Vapor Monitoring and Detection System (VMDS) Pilot-Scale Test Phase 1 Report (FY 2016) Summary

In 2014, Washington River Protection Solutions (WRPS) asked Savannah River National Laboratory (SNRL) to lead a panel of independent experts to review the current programs and practices in place to protect workers from chemical vapors at the Hanford site Tank Farms. The resulting Tank Vapor Assessment Team (TVAT) issued their report in October 2014 and identified 10 overarching recommendations and 47 supporting recommendations designed to improve the safety and health management program as it relates to Hanford tank vapors.

In response to TVAT recommendation 33, "Accelerate implementation of tailored engineering technologies to detect and control vapor emissions and exposures experienced in the Hanford tank farms," WRPS began developing the Vapor Monitoring and Detection System (VMDS). The WRPS Chemical Vapors Solutions Team (CVST) set forth the requirements for this program, and a request for solutions was put out to multiple entities including: industry, national laboratories, and academia. To ensure that the technologies selected would satisfy the needs of the program, a rigorous Technology Maturation Plan (TMP) was developed to guide the program and provide requirements for the instrumentation and software used to control the system. This report includes the results of the VMDS Phase 1 pilot-scale test conducted in 2016.

The pilot-scale test is composed of four discrete categories:

- **TMP requirements** guide the overall program and set specific criteria for each component to be included in the system.
- **Component level requirements and functionality** are the requirements that each individual instrument must meet in order to satisfy the requirements of the TMP.
- **Integrated component requirements and functionality** are the requirements for how the instruments, software, communication devices, etc. must interact with the central control system in order to meet the requirements of the TMP.
- **Initial data analysis as appropriate**.

During the Phase 1 pilot-scale test, the instruments performed their functions adequately. However, communication and software issues were apparent as a part of the integrated system. A summary of the VMDS integrated components is below:

Meteorological Stations – Two meteorological towers were installed in the tank farms: the primary meteorological station, or Coastal Environmental meteorological station (CMS), and the secondary meteorological station, or Lufft meteorological station (LMS). The CMS has operated throughout the duration of the Phase 1 test and has met all five test requirements. The LMS, however, has suffered communication and mechanical issues and has not met any of the test requirements.

Direct-Reading Instrumentation (DRI) – The DRI used to detect the possible presence of ammonia, volatile organic compounds (VOCs), and/or nitrous oxide (RAE Meshguard, AreaRAE, MultiRAE Pro, and Gastronics FIS) functioned well, although some pieces of equipment experienced intermittent communications and software challenges. Additionally, the nitrous oxide (N_2O) sensors are undergoing re-engineering.

Spectroscopic Equipment – The infrared (IR) and ultraviolet (UV) spectroscopic instruments used for chemical detection (UV-DOAS, OP-FTIR and UV-FTIR) installed on the AP stack, AP fence line and in A Farm, operated consistently throughout the Phase 1 test, but will require additional seasonal testing.

Optical Gas Imaging (OGI) Systems – Challenges emerged with the fixed forward-looking infra-red (FLIR) OGI camera used to image potential gas vapors due to configuration and software issues. However, the portable FLIR OGI camera was used to evaluate the passive breather filters indicating successful use of the gas imaging technology.

Autosamplers – The autosamplers (stack/area and grab) were successfully field deployed and have met the bulk of test plan objectives and test requirements, but will require seasonal testing.

Personal Location Units – The Blackline Loner IS+ personal global positioning system (GPS) units tested to determine occupancy rate information met all of the functional testing requirements.

Personal Badges – Preliminary testing (calibration and connection to data downloading systems) of the ToxiRAE Pro and the IonScience Cub units indicate that they will provide the information and protection needed in the tank farms for total volatile organic compound (VOC) detection.

Communications – Overall, the communications to Tank Farm Monitoring and Control System (TFMCS), OSIsoft PI Data Historian (OSI/PI), and the SAFER Systems RealTime software worked satisfactorily and are ready – with minor exceptions noted in the equipment summaries – for continued operation of pilot-scale testing. However, unique configurations were necessary to ensure compatibility between infrastructure and some detectors resulting in intermittent or no communications to the software services.

Data Display and Alarming Software – The TFMCS human-machine interface proved better than SAFER RealTime or ProRAE Guardian, primarily in the area of software/human interface due to the use of site-standard backgrounds, site-standard alarm color designators, and existing infrastructure compatibility. Similarly, OSI/PI, a standard Hanford Site product, has been used effectively as a simple graphing and analysis tool.

Modeling – Initial system operation showed the data acquisition module of SAFER Systems needs to allow better access to sensor groups and increase the quantity of sensors in a given group. Also, the testing results suggest that the software source area locator (SAL) and forward plume modeling modules require system-to-tank-farms scaling development.

The VMDS testing to date demonstrates the ability to detect chemical vapors, chemicals of potential concern (COPCs), and leading indicators in real-time from both stationary and fugitive emission sources. Phase 2 of VMDS testing is expected to demonstrate reliable operations across varying seasonal conditions. Successful implementation of the VMDS will greatly enhance the ability to detect and respond to chemical vapor release events, and over time, potentially allow the capability to predict when and where such events are likely to occur.

PHASE 2 RECOMMENDATIONS

In addition to evaluating the suitability of each of the components that make up the VMDS, the pilot-scale testing team devised a number of Phase 2 recommendations. The path forward focuses on working to make all VMDS components technically operable. The recommendations for further design and testing are as follows:

- Continue Phase 2 testing until a reasonable amount of data for Reliability, Availability, Maintainability and Inspectability (RAMI) determination can be collected – estimated to be between 3 and 6 months.
- When tank waste-disturbing activities are planned, ensure all relevant instrumentation is in place to record any release events – for example, a proton transfer reaction-mass spectrometer (PTR-MS), open path Fourier transform infrared (OP-FTIR) spectrometer, auto samplers (both grab and area), and DRIs in strategic locations based on daily weather conditions. (All data to date has been collected under quiescent conditions.)
- Devise a test to exercise the full system, including modeling efforts (e.g. a planned release of a detectable gas in quantities that will provide responses from a large fraction of instruments).
- Perform Phase 2 long enough to collect the data necessary for design inputs to the final VMDS design (e.g., occupancy rates, location of fugitive emissions sources, determination of the efficacy of leading indicators, selecting new species as leading indicators, identify potential new COPCs) – anticipate a minimum of 4 months of testing.
- Perform an extensive data evaluation on pilot-scale data plus data from other studies that can provide a better picture of the Tank Farms environment.
- Evaluate modifications required within the Tank Farms infrastructure to help determine the timelines to set up new VMDS.
- Evaluate potential abatement technologies and locations if detection does not provide the safety margin required for working in Tank Farms without supplied air.

Table 1. Path Forward Recommendations for VMDS Component instrumentation

Level	Criteria	Equipment	Recommendations
1	Ready for formalization of specification and functional requirements	Coastal Environmental meteorological station Blackline Loner IS+ GPS	Continue testing to determine seasonal variations and during waste-disturbing activities. Develop final engineering, procurement specifications, and functional requirements.
2	Required minor modifications for acceptable use	Cerex UV-FTIR Cerex OP-FTIR Cerex UV-DOAS Autosamplers	Continue testing to determine seasonal variations and during waste-disturbing activities. Initiate development of engineering, procurement specifications, and functional requirements.
3	Requires more data to establish necessary final modifications	Gastronics FIS (N_2O sensor only) Portable FLIR OGI Lufft meteorological station	Continue testing to determine seasonal variations and during waste-disturbing activities. Resolve issues with the N_2O sensors on Gastronics FIS.
4	Extensive modifications necessary for use	Fixed FLIR OGI (software installation) SAFER Systems ToxiRAE AreaRAE (functionality) MeshGuard NH_3 monitor (communications)	Continue testing to determine seasonal variations and during waste-disturbing activities. Resolve communication challenges with AreaRAE. Fixed FLIR OGI requires software installation. Re-evaluate need for SAFER given ease of TFMCS, OSI/PI.
5	Low confidence that major modifications will meet program requirements	MultiRAE Pro SKC HAZ-SCANNER	Continue testing to determine seasonal variations and during waste-disturbing activities. MultiRAE Pros continue to require premature sensor replacement. Continue to resolve communications challenges with RAE Systems units. The SKC HAZ-SCANNER has been completely re-engineered and has not functioned effectively as of yet.