RPP-RPT-55263
Revision 0

# Evaluation of Tank 241-TY-105 Level Data and In-Tank Video Inspection

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-08RV14800

washingtonriver protectionsolutions

**P.O. Box 850**
**Richland, Washington 99352**

## TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

## ACRONYMS

| | |
|---|---|
| BBI | Best Basis Inventory |
| cfm | cubic feet per minute |
| DST | double-shell tank |
| HWS | Hanford Weather Station |
| HLAN | Hanford Local Area Network |
| HSIHD | Hanford Sitewide Industrial Hygiene Database |
| in. | inches |
| ILL | interstitial liquid level |
| IS | interim stabilization |
| kgal | thousand gallons |
| LOW | liquid observation well |
| RH | relative humidity |
| SL | surface level |
| SST | single-shell tank |
| TWINS | Tank Waste Information Network System |
| yr | year |

# 1.0 Summary

This report documents the level decrease evaluation for single-shell tank (SST) 241-TY-105 (TY-105). The evaluation indicates there is no evidence the tank is actively leaking based upon the parameters used for estimating the liquid loss rate and evaporation rate. The document conclusion is that evaporation is the probable cause of the tank TY-105 level decrease since the liquid observation well (LOW) was installed in 2003. The waste surface level in the center of the tank has decreased 14 inches since 1982. The reason for this decrease is unknown, but is likely related to waste settling following evaporation.

Tank TY-105 has decreasing waste surface level (SL) and interstitial liquid level (ILL) data trends and was recommended for level decrease evaluation in Letter, WRPS-1301005, *Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Submittal of Single-Shell Tank Level Decrease Evaluation Plan to The U.S. Department of Energy, Office of River Protection*, March 18, 2013, C. A. Simpson, Washington River Protection Solutions LLC, to S. E. Bechtol, U.S. Department of Energy.

The tank is designated as an Assumed Leaker in HNF-EP-0182, *Waste Status Summary Report for Month Ending April 30, 2013*, Revision 301.

# 2.0 Introduction

During the summer of 2012 SL and interstitial liquid level (ILL) plots were prepared for all 149 single-shell tanks (SST). Linear trendlines were drawn through the SL and ILL data points for each tank to provide an estimate of the SL or ILL long term change rates. Linear trendlines are of the form y = mx +b, with m being the slope of the line. Positive values of m mean the level is increasing and negative values mean it is decreasing.

An evaluation plan for SSTs with increasing SLs or ILLs was issued September 13, 2012 as an attachment to WRPS-1203139 R1, *Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Submittal of Single-Shell Tank Suspect Intrusion Evaluation Plan to The U.S. Department of Energy, Office of River Protection.* Concurrently with development and release of this plan, a second evaluation plan was drafted for SSTs with decreasing level data. This level decrease plan was issued on March 18, 2013 with WRPS-1301005.

**Note:** WRPS-1301005 has since been released as RPP-PLAN-55113, 2013, *March 2013 Single-Shell Tank Waste Level Decrease Evaluation Plan*, Revision 1, and is referred to by this number in the remainder of this document.

RPP-PLAN-55113, Rev 1, listed 83 SSTs with a decreasing ILL or SL. These tanks were screened down to a list of 20 recommended for further level decrease evaluation.

The level decrease plan in RPP-PLAN-55113, Rev 1, committed to perform an initial evaluation for each of the 20 tanks that includes:

- Review of tank conditions.
- Evaporation estimates.
- Analysis of other conditions [e.g., long term response to interim stabilization (IS) or liquid observation well (LOW) installations, equipment calibrations or repairs] that could explain level decreases.

Following initial evaluation the 20 tanks were to be sorted into:

- Tanks for which the level decrease can be readily explained without further investigation, and,
- Tanks for which field investigations are needed to better understand the cause of the level decrease:
  - In-tank videos
  - Drywell logging
  - Other (as applicable)

The following results were to be documented:

- Initial evaluations
- Field investigations
- Determine if results warrant evaluation of any of the additional SSTs with negative SL or ILL trends not included in the list of 20

An announcement was made on February 15, 2013 that tank 241-T-111 (T-111) was leaking. On February 22, 2013 an additional five tanks with level decreases were announced. The level decreases for all six tanks were interpreted as leaks. As a result of the February 22, 2013 announcement the planned 20 tank evaluation was divided into 5 reports:

- T-111 (RPP-RPT-54964)
- T-203 and T-204 (RPP-RPT-55264)
- B-203 and B-204 (RPP-RPT-55265)
- TY-105 (RPP-RPT-55263) – this report
- Remaining 14 tanks (RPP-RPT-54981)

Each of the first four evaluations will include, for each tank:

- Review of tank conditions
- Evaporation estimates
- Analysis of other conditions
- Results of in-tank videos
- Conclusions

The fifth evaluation includes:

- Review of tank conditions for each tank
- Evaporation estimates for each tank
- Analysis of other conditions for each tank
- Conclusions for each tank
- An appendix providing evaporation rate vs. relative humidity plots and estimated headspace relative humidity for all 20 tanks
- An appendix providing the estimated heat generation rates for all 20 tanks

This report is the evaluation for tank TY-105.

Table 1 provides the ILL and SL trendline decrease rates for tank TY-105. Columns 2 and 3 provide the decrease rates given in RPP-PLAN-55113, Rev. 1. These values were based upon ILL and SL plots with data current as of October-November 2012. Columns 4 and 5 provide the updated ILL and SL decrease rates used in this document.

**Table 1 Waste Surface Level Decrease Trends for Tank TY-105**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Tank | Values from RPP-PLAN-55113 Rev. 1 | | Updated Values for RPP-RPT-55264 | |
| | ILL Change Rate (in./yr) | SL Change Rate (in./yr) | ILL Change Rate (in./yr) | SL Change Rate (in./yr) |
| TY-105 | -0.256 | -0.292 | -0.258 | -0.282 |

# 3.0 Discussion

## 3.1 Selection of Tanks for Level Decrease Evaluation

Tanks were included on the list of 83 tanks in RPP-PLAN-55113, Rev 1 Appendix A, Table A-1, based upon their ILL and/or SL data change rate. All tanks with a change rate <0.001 in./yr were included. The basis for selection of tank TY-105 for evaluation is described in that document, as well as the basis for the level change values in Column 3 of Table 1.

## 3.2 Updating of Tank Level Data Change Rates

The updated level data change rates in Columns 4 and 5 of Table 1 are based upon linear trendlines drawn through the SL data points for each tank for as far back as a reasonable linear rate can be established.

The ILL and SL data change rates in Columns 4 and 5 of Table 1 were estimated by:

- Downloading ILL and SL data from the Tank Waste Information Network System (TWINS - https://twins.labworks.org/twinsdata/Forms/About.aspx) database from January 1, 1990 to the present. The data back to 1980 is also included for some plots to show longer term trends.
- Plotting the results in Excel®. The following level data change plots were made for the tank:
    - A plot showing the ILL and SL raw data for the tank. The raw data is exactly as retrieved from TWINS with no adjustments for data correction. The y-axis is shown as approximately the same height as the full depth of the tank, to give the reader an indication of the relative rate of change for the tank ILL and SL.
    - A plot of the raw ILL data, with the y-axis significantly expanded so that recent changes in the SL with time can be discerned.
    - A plot of the raw SL data, with the y-axis significantly expanded so that recent changes in the SL with time can be discerned.
- The expanded raw data plots were then reviewed for problems which could result in incorrect data interpretation. These include:
    - Repair or replacement of level gauge (SL only).
    - Recalibration of level gauge resulting in different baseline depth value (SL only).
    - Changing of zero value for tank reference level (i.e., changing from bottom of knuckle to tank centerline bottom) (SL only, ILLs always referenced to tank centerline bottom).
    - Not selecting a representative neutron count feature for ILL interpretation (ILL only).
    - Changing of method of interpretation for ILL data (i.e., neutron or gamma count data selected for indication of ILL) (ILL only).

For the purpose of data evaluation in this document a linear regression line provides an acceptable data change rate. The trendline formula is shown on the expanded y-axis plots, with the conversion factor to convert the trendline slope to a level data change rate in inches per year.

The final ILL and SL data change rates based upon the plot trendlines are given in Columns 4 and 5 of Table 1. The plots for each tank are given in the tank evaluation section for the tank.

### 3.3 Volumetric Change Rates

The level change rates in Columns 4 and 5 of Table 1 are converted to a volumetric change rate to assess the potential for a tank to be leaking. Estimation of a volumetric level change rate for any 75 ft diameter tank is based upon the following equation:

$$volumetric\ change\ rate = LCR\ in./yr \times 2{,}750\ \frac{gal}{in.} \times (FSL + (1 - FSL) \times \sigma)$$

where:

LCR = level change rate in inches/yr

FSL = fraction of waste surface that is liquid

σ = waste porosity

The fraction of waste surface that is liquid is calculated with a planimeter from sketches drawn after viewing the in-tank videos. For tank TY-105 the in-tank video (see section 4.1.4) showed zero liquid on the surface

The porosity assumed in RPP-5556, 2000, *Updated Drainable Interstitial Liquid Volume Estimates for 119 Single-Shell Tanks Declared Stabilized*, Rev. 0, is used for consistency with past calculations.

### 3.4 Data Analysis

Changes in the ILL or SL data do not necessarily mean the level is changing. Analysis of the data is necessary to interpret what is occurring. Factors that could cause changes in the surveillance data are listed in Table 2.

**Table 2 Factors Impacting Surface Level or Interstitial Liquid Level Data**

| | **Factor** |
|---|---|
| 1 | ILL increase and/or SL decrease due to consolidation/slumping of waste into pores. |
| 2 | Gas generation and entrapment within the waste causing level increase. |
| 3 | Release of retained gas entrapped within the waste causing a level decrease. |
| 4 | Conscious liquid additions to the tanks such as core sampling drill string flushes, core sampling head fluid additions, level gauges flushes, water lancing of equipment during installation, grab sample flushes. |
| 5 | Chemical changes within the waste. |
| 6 | ILL not at equilibrium following LOW installation or saltwell pumping (ILL only). |
| 7 | Level gauge plummet resting on uneven solid surface, (plummet rests on different spot when raised and lowered, or surface resistance changes), gauge maintenance or calibration problems, changing of tank reference location for zero level (SL only). |
| 8 | Water intrusion for level data increase. |
| 9 | Evaporation for level data decrease. |
| 10 | Tank leak for level data decrease. |

The volumetric change rate is not necessarily a liquid volume change rate. The volumetric change rate is the sum of:

- Liquid addition to and/or removal from the tank
- Retained gas growth in and/or release from the tank
- Loss of gas due to porosity decrease
- Waste density change due to chemical changes

The tank volumetric change rate is equal to the net effect of intrusion, evaporation, leaks, and all other factors:

$$volumetric\ change\ rate = intrusion\ rate + evaporation\ rate + leak\ rate + \Sigma\ other$$

The intrusion rate, Factor 8, is positive or zero, the evaporation rate and leak rate, Factors 9 and 10, are negative or zero, and [Σ other] is equal to the net impact of Factors 1 through 5 in Table 2 and may be either positive or negative.

Factor 6 is a subjective assessment based upon review of the ILL data plot trend and, if necessary, the raw neutron count data. There is no numerical value associated with Factor 6. Rather, it is a judgment as to whether the net level change rate estimate shows a change to the liquid level in the tank or a redistribution of the liquid as it slowly seeks an equilibrium level.

Factor 7 is an assessment based upon review of the SL data plot trend and the data. If the plummet is resting on liquid or a reasonably flat solid surface, data changes can be assumed to represent changes in the waste surface. However, if the plummet is resting against debris in the tank or is perched on the edge of a crack or clump of waste such that data will be inconsistent, the data changes cannot be assumed to represent changes in the waste surface. In addition, some tanks had problems with the level gauge operation that resulted in misleading data trends, this became evident when the level gauge maintenance history was reviewed.

Rearranging the volumetric change rate equation:

$$leak\ rate = volumetric\ change\ rate - intrusion\ rate - evaporation\ rate - \Sigma\ other$$

or:

$$intrusion\ rate = volumetric\ change\ rate - leak\ rate - evaporation\ rate - \Sigma\ other$$

The volumetric change rate and the evaporation rate can be estimated from available data, and a value for [Σ other] assumed following a review of the available information. The net effect of the leak rate and intrusion rate can then be roughly estimated. It cannot be shown from SL and ILL data alone what a leak rate (or an intrusion rate) is for a tank without making assumptions as to the other variables in the equation. If the intrusion rate calculates to, e.g., (100 gal/yr + leak rate), this could mean there is a 100 gal/yr intrusion rate if the leak rate is zero, or a 300 gal/yr intrusion rate masking a -200 gal/yr leak rate, or any combination of intrusion plus leak rate that sums to a net 100 gal/yr. Data analysis cannot give separate values for a leak rate (or intrusion rate) but it can provide a degree of confidence as to what is probably occurring.

Data analysis is provided in the tank evaluation section.

## 4.0 Tank Evaluation

The evaluation is divided up into the following subsections:

**Tank Summary** - Provides a short summary of the tank history and lists the Best Basis Inventory (BBI) tank waste volumes from a TWINS query on September 25, 2012.

**Liquid Volume Change Rate** – Converts the in./yr level change rates in Columns 4 and 5 of Table 1 to gal/yr.

**Data Analysis** - The tank data analysis uses the equation from Section 3.4:

$$volumetric\ change\ rate = intrusion\ rate + evaporation\ rate + leak\ rate + \Sigma\ other$$

where [Σ other] equals the net impact of:

- Waste subsidence
- Gas generation, entrapment, and release within the waste causing level increase or decrease
- Conscious liquid additions to the tanks such as core sampling drill string or grab sample bottle flushes, core sampling head fluid additions, level gauges flushes, water lancing of equipment during installation
- Chemical changes within the waste

Data analysis passes through the following steps:

- Estimation of a value for [Σ other]
- Estimation of a value for a potential intrusion rate
- Evaluation of whether the ILL is at equilibrium and/or changes in the SL data represent actual movement of the waste surface.

The first part of [Σ other] concerns waste subsidence, or compression of the waste above the ILL onto the open pores. The potential for waste subsidence to be a factor in the level change rate is evaluated for the tank.

The second part of [Σ other] is the effect of retained gas on the level change. The volume of retained gas in a tank is unknown, but the relative volume can sometimes be inferred from combined plots of the ILL and the inverse of atmospheric pressure vs. time. If retained gas is present an increase in the atmospheric pressure will result in a decrease in the ILL level as the gas bubbles are compressed, and a decrease in the pressure will result in an increase in the ILL level. Predominantly sludge tanks like tank TY-105 do not have a rigid waste matrix and show far less or no response to atmospheric pressure when compared to a tank with saltcake.

A retained gas plot was prepared using Excel file *BP Correlation with DB Connect*, SVF-1002, June 27, 2005. This file was developed to enable surveillance personnel to assess retained gas content of tanks. It downloads the hourly atmospheric data from the Hanford Site Weather Station (HWS) and the tank SL or ILL data from the Personal Computer Surveillance Analysis Computer System (PC-SACS) database, scales the data, adds a slope where helpful for display, and calculates an $R^2$ value for the two data files to show the degree of correlation. The higher the $R^2$ value (closer to 1.0) the better correlation between the ILL reading and barometric pressure and thus the more gas there is in the tank, the lower the $R^2$ value (closer to 0.0) the less correlation and thus less gas is present.

A limitation to the retained gas plot is the frequency of ILL data. The LOW scans used to be done weekly, which resulted in a nominal 50 data points per year. Since the 2003-2005 time frame LOW scan frequencies have been reduced to quarterly for most tanks, resulting in only four data points per year. Four data points in a year is inadequate for showing a correlation between retained gas and atmospheric pressure, so the retained gas plot in this document is based upon the period January 1, 2003 to July 1, 2003. If there is retained gas in a tank in 2013, some would also have been present in 2003. The retained gas volume may or may not be higher in 2013.

The ILL data points are obtained from neutron scans taken periodically inside an LOW. Scans are obtained from near the top of the LOW riser to near the bottom of the tank. The ILL software interrogates the raw neutron count rate data and looks for a maximum change rate in a directed region of the data and calculates a value for the interstitial liquid level. While plots of the ILL data points are used to determine level trends, at times the plots of the raw neutron count data are also useful for estimating what is occurring in a tank above or below the ILL. Comparing past and present neutron scan data can show where liquid is moving either up or down in all levels of the tank, and a reduction in the liquid content below the ILL is evidence for growth of retained gas in that region. The PC-SACS database includes all past neutron scan data for all past LOW scans as well as the calculated ILL data points. A neutron scan plot for TY-105 was prepared by downloading the neutron count data from the PC-SACS database and transferring it into an Excel plot.

Conscious liquid additions make up the third part of [Σ other].

The last portion of [Σ other] is chemical change which may be occurring in the tanks over time.

A value is provided for [Σ other] consisting of four entries: The first entry is either 0 or PCE (for porosity change effect), the second entry is either 0 or RGG (for retained gas growth), the third is a numerical value to account for annual liquid addition to a tank, and the last is either 0 or WCE (for waste change effect).

**In-Tank Video Results** – An in-tank video was obtained for tank TY-105. A description is provided of the waste surface, how the Enraf plummet is sitting, and any visible evidence of intrusion into the tank.

**Evaporation Estimate** - Estimating a tank evaporation rate without having equipment on each tank to measure all the conditions requires knowledge or estimation of:

- the temperature and water vapor content of the air entering a tank
- the temperature and water vapor content of the air leaving the tank
- the effective flow rate of air through the tank, and,
- accounting for condensation of water vapor from exiting air that returns to the tank.

The evaporation estimate methodology is described in RPP-RPT-54981, Rev 0, Appendix A. A summary of the evaporation estimate results are provided in the Evaporation Estimate section of each evaluation.

**Tank Heat Generation Rate** - The energy to evaporate water from a tank comes from two sources:

- latent heat of the waste, surrounding soil, and air passing through the tank, and,
- heat generated within the waste by radioactive decay

An estimate of the heat generation rate for each tank is provided based upon the radionuclide content.

**Tank Leak Potential** This subsection summarizes the information from the previous subsections.

Each evaluation has a summary plot that provides evaporation, relative humidity, and liquid loss information to assess the potential for the tank to be leaking. Each of these plots contains:

- A blue line showing the estimated evaporation rate as a function of the relative humidity (RH) in the air leaving the tank headspace.
- A black vertical line for the estimated tank headspace RH for each tank. The basis for the estimate of the RH is provided in RPP-RPT-54981, Rev 0, Appendix A, Section A.6.
- A black horizontal dashed line for the estimate of the liquid loss rate.

Where the black line crosses the blue line is the estimated evaporation rate for a tank, based upon the conditions assumed for the tank conditions.

If the liquid loss rate is below the estimated tank evaporation rate for the conditions assumed for a tank, there is no evidence the tank is leaking.

The evaporation rate, liquid change rate, and headspace relative humidity values presented for each tank are used together to provide a basis to determine the potential for a tank to be actively leaking.

**Conclusion** The final subsection summarizes the information in the previous subsections and gives a conclusion as to whether there is evidence the tank is leaking or not.

## 4.1 Tank TY-105

### 4.1.1 Tank Summary

Tank TY-105 was put into service in 1953 when it received TBP uranium recovery waste. It continued to receive this waste until the tank was full in 1954, the tank received no more waste after 1954. In 1962 the tank was declared a leaker. Interim stabilization was documented as complete in 1983 (RPP-RPT-43197, *2009 Auto TCR for Tank 241-TY-105,* Revision 0, HNF-SD-RE-TI-178, 2007, *Single-Shell Tank Interim Stabilization Record,* Rev 9(a). Per a TWINS query on September 25, 2112 the tank contains 35.9 kgal sludge and zero supernatant liquid.

Figure 1 shows the raw ILL and SL data for tank TY-105 from January 1, 1990. Figure 2 and Figure 3 are plots of the data used for calculation of the -0.256 in./yr ILL and -0.292 in./yr SL trendline slopes for RPP-PLAN-55113, Rev 1, with an expanded y-axis so the SL data changes can be seen.

Figure 4 is an updated plot showing the latest ILL data included for this document. The slope of the decrease line is essentially the same at -0.258 in./yr. Figure 5 is an updated plot showing the latest SL data included for this document. The slope of the decrease line is essentially the same at -0.282 in./yr.

A linear trendline is a reasonable fit for the ILL data in Figure 4. It is also a reasonable fit for the time period selected for the SL trendline in Figure 5, but it is obvious from Figure 5 that the SL decrease has gone on for a long time and a polynomial trendline would be a better fit for a longer trendline period. Figure 6 is a combined plot of the manual tape and Enraf SL data going back to the completion of saltwell pumping in 1982. The manual tape data are adjusted to match the Enraf data as described in the plot note. The tank TY-105 SL data have decreased 14 inches in the past 31 years, no other SST with a solid waste surface has shown such a decrease in SL data in that time. Using the polynomial SL trendline formula in Figure 6, taking the first derivative to obtain the level change rate on a given date, The SL decrease rate as of September 12, 2013 is -0.190 in./yr. Extrapolating the polynomial trendline formula in Figure 6, the level decrease in tank TY-105 should cease in about 2024.

The tank SL decrease is addressed further in Section 4.1.4.

### 4.1.2 Liquid Change Rate Estimation

The liquid change rate estimate is based upon the -0.258 in./yr SL change.

The RPP-5556 tank TY-105 porosity of 0.07 assumed for the tank waste.

Per Section 4.1.4 the fraction of liquid on the waste surface is zero.

The estimated tank TY-105 liquid change rate is:

$$Tank\ TY-105\ estimated\ liquid\ change\ rate = -0.258 \times 2{,}750 \times (0 + (1-0) \times 0.07)) = \mathbf{-50}\ \boldsymbol{gal/yr}$$

### 4.1.3 Data Analysis

**<u>Estimation of [Σ other]</u>** – Figure 6 indicates there has been a significant SL decrease since 1982. Per Section 4.1.4. there has been subsidence in the central region of the tank.

Figure 7 is a plot of the inverse of the barometric pressure and the ILL data. The $R^2$ value of 0.440 shows there is some correlation between the two, but it is not significant. The $R^2$ value is actually higher than for most sludge tanks. Figure 8 is a comparison of tank TY-105 LOW neutron scan data from 2003 and 2013. Figure 9 is an expanded version of the same plot. There is no obvious gas volume decrease apparent. The liquid content has receded proportionately from the top of the waste, rather than showing the expected liquid increase at some level that would have occurred if a large volume of gas were released and replaced with liquid. The BBI shows zero retained gas in tank TY-105. Buildup and release of gases within the waste has been observed in double-shell tanks (DSTs) as evidenced by a slow increase in the waste level followed by a sudden decrease when the gas is released. Some SSTs may exhibit chronic release of gases at roughly the same rate gases are generated. A buildup of retained gas in the tank over a number of years followed by a steady release over >30 years is not expected based upon past experience. Additionally, monitoring for gases was performed prior to the in-tank video on April 22, 2013. Results recorded on industrial hygiene sample DRI-13-01420 showed 0.0 ppm ammonia and 11 ppb volatile organic compounds (VOC), no flammable gas data were recorded. It is highly unlikely that gas would be retained in TY-105 and then released slowly over ~30 years to cause the SL decrease in the tank.

No large items of equipment are known to have been lanced into the tank in the past 10 years and the TWINS database indicates no samples have been taken from the tank in that time. The water usage data sheets were not reviewed, but making the assumption that a level gauge is flushed with a nominal 10 gal of water every two years results in a nominal 5 gal/yr conscious liquid addition.

The last waste solids were put into the tank in ~1954. The assumption is made that any significant chemical changes that may occur within the waste would have already occurred so the potential for chemical reactions to be causing changes that would affect the level data is very small.

Therefore, the value [Σ other] for TY-105 is assumed to be = PCE + 0 + 5 + 0 = 5 gal/yr + PCE

**<u>Potential for Intrusion</u>** - Per Section 4.1.4, no evidence of intrusion was observed during the in-tank video taken in tank TY-105. Figure 5 and Figure 6 do not show evidence of any intrusion back to 1982.

From Section 3.4:

$$intrusion\ rate = volumetric\ change\ rate - leak\ rate - evaporation\ rate - \Sigma\ other$$

$$intrusion\ rate = -50\frac{gal}{yr} - leak\ rate - evaporation\ rate - \left(5\frac{gal}{yr} + PCE\right)$$

$$= -55\frac{gal}{yr} - leak\ rate - evaporation\ rate - PCE$$

Since both evaporation rate and leak rate are negative values, the sum of the leak rate plus the evaporation rate would have to be <-55 gal/yr - PCE before an intrusion would be considered. As described below, evaporation is estimated to be -72 gal/yr so a small intrusion is theoretically possible, ignoring any porosity change effect, if the evaporation rate and volumetric change rate are accurate.

**<u>Evaluation of ILL or SL Validity</u>** – There ILL has shown a steady decrease since shortly after installation, and with liquid at or near the surface (see Section 4.1.4). it is assumed the ILL is stabilized and reading acceptably.

Table 3 lists all tank TY-105 Enraf work packages for the 2006 to 2013 time period. The last two columns list the as-found and as-left data from the work packages. There is negligible change between calibrations, there is no calibration impact change affecting the level decrease rate.

**Table 3 Tank TY-105 Enraf Gauge Work Packages Since January 1, 2006**

| Work Package No. | Title | Date | As Found (in.) | As Left (in.) |
|---|---|---|---|---|
| CLO-WO-07-1106 | 241-TY, 105 ENRAF INSPECTION | August, 7, 2007 | 79.80 | 79.77 |
| TFC-WO-09-1354 | 241-TY, 105 ENRAF CAL | May 6, 2009 | 79.29 | 79.29 |
| TFC-WO-11-1530 | 241-TY, 105 ENRAF CAL | July 26, 2011 | 78.75 | 78.73 |

The in-tank video taken on April 22, 2013 in TY-105 shows the plummet in Figure 10 sitting on the waste surface over a slight crack. In the video the area in the upper right of Figure 10 appears moist.

Figure 11 is the tank TY-105 isolation drawing (H-2-73090, Rev 6). The Enraf and the LOW are within a few feet of each other so if the waste is moist under the Enraf the ILL and the SL data should be close together, it would seem at first glance that the ILL data should not be 15 inches below the SL like it is.

There is the possibility that there is an error somewhere in the reference values used for calculating either the Enraf and/or ILL values, but it is doubtful there could be an ~15 inch error. The ILL plot in Figure 1 shows the ILL was only a few inches below the waste surface when the LOW was installed, with the resulting expected decrease at a fast rate until the ILL stabilized about a year later.

What is presumed to be happening with the SL is shown schematically in Figure 12. The waste surface remains the same around the outside of the waste matrix but collapses towards the center of the tank as the liquid level drops. The surface level assumed to be at the end of saltwell pumping, is represented by the red dashed line. The current surface level is represented by the brown dashed line.

Since tank TY-105 is a sludge tank the ILL is nowhere near as distinct as it is in a saltcake tank with a large porosity. In most sludge tanks there is no distinct level at which the ILL appears. The porosity is very low in tank TY-105 and the combination of slow draining plus capillary action causes the liquid to be present in a band of increasing liquid content with depth. The point selected for measurement of the ILL is not necessarily the top of the neutron scan count rate. For sludge tanks the location selected for the ILL is the spot within the band of rising neutron count data that can be most consistently measured and relied upon to provide the best indication of where liquid is moving in the tank. From Figure 9 it can be seen that the point selected as the ILL in tank TY-105 is towards the bottom of the scan, not near the top.

In tank TY-105 there was liquid at the surface at the end of saltwell pumping (the LOW wasn't installed until 2003). Since the end of saltwell pumping the waste surface has slowly decreased in the tank center, presumably because it is lower and the water content is higher and evaporates more from the low spot. Liquid is present at or near the surface with the concentration increasing with depth until the waste is saturated several feet below the surface. See Section 4.1.4 for more discussion.

It is believed that both the SL data and ILL data are valid.

There has been no reference change for the SL data since before 1980. The ILL has always been referenced to the tank centerline bottom.

#### 4.1.4 In-Tank Video Results

An in-tank video was obtained in tank TY-105 on April 22, 2013. The following discussion is limited to results of the in-tank video information as it relates to evaluation of the tank for level change; i.e., the waste surface, the Enraf plummet, and evidence of intrusion.

Figure 13 is a composite of screen images from the April 22, 2013 video. There are no liquid pools present on the surface. The surface is a relatively smooth sludge surface with some shallow cracks.

The fact that the waste surface is not decreasing around the outside of the waste matrix can be seen by comparing screen shots from the April 22, 2013 video with photos taken in the 1980s. Figure 14 is from the video showing an irregularity on the waste surface under the condenser riser in the upper left of Figure 13. Figure 15 is a photo from 1989 of the same irregularity. Note the waste edge where it meets the wall in locations A, B, and C in both the video image and the photo, there is essentially no change in the wall space shown. If the waste surface had dropped equally there should be an additional 10 inches of wall showing in Figure 14.

Figure 16 is from the video showing an old sample bottle resting on the waste surface. This is from the approximate location designated on Figure 11. Figure 17 is a photo from 1989 of the same bottle. Note the waste edge where it meets the wall in locations A, B, C, and D in both the video image and the photo, again there is essentially no change in the wall space shown.

Assuming the ILL was at the waste surface at the end of saltwell pumping is a valid assumption. Figure 18 is a photo from June 30, 1978 showing the waste surface still smooth and with a three to four ft diameter pool around the saltwell screen. Figure 19 is a photo from August 21, 1987 showing essentially all liquid gone, with only a few inches present around the screen.

No drips were noted and no evidence of past intrusion was observed, but one location is worth noting. Figure 20 is a close of the anomaly on the waste surface seen in Figure 13, Figure 14, and Figure 15. It is the only such anomaly on the waste surface and has obviously been in the tank with little change for at least 24 years and likely longer. It is under the condenser riser so it is assumed the shape of the depression was formed by liquid dripping onto the waste. No intrusion evidence was noted from the condenser riser, but Figure 20 is a close-up of the depression and liquid is visible. It is possible this liquid is from an intrusion that wasn't observed, but it is also an indication that there is liquid just below the surface in this tank, which is supported by the moist appearance of the waste in Figure 10. The moist surface appeared more obvious in the April 22, 2013 video than in Figure 10, but Figure 10 was the best screen image that was obtained that hinted at moisture being present.

### 4.1.5 Evaporation Estimate

Figure 21 provides the evaporation estimate results for tank TY-105. Figure 21 indicates tank TY-105 would evaporate -72 gal/yr.

Derivation of the evaporation rate for tank TY-105 is described in RPP-RPT-54981, Revision 0, Appendix A.

The evaporation rate exceeds the estimated liquid loss rate by about 22 gal/yr.

The blue line Figure 21 shows the estimated evaporation rate from tank TY-105 as a function of the RH in the tank vapor space. The estimated average RH value for tank TY-105 is indicated by the vertical black line.

Where the vertical black RH line crosses the blue evaporation line in Figure 21 is the best estimate for evaporation from tank TY-105, assuming the parameters used in RPP-RPT-54981, Revision 0, Appendix A are valid. Figure 21 indicates the tank TY-105 evaporation rate is -72 gal/yr.

RPP-RPT-54981, Revision 0, Appendix A describes the variables involved with the evaporation rate estimate and provides a basis for the value selected. The ambient air conditions and tank headspace temperatures are obtained from recorded data. The primary variables in Appendix A that will impact the tank TY-105 evaporation rate are the assumed breathing rate and the assumed tank headspace relative humidity.

The breathing rate used for tank TY-105, 2.41 cfm, is similar to the rates for other 75 ft. diameter tanks excluding A and AX tank farms, and is within the range of breathing rate data for the non-A/AX tanks with tracer gas tests in 1996 to 1998. The basis for the breathing rate assumed for tank TY-105 is provided in Appendix A and is the best estimate when considering the information. The complete basis for the breathing rate assumed for tank TY-105 is provided in RPP-RPT-54981, Revision 0, Appendix A and is the best estimate available when considering the information, but the actual rate could be higher or lower than assumed. Changing the breathing rate would result in a proportional change in the evaporation rate.

The assumed tank TY-105 headspace RH of 80% is based upon the October 20, 1997 vapor space sample of 82.1%. The headspace temperature was 72°F when sampled. The temperature for an October 20 annual date from Appendix A, Figure A-20, is slightly higher at about 76°F. A slightly lower value of 80% was assumed due to the slightly higher calculated temperature in the tank.

In conclusion, an evaporation rate of -72 gal/yr for tank TY-105 appears reasonable.

### 4.1.6 Tank Heat Generation Rate Impact

RPP-54981, Revision 0, Appendix B describes the process used to estimate a heat generation rate for the waste in a tank. Table 4 in this document lists the nuclides contributing >0.01 percent to the tank TY-105 heat generation rate, which is about 4,200 BTU/hr. This is based upon a radionuclide decay date of January 1, 2008, so the heat generation rate as of July 1, 2013 is about 12% less. The heat generation rate is likely responsible for most evaporation from the tank, with a small amount coming from the latent heat of the incoming air, surrounding waste, and soil.

**Table 4  Radionuclides Contributing Greater Than 0.01% to the Tank TY-105 Waste Heat Generation Rate**

| Radionuclide | Ci[1] | Heat Generation Rate (watts/Ci)[2] | Heat Generation Rate (watts) |
|---|---|---|---|
| 90Sr | 1.79E+05 | 6.70E-03 | 1.20E+03 |
| 90Y | 1.79E+05 | 0.00E+00 (with parent) | 0.00E+00 |
| 137Cs | 7.61E+03 | 4.82E-03 | 3.66E+01 |
| 137mBa | 7.19E+03 | 0.00E+00 (with parent) | 0.00E+00 |
| 234U | 2.36E+00 | 2.88E-02 | 6.80E-02 |
| 239Pu | 2.84E+01 | 3.11E-02 | 8.83E-01 |
| 240Pu | 3.04E+00 | 3.12E-02 | 9.47E-02 |
| 241Am | 1.01E+00 | 3.34E-02 | 3.38E-01 |
| Sum | | | 1,237 (4,219 BTU/hr) |

[1] From TWINS download March 19, 2013, radionuclide decay date January 1, 2008
[2] From HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, Rev 14 (reissue), August 11, 2008

### 4.1.7 Tank TY-105 Leak Potential

Based upon Figure 21 the tank TY-105 estimated evaporation rate can account for the observed liquid loss rate.

Using the equation from Section 3.4:

$$leak\ rate = volumetric\ change\ rate - intrusion\ rate - evaporation\ rate - \Sigma\ other$$

$$leak\ rate = -50\frac{gal}{yr} - intrusion\ rate - \left(-72\frac{gal}{yr}\right) - \left(5\ \frac{gal}{yr} + PCE\right)$$
$$= 22\frac{gal}{yr} - intrusion\ rate - PCE$$

If the evaporation rate for tank TY-105 is -72 gal/yr, the intrusion rate would have to exceed 22 gal/yr, excluding PCE impacts, for a leak to exist.  The PCE impact is zero since the volumetric change rate is based upon the ILL change.  It is possible there is a 22 gal/yr intrusion into tank TY-105, but no evidence was observed other than the liquid in Figure 20.

### 4.1.8 Tank TY-105 Conclusion

Based upon the evaporation rate exceeding the liquid loss rate determined from the ILL decrease, there is no evidence tank TY-105 is actively leaking.

**Figure 1 Tank TY-105 Full Depth Raw Data Plot**

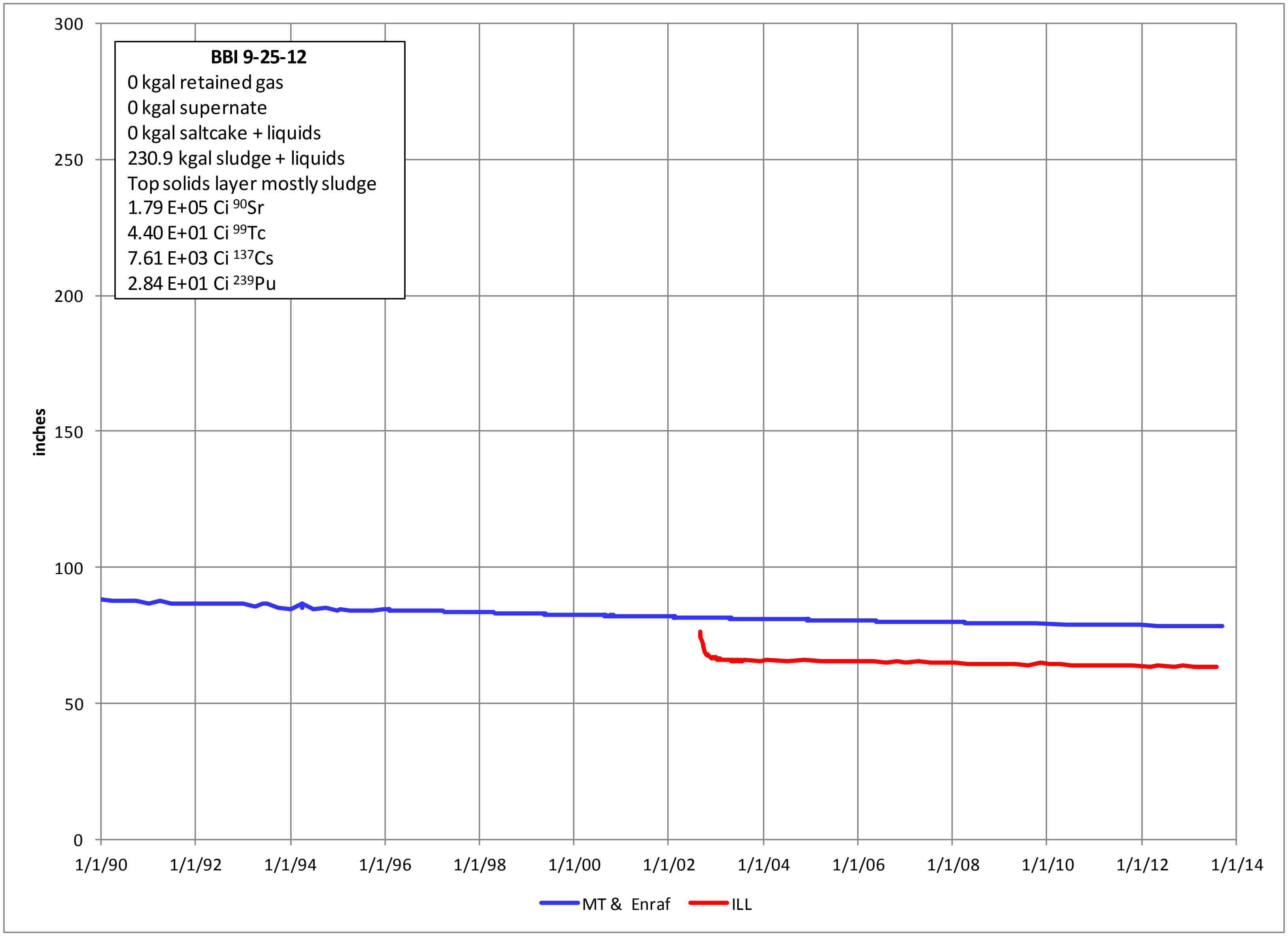


**Figure 2 Tank TY-105 Expanded ILL Data Plot Used for RPP-PLAN-55113, Rev. 1**

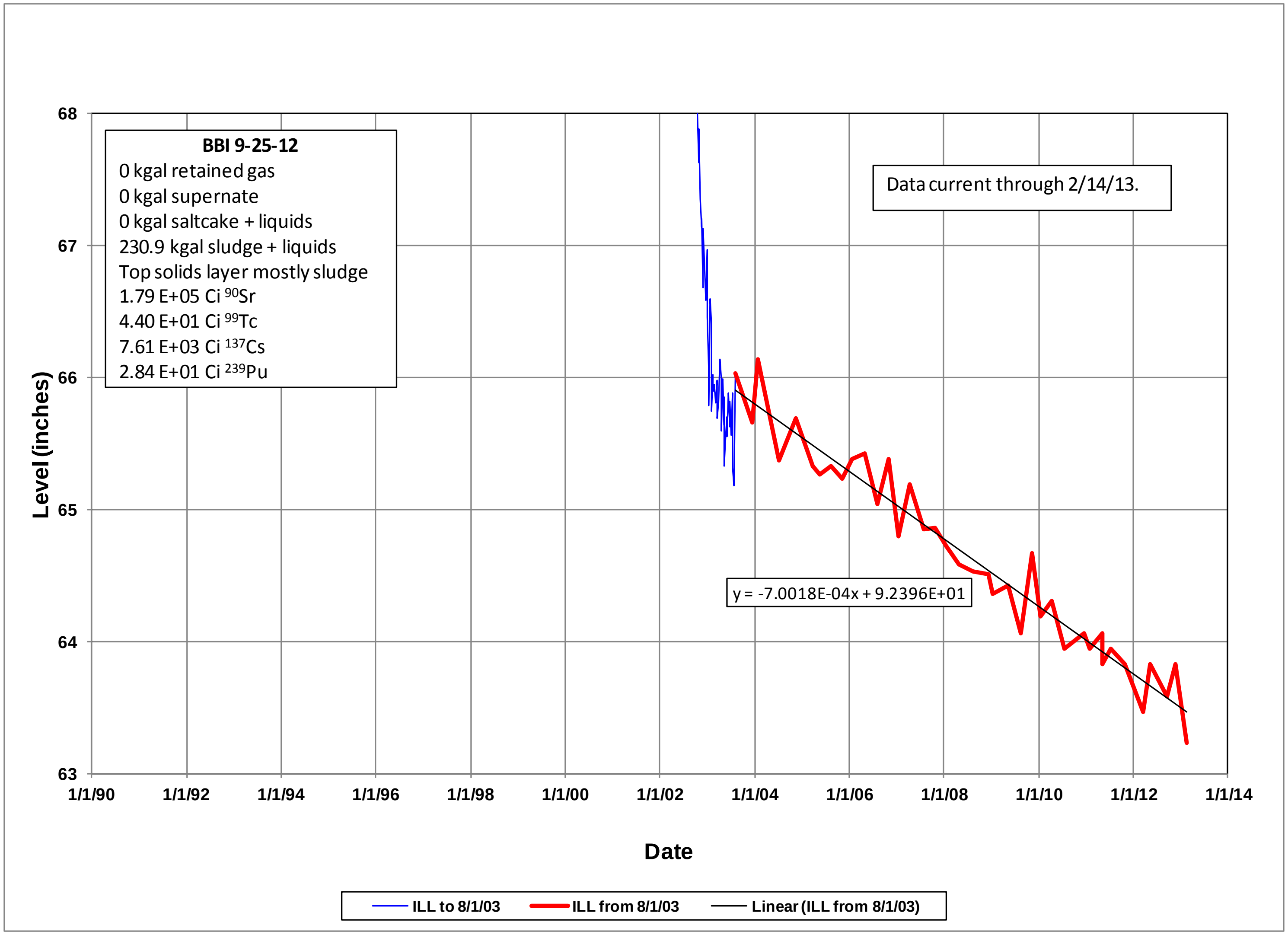


**Figure 3 Tank TY-105 Expanded SL Data Plot Used for RPP-PLAN-55113, Rev. 1**

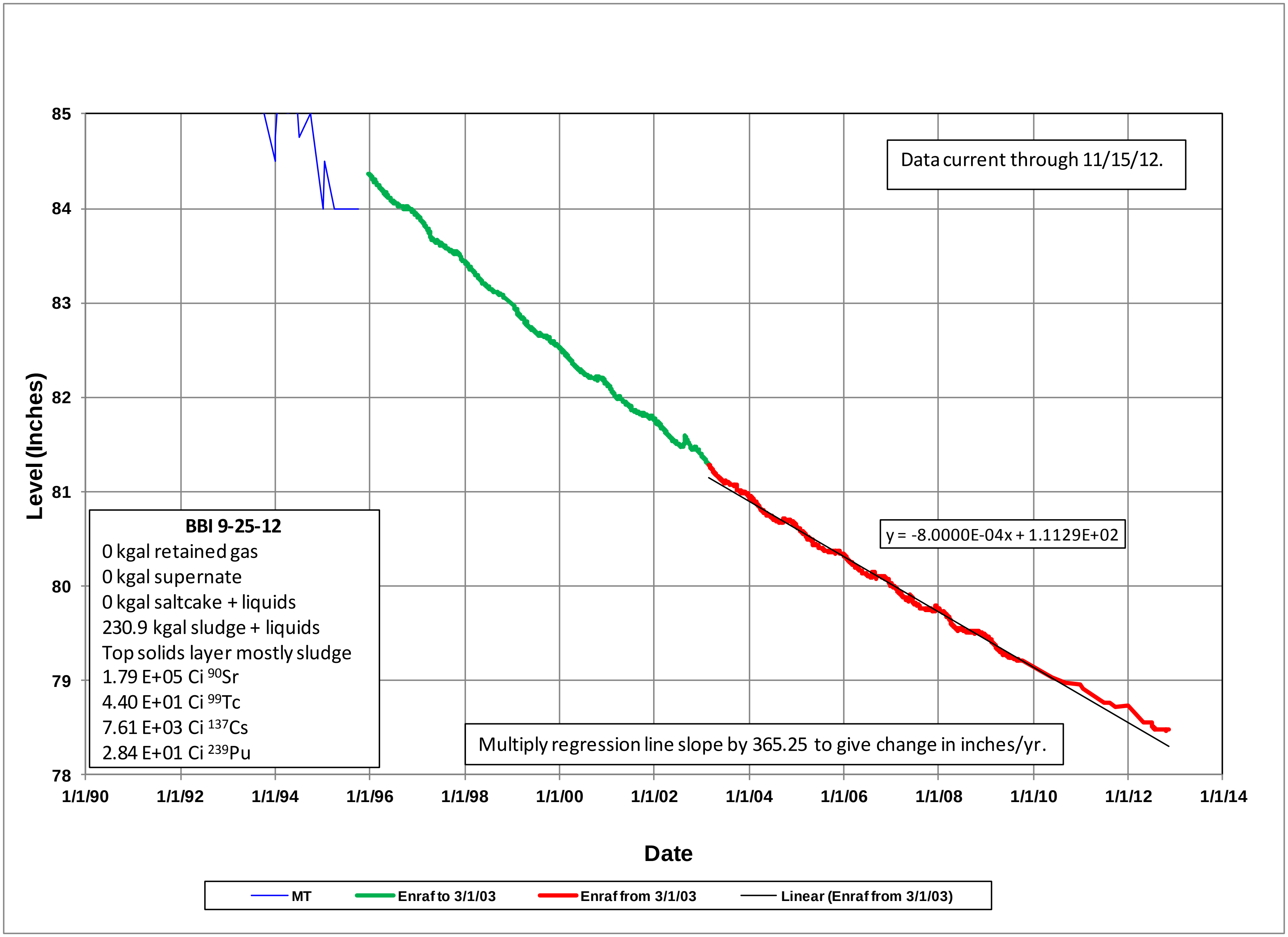


**Figure 4  Tank TY-105 Expanded ILL Data Plot Used for RPP-RPT-55263**

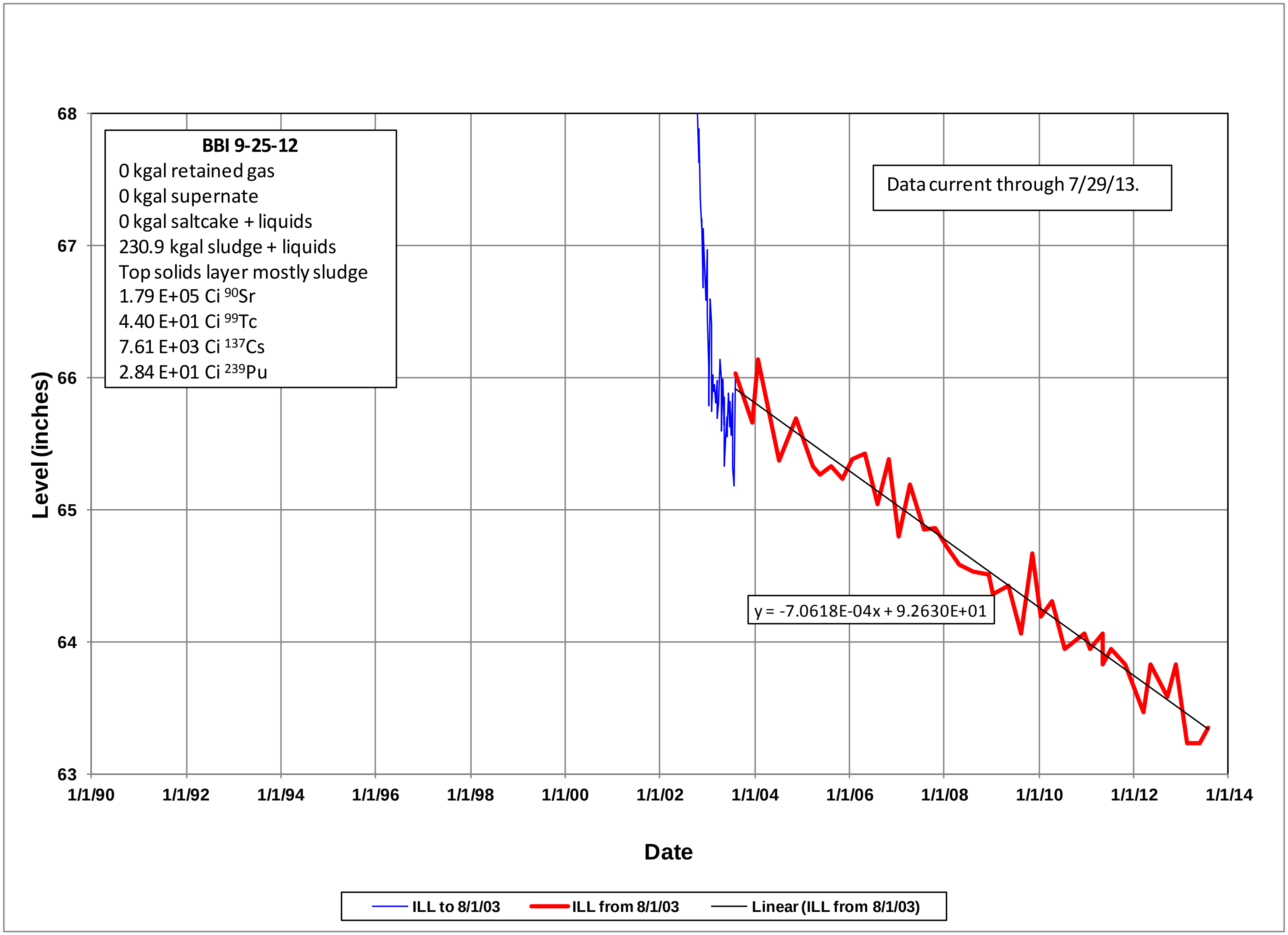


**Figure 5  Tank TY-105 Expanded SL Data Plot Used for RPP-RPT-55263**

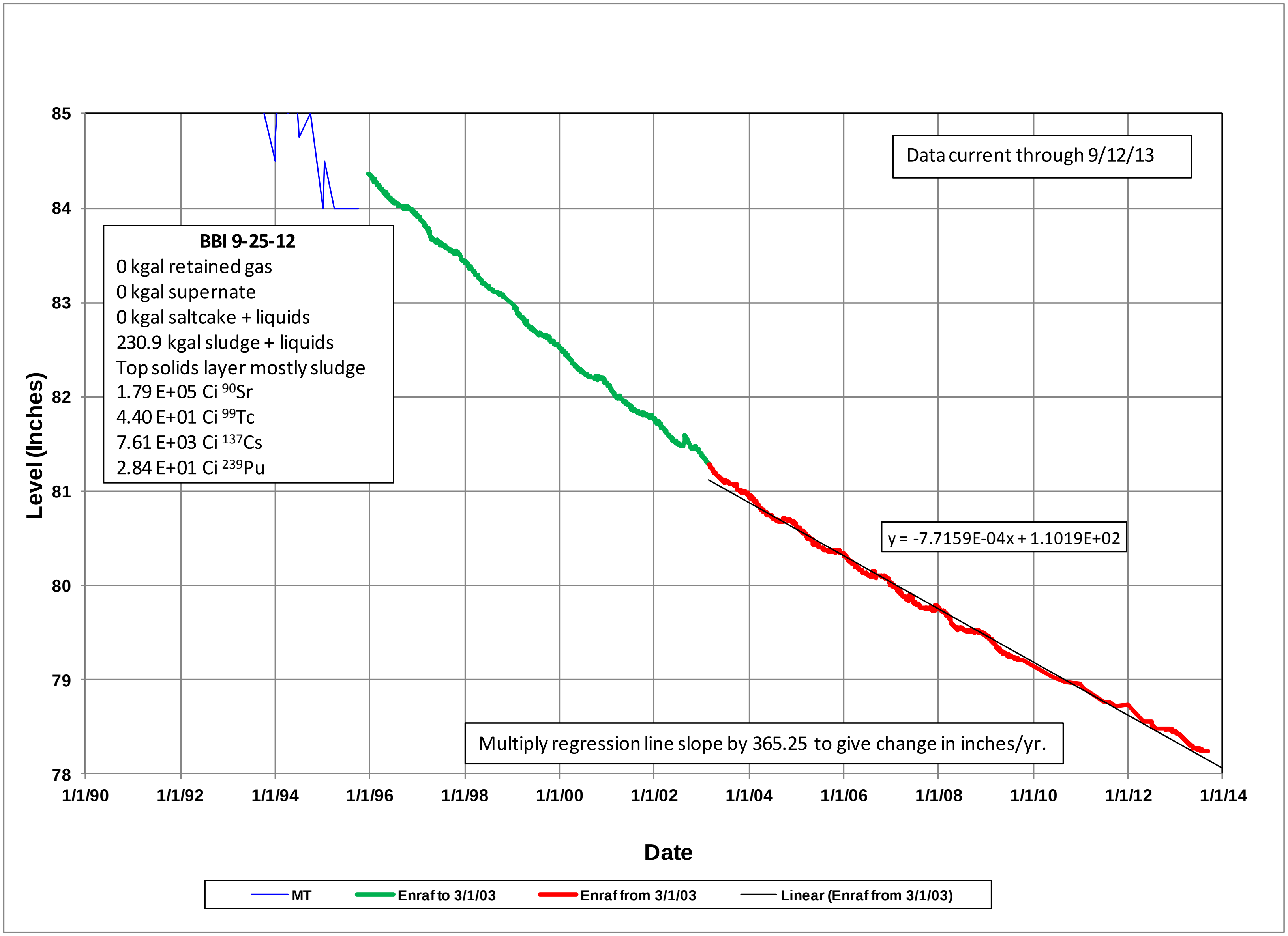


**Figure 6 Tank TY-105 Expanded and Adjusted SL Data Plot from 1982**

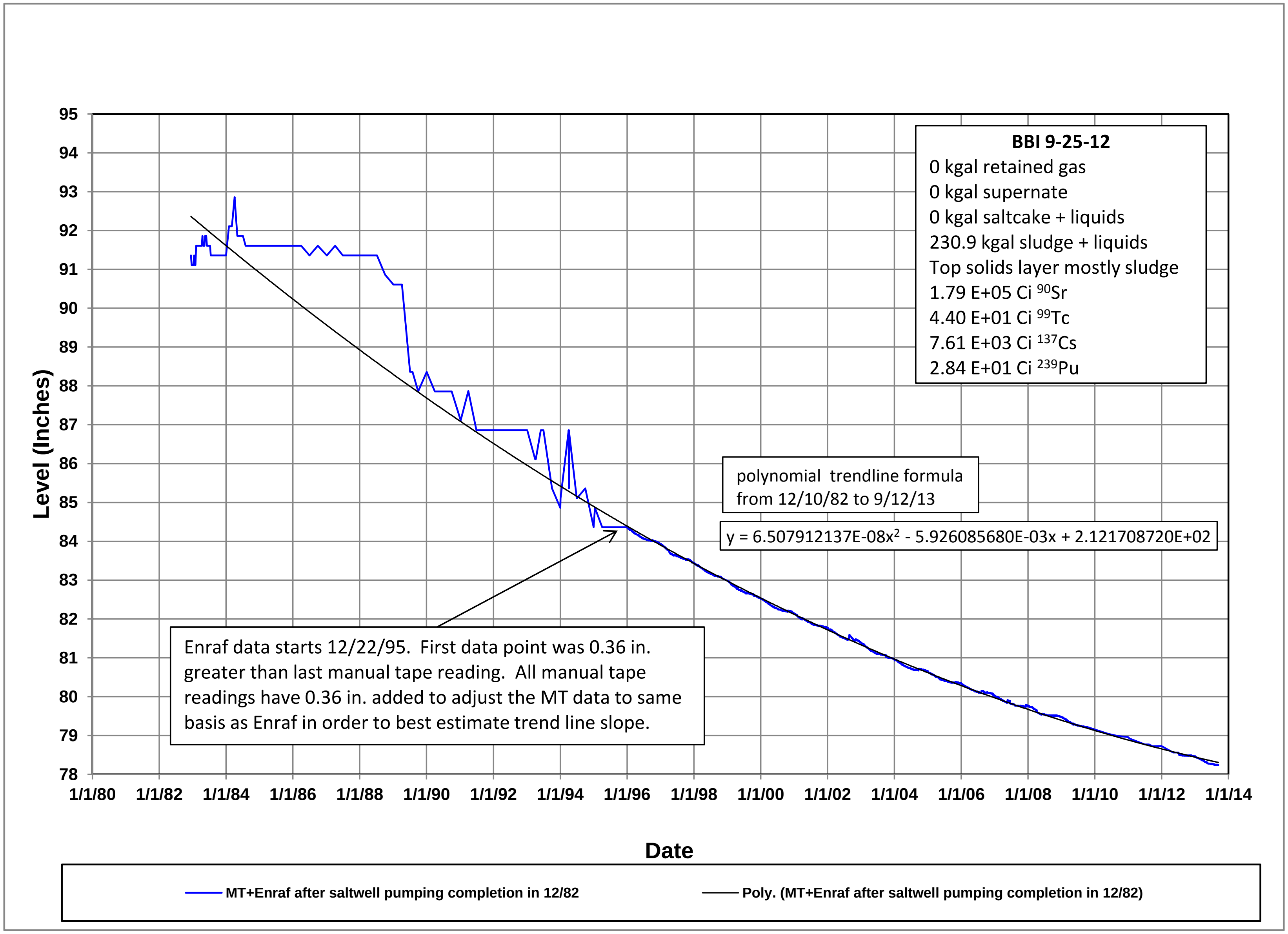


**Figure 7 Tank TY-105 Raw Interstitial Liquid Level Data and Adjusted Inverse Barometric Pressure**

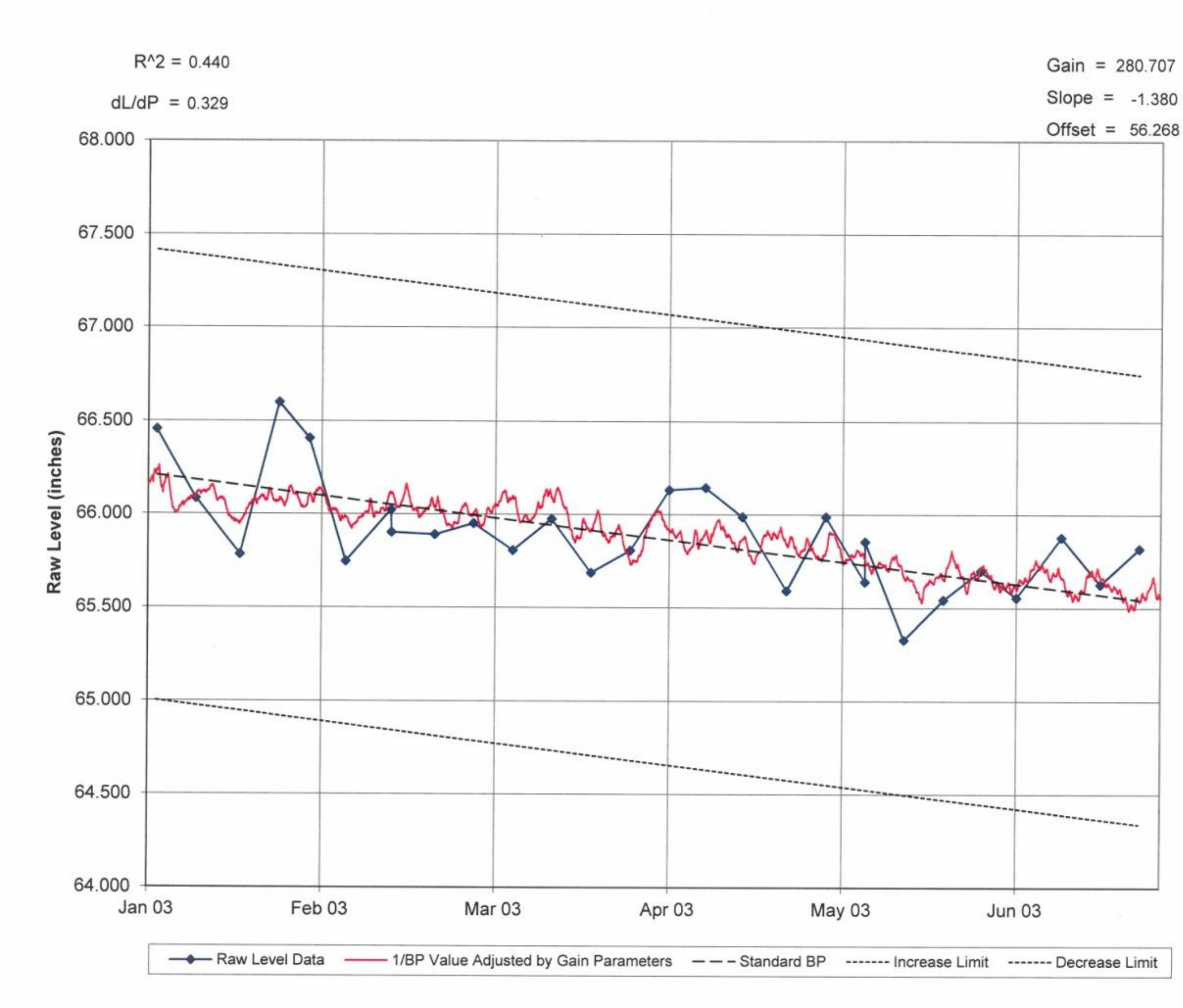


**Figure 8  Comparison of Tank TY-105 2003 and 2013 Liquid Observation Well Neutron Scans**

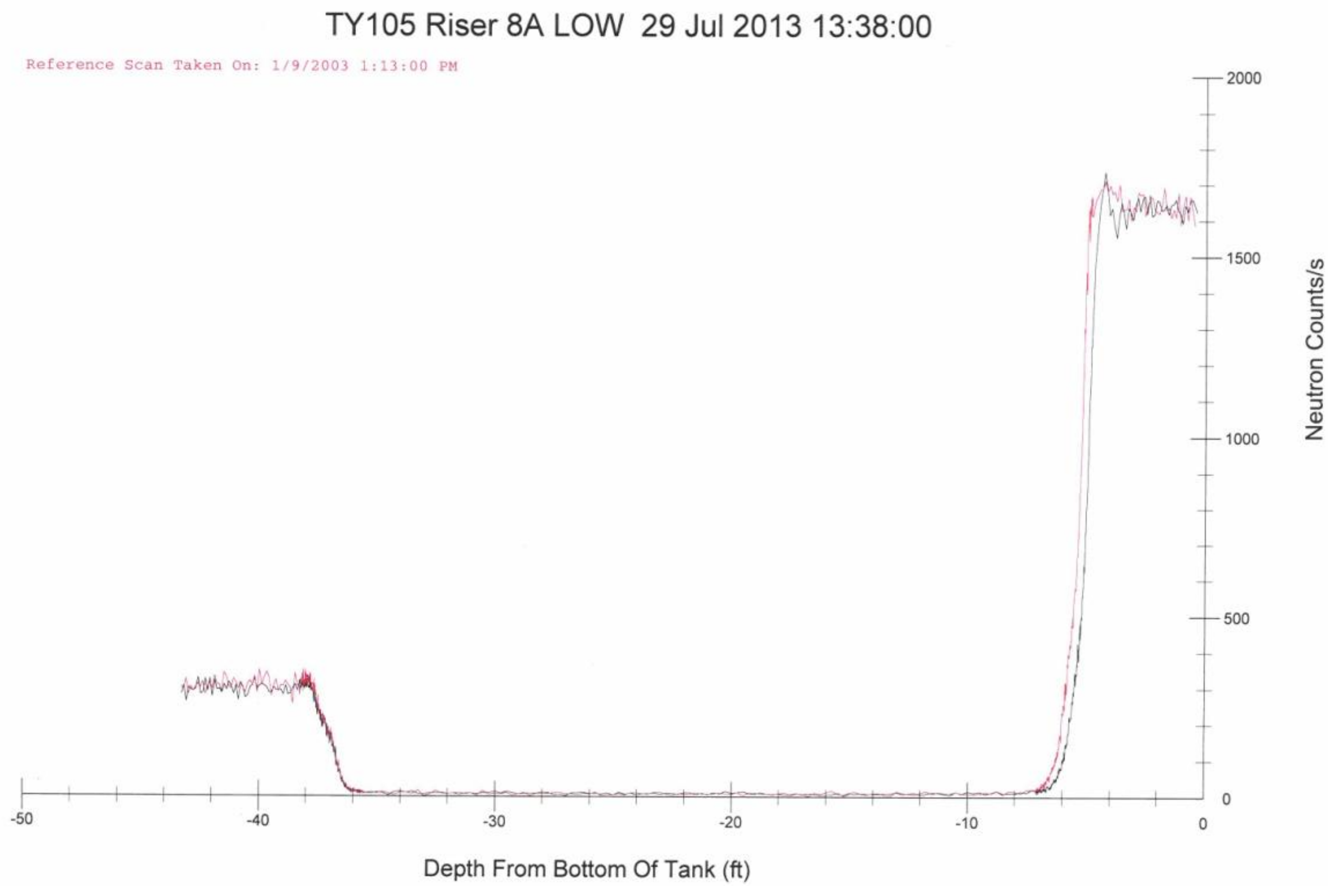


**Figure 9  Expanded Comparison of Tank TY-105 2003 and 2013 Liquid Observation Well Neutron Scans**

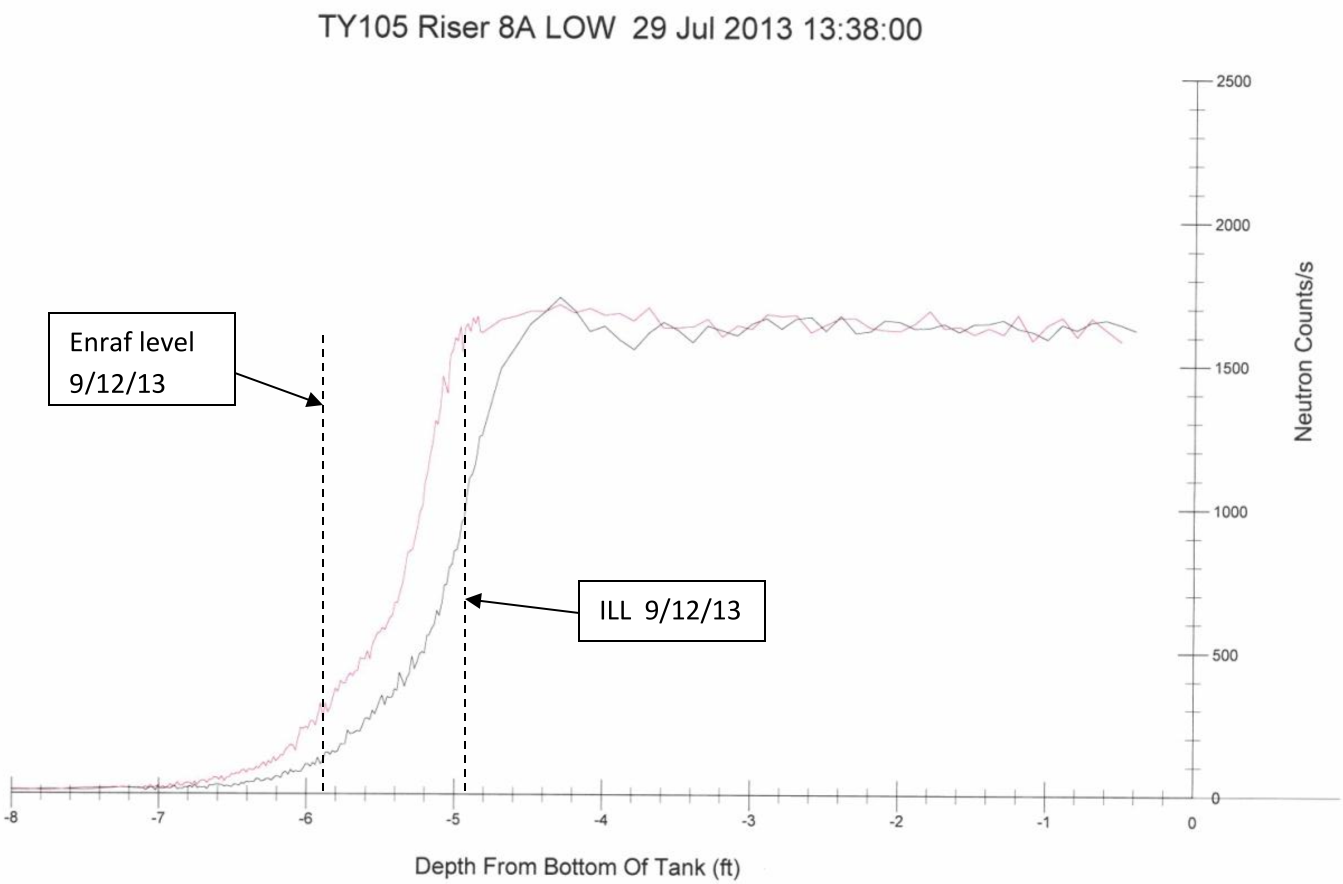


**Figure 10  Close-Up of Tank TY-105 Enraf Plummet on Wet Appearing Surface**

**Figure 11  Tank TY-105 Waste Tank Isolation Drawing (H-2-73090, Rev 6)**

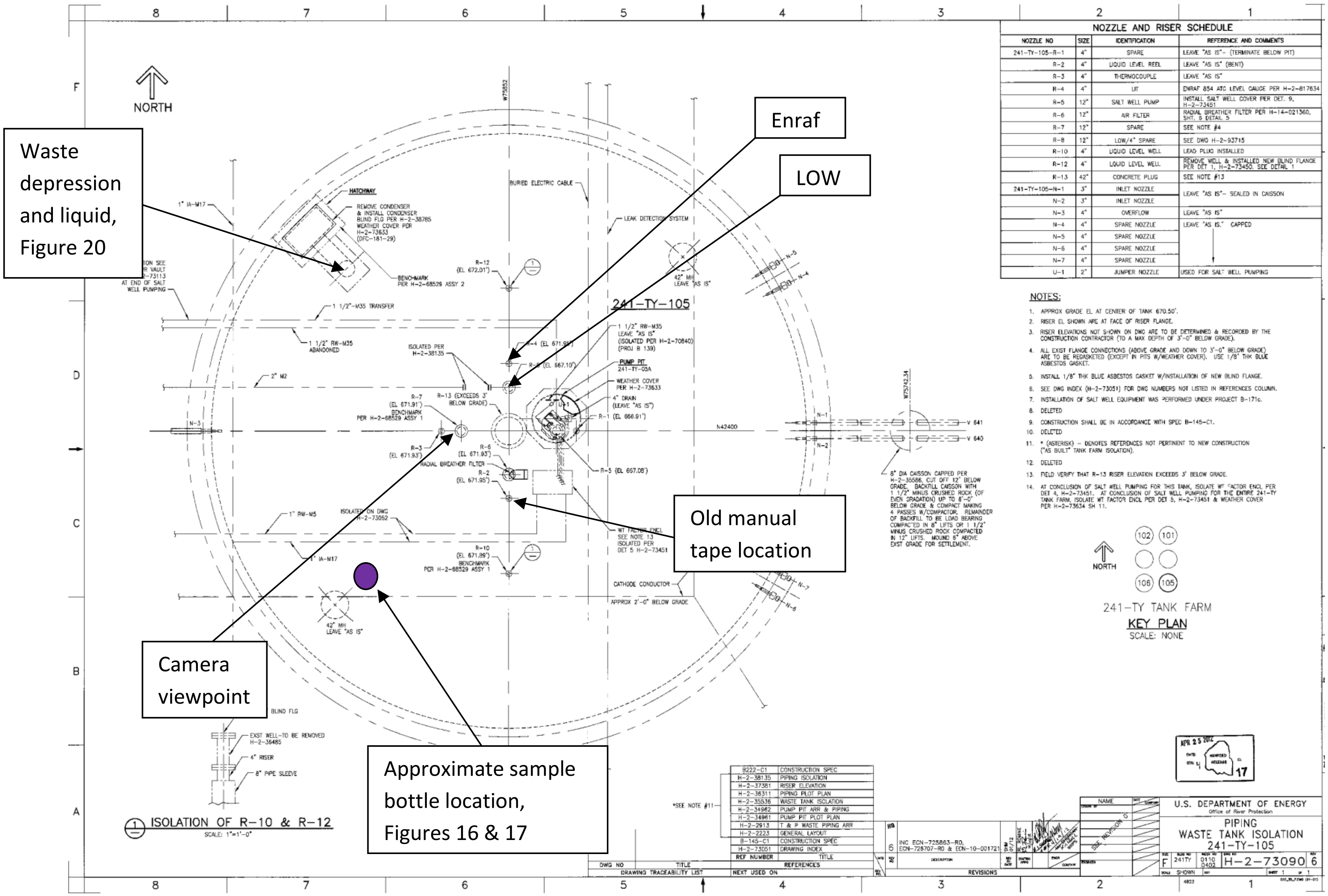


**Figure 12  Cross Section of Tank TY-105 Showing Postulated Waste Level Changes**

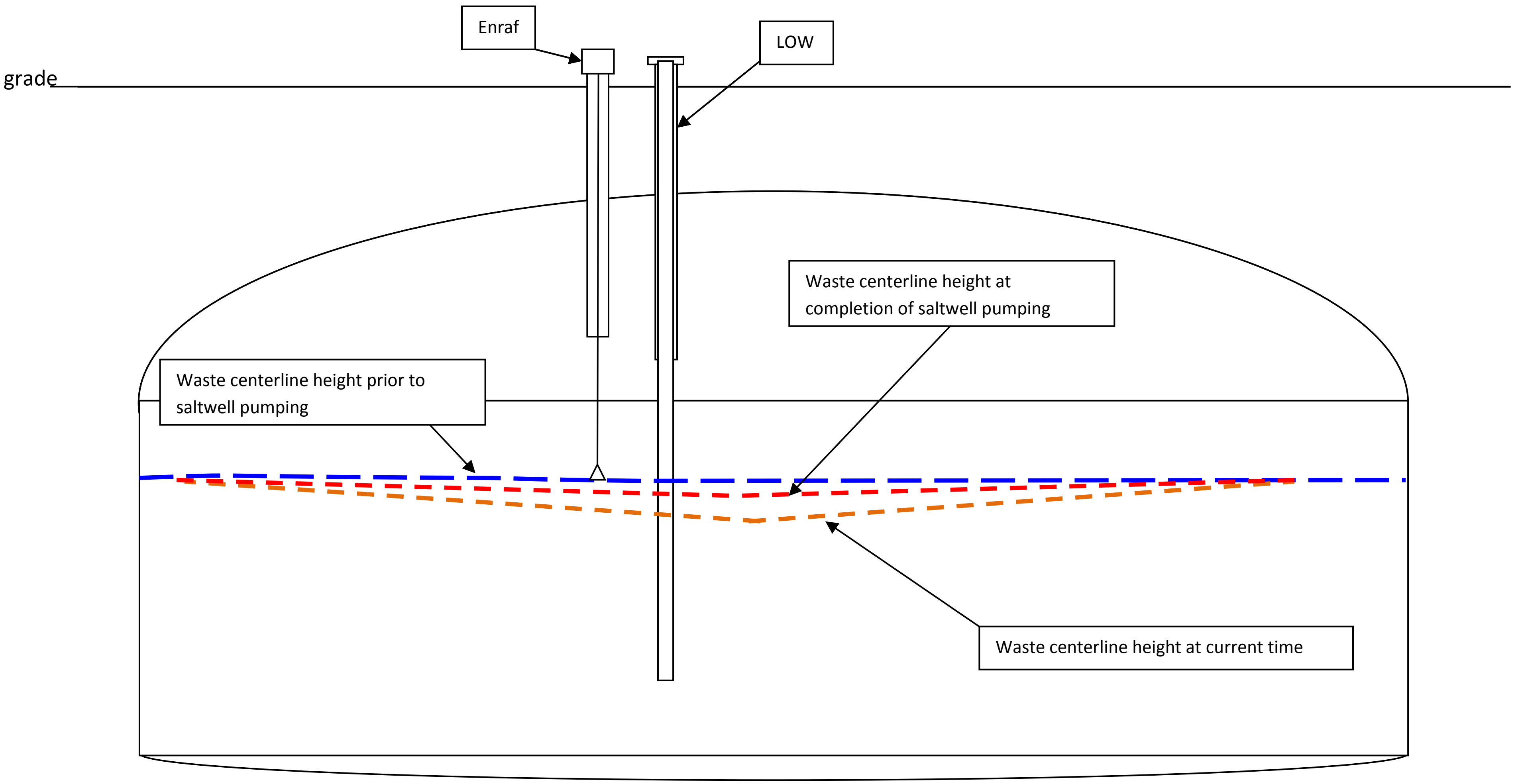


**Figure 13 Screen Image Composite of Tank TY-105 Waste Surface from April 22, 2013 In-Tank Video**

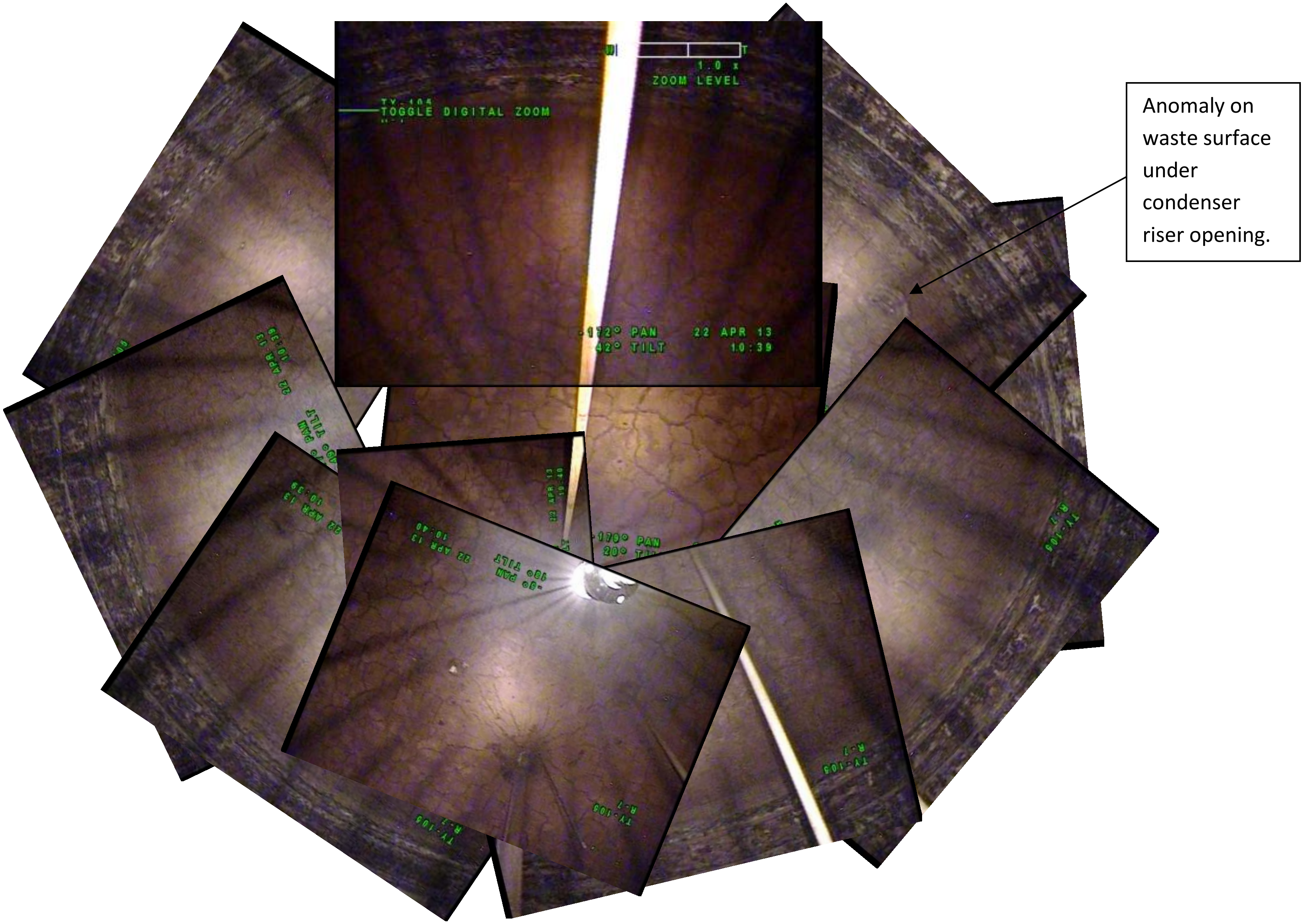


**Figure 14  Screenshot from April 22, 2013 Video Showing Waste Surface Anomaly and Wall in Northwest Quadrant of Tank**

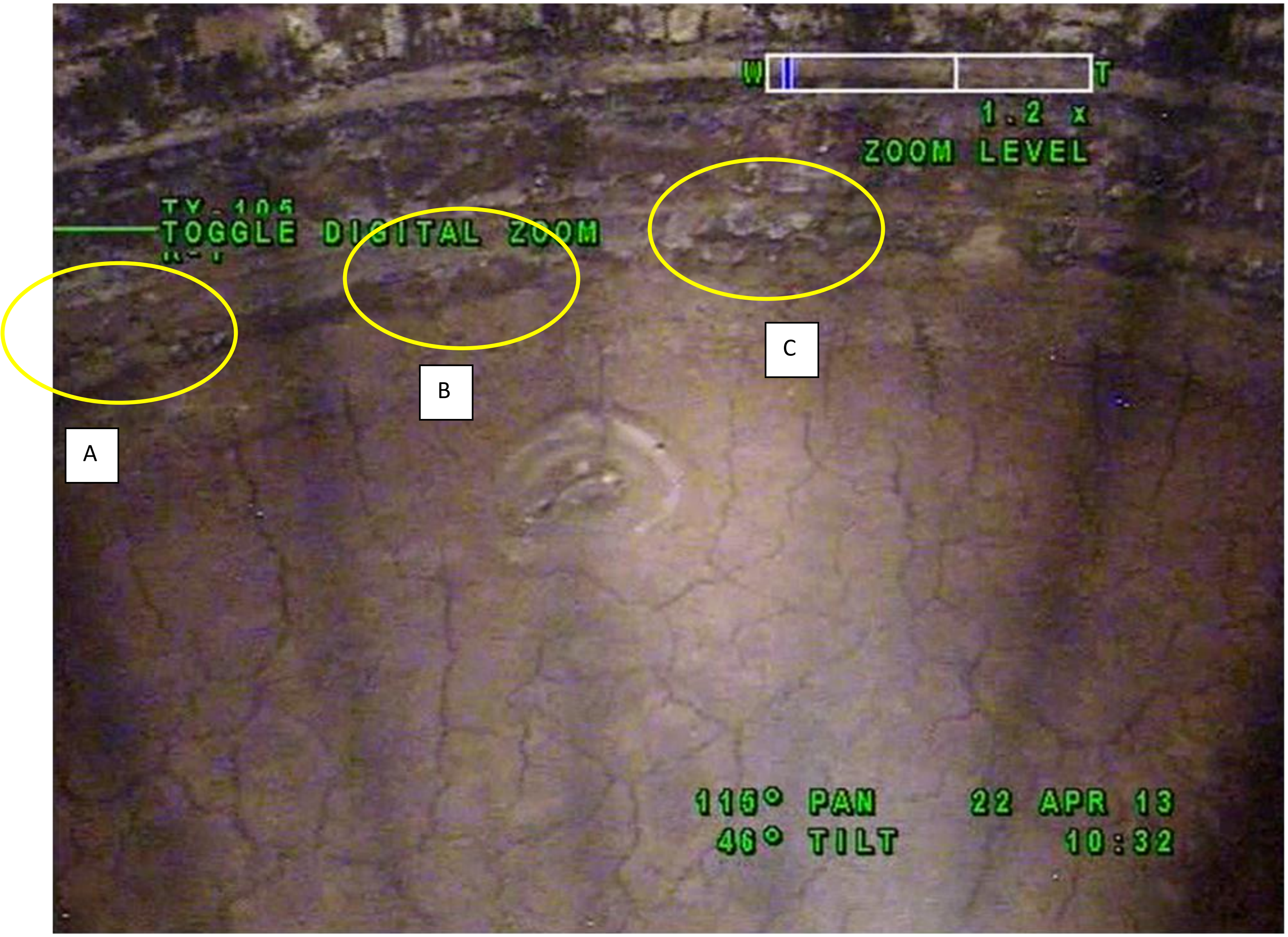


**Figure 15  Photo from September 7, 1989 of Same Location as Figure 14**

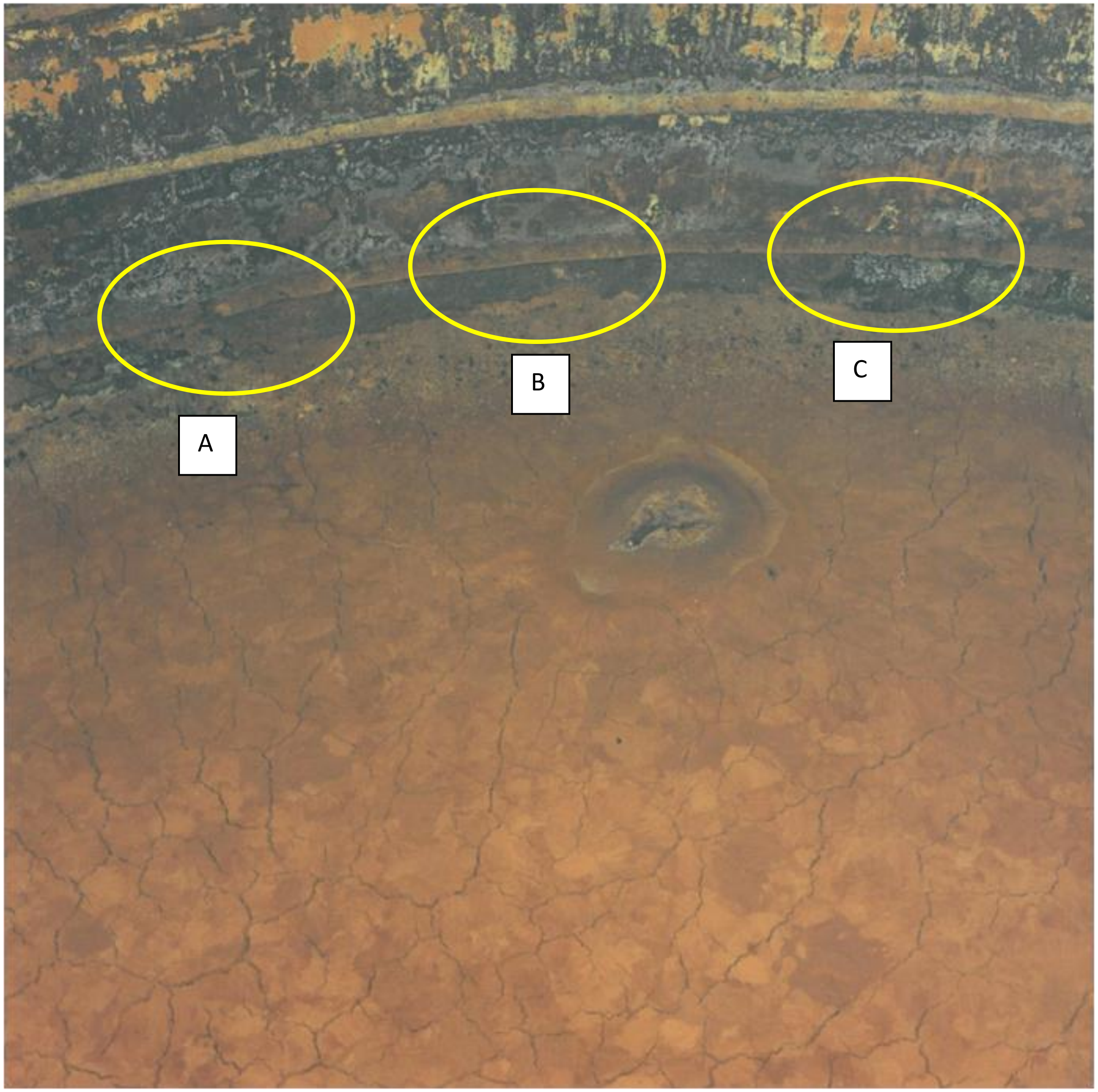


**Figure 16  Screenshot from April 22, 2013 Video Showing Tank Waste and Wall in Southwest Quadrant of Tank**

**Figure 17 Photo from September 7, 1989 of Same Location as Figure 16**

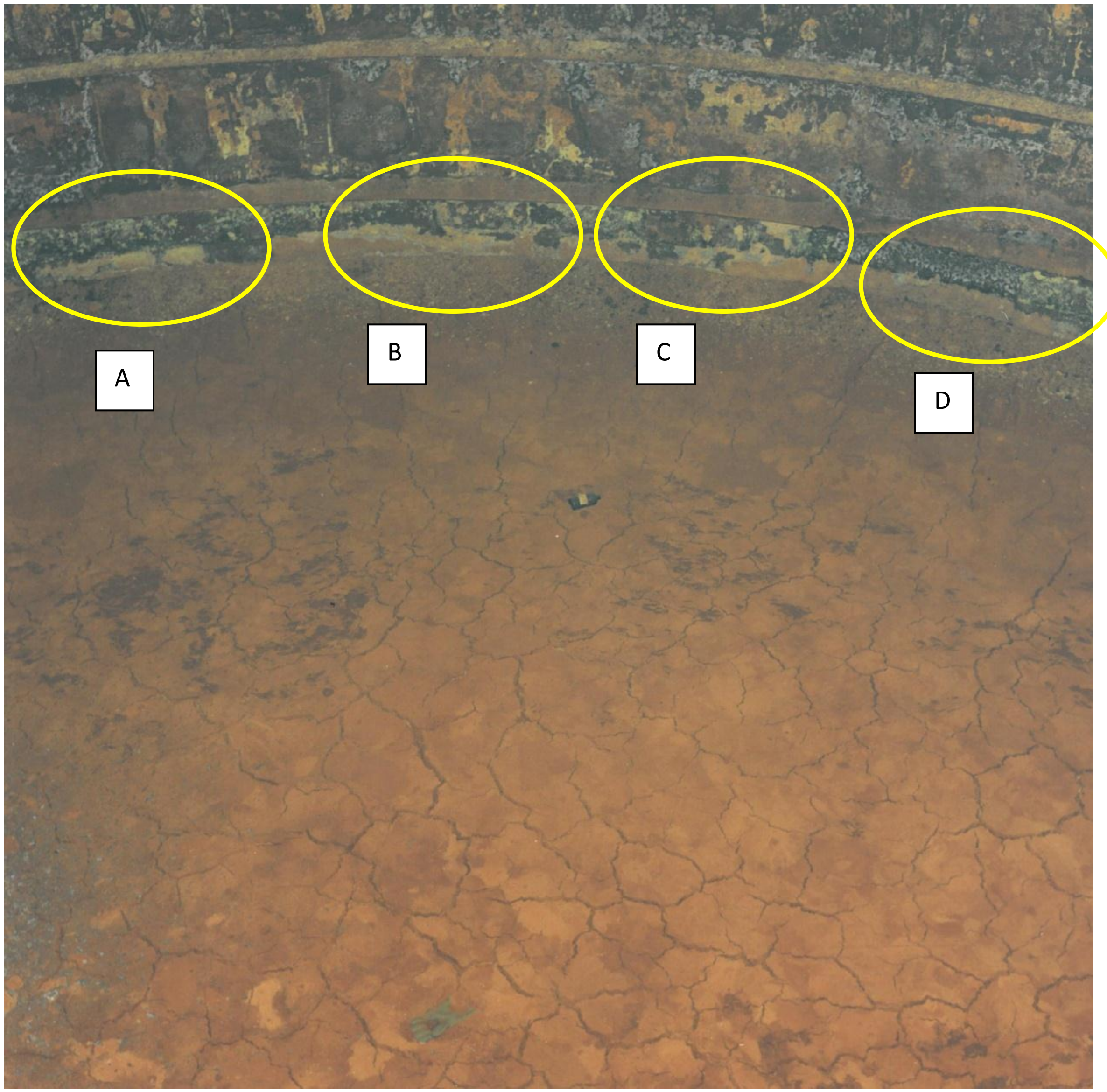


**Figure 18  Photo of Liquid around Saltwell Screen, June 30, 1978**

**Figure 19  Photo of Liquid around Saltwell Screen, August 21, 1987**

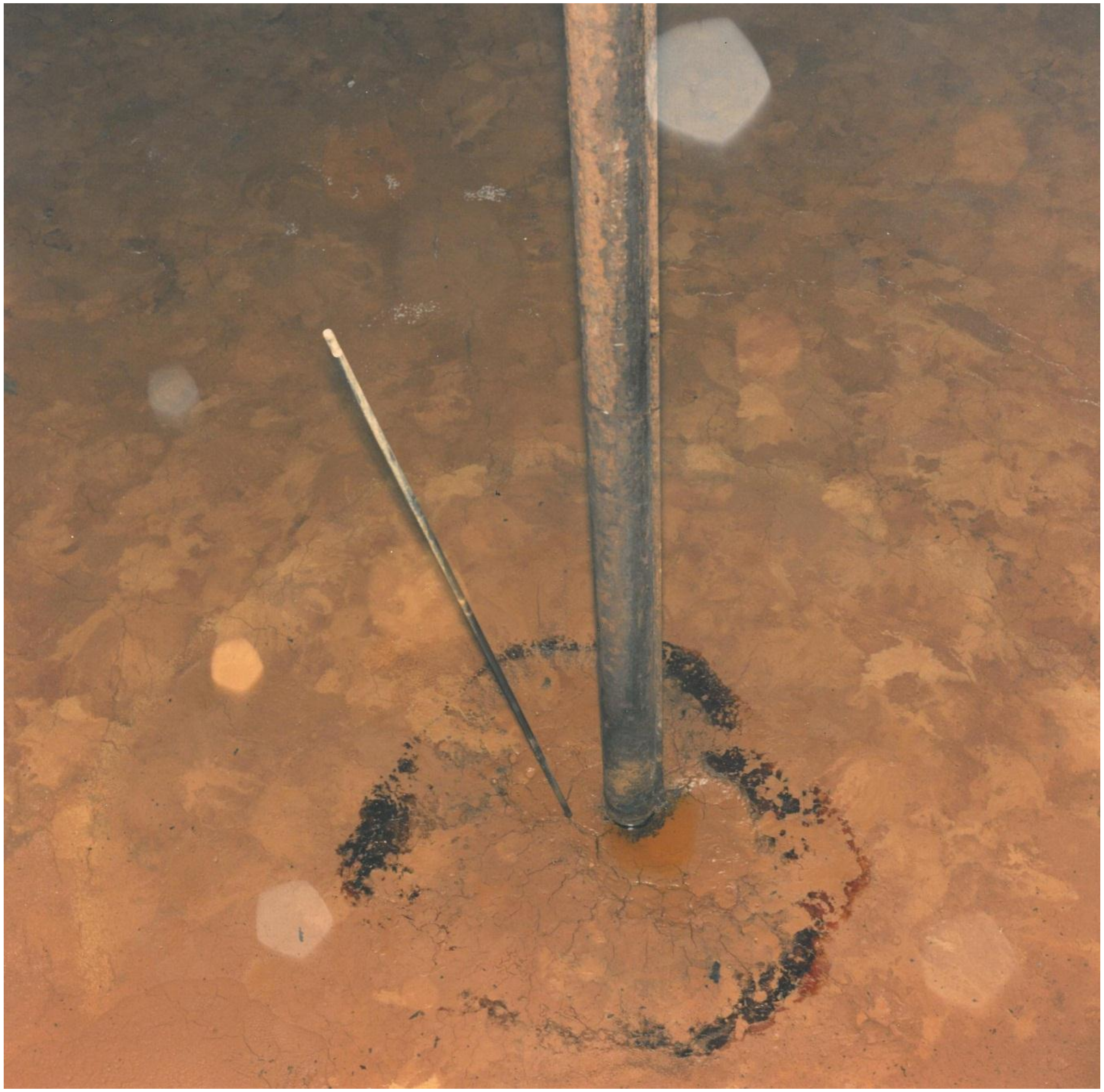
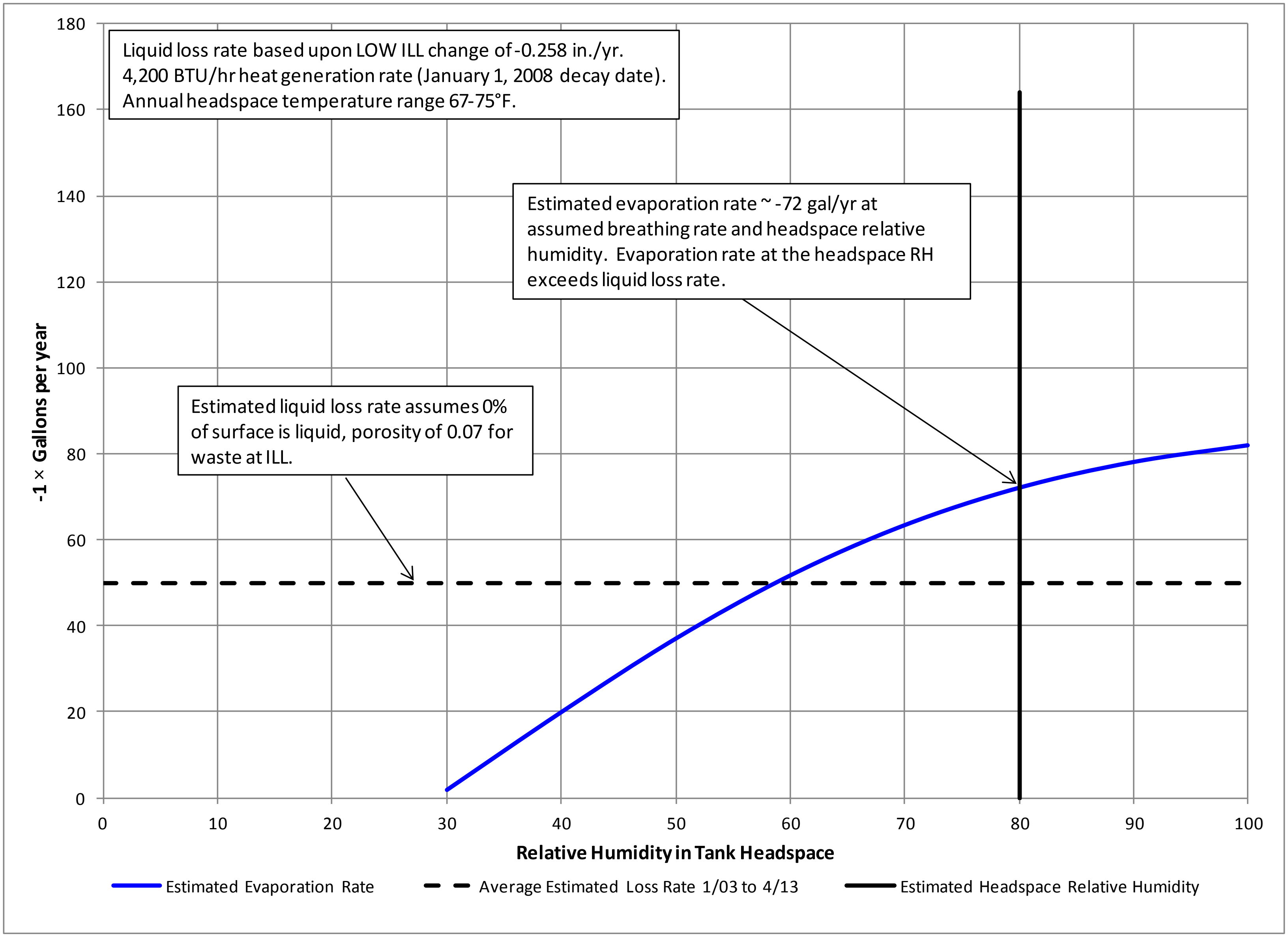


**Figure 20  Close-Up from April 22, 2013 Video Showing Liquid in Waste Surface Depression from Figure 13**

**Figure 21 TY-105 Estimated Evaporation Loss Rate and Observed Liquid Loss Rate**



# 5.0 Discussion of Results

The evaluation for tank TY-105 is dependent upon the validity of three separate estimates: evaporation rate, volumetric change rate, and tank headspace relative humidity. The possible variation in these is addressed in the following subsections.

## 5.1 Evaporation Rate Variation

The tank evaporation rate depends upon the following variables:

- Ambient temperature, pressure, and relative humidity
- Tank headspace air temperature
- Tank headspace relative humidity
- Tank breathing rate
- How a tank breathing rate differs from a once-through active ventilation process with its effect on water vapor condensing out of headspace air before the air reaches the atmosphere.

Ambient conditions are assumed the same as measured at the Hanford Weather Station (HWS). While local conditions at each tank can vary slightly from at the HWS, and the HWS data used is hourly not continuous, any errors in using the HWS are assumed to be minor and should cancel each other out over three years' worth of data.

The tank headspace air temperature is based upon a regression line formula for each tank, which is in turn dependent upon the accuracy of the tank thermocouple used and the degree of variation of the data over the years used for the regression line. The tank thermocouples themselves cannot be calibrated since they are located inside pipes inserted into the waste, but it is assumed that the tank thermocouple data is reasonably accurate as the data points read about as expected and show the same nominal 60 to 70°F temperature range for tanks with low heat generation rate. It is also assumed that variations in the headspace temperature in comparison to the regression line formula will cancel out over the period of evaporation calculations.

RPP-RPT-54981, Rev 0, Appendix A, Section A.4 explains the derivation of breathing rate estimates. The breathing rate estimates are based upon extrapolation of results from 13 tracer gas tests made in the 1990s. Information presented in Appendix A indicates atmospheric pressure variation may not have a major impact on tank breathing rate. See RPP-RPT-54981, Rev 0, Appendix A for further discussion of the assumed breathing rates.

How condensation during a tank breathing process differs from a once-through active ventilation system was estimated conservatively. In an active ventilation system there should be minimal condensation until the ventilated air leaves the tank and is above ground. For a breathing tank it is conservatively assumed that the air leaving the tank headspace and entering the bottom of the breather filter (in the process of leaving the tank), and the ambient air entering the top of the breather filter (in the process of entering the tank) are mixed, and any water vapor remaining at 100% relative humidity for the air mixture is returned to the tank. This assumption should overestimate the quantity of water returned to the tank at higher tank headspace relative humidities, resulting in an underestimation of the tank evaporation rate.

### 5.2 Liquid Change Rate Variation

The tank liquid loss rate depends upon the following variables:

- Accuracy of ILL or SL data used
- Assumed fraction of a tank surface that is liquid
- Assumed tank waste porosity

The tank ILL and SL data are assumed accurate since the instruments used are routinely calibrated. The most important data attribute is repeatability so that trends can be observed. Section 4.1.3 shows the data are acceptable for this purpose.

The fraction of tank surface that is liquid is zero based upon the April 22, 2013 video.

The waste porosity of 0.07 assumed for tank TY-105 is the value used in RPP-5556. The porosity in the tank is unknown, but based primarily upon saltwell pumping information. The 0.07 value is low compared to other sludge tanks. Underestimation of the waste porosity will result in underestimation of the liquid change rate. The 0.07 value is assumed valid because the presence of liquid near the surface indicates the low drainability of the waste.

The liquid change rate estimate is assumed reasonable.

### 5.3 Headspace Relative Humidity Variation

The assumed current tank headspace relative humidity for tank TY-105 is based upon water vapor data from a tank TY-105 headspace sample taken in 1997. Tank TY-105 is believed to have similar current conditions as when sampled so the assumed relative humidity should be reasonable.

## 6.0 Conclusions

The conclusion from this document is:

1. Based upon Figure 21 the liquid loss rate for tank TY-105 can be explained by evaporation.

## 7.0 References


CLO-WO-07-1106, 241-TY, 204 ENRAF INSPECTION, completed August 7, 2007, CH2M Hill Hanford Group, Inc., Richland, Washington.

DRI-10-01420, Survey Results for Tank TY-105 Video Inspection on April 22, 2013, available from Hanford Sitewide Industrial Hygiene Database (HSIHD), restricted access through Industrial Safety and Health, Washington River Protection Solutions, Richland, Washington.

Excel file *BP Correlation with DB Connect*, SVF-1002, June 27, 2005, CH2M HILL Hanford Group Inc. and Lockheed Martin Services Inc., Richland Washington.

H-2-73090, 2012, *Piping Waste Tank Isolation 241-TY-105*, Rev. 6, Washington River Protection Solutions, Richland, Washington.

HNF-EP-0182, *Waste Status Summary for Month Ending April 30, 2013*, Rev 301, 2013, Washington River Protection Solutions, Richland, Washington.

HNF-SD-RE-TI-178, *Single-Shell Tank Interim Stabilization Record,* Rev 9(a), 2007, CH2M Hill Hanford Group, Inc., Richland, Washington.

OSD-T-151-00031, 2012, *Operating Specifications for Tank Farm Leak Detection and Single-Shell Tank Intrusion Detection*, Revision 1, Washington River Protection Solutions, Richland, Washington.

RPP-5556, 2000, *Updated Drainable Interstitial Liquid Volume Estimates for 119 Single-Shell Tanks Declared Stabilized*, Rev 0, CH2M Hill Hanford Group, Inc., Richland, Washington.

RPP-PLAN-55113, 2013, *March 2013 Single-Shell Tank Waste Level Decrease Evaluation Plan*, Revision 1, Washington River Protection Solutions LLC, Richland, Washington.

RPP-RPT-43197, 2009, *2009 Auto TCR for Tank 241-TY-105*, Revision 0, Washington River Protection Solutions, Richland, Washington.

RPP-RPT-54981, 2013, *Evaluation of Fourteen Tanks with Decreasing Baselines Selected for Review in RPP-PLAN-55113, Revision 1*, Revision 0, Washington River Protection Solutions, Richland, Washington.

TFC-WO-09-1354, 241-TY, 105 ENRAF CAL, completed May 6, 2009, Washington River Protection Solutions, Richland, Washington.

TWINS, *Tank Waste Information Network System*, database available on the Hanford Local Area Network (HLAN) at https://twins.labworks.org/twinsdata/Forms/About.aspx

WHC-MR-0132, 1990, *A History of The Hanford 200 Area Tank Farms*, Revision 0, Westinghouse Hanford Company, Inc., Richland, Washington.

WRPS-1203139R1, *Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Submittal of Single-Shell Tank Suspect Intrusion Evaluation Plan to The U.S. Department of Energy, Office of River Protection*, Letter, C.A. Simpson, WRPS to S.E. Bechtol, US Department of Energy, Washington River Protection Solutions, Richland, Washington, dated September 13, 2012.

WRPS-1301005, *Contract Number DE-AC27-08RV14800 – Washington River Protection Solutions LLC Submittal of Single-Shell Tank Level Decrease Evaluation Plan to The U.S. Department of Energy, Office of River Protection*, Letter, C.A. Simpson, WRPS to S.E. Bechtol, US Department of Energy, Washington River Protection Solutions, Richland, Washington, dated March 18, 2013.