Hanford Concerns Council

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October 2010

Mr. Tom Carpenter
Hanford Challenge

Mr. Chuck Spencer
Washington River Protection Solutions

Dear Messrs. Carpenter and Spencer:

Herewith is the final report of the independent review of WRPS Tank Farm Chemical Vapors Strategy that Washington River Protections Solutions and Hanford Challenge jointly requested the Hanford Concerns Council to manage in a memorandum of understanding dated May 2009. Two internationally recognized experts on industrial hygiene conducted the review: Dr. Patrick Breysse of the Johns Hopkins University School of Public Health and Mr. Mark Stenzel of Exposure Assessment Applications. These experts were selected by consensus of the Council, including WRPS management and Hanford Challenge representatives.

The Council ensured that Dr. Breysse and Mr. Stenzel had opportunities to meet with WRPS industrial hygiene professionals, tank farm workers, the Office of River Protection, and other interested parties in three visits to the Hanford site. The Council also provided opportunities for concurrent dialogue on issues the experts identified so that WRPS could make real-time improvements in planning and actions regarding worker protection from chemical vapors.

We believe this report provides a basis for strengthening and enhancing WRPS' and workers' ability to collect samples, analyze data and make informed decisions about protection from potentially harmful exposure to chemical vapors. We hope you and your respective organizations will find the report helpful as you pursue your shared goals of a safe work environment in the unusually complex, challenging and potentially hazardous task of cleaning up Hanford's high level waste tanks.

We appreciate your unfailing cooperation and support during the conduct of this independent review.

Sincerely,

Jon Brock
Chair

Independent Review Panel
Report On
Chemical Vapors Industrial Hygiene Strategy

September 2010

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Independent Review Panel Final Report

On Chemical Vapors Industrial Hygiene Strategy

Executive Summary:

An Independent Review Panel (IRP) was asked to evaluate Washington River Protection Solutions' proposed Tank Farm Chemical Vapor Management Strategy (TFCVMS) in the context presented in a document prepared by the Hanford Concerns Council, titled "Scope for Independent Review of Washington River Protection Solutions' proposed Tank Farm Chemical Vapor Management Strategy, Memorandum of Understanding (MOU), dated May 2009" (See Attachment 3). As outlined in the MOU, this review adopted an iterative approach, allowing Washington River Protection Solutions (WRPS) to seek input from the IRP and respond with improvements to the proposed strategy.

Managing chemical vapors at the Hanford Tank Farms is complex and requires development of strategies and procedures not typically encountered in traditional workplaces. The complexities of this situation are well appreciated by WRPS. During the process of this review, WRPS has made important improvements over previous drafts of the TFCVMS. Further, it is evident to the IRP that WRPS recognizes the unique challenges and is committed to developing comprehensive, defensible, and appropriate strategies and continued improvements. While strides have been made to improve exposure assessment strategies, this report identifies further opportunities to improve on the proposed management strategy.

Some of the suggestions and recommendations outlined in this report are intended to ensure a robust statistical approach for evaluating exposures within the tank farms. It is important to recognize that any assessment strategy should err on the side of being protective. In some cases, the IRP is concerned that the proposed application of statistical tools designed to be used in more routine work places may lead to an underestimation of exposure. In other cases the IRP's comments focus on the need to improve risk communication and risk management procedures. If implementation of the TFCVMS ultimately incorporates these suggestions, the proposed new strategy will strengthen current practices for managing chemical vapor exposures in the tank farms, a complex and uniquely challenging environment.

The following summarizes the analysis and recommendations outlined in this report:

- WRPS' proposed strategy is based on an established exposure assessment model developed by the American Industrial Hygiene Association (AIHA EA Model). The IRP finds that this is generally an appropriate model for use in the tank farms. As such, suggestions and recommendations are largely focused on 1) changes to the proposed strategy that are needed to fully capitalize on the benefits of using this model as a foundation for protecting workers, and 2) enhancements to ensure additional protection given the unique challenges presented by the tank farm environment.

- WRPS has already incorporated some IRP recommendations made during this review and during a prior review phase. These changes include improvements to exposure metrics, thresholds, and screening exposure metric usedto include chemicals in the COPC list

including carcinogens, and techniques to analyze data that are heavily censored (i.e. significant portion of the measurement data is observed to be less than the limit of detection of the analytical method).

- The AIHA EA Model is based on identification of similar exposure groups (SEGs) which allows for worker data to be tracked according to a metric of similar characteristics that can ultimately improve workers' access to exposure data and provide for more robust statistical analysis. WRPS has adopted part of the AIHA EA model through its characterization of tanks and development of Homogeneous Exposure Groups (HEGs).

- The use of SEGs is a foundational principle in the AIHA EA model and methodology used to characterize chemicals of potential concern and identify chemicals that require monitoring, so working toward full adoption of this part of the model is of central importance to the success of the overall strategy.

- The proposed strategy for evaluating tank vent emission data may not be sufficient to characterize emissions during activities that require active ventilation, such as waste disturbing activities. The sampling strategy presented in the tank farm source characterization section of TFC-PLN-111 should be reassessed and strengthened to consider variability in emissions in the tank farms.

- In the IRP's judgment, WRPS should consider adding flow measurements to supplement source sampling at vents in order to properly evaluate the significance of a vent source. Measuring flow at various vent sources could provide more detailed information about the volume of emissions. Testing or other technical evaluations could help determine if flow measurements provide an increased level of certainty in the tank farm environment.

- WRPS' proposed periodic sampling strategy is appropriate for traditional workplaces that are more static in nature. However, given the complex and dynamic nature of the tank farms, the IRP suggests that the proposed periodic sampling strategy be expanded to strengthen the exposure assessment process. Specific suggestions are outlined within the body of the report.

- WRPS should expand its job hazard analysis to include data, information and analysis techniques capable of supporting the AIHA EA Model. WRPS has expressed its intent to undertake this expansion but currently it is not reflected in the draft TFCVMS. Additionally, Industrial Hygienists (IHs) at the site should expand their capabilities to make sound professional judgments and perform non-quantitative exposure assessments when the collection of quantitative data is not practical or possible.

- Based on discussion with site IHs and IH Techs, the IRP is concerned that some of these professionals do not fully appreciate the possibility for over exposures at the site, and therefore may not be open to considering that ill effects reported by the workers could be job related. An inherent belief that exposures are minimal or non-existent can affect professional judgment and in turn, cause an IH to overlook important warning signs. Current analytical capabilities and sampling strategies to evaluate potential exposures associated with upsets may miss some short-term exposure situations. The IRP is aware that WRPS and The Department of Energy, Office of River Protection (DOE-ORP) have named a team to address these issues and that the team has made some progress in this area. The progress of this team has not yet been incorporated in the draft TFCVMS, but improving this aspect of the program would strengthen the overall strategy.

- WRPS has invested very significant resources (manpower and financial) in collecting quantitative measurements associated with full shift and short term samples. At least to date, they have allocated limited resources to analyzing and interpreting the data necessary to support all the requirements of an industrial hygiene program based on the AIHA EA model. Because exposure distributions are skewed (i.e. the data are not "normally" distributed in a statistical bell curve) a robust statistical analysis is needed to properly characterize exposures. The traditional approach of comparing individual measurements to the exposure limit or the action level (which is 50% of the exposure limit) is biased toward underestimating the actual exposure. Specific suggestions for improving analytical techniques are included in the body of the report to reduce the chance that exposures are underestimated.

- Odor complaints are the primary warning signal that a scheduled or upset condition may be presenting a potential exposure problem. WRPS has indicated that they have training programs not reviewed by the IRP that address other symptoms such as headaches, watering of eyes, tightness in the chest, but these other symptoms are not addressed in TFC-PLN-111 or TFC-PLN-34. A process should be established within the overall strategy to address other types of symptoms and recognize that many chemicals do not have adequate odor warning properties.

- In the IRP's judgment, it may not be possible or practical to fully characterize the emission sources associated with some waste disturbing activities. Therefore, the IRP suggests a protection hierarchy of containment, capture and dilution of vapors. This principle may be achieved through practices such as the use of stack scrubbers to capture harmful vapors and increased stack heights to improve dispersion in workers' breathing zones.

- During this review, the IRP raised concerns that the approximate 25 foot height of active vent stacks may not assure that vapors are sufficiently diluted in the workplace. WRPS has undertaken steps to increase the stack height in one farm to 40 feet. This is a positive step, and the IRP recognizes that determining the efficacy of this type of engineering control before investing in its widespread use throughout the tank farms is a reasonable approach. In addition to evaluating the efficacy of this increased stack height in reducing potential concentrations in worker breathing spaces, WRPS should also consider capturing vapor emissions with equipment such as scrubbers or by extending stack heights even further where beneficial and effective, or in the absence of evidence, as a precautionary measure.

- There are opportunities to improve the information provided to the medical provider (MP) that would enhance the MP's capabilities to properly interpret medical findings and provide an important feedback loop for an effective IH program. Currently, exposure measurements are only assigned to the individual who carried the monitoring (in many cases this is the IH Tech). Additionally, a work history linked to SEGs is not currently available, although such a history may provide a much more complete picture of a specific worker's exposure history related both to a discrete event and over time.

- The IRP has identified a number of issues where further training may be appropriate for workers, professionals and management. Again, it was not within the scope of the IRP to review specific training materials. However, the IRP notes that an ideal training program would include: issues related to odor and non-odor complaints; the new exposure assessment process; the interpretation and application of occupational exposure limits; the importance that workers agree to wear exposure monitors when requested; and interpretation of the summary of exposure assessment information. If WRPS' training materials include these items, the IRP would consider the training program effective.

Background:

The Hanford Concerns Council (Council) facilitated this assessment at the joint request of Washington River Protection Solutions (WRPS) and Hanford Challenge. This assessment represents the second phase of a review initiated in 2006 at the joint request of CH2M HILL Hanford Group and Hanford Challenge (then the Government Accountability Project). The following describes the history and process of the two phases of review and assessment.

Phase one of the review evaluated the *Industrial Hygiene Chemical Vapor Technical Basis,* a complex analysis developed by CH2M HILL Hanford Group and codified into a document which became part of the industrial hygiene program to protect workers in Hanford's tank farms. The goals for the first phase of the review were to evaluate the methodology for setting worker protection practices and procedures, and to determine whether the resulting standards were sufficiently protective of workers.

The Council retained three independent experts to conduct the phase one of the review:

- Dr. Hanspeter Witschi, Professor Emeritus of Toxicology, University of California-Davis, Chair
- Dr. Alfred Franzblau, Professor of Occupation Medicine, University of Michigan
- Dr. Patrick Breysse, Professor of Industrial Hygiene, School of Public Health, The Johns Hopkins University, assisted by doctoral student Katie Clark

This expert committee met with members of the Council and other representatives of CH2M HILL Hanford Group and Hanford Challenge, and toured Hanford's tank farms. The committee reviewed the *Industrial Hygiene Chemical Vapor Technical Basis*, Rev. 1, and supporting documentation. On June 30, 2008, the committee submitted its report to the president of CH2M HILL Hanford Group and the executive director of Hanford Challenge. (This report can be accessed at the Hanford Concerns Council's website).

The committee found that the methodology used in developing the *Technical Basis* was consistent with processes used by standard-setting bodies and best practices employed by industry. However, the committee members concluded that, given the complexity of Hanford's tanks, significant uncertainties remained about the concentrations of chemical compounds that might be encountered in worker breathing spaces. Committee members recommended a number of steps that might be taken to reduce these uncertainties until further employee exposure sampling was completed in order to be more conservative and protective of workers. The committee members also acknowledged that their scope did not include review of data collected subsequent to the development of the *Technical Basis*.

On October 1, 2008, Washington River Protection Solutions (WRPS) succeeded CH2M HILL Hanford Group as the contractor charged with cleanup of the tank farms. WRPS reviewed the *Technical Basis,* the independent review facilitated by the Council, and the data collected subsequent to completion of the *Technical Basis* Rev. 1. Based on its review of the program in place at the time of its arrival, and of the independent review facilitated by the Council, WRPS proposed and implemented specific changes to its industrial hygiene program. WRPS has developed a separate industrial hygiene strategy focused on chemical vapors in order to provide greater emphasis on protecting workers from chemical vapors. This strategy is outlined in WRPS' proposed *Tank Farm Chemical Vapor Management Strategy*.

Phase two of the review adopted an integrated approach to evaluate the effectiveness of the proposed *Tank Farm Chemical Vapor Management Strategy* in managing and identifying worker exposures to tank farm vapors. Specifically, the review sought to evaluate the effectiveness of the company's risk assessment, risk management and risk communication processes. In addition, the review evaluated worker protection strategies revised in response to the phase one review of the *Technical Basis*.

The Council selected two experts who collectively brought knowledge in the industrial hygiene areas of analytical chemistry (including specific knowledge of chemical vapors and mixtures), field application of IH equipment and sampling strategies, personal protective equipment and engineering controls. The following two independent experts conducted phase two of the review:

- Dr. Patrick Breysse, Professor of Industrial Hygiene, School of Public Health, The Johns Hopkins University
- Mark Stenzel, Exposure Assessment Applications LLC.

The process for the second phase of the review was collaborative and interactive, and relied on shared mutual goals of seeking ways to reduce uncertainties about potential chemical vapor concentrations in worker breathing spaces, and lowering the risk of worker exposures. As such, the second phase of the review adopted an iterative approach, allowing for greater feedback and interaction between WRPS, Hanford Challenge and the Independent Review Panel (IRP).

The two experts representing the IRP visited the Hanford site on three occasions, and reviewed a draft version of the *Tank Farm Chemical Vapor Management Strategy*. In addition, the Council hosted several conference calls between the IRP, WRPS and Hanford Challenge. With the benefit of initial feedback on the *Strategy* document, WRPS made some revisions and improvements in response to the IRP's suggestions. After this initial dialogue and feedback process, the IRP conducted its review and assessment of the strategy for managing chemical vapors and protecting workers.

Introduction:

The Independent Review Panel (IRP) was asked to address 10 questions defined in a document titled “Scope for Independent Review of WRPS’ Proposed Tank Farm Chemical Vapors Management Strategy, Memorandum of Understanding”. The IRP addressed the questions based on the following:

- WRPS TFC-PLN-111 which proposes a new Tank Farm Chemical Vapor Management (TFCVM) Strategy dated March 18, 2010,
- WRPS TFC-PLN-34 Industrial Hygiene Exposure Assessment Strategy dated July 29, 2009,
- An informal document titled “Summary of Phase Two Dialogue between WRPS and the Independent Review Panel (HCC IRP Discussion document), dated March 18, 2010”.
- Information provided in numerous other documents by WRPS and the Hanford Concerns Council,
- Three site visits that occurred June 17, 2009, September 15-16, 2009 and December 7, 2009 along with information conveyed during a number of conference calls.

Discussion:

Section 1.1 of TFC-PLN-111 includes the following statement:

> *Guidance for the industrial hygiene exposure assessment aspect of the Worker Safety and Health Program is provided in TFC-PLN-34 "Industrial Hygiene Exposure Assessment Strategy". The TFCVM strategy supplements TFC-PLN-34 and provides guidance for the recognition, the evaluation, and control of tank farm chemical vapor exposures. Part of the guidance provided by this document is selected from DOE G 440.1-3, "Implementation Guide for use with DOE O 440.1," "Occupational Exposure Assessment," the American Industrial Hygiene Association publication, "A Strategy for Assessing and Managing Occupational Exposures" (2006) and the National Institute for Occupational Safety & Health (NIOSH) publication "Occupational Exposure Sampling Strategy Manual." (No.77-173). These documents provide guidance for implementing a comprehensive strategy incorporating performance-based approaches for conducting IH exposure assessments, an approach more conservative than a strict compliance strategy.*

The IRP evaluated TFC-PLN-111 and TFC-PLN 34 against the exposure assessment methods presented in the above mentioned guidance documents. Note that TFC-PLN-34 presents WRPS' proposed overall industrial hygiene exposure assessment strategy and TFC-PLN-111 is specific to the tank farm chemical vapors. TFC-PLN-111 management strategy provides guidance regarding anticipating, recognizing, evaluating and controlling exposure to the tank farm chemical vapors. To facilitate the readers' understanding of this report, the IRP has included an overview of the American Industrial Hygiene Association Exposure Assessment (AIHA EA) Model. The overview is presented in Attachment 1 and includes a general summary of the AIHA EA Model, a detailed discussion of the steps included in the model and a section on related topics that can impact the understanding of the exposure assessment process.

WRPS' plans have incorporated many of the IRP ideas, comments and suggestions generated through dialogue early in the review process in the current proposed version of TFC-PLN-111 and TFC-PLN-34 and WRPS has stated in the HCC IRP Discussion document their intent to address others.

The Memorandum of Understanding agreed to by WRPS and Hanford Challenge (Attachment 3) provided for 10 questions categorized in terms of risk assessment, risk management, and risk communication. The IRP response to the questions included in the MOU are as follows.

1. Risk Assessment: **Does the chemical vapor exposure assessment and sampling strategy (combined with data used to develop the *Technical Basis* and data gathered since revision 1 of this document) represent a statistically robust approach to identifying and evaluating tank farm chemical vapor exposures in worker breathing zones?**

The American Industrial Hygiene Association Exposure Assessment (AIHA EA) Model outlined in Attachment 1 presents a systematic process to conduct exposure assessments in the work setting. The complexity and dynamics of work settings can vary significantly and therefore in many cases the AIHA EA Model will need to be customized to address specific issues. This customization should not compromise the fundamental principles and concepts that form the basis of the AIHA EA Model. Following is a critique of WRPS's proposed Tank Farm Chemical Vapor Management Strategy (TFCVMS) using the AIHA EA Model (discussed in Attachment 1) as a point of reference.

The AIHA EA Model is applied to each similar exposure group (SEG) and more specifically to each agent associated with each SEG. The outcomes of the AIHA EA Model are a determination regarding whether specific exposures are acceptable, uncertain or unacceptable, and an exposure rating that provides a comparison of the exposure to the chemical's occupational exposure limit. The scope of the assessment includes: ongoing routine operations (operations); ongoing support activities (maintenance); activities that happen periodically (several times per month or year) but are planned; and upset conditions (equipment failures, spills and unusual conditions including weather). Exposure durations include full shift, short term and peak exposures.

As noted earlier, WRPS has incorporated a number of recommendations including; procedures for handling censored data (less than detectable limits); selection of exposure metrics; selection of an appropriate geometric standard deviation (GSD); and screening levels for carcinogens to name a few.

The IRP still has concerns and suggestions about several items that are discussed below.

Tank Farm Source Characterization

The AIHA EA Model includes workplace, work force, and work practice characterization; identification of determinants of exposure; identification of similar exposure groups (SEGs); and the identification of chemical hazards associated with working in the SEG. WRPS proposes using a different approach. They consider a subset of the information that typically makes up the workplace characterization and establish tank farm specific homogeneous exposure groups (HEGs). The tanks are grouped, within a farm, by the following criteria:

- waste streams and process chemistry associated with the specific tank,
- whether the tanks are cascaded (potentially share headspace vapors),
- whether the tanks share common ventilation systems, and
- whether current source and breathing zone data are consistent with headspace data.

Source data are collected at tank vents and statistically analyzed to estimate the 95th percentile of the source concentrations. The 95th percentile means that 95% of all possible concentrations in the distribution will fall below this level (see discussion of exposure distributions under related issues in Attachment 1). The determination of the number of samples required to estimate the 95th percentile is obtained by WRPS from the National Institute for Occupational Safety and Health (NIOSH) document No. 77-173. The output from this portion of WRPS exposure assessment process is the list of chemicals of potential concern (COPC) and a subset of this COPC list of chemicals where it is determined that exposure monitoring is warranted. This information is the input to the next phase of their exposure assessment which includes the identification of similar exposure groups.

The inclusion of a chemical on the COPC list is triggered by exceeding the screening level (SL) and the exposure monitoring requirement is triggered by exceeding the administrative control level (ACL), defined in Table 1 on page 6 of the TFC-PLN-111. By definition, the SL is considered to be exceeded if the 95th percentile of the source data for a specific chemical exceeds 1% the chemical's exposure limit. The ACL is considered to be exceeded if the 95th percentile of the source data for a specific agent exceeds 10% of the chemical's exposure limit.

The IRP does not have a conceptual problem with the formation of tank farm specific HEGs. The grouping of equipment is a common practice in the AIHA EA Model. The IRP does have a number of concerns about some issues within the Tank Farm Source Characterization process (see sections 2.1.1 – 2.1.4 pages 9-13). These issues include: 1) determination of the number of required source samples; 2) variation in source data, 3) passive versus active ventilation tank source data, and 4) potential exposures other than vent sources. Following is a discussion of these issues:

Number of samples necessary to characterize tank farm HEGs:

The process used to identify the required number of source samples in each tank farm HEG is discussed in section 2.1.2 of the TFCVMS. It is based on a discussion included in Chapter 3 and Appendix A of NIOSH publication No. 77-173. In this chapter NIOSH discusses groups of workers with similar exposure risk referred to as a HEG. The discussion relates to assuring that when there are a number of workers basically performing the same activity, and the worker at maximum exposure risk cannot be readily identified, the sampling strategy presented will result in a high probability that at least one of the workers sampled will come from the high exposure group.

WRPS proposed a sampling strategy where one would be 90% certain that at least one measurement would be in the top 20% of the exposures. No rationale is provided regarding why WRPS proposed these criteria or how this sampling strategy can support the 95th percentile metric used related to the SL (screening level) or ACL (administrative control level). It should be noted that the reference also provides the number of required samples to support other confidence level or other criteria for high exposure such as 10% or 5%.

No matter what criterion is selected for tank farm specific HEGs as defined by the WRPS, the HEG selection would only be analogous to the NIOSH maximum exposure risk worker discussed in Chapter 3 of NIOSH document No.77-173 for a specific set of conditions, meaning this process would need to be repeated for each configuration of conditions (such as weather condition, relative wind velocity, relative temperatures, etc.) resulting in a much higher number of required samples.

To illustrate an example where the NIOSH sampling strategy discussed above is applicable, consider that on a given day in Tank Farm C, WRPS has determined that 10 individuals were all working in the same SEG. Table 2 (found on page 10 of TFC-PLN-111) indicates that for groups of 10 to 14 individuals, seven of the individuals would have to be monitored to be 90% certain that at least one of the individual's exposures would fall in the top 20% of all the potentially exposed individuals on that day.

Variation in Source Data:

TFC-PLN-111 indicates that source measurement data is 1 to 2 orders of magnitude below the head space data and the HCC IRP Discussion document reported source data may be 1 to 3 orders of magnitude below the headspace data. [For the non-technical reader, an order of magnitude is a factor of 10. For example, if the source data were 2 orders of magnitude below the headspace data, the source data would be 10 times 10 or 100 times lower than the headspace.] Consider that when tanks are in the passive ventilation mode, the ventilation rate is only 3 -15 cubic feet per minute. This is a very small volume compared to the overall volume of the tank headspaces or the piping and pit volumes associated with the tank farm HEG. The 3 to 15 cubic feet ventilation rate corresponds to a volume of 25 to 110 gallons of tank space. The tank volumes are on the order of 1 million gallons and some are connected together. This ventilation rate in the passive mode is only affecting a small portion of the tank volume.

Without some ongoing record of ventilation rates it is generally difficult to interpret the significance of source data. The IRP feels one would have to know more than just the fact that the tank was exhaling. The ventilation rate is likely important but also must be used in context with the determinants of exposure.

The IRP was provided with a number of charts that report concentrations (ammonia) at the vent source and these charts lead the IRP to believe that the number of measurements required in Table 2, page 10 of TFC-PLN-111 should be more robust. Considering workplace, workforce and work practice characterization, the AIHA EA Model would further subdivide each HEG into a number of SEGs.

The exact number of measurements needed to obtain the required level of statistical certainty is dictated by the actual level of exposures observed, but generally 6 to 10 measurements are required for each chemical within each SEG. There are some IH techniques and tools available that can somewhat lower the number of measurements required, but even with these techniques the number of measurements required will most likely far exceed the numbers presented in Table 2 referred above.

Passive ersus Active Tank Source Samples:

It does not appear that active versus passive tank source samples are being differentiated at this point in the process to make the SL (screening level) or ACL (administrative control level) determinations. Attachment 2 contains tables grouped by chemical that displays source data on each tank of the HEG made up of tanks C-101, C-102, C-103, C-104, C-105 and C-106. This grouping of tanks was provided by WRPS as a Tank Farm HEG (EG-1) in C-Farm. A chemical was included in the table if any source measurement data was above the detectable limit of the method. Notice that virtually all the high measurements occurred during waste disturbing activity. This implies that at least in the AIHA EA Model, activity would be an important determinant is establishing SEGs and that the data should not be pooled with data that is not associated with waste disturbing activities. In other words, using a HEG which simply accounts for similar tank characteristics doesn't account for different types of activities or circumstances that should factor into the formation of an SEG.

It was noted that active ventilation is used during waste disturbing activities. This means the ventilation rate was on the order of 500 cubic feet minute versus the 3 to 15 cubic feet per minute in the passive mode, and that the active vent stack height is 20 to 25 feet tall versus the 3 to 4 feet of the passive vent. There is no question that a 20 to 25 foot stack is better than a 3 to 4 foot stack, but if the concentration in the vents were the same, the active vent would be emitting a quantity roughly 50 times more volume than the passive vent. The potential for workers' exposure relates to the generation rate of chemicals coming from the vent. To calculate the chemicals generation rate (mass/minute) the concentration of chemical in the vent (mass/volume) and the vents flow rate (volume/minute) must both be known. WRPS is not currently measuring the vents flow rate which is obtained from the velocity of air leaving the vent and the area of the vent opening. Also, the active vent concentration would likely more closely track the head space concentration (meaning it would be much higher) than the passive vent concentration.

A 20 to 25 foot vent is not very tall. The chimney height on a typical 2 story house would be greater than 25 feet tall. Considering it can be shown that it takes about 15 hours to turn over all the air in a 500,000 gallon tank (assuming one tank half full) ventilated at a rate of 500 cubic feet per minute, there can be an appreciable period of time that large quantities of contaminants are being vented. Even with the purging, the tank headspace concentration does not go to zero but rather approaches the equilibration rate which can be affected by removal activities.

TFC-PLN-111 does contain a good discussion of the active ventilation process including a description of the concentrations in the tank headspace but there appears to be a lot of uncertainty associated with this process. This uncertainty is related to the weather conditions, height of the stack, terrain near the stack, chemical concentration profile coming from the stack, and activity in the tank farm and vessel. Over time, the contribution of the various determinants of exposure may be better quantified with ongoing breather vent concentrations and flow measurement; modeling that considers weather conditions and terrain; and the activity taking place related to the tank.

It is not known for certain that past observations will be always predicative of future events. From the perspective of the AIHA EA Model, it may not be possible to characterize the exposure as anything but uncertain. According to the model then, under uncertain conditions, some other control strategy should be employed to reduce exposures to the acceptable category. Examples of other control strategies include:

- raising the stack height considerably;
- restricting activity in the area if workers are downwind from the stack;
- modeling weather conditions assuming worst case conditions
- assuming that the tank is venting at the head space concentration; and
- collecting or trapping the chemicals emitting from the tank at the vent.

Portable, commercially available scrubbers (such as caustic scrubbers) are widely used in the chemical industry and a 500 cubic feet per minute (CFM) vent is likely well within the capacity of these scrubbers.

Note that personal protective equipment (PPE) was not mentioned as a primary control strategy. PPE should be used as a second line of defense because the selection of appropriate PPE is a function of the concentration levels present which may not be known and the wearing of PPE can increase other risks such as heat stress. This does not mean that PPE should not be considered but rather it should be used in conjunction with more desirable controls strategies. In deciding the appropriate controls strategy, the desired hierarchy of controls in order is containment, capture, dilution, and isolation (including PPE).

Potential Exposure at Sources other than the Vent:

a. It is not clear to the IRP why the vent data are representative of concentrations that could be encountered at other points such as the pit covers, especially considering that the vent source data is 1 to 3 orders of magnitude below the headspace concentrations. Additionally, it is not clear why the headspace data is representative of the exposure that could occur when workers are performing specific activities such as changing out filters. The IRP would consider these exposures as uncertain.

b. It is not clear to the IRP why this Tank Farm Source Characterization step is in the process at this point. In the WRPS-IRP Discussion document at the bottom of page 4 and top of page 5, WRPS agrees that a more defined process to establish SEGs should be developed in keeping with the AIHA EA Model. This tank farm source characterization step may cause problems or at least need to be reworked when the site implements a more robust SEG exposure assessment process. If the issue is to get the strategy document finalized, reference a document that will define the new AIHA EA SEG process and then write the remainder of the document as if the SEG process exists. Of course this means that work will have to begin formulating this methodology.

c. The current Job Hazard Analysis (JHA) document (TFC-ESHQ-S_SAF-C-02, dated December 10, 2008) will either need to be revised to include the exposure assessment methodology or a separate document will need to be established. The current JHA is a good classical safety focused JHA but the IH component is limited. If the IH component of a JHA is limited, it may mean that some IH aspects of the hazard analysis are not getting an in-depth review.

In the AIHA EA Model, the exposure assessment and risk assessment are conducted from the perspective of the SEG. The characterization data, along with existing measurement data and other exposure assessment data are used to make decisions regarding an appropriate control strategy. WRPS has stated they agree that a more defined strategy should be used to develop SEGs. It seems logical that instead of reworking the JHA process to assess IH issues, they should consider refining their SEG process to address IH issues. WRPS may want to consider forming small pilot study teams to develop the process for various types of activities at the site which will allow them to gain a more in-depth understanding of the AIHA EA approach before they try to implement it across the site. The IRP feels that the initiation of the process should have a high priority.

d. Removing the Tank Farm Source Characterization step does not change the IRP concern regarding the use of the NIOSH sampling strategy criteria. The overall variability in the tank vents should be better characterized. This improvement can be realized through the collection of additional samples over a wider set of conditions as set forth using the AIHA EA Model and a more intense analysis of the data that already exists. The information and data developed from this effort should then be used to better formulate and assess exposures related to working in particular SEGs.

e. The draft TFC-PLN-111 document appears to be focused on the long term full shift exposures and provides limited discussion regarding the short term exposure assessment process, for both regular tasks and for upsets where the potential exposure is short term. WRPS has stated its commitment to improve in this area (WRPS-IRP- Discussion, Page 5) and is working on this issue and has presented several preliminary improvements. The IRP expects that this will be an evolutionary process. It is unlikely that WRPS wants to keep the TFC-PLN-111 document in draft form until they have fully evolved their techniques to quantify short term exposures and the need to perform real time measurements. One solution to this problem is for WRPS to reference a document in TFC-PLN-111 that addresses these short term exposure issues. Then as their short term assessment methodology evolves, they would just need to revise the referenced document rather than TFC-PLN-111.

f. The IRP is concerned about the over-reliance on the ppbRAE instrument to make decisions regarding acceptability of exposures. The IH Techs stated that this instrument is commonly used for investigation. The ppbRAE is a reliable and valuable tool but it has its limitations. The detector only senses a limited number of chemicals and it cannot differentiate between chemicals. The ppbRAE detects VOCs and SVOCs based on the ionization potential. WRPS selected the PID with the lower energy lamp, 10.6 eV to reduce interference from ammonia but even with this lower energy lamp, an atmosphere that contains ammonia concentration at its exposure limit of 25 ppm will result in an instrument response of 2.5 ppm. Additionally, the ppbRAE does not respond to a number of chemicals, and therefore, the lack of a reading on the instrument does not assure that exposures are acceptable. For these reasons, PID use is described in the chemical exposure hazard assessment based on sampling results. In addition, for grab samples, additional bench top equipment is utilized. WRPS has also made efforts to implement the use of state-of-the-art instrumentation to assist with timely analysis. Instrumentation needs to be addressed in any plan related to short term and real time measurement strategies.

g. The sampling strategy should be dictated by the initial screening level qualitative exposure assessment that identifies the exposure rating for the chemical in the SEG. Although the sampling should be concentrated for exposure ratings above the ACL (administrative control level), measurements should be made across the entire range of ratings (including the low exposure ratings) so that the rating system can be calibrated and validated.

h. The periodic personal exposure sampling frequency is presented in Table 3 of TFC-PLN-111, page 17. The Table does not provide a reference regarding the justification for the indicated periodic sampling frequency. The IRP feels that WRPS should add a reference to support this schedule and also identify how they will determine if the exposure is consistent with the initial determination. For example, Bayesian statistics could be used to determine if exposures have changed. The initial determination measurement data will be used as the prior and the periodic measurements will be used as the likelihood. The IRP feels that strategy presented in Table 3 should be expanded. Generally, the sampling strategy for exposure ratings 3 and 4 are the same. Considering that the activities at the Hanford site are quite dynamic, sampling frequencies longer than a month or two are probably not useful and there is always a need to collect some samples in the lowest group to assure that something (determinants of exposure) has not changed.

i. Neither TFC-PLN-111 nor TFC-PLN-34 make mention of worker tracking related to SEGs. Currently, an exposure record is tied to the worker who carried the monitor and during the site visits it was stated that the IH Tech carries the monitor if other workers cannot be recruited. A mechanism must be established to associate the measurements (or other exposure assessment information) to all the workers who were expected to have similar exposure. Once a worker tracking mechanism is developed add a reference to this record by adding the worker tracking data under Section 1.5 Exposure Assessment Strategy Records on page 6 or TFC-PLN-34.

j. The basic characterization information: determinants of exposure; chemical or physical hazards associated with each SEG; results of any exposure assessments including screening level assessments (see Attachment 1); modeling data; and quantitative measurement data should all be documented. A reference to these records should be included in Section 1.5 Exposure Assessment Strategy Records on page 6 or TFC-PLN-34.

k. Both documents imply that final decisions regarding whether an exposure is acceptable, uncertain or unacceptable along with the exposure rating is made with quantitative measurements. In many cases and likely the overwhelming majority of the time, it is neither practical nor possible to collect quantitative data (see reasons for an exposure assessment in the related issues section of Attachment 1). This is why it is imperative that professional judgment must be calibrated and validated in situations where quantitative measurements do exist either at the site or have been reported in the literature. Also, deterministic based models or models based on chemical and physical properties must be calibrated and validated as they relate to the site. The use of non-quantitative data to make decisions is common practice in our lives. We don't wait until someone is struck by lightning to make a determination that a severe storm is approaching. We depend on the weather service to make projections and our experience related to clouds and wind and the degree of darkness.

l. Currently, WRPS is expending thousands of hours of time and millions of dollars in measuring exposures. The site has spent minimal resources analyzing and interpreting information and data, evaluating the impact of various determinants of exposure, developing and calibrating exposure assessment models, and expanding the professional judgment of site health professionals. Even if it means collecting less quantitative data, this analysis, evaluation and interpretation should be significantly expanded to realize all the benefits of the data being generated. Data should be evaluated and/or analyzed on a frequent basis, such as after a sampling survey has been completed or after a sufficient number of samples have been collected to draw inferences. The statistical software the site has already purchased (Exposure Assessment Strategy Simulator V2.5.1) is very user friendly and requires minimal training.

m. The IRP would like to note the importance of professional judgment applied by an industrial hygienist. This judgment includes the application and appropriate use of knowledge gained from formal education, experience, observation, experimentation, inference, peer review and analogy. It allows an experienced industrial hygienist with incomplete or a minimum amount of data to estimate worker exposure in nearly any scenario (adapted from DOE Guide and AIHA [1]).

The AIHA definition is as follows:

> The application and appropriate use of knowledge gained from formal education, experience, experimentation, inference, and analogy. The capacity of an experienced professional to draw correct inferences from incomplete quantitative data, frequently on the basis of observations, analogy, and intuition.

The AIHA definition states that judgment must be correct whereas the TFC-PLN-111 definition only requires that a judgment is made. The IRP feels that the difference between the definitions is very important in determining an acceptable exposure endpoint. The AIHA definition requires a much more rigorous effort. It should be noted that recently published papers related to IH professional judgment have demonstrated that even certified IH's tend to underestimate exposure when limited quantitative data are available. And, when no quantitative measurements are available, the assignment of exposure to the appropriate exposure rating is only marginally better than a random assignment. Fortunately, the papers also have been able to demonstrate that judgments can be significantly improved with the use of rules-of-thumb.

Also, in meetings with the site IHs, the IRP had the distinct impression that the IHs have concluded that the overwhelming number of exposures at the site are not significant and that expressions of symptoms by workers were likely not job related. This type of mindset will further impair the application of professional judgment because warning signs could be overlooked or rationalized away.

Other Specific comments on TFC-PLN-111:

- Page 5, item 6, 3rd bullet – the report references the 2005 edition of the ACGIH TLV's. At least some TLVs are revised each year. The IRP was informed that 10 CFR 851 "Worker Safety and Health Program" is the DOE's worker safety and health regulation that require exposure limits from the 2005 edition. Changes made and published in current editions can be included on a case-by-case basis as described in the regulation. This issue may be beyond WRPS's control, but the use of the current values is more relevant to assure worker protection.
- Page 7, paragraph above section 2.1, 5th line from the end of the paragraph – the sentence addresses "chemicals that pose a long term risk". What about chemicals which pose an acute risk or how about chemicals where an acute exposure can pose a chronic risk?
- Page 14, last paragraph, 5th line from the bottom, "evaluate homogeneity" – what is probably meant is the uniformity of the exposure distribution. Homogeneity in this context usually means that the GSD of the distribution is 1.2 or less. Uniformity of the

distribution means that there is only one distribution and if the log concentration is plotted against the sample points, the curve will be a straight line with a high correlation coefficient ($r^2 > 0.9$).

- Page 17, section 3.1, first line of last paragraph, "based on full shift" – The exposure should be reported for the period sampled (typically 2 to 4 hours at the site) along with the period of the sample. WRPS does report concentrations; this data is generated for the sampling period and not adjusted for full shift. If the site also would like to report the data as a full shift sample where zero exposure is inserted for the time not sampled, this is acceptable if the full shift data is reported in addition to the period sampled data. Decisions related to the SL, ACL, AL or OEL should be made based on the period of sampled data. This also is recommended for STEL or ceiling samples. In other words, the current wording is open to interpretation but WRPS' current practice is appropriate.
- Page 20, section 4.2, last sentence of first paragraph, includes the statement "It is impossible to determine the nature of the distribution of a dataset where all samples are censored." – It may not be possible to determine the nature of the distribution but it is possible to estimate the 95th percentile. Nonparametric statistics can be used to estimate upper bound metric such as the 95th percentile. See page 420 of the AIHA "A Strategy for Assessing and Managing Occupational Risk" (2006). Additionally, freeware from EAS_i, Exposure Assessment Solutions can be used to do these calculations (Exposure Assessment Strategy Simulator V2.5.1).
- Page 25, last paragraph prior to section 5.1, "OEL is below $UTL_{95\%.95\%}$" – This should be reversed, that is "$UTL_{95\%.95\%}$ is below OEL"
- Page 25, section 6.0, second bullet – after "updated" add "as required, but no longer than every two years".

2. Risk Assessment: Are current monitoring instruments appropriate to use for determining potential or actual exposures to tank farm chemical vapors?

Personal monitoring: WRPS is well equipped to collect personal monitoring samples. Equipment is properly calibrated and validated analytical methods are available for nearly all chemicals of concern. The IH Technicians appear to be well trained to complete this responsibility. The IRP did identify a couple of issues such as the improper documentation on LOD data and possible problems with the analytical method for nitrosamines. These issues are being addressed by WRPS. The important point is that someone with a strong IH chemistry background should be responsible to periodically review the personal monitoring program from the analytical perspective.

Direct reading equipment: Many of the direct reading instruments are non-specific meaning that multiple agents can contribute to the instruments response. The site does use an array of instrument types that can be useful in the proper interpretation of readings. The caution here is that any direct reading data needs to be interpreted in context. If a reading is low it can be concluded that concentrations of known chemicals such as ammonia are not excessive. Considering that ammonia is usually present it may be used as an indicator to make judgment regarding other agents. But it cannot be concluded with certainty that there are no other agents present that the instrument does not detect, or whose presence does not correlate with that of ammonia. For example, during retrieval, there may be chemicals in the supernatant or chemicals released from the sludge/salt cake at concentration levels that are important but are not correlated to the ammonia concentration.

Short Term Exposure Assessment Process: WRPS is aware of issues with short term exposure assessments associated with tasks and possibly upset conditions such as releases or spills. A team has been formed to address these issues and progress is being made. Many of the problems in this area relate to limitations in instrumentation. It is understood that this may be an ongoing evolving effort. It would be advisable to document the procedures to be used with the understanding that the document may need periodic revisions. The document should be referred in section 5.1 of TFC-PLN-111 on page 25 analogous to documents Abnormal Operating Procedure (AOP) 11 and 15.

***3. Risk Assessment*: Do the IH procedures and strategy provide for appropriate monitoring and response activities during and after a potential exposure event?**

The monitoring portion of this question is addressed in question (2) above. In section 5.1, page 25 of TFC-PLN-111, symptoms triggered by odor is addressed. The IRP is not comfortable limiting this section to symptoms triggered by odor. Many chemicals' odor thresholds are well above the level that can cause either short term or long term symptoms or adverse health effects.

For example, ammonia does not have good odor warning properties. Only about 50% of individuals can smell ammonia at its 25 ppm OEL. With formaldehyde, eye irritation occurs near its 0.3 ppm OEL, but the odor threshold for most people is near one ppm. A majority of people will feel a tingling to the skin at concentrations of about 0.5 ppm. With methanol, the odor threshold is about 3000 ppm, but exposure in the 500 to 1000 ppm level can be associated with damage to the eye. Carbon monoxide does not have an odor but exposure can be lethal. Methylene chloride (MeCl) has a mean odor threshold of 160 ppm but the OEL is 25 ppm. Although the MeCl OEL was established related to a cancer endpoint, serious delayed acute effects can be observed where the oxygen in tied up in the blood much like is the case with CO at concentration levels below MeCl odor threshold.

The point of this discussion is that odor has a limited role in identification of potential exposures. The presence of odor does not mean that exposure problems exist, and the lack of odor does not indicate that exposures are acceptable. In some cases, efforts to track odors to their source are wasted effort that may also leave the worker with doubts concerning their well-being. TFC-PLN-111 or TFC-PLN-34 should address the topic of odor. In discussions, WRPS has informed the IRP that this is part of the (Chemical Hazard Awareness Team) CHAT refresher course. WRPS should consider reviewing their training material to ensure that will help workers better understand chemicals warning properties or lack of properties.

Additionally, WRPS should include other health related criteria beyond odor in its plan to identify potential exposure events. The IRP recognizes that there is not always a clear distinction between an adverse health effect associated with work and one that may have another cause, such as the flu. Minor symptoms such as tearing of the eye, irritation of the sinuses, scratchy throat, or tingling of the skin, light headedness or an upset stomach may all be signs of possible exposures. It is not always necessary to send these individuals to the medical provider because the symptoms are minor, but they may trigger the need for further assessment of the workplace. The IRP also recognizes that some people are hypersensitive and that these types of symptoms can be very subjective. This problem is not unique to the Hanford Site and is routinely encountered in the chemical industry. The large chemical companies may be able to provide some insights into how to address these types of issues.

***4. Risk Assessment*: Does the chemical vapor exposure assessment and sampling strategy appropriately incorporate threshold limits (percent of source) in the process for developing and maintaining the COPC list as recommended in the first phase of the review?**

The screening level value has been lowered to 1% of the OEL using the 95th percentile as the exposure metric for non-carcinogens, and the SL for carcinogens has been lowered to any measurements above the chemical's limit of detection. The IRP supports these levels, but believes that the decision to include or exclude a chemical on the COPC list should be reassessed once the basic characterization is completed for the SEGs, rather than based only on the source data related to tank farm HEGs. The determination of inclusion or exclusion of a chemical in the COPC list for the SEG is based on the screening level exposure assessment, which considers source data but also considers other determinants of exposure including activity and task being performed, and chemicals that are introduced associated with the process, such as the supernatants.

***5. Risk Assessment*: Does the chemical vapor exposure assessment and sampling strategy include appropriate strategies and instruments for detecting carcinogens as designated by IARC, NTP, ACGIH and OSHA?**

The site does have a carcinogen control policy, TFC-ESHQ-IH-STD-11, REV A-2 issued March 31, 2009. The policy is primarily focused on the management of the introduction of chemical carcinogens into the worksite, but also has provisions that relate to carcinogens that are already in the site there such as in the tank vapor. TFC-PLN-111 has lowered the threshold for the inclusion of carcinogens to any detectable level. The IRP agrees with this approach, but believes that the decision regarding inclusion should be reassessed at the SEG step rather than only at the presently proposed Tank Farm Source HEG step.

***6. Risk Assessment*: Is the company providing appropriate information to the medical provider for the purposes of evaluating the effects of potential exposures on worker health? Conversely, is the company adequately responding to the medical monitoring information it receives from the medical provider in a way that is consistent with its strategy for lowering uncertainties about worker exposures?**

A successful medical monitoring and medical surveillance program requires close teamwork between medical and IH staff. With most effective occupational health programs, the medical surveillance program is highly integrated with the other occupational health programs. In discussion with WRPS, it is apparent that they recognize this need, although there are some constraints on this relationship because medical services are provided by another contractor.

Currently the exposure record is limited to when an individual carried the monitor rather than all the representative exposure data. Additionally, a detailed work history linked to SEGs is not available. That is, unless a worker specifically carried a personal exposure monitor, there is no available exposure data for that individual employee.

WRPS has been providing tank farm data, differentiated by farm, showing the highest concentrations of constituents of source, area and personal samples. Although, providing this information to medical services is a useful practice, this practice does not result in the capability of medical services to address all the issues or questions that could arise. Individual work histories and exposure histories are needed.

As stated under question 1, worker tracking against SEGs should be established, at least on an ongoing basis, for workers' time spent in the various SEGs. As needed, this worker tracking data should be provided to the medical organization along with the chemicals associated with the SEG and the overall SEG exposure assessment. In order to gain the full benefit of the AIHA EA model including tracking data and allowing for a more integrated effort between IH and the medical provider, improvements in the kind of data provided to the medial provider are needed so that they have the capability to analyze trends and report back to the company.

***7. Risk Management*: Is the hierarchy of control strategies (engineering, administrative, personal protection) appropriately derived from the chemical vapor exposure assessment and sampling strategy?**

The IRP suggests that the engineering component of the control strategy be further delineated into the hierarchy of containment, capture or dilution. As stated earlier in the report, some situations may require containment.

The IRP does not have concerns about the hierarchy of controls specified in the document, but there are some enhancements that could be added to aid the site in determining the effectiveness of the controls. For example, flow devices used when source sampling the passive stacks would be useful to determine the quantity of agent that is being dispersed. This in turn could help determine if stack heights, ventilation rates, etc., are acceptable under various conditions.

***8. Risk Management*: Is the plan for implementing controls (engineering, administrative, and personal protection equipment) consistent with the company's stated goals, and are they also consistent with a program that will effectively protect worker health and safety?**

In some situations or under some conditions such as weather inversions, it may not be possible to draw conclusions regarding the acceptability of potential exposures. Currently, the control is dilution. It may be necessary to significantly raise the active vents beyond 20 to 25 feet (the IRP recognizes that WRPS is extending the stacks in C farm). Additionally, the site is reviewing several methods to collect chemicals emitted from the stacks. Examples of collection devices include: sorbents beds such as charcoal; burning the gases in a flare fueled by natural gas; decomposing the chemicals with a device analogous to a catalytic converter on a car; or scrubbing the gas with a water solution or caustic solution. Of all these options, if would appear that the scrubbing option is the most practical. Many of the chemicals in the vents are water soluble and portable scrubbers are commercially available and in widespread use in the chemical industry. Also, 500 cubic feet per minute vent is rather small considering the size of vents that are common to the chemical industry. The point is that there are likely other options beyond dilution which may also support WRPS' commitment to As Low As Reasonably Achievable (ALARA).

***9. Risk Communication*: Are there appropriate and clear training and communications about the risks and protection strategies in place to ensure that workers understand risks and how to achieve worker protection goals?**

WRPS has an opportunity to improve risk communication by addressing the following:

- A training program related to the odor issues (see discussion above), included in the ongoing CHAT training
- Training to explain this new strategy, if carcinogens are added to the COPC list when measured above the limit of detection.
- Training related to how OELs should be interpreted and their limitations. The IRP doubts that the workers, IHs, IH Techs and medical services provider have a common understanding. Although the IRP understands this subject is covered in CHAT training for tank farm entrants, those materials were not part of the review. So, these suggestions are offered to add items to an ongoing training program.
- Many workers are currently reluctant to wear monitoring devices. This is a common problem in other workplaces, but workers need to be convinced that they should carry the device to assure that they and their fellow workers are being adequately protected. Even if an exposure on a particular day appears to be acceptable, this information may be very pertinent to properly interpret exposures over months or years of their work experience at Hanford.
- A periodic (e.g. yearly) report that interprets the significance of a worker's exposure over longer periods of time might help that worker understand the importance of wearing a monitor or otherwise participating in activities to establish exposure history for that worker and coworkers. The lack of this information fuels mistrust and concern. The IH professional is frustrated when the same individual who was reluctant to participate in the monitoring program later questions why they were not informed when health problems develop.
- Finally, some of the industrial hygiene field staff have expressed the belief that exposures in the tank farm are trivial, while others expressed concern to the IRP that symptom concerns associated with working in the tank farm are not always taken seriously. When staff responsible for worker health and safety discount exposure and symptom concerns it creates a climate where effective risk communication and management are difficult. This

will also bias the application of professional judgment when conducting qualitative exposure assessments.

10. Do the responses to the Phase 1 recommendations provide an effective approach to the concerns and uncertainties raised in Phase 1?

Phase 1 of the review offered several suggestions for reducing uncertainties in workplace exposures, and many of these were adopted by WRPS. The principal conclusion of the Phase 1, however, identified the need to develop and implement a systematic sampling strategy in order to address worker exposure issues. WRPS has since developed a new strategy for managing vapors, which was the primary focus of this review. In many ways, this new strategy offers a fundamentally different approach than the strategy in place during the first phase of the review. So, it is appropriate for this review to focus on the proposed new strategy with particular attention given to sampling and data analysis methodologies.

Recommendations:

Following is a summary of the IRP's recommendations related to WRPS' proposed Tank Farm Chemical Vapor Management Strategy (TFC-PLN-111). The recommendations are discussed in more detail in the above report.

1. **Adopt Similar Exposure Groups (SEGs):** Currently, the first portion of the proposed WRPS exposure assessment process is based in the development of tank farm source homogeneous exposure groups (HEGs). While this is a useful step in identifying SEGs, this grouping of equipment should be incorporated into the SEG process defined in the AIHA EA Model. The screening level (SL) and administrative control level (ACL) assignment decisions are a component of the formation of SEGs and the SEG exposure assessment strategy.

2. **Revise sampling strategies at vent sources to consider additional factors.** The sampling strategy based on collecting vent source samples using the approach as presented in NIOSH publication number 77-173 is not appropriate for the tank farm source characterization. Again, the sampling strategy should be moved to the AIHA EA formation of SEGs where all the components of an exposure assessment (workplace, workforce and work practice) are considered rather than just a portion of the workplace data. Additionally, waste disturbing and passive tank operations should not be grouped. And, WRPS should collect more source measurements to better identify the true variability in the source data under a wide range of conditions including environmental conditions (such as the weather).The collection of vent flow measurements should be added to the data measured when vent source sampling occurs.

3. **Identify a process for determining when to apply headspace or source concentrations in an exposure assessment model.** The contribution of various determinants of exposure should be quantified for use in an exposure assessment model. The relationship between source concentration data and the headspace concentration data varies by orders of magnitude. WRPS should better identify and analyze the source of variation between vent source data and tank headspace data and identify those situations where the headspace concentration data should be used versus the vent source concentration data. For example, when a tank is actively ventilated, the concentration coming out of the stack is probably better represented by the headspace concentrations.

4. **Evaluate control strategies that capture or contain vapors.** Because of the uncertainties inherent in the tank farms, WRPS should evaluate containing or capturing vapors emitted from an active vent. For example, the vent could be scrubbed. If scrubbing of the vent vapors is not practical, WRPS should model the dispersion patterns using worst case environmental conditions and assuming that the vapors coming out the vent approximate the headspace concentration. This information can then be used to determine the required height of the stack.

The current stack heights of approximately 25 feet may not be adequate at least under some conditions. Doing the kind of analysis suggested above can help determine whether the existing stack heights achieve an appropriate level of dilution. The IRP recognizes that WRPS plans to extend the stack height to 40 feet in one farm for which the next retrieval is planned. This is a positive step which can add an additional layer of protection under most circumstances.

One other very important consideration regarding active vent stacks is the elimination of rain caps. Rain caps drive the ventilated air downward which greatly reduces vapor dispersion. If air is blowing out of the vent, rain can not enter and if the vent is not always on, rain caps are available that do not impede the air upward movement.

5. **Develop and refine the exposure assessment process (qualitative, semi-quantitative and quantitative process) needed to support the decision making process associated with implementing the AIHA EA Model**. WRPS should develop a sampling strategy that considers a range of environmental conditions and vent flow rates as discussed above. Additionally, the date and information collected to support the model should be documented in a format that is easily accessible over time. Then, WRPS should consider more frequent analysis of these data to ensure that models are accurately predicting actual events.

6. **Complement the use of the ppbRAE direct reading instrument and related sampling methodologies to identify points of emissions and short term exposures associated with scheduled events or upsets.** WRPS uses the ppbRAE direct reading instrument extensively to identify points of emissions and short term exposures associated with either scheduled events or upsets. This instrument uses a photo ionization detector and is not specific. Although the ppbRAE is a very useful instrument, because of its limitations it should be complemented with other analytical tools and procedures. It is likely that in many cases the ppbRAE is only responding to ammonia concentration. WRPS has a project team working on these issues and this effort should have a high priority. Several IH Techs reported that they use the instruments readings to determine if exposures are acceptable. There are likely cases where the negative response of the instrument only means that the agent of concern is not detectable rather than that exposures are acceptable. WRPS has an effort underway to enhance its analytical capabilities with other instrumentation and sampling methodologies.

7. **Strengthen sampling strategies to rely on a specific rationale through an iterative process that supports development of professional judgment.** The IRP does not believe that the periodic sampling strategy is as robust as it should be considering the dynamic nature of the work in the tank farms. There are many issues that impact the development of a sampling strategy. The rationale for sampling should be clearly developed and documented. That is, how does WRPS know that the sampling strategy is adequate to address all the needs of an exposure assessment and have the IHs been adequately trained in how analyze and interpret the data when collected? Note that this strategy must also be able to support the

evaluation and calibration of professional judgments and modeling activities including determining the exposure contribution associated with various determinants of exposure.

8. **Ensure a representative sample of workers within an SEG wear monitoring devices.** The IRP is concerned that although on a given day many individuals may be working in a SEG, only one individual is monitored and the IH Techs suggested that many times they carry the monitor. Is the IH Tech's exposure representative and is one measurement sufficient to characterize exposure in the SEG? At least a preliminary analysis of the monitoring data should be conducted on a very regular basis, such as at least weekly, using techniques such as Bayesian Statistics. The statistical package used by WRPS contains this capability. A comprehensive analysis of the data should be completed such as semiannually or annually. This will likely be a major effort and appropriate resources should be allocated.

9. **Foster the development of sound professional judgment and communicate with workers about how it is applied.** WRPS agrees with the use of professional development, and the use of data analysis (modeling), while stakeholders (including representatives of employees) have discouraged the use of any modeling and instead encouraged reliance on ongoing sampling data. This belief that quantitative measurements should be used exclusively is a misconception and unfortunately is biased toward the failure to identify exposures that are potentially significant. A robust, scientifically-sound exposure assessment process incorporates quantitative measurements, professional judgment and modeling, used in concert to accurately and efficiently characterize exposure.

   Considering that the site has hundreds of chemicals used under many different conditions, it is neither practical nor possible to assess each exposure situation with quantitative measurements. Additionally, many exposures must be characterized prior to the start of work. For example, the selection of personal protective equipment, appropriate engineering controls or the appropriate hazard communication must be completed prior to the start of work and therefore cannot be based on quantitative measurements. WRPS has agreed that the use of professional judgment should be expanded both in definition and in practice and better explained to workers over time.

10. **Use SEG data to support medical monitoring.** WRPS should develop the capability to collect the time individuals spend working in the various SEGs in order to support medical surveillance, illness investigations, and health surveillance of groups of workers. This information should be made available to the medical provider along with the basic characterization and exposure assessment data associated with working in the SEG.

11. **Expand awareness of potential symptoms of exposure.** Potential symptoms of over-exposure should be expanded beyond the perception of odor to include other symptoms such as watering of the eyes, tingling of the skin, tightness of breathing, etc.

12. **Clarify hierarchy of controls.** WRPS should delineate in its proposed strategy that engineering controls should consider containment, capture and dilution and that preference should be given to containment and capture if beneficial and effective, or in the absence of evidence, as a precautionary measure.

Signed,

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ACRONYMS and DEFINITIONS

ACGIH	American Conference of Governmental Industrial Hygienists
ACL	Administrative Control Level
AIHA	American Industrial Hygiene Association
AIHA EA	American Industrial Hygiene Association Exposure Assessment Model
AL	Action Level (usually 50% of OEL)
AOEL	Acceptable Occupational Exposure Limit
CHAT	Chemical Hazard Awareness Training
COPC	Chemical of Potential Concern
GM	Geometric Mean
GSD	Geometric Standard Deviation
HCC	Hanford Concerns Council
HCC IRP	Discussion Document: Summary of Phase Two Dialogue between WRPS and the Independent Review Panel, dated March 18, 2010
HEG	Homogeneous Exposure Groups
IARC	International Agency for Research on Cancer
IRP	Independent Review Panel
JHA	Job Hazard Analysis
LOD	Limit of Detection
MP	Medical Provider
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
OEL	Occupational Exposure Limit
OSHA	Occupational Safety and Health Administration
PID	Photo Ionization Detector (a type of detector used in an analytical instrument)
ppbRAE	Name of a Specific Direct Reading Instrument Produced by RAE Systems
PPE	Personal Protective Equipment
SEG	Similar Exposure Groups
SL	Screening Level
STEL	Short Term Exposure Limit (typically 15 minute duration)
SVOC	Semi Volatile Organic Compound
TFCVMS	Tank Farm Chemical Vapor Management Strategy
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compound
WRPS	Washington River Protection Solutions

ATTACHMENT 1

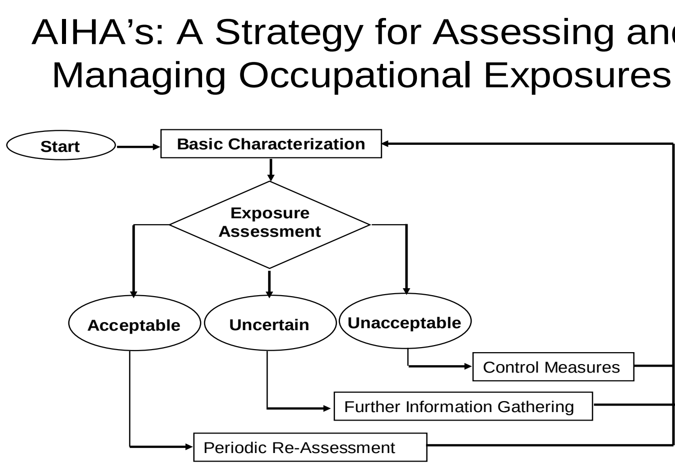
AIHA Exposure Assessment Model:

The purpose of the document is to provide the reader with background information related to the independent expert panel's report on the WRPS Tank Farm Chemical Vapor Management Strategy (TFC-PLN-111). This document will present a simplified overview of the AIHA exposure assessment (AIHA-EA) model; followed by a more detailed discussion of the process; and a discussion of several related topics including: purpose of the exposure assessment; occupational exposure limits (OELs); exposure distributions; and exposure metrics that are important to the understanding and application of the model.

♦ **Overview:**

Figure 1 illustrates the AIHA Exposure Assessment Model.

Figure 1 – AIHA Exposure Assessment Model



The AIHA ES model is to be applied on unique exposure groups called similar exposure groups (SEGs). The model is built on the premise that there are workplace, workforce and work practice characteristics along with the list of chemicals present in the SEG workplace that can be used to identify determinants of exposure. The health professional can then use these determinants of exposure along with quantitative, semi-quantitative and qualitative exposure assessment techniques to estimate workers' exposure as compared to the chemicals' accepted exposure limit. Examples of exposure assessment techniques include quantitative measurements; mathematical modeling techniques (use the agent's chemical and physical properties such as volatility along with air fluid dynamics); descriptive statistical, knowledge based deterministic modeling; and IH professional knowledge derived from education and practical experience. There can be many chemicals associated with working in a SEG and the exposure assessment is performed on each chemical in a SEG. These exposure estimates can be derived for past, current or future exposures that a worker has or would encounter while working in the SEG.

The definition of a SEG follows:

Similar Exposure Group (SEG)*: "Group of workers having the same general exposure profile for the agent(s) being studied because of the similarity and frequency of the tasks performed, the materials and processes with which they work, and the similarity of the way they perform tasks."* ***[WRPS also uses homogeneous exposure groups (HEGs) that will be discussed in the detailed portion of the document including how the HEGs and SEGs. differ.]***

An in-depth discussion of the basic characterization, determinants of exposure, and the exposure assessment process is included in the detailed portion of the document.

The output of the AIHA EA Model is a decision whether the exposure is acceptable, unacceptable, or that the acceptability or unacceptability is uncertain. Additionally, the Model assigns an exposure rating as compared to the chemical's occupational exposure limit (OEL).

There are several different sources of exposure limits including: non-government professional health organizations (ACGIH TLVs); government (OSHA PELs); company exposure limits, exposure limits defined by WRPS as acceptable occupational exposure limits (AOELs) based on its technical approach; or an industrial hygienist's working or provisional exposure limits. Each exposure limit is developed using a specific definition that provides guidance on how to assess exposure levels against the exposure limit. In nearly all cases, the upper bound of the exposure profile (see SEG definition) is used to determine acceptability. The upper bound metric can be thought of as being analogous to a speed limit. Exposure limits are not bright lines between safe and unsafe but rather the exposure limits include safety and uncertainty factors which allow nearly all workers to encounter exposure at the exposure limit without experiencing a significant adverse health outcome.

There are different types of exposure limits that consider how the chemical agent can affect the body. For example, some agents have acute effects (ammonia causes respiratory irritation), others have chronic effects (excessive exposure to benzene incurred over time can cause leukemia) and with some chemicals an acute exposure can lead to chronic effects (acute inhalation exposure to high levels of methanol can lead to blindness). Some chemicals have more than one effect (formaldehyde can cause acute irritation and chronic illness including some forms of leukemia).

Again, as can be seen in Figure 1, the possible decisions regarding exposure are acceptable, uncertain and unacceptable. It should be noted that exposures are typically highly variable which adds a level of complexity to the exposure assessment process. Highly variable means that if every exposure were known there would be a large range in the exposure observed (typically a factor of 100 or more). Uncertain means that there is not enough information to determine where the actual exposure falls as compared to an exposure limit. If the exposure assessment outcome is uncertain; the IH can collect more data; conduct a more rigorous analysis of the available data; research other information on the determinants to expand the level of their professional judgment; or modify one or more of the exposure determinants. For example, the level of control determinant can be changed from dilution of the vapor in air to enclosure of the point of emission, which would eliminate the release of the agent to the workplace.

Because exposures are usually highly variable, collecting just a few measurements can easily lead to incorrect conclusions. A simple example can be used to illustrate the variability. Intuitively we think exposure is constant but in reality it is much like phenomena that have a high degree of variability such as the weather or the water line on an ocean beach. Consider the water line example and assume that someone would like to build a house at the ocean's shore and would like a high degree of certainty regarding a safe location to build. At any point in time, the ocean's shoreline could be measured, but the water line varies minute to minute due to the waves and over the day and month due to the tides. Also, the water line can vary with the weather and with the season of the year. Even though the water line on the shore is highly variable, we have been able to develop measurements and modeling techniques to accurately predict the upper bound of the water level and it turn where it is safe to build a house. This is also true with exposure assessment techniques.

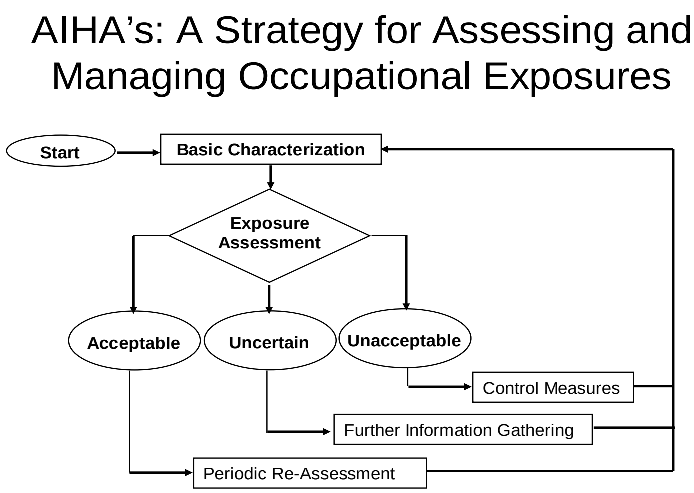
All the measurement and modeling are only useful if it is known that the characterization data are representative. With the tank farms, the process change could mean that one set of conditions cannot be extrapolated to another set of conditions. For example, tanks that are passively venting may have different determinants of exposure than the same tanks actively during waste disturbance activities. The tank farm issues related to the passive or waste disturbing mode and will be discussed in the expert panel report.

- **Detailed Discussion of AIHA EA Model:**

The ultimate goal of WRPS Tank Farm Chemical Vapor Management Strategy is to assure that workers' wellbeing is protected in both the short and long term; while attempting to assure the environment is not adversely affected; and that the company can complete its contractual requirements in an efficient, timely and cost effective manner. WRPS has based their exposure assessment process on the American Industrial Hygiene Association (AIHA) "The Strategy for Assessing and Managing Occupational Exposures (2006) and a variation of the National Institute for Occupational Safety and Health (NIOSH) "Occupational Exposure Sampling Strategy Manual" (1973). The AIHA strategy is illustrated in the Figure 1.

This section will present a detailed discussion of the AIHA EA Model that will hopefully enable the reader to better understand The Independent Review Panel's (IRP) comments and critique of the WRPS Tank Farm Chemical Vapor Management Strategy. The AIHA EA Model was developed with the understanding that it can be customize for each unique situation. The purpose of this memo is to discuss, in general terms, the model's fundamental principles and assumptions. The Hanford site is very complex and with many dynamic changes occurring that may not be readily identified nor their effects understood.

Figure 1 – AIHA Exposure Assessment Model



<u>Major Steps:</u>

The major steps in the risk assessment strategy are as follows:

1. ***Strategy:*** Establish the exposure assessment strategy.

2. ***Basic Characterization:*** Gather information to characterize the workplace, workforce and environmental agents.

3. ***Exposure Assessment:*** Assess exposures in the workplace in view of the information available about the workplace, workforce and environmental agents. The assessment outcomes include:
a. Groupings of workers having similar exposures.
b. Definition of an exposure profile for each group of similarly exposed workers.
c. Judgment about the acceptability of each exposure profile.

4. ***Further Information Gathering:*** Implement prioritized exposure monitoring or the collection of more information on health effects so that uncertain exposure judgments can be resolved with higher confidence.

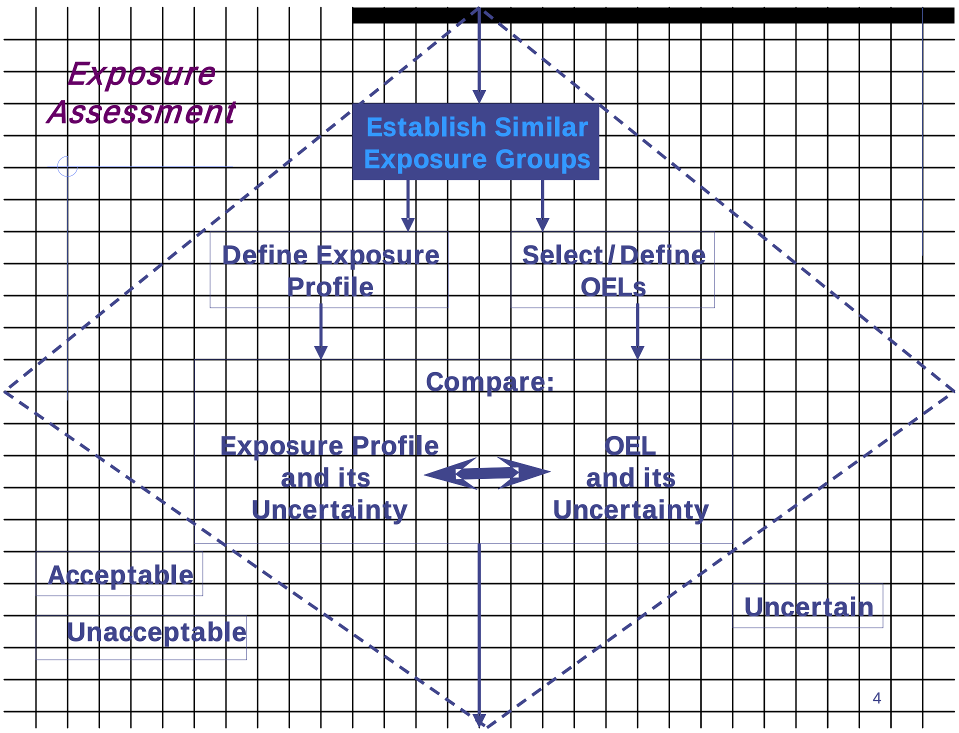
5. ***Health Hazard Control:*** Implement prioritized control strategies for unacceptable exposures.

6. ***Re-assessment:*** Periodically perform a comprehensive re-evaluation of exposures. Determine whether routine monitoring is required to verify that acceptable exposures remain so.

7. ***Communications and Documentation:*** Although there is no element in the above Figure for "communication and documentation," the communication of exposure assessment findings and the maintenance of exposure assessment data are assumed throughout as essential features of an effective process.

Figure 2 provides additional detail into what is included in the "exposure assessment" diamond in Figure 1.

Figure 2 - Detail of Exposure Assessment Diamond



The AIHA exposure assessment strategy is organized around exposure groups referred to as similar exposure groups (SEGs) that are defined as follows:

Similar Exposure Group (SEG): *"Group of workers having the same general exposure profile for the agent(s) being studied because of the similarity and frequency of the tasks performed, the materials and processes with which they work, and the similarity of the way they perform tasks."*

As an aside, WRPS also uses a term called tank farm source homogeneous groups where they group tanks with similar process chemistry, have headspace connectivity by ventilation or transfer piping systems and have similar source and headspace characterization data. WRPS then make the assumption that they can apply the same sampling strategy statistics presented in the above mentioned 1973 NIOSH document. The NIOSH document uses the term homogeneous risk group of workers which is referred to as an HEG. Note that NIOSH is referring to workers with similar expected exposure risk and WRPS is using tanks with similar characteristics. This component of WRPS's exposure assessment process will be discussed in detail in the IEP report *but it should be noted that the IRP does not believe the proposed sampling strategy is valid for the tank farm source homogeneous groups and the required number of samples presented Table 2 or TFC-PLN-111 is likely much higher.*

The overall objective of the exposure assessment process is to establish the exposure rating for each agent in the SEG. A numeric exposure rating is assigned to a band of exposure as compared to the OEL. (See Table 1 below)

Table 1 – Exposure Ratings Associated with OEL Exposure Bands

Exposure Rating	OEL Exposure Bands Statistical Interpretation (OEL)[1]
0	$X_{0.95} \leq 0.01$ x Occupational Exposure Limit (OEL)
1	0.01 x OEL < $X_{0.95} \leq 0.1$ x OEL
2	0.1 x OEL < $X_{0.95} \leq 0.5$ x OEL
3	0.5x OEL < $X_{0.95} \leq 1.0$ x OEL
4[2]	$X_{0.95}$ > OEL

[1] $X_{0.95}$ is defined to be the 95th percentile of the data distribution
[2] Exposure Rating 4 is further divided into additional categories based on respirator applied protection factors (APFs)

To illustrate, assume that measurement data indicate exposure to methyl ethyl ketone (MEK) of 50 ppm ($X_{0.95}$) and that MEK's OEL is 200 ppm. The exposure metric that is used is the 95th percentile and is represented by $X_{0.95}$ (see discussion of related topics). Substituting MEK's 200 ppm OEL into the exposure bands in Table 1 results in the following concentrations: exposure at 0.01 times the 200 ppm OEL is 2 ppm; exposure at 0.1 times the 200 ppm OEL is 20 ppm; and exposure at 0.5 times the 200 ppm OEL is 100 ppm. Therefore a MEK exposure of 50 ppm falls between 0.1 and 0.5 times the MEK OEL and therefore the exposure rating 2 is associated with this range.

Actions are associated with each exposure band (See Table 4 Exposure Control Strategy on page 24 of TFC-PLN-111 REV A.

Specific Steps Associated with the AIHA Exposure Assessment Model:

- **Basic Characterization:** In this step, descriptive data are collected that can be used to identify unique exposure groups (SEGs). The three types of data include workplace, work force and work practice information along with determinants of exposure in each grouping that are useful in estimating exposures.

    - **Workplace Data**
        - Geographic location
        - Physical layout
        - Location of each process
        - Building location within process units
        - Description of the process
        - Description of the chemistry
        - Design and actual production rates

        - Operating conditions
        - Points and quantity of emissions
        - Engineering controls (type and likely effectiveness)

    - **Workforce Data**

        - Organization charts as they relate to department or process
        - Job titles
        - Job assignments (frequency and duration)
        - Task descriptions (frequency and duration)
        - Non-routine activities (frequency and duration)
        - Shift schedules
        - Responsibilities related to upsets or emergencies
        - Job/task rotations and schedules
        - Training level (dictates job assignments and tasks that can be performed)

    - **Work Practice Data**

        - Operating procedures
        - Preventive maintenance procedures
        - Housekeeping procedures (e.g. how often was an area or equipment cleaned?)
        - Emergency procedures
        - Records of the content of training programs
        - Use of personal protective equipment

- **Determinants of Exposure:** Exposure determinants are those items or factors that are thought to affect exposure. There are determinants that are related to where and how the work is being conducted (environmental determinants) and related to the agent or chemical (agent determinants).

    - **Environmental determinants:**

        - Points of emission
        - Height of vents
        - Type of control
        - Efficiency of control
        - Frequency and duration of exposure
        - Distance form source
        - Size of container opening
        - Surface area
        - Tasks

    - **Agent Determinants**:

        - Agent surface area
        - Vapor hazard index (Agent's vapor pressure divided by the agents OEL)

    - Composition
    - Quantity of agent
    - Absorption rate
    - Application method

  The above determinants are examples for illustration. The Hanford Site likely has its own unique set. The important point is that a trained health professional can likely identify most or all of the potential determinants that can contribute to exposure and the list is finite.

- **Identification of SEGs:** The IH considers all the basic characterization data and the determinants of exposure to identify the SEGs that satisfy the SEG definition stated above. The number of SEGs is determined by the activities at the site and the workers' responsibilities. It is important to note that it must be possible to track workers time against SEGs. In concept, all data is identified by SEG, including measurement data, and therefore data collected on one individual in the SEG can be linked to every other worker in the group. Additionally, other requirements such as training; PPE requirements; and medical surveillance requirements are also defined by SEG.

- This compilation of information only has to be done once (or at least only once until something changes requiring a new or updated SEG) rather than separately for each individual which, in the long term, means that the effort required to accurately establish a workers exposure record over time is greatly reduced. SEGs can meet the need to know workers' exposure profile over days, months and years.

- **Identification of Chemicals:** Once the SEGs are formed, all chemicals and physical hazards associated with working in an SEG are identified. For example this list of chemicals would include chemical present in the tanks or vents, chemicals associated with specific tasks such as solvents, chemicals associated with crafts such as welding fumes and chemicals used in the process such as supernates.

- **Exposure Assessment:** Considering that the exposure assessment may need to be conducted on hundreds of chemicals in a large number of SEGs (each chemical SEG combination is referred to as a exposure scenario) a simple or screening level exposure assessment is usually conducted first to determine if the IH can conclude that the exposure is definitely acceptable or definitely unacceptable as illustrated in Figure 1. Again note that the output of an exposure assessment is a determination of the exposure rating presented in Table 1. This screening exposure assessment is based on the basic characterization data and information; the IH professional judgment; determinants of exposure; existing quantitative measurements; and calibrated knowledge-based models. The screening level exposure assessments are completed quickly (on the order of seconds or minutes). If it can be concluded that exposure is very low with an adequate degree of certainty, the exposure is documented as acceptable, if not the exposure is classified as uncertain and documented. For those exposure that are uncertain, more rigorous tools are used to conduct a more in-depth exposure assessment. If the more extensive assessment concludes exposures are acceptable, the decision is documented; and if not it is still considered uncertain. It should be noted that even with the screening assessment, exposure may be concluded to be unacceptable and then appropriate actions to lower exposure to acceptable levels are undertaken. If the uncertainty of the exposure cannot be resolved, actions such as improvements in engineering controls or changes in procedures are implemented to move the exposure into the acceptable category.

- **Quantitative Measurements:** Quantitative measurements are used to calibrate the various models, identify the impact of various exposure determinants and, if sufficient data are collected, estimate the exposure associated with a SEG. A sampling strategy should collect some samples across all exposure ratings to help calibrate professional judgment and the various models used in the assessments. The most samples should be taken on exposure scenarios with higher exposure ratings. Because exposure data are highly variable if only a few quantitative measurements are collected, significant exposures may be missed. For this reason, the IRP had a lot of discussion regarding descriptive statistics including averages, geometric means, geometric standard deviations, and 95^{th} percentiles. Even if quantitative measurements are acceptable, the IH should also apply their professional judgment and various modeling techniques. All three perspectives should lead to the same conclusion, and if they don't, the results of quantitative measurements should be questioned.

- **Data Analysis:** One large failure of many IH programs is the failure to spend the time and resources necessary to properly interpret the data. These programs default to a comparison of each individual measurement to the OEL. Because exposure data are highly variable, significant exposure is many times missed and unacceptable exposure are considered acceptable. The analysis of data is used to determine the contribution of various determinants, it is used to develop and validate models specific to the worksite and it is used to improve and calibrate the IH's profession judgment. The following definition of professional judgment is presented in the above mentioned AIHA EA publication.

  Professional Judgment: The application and appropriate use of knowledge gained from formal education, experience, experimentation, inference, and analogy. The capacity of an experienced professional to draw correct inferences from incomplete quantitative data, frequently on the basis of observations, analogy, and intuition.

  Note that the outcome of professional judgment is to "draw the correct inference" and therefore it should be possible to measure the quality of one's professional judgments.

♦ **<u>Discussion of Issues Related:</u>**

This section will discuss related issues such as the purpose of the exposure assessment; OELs and their interpretation; exposure distributions; and exposure metrics.

- **Purpose of the Exposure Assessment –** The rigor of the assessment and the interpretation of the exposure assessment data, as it compares to the OEL, is dependent on the reasons or purposes for conducting the exposure assessment. Examples or reasons for conducting an exposure assessment are listed below:

  - Compliance with health based exposure limits – is the worker's wellbeing assured?
  - Compliance with regulations

- Chemical approval program (identify requirements associated with introducing the agent into the work place.)
- Personal protective equipment (PPE) assessment
- Respiratory protection selection
- Assess the impact of a process change, the introduction of a new process or the impact of work practice changes
- Ventilation requirements associated with introduction of new material or changes in process or work practices
- Support accident or illness investigations
- Assessing potential for upsets and their impact
- Emergency planning
- Retrospective exposure assessment
  - Epidemiology studies
  - Toxic tort
  - Illness clustering

For example, an exposure assessment program than only assures regulatory compliance may not be capable of assuring a worker's wellbeing or support accident or illness investigations.

- **OELs –** OELs were addressed in detail in the first phase of this project but there are several concepts that should be stressed here. The OEL is not a bright line between safe and unsafe but rather is a point of reference. The OELs are established at levels where it is felt, by knowledgeable scientific professionals, upon an extensive review of the literature that most individuals can be exposed over minutes, hours, days, months or years and not incur any significant adverse health outcomes. Periodic, but rare exposure above these limits will not likely result in harm as long as the exposures are just marginally above the limits. Man can tolerate these periodic exposures as long as the body's capacity to neutralize or negate their potential to cause harm is not exceeded. Examples of ways that the body can neutralize or negate the adverse effects of agents include the following:

- expel the agent in exhaled breath,
- expel the agent in urine or feces,
- change the agent to some other chemical and expel the new agent in the breath, urine or feces,
- store the agent in tissue that is not highly affected by the chemical's toxic properties,
- metabolize the agent to a less toxic chemical,
- repair damaged tissue or generate new tissue, or
- the individual can live with the damaged tissue as long as the damage has not reduced the body's organ's capacity below acceptable levels.

The point here is not that it is periodically acceptable to expose workers above accepted values. An employer should strive to maintain exposure well below the OEL. The point is that irreversible harm will not likely occur with a single exposure as long as the exposure is rare and only marginally above the OEL.

Note that over-exposure can lead to harm due to exposure accumulated over long periods of time and the effect may not be manifested for months or years. Short term or peak exposure can lead to acute effects that occur shortly after the exposure or in some cases peak exposures can lead to chronic health outcomes. And some agents have the capacity to cause both acute and chronic health outcomes.

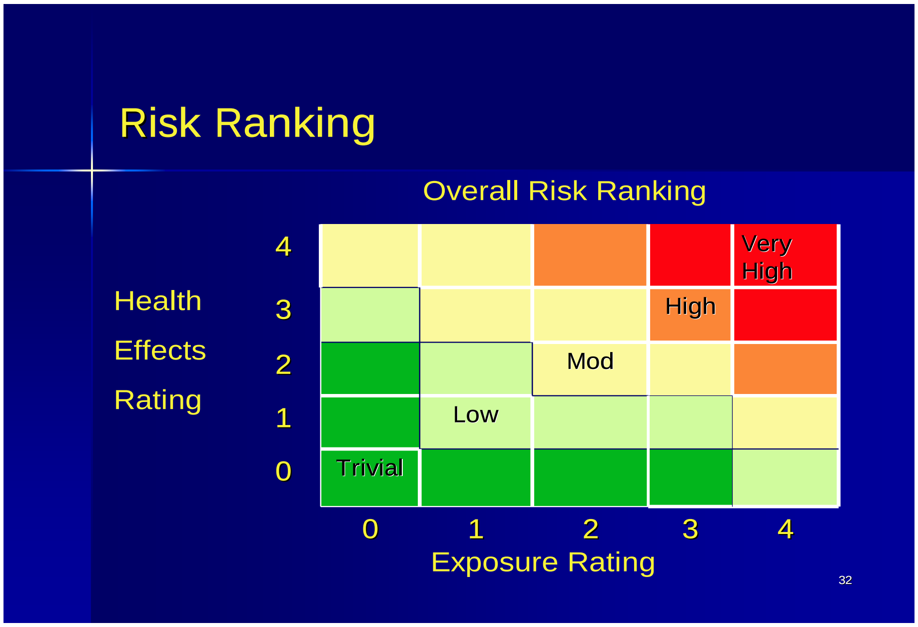
Besides the exposure limit, the agent's ability to do harm should be considered in the exposure control strategy. Table 2 contains examples of the types of harm that can be caused by excessive exposure.

Table 2 - Health Effect Rating

Health Effect Rating	Description of the Health Effect
0	At most, nuisance effects (e.g. watery eyes or obnoxious odor)
1	Reversible irritation or discomfort (whiff of ammonia)
2	Dermal or inhalation sensitization or reversible toxicity that can impair ability to function or the individual's judgment
3	Dysfunction effects (e.g. lung, kidney, liver, blood), risk of cancer due to suspected human carcinogens, or severe adverse short-term health effects
4	Significant reproductive effects, irreversible neurotoxicity, irreversible toxicity to a significant body system, known human carcinogenicity or mortality from a single exposure (e.g. carbon monoxide, phosgene, hydrogen cyanide)

Both the health effects rating and the exposure rating are used to construct a risk matrix. Figure 1 illustrates a risk matrix.

Figure 3 - Risk Ranking Matrix



Risk ranking allows the industrial hygienist to incorporate both the intensity of the exposure and severity of the hazard. In general, the more severe the health rating, the lower the OEL; however, this is not true in all cases and both the health affects rating and the exposure rating must be considered in determining risk which, in turn, dictates risk management and risk communication efforts.

- **Exposure Distribution** – Workplace, workforce and work practice characteristics result in a high degree of day-to-day variability in exposure data. Note, this variability is not due to measurement error but rather natural variability in the workplace. For example, if an IH is attempting to determine the exposure associated with a specific agent while working in a specific SEG and collected 10 random samples over the year, the highest sample would be roughly 20 to 100 times the lowest. Half (5 out of the 10) would likely be less than $1/4^{th}$ the highest sample. This distribution is counter-intuitive to how most individuals think about exposure. We think exposure is a point or level with a small uncertainty factor. When a limited number of samples are collected, there is a strong bias (published scientific papers has documented), even by the trained IH, to judge unacceptable exposures as acceptable. There are statistical tools that can be used overcome these biases but the tendency is to make a direct comparison to the OEL. That is, is the measurement data below the OEL? If one or two samples are observed below the OEL it is common for an IH to conclude exposures are acceptable.

- **Exposure Metric** – An exposure metric should be selected that is consistent with the definition of the OEL. The AIHA recommends that the 95^{th} percentile be used as the exposure metric. As most people know, if one takes a test and scores at the 95^{th} percentile, then they would have scored better than 95 % of the individuals tested and poorer than 5 percent of the individuals tested. In the workplace, if an individual works 250 days a year, then no more than 5 percent of the days or 12 to 13 days could encounter exposures at or above the OEL and then only marginally above the OEL. The 95th percentile is referred to an upper bound metric because it is like a speed limit that should rarely be exceeded. Additionally, WRPS uses the upper tolerance limit (UTL) of the 95th percentile. The use of the UTL provides a way to address statistical sample error that can be encountered because only a small portion of all the work shifts are sampled.