DOCUMENT RELEASE AND CHANGE FORM

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By Washington River Protection Solutions, LLC., PO Box 850, Richland, WA 99352
Contractor For U.S. Department of Energy, Office of River Protection, under Contract DE-AC27-08RV14800

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8. Description of Change and Justification

The A-Farm tank vapor spaces are tied into one another through a ventilation system that was installed in the past. As-built conditions for these headers can be seen in H-2-55948. The 24-inch vapor header tie-in detail to each of the six tanks is shown on drawing H-2-55949. The vapor space header pipe then ties into a 24-inch vapor space manifold which is routed out of the farm to a common ventilation facility.

Overflow lines between the tanks poses an air intrusion when exhausting individual tank. These overflow lines are shown as Nozzle N-1 and N-6 on drawings H-2-73386, H-2-73387, H-2-73388, H-2-73390, H-2-73392 and H-2-73394.

Ventilation of the tanks is required during all retrieval operations. In order to obtain adequate vacuum within the tanks during retrieval, isolation of the tanks from the vapor space header and overflow lines must be achieved.

The purpose of this study is to determine the preferred way to isolate the A-Farm tanks from their common vapor space manifold and isolation of overflow lines to prevent any air intrusion.

Because of the general service status of the equipment, the design verification required box above was checked “No” because Kurion’s enhanced design verification, which is comparable to WRPS’s Design Verification, was not performed as allowed per Kurion’s procedure K-ENG-PRO-03-03, Enhanced Design Verification.

9. TBDs or Holds

☒ N/A

10. Related Structures, Systems, and Components

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11. Impacted Documents – Engineering

☒ N/A

12. Impacted Documents (Outside SPF):

N/A

13. Related Documents

☒ N/A
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A-Farm Air Intrusion Pathways Isolation Assessment

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Key Words: isolation, A-Farm, vapor space, retrieval

Abstract: The purpose of this study is to determine if isolation of major air intrusion pathways is necessary at A Farm to ensure adequate function of the new ventilation system to support waste retrieval. If isolation is necessary, the preferred way to isolate these lines is proposed.

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1.0 Purpose
A new ventilation system will be installed at the 241-A Tank Farm (A Farm) to support waste retrieval activities. The tanks were constructed with the headspace of each single-shell tank (SST) in communication with the other six tanks in A Farm through underground ventilation ducts connected to the common vapor header and through supernatant overflow lines. The purpose of this study is to determine if isolation of these major air intrusion pathways is necessary and, if so, determine the preferred way to isolate these lines. The following options were considered as part of this study:

1. **No Isolation**: Operate the new ventilation system without isolation of the major air intrusion pathways.
2. **Spray Foam**: Fill the seal loops for each tank with spray-foam insulation.
3. **Cut and Cap**: Cut and cap the underground piping of the major air intrusion pathways.
4. **Fill Seal Loops with Grout**: Fill the seal loops with non-shrink grout using existing water fill lines.
5. **Fill Seal Loops with Water**: Fill the seal loops with water using existing fill lines.
6. **Seal Internal Tank Baffle**: Fill the internal tank baffle with a spray sealant.

2.0 Summary of Results

1. Option 4, Fill Seal Loops with Grout, is the preferred option to pursue for isolation of the A Farm tanks from the vapor header, based on a weighted ranking of the options considering cost and schedule impact, uncertainty, and risk to personnel.

2. Option 1, No Isolation, is the second preferred option, but the uncertainty associated with this option is relatively high. Additional evaluation of ventilation system requirements and capability would need to be performed to provide more confidence in this option.

3. A scoping analysis shows that isolation of the 6-inch overflow lines is not necessary, but isolation of the vapor header should still be considered.

4. The current isolation status of the A Farm tanks is not clear and an attempt should be made to verify the existing isolation condition.

3.0 Description of Existing Condition
The 241-A tanks are vented to an underground vapor header, which is connected to the 241-AX Tank Farm and later to the 241-AY Tank Farm. The purpose of this vapor header was to remove off-gas and water vapor from these tanks, which were often operated with the wastes at boiling conditions.

The design of the branch connections to each tank included a baffled, 20-in.-diameter pipe inside each tank, as shown in Figure 1. The 20-in. diameter branch connections are connected to the main vapor header, which is a 24-in. diameter stainless-steel pipe. Historical drawings (H-2-
55949) indicate a minimum burial depth of the 20-inch branch connections of 4-feet, with another approximately 2-feet to the top of the seal loop. The 24-in. vapor header runs between the tanks, as shown in Figure 2, and to the 241-A-431 ventilation building. Dresser couplings provide a compression seal on the outer surface of vapor header piping segments that are ~25 ft in length. The couplings provide for expansion and contraction of the vapor header pipe segments.

![Figure 1: Elevation View of Vapor Header Connection to Tanks](image1)

![Figure 2: Plan View of Existing A Farm Vapor Header](image2)

Each vapor header seal loop has a 1-inch Sch. 80 water fill line and ½-inch Sch. 80 weight factor line as shown on drawing H-2-55949. The water fill line is capped with a welded cap at or slightly below grade level for all tanks, with the possible exception of Tank A-102. This pipe
runs vertically down, turns 90-degrees and ties into the 20-inch seal loop wall at the center line. The weight factor line runs underground to the instrument house and the isolation status of this line is not clear. Each seal loop also has a 2-inch drain line that slopes back to the 24-inch vapor header. Each drain line has an isolation valve with a valve handle extension and casing to grade level. The position and operability of these drain valves is not known.

The waste overflow lines consist of a 6-inch Sch. 80 carbon steel pipe installed with a 3% slope between tanks. These lines allowed overflow to cascade from Tank A-101 to A-102 and then to A-103 and from Tank A-104 to A-105 and then to A-106. Tank A-103 also overflows into Tank A-106 for a total of five overflow lines in A Farm. Each overflow line has a seal loop located near the upstream tank as shown in Figure 3. Each seal loop has a 1-inch fill line and ½-inch weight factor line similar to the vapor header seal loops. The overflow lines are approximately 21 feet deep for all tanks as shown on H-2-55911. Table 1 provides a summary of the overflow nozzles for each tank.

<table>
<thead>
<tr>
<th>Tank Number</th>
<th>Drawing Number</th>
<th>Nozzle</th>
<th>Inlet or Outlet</th>
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<tr>
<td>A-101</td>
<td>H-2-73388</td>
<td>N-1</td>
<td>Outlet</td>
</tr>
<tr>
<td>A-102</td>
<td>H-2-73390</td>
<td>N-1</td>
<td>Outlet</td>
</tr>
<tr>
<td>A-102</td>
<td>H-2-73390</td>
<td>N-6</td>
<td>Inlet</td>
</tr>
<tr>
<td>A-103</td>
<td>H-2-73392</td>
<td>N-1</td>
<td>Outlet</td>
</tr>
<tr>
<td>A-103</td>
<td>H-2-73392</td>
<td>N-6</td>
<td>Inlet</td>
</tr>
<tr>
<td>A-104</td>
<td>H-2-73386</td>
<td>N-1</td>
<td>Outlet</td>
</tr>
<tr>
<td>A-105</td>
<td>H-2-73387</td>
<td>N-1</td>
<td>Outlet</td>
</tr>
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<td>A-105</td>
<td>H-2-73387</td>
<td>N-6</td>
<td>Inlet</td>
</tr>
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<td>H-2-73394</td>
<td>N/A</td>
<td>Inlet (A-103)</td>
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Figure 3: Configuration of Overflow Lines
Evidence exists that the vapor header and/or the overflow lines may already be isolated from some tanks, but conflicts exist in the existing documentation and field knowledge. RPP-ENV-37956, Hanford 241-A/AX Farm Leak Inventory Assessments Report, Rev 2, Section 3.1.1, states that the A Farm and the AX Farm tanks were isolated from this vapor header in the early 1980s, although this conflicts with the isolation drawings. Drawing H-2-36577 shows that the 20-inch vent pipe connected to tank A-105 and the 6-inch overflow line between Tanks A-105 and A-106 has been isolated with welded plate blanks. Other drawings indicate no evidence of vapor header and overflow line isolation as shown in Table 2. General plant knowledge indicates that there may be more tanks isolated than are shown on the drawings.

Table 2: Documented Status of A Farm Tank Isolation

<table>
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<tr>
<th>Tank</th>
<th>Vapor Header Status</th>
<th>Overflow Line Status</th>
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<td>All</td>
<td>Isolated from vapor header in the early 1980s. RPP-ENV-37956</td>
<td>N/A</td>
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<td>241-A-101</td>
<td>Not isolated. Vapor Riser R-9, Leave &quot;as is&quot;. H-2-73388, Sh 1, Zn F6</td>
<td>Not isolated. Overflow outlet N-1, Leave &quot;as is&quot;. H-2-73388, Sh 1, Zn D4</td>
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<tr>
<td>241-A-102</td>
<td>Not isolated. Vapor Riser R-9, Leave &quot;as is&quot;. H-2-73390, Sh 1, Zn F6</td>
<td>Not isolated. Overflow outlet N-1, inlet N-6, Leave &quot;as is&quot;. H-2-73390, Sh 1, Zn D4</td>
</tr>
<tr>
<td>241-A-103</td>
<td>Not isolated. Vapor Riser R-9, Leave &quot;as is&quot;. H-2-73392, Sh 1, Zn F6</td>
<td>Not isolated. Overflow outlet N-1, inlet N-6, Leave &quot;as is&quot;. H-2-73392, Sh 1, Zn F6</td>
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<tr>
<td>241-A-104</td>
<td>Not isolated. Vapor Riser R-9, Leave &quot;as is&quot;. H-2-73386, Sh 1, Zn B6</td>
<td>Not isolated. Overflow outlet N-1, Leave &quot;as is&quot;. H-2-73386, Sh 1, Zn D4</td>
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<td>Vapor Riser R-10, Leave &quot;as is&quot;. H-2-73387, Sh 1, Zn B6</td>
<td>Overflow outlet N-1, Leave &quot;as is&quot;. H-2-73387, Sh 1, Zn D4</td>
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<td>241-A-106</td>
<td>Not isolated. Vapor Riser R-9, Leave &quot;as is&quot;. H-2-73394, Sh 1, Zn B6</td>
<td>Not isolated. Overflow outlet, inlet N-1, Leave &quot;as is&quot;. H-2-73394, Sh 1, Zn B6</td>
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Verification of the isolation mentioned in RPP-ENV-37956 and shown on the drawings for Tank A-105 should be verified prior to initiating any new efforts for tank isolation. An inspection of the vapor branch connections may be performed by a variety of methods including inserting a flexible borescope or other inspection device into the 1-inch schedule 80 water fill lines, using electrical fish tape to check for blockage in the fill lines, or pressurizing the water fill lines or weight factor lines with air. The preferred method of inspection will need to be determined. The 1-inch fill line is isolated at grade with a welded pipe cap, with the exception possibly of Tank A-102, and this cap would need to be removed depending on the inspection method.

4.0 Basis for Need for Isolation

The functions of the A Farm ventilation system, as defined in RPP-SPEC-60378, 241-A Tank Farm Ventilation System Level 2 Specification, that are potentially affected by the existing connection of all tank headspaces include:

- Provide measurable vacuum in each of the tanks individually
- Remove aerosols from the tank headspace to support the use of in-tank cameras as a visual aid during retrieval and closure activities
- Provide confinement controls as outlined in RPP-13033, Tank Farms Documented Safety Analysis, Chapter 2

Past experience with SST waste retrieval has required extra measures to seal the confinement boundary in order to maintain a measurable differential pressure. This is due to the multiple in-leakage pathways into the tank headspace. Ventilating a single tank during waste retrieval without first isolating the major air intrusion pathways would substantially increase the in-leakage pathways, thus substantially increasing the risk that the vacuum needed to maintain confinement cannot be achieved.

A scoping calculation was performed to evaluate the impact on the ability of the new ventilation system to maintain a vacuum in the tank being retrieved without isolation of the connecting air pathways to other tanks. It is not possible to precisely quantify tank in-leakage and the ability to maintain vacuum, neither based on the existing tank condition nor as it changes due to installation of retrieval equipment. However, the worst case condition can be evaluated for scoping purposes. This worst case condition postulates that the tank adjacent to the tank being retrieved is so leaky that no measurable vacuum can be achieved in that adjacent tank. This is expected to be the most challenging condition for maintaining vacuum in the tank being retrieved. Conversely, the tank being retrieved is assumed to have no other in-leakage pathways in order to evaluate the effect of the in-leakage through the vapor header and overflow lines. Although actual tank leakage is expected to be significant, this assumption allows determination of the margin available for other leak paths. Then the ability to maintain vacuum in the tank being retrieved is evaluated, constrained by the capacity of the exhausters.

Six scenarios are explored and the results are summarized in Table 3. Initially, each scenario was evaluated based on maximum potential pressure difference between the retrieval and adjacent tanks. If the resulting air flow between the tanks exceeds the capacity of the ventilation system, then the model was revised to estimate that vacuum that could be achieved in the retrieval tank when operated at the maximum flow capacity of the ventilation system, both with one and two exhausters operating.
AFT Fathom was used to perform this analysis and the inputs and outputs from Fathom are shown in Appendix A. The entire tank farm was not included in this model for simplicity, only the retrieval tank and an adjacent tank.

These results show that under these worst case conditions, sufficient vacuum should be able to be maintained in the tank being retrieved if the vapor header is isolated, but the overflow lines are not (Scenarios 1 and 2), with considerable capacity margin still available to account for additional leak paths. However, the results are inconclusive regarding isolation of the vapor header. Vacuum may not be able to be maintained if the vapor header is not isolated (Scenarios 3 and 4) and the tank is ventilated with one exhauster. Operating two exhausters may achieve the required vacuum in this case, but at the cost of reduced operational flexibility and increased cost and schedule risk (Scenarios 5 and 6).

### Table 3: Scoping Evaluation Results of No Isolation

<table>
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<tr>
<th>Scenario</th>
<th>Vapor Header Isolated</th>
<th>Overflow Line Isolated</th>
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<th>Exhauster Flow</th>
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<tr>
<td>1</td>
<td>Yes</td>
<td>No</td>
<td>1</td>
<td>571 cfm</td>
<td>-2.4 inwg</td>
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<tr>
<td>2</td>
<td>Yes</td>
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<td>1</td>
<td>1142 cfm</td>
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<td>-0.99 inwg</td>
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Scenario 1 is for tanks with only one overflow line (Tanks A-101 and A-104), while Scenario 2 looks at tanks with two overflow lines (Tanks A-102, A-103, A-105 and A-106).

The conclusions of this scoping analysis are that isolation of the overflow lines is not required, but is inconclusive regarding isolation of the vapor header. Therefore, the option for no isolation of the vapor header is still considered in this study because the risks must be weighed against the options for isolation. It can also be concluded that a complete leak tight seal of the vapor header is not required, since leakage through two 6-inch diameter overflow lines is acceptable.

### 5.0 241-AX Tank Farm Lessons Learned

An isolation assessment similar to this report was performed for AX Farm and is documented in RPP-RPT-57484, AX Farm Isolation Assessment. The recommendation from this report was similar to the cut and cap method described in Section 9.3 of this report. Contamination was encountered as expected, however the dose rates in proximity to the vapor header piping was much higher than expected, over 1 R/hr. Much of the surrounding soil was heavily contaminated and had to be removed and contained for disposal. Continuation with this option would have resulted in unacceptable personnel exposure due to the extensive manual excavation required and the installation of the pipe caps.
An alternative option was proposed for isolation using a grout plug. The AX Farm vapor header does not include seal loops. To contain the grout, a hole was drilled on either side of the location where the grout plug was established. A bag was inserted into each hole and filled with grout. A dam was, therefore, created on each side of the plug, which contained the grout to form the isolation seal. Mockup testing was performed to validate this concept. During implementation of this option, some difficulty getting the bag to fill sufficiently was experienced in the field. A steel plate was placed in the bottom of the excavation due to the high dose rates coming from the vapor header.

Significant cost and schedule impacts were realized due to cessation of work, development of the new concept and mockup testing.

### 6.0 Requirements, Constraints and Assumptions

The following were used to determine feasibility and to develop the option descriptions:

1. Ventilation system performance must be maintained and is defined in RPP-SPEC-60378.
2. Best available knowledge of the current configuration of the A Farm tanks is taken from historical drawings.
3. The isolation must provide a nearly complete seal, but as shown in Section 4.0, a leak-tight seal is not required.
4. Excavation must be completed prior to installation of the new ventilation system equipment.

### 7.0 Methodology

The options for tank isolation in A Farm are evaluated using a weighted ranking model. Attributes are identified that involve characteristics that will discriminate between the options. The attributes are assigned weights, which quantify the relative importance of each attribute for the isolation project. Each option is then ranked according to each attribute, in relation to the other options. The rankings are then multiplied by the weights, and then summed to provide an overall ranking score for the options. The rankings are relative between the options. To emphasize this relative ranking system, options are given ranking scores of -1, 0, or 1. A “-1” or “1” ranking indicates the option is less preferred or more preferred, respectively, when compared to other options for that attribute. A “0” ranking indicates an option is average relative to the other options.

The weights and rankings are subjective and based on the descriptions of the options in this report. This model quantifies a subjective process by isolating aspects of each option such that they can be readily compared. This model reduces a complex problem into more manageable concepts through the use of weighted attributes.

Preliminary option descriptions were prepared, attributes selected, and preliminary attribute weightings were selected in advance of the formal ranking meeting. This meeting was held on March 23, 2016 and included personnel with extensive knowledge and experience with Tank Farm operations and A Farm. This included representatives from engineering, construction, and
radiological control as shown in Table 4. The options were reviewed and discussed in detail at the meeting and the lessons learned from the AX Farm isolation effort were presented. Then the attribute weightings were confirmed and the options ranked within each attribute. The rankings for each option were multiplied by the attribute weights and summed to provide a total score for each option. The preferred option is the one with the highest overall score. All weightings and rankings were based on consensus of the group.

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<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craig Anderson</td>
<td>WRPS</td>
<td>Engineering</td>
</tr>
<tr>
<td>Danny Schoepflin</td>
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<td>David Parkman</td>
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<tr>
<td>Shaun Cook</td>
<td>WRPS</td>
<td>Engineering</td>
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8.0 Attributes for Comparison of Alternatives

Attributes are selected that are discriminators in the determination of the preferred option. Other attributes may be very important for success of the option, but these attributes are not considered in this report if they do not help discriminate between the options. The following sections describe how the attributes were considered when evaluating each option.

8.1 Cost and Schedule Impact

The cost and schedule impact attribute considers the duration of the work activity under which the isolation is performed. This includes procurement, testing, fieldwork, post installation testing, and restoration. Cost and schedule impact due to failure of the option to provide isolation is covered under the uncertainty attribute.

This attribute also considers the impact on the cost and schedule for other tank retrieval or construction activities. Options that inhibit or constrain these other activities are ranked less favorably under this attribute.
Cost and schedule impact was evaluated based on working experience and complexity of the option.

### 8.2 Uncertainty

The uncertainty attribute considers the successful isolation of the A-Farm tanks and answers the question “Will it work?”. Uncertainty can be related to operation of equipment used to perform the isolation, performance of field work for the option, validation of successful isolation, life expectancy of isolation method, required maintenance of the option, and environmental risk.

As shown in the scoping calculation in Section 4.0, the 6-inch overflow lines do not require isolation; therefore, leak tight isolation is not required. However, options that provide greater assurance of positive isolation may be ranked more favorably than those that do not.

### 8.3 Risk to Personnel

The risk to personnel attribute considers the industrial, chemical, and radiological hazards to which personnel will be exposed. Options that implement the principles of as low as reasonably achievable (ALARA) to a higher degree are ranked more favorably under this attribute. Tank farm personnel are required to wear breathing apparatus for protection from chemical vapors and this must be considered when evaluating options under this attribute.

### 8.4 Weighting the Attributes

The decision criteria described above are weighted according to their relative degree of importance. These weights contribute significantly to the overall ranking of the options because option rankings are multiplied by the weights and then summed to provide an overall ranking score for the options. For this study, the uncertainty and risk to personnel attributes are weighted equally and heavily, emphasizing the importance of successful isolation and for minimizing worker exposure to hazards. Cost and schedule impact is important, but is weighted less relative to the other attributes.

The weighting factors listed below were confirmed at the meeting on March 23, 2016, with consensus of all participants.

- Cost and Schedule Impact: 20%
- Uncertainty: 40%
- Risk to Personnel: 40%

### 9.0 Option Description

#### 9.1 Option 1: No Isolation

Operate the ventilation system without isolation of the communication pathways between the tank headspaces. This is the “do nothing” alternative. This option requires no isolation of the main vapor header, seal loops, or overflow lines between the tanks. As shown in Section 4.0,
isolation of the overflow lines is not required, so the alternative considered under this option is to not isolate the vapor header as well.

Several different methods are possible for operating the new ventilation system under this option. These include, but are not limited to;

1. Exhaust only the retrieval tank with one exhauster and allow air to flow in from other tanks through the vapor header and overflow lines.

2. Exhaust the retrieval tank and one or more adjacent tanks with one exhauster, using butterfly valves for system balancing.

3. Exhaust all six tanks simultaneously with two exhausters, using butterfly valves to balance the system as required to increase flow and vacuum in the tank or tanks being retrieved. This may be the preferred operating mode selected for the ventilation system to mitigate hazardous vapors, regardless of the vapor header isolation.

**9.1.1 Cost and Schedule Impact**

This option requires no additional preparations for A-Farm retrieval and, therefore, the cost and schedule impact is almost negligible.

**9.1.2 Uncertainty Level**

The ability to maintain the tank vacuum required for confinement during retrieval is uncertain. The requirement for the ventilation system is to maintain measurable vacuum, so more confidence can be had with this need for minimal vacuum. If unsuccessful in maintaining sufficient vacuum, however, proceeding with one of the other options for isolation, after it is found that tank vacuum cannot be achieved, would be a significant impact for the retrieval schedule and is physically constrained because all the ventilation system equipment would be installed and potentially in the way.

The amount of in-leakage in the tanks is the key driver for that ability to maintain vacuum, and this is unknown at this time. The ability to perform in-tank construction activities concurrent with tank retrieval may not be possible. Operational flexibility is potentially limited because if two exhausters are required to operate, a shutdown of one of the exhausters, either for scheduled or unscheduled maintenance, will cause all retrieval operations to be halted.

Tank 241-A-101 is a Waste Group B tank and could potentially release flammable gas. This gas could migrate between tanks through the open vapor header. Other non-flammable, but hazardous vapors that are more prevalent in some tanks would also potentially migrate. Operational limitations or controls for individual tanks may then be required for all six tanks. Some uncertainty remains whether the system can be licensed without isolating the vapor header.

One favorable aspect resulting from this option is that removal of mist and vapors from the tank headspace could be enhanced due to multiple inlet locations resulting in more uniform flow patterns and higher flow rates.
9.1.3 Risk to Personnel

The risk to personnel for construction in this option is negligible because there are no additional work activities.

9.2 Option 2: Spray Foam Insulation

Fill the vapor header piping with spray foam insulation where the branch connections tie into the vapor header as shown in Figure 4. It is not expected that the 1-inch water fill line could be used to inject this spray foam because the foam does not readily flow, so this option will require excavation down to the vapor header. A 4-inch hole would be cut into the vapor header to allow placement of the spray foam. A total of three excavations would be required of up to approximately 6-feet deep; one for each junction of branch connections from two tanks with the vapor header.

Full scale pilot testing is recommended to minimize risk and uncertainty with this option. A full scale, high fidelity mockup of the seal loops could be made and the feasibility of this option demonstrated. A mockup could also be used for training and pre-job walkthrough of the isolation process.

9.2.1 Cost and Schedule Impact

The cost and schedule impact associated with this option is influenced mostly due to the extensive manual excavation in A Farm and the recommended mock-up testing. Selection and evaluation of the actual spray foam compound will require time.

Cost and schedule is also impacted by the recommended mock-up testing to mitigate uncertainty.
9.2.2 Uncertainty Level

The use of spray foam does not guarantee an absolute isolation of the vapor space header. There is potential for gaps in the plug that would allow airflow or pinhole openings throughout the cross-section. Although not ideal, total leak tightness is not required for successful isolation. While the availability of the technologies and resources for isolation using spray foam are available, the exact mix and behavior of the compound would need to be tested to show that the principle was feasible and repeatable. These uncertainties could be mitigated during the mockup testing. As with any excavation in the tank farms, all obstacles and difficulties encountered during the excavation are not known.

Due to the heat of curing, the installation would probably have to be done in at least two lifts, with a cure time of a few hours between lifts. The mockup testing would demonstrate the required number of lifts can be performed safely and successfully. The excessive heat can potentially cause a fire if not controlled.

The longevity of the seal is unknown when exposed to the chemical and radiation environment near the waste tanks in A Farm. Some evaluation would be required to ensure isolation is maintained through the life of the retrieval project.

9.2.3 Risk to Personnel

Exposure of the vapor space header, approximately 4-feet below grade, would be required in three locations in A-Farm. This excavation could be at the junction of the branch connection piping from two tanks and the main vapor header as shown in Figure 4, and would only need to expose the top surface of the branch connection piping. Based on the AX Farm lessons learned and the operation of these boiling waste tanks, it is expected that elevated dose rates will be seen from the vapor header, increasing the radiological exposure of personnel. This exposure will occur during the final part of the excavation and the spray foam installation. Manual excavation will be required while on-mask.

9.3 Option 3: Cut and Cap

Cut the 20-inch branch connection piping to each tank between the seal loop and the vapor header as shown on Figure 5. Cap both sides of the cut piping with Dresser Style 31 line caps with no vent connection on the cap. This option will require manual excavation above and below the seal loops at six places, where the top of pipe is at least 4-feet deep.

9.3.1 Cost and Schedule Impact

The cost and schedule impact associated with this option is influenced mostly due to the extensive manual excavation in A Farm and managing the contamination and elevated dose rates. This option requires the most excavation of all the options. Work must be performed in a glove bag, further extending the required amount of time. Procurement of the Dresser Type 31 line cap, in this large pipe size, may be long lead.
9.3.2 Uncertainty

This option will establish zero leakage isolation with a high degree of confidence. As with any excavation in the tank farms, all obstacles and difficulties encountered during the excavation are not known. The integrity of the pipe and the ability to install the Dresser pipe cap is also not known, although the pipe is stainless steel, which provides some confidence regarding its integrity. Residual pipe spring, if present, could cause binding during the cutting operation.

Figure 5: Cut and Cap Option for Vapor Header Isolation

9.3.3 Risk to Personnel

Exposure of the vapor space header, approximately 4-feet below grade, would be required in six locations in A-Farm. This excavation would need to expose the entire perimeter of the branch connection piping, including underneath, with enough clearance to install the Dresser pipe cap. Based on the AX Farm lessons learned and the operation of these boiling waste tanks, it is expected that elevated dose rates will be seen from the vapor header, increasing the radiological exposure of personnel. Elevated dose rates and contaminated soil were seen in AX farm even before the pipe was exposed. This majority of the personnel exposure will occur during the final part of the excavation and installation of the cap. Manual excavation will be required while on-mask.

9.4 Option 4: Fill Seal Loops with Grout

Fill the six 20-in. diameter vapor space seal loops in the branch connections to each tank with non-shrink grout as shown on Figure 6. Liquefied non-shrink grout can be poured or pumped into the seal loop through the existing 1-inch water file line. The 1-inch fill line is isolated at or
slightly below grade with a welded pipe cap, which would have to be excavated and cut off. Also, the isolation valve on the seal loop drain line would have to be confirmed to be closed; otherwise grout would flow into the main 24-inch vapor header. The volume of grout required to fill the seal loop can be calculated from the geometry of the seal loop. Several fluid, self-leveling, liquified grout products are available such as Five Star Special Grout 400, a fluid, non-shrink grout for cables, tendons and tight clearances. This type of flowable grout can be expected to be successfully poured or pumped through the 1-inch water fill line.

Full scale pilot testing is recommended to minimize risk and uncertainty with this option. A full scale, high fidelity mockup of the seal loops and fill lines could be made and the feasibility of this option demonstrated. A mockup could also be used for training and pre-job walkthrough of the isolation process.
9.4.1 Cost and Schedule Impact

The welded caps on the water fill lines for all six seal loops would need to be cut off and a fitting installed for connection of a hose. No excavation is required other than exposure of the water fill line.

High confidence of complete isolation is expected with this option because the amount of grout required to make the seal can be easily calculated and the volume can be controlled during installation. Any uncertainties with ability to insert grout through the 1-inch fill line could be mitigated during the mockup testing. The only real uncertainty with this option is the position of the seal loop drain valve, but it was likely closed during the original tank isolation project, so the risk is low that this valve is open.

9.4.3 Risk to Personnel

The risk to personnel associated with this option is very low because all work is done at grade with minimal exposure to additional radiological or significant industrial hazards.
9.5 Option 5: Fill Seal Loops with Water

Fill the six 20-in. diameter vapor space seal loops in the branch connections to each tank with water, similar to the grout fill option shown on Figure 6. This would return the loop seals to their original function for isolating each tank from the vapor header. Water can be poured into the seal loop through the existing 1-inch water file line. The 1-inch fill line is isolated at grade with a welded pipe cap, which would have to be cut off. Also, the isolation valve on the seal loop drain line would have to be confirmed to be closed; otherwise water would flow into the main 24-inch vapor header. The volume of water required to fill the seal loop can be calculated from the geometry of the seal loop.

Maintenance of the water level would be required due to evaporation. This could be done by either periodic addition of water, adding water when tank pressures indicate that a tank is no longer isolated, or reactivating the existing ½-inch weight factor lines.

9.5.1 Cost and Schedule Impact

The welded caps on the water fill lines for all six seal loops would need to be cut off and a fitting installed for connection of a hose. No excavation is required other than exposure of the water fill line.

Evaluation of the environmental risks of this option would be required to investigate the potential for water addition to the tanks and for water leakage out of the seal loops and associated drain piping.

9.5.2 Uncertainty Level

High confidence of complete isolation is expected with this option because the amount of water required to make the seal can be easily calculated and the volume can be controlled during installation. The position of the seal loop drain valve must be confirmed, but it was likely closed during the original tank isolation project, so the risk is low that this valve is open. Maintenance of the water level in the seal loop introduces uncertainty with maintaining effective isolation, overflow into waste tanks, and external leakage. The environmental risk of adding water to the seal loops and potentially to the waste tanks would need to be evaluated.

9.5.3 Risk to Personnel

The risk to personnel associated with this option is very low because all work is done at grade with minimal exposure to additional radiological or significant industrial hazards.

9.6 Option 6: Seal Internal Tank Baffle

Seal the vapor header at the air outlet baffle located in the head space of each tank as shown in Figure 7. Access would be required through a nearby spare riser. A urethane foam spray sealant could be injected through a long spray wand to first seal the drain holes in the baffle and then to seal the vapor header itself.

This option was added to the evaluation during the ranking meeting, so the option description is not as detailed as the other options.
9.6.1 Cost and Schedule Impact
Selection of the right sealant and development of the injection method will take time and effort, but installation of the seal would have relatively low cost and schedule impact.

9.6.2 Uncertainty Level
The ability to access the baffle from existing nearby tank risers is uncertain. Special tooling would likely be required to enter the riser, travel horizontally to the baffle, and then inject the sealant. It is not known if a suitable sealant exists that will seal this specific geometry.

9.6.3 Risk to Personnel
All operations would take place at grade, through an existing tank riser. Additional risk to personnel is minimal with this option.

![Figure 7: Seal Internal Tank Baffle](image)

10.0 Evaluation of Options
A meeting of stakeholders, all with extensive knowledge of Tank Farm operations and A Farm, was held on March 23, 2016. The ranking of options described in this section were reached through consensus of this working group.

The most preferable option under the cost and schedule impact attribute is Option 1 because no additional activities are required and the cost and schedule impact is negligible. The least favorable option in terms of cost and schedule impact is Option 3 because extensive manual
excavation is required around the entire perimeter of the branch connection piping. The other four options have relatively moderate cost and schedule impact, even those requiring mockup testing because this testing could be performed in parallel with other work planning activities.

The most preferable option under the uncertainty attribute is Option 4 because effective isolation is almost guaranteed and almost all other uncertainties can be mitigated through mockup testing. The least favorable option in terms of uncertainty is Option 1 because it cannot be determined if the ventilation system can continue to perform its function, exhauster down time will effect retrieval activities, and vapor migration may cause other problems. Options 2 and 6 were also scored low for uncertainty. The other two options have various levels of uncertainty, but relatively similar to each other.

The least preferable option under the risk to personnel attribute is Option 3 due to the expected elevated dose rates and large amount of time required in the vicinity of these dose rates due to the extensive excavation and installation of the pipe caps. Option 2 also involves risks of exposure due to excavation, so it was also scored low relative to the other options other than Option 3. Options 4 and 5 involve some excavation and hot work in the farm, but this is much less extensive. Options 1 and 6 are most favorable in this attribute because they introduce minimal additional hazards to personnel.

Table 5 shows the relative ranking of the five options within each attribute. These rankings are multiplied by the attribute weights and summed to provide a total score for each option. Option 4 receives the highest score and is the preferred option.

### Table 5: Ranking of Isolation Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost and Schedule</th>
<th>Uncertainty</th>
<th>Risk to Personnel</th>
<th>Score</th>
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<td>40</td>
<td>40</td>
<td>100</td>
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<td>1 40</td>
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<td>Option 4: Fill Seal Loops with Grout</td>
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<tr>
<td>Option 6: Seal Internal Tank Baffle</td>
<td>0 0</td>
<td>-1 -40</td>
<td>1 40</td>
<td>0</td>
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</table>

### 11.0 Conclusions

1. Option 4, Fill Seal Loops with Grout, is the preferred option to pursue for isolation of the A Farm tanks vapor header. This option scored highest due to its high level of certainty of success and relatively moderate risk to personnel and cost and schedule impact. The amount of manual excavation required is minor, only enough to remove the welded pipe cap on the 1-inch seal loop fill line. This option avoids the extensive excavation and
elevated dose rates that were extremely problematic in the AX Farm vapor header isolation effort.

2. **Option 1, No Isolation, is the second preferred option, but the uncertainty associated with this option is relatively high. Additional evaluation of ventilation system requirements and capability would need to be performed to provide more confidence in this option.**

3. **A scoping analysis was performed to establish the need for isolation. This scoping analysis showed that isolation of the 6-inch overflow lines is not required because tank headspace vacuum can be maintained. It is inconclusive, however, regarding isolation of the vapor header.**

4. **Some field work is recommended to confirm the current status of isolation of the A Farm tanks. Some evidence suggests that the tanks may already be isolated from the main vapor header.**

### 12.0 References


Appendix A
Scoping Analysis
SCENARIO 5

J201
Retrieval
Tank
P ln=1.51 in. H2O std. (g)
P Out=1.61 in. H2O std. (g)

P220
Vapor Header
V=2,874 feet/min
Q=6,000 ft³/min

J202
Adjacent
Tank
P ln=0.00 in. H2O std. (g)
P Out=0.00 in. H2O std. (g)

SCENARIO 6

J301
Retrieval
Tank
P ln=0.994 in. H2O std. (g)
P Out=0.994 in. H2O std. (g)

P300
Overflow Line
V=2,303 feet/min
Q=417 ft³/min

J302
Adjacent
Tank
P ln=0.00 in. H2O std. (g)
P Out=0.00 in. H2O std. (g)

P320
Vapor Header
V=2,874 feet/min
Q=6,553 ft³/min
### General

Title: AFT Fathom Model
Input File: P:\KUR-WASH03 - WRPS\103_A-Farm Retrieval Ventilation Design Support 3.0 DESIGN\Engineering Reports\Isolation Assessment\Rev C/A Farm Isolation.fth
Scenario: Base Scenario; One Contauser

- Number Of Pipes: 5
- Number Of Junctions: 8

- Pressure Head Tolerance: 0.0001 relative change
- Flow Rate Tolerance: 0.0001 relative change
- Temperature Tolerance: 0.0001 relative change
- Flow Relaxation: (Automatic)
- Pressure Relaxation: (Automatic)

**Constant Fluid Property Model**
- Fluid Database: AFT Standard
- Fluid: Air @ 1 atm (vapor)
- Max Fluid Temperature Data: 250 deg. F
- Min Fluid Temperature Data: 0 deg. F
- Density: 0.07067 lbm/ft³
- Viscosity: 0.04500 lbm-ft/ft²-s
- Vapor Pressure: Unspecified
- Viscosity Model: Newtonian

Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polymorphisms

Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Y, Y, Control Valve, Spray Discharge, Relief Valve

- Ambient Pressure (constant): 1 atm
- Gravitational Acceleration: 1 g
- Turbulent Flow Above Reynolds Number: 4000
- Laminar Flow Below Reynolds Number: 2300

### Pipes

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<th>Hydraulic Diameter</th>
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### AFT Fathorn 8 (Model)  
3/21/2016  
Page 2

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<td>Cylindrical Pipe</td>
<td>Stainless Steel - ANSI</td>
<td>20 inch</td>
<td>schedule 10S</td>
<td>None</td>
</tr>
</tbody>
</table>

### Assigned Flow Table

<table>
<thead>
<tr>
<th>Assigned Flow</th>
<th>Name</th>
<th>Object Defined</th>
<th>Inlet Elevation</th>
<th>Elevation Units</th>
<th>Database Source</th>
<th>Special Condition</th>
<th>Type</th>
<th>Flow Units</th>
<th>Flow Loss Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>201</td>
<td>Retrieval Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>Outflow</td>
<td>3000 ft³/min</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>301</td>
<td>Retrieval Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>Outflow</td>
<td>3000 ft³/min</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Assigned Pressure Table

<table>
<thead>
<tr>
<th>Assigned Pressure</th>
<th>Name</th>
<th>Object Defined</th>
<th>Inlet Elevation</th>
<th>Elevation Units</th>
<th>Initial Pressure</th>
<th>Initial Pressure Units</th>
<th>Pressure</th>
<th>Pressure Units</th>
<th>Pressure Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>Retrieval Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>-2.400 in. H2O std. (g)</td>
<td>-2.4 in. H2O std. (g)</td>
<td>Basic</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Branch Table

<table>
<thead>
<tr>
<th>Branch</th>
<th>Name</th>
<th>Object Defined</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Branch</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Reservoir Table

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Name</th>
<th>Object Defined</th>
<th>Inlet Elevation</th>
<th>Elevation Units</th>
<th>Liquid Elev. Units</th>
<th>Liquid Elev. Units</th>
<th>Surface Pressure</th>
<th>Surface Pressure Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>Adjacent Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>0 psi</td>
<td>0 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>Adjacent Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>0 psi</td>
<td>0 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>302</td>
<td>Adjacent Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>0 psi</td>
<td>0 psi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>303</td>
<td>Adjacent Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>0 psi</td>
<td>0 psi</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# General

Title: AFT Fathom Model
Input File: "P:\KUR-WASH03 - WRPS\103_A-Farm Retrieval Ventilation Design Support\DESIGN\Engineering Reports\Isolation Assessment\Rev C\A-Farm Isolation.fth"
Scenarios: base Scenarios\Two Consumers

Number Of Pipes: 4
Number Of Junctions: 6

Pressure Head Tolerance: 0.0001 relative change
Flow Rate Tolerance: 0.0001 relative change
Temperature Tolerance: 0.0001 relative change
Flow Relaxation: (Automatic)
Pressure Relaxation: (Automatic)

## Constant Fluid Property Model

Fluid Database: AFT Standard
Fluid: Air @ 1 atm (vapor)
Max Fluid Temperature Data = 250 deg. F
Min Fluid Temperature Data = 0 deg. F
Temperature = 100 deg. F
Density = 0.0786 lbm/ft³
Viscosity = 0.00400 lbm/ft-h
Vapor Pressure: Unspecified

Viscosity Model: Newtonian
Apply laminar and non-Newtonian correction to: Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Polymetrics

Corrections applied to the following junctions: Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Wye, Control Valve, Spray Discharge, Relief Valve

Ambient Pressure (constant) = 1 atm
Gravitational Acceleration = 1 g
Turbulent Flow Above Reynolds Number = 4000
Laminar Flow Below Reynolds Number = 2300

## Pipes

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Name</th>
<th>Pipe Defined</th>
<th>Length</th>
<th>Units</th>
<th>Hydraulic Diameter</th>
<th>Units</th>
<th>Diameter Units</th>
<th>Friction Data Set</th>
<th>Roughness</th>
<th>Roughness Units</th>
<th>Losses (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pipe</td>
<td>Yes</td>
<td>0.1</td>
<td>feet</td>
<td>47.25 inches</td>
<td></td>
<td></td>
<td>Standard</td>
<td>0.0018 inches</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>220</td>
<td>Vapor Header</td>
<td>Yes</td>
<td>60</td>
<td>feet</td>
<td>19.564 inches</td>
<td></td>
<td></td>
<td>Standard</td>
<td>0.0006 inches</td>
<td>1.810575</td>
<td></td>
</tr>
<tr>
<td>306</td>
<td>Overflow Line</td>
<td>Yes</td>
<td>20</td>
<td>feet</td>
<td>5.761 inches</td>
<td></td>
<td></td>
<td>Standard</td>
<td>0.0018 inches</td>
<td>2.32868</td>
<td></td>
</tr>
<tr>
<td>320</td>
<td>Vapor Header</td>
<td>Yes</td>
<td>60</td>
<td>feet</td>
<td>19.564 inches</td>
<td></td>
<td></td>
<td>Standard</td>
<td>0.0006 inches</td>
<td>1.810575</td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Geometry</th>
<th>Material</th>
<th>Size</th>
<th>Type</th>
<th>Special Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cylindrical Pipe</td>
<td>Steel - ANSI</td>
<td>48 inch</td>
<td>STD</td>
<td>None</td>
</tr>
<tr>
<td>220</td>
<td>Cylindrical Pipe</td>
<td>Stainless Steel - ANSI</td>
<td>20 inch</td>
<td>schedule 10S</td>
<td>None</td>
</tr>
<tr>
<td>306</td>
<td>Cylindrical Pipe</td>
<td>Steel - ANSI</td>
<td>6 inch</td>
<td>schedule 80</td>
<td>None</td>
</tr>
<tr>
<td>320</td>
<td>Cylindrical Pipe</td>
<td>Stainless Steel - ANSI</td>
<td>20 inch</td>
<td>schedule 10S</td>
<td>None</td>
</tr>
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</table>
### Assigned Flow Table

<table>
<thead>
<tr>
<th>Assigned Flow</th>
<th>Name</th>
<th>Object Defined</th>
<th>Inlet Elevation</th>
<th>Elevation Units</th>
<th>Database Source</th>
<th>Special Condition</th>
<th>Type</th>
<th>Flow</th>
<th>Flow Units</th>
<th>Loss Factor</th>
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</thead>
<tbody>
<tr>
<td>201</td>
<td>Retrieval Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>Outflow</td>
<td>6000 ft³/min</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>301</td>
<td>Retrieval Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td>None</td>
<td>Outflow</td>
<td>6000 ft³/min</td>
<td>0</td>
<td></td>
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<td></td>
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### Branch Table

<table>
<thead>
<tr>
<th>Branch</th>
<th>Name</th>
<th>Object Defined</th>
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</thead>
<tbody>
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<td>Branch</td>
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### Reservoir Table

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<thead>
<tr>
<th>Reservoir</th>
<th>Name</th>
<th>Object Defined</th>
<th>Inlet Elevation</th>
<th>Elevation Units</th>
<th>Liquid Elev. Units</th>
<th>Liquid Elev. Units</th>
<th>Surface Pressure</th>
<th>Surface Pressure Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>202</td>
<td>Adjacent Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>302</td>
<td>Adjacent Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>303</td>
<td>Adjacent Tank</td>
<td>Yes</td>
<td>0 feet</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>AFT Fathom 9 (Output)</td>
<td>AFT Fathom Model</td>
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<td></td>
</tr>
<tr>
<td>Page 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
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</table>

Model Reference Information

**General**

**Title:** AFT Fathom Model
**Analysis run on:** 3/2/2016 2:12:50 PM
**Application version:** AFT Fathom Version 9 (2016.01.25)
**Input File:** P:\KUR-WASH03 - WRRPS.103_A-Farm Retrieval Ventilation Design Support.3.0_DESIGN\Engineering
**Reports/Assessment No.:** Rev C1A Farm Isolation.8th
**Scenario:** Ultra Scenario/One Lethaluster
**Output File:** P:\KUR-WASH03 - WRRPS.103_A-Farm Retrieval Ventilation Design Support.3.0_DESIGN\Engineering
**Reports/Assessment No.:** Rev C1A Farm Isolation.2.aar

**Execution Time:** 0.24 seconds
**Total Number Of Head/Pressure Iterations:** 28
**Total Number Of Flow Iterations:** 8
**Total Number Of Temperature Iterations:** 0
**Number Of Pipe:** 5
**Number Of Junctions:** 8
**Matrix Method:** Gaussian Elimination

**Pressure/Head Tolerance:** 0.0001 relative change
**Flow Rate Tolerance:** 0.0001 relative change
**Temperature Tolerance:** 0.0001 relative change
**Flow Relaxation:** (Automatic)
**Pressure Relaxation:** (Automatic)

**Constant Fluid Property Model**
**Fluid Density:** AFT Standard
**Fluid:** Air @ 1 atm (vapor)
**Max Fluid Temperature Data:** 230 deg. F
**Min Fluid Temperature Data:** 0 deg. F
**Temperature:** 100 deg. F
**Density:** 0.00787 lbm/ft³
**Viscosity:** 0.00485 lbm/ft·sec
**Vapor Pressure:** Unspecified
**Vapor Density:** Newtonian

**Apply laminar and non-Newtonian correction for:** Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Proof tests
**Corrections applied to the following junctions:** Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Bend, Tee or Y, Y, Control Valve, Spray Discharge, Relief Valve

**Ambient Pressure (constant):** 1 atm
**Gravitational Acceleration:** 1 g
**Turbulent Flow Above Reynolds Number:** 4000
**Laminar Flow Below Reynolds Number:** 2300
**Total Inflow:** 49,153 gal/min
**Total Outflow:** 49,153 gal/min
**Maximum Static Pressure is 14.09 psia at Pipe 306 Inlet**
**Minimum Static Pressure is 14.61 psia at Pipe 106 Outlet**

**Warnings**
**No Warnings**

**Reservoir Summary**
### AFT Fathom 9 (Output)
3/21/2016
Page 2

<table>
<thead>
<tr>
<th>Jct</th>
<th>Name</th>
<th>Type</th>
<th>Liq Height (feet)</th>
<th>Liq. Elevation (feet)</th>
<th>Surface Pressure (psia)</th>
<th>Liquid Volume (feet³)</th>
<th>Liquid Mass (lbm)</th>
<th>Net Vol Flow (gallon/min)</th>
<th>Net Mass Flow (lbm/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>Adjacent Tank</td>
<td>Infinite</td>
<td>0</td>
<td>14.70</td>
<td>N/A</td>
<td>-4.270</td>
<td>-0.6743</td>
<td></td>
<td></td>
</tr>
<tr>
<td>202</td>
<td>Adjacent Tank</td>
<td>Infinite</td>
<td>0</td>
<td>14.70</td>
<td>N/A</td>
<td>-22.442</td>
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</tr>
<tr>
<td>302</td>
<td>Adjacent Tank</td>
<td>Infinite</td>
<td>0</td>
<td>14.70</td>
<td>N/A</td>
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<td>-3.2677</td>
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<td></td>
</tr>
<tr>
<td>303</td>
<td>Adjacent Tank</td>
<td>Infinite</td>
<td>0</td>
<td>14.70</td>
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<td>-1.557</td>
<td>-0.2458</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pipe Output Table

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Name</th>
<th>Vol Flow Rate (ft³/min)</th>
<th>Velocity (ft/min)</th>
<th>dp Static Total (in. H₂O std.)</th>
<th>P Static In (in. H₂O std. (g))</th>
<th>P Static Out (in. H₂O std. (g))</th>
<th>P Stag In (in. H₂O std. (g))</th>
<th>P Stag Out (in. H₂O std. (g))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pipe</td>
<td>3.000.0</td>
<td>246.4</td>
<td>0.000001686</td>
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<td>-0.2518</td>
</tr>
<tr>
<td>106</td>
<td>Overflow Line</td>
<td>570.9</td>
<td>3,153.6</td>
<td>1.815145210</td>
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<td>-2.4000</td>
<td>0.0000</td>
<td>-1.8151</td>
</tr>
<tr>
<td>220</td>
<td>Vapor Header</td>
<td>3,000.0</td>
<td>1,437.1</td>
<td>0.28956282</td>
<td>-0.12146</td>
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<td>-0.2899</td>
</tr>
<tr>
<td>306</td>
<td>Overflow Line</td>
<td>208.1</td>
<td>1,149.6</td>
<td>0.251837350</td>
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<td>-0.3266</td>
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<td>-0.2518</td>
</tr>
<tr>
<td>320</td>
<td>Vapor Header</td>
<td>2,791.9</td>
<td>1,337.4</td>
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<td>-0.10520</td>
<td>-0.3570</td>
<td>0.0000</td>
<td>-0.2518</td>
</tr>
</tbody>
</table>

### All Junction Table

<table>
<thead>
<tr>
<th>Jct</th>
<th>Name</th>
<th>Vol Flow Rate Thru Jct (ft³/min)</th>
<th>P Static In (in. H₂O std. (g))</th>
<th>P Static Out (in. H₂O std. (g))</th>
<th>P Stag In (in. H₂O std. (g))</th>
<th>P Stag Out (in. H₂O std. (g))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Branch</td>
<td>N/A</td>
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<td>-0.3007</td>
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<td>-0.2518</td>
</tr>
<tr>
<td>101</td>
<td>Retrieval Tank</td>
<td>570.9</td>
<td>-2.4000</td>
<td>-2.4000</td>
<td>-1.8151</td>
<td>-1.8151</td>
</tr>
<tr>
<td>102</td>
<td>Adjacent Tank</td>
<td>570.9</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>201</td>
<td>Retrieval Tank</td>
<td>3,000.0</td>
<td>-0.4113</td>
<td>-0.4113</td>
<td>-0.2899</td>
<td>-0.2899</td>
</tr>
<tr>
<td>202</td>
<td>Adjacent Tank</td>
<td>3,000.0</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>301</td>
<td>Retrieval Tank</td>
<td>3,000.0</td>
<td>-0.2554</td>
<td>-0.2554</td>
<td>-0.2518</td>
<td>-0.2518</td>
</tr>
<tr>
<td>302</td>
<td>Adjacent Tank</td>
<td>2,791.9</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>303</td>
<td>Adjacent Tank</td>
<td>208.1</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
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</table>
### Model Reference Information

#### General

**Title:** AFT Fathom Model

**Analysis run on:** 3/2/2016 2:17:42 PM

**Application version:** AFT Fathom Version 9.0 (2016.01.20)

**Input File:** P:\KUR-WASH03 - WRP\103_A-Farm Retrieval Ventilation Design Support\3.0 DESIGN\Engineering Reports\Assessment\Rev C\A-Farm Isolation

**Scenario:** Belize Scenario Two Exhusters

**Output File:** P:\KUR-WASH03 - WRP\103_A-Farm Retrieval Ventilation Design Support\3.0 DESIGN\Engineering Reports\Assessment\Rev C\A-Farm Isolation\3.txt

**Execution Time:** 0.97 seconds

**Total Number Of Head/Pressure Iterations:** 32

**Total Number Of Flow Iterations:** 4

**Total Number Of Temperature Iterations:** 0

**Number Of Pipes:** 4

**Number Of Junctions:** 8

**Matrix Method:** Gaussian Elimination

**Pressure/Head Tolerance:** 0.0001 relative change

**Flow Rate Tolerance:** 0.0001 relative change

**Temperature Tolerance:** 0.0001 relative change

**Flow Relaxation:** Automatic

**Pressure Relaxation:** Automatic

**Constant Fluid Property Model**

**Fluid Database:** AFT Standard

**Fluid:** Air @ 1 atm (vapor)

**Max Fluid Temperature Data:** 250 deg. F

**Min Fluid Temperature Data:** 0 deg. F

**Temperature:** 100 deg. F

**Density:** 0.07067 lbm/ft³

**Dynamic Viscosity:** 0.00485 lbm/ft·h

**Vapor Pressure:** Unspecified

**Vapor Density Model:** Newtonian

**Apply laminar and non-Newtonian correction to:** Pipe Fittings & Losses, Junction K factors, Junction Special Losses, Junction Pressure Loss

**Corrections applied to the following junctions:** Branch, Reservoir, Assigned Flow, Assigned Pressure, Area Change, Blend, Tee or Wyse, Control Valve, Sprinkler Discharge, Relief Valve

**Ambient Pressure (constant):** 1 atm

**Gravitational Acceleration:** 1 g

**Turbulent Flow Above Reynolds Number:** 4000

**Laminar Flow Below Reynolds Number:** 2300

**Total Inflow:** 89,766 gal/min

**Total Outflow:** 89,766 gal/min

**Maximum Static Pressure is 14.68 psia at Pipe 906 Inlet**

**Minimum Static Pressure is 14.64 psia at Pipe 220 Outlet**

#### Warnings

No Warnings

#### Reservoir Summary
### Pipe Output Table

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Name</th>
<th>Vol Flow Rate (gpm)</th>
<th>Velocity (ft/min)</th>
<th>dP Static Total (in. H2O std.)</th>
<th>P Static In (in. H2O std. (g))</th>
<th>P Static Out (in. H2O std. (g))</th>
<th>P Stag. In (in. H2O std. (g))</th>
<th>P Stag. Out (in. H2O std. (g))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>-0.4858</td>
<td>-1.6139</td>
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</tr>
<tr>
<td>306</td>
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### All Junction Table

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