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Tank 16 – Response To NRC Comments

On Closure Module

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Introduction

The United States Nuclear Regulatory Commission (NRC) provided comments to South Carolina Department of Health and Environmental Control (SCDHEC) on *Industrial Wastewater Closure Module for Liquid Waste Tank 16H H-Area Tank Farm Savannah River Site*, SRR-CWDA-2013-00091, during the SCDHEC public comment period. Several of the comments are associated with final residual volume estimates for the Tank 16 annulus. As discussed in Section 3.2.1 of the Closure Module, the residual waste volume has been estimated on three occasions in the recent past (i.e., 2007, 2012, and 2013). In the revised estimates, the annulus volume decreased from 4,760 gallons to 3,300 gallons to 1,910 gallons although no additional waste removal had occurred. The decrease in the estimated volume was not unexpected considering subsequent volume estimates apply additional rigor which is intended to remove uncertainty. Since the volume estimates are typically biased high in cases when few relative landmarks are present (such as the Tank 16 annulus), removing uncertainty would reasonably result in volume decreases.

In March 2007, the Tank 16 annulus was inspected using a camera mounted on a magnetic wall crawler. Based on this inspection, an estimated 4,760 gallons of waste remained in the annulus. However it was recognized that this volume was probably biased high due to the conservative assumption that the waste height inside the dehumidification duct was equal to the height of the waste outside the duct. This estimated volume was based entirely on visual evidence with no supporting measurements of waste depth. [LWO-LWE-2007-00085]

In 2011 as part of an annulus cleaning evaluation, samples of the annulus waste were collected under the North, South, East, and West annulus risers. Based on waste depth information obtained at the four sample locations, the annulus waste volume estimate was revised to 3,300 gallons in February 2012 (hereinafter referred to as: 2012 volume estimate). The four measured values were all lower than the previously predicted (i.e., 2007 volume estimate) values that were based on visual evidence. The measured waste depth measurements were used to assign waste heights at the measurement locations. However, a large portion of the 2012 volume estimate (in all the regions where measurement values were not available) was based solely on waste heights assigned by interpretation of visual observations and video evidence. [SRR-LWE-2012-00039]

The final annulus waste volume estimate, performed in 2013 (hereinafter referred to as: 2013 volume estimate), determined the annulus volume to be 1,910 gallons, with 410 gallons inside the dehumidification duct and 1,500 gallons on the annulus floor outside of the duct. [U-ESR-H-00113] During Tank 16 annulus characterization sampling in 2013, a total of 11 new samples were collected from different locations inside and outside the ductwork. During the sampling evolutions, the waste depth was measured at each of those locations. Additional photographs and video footage were also collected. The additional photographs were taken utilizing a high resolution camera and in general provided improved images when compared to the photographs utilized in the 2012 volume estimate. Due to the increase in the number of actual waste depth measurement locations the methodology for the 2013 volume estimate shifted from a largely visual interpretation of waste depth in previous estimations to the use of primarily

measured data with the visual information being utilized to evaluate reasonableness of the assumed waste depths that were based on measurement data. In all but two cases, including measurements supporting both the 2012 and 2013 volume estimates, the actual measured depth of the waste was less than the depth previously assigned utilizing visual evidence. As expected, the final estimated volume was lowered based on the increased reliance on measured data and less reliance on conservatively biased high visual interpretation.

Relative to final volume estimates for the Tank 16 annulus, the NRC provided the following general comment:

> "Based on NRC staff's detailed review of the Closure Module and associated references, documentation could be more transparent on how the revised volume was determined. NRC staff offers several detailed comments related to (1) the sampling method used to determine material heights, (2) the use of photographic evidence and landmarks to assign material heights, and (3) interpolation method used to assign material heights in areas where no sample or visual observation are available."

The NRC provides 13 detailed comments related to the final volume estimate. This document repeats each of the NRC detailed comments and provides a response which outlines additional information further explaining the methodology utilized in the final volume determination. In all of these responses, it is important to keep in mind the fundamental shift in the volume estimation methodology from waste heights being primarily assigned based on visual evidence, to waste heights being assigned based on measured values and visual evidence being utilized to verify the reasonableness of the assigned values. The comments are numbered, 5.1 through 5.13 as provided by the NRC.

Figure 1 provides orientation (station locations, sample locations, and photograph locations) around that Tank 16 annulus to support the individual comment responses in this document.

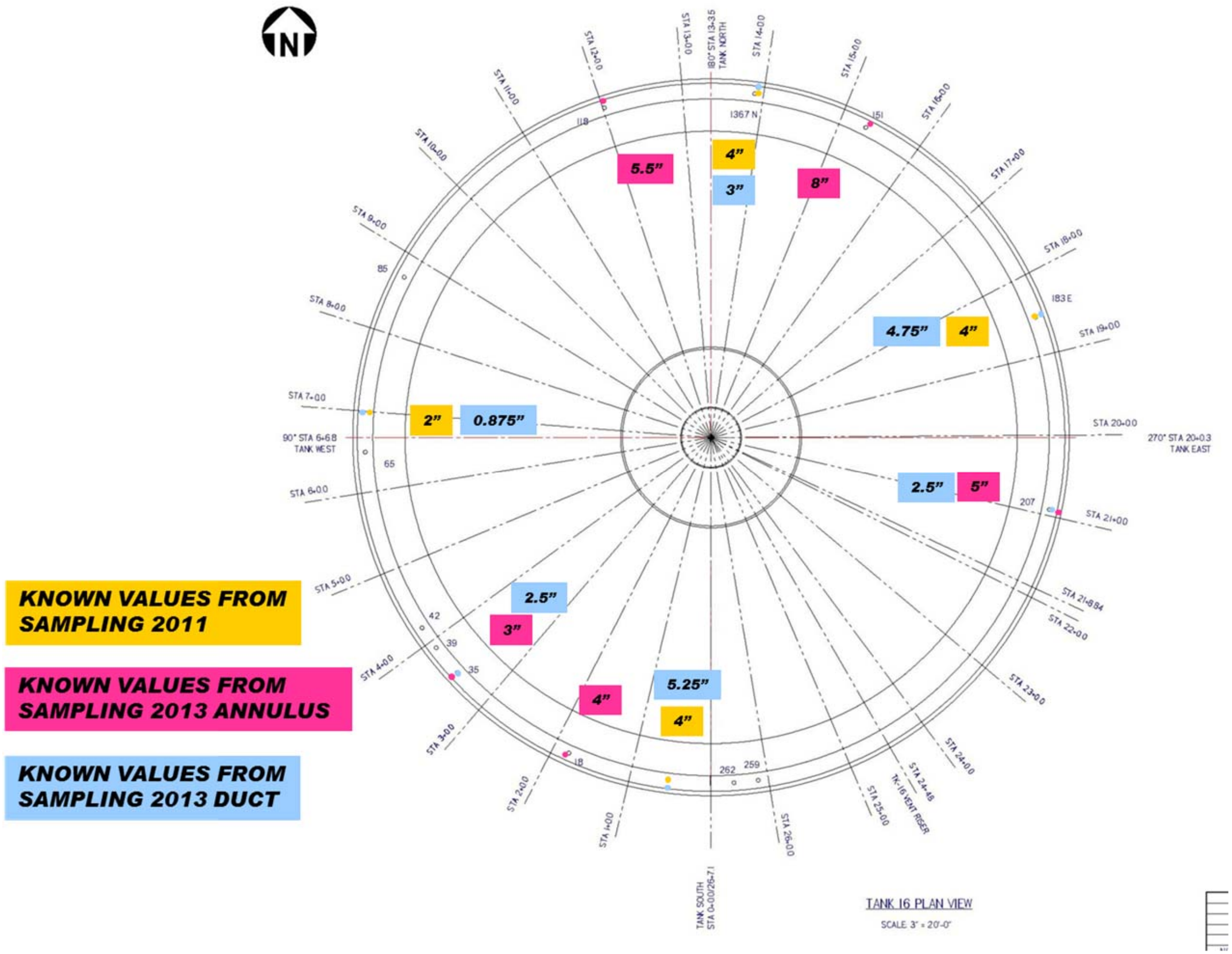

Figure 1: Tank 16 orientation and sample locations

NRC Comment 5.1

Observation: The Closure Module (page 60) discusses the annulus residuals volume determination. U-ESR-H-00113 "Tank 16 Final Residual Solids Determination and Uncertainty Estimate" summarizes the revised volume estimate for the Tank 16H annulus.
Suggestion/Question: This document thoroughly describes the conceptual geometry assumptions, equations, and calculations used to come up with the final volume estimate from the individual height assignments. However, it could better describe the rationale behind the individual height estimates at the Stations, especially where measurements were not taken and visual landmarks are used. It could also better describe the uncertainty associated with the measured heights.

Response:

Comment acknowledged. Responses to the comments within this response document provide additional data on a number of specific individual height measurements. DOE will consider this general comment in the development of documentation for future volume determinations.

NRC Comment 5.2

Observation: The volume estimate in the Performance Assessment was 3,300 gallons (SRR-LWE-2012-00039), which was revised to be 1,900 gallons (U-ESR-H-00113). The 3,300 gallons was informed by the four samples taken from the annulus in 2011 in addition to visual observation. This reduction of about 42% is stated to be a result of the new information gained from the 2013 sampling effort (5 samples from annulus and 6 samples from the duct), as well as new photographs taken in 2013. Given the reduction in the revised estimate, one might expect all the measured sample height levels from 2013 to be lower than the measured heights from the samples in 2011, but this is not the case. As seen in the Figure A12-1: Annulus Sample Locations and Image Locations (SRR-LWE-2012-00039), some of the measured heights in 2013 were lower and some were higher. The overall estimate is lower, in part, because many of the visual observation heights that were assumed for the 3,300 gallon estimate were replaced by lower assumptions. In comparing the Figure from 2013 to that documenting the sampling from 2011, one can see that many of the visual observations are from the same locations. The Closure Module (page 60) states, “Video footage and photographs taken during the sampling were also used to estimate the waste thickness at other locations using visual landmarks (Table 4.1-2).” However, it does not appear that photographs presented in SRR LWE 2014 00151 are used in all cases to assign waste heights.
Suggestion/Question: The documentation in the Closure Module could better explain why many of the visual observations from 2011-2012 were replaced with new assumptions. It seems that the photo technology would not have changed much from 2011 to 2013 to yield such different results. The differences between the use of landmarks or visual assumptions applied in SRR-LWE-2012-00039 versus U-ESR-H-00113 could be better explained. Specific examples are also provided in the following comments.

Response:

A large portion of the 2012 volume estimate depended on visual observations and the engineer’s interpretations of video evidence. After 2013 sampling, a total of 15 sample heights provided measured solids heights for a large portion of the annulus (inside and outside of the ventilation duct). Due to the amount of reliable data available, the methodology for the 2013 volume estimate shifted from a largely visual interpretation of solids heights to the use of measured heights.

During Tank 16H annulus characterization sampling for the 2013 volume estimate, five new samples were collected outside the ductwork and six new samples were collected inside the ductwork. The waste depths were measured at those locations using an auger that loosened that waste prior to sampling. The sample depth measurements for the 2012 and 2013 estimates seem to be consistent across the tank, with the exception of the IP 151 sample of 8 inch depth. The 2012 and 2013 samples were taken from unique locations, so there is no reason to believe that 2013 sample heights would all be necessarily lower than 2012 sample heights.

As shown in Table 1 below, the measured waste heights in 2013 were significantly lower than the previous estimated waste heights that were based on visual evidence in all locations except IP-151 and IP-207. At IP-151 eight inches were estimated and measured. At IP-207 four inches were estimated and 5 inches were measured (SRR-LWE-2013-00027). The 2013 sample heights justified lowering the estimated solids depth in the vicinity of each sample. It should be noted that in all four locations (N, E, W, and S risers) supporting the 2012 volume estimate where material heights were measured, the measured values were all lower than the predicted values that were based on previous visual evidence. This indicated to the mapping team that greater confidence should be placed on measured values where available. Visual interpretation of solids heights can be influenced by factors such as depth perception and shadows / poor lighting, especially in cases when few relative landmarks are present (such as the Tank 16 annulus).

It should be noted that the same two engineers estimated the volume in 2012 and 2013 providing continuity and historical knowledge.

Table 1

Comparison of 2011 Estimated (Visual) and 2013 Measured Waste Heights

Location	2011 Estimated Waste Height (in.)	2013 Measured Waste Height (in)
IP-18 Annulus	8	4
IP-35 Annulus	7	3
IP-35 Inside Duct	10	2.5
West Inside Duct	8	0.875
IP-118 Annulus	13	5.5
North Inside Duct	10	3
IP-151 Annulus	8	8
East Inside Duct	12	4.75
IP-207 Annulus	4	5
IP-207 Inside Duct	14	2.5
South Inside Duct	12	5.25

The measuring process (discussed in the response to NRC Comment 5.10) provided confidence in the validity of the measured height values. In most cases, material heights were assigned to areas between the measured locations by interpolating the measured values from the closest locations. Visual evidence of the areas between the measured height locations was evaluated. In most cases visual evidence was not compelling enough to adjust the interpolated values.

As stated earlier, the methodology for the 2013 volume estimate shifted from a largely visual interpretation of solids heights to the use of measured heights. SRR-LWE-2014-00151 contains photographs that are captured from video surveillances. These photographs were meant to highlight representative areas and residual material thicknesses. This slide presentation was not intended to be a 100% coverage of the annulus floor. All of the evidence provided in SRR-

LWE-2014-00151 was considered when assigning material height. However, height measurements from sampling were the primary input. Visual evidence was used to confirm or deny the plausibility of measured values. Visual evidence was also used when interpolating solids heights between sampling locations. In this way (unlike SRR-LWE-2012-00039), visual evidence alone was not used to estimate height in any area for U-ESR-H-00113.

The visual appearance of solids in areas with measured heights were compared to the visual appearance of solids in unknown areas to interpolate heights. Tank landmarks were also used when available. However there are minimal relative landmarks in the annulus, especially in comparison to the tank primary floor. Previous height assignments (SRR-LWE-2012-00039) utilized in the 2012 volume estimate based on visual observation were not carried as inputs into the 2013 volume estimate because of the decreased confidence in visual interpretation of photographs supporting the 2012 volume estimate. All available measured sample heights were incorporated into the 2013 volume estimate.

Additionally, photographs used in the 2012 volume estimate were not used again in the 2013 volume estimate due to quality. Material heights determined by visual observation in 2012 were not carried over into the 2013 volume estimate. Higher quality images were used in conjunction with measured height values to calculate volume. Comparison photos and justification of the height differences between the reports are provided below.

Photographs of STA 5+00 below show an area that was revised from 8 inch height in 2012 to 3 inch height in 2013. Waste height outside the duct at STA 6+00 was assigned a height of 2 inches based on interpolation of the 2 inch measured height at STA 7+00. The photograph from 2012 was used to assign a height of 8 inches to this area without close sampling measurements (Figure 2). The closest sampling data in 2012 was from 20 feet away. This value was believed to be the most realistic height based on the visual evidence at the time. The 2013 sampling effort at STA 3+50 indicated a height of 3 inches. Photo I from U-ESR-H-00113 displays the area in more detail (Figure 3). The measured sample height of 3 inches was assigned to this area because it was believed that Photo I was consistent with a height of 3 inches.

Figure 2: (Area at STA 5+00 estimated to a height of 8 inches in 2012. Attachment SRR-LWE-2012-00039)

Figure 3: (Area at STA 5+00 interpolated to a height of 3 inches in 2013. Photo I U-ESR-H-00113)

Photographs of STA 8+00 below show an area that was revised from 6 inch height in the 2012 volume estimate to 2 inch height in the 2013 volume estimate. The photograph from 2012 was

used to assign a height of 6 inches to this area (Figure 4) from visual observation. Based on photographs available at the time, this value would have been higher in 2012 if not for the measured sample height of 2 inches in the vicinity. This value was believed to be an accurate representation of the area based on both visual observation and measurement data. Photo L from U-ESR-H-00113 displays the area in more detail from 2013 (Figure 5). The measured sample height of 2 inches was interpolated across STA 8+00 due to the appearance of minimal material in the newer photos. Note the improved quality of the photograph in 2013 compared to the 2012 photograph.

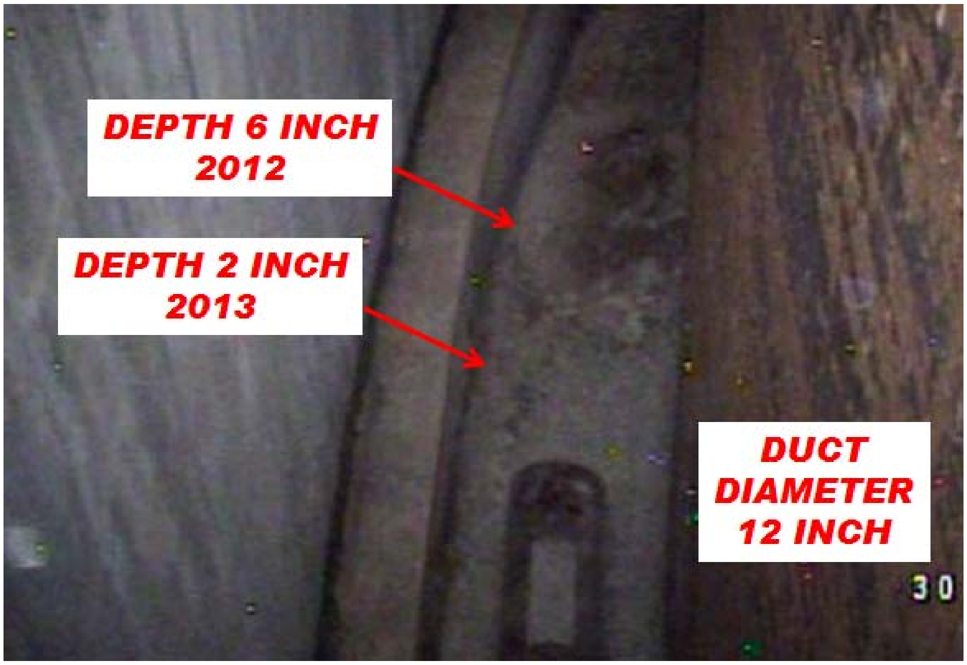

Figure 4: (Area at STA 8+00 interpolated to a height of 6 inches in 2012. Attachment SRR-LWE-2012-00039)

Figure 5: (Area at STA 8+00 interpolated to a height of 2 inches in 2013. Photo L U-ESR-H-00113)

These two examples were areas of large height change from the 2012 volume estimate to the 2013 volume estimate. As is illustrated from the included photos, lighting and the angles can make objects appear differently. The team that estimated the annulus volume in 2012 also estimated the volume in 2013, providing continuity and historical knowledge. Solids heights were a consensus agreement by the subject matter experts. The final report and estimation was verified / checked by an independent, qualified person.

NRC Comment 5.3

Observation: DOE collected photos (near Stations 2, 3, 8, and 10 in both 2011 and 2013 and the depth estimates for waste outside the duct for these stations were reduced by about 50 percent in these locations.
Suggestion/Question: In general, the potential discrepancies between the measurements and what is observed in the photos using the landmarks could be better addressed. For example, it would be helpful if the photographs from similar locations from both 2011 and 2013 could be analyzed side by side, with the landmarks and depth assumptions clearly labeled. Information available from the measured samples could be discussed in terms of how it relates to the landmarks in each of the photos with any ambiguous or conflicting observations explained. Could DOE explain the visual evidence that supports the reduction in height for waste outside the duct near Stations 2, 3, 8, and 10?

Response:

The measured height at STA 1+80 was 4 inches in 2013. This is consistent with the measured value at South Riser STA 0+00 in 2012. A photo of the area in question is provided below (Figure 6). There are no landmarks in the area that are close to being 4 inches tall. The annulus knuckle has a 12 inch radius and the duct steel band joint is approximately 8 inches off the floor. Note that the steel band joint appears higher on the left side (Figure 7). If the steel band was configured with the joint horizontal, the level of the joint would be 10.4 inches. The solids layer in this area is below all available landmarks. There is no evidence to suggest that 4 inches is not an accurate depth for this area.

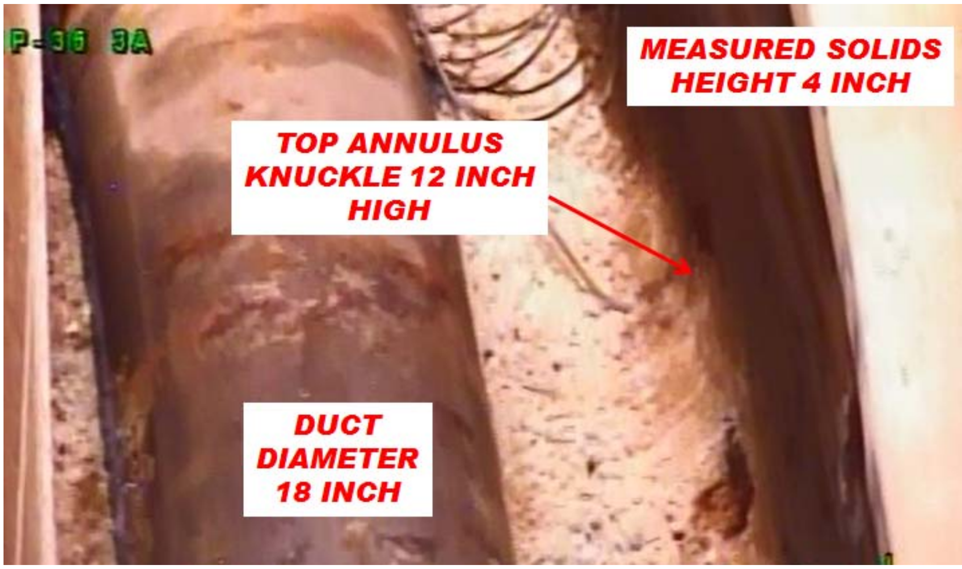

Figure 6: (Area at STA 1+80 measured at 4 inches. Photo E U-ESR-H-00113)

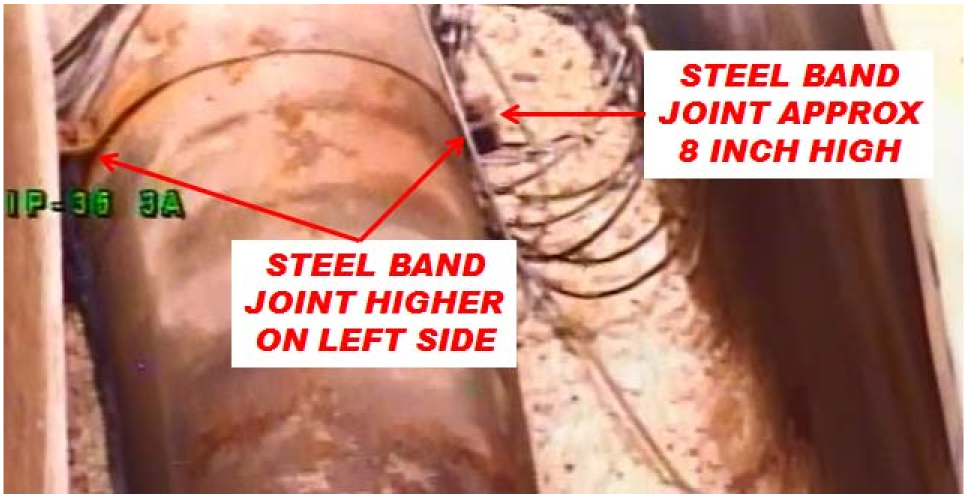

Figure 7: (Area at STA 1+80 measured at 4 inches. Photo E U-ESR-H-00113)

The measured height at STA 3+50 was 3 inches in 2013. A photo of nearby area 3+00 is provided below (Figure 8). There are no landmarks in the area that are close to being 3 inches tall. The steel band joint at this point is 8.9 inches. Notice the distance between the joint and where the shadow is cast on the solids surface. There is no evidence to suggest that 3 inches is not an accurate depth for this area.

Figure 8: (Area at STA 3+00 near STA 3+50 measured at 3 inches. Photo F U-ESR-H-00113)

The measured height at STA 7+00 was 2 inches in 2012. A photo of nearby area 8+00 is provided below (Figure 9). There are no landmarks in the area that are close to being 2 inches tall. There is a definite change in material color. Material north of STA 8+00 appears to be minimal and reducing as it continues north. There is no evidence to suggest that 2 inches is not an accurate depth for this area.

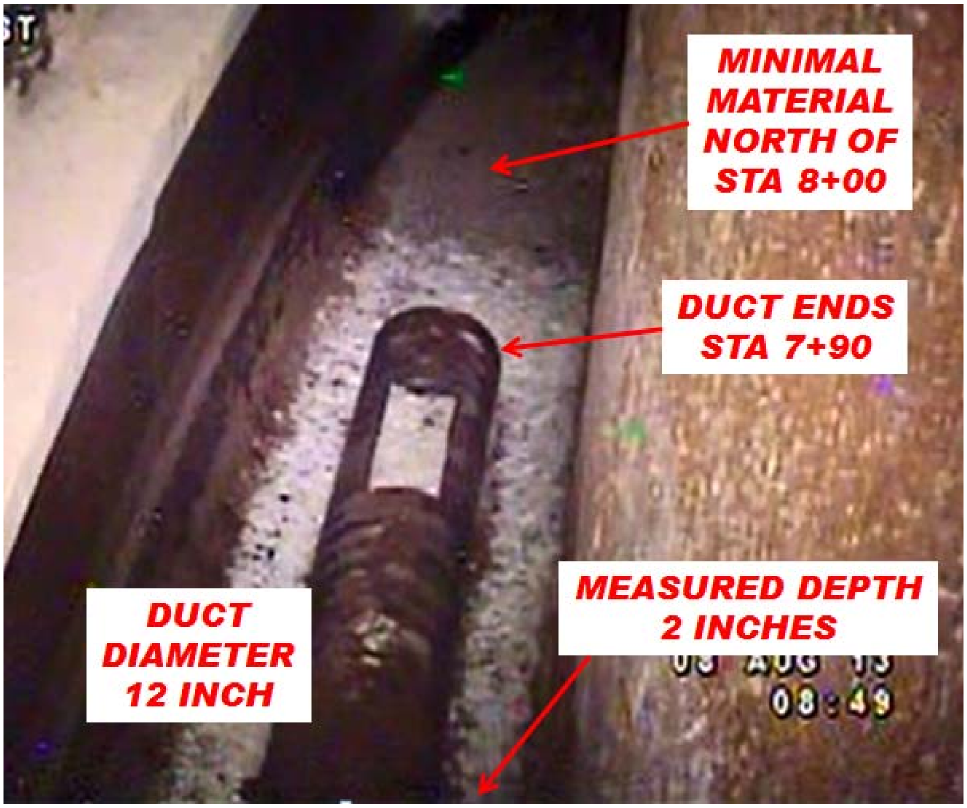

Figure 9: (Area at STA 8+00 near STA 7+00 measured at 2 inches. Photo L U-ESR-H-00113)

STA 10+00 is an area between two measured values of 2 inches and 5.5 inches. Visual evidence suggests that the solids height did not increase between the two sample locations, therefore the value at STA 10+00 would 5 inches or less. There is a minimal amount of material to the right side of the duct, material is coating the left side of the duct, then the material appears to decrease in height away from the duct to the left (Figure 10). Several data points were used to assign a value:

- material height to the right and left
- duct height for material collected on the duct
- the appearance of decreasing material as the annulus continues to the west

The interpolated height from the nearest measured heights (3 inches) was assigned for this area, and evaluation of visual evidence did not result in adjustment to the interpolated height. Visual depth perception was a factor in the decision to not adjust the interpolated height. A photo of the area is included below (Figure 10).

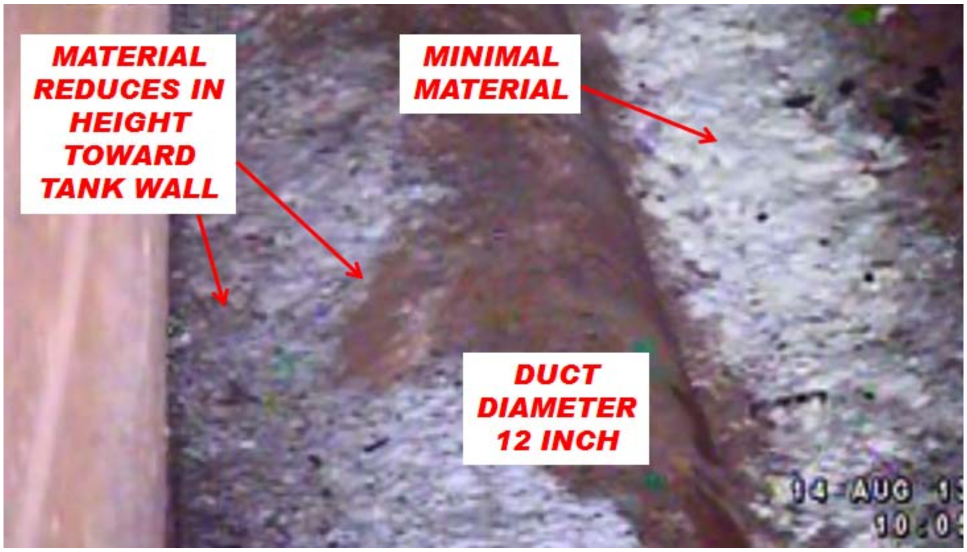

Figure 10: (Area at STA 10+00 interpolated to a height of 3 inches. Photo M U-ESR-H-00113)

NRC Comment 5.4

Observation: It does not appear that photographs in SRR-LWE-2014-00151 are consistently used to assign waste heights when no sampling data is available for waste located inside the Tank 16H annulus duct. In reviewing the photo near Station 8+00 (Photo L in SRR-LWE-2014-00151, Rev 0), the waste inside the duct can be seen through the register. The duct diameter in this picture is 12 inches and it appears as if the waste in the duct may be at the same height as the waste outside of the duct. However, the 2013 estimate for the waste inside the duct was zero inches (Attachment 4, U-ESR-H-00113). (The estimate for the waste outside the duct at this location was revised from six inches in 2011 to two inches in 2013.) For comparison, in reviewing another photo with a register visible near Station 15+40 (Photos Q and R), there does not appear to be as much waste inside the ventilation duct, and yet three inches is assumed inside the duct at this Station 15+40 (Attachment 4, U-ESR-H-00113). Also, in photos near Station 0+00 (Photo A, B and C), where the inside of the duct is visible through a broken piece of the duct, there does not appear to be as much waste inside the duct as appears in Photo L, and yet the sample inside the duct measured 5.25 inches.
Suggestion/Question: Could DOE explain the seeming inconsistencies in visual photos versus height assumptions and describe the visual evidence used in these photographs to support the heights?

Response:

The duct actually ends at STA 7+90. Therefore the duct diameter at STA 8+00 is 0 inches, which is reflected on the spreadsheet. Material in the duct is reported as 0 inches because there is no duct. In the area of the duct, material depth is reported to be 2 inches outside, which comes from a sampling depth measurement. The photo shows consistent visual evidence (Figure 9). Material height inside of the duct at STA 7+90 was reported as the measured value of 0.875 inches from STA 7+00.

Visibility is very poor due to lighting inside of the duct at STA 15+40. Photo R is included below (Figure 11). Lessened confidence due to depth perception again factored in to the decision not to adjust the interpolated values. In accordance with our methodology, a solids height of 3 inches inside the duct at STA 15+00, 15+40, and STA 16+00 were interpolated from an adjoining sample location (STA 13+67) that measured 3 inch height. The value assigned was reasonable and in accordance with this photograph (Figure 11).

Figure 11: (Area at STA 15+40 interpolated to a height of 3 inches. Photo R U-ESR-H-00113)

The measuring process provided confidence in the validity of the measured height values in the area of STA 0+00. Visibility in this area is very poor and the vantage point is exactly vertical from the area in question. Photos A, B, and C demonstrate that height estimation from a near vertical vantage point, inside of a duct, with no local landmarks is inconclusive. There is no evidence to suggest that the 5.25 inches measured value is not correct. Photo B is included below (Figure 12).

Figure 12: (Area at STA 0+00. Photo B U-ESR-H-00113)

NRC Comment 5.5

Observation: In reviewing the photo near Station 10 (Photo M in SRR-LWE-2014-00151, Rev 0), the waste appears to be near the top of the duct on the left side. The duct diameter at this location is 12 inches high (so the top of the duct sits at approximately 13.4 inches from the annulus floor) and yet the height assumption for the waste at Station 10 outside the duct was revised from 9 inches in 2011 to 3 inches in 2013 (Attachment 4, U-ESR-H-00113).
Suggestion/Question: Could DOE describe the visual landmarks used in Photo M to support the height assumption at that location? Or, if instead, the height of the annulus waste near Station 10 is based on interpolation between nearby sampling locations, could DOE describe why the photographs near this Station were not used?

Response:

As stated in our methodology, an interpolation between measured sample heights was used in conjunction with visual observation to assign a height to the material in this area. STA 10+00 is an area between two measured values of 2 inches and 5.5 inches. Visual evidence suggests that the solids height did not increase between the two sample locations, therefore the value at STA 10+00 would 5 inches or less. There is a minimal amount of material to the right side of the duct, material is coating the left side of the duct, then the material appears to decrease in height away from the duct to the left (Figure 10). Several data points were used to assign a value:

- material height to the right and left
- duct height for material collected on the duct
- the appearance of decreasing material as the annulus continues to the west

The interpolated height from the nearest measured heights (3 inches) was assigned for this area, and evaluation of visual evidence did not result in adjustment to the interpolated height. Visual depth perception was a factor in the decision to not adjust the interpolated height.

NRC Comment 5.6

Observation: At Station 9+00 the depth estimate was reduced from six inches to one inch, and at approximately Station 25+00 from ten inches to four inches. The 2011 estimates were based on visual observation according to the Figure in Attachment 1 of SRR-LWE-2012-00039. There do not seem to be new photos or samples for these Stations in 2013 to help inform the reduction in these estimates. Instead, it appears that the reduction seems to be a result of interpolation between 2013 measured sample heights.
Suggestion/Question: Could DOE describe the basis for the reduction in estimate, or why the visual observations from 2011 were replaced by interpolated assumptions in 2013?

Response:

All values based on visual evidence in SRR-LWE-2012-00039 were not included in the data set for U-ESR-H-00113. STA 25+00 was assigned a height of 4 inches due to an interpolation from the nearest sample. This is in accordance with our accepted methodology. An assumption that was discussed in U-ESR-H-00113 stated that areas out of view would be assumed to have a relatively consistent height. Even though the data was not included as an input to the report, it is reasonable to assume that the solids height in this area is less than as it appeared during the 2011 100% annulus inspection.

The measured height at STA 7+00 was 2 inches in 2013. A photo of nearby area 8+00 was provided in Figure 9. There are no landmarks in the area that are close to being 2 inches tall. There is a definite change in material color. Material north of STA 8+00 appears to be minimal and reducing as it continues north. There is no evidence to suggest that 2 inches is not an accurate depth for STA 8+00. Material height at STA 9+00 was reported to be 1 inch from visual observation that indicated solids were reducing in height toward the north.

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NRC Comment 5.7

Observation: The Closure Module (page 18) states that "Due to leakage from the Tank 16H primary tank into the annulus pan, thirteen additional annulus riser openings, or inspection ports (IPs), were added later to permit 100% annulus inspections." The southeast portion of the annulus was not accessed in 2013 (Figure A12-1 SRR-LWE-2012-00039) but visual observations were made in 2011 from the southeast portion of the tank near Stations 21+00, 23+00, 24+48, and 26+00 (Attachment 1 of SRR-LWE-2012-00039).
Suggestion/Question: The Closure Module could better explain the limitations in visual observation of the annulus and how this impacted the areas that required interpolation versus the use of landmarks in photos. It is not clear if DOE verified its determination of measured or interpolated waste heights based on visual landmarks, or how DOE used visual tools to estimate waste heights where no measured sampling data was available. Could DOE explain why the inspection ports to the southeast of the annulus could not be used for visual observation in 2013 or what efforts were made to obtain access to this portion of the annulus to verify waste heights? Could DOE explain other limitations in visual observation of the annulus that would prevent 100% visual annulus inspections?

Response:

Solids levels assigned in SRR-LWE-2012-00039 were the result of visual observations taken from a magnetic tank wall crawler. This allowed a true 100% annulus inspection of the tank, as the crawler could reach any vantage point around the tank. Video and photos from that evolution (2012) were deemed not as credible as the measured values and newer video evidence (2013) – and therefore not included in the 2013 volume estimate (U-ESR-H-00113). Video evidence gathered for the final volume determination was taken from risers and inspection ports. There are no risers or inspection ports from STA 21+00 to STA 26+00. This area houses the ventilation inlet and exhaust. Reasonable assumptions about solids height were made in areas that could not be visually observed and in the ducting in this region. These assumptions are discussed in U-ESR-H-00113.

NRC Comment 5.8

Observation: U-ESR-H-00113 (page 12) states that there were areas of the annulus that could not be inspected with a camera, "Visual observation of all of the annulus floor is unavailable at this time. Since solids were distributed around the annulus by way of liquid, it is reasonable to assume that solids elevation does not acutely change in areas that cannot be seen."
Suggestion/Question: The measured sampling results show significant variability in waste annulus heights between stations located nearby (eight inches at Station 15+40 versus four inches at Station 13+67) making it difficult to determine whether the assumption that the waste heights are well correlated between sample locations is valid (U-ESR-H-00113 and SRR-LWE-2014-00151). DOE could use geostatistical tools to better understand correlation lengths and determine optimum sampling locations in future efforts.

Response:

The measured values around the annulus are very uniform and consistent with the exception of the area mentioned above, STA 13+67 versus STA 15+40. Interpolations were also guided by visual evidence where available. Sampling locations are largely a function of available access to the annulus. While the scope of sampling data is constrained by the ports available, the samples are well distributed around the annulus and provide a reasonably broad range of data.

NRC Comment 5.9

Observation: Table 4.1-2 (page 60) of the Closure Module lists landmarks used to evaluate annular waste heights. One of the landmarks listed is the duct air supply openings. It is not clear what air supply openings are being referred to that would constitute a vertically oriented feature that could provide information on waste height.
Suggestion/Question: Please describe in more detail what air supply openings are being referred to or explain how the air supply openings are used as landmarks to gauge waste height.

Response:

The air supply openings were not utilized to gage waste height. The air supply openings (registers) are a horizontally oriented feature. However, they give a distance reference relative to location circumferentially within the annulus that is helpful. There are not a lot of landmarks which can be used as distance references in the annulus. It is helpful to know relative sizes when looking from a remote location. The register length and width were not necessarily used to determine solids heights in any particular area.

NRC Comment 5.10

Observation:

The Closure Module describes the process by which waste heights were estimated (page 66),

"By measuring the height of the waste at the start of drilling, and the height when auger bit speed increased (indicating the material had been disaggregated) and penetration stopped (indicating the presence of a hard surface such as the annulus pan or duct bottom) the waste thickness was determined."

U-ESR-H-0013 page 11 describes how the depth was measured during sampling:

"The depth of the solids layer was determined by lowering an auger to the top of the solids layer and marking the shaft of the auger. The auger was then lowered through the solids layer and the shaft marked again. The difference in the initial and final marks indicated the depth of the solids layers."

The depth measurements taken during sampling seem to be relied upon heavily in the final volume estimate but the documentation lacks a discussion of the uncertainty associated with the measured depths. It would be helpful to know uncertainty of waste height measurements based on uncertainty in marking the auger at the point where the top of the waste is reached. It is not clear how one would know when the top of the waste is reached. It would be helpful if DOE could address the following questions in the documentation:

Suggestion/Question:

(*Note: Designation of individual suggestions/comments listed below as [a] through [e] not included in NRC comments, designation added by DOE for response purposes.)*

a. Is reaching the top of the waste based on visual observation, or some other indicator?
b. How variable are the waste height measurements due to surface roughness? If the surface of the waste is rough or variable along the radius, then there may be significant uncertainty in the height measurement in roughly the same measurement location.
c. How variable are the waste heights based on distance from the annulus wall or duct (i.e., does waste tend to accumulate on vertical surfaces)?
d. It is not clear how one would determine when the top of the waste is reached in a duct where the duct itself is obstructing the view? How would one know when the auger reaches the top of waste in a duct in cases where a hole needs to be cut into the duct to sample (e.g., photograph H in SRR-LWE-2014-00151)?
e. When the duct is corroded, how does DOE determine the waste height in the duct if the bottom of the duct has collapsed (photograph B in SRR-LWE-2014-00151)?

Response to 5.10(a):

The measuring process was implemented by step-by-step instructions in a work package. Engineering personnel observed the measuring activities by remote video from a camera located in the same access point as the sample location, and they had radio communication with the workers taking the measurements. The auger and drill shaft were lowered into the

annulus by way of a crane. When the auger rested on the surface of the residual solids, the drill shaft was joined to the drill rig. During this time the crane supported the weight of the shaft and auger. Auger contact with the solids was apparent when the shaft was no longer hanging freely in space. Operators indicated that it was readily apparent when the auger contacted the solids and were confident in the accuracy of marking this location on the rig. The residual solids seem to have the consistency of very weak grout. Engineering was present and observing during all sampling efforts. Visually, the material appeared to consist of very fine aggregate that is loosely bonded together. Due to the consistency of the solids, it was not believed that the auger would penetrate the surface in any significate amount. This resulted in a very small amount of uncertainty introduced by the positioning of the auger.

Measurements of the heights of samples were taken at the drill rig, at the tank top. The rig was marked with the auger at the surface of the solids and then again at full penetration. The difference between the marks was measured at the tank top and recorded in the work package.

4.15.3. **STOP** the drill when the depth provided by engineering in step 4.13 has been reached or as determined by engineering, **THEN RECORD** the drill depth achieved.
5 1/2" . 8/14/13

The drill rig used is similar to the one pictured below (Figures 13 and 14). Vertical moment is controlled by the handwheel. The gear on the handwheel interfaces with a rack on the vertical column to hold or adjust vertical position. Marking and measuring vertical position on the column is simple and accurate. Uncertainty in this measurement would be very low.

Figure 13: Portable Drill Rig

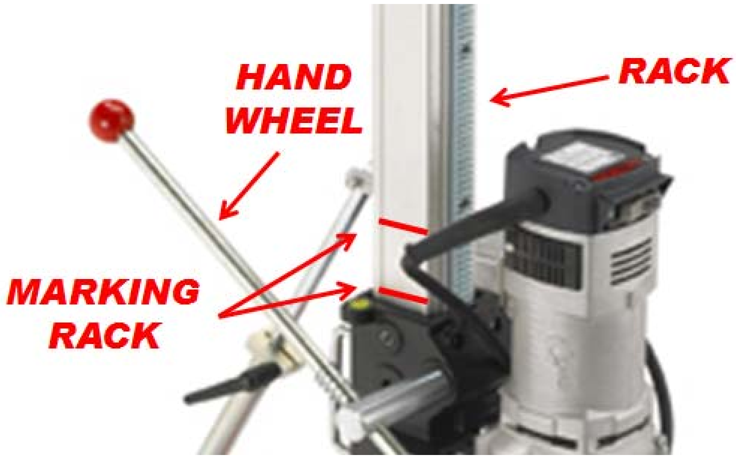

Figure 14: Vertical Rack

Response to 5.10(b):

There are areas where the residual solids have a definite "texture". An example of this is shown below near STA 15+40 (Figure 15). The material in this area was measured at 8 inches. The shadows thrown across the surface of the solids indicate that the surface is not completely smooth, but the height irregularities are not substantial. This is a common situation when determining volume. The uncertainty created by the surface irregularities is expected to be relatively insignificant and is encapsulated in the overall uncertainty.

Figure 15: (Area near IP 151 and STA 15+40. Photo Q U-ESR-H-00113)

Response to 5.10(c):

Generally, solids were not observed accumulating on vertical surfaces (Figure 15). In some areas where solids height was minimal along the outside of the annulus, the level appears to conform to the curvature of the knuckle. Volumes estimated in these areas are determined according to the mapping team's judgement and experience. This was accounted for in the uncertainty values.

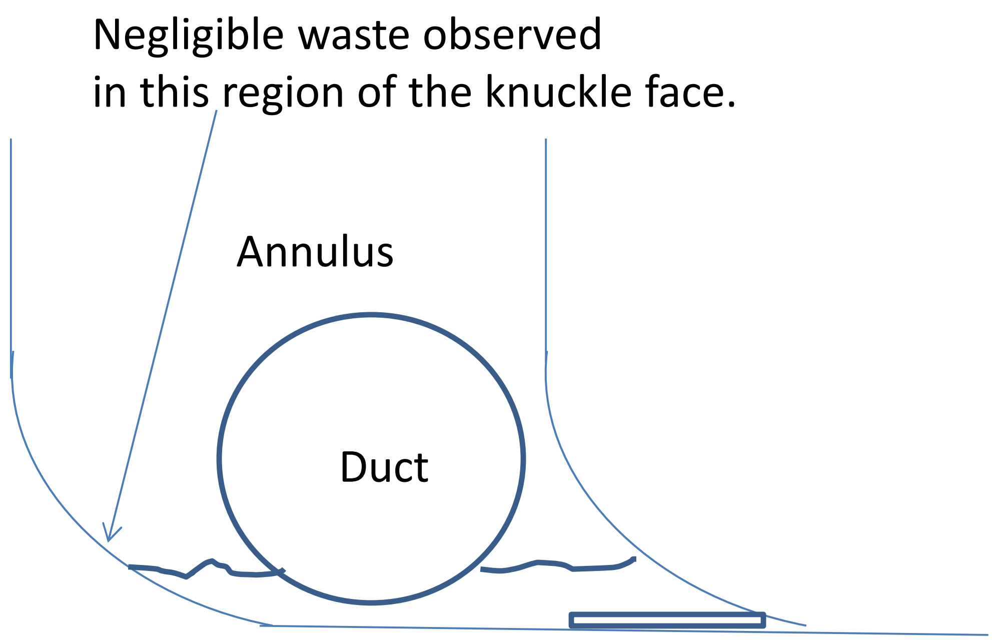

Figure 16: Material Accumulated on Annulus Knuckle

Response to 5.10(d):

Measurements inside the duct where performed in the same manner as those outside the duct. Auger contact with the solids was apparent when the shaft was no longer hanging freely in space. Operators indicated that it was readily apparent when the auger contacted the solids. As seen below, while sampling through a hole in the duct, the auger and residual solids can be seen from the camera vantage point (Figure 17). This was useful when positioning the auger.

Figure 17: (Sample at IP-35. Sample bore location visible from above. SRR-LWE-2013-0027)

Response to 5.10(e):

Photo B in SRR-LWE-2014-00151 does not indicate that the duct is corroded. The large hole in the duct is the result of earlier sampling or waste removal efforts. There is no indication that the bottom of the duct has collapsed. Photo A is included below (Figure 18). It shows a wider view of the area than what is provided in Photo B.

Figure 18: (Area at STA 0+00 measured at 5.25 inches. Photo A U-ESR-H-00113)

NRC Comment 5.11

Observation: Uncertainty in the waste height measurements appears significant. Several measurements do not appear to be correlated to the photographs (SRR-LWE-2014-00151). Specific examples are provided above under comments related to visual observations and some examples are repeated below. • Waste under the duct register in photograph J (and nearby photograph L) looks much higher than the sampled value of 0.875 inches (and higher than the 0 inches assigned to the location depicted in photograph L). • Waste appears to be located near the top of the duct in photographs H (2.5 inches), O (3 inches), P (3 inches), V (2.5 inches), and X (2.5 inches) but the waste heights assigned are much smaller than the duct diameters that are all > 12 inches.
Suggestion/Question: Could DOE describe the uncertainty in the measured heights given the apparent inconsistencies with landmarks in photographs?

Response:

The measured height of 0.875 inches is applied to this region of the duct. Considering that visual interpretation of solids heights can be influenced by factors such as depth perception and shadows / poor lighting, the visual evidence did not compel a change to the measured value. Solids reported at a depth of 0 inches in Photo L are at a region where there is no duct – therefore there are no solids in the duct (Figure 19).

Figure 19: (Area at STA 8+00. Photo L U-ESR-H-00113)

The measuring process provided confidence in the validity of the measured height values as discussed in response to Comment 5.10. Visual evidence of the areas between the measured

height locations was evaluated and visual evidence did not provide any compelling reason to adjust the values assigned based on the measurements.

These are examples of the difficulty with depth perception when viewing areas from a remote camera. For this reason the methodology for this estimate placed a priority on the measured sample heights.

The current volume estimation methodology does not include assigning different uncertainties to different tank areas based on method of observation. An overall uncertainty for the entire annulus is based on both higher confidence in the measured values and nearby regions, and lesser confidence in the non-measured regions. In the development of U-ESR-H-00113 visual evidence was used to corroborate measured heights. All available data was used to report heights at all discrete areas.

The assignment of uncertainty in discrete areas of the annulus is based on the team’s experience and determination of the highest and lowest reasonable values. Reasonable values are limits that bracket the values that can be considered reasonably possible based on evidence.

The mapping team did not see evidence to warrant changes to the results after revisiting Photographs H, O, P, V, and X.

NRC Comment 5.12

Observation: U-ESR-H-00113 also states that "for other areas that were not sampled the solids depth was estimated based on the use of visual landmarks where possible. Where cameras were not able to be utilized to visually inspect the annulus, the solids depth was extrapolated from the nearest known areas." It is not clear how heights are determined for Tank 16H annulus waste located inside the duct between Stations 20.70 and 00.30 in the absence of sample measurements and photographs (SRR-LWE-2014-00151).
Suggestion/Question: The documentation could better explain the extrapolation method used for areas lacking sample or photographic data (e.g., it does not appear to be a linear interpolation based on segment length). In looking at the depth assumptions listed in the spreadsheet in Figure A4-1: Tank 16H Annulus Residual Solids Chart of U-ESR-H-00113, it appears that the measured heights were entered at the various stations and an approximate interpolation between those measured heights was assumed. Also, as stated above in the comments regarding visual observation, it is unclear how the photo observations and landmarks helped inform the interpolated values.

Response:

The area between STA 20+70 and STA 0+00 is discussed in assumption 3.2.1.3 in U-ESR-H-00113:

- Annulus duct solids level is assumed to abruptly change at Station 22+00.
  Justification: This is the inlet of the annulus exhaust and the duct splits into two at an elevation well above the solids level on the floor. Therefore the two horizontal halves of the duct are not connected at this point. Since there is no visual evidence otherwise, it has been assumed that the solids level inside the duct on either side is similar to the level measured during sampling. This remains conservative as the highest observed levels on each side of the split duct are assumed and there is no reduction taken for the gap in the duct as it rises (see Figure 20, which is Figure 3.2-2 in U-ESR-H-00113).

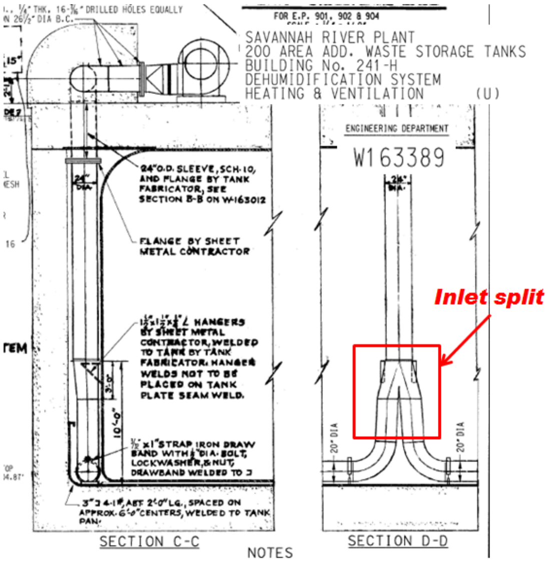

Figure 20: Annulus Duct Split

NRC Comment 5.13

Observation: DOE assigns high and low end waste heights to account for volume uncertainty (U-ESR-H-00113). Uncertainty in measurements based on sampling, photographic evidence, and interpolation should be different. However, it appears that uncertainty in the measurements is not based on the method used to assign the waste heights. For example, it appears that the uncertainty in the duct waste height values is always +/- 0.5 inches irrespective of assignment method. Furthermore, it is not clear that +/- 0.5 inches adequately accounts for uncertainty in the waste height measurements in the annulus duct based on measurement error, sample representativeness, access limitations, and extrapolation methods.
Suggestion/Question: Please explain how DOE considers uncertainty in the Tank 16H annulus volume estimates and at what confidence level DOE expects the high end volume estimates bound the true waste volume.

Response:

The current volume estimation methodology does not include assigning different uncertainties to different tank areas based on method of observation. An overall uncertainty for the entire annulus is based on both higher confidence in the measured values and nearby regions, and lesser confidence in the non-measured regions. In the development of U-ESR-H-00113 visual evidence was used to corroborate measured heights. All available data was used to report heights at all discrete areas.

The assignment of uncertainty in discrete areas of the annulus is based on the team's experience and determination of the highest and lowest reasonable values. Reasonable values are limits that bracket the values that can be considered reasonably possible based on evidence.