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**ENVIRONMENTAL
RESTORATION
PROGRAM**

**GAAT Dry Well Conductivity Monitoring
Report, July 1997 Through January 1998,
Oak Ridge National Laboratory,
Oak Ridge, Tennessee**

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FOR THE UNITED STATES
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**GAAT Dry Well Conductivity Monitoring
Report, July 1997 Through January 1998,
Oak Ridge National Laboratory,
Oak Ridge, Tennessee**

Date Issued—March 1998

Prepared by
Vista Research, Inc.
Oak Ridge, Tennessee
under subcontract 78X-SP750C

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Environmental Management Activities at
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
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LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
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under contract DE-AC05-84OR21400

PREFACE

This report, *GAAT Dry Well Conductivity Monitoring Report, July 1997 Through January 1998*, Oak Ridge National Laboratory, Oak Ridge, Tennessee (ORNL/ER-437), was developed under Work Breakdown Structure 6.1.01.41.05.05.05 (Activity Data Sheet 3301, "WAG 1"). This document provides the Environmental Restoration Program with the dry well conductivity monitoring data for the gunite tanks in the North and South Tank Farms for the period from July 1997 through January 1998. Information provided in this report forms part of the technical basis for criticality safety, systems safety, engineering design and waste management as they apply to the Gunite and Associated Tanks treatability study and waste removal actions.

LOCKHEED MARTIN

LTR/ERPS-98-029

March 16, 1998

Ms. Jane Powell, Program Manager
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Contract DE-AC05-84OR21400, Transmittal of GAAT Dry Well Conductivity Monitoring Report, July 1997 Through January 1998, Oak Ridge National Laboratory, Oak Ridge, Tennessee (ORNL/ER-437) and Response to TDEC and EPA Comments on the October 1997 report Dry Well Conductivity Monitoring Report for Tanks W-8, W-9 and W-10, Oak Ridge National Laboratory, Oak Ridge, Tennessee (ORNL/ER-421)

Seven copies of the subject document (ORNL/ER-437) are enclosed for your information and transmittal to the Tennessee Department of Environment and Conservation (TDEC) and the U.S. Environmental Protection Agency (EPA) for their review. As discussed in this document, a thorough analysis of the monitoring results from the dry wells for the period between July 1997 and January 1998 indicates that no releases have occurred from the gunite tanks being monitored.

A detailed response to TDEC and EPA comments on ORNL/ER-321 is also enclosed. As indicated in this response and supported by the data presented in ORNL/ER-437, the Gunite Tank Team believes that three conductivity levels (900 $\mu\text{S}/\text{cm}$, 1200 $\mu\text{S}/\text{cm}$, and 1500 $\mu\text{S}/\text{cm}$) should be used as administrative, alert, and alarm thresholds for the dry well conductivity monitoring in the South Tank Farm.

The dry well monitoring program will expand during the next reporting period to include dry wells DW-5, DW-6, and DW-7. The conductivity data will be reviewed and analyzed on a routine basis even in the absence of any elevated conductivity levels or alarms. The conductivity data for DW-8, DW-9, and the tank being actively sluiced will be monitored at the Waste Operations Control Center on a continuous 24-hour basis.

If you have any questions regarding this information, please contact me at (423) 574-7264.

Sincerely,

S.D. Van Hoesen, Project Manager
Gunite Tanks Remediation Project

Enclosures

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Subj: Response to comments by the U.S. Environmental Protection Agency and the Tennessee Department of Environment and Conservation on *Dry Well Conductivity Monitoring Report for Tanks W-8, W-9 and W-10, Oak Ridge National Laboratory, Oak Ridge Tennessee* (ORNL/ER-421) from letters dated November 14, 1997, and November 18, 1997, respectively

The essence of the letters from the U.S. Environmental Protection Agency (EPA) and Tennessee Department of Environment and Conservation (TDEC) is that they agreed with the plan to use Tanks W-8 and W-9 as consolidation tanks but requested that the conductivity alarm threshold be lowered from 900 $\mu\text{S}/\text{cm}$ to around 500 $\mu\text{S}/\text{cm}$. EPA and TDEC based their request to lower the threshold on an initial statistical analysis of the limited set of baseline data presented in the report. The 900 $\mu\text{S}/\text{cm}$ alarm level, recommended in the subject report, was arbitrarily set above what the initial statistics of the data might indicate to minimize the probability of false alarms while still maintaining the capability of detecting very small releases (0.5 gal/h or less) from the tanks. The assumption in selecting the 900 $\mu\text{S}/\text{cm}$ level was that over a longer monitoring period, greater fluctuations would occur in the data as a result of seasonal changes and affects from construction in the South Tank Farm (STF) and other activities. Subsequent monitoring data for DW-8, DW-9, and DW-10 has in fact shown a larger variation in the conductivity data as a result of seasonal changes and construction-related affects.

Between July 1997 and January 1998, there was a general increase in the average conductivity values in the dry wells in the STF. In addition, transient increases above the 900 $\mu\text{S}/\text{cm}$ level occurred in DW-8, DW-9, and DW-10. The data presented in this report indicate that the increases in conductivity are the result of rainfall and runoff leaching material from the new construction backfill and infiltrating into the dry wells and groundwater. The construction-related effects on the dry well conductivity are being monitored closely and these effects are expected to diminish with time. A thorough analysis of the monitoring results from the dry wells for the period between July 1997 and January 1998 indicates that no releases have occurred from the gunite tanks being monitored. This conclusion is substantiated by water samples collected from Tank W-8 and dry wells with elevated conductivity readings (DW-8 and DW-10). A detailed discussion of these results is provided in ORNL/ER-437.

Overall, the dry well conductivity monitoring is providing a robust and sensitive method for detecting potential releases from the gunite tanks and for monitoring seasonal and construction-related changes in the dry well and drain system. However, to minimize false alarms while still providing a reliable and sensitive release detection system, a three tiered approach that uses 900 $\mu\text{S}/\text{cm}$ as an administrative threshold, 1200 $\mu\text{S}/\text{cm}$ as an alert level, and 1500 $\mu\text{S}/\text{cm}$ as an alarm level will be used for the dry well conductivity monitoring in the STF. If dry well conductivities approach or exceed the 900 $\mu\text{S}/\text{cm}$ threshold, increased scrutiny, data analysis, and sampling will be implemented as appropriate. A 1200 $\mu\text{S}/\text{cm}$ threshold will be set to alert Waste Operations Control Center operations to an elevated conductivity condition. The 1500 $\mu\text{S}/\text{cm}$ threshold will constitute the alarm level at the Waste Operations Control Center. These levels will be modified in the future, if warranted, as additional experience is gained through the dry well conductivity monitoring program.

The letter from EPA recommended that "The most effective way to assure that leaks will be detected is through periodic monitoring and recording of conductivity measurements with analysis by trained personnel." The GAAT Team fully concurs with this recommendation. In addition to the dry well conductivity alarm threshold monitoring, the data has been and will continue to be recorded

and analyzed, on a routine basis, by experienced personnel, to detect any significant changes in conductivity data (increases or decreases) that warrant further investigation.

Dry well conductivity monitoring is used in conjunction with other data as part of the overall tank integrity monitoring that is being conducted for the gunite tanks. This includes gunite tank liquid levels, conductivity, and radiation levels from Pump Station 1. An alarm response procedure is in place at the Waste Operations Control Center and at the sluicing operations control center. If one or more of the sensor systems indicates a potential problem, information from all of the sensor systems is reviewed and correlated. Thus, the proactive dry well conductivity monitoring approach being implemented for the gunite tanks along with the data from the other sensor systems provides a robust and redundant system for detecting potential releases from the gunite tanks.

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ABBREVIATIONS

CMM	Conductivity Monitoring Method
GAAT	Gunite and Associated Tanks
NTF	North Tank Farm
ORNL	Oak Ridge National Laboratory
SLR	simulated liquid release
STF	South Tank Farm
WOCC	Waste Operations Control Center

EXECUTIVE SUMMARY

A waste removal program is being implemented for the Gunitite and Associated Tanks (GAAT) Operable Unit at Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee. The waste is being removed by means of remotely operated, in-tank, confined sluicing equipment. The waste removal operations in Tanks W-3 and W-4 in the North Tank Farm (NTF) have been completed and the equipment is being moved to the South Tank Farm (STF), where it will be used to remove the sludges from the six STF tanks (W-5, W-6, W-7, W-8, W-9, and W-10) beginning later this year. During sluicing operations the dry wells adjacent to each of the tanks are instrumented so that potential releases can be detected by means external to the tank. The method of detection is by monitoring the electrical conductivity of the water in the dry well associated with each tank (Lockheed Martin Energy Systems, Inc. 1996; 1997a,b,c).

This report documents the dry well conductivity monitoring data for the period from July 1997 through January 1998. The dry wells monitored during this period include DW-3, DW-4, DW-8, DW-9, and DW-10. The conductivity of the water passing through Pump Station 1 (PS1) was also monitored. The principal activities that occurred during this period were the sluicing of Tanks W-3 and W-4 in the NTF, transfer of tank liquids from the NTF to the STF, and the installation of new risers, tank dome leveling, and emplacement of stabilized base backfill in the STF. Presented in this report are the dry well conductivity, rainfall, tank level, and STF construction information that is relevant to the analysis and interpretation of the monitoring data for the reporting period.

Between July and January there was a general increase in the average conductivity values in the dry wells in the STF. In addition, transient increases above the 900 $\mu\text{S}/\text{cm}$ level occurred in DW-8, DW-9, and DW-10. The data presented in this report indicate that the increases in conductivity are the result of rainfall and runoff leaching material from the new construction backfill and infiltrating into the dry wells and groundwater. The construction-related effects on the dry well conductivity are being monitored closely and these effects are expected to diminish with time.

A thorough analysis of the monitoring results from the five dry wells and PS1 for the period between July 1997 and January 1998 indicates that no releases have occurred from the gunitite tanks being monitored. This conclusion is substantiated by water samples collected from Tank W-8 and dry wells with elevated conductivity readings (DW-8 and DW-10). Analysis of the water samples showed that the water in the dry wells was high in calcium (which is consistent with leaching from limestone-based backfill material) but low in sodium (which is not consistent with a possible leak of high-sodium liquids from a tank). On the basis of the preponderance of evidence gathered and analyzed, the observed increases in conductivity in the dry wells are not related to releases of liquid from a tank but are transient conditions resulting from the recently completed construction activities in the STF.

Overall, the dry well conductivity monitoring continues to provide a robust and sensitive method for detecting potential releases from the gunitite tanks and for monitoring seasonal and construction-related changes in the dry well and drain system. The dry well monitoring program will expand during the next reporting period to include dry wells DW-5, DW-6 and DW-7. In addition, conductivity and radiation measurements at PS1 will be monitored and routinely reviewed as part of the overall STF monitoring program.

1. INTRODUCTION

A waste removal program is being implemented for the Gunitite and Associated Tanks (GAAT) Operable Unit at Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee. The waste is being removed by means of remotely operated, in-tank, confined sluicing equipment. The waste removal operations in Tanks W-3 and W-4 in the North Tank Farm (NTF) have been completed and the equipment is being moved to the South Tank Farm (STF), where it will be used to remove the sludges from the six STF tanks (W-5, W-6, W-7, W-8, W-9, and W-10) beginning later this year. The dry wells connected to each of the tanks in the NTF and STF have been instrumented as a means of monitoring these tanks externally, through the use of the conductivity monitoring method (CMM), so that potential releases can be detected during sluicing operations. A detailed description of the CMM is provided in earlier reports (Lockheed Martin Energy Systems, Inc. 1996; 1997a,b,c).

This report documents CMM data collected during the period from July 1997 through January 1998. The dry wells monitored during this period include DW-3, DW-4, DW-8, DW-9, and DW-10. The CMM was used in DW-3 and DW-4 to monitor Tanks W-3 and W-4 during sluicing operations and in DW-8 and DW-9 during the transfer of sluicing liquids to Tanks W-8 and W-9. DW-10 was monitored in preparation for sluicing operations in the STF. The conductivity of the water passing through Pump Station 1 (PS1) was also monitored because the water from the dry well and drain system in the NTF and STF flow through PS1. In addition, water samples were collected and analyzed from DW-8 and DW-10 to provide supporting information in evaluating the source of increased conductivity in these dry wells.

The CMM is based on the fact that there is a significant difference in conductivity between the liquid in the tanks (which has high conductivity) and the water in the dry wells (which has low conductivity). Interpretation of the conductivity monitoring data requires an understanding not only of the response in the dry well to potential releases but also of the response to non-release-related factors. Previous studies have shown that even a relatively small release (0.5 gal/h) would result in a significant increasing trend in the conductivity of the water in the dry well (Lockheed Martin Energy Systems, Inc. 1997a,b,c). Non-release-related factors such as rainfall, seasonal variations in groundwater quality, and construction activities can also cause increases in dry well conductivity. These factors are taken into account during the routine processing and analysis of the data to reduce the probability of false alarms while maintaining the sensitivity of the CMM.

The dry well conductivity data are presented in this report as time series plots that also show the rainfall, tank liquid level, and construction activities relevant to the analysis and interpretation of the data. The principal tank-related activities that occurred during this period were the sluicing of Tanks W-3 and W-4 in the NTF, the transfer of sluiced material and supernatant to Tank W-9, the installation of new risers on the tanks in the STF, the removal of 3 ft of earthen cover from the top of tank domes in the STF, and emplacement of stabilized base backfill in the STF.

An overview of the monitoring, sluicing and construction activities and tank liquid transfers is provided in Chap. 2. Chapter 3 presents the data and analysis of the dry well conductivity monitoring for DW-3 and DW-4, and Chap. 4 provides the data and analyses for DW-8, DW-9, and DW-10. The monitoring data for PS1 are presented in Chap. 5 along with the results of a high-rate surrogate release test. Conclusions and recommendations are provided in Chap. 6.

2. OVERVIEW OF MONITORING, SLUICING, AND CONSTRUCTION ACTIVITIES

Sluicing operations were conducted on Tanks W-3 and W-4 during the reporting period. Tank W-3 sluicing was started on 7 July 1997 and completed on 18 September 1997. Tank W-4 sluicing was started on 17 November 1997 and completed during the second week in February 1998. During sluicing operations, the conductivity in the dry wells (DW-3 and DW-4) was monitored in real time in the sluicing operations control trailer. The conductivity data were also recorded through the use of a chartless recorder located on the NTF sluicing platform.

Tanks W-9 and W-8 were used to consolidate sluiced material and supernatant from Tanks W-3 and W-4. Tank W-9 was the primary tank for temporary consolidation of the sluiced material, and Tank W-8 was used to store the supernatant liquids. In addition to the transfers associated with NTF sluicing operations, liquids in Tanks W-8, W-9, and W-10 were removed and transferred into the active liquid low-level waste system to make room for the liquids generated by the sluicing activities.

In support of the liquid transfer activities and to provide release detection for Tanks W-8, W-9, and W-10, the conductivity in DW-8, DW-9, and DW-10 was monitored. Initially the data were recorded on data loggers and then downloaded and analyzed weekly. In November 1997, DW-9 was connected to the NTF operations trailer so the conductivity data could be monitored in real time. In January 1998, DW-8 and DW-9 were connected directly to the Waste Operations Control Center (WOCC) for continuous real time monitoring. PS1 is the downgradient collection point for all the water that flows through the NTF and STF dry well and drain system. As part of the overall monitoring for the NTF and STF, the conductivity of the water at PS1 was also monitored.

Construction activities took place in the STF during the reporting period in preparation for the sluicing operations on Tanks W-5 through W-10. These activities included adding new risers to each of the tanks; extending dry wells and other structures upward in preparation for grading and backfilling the STF; removing approximately 3 ft of dirt and leveling the earthen cover on the domes of the six tanks; and backfilling, compacting, and grading the entire STF with stabilized crushed-limestone gravel. In some cases, the construction activities were concurrent with rainfall, and this affected the conductivity measurements. In particular, gravel backfilling and riser installation, when coincident with heavy rainfall, caused conductivity readings in the dry wells to rise significantly. Therefore, the dates and duration of construction activities, along with the rainfall record, are used in the review and analysis of the dry well conductivity monitoring data.

Figure 2.1 shows the location of Tanks W-3 through W-10 in the NTF and STF. Also shown in this figure are the dry wells adjacent to each tank and the drain system that carries the groundwater in the NTF and STF to PS1. Table 2.1 shows the key sluicing and construction activities and liquid transfers in the NTF and STF, as well as the approximate dates on which they occurred. This information is provided to clarify the relationship in time between these activities and the conductivity data from the dry wells. Where appropriate and relevant, this information is annotated on the time series conductivity plots in Chaps. 3, 4, and 5.

Fig. 2.1. Plan view showing the location of the gunite tanks in the NTF and STF, the dry wells adjacent to each tank, and the drain system leading to Pump Station 1.

Table 2.1. Key sluicing and construction activities and liquid transfers

Sluicing/construction activity	Dates		Liquid transfer	Amount (gal)	Dates	
	From	To			From	To
W-3 sluicing	7 Jul 97	18 Sep 97	W-10 to active system	80,000	16 Jul 97	14 Aug 97
W-4 sluicing	17 Nov 97	6 Feb 98				
W-8 riser installation (34 in.)	4 Aug 97	29 Aug 97	W-9 to W-10	50,000	14 Aug 97	16 Aug 97
W-12 riser installation (12 in.)	17 Oct 97	22 Oct 97				
W-9 riser installation	11 Aug 97	10 Nov 97	W-10 to active system	50,000	17 Aug 97	5 Sep 97
W-7 riser installation	14 Aug 97	10 Nov 97				
DW-5, 6, 7, 8 extensions	23 Oct 97	20 Nov 97	W-8 to active system	45,000	8 Sep 97	16 Oct 97
DW-9 extension	6 Jan 98	12 Jan 98				
W-5 and W-6 dome leveling	22 Nov 97	25 Nov 97	W-4 to W-9	52,000	17 Aug 97	19 Sep 97
W-8 dome leveling	24 Nov 97	26 Nov 97				
W-7 and W-9 dome leveling	2 Dec 97	4 Jan 98	W-4 to W-9	40,000	17 Nov 97	18 Nov 97
W-7 and W-9 backfill	15 Aug 97	15 Nov 97	W-9 to W-8	70,000	5 Dec 97	6 Dec 97
W-8 and W-10 backfill	24 Nov 97	13 Feb 98				
			W-4 to W-9	85,000	8 Dec 97	6 Feb 97

3. CONDUCTIVITY MONITORING DATA FOR DW-3 AND DW-4

The conductivity of the groundwater in DW-3 and DW-4, adjacent to Tanks W-3 and W-4, respectively (as shown in Fig. 2.1), was monitored during the in-tank sluicing operations in those tanks. To log the data, the conductivity sensors in the dry wells were connected to a data recorder. The conductivity values measured by these sensors were also displayed in real time on the control display monitor for the sluicing operations. The alarm level, which had been set at 1500 $\mu\text{S}/\text{cm}$ (Vista Research, Inc. 1996), was not exceeded at any time during the reporting period.

Figure 3.1 is a plot of conductivity data for DW-3 and DW-4 from 1 July 1997 to 9 February 1998. Also plotted are the cumulative rainfall and the periods during which sluicing operations were conducted. The scale for conductivity (0 to 1800 $\mu\text{S}/\text{cm}$) is shown to the left of the plots; the scale for cumulative rainfall (0 to 24 in.), to the right.

The cumulative rainfall total for the reporting period represented by Fig. 3.1 is approximately 23 in. The rainfall plot shows an increase in precipitation in December and January, which are typically wetter than summer and fall. During summer and fall, the lower rainfall, combined with warmer temperatures, increases evaporative losses from the soil, and the infiltration of rainfall through the soil profile is diminished. This can be seen in Fig. 3.1, where the conductivity data for DW-3 and DW-4 show increased noise from November through January, a phenomenon that is correlated with increased rainfall activity and increased infiltration of that rainfall into the shallow water table.

The seasonal variation in rainfall and the resultant infiltration into the groundwater did not, however, significantly affect the overall level of conductivity in DW-3 and DW-4. The conductivity values for DW-3 ranged from 270 to 370 $\mu\text{S}/\text{cm}$, with a mean of approximately 330 $\mu\text{S}/\text{cm}$. Those for DW-4 ranged from 390 to 650 $\mu\text{S}/\text{cm}$, with a mean of approximately 460 $\mu\text{S}/\text{cm}$. Neither dry well showed significant or sustained increases in conductivity that might be indicative of a potential release from the associated tank. Furthermore, conductivity measurements did not exceed alert levels (900 $\mu\text{S}/\text{cm}$ in the STF, and 1500 $\mu\text{S}/\text{cm}$ in the NTF). The data from DW-3 and DW-4 indicate that there were no releases from the tanks during the reporting period.

The sluicing operations for Tanks W-3 and W-4 have been completed, and the waste has been removed from the tanks. The sluicing equipment will be moved to the STF during the next 2 months. As a result, the conductivity sensors in DW-3 and DW-4 are no longer needed and will be disconnected. Conductivity data for DW-3 and DW-4 will not be included in the next report on the dry wells.

Fig. 3.1. DW-3 and DW-4 conductivity data (2 July 1997 to 10 February 1998).

4. CONDUCTIVITY MONITORING DATA FOR DW-8, DW-9, AND DW-10

Conductivity in the STF dry wells DW-8, DW-9, and DW-10 was monitored during the reporting period. The data served several purposes: (1) to monitor Tank W-9 while it was being used for temporary consolidation of sluiced material from Tanks W-3 and W-4, (2) to monitor Tank W-8 while it was being used for temporary storage of supernatant liquids from Tank W-9, (3) to monitor Tank W-10 during transfers of extant liquids to the active system, and (4) to create a long-term record of baseline conductivity levels in preparation for the STF sluicing operations. Originally, dry well conductivity data were recorded on portable, field-type data loggers and then downloaded and analyzed weekly. In November 1997, DW-9 was connected to the NTF operations trailer so that conductivity data could be monitored in real time. In January 1998, DW-8 and DW-9 were connected to the WOCC for continuous real-time monitoring and recording of data. During the next reporting period, all six of the dry wells in the STF will be connected to the WOCC to facilitate real-time monitoring and recording of data.

Time series plots of conductivity data from DW-8, DW-9, and DW-10 are presented in Figs. 4.1, 4.2, and 4.3, respectively. These plots, which cover the period from 11 July 1997 through early February 1998, show not only the conductivity data but cumulative rainfall and level of tank liquid (in gallons) as well. The scale for the conductivity data (0 to 2000 $\mu\text{S}/\text{cm}$) is shown to the left of each plot. To the right there is a dual-purpose scale in increments of 0 through 12; for the cumulative rainfall plot, this represents a range of 0 to 24 in. of rain (i.e., 2 in. per increment); for tank level, it represents a volume range of 0 to 120,000 gal (i.e., 10,000 gal per increment). Superimposing the three sets of data allows the conductivity levels, rainfall, and significant changes in the level of liquid in the tank to be compared. Lastly, each of the plots is annotated so as to show tank and construction activities during the reporting period that may have affected the conductivity data.

The cumulative rainfall data are, of course, the same on all three plots (DW-8, DW-9, and DW-10), as well as on the plots for DW-3 and DW-4, with the exception that the reporting period for the former was 10 days shorter. As noted for the DW-3 and DW-4 data, the cumulative rainfall total in Figs. 4.1, 4.2, and 4.3 is approximately 22 in., with increasing precipitation during the latter part of the reporting period. Unlike what was observed in DW-3 and DW-4, however, the increased rainfall and infiltration of water through the soil (particularly in December and January) do appear to have affected the level of conductivity in DW-8, DW-9, and DW-10. A thorough analysis of the data indicates that this is a result of the tank riser construction and backfilling activities that occurred in the STF coincident with significant rainfall events. The correlation between conductivity levels and rainfall and construction activities is evident from the plotted data. This is discussed in more detail herein.

The tank level data presented in Figs. 4.1, 4.2, and 4.3 clearly reflect the liquid transfers listed in Table 2.1. Tank level data are provided for two reasons: to illustrate the transfer activities that occurred during the reporting period and to aid in determining a possible correlation between tank level and changes in conductivity in the dry wells. For example, if conductivity readings were consistently observed to increase either coincident with or shortly after significant increases in tank level, this would indicate a possible leak correlated to the increased tank level and pressure. In general, the plots in these three figures *do not* show a correlation between increases in the level liquid in the tanks and coincident changes in conductivity in the dry wells. There is, however, some

overlap between periods of high liquid level in the tanks and instances of increased conductivity in the dry wells.

The tank level data shown in Fig. 4.1 reflect the transfer of 45,000 gal of liquid from Tank W-8 to the active system during September and October. Subsequently, from approximately 12 October through 5 December, Tank W-8 was at its lowest level. On 5 and 6 December 1997, 70,000 gal were transferred from Tank W-9, putting Tank W-8 at its highest level. Tank W-8 was kept at this level for rest of the reporting period. Although there are some periods of overlap, there was no direct correlation observed between level changes in Tank W-8 and conductivity changes in DW-8. It is noted in particular that the trend toward increasing conductivity levels in DW-8 (starting in late November) was observed *before* the very large transfer on 5 December took place. After the transfer, there was a trend toward decreasing conductivity levels during a 10-day non-rainy period. Conductivity levels in DW-8 subsequently increased in response to more rainfall, demonstrating that the conductivity increases in the dry well are related to rainfall but not to changes in tank level.

The level data shown in Fig. 4.2 reflect the initial transfer of liquid from Tank W-9 to Tank W-10 on 14 August 1997, followed by a series of transfers from Tank W-4 to Tank W-9 between 17 August and 19 September. Although these transfers occurred during the same period as some abrupt changes in DW-9 conductivity levels, the changes in conductivity are evidently correlated with rainfall and not with changes in the level of liquid in the tank. The plot in Fig. 4.2 continues to chart level changes reflecting the transfer of 40,000 gal from Tank W-4 to Tank W-9 on 17 November, the transfer of 70,000 gal from Tank W-9 to Tank W-8 on 5 December, and additional transfers from Tank W-4 to Tank W-9 between 8 December 1997 and 6 February 1998. Again, Fig. 4.2 clearly shows that changes in conductivity are not correlated with changes in tank level.

The level data shown in Fig. 4.3 reflect transfers from Tank W-10 to the active system during July, August, and September. Also shown is the transfer from Tank W-9 to Tank W-10. From 5 September through the remainder of the reporting period, no further transfers took place, and the level of liquid in the tank remained constant. The data do not show any correlation between liquid level in Tank W-10 and conductivity levels in DW-10. The large fluctuations in conductivity seen in December and January are not associated with tank level but rather with increased rainfall and construction activities.

The data in Figs. 4.1, 4.2, and 4.3 show that in all three dry wells there was, during this reporting period, a general increase in average, or baseline, conductivity. Average conductivity levels have increased from a range of 300 to 400 $\mu\text{S}/\text{cm}$ in July to a current range of approximately 500 to 700 $\mu\text{S}/\text{cm}$. This is a result of long-term seasonal effects (i.e., increased rainfall and infiltration), tank riser construction activities, and the backfilling of areas in the STF with stabilized crushed limestone. The three figures also show periods of sharply increased conductivity. All three dry wells have experienced increases in conductivity in excess of the 900 $\mu\text{S}/\text{cm}$ alarm threshold set for the STF (Lockheed Martin Energy Systems, Inc. 1997c). DW-9 exceeded that alarm level in late September, and DW-8 and DW-10 did so in late December and January. All of the alarms are correlated with rainfall events and with construction and backfilling activities around the tanks and dry wells; none has been associated with a release from a tank. The 900 $\mu\text{S}/\text{cm}$ threshold is lower than the original 1500 $\mu\text{S}/\text{cm}$ threshold set for the NTF and was based on an initial set of baseline data from May and June 1997 (Lockheed Martin Energy Systems, Inc. 1997c). Additional discussion of threshold levels is provided at the end of this chapter and in Chap. 6.

The construction activities (as identified in Figs. 4.1, 4.2, and 4.3) appear to have had the greatest affect on levels of conductivity in the dry wells. This occurred through three mechanisms:

(1) the direct infiltration of rainwater onto uncovered tank domes during riser construction, (2) the direct flow of rainwater through stabilized limestone backfill and into dry wells, and (3) the infiltration of rainwater with dissolved backfill material through the soil and into the groundwater and dry wells. The affect of mechanisms (1) and (2) can be seen in the conductivity data from DW-9 and DW-10. The affect of mechanism (3) is most apparent in the conductivity data from DW-8.

Fig. 4.2, which is illustrative of mechanism (1), shows several sharp increases in DW-9 conductivity beginning about 20 August 1997, one of which exceeds the alarm level (24 September). These increases are correlated with riser installation activities for Tanks W-9 and W-7. During this construction, the top of Tank W-9 was partially uncovered and large amounts of limestone backfill were placed around it, as well as in the area around Tank W-7 and dry well DW-9 (which is between Tanks W-9 and W-7). Rainfall came into direct contact with the top of the dome, and rainwater was able to drain directly down the side of the tank and infiltrate the dry well. This rapidly infiltrating water may have picked up additional dissolved material or residual salt remaining from the simulated liquid release (SLR) testing (Lockheed Martin Energy Systems, Inc. 1997c). The end result was an increase in dry well conductivity readings. The effect was very pronounced in DW-9. It is correlated with significant rainfall events that took place during the riser construction.

The sharp increase in DW-9 conductivity seen on 24 September 1997, illustrative of mechanism (2), is directly related to the placing of new backfill material around Tanks W-9 and W-7. This material basically surrounded the top of DW-9. During the rainfall event on 24 September, rainwater flushed through the new material and directly into the dry well, causing the conductivity to increase sharply. This situation was monitored closely and other indicators were checked to make sure that a release was not indicated. As shown in Fig. 4.2, the conductivity did *not* continue to increase after the rainfall event (as would be expected if there had been a leak in the tank). Subsequently, the dry well was flushed out and the sensor recalibrated. Steps were taken to prevent the flushing of additional backfill material into the dry well. On 26 October 1997, another significant rainfall event occurred. This time, because of the preventive measures that had been implemented, conductivity did not increase.

A similar situation occurred in DW-10 during January 1998. A large amount of backfill was placed around DW-10 and Tank W-10 coincident with a series of heavy rainfall events, as shown in Fig. 4.3. Several sharp increases in conductivity can be seen in the DW-10 data during January. The dry well was flushed twice, and steps were taken to minimize direct entry of rainfall runoff into the dry well. As a result, the large rainfall event at the end of the reporting period (as shown in Fig. 4.3) did not cause the sharp increases in conductivity that had occurred earlier in the month.

The third mechanism by which construction activities affected dry well conductivity is the overall infiltration of rainwater through the new backfill material and into the shallow groundwater around the tanks. As noted earlier, this effect became more pronounced during the periods of increased rainfall (November, December, and January). As the ground became saturated, it was easier for rainwater to infiltrate to the water table and to carry with it dissolved material from the limestone fines that constituted the backfill. This can be seen in the DW-8 data from Fig. 4.2.

The conductivity data in Fig. 4.2 show the response in DW-8 to the SLR test conducted on Tank W-8 in August 1997. After spiking during the SLR test, conductivity in DW-8 decreased to an average of $550\ \mu\text{S}/\text{cm}$, approximately $100\ \mu\text{S}/\text{cm}$ higher than it had been before the test. This higher average was most likely caused by the presence of residual potassium chloride in the soil (resulting from the SLR test) and the general infiltration of rainwater through the soil and into the groundwater and dry well.

The conductivity in DW-8 remained relatively stable until approximately 27 November 1997, when conductivity levels started to trend upward. This was coincident with the removal of 3 ft of earthen cover from the Tank W-8 dome and the start of backfilling around DW-8 and Tank W-8. The increasing trend continued until approximately 11 December 1997, when conductivity levels trended back down in response to a 10-day nonrainy period. Around 26 December 1997, the conductivity in DW-8 began increasing in response to the significant increase in rainfall in late December and throughout January. This increasing trend clearly illustrates the third mechanism by which the construction activities affected dry well conductivity. The increase in conductivity in DW-8 between 27 November 1997 and 6 February 1998 was coincident with and was caused by the increased rainfall, which saturated the ground, slowly infiltrating and bringing dissolved constituents (from the backfill placed around and between Tanks W-8 and W-10) into DW-8. This resulted in the gradual increase in conductivity seen in the data for DW-8. The location and construction of DW-8 is such that runoff did not flow directly into it and did not cause the type of *sharp* increases in conductivity seen in the DW-9 and DW-10 data.

As noted previously, the trend toward increasing conductivity in DW-8 started around 27 November, before the large transfer of liquid from Tank W-9 to Tank W-8 on 5 December 1997. In addition, after this transfer and with the tank level remaining constant, conductivity decreased somewhat during a nonrainy period in mid-December and then increased again with renewed precipitation. This demonstrates that the increasing trend in DW-8 conductivity shown in Fig. 4.1 is related to the construction activities and the increased rainfall and not to a release from Tank W-8.

On those occasions when conductivity in DW-8 and DW-10 exceeded alarm levels, a series of actions was taken to determine whether these alarms were indicative of a leak from either of the associated tanks. The instruments were checked to ensure proper readings. Tanks W-8 and W-9 level data from WOCC were reviewed, as were PS1 conductivity and radiation-monitoring data. None of these checks revealed any indication of a leak from either tank. (A detailed analysis of the PS1 data is provided in Chap. 5.)

At the end of January, water samples were collected from DW-8 and DW-10. These showed a relatively high concentration of calcium (580 and 300 mg/L, respectively, in DW-8 and DW-9) and a low to normal concentration of sodium (35 and 15 mg/L, respectively, in DW-8 and DW-10). Analysis of groundwater samples from a monitoring well (Well 873) due south of the STF show calcium concentrations of approximately 100 to 130 mg/L and sodium concentrations of approximately 20 to 22 mg/L (Martin Marietta Energy Systems, Inc. 1992). These results show the sodium concentrations in DW-8 and DW-10 to be consistent with the nearby groundwater samples from Well 873. The calcium values in DW-8 and DW-10 are, however, significantly higher than those from Well 873. This indicates that the increase in conductivity observed in DW-8 and DW-10 is from a source with readily dissolveable calcium, such as the stabilized limestone backfill in the STF.

A recent sample of liquid from Tank W-8 (taken on 17 December 1997) had a high concentration of sodium (3000 mg/L) and a low concentration of calcium (1.5 mg/L). Similar results would be expected for the liquid in Tank W-10. If liquid were leaking from either tank, and causing the observed increases in conductivity, the water in the dry wells would be expected to exhibit elevated sodium concentrations and not elevated calcium concentrations. The analysis of the water from these dry wells shows the opposite. This analysis is therefore consistent with the conclusion that the increased levels of conductivity in DW-8 and DW-9 are caused by rainfall infiltrating through the fresh limestone backfill and are not indicative of a leak from either tank.

The fluctuations in conductivity evident in Figs. 4.1, 4.2, and 4.3 are consistent with, and have been shown to be related to, construction-related activities in the STF that coincided with periods of increased rainfall. These activities (riser construction and backfilling) are now almost complete, and their affect on dry well conductivity measurements is expected to diminish over the next several months. Overall, the dry well conductivity monitoring method has been demonstrated to be a sensitive indicator of changing conditions around the tanks and dry wells. Despite the construction-related interference, even small releases that might occur can be expected to cause continual increases in dry well conductivity that will exceed both the 900 and 1500 $\mu\text{S}/\text{cm}$ thresholds. During the next few months all the dry wells in the STF will be instrumented. The conductivity data will be reviewed and analyzed on a routine basis even in the absence of any elevated conductivity levels or alarms. The conductivity data for DW-8, DW-9, and the tank that is being actively sluiced will be monitored at the WOCC on a continuous 24-hour basis.

To minimize false alarms while still providing a reliable and sensitive release-detection system, a three tiered approach that uses 900 $\mu\text{S}/\text{cm}$ as an administrative threshold, 1200 $\mu\text{S}/\text{cm}$ as an alert level, and 1500 $\mu\text{S}/\text{cm}$ as an alarm level will be used for the dry well conductivity monitoring in the STF. If dry well conductivities approach or exceed the 900 $\mu\text{S}/\text{cm}$ threshold, increased scrutiny, data analysis, and sampling will be implemented as appropriate. A 1200 $\mu\text{S}/\text{cm}$ threshold will be set to alert WOCC operations to an elevated conductivity condition. The 1500 $\mu\text{S}/\text{cm}$ threshold will constitute the alarm level at the WOCC.

If the 1500 $\mu\text{S}/\text{cm}$ threshold is exceeded, an immediate notification procedure will be implemented by the WOCC. The tank level, conductivity, and radiation sensor readings will be thoroughly evaluated and dry wells will be sampled, as appropriate, to determine both if a tank release has occurred and the magnitude of the release rate if it is occurring. In the event a tank release is indicated, appropriate actions will be taken to address the tank release and verify that any released tank liquids are contained by the drain system.

As part of the overall monitoring program, the radiation and conductivity at PS1 will also be monitored and analyzed on a routine basis. A discussion of the PS1 monitoring data for the reporting period is presented in Chap. 5.

Fig. 4.1. DW-8 conductivity data (11 July 1997 to 6 February 1998).

Fig. 4.2. DW-9 conductivity data (1 August 1997 to 9 February 1998).

Fig. 4.3. DW-10 conductivity data (11 July 1997 to 6 February 1998).

5. CONDUCTIVITY MONITORING DATA FOR PUMP STATION 1

The conductivity of the water flowing through PS1 was monitored during the reporting period. All of the groundwater from the dry well and drain systems in the NTF and STF flow through PS1, as shown in Fig. 2.1. This provides a downgradient location to monitor the conductivity of the groundwater and correlate that information with conductivity changes in the dry wells. The conductivity sensor at PS1 was installed specifically as part of the dry well conductivity monitoring program. The water at PS1 is also continuously monitored for radiation by Waste Operations. At PS1, water is circulated through a piping loop from the sump to the surface and back into the sump. The radiation and conductivity sensors are installed in-line at the surface. The radiation sensor provides a reading in counts per minute, and these data are monitored by the WOCC and stored on the WOCC database. The data from the conductivity sensor is recorded on a logger at PS1 and downloaded periodically.

The time series plot of the conductivity at PS1 is provided in Fig. 5.1. The data cover the reporting period from 10 July 1997 through 6 February 1998. Conductivity and cumulative rainfall data are shown along with the radiation data for the last half of the reporting period. The scale on the left side of the plot is for both conductivity and radiation data. The conductivity scale ranges from 0 to 1800 $\mu\text{S}/\text{cm}$ and the radiation scale from 0 to 1800 counts per minute (cpm). The cumulative rainfall scale (0 to 24 in.) is on the right side of plot. The rainfall data are the same as shown on the dry well plots, with increased rainfall occurring during the latter part of the reporting period.

The average conductivity at PS1 was approximately 400 $\mu\text{S}/\text{cm}$, which is consistent with the range of conductivity readings from the NTF and STF dry wells. The conductivity data were fairly uniform from July through October. From mid-December through January, conductivity increased slightly and fluctuated more in response to increased rainfall activity. A similar pattern can be seen in the radiation data. The conductivity and radiation data are correlated with the rainfall events shown in Fig. 5.1. The increase in rainfall in December and January, and the resulting increase in groundwater flow into the drain system, most likely caused an increase in the turbidity and dissolved constituents in the water flowing past PS1. This would cause the increases and fluctuations seen in both the conductivity and radiation data.

There are no significant or sustained increases in the conductivity or radiation data that would indicate a release from the NTF or STF tanks. The PS1 conductivity values are consistent with the normal baseline concentrations of the groundwater in the dry wells. The radiation measurements ranged from 150 to 300 cpm, which corresponds to a gross alpha/beta concentration in the water of 1 to 2 Bq/mL. This concentration is consistent with the average gross alpha/beta concentration in the dry well water samples of 1 to 2 Bq/mL. By comparison, the alpha/beta concentration of the water in Tank W-8 is 18,000 Bq/mL, or 1000 times higher than at PS1. A release of any significant size (approximately 5 gal/h or greater) from a tank would cause the radiation readings to rapidly exceed the alarm level at the WOCC. In its monitoring of radiation data, the WOCC uses 600 cpm as an alert level and 900 cpm as an alarm level. The radiation data were far from approaching either of these levels during the reporting period.

The conductivity and radiation data at PS1 confirm the results of the dry well conductivity monitoring method and show no indication of a tank release during the reporting period. Three "spikes" in the conductivity data are, however, worth discussing further.

The first occurred on 20 October 1997 and is identified in Fig. 5.1. This spike is the response at PS1 to a high-rate surrogate release test in the STF. The test was conducted to measure the continuity and characteristics of the dry well and drain system by measuring the response at PS1 to a relatively large simulated release (20 gal/h) at Tank W-10 in the STF. A solution of potassium chloride was introduced at a controlled rate through a vertical pipe parallel to the tank wall; the solution drained from this pipe into the gravel and drain system at the base of Tank W-10 in the STF. A total of 70 gal was pumped in at a rate of 20 gal/h. The conductivity of the solution was approximately 18,000 $\mu\text{S}/\text{cm}$ (simulating a tank liquid).

The response to the test at PS1 can be seen in the detailed conductivity plot presented in Fig. 5.2. This plot represents an expansion of the data from Fig. 5.1 covering the period 19 through 21 October. The "spike," or response to the high-rate drain test, is clearly seen. The conductivity at PS1 began to increase approximately 40 min after the high-rate drain test was started; this shows that the drain system is hydraulically efficient. The amount of potassium chloride that can be accounted for under the response curve at PS1 is approximately 90% of the amount introduced during the test; this demonstrates the continuity of the drain system. The results of the high-rate drain test demonstrate that the dry well and drain system serving the gunite tanks in the STF is efficient and that its connection to the PS1 drain is intact. Any tank liquids that might be released in the STF can be expected to be captured by the drain system and flow through PS1 and then to process-waste treatment. In addition, if a significant tank release were to occur it would be readily detected both at the dry wells and at PS1. Thus, the PS1 monitoring provides a second level of release detection for the STF.

The second spike in the conductivity data occurred on 29 December 1997 and was the response at PS1 to the flushing of DW-10 with process water. The conductivity in DW-10 had become elevated because of rainwater flowing through the new backfill in the STF and into the dry well. Process water was used to flush the backfill material out of DW-10. The response at PS1 to the flushing activity was similar to that observed during the controlled test on 20 October. The material that was flushed out of DW-10 produced the spike in the conductivity at PS1. It did not, however, produce a similar spike in the radiation data. This demonstrated that the material causing the high conductivity was from a nonradiation source (such as calcium from crushed limestone). If the increase in DW-10 had been caused by a leak from a tank, it would have had elevated concentrations of radioactive material that would have caused an increase in the radiation readings at PS1.

The third spike in the PS1 conductivity occurred around 5 February 1998. It is similar to the second spike but was caused by a very large amount of rainfall infiltrating rapidly into the drain system and flushing material out of the STF to PS1. During early February, there was a lot of new crushed-limestone backfill in the STF, which most likely was the source for the elevated conductivity in the drain system. As with the second spike in conductivity, no corresponding spike in radiation occurred, demonstrating that the increased conductivity was from a nonradiation source such as rainfall runoff. The analysis of the second and third spikes in the PS1 conductivity data confirms the results of the controlled test that produced the first spike. These results demonstrate the continuity of the drain system and the sensitivity of conductivity measurements to changes in conditions in the STF. The conductivity and radiation levels at PS1 will continue to be monitored as part of the overall release detection monitoring for the STF during sluicing operations.

Fig. 5.1. Pump Station 1 conductivity data (11 July 1997 to 6 February 1998).

Fig. 5.2. Response at PSI to input of 3800 g KCL at Tank W-10 in STF.

6. CONCLUSIONS AND RECOMMENDATIONS

This report has presented the conductivity data, and related supporting data, for dry wells DW-3, DW-4, DW-8, DW-9, and DW-10 for the period from July 1997 through January 1998. The analysis of the data shows that no tank releases have occurred during the reporting period. The conductivity in DW-3 and DW-4 remained below any alarm levels, and no tank releases were indicated during the sluicing operations in Tanks W-3 and W-4. A thorough analysis of the DW-8, DW-9, and DW-10 conductivity data also indicates that there were no tank releases during the reporting period. The 900 $\mu\text{S}/\text{cm}$ administrative threshold, however, was exceeded at different times in each of the dry wells. The transient increases in conductivity in DW-8, DW-9, and DW-10 were thoroughly evaluated with respect to rainfall, tank level, and construction-related affects. The results indicate that the increase in conductivity is correlated with increased rainfall in conjunction with construction and backfilling activities in the STF. Analysis of water samples from DW-8 and DW-10 and analysis of conductivity and radiation monitoring data from PS1 are consistent with these results. It is expected that the construction-related affects will diminish over the next few months and that dry well conductivity monitoring in the STF will continue to be used for release detection monitoring and to provide a sensitive measure of changing conditions in the dry well and drain system.

On the basis of the results presented in this report, the following recommendations are made:

1. The dry well conductivity monitoring in the STF will be expanded to include all six dry wells; the data will be recorded and reviewed and analyzed on a routine basis for any significant trends or changes. DW-8, DW-9, and the dry well for the tank being actively sluiced will be connected to the WOCC to provide continuous 24-hour monitoring.
2. An administrative threshold of 900 $\mu\text{S}/\text{cm}$ will be used for the STF dry well monitoring. Increased scrutiny and data analysis will be implemented for any dry well in which the 900 $\mu\text{S}/\text{cm}$ threshold is exceeded.
3. An alert level of 1200 $\mu\text{S}/\text{cm}$ and an alarm level of 1500 $\mu\text{S}/\text{cm}$ will be used at the WOCC. If the 1500 $\mu\text{S}/\text{cm}$ threshold is exceeded, an immediate notification procedure will be implemented by the WOCC. Response procedures will be implemented to confirm whether or not a tank release is indicated. This could include but is not limited to verification of instrument readings with a second instrument, dry well water sampling and analysis, comparison of readings with PS1 conductivity and radiation data, and analysis of tank level data. In the event a tank release is indicated, appropriate actions will be taken to address the tank release and verify that any released tank liquids are contained by the drain system.
4. As part of the STF monitoring effort, the conductivity and radiation data at PS1 will be monitored and analyzed on a routine basis.
5. Additional data reports will be issued as appropriate. The next planned data report will cover the period from February through June 1998 and will be issued in July 1998.

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