delta P_{100_alt2} := \frac{\text{TDH}_{100_alt2} \cdot \rho}{144 \cdot \frac{\text{in}^2}{\text{ft}^2}} \quad \Delta P_{100_alt2} = 143 \cdot \frac{\text{lb}}{\text{in}^2}$$

5.3 80 GPM: 241-AN**5.3.1 Constant Data**

Volumetric Flow Rate,

$$Q_{80} := 80 \cdot \frac{\text{gal}}{\text{min}}$$

$$q := \frac{Q_{80} \cdot 0.13368 \cdot \frac{\text{ft}^3}{\text{gal}}}{60 \cdot \frac{\text{sec}}{\text{min}}} \quad q = 0.18 \cdot \frac{\text{ft}^3}{\text{sec}}$$

Velocity of Flow,

$$\underline{2 \text{ inch pipe}} \quad v_{2\text{in}} := \frac{q}{A_{2\text{in}}} \quad v_{2\text{in}} = 7.6 \cdot \frac{\text{ft}}{\text{sec}}$$

$$\underline{3 \text{ inch pipe}} \quad v_{3\text{in}} := \frac{q}{A_{3\text{in}}} \quad v_{3\text{in}} = 3.5 \cdot \frac{\text{ft}}{\text{sec}}$$