JACK RABBIT TRIALS I:

TRAINING VALUE ANALYSIS MEETING

Monday, February 11th – Thursday, February 14th, 2013
Saint Anthony's Parish Hall, Emmitsburg, MD

DRAFT REPORT

For Final Participant Review

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Introduction

In April and May of 2010, the Transportation Security Administration (TSA) of the Department of Homeland Security (DHS), in collaboration with the Chemical Security Analysis Center (CSAC), sponsored a series of tests called the Jack Rabbit Trials at Dugway Proving Ground, UT. In the trials, multiple successive releases were performed of 1 ton amounts of chlorine and anhydrous ammonia in various wind and other atmospheric conditions from a standardized release container and within a standardized outside test area.

The purpose of the tests was to study and improve understanding of rapid large-scale releases (60-90 tons) of pressurized, liquefied toxic inhalation hazard (TIH) gases from a railcar.

Initial analyses of test results and the recommendations made by subsequent CSAC and TSA strategy conferences on the subject suggest the need for re-assessment of planning, preparedness, and response protocols for comparable TIH releases. If that re-assessment prescribes actual changes in response protocols or a more accurate understanding of the risks and hazards that should be considered during planning, preparedness, and response, then there will also be the need for national communication and training strategies to reach the nation's response community with the new information that has been learned from the tests.

It was also recommended in these initial analyses that there is the clear need for additional tests and study to further refine our understanding of the risks and product behaviors that may be encountered in response to similar large scale TIH releases. Plans for these additional tests are currently underway.

Under the guidance of TSA and CSAC, the National Fire Academy (NFA), U.S. Fire Administration (USFA) conducted a meeting of national hazardous materials/TIH emergency response experts to make recommendations regarding the Jack Rabbit Trials findings. The meeting was held in Emmitsburg, Maryland, on February 11-14, 2013.

The 15 meeting attendees were asked to examine implications of the Jack Rabbit trials on the planning, preparedness and response procedures and guidelines used for handling major TIH incidents and releases. The meeting attendees were then asked to recommend national information and communication strategies to best inform the nation's emergency services community about the findings of the trials, including identifying areas impacted in the NFA hazardous materials curriculum as well as identifying training and information materials to be developed and released nation-wide. Finally, meeting attendees were asked to recommend areas of further study of such TIH releases and possible supplemental test procedures and measurement approaches to be considered for inclusion in a second round of Jack Rabbit trials, currently planned for March and April, 2015, and thereafter.

This is the report of the recommendations made by attendees at that meeting.

1. Review of Jack Rabbit Trials and Findings

In the meeting, a full review of the Jack Rabbit tests and subsequent data analysis was presented by Dr. Shannon Fox and Dr. Joseph Chang. A full account of these presentations is available under separate cover with restricted distribution as Appendix G of this report. Alternative written reports that also provide the full information on the Jack Rabbit tests are also available, again under controlled distribution, from the Chemical Security Analysis Center (CSAC), Science and Technology (ST), DHS.

The Jack Rabbit test program was conducted at Dugway Proving Ground, UT in April/May 2010, sponsored by DHS TSA, with program oversight provided by the CSAC. The purpose of the tests was to study and improve understanding of rapid large-scale releases (60-90 tons) of pressurized, liquefied toxic inhalation hazard gases from a railcar.

A great deal of detailed information was gathered in the tests and presented in the meeting. Some of the highlights of the findings that were discussed in depth in the presentations include:

- The highly dramatic visual account of the product behavior during initial release, which is an event stage that is usually not seen by responders.
- The occurrence of a phenomenon called Rapid Phase Transitions during the release, which were small explosions in the initial isolation zone area that have not previously been observed.
- The detailed information on the tracking of the release dispersions and downwind concentrations that provided in some cases surprising product behavior information, such as vapor having the potential to disperse against light wind under some conditions or the degree of vertical change in lethal concentrations of chlorine.

Much of the specific findings of importance to responders are detailed below in later sections of this report. In general, initial analyses of test results and the recommendations made by subsequent CSAC and TSA strategy conferences on the subject suggest:

- The need for re-assessment of planning, preparedness, and response protocols for comparable TIH releases.
- The need for national communication and training strategies to reach the nation's response community with the new information that has been learned from the tests.

- The need for additional tests and study to further refine our understanding of the risks and product behaviors that may be encountered in response to similar large scale TIH releases.

In general, the meeting attendees felt the Jack Rabbit test findings, and the future Jack Rabbit II tests that are currently being planned, were of high importance to the nation's emergency services, and meeting attendees were very supportive of the program. The work of meeting attendees subsequent to this presentation, as documented in this report, was to provide an assessment of the relevance and importance of the specific findings to the nation's emergency response community, to recommend strategies for communicating the findings to the nation's emergency response community, and to provide recommendations for further study in the Jack Rabbit II tests that are being planned to best address the response and safety informational needs of the nation's fire and emergency services.

2. Ramifications of Jack Rabbit Findings for Emergency Preparedness, Planning and Response Communities

Meeting attendees determined that the Jack Rabbit test information of particular importance to the USFA/NFA hazardous materials and incident commander curriculum included:

- The observed events called Rapid Phase Transitions which may have an impact on responder safety and safe action options, depending on further scientific analysis of cause;
- The extent and length of off gassing after dispersion from soil and impacted areas and its significance for responder decisions about when it is safe to enter the initial isolation zone;
- The observed plume dispersion information and the clarification of factors affecting dispersion, and the potential impact of this information on responder calculations of downwind areas of exposure and protective action needs;
- The enhanced understanding of dispersion and area contamination that may indicate the need to revisit some of the currently accepted strategies and tactics which may no longer be appropriate under unique conditions;
- The observed level of reactivity of an oxidizer as it comes into contact with a organic material or other reactive materials, and its impact on responder assessment of risk;
- The confirmation of the accuracy of the current ERG guidelines that are used by responders to calculate the size of initial isolation zones;
- The confirmation of the current understanding in the response community of the dominant impact of wind and weather on dispersion patterns; and
- The dramatic graphic portrayal of initial release that is rarely seen by responders, which was deemed by meeting attendees to be very important to share in order to reinforce responder understanding of and respect for the scope of risk at such releases.

Meeting attendees recommended that the best way to assess the significance to responders for specific findings and observations from the Jack Rabbit tests was to array each of the detailed findings against the relevant stages of the General Hazardous Materials Behavior Model (GEBMO). In that way, the significance of each of the findings and observations can be assessed for their relevance to actual response decision-making and for their significance in whether they would

necessitate any changes in current responder actions at the scene of a comparable release.

The stages of GEBMO are:

- **Stress**—(thermal, mechanical, or chemical stress on the material container or containment system)
- **Breach**—(including disintegration, cracking, etc., splits and tears, or punctures to the container or containment system)
- **Release**—(key characteristics include speed of release. Instantaneous? Slow? Etc.)
- **Engulf**—(what form can it take? How it flows, the regimes, terrain, urban, etc.)
- **Impinge**—(including persistence, off-gassing, dense gas trapping, etc.)
- **Harm**—(including damage caused by differences in time frame and exposure, consequences, etc.)

Meeting attendees arrayed all the findings from the Jack Rabbit I tests that were explored in the meeting against the relevant stage of the GEBMO model for hazardous materials response, and evaluated each observation's significance to current response procedures and protocols. The results of that analysis and informational array are provided in this report in Appendix D.

3. Recommendations for Informing the Nation's Emergency Preparedness, Planning and Response Community

The meeting attendees discussed at length how best to communicate the findings of Jack Rabbit 1 to the nation's fire and emergency services personnel. It was felt that it was very important to reach everyone with the information as quickly as possible, but it was also cautioned that the method of information dissemination and how the message itself is framed will be critical to avoid inadvertently over-stating or under-stating the importance of the findings. For example, it was noted that the highly dramatic effect of the visual images of the release, something rarely seen by responders, may have the potential to overly alarm and to be misinterpreted by less informed audiences, without careful messaging that is targeted correctly for the different audience groups in the emergency services and response community.

After exploring a range of information dissemination options, the meeting attendees recommended the following four step information strategy for reaching the nation's fire and emergency services audiences.

1. **Bulletin to Responders.** An immediate information bulletin should be prepared that is focused directly on the areas of interest of responders. This bulletin should be short, simple, clear and direct in terms of the practical application of the Jack Rabbit findings to response protocols; should state in responder language what has been learned and what is still unclear about risks impacting response operations; and should state clearly whether or not there are any changes to response protocols that are suggested by the findings.

   A draft of the recommended key points for this "bulletin to responders" is in Appendix C, below. In general, the bulletin should emphasize that most of the current recommended actions in the ERG are confirmed and that there are some additional potential risks that will merit further study. Some of the main points recommended by the meeting attendees are:

   - Initial isolation zone of ERG is validated.
   - Wind is validated as the dominate factor affecting dispersion. At low wind, the initial expansion from the release will be in 360 degrees. At moderate to higher winds, the expansion area will be strongly influenced by wind direction.
   - The phenomena of some movement of the vapor upwind in low wind conditions was observed and will require additional study to determine factors affecting response.
   - ERG calculations for protective actions downwind may need additional critical data, and further study will be required to determine how additional factors such as unusual weather

patterns or unusual topography features should affect protective actions downwind.

- The phenomena called Rapid Phase Transitions was observed and will require additional study to determine factors affecting risk assessment and response.

- The phenomena of longer periods of off-gassing in the initial isolation zone area was observed and will require additional study to determine factors affecting risk assessment and response.

It was recommended that this bulletin be released broadly in print and on the internet and disseminated concurrently to the fire press, to the national fire and EMS professional associations, through NFA TRADE networks to state and metropolitan fire training departments, and through USFA and through the IAB to the entire hazardous materials preparedness, planning and response communities.

2. **Fire and Emergency Services Conference Presentations.** In order to avoid the potential for misinformation (especially given the dramatic nature of some of the Jack Rabbit I visual material and given the scientifically complicated nuances in the initial findings at this stage of the program) the meeting attendees recommended that the next level of communication after the bulletin (above) would best be achieved by direct expert presentations on the findings at professional conferences.

   It was felt that the initial bulletin recommended above would reach the rank and file of the emergency services adequately with the initial, simpler information, but that the more technically schooled hazardous materials technician and command audiences would need the more in-depth information and would benefit from the opportunity for the face-to-face technical dialogue with experts that occurs in the hazardous materials conference environment.

   It was recommended that DHS ST CSAC select a limited group of hazardous materials response experts to help represent the Jack Rabbit program to the hazardous materials community at appropriate national conferences and response community national meetings. It was recommended that a standardized presentation be prepared that the team would use and that the team be schooled as necessary to ensure consistency in message.

   The meeting attendees recommended that the standardized presentation should be a direct derivative of the program presented by Dr. Shannon at the meeting, with the addition of script modifications to properly frame the findings framed into the standardized hazardous materials behavior model (stress, breach, release, impingement, harm) that is used in the hazardous materials response community.

3. **Internet Information Website.** The meeting attendees strongly recommended that DHS ST CSAC create a publically accessible website on the Jack Rabbit test program that would include both searchable detail on the findings, possible dialogue or chat opportunities for the emergency services community to provide on-going comments and input into the Jack Rabbit program, and also calendars and updates regarding plans for Jack Rabbit II.

   Meeting attendees also noted that the Jack Rabbit program, especially given the plans for Jack Rabbit II, will involve an on-going series of evolving analysis and discovery. A national internet site for exchange and dissemination of information regarding such a dynamic program would allow for continuous growth and the immediate updating of information that is not possible in other information dissemination venues.

   The other audience that would benefit from access to such a site would be other agencies and organizations that could use the site to get informed about the program and possibly to find ways to support, contribute, and otherwise participate or help in the future tests.

4. **Video Program.** Meeting attendees recommended that the fourth step of information outreach be production and national dissemination of a full video on the Jack Rabbit program and findings, targeted to the emergency services but applicable to much broader audiences. It was recognized that such a production would take longer and would not provide the immediate information release of the bulletin and conference presentations described above. But the meeting attendees felt that such a production eventually would become the primary national message channel for informing the public and nation's emergency services community about the findings of the Jack Rabbit program.

   If the internet information website (recommendation above) is established, the meeting attendees felt this would be the correct dissemination vehicle for the video program, both for online viewing on the website and for downloading.

   The meeting attendees began working on a draft script for a possible video production on the Jack Rabbit I tests, targeting the information needs of emergency responders. The initial draft of the portion of the script that was completed as a supplemental work product of the meeting is included in this report as Appendix F, below.

4. Overview of Recommendations for Including Jack Rabbit Findings into USFA/NFA Curriculum and Programs

The meeting attendees assessed the relevance of the information stemming from the Jack Rabbit trials for USFA NFA hazardous materials training, and they concluded that there was important information that should be included in USFA/NFA hazardous materials and emergency services training delivered on campus at Emmitsburg and at regional and State training sites nationally.

Meeting attendees determined that the Jack Rabbit test information of particular importance to the USFA/NFA hazardous materials and incident commander curriculum included:

- The observed events called Rapid Phase Transitions which may have an impact on responder safety and safe action options, depending on further scientific analysis of cause;
- The extent and length of off gassing after dispersion from soil and impacted areas and its significance for responder decisions about when it is safe to enter the initial isolation zone;
- The observed plume dispersion information and the clarification of factors affecting dispersion, and the potential impact of this information on responder calculations of downwind areas of exposure and protective action needs;
- The enhanced understanding of dispersion and area contamination that may indicate the need to revisit some of the currently accepted strategies and tactics which may no longer be appropriate under unique conditions;
- The observed level of reactivity of an oxidizer as it comes into contact with a organic material or other reactive materials, and its impact on responder assessment of risk;
- The confirmation of the accuracy of the current ERG guidelines that are used by responders to calculate the size of initial isolation zones;
- The confirmation of the current understanding in the response community of the dominant impact of wind and weather on dispersion patterns; and
- The dramatic graphic portrayal of initial release that is rarely seen by responders, which was deemed by meeting attendees to be very important to share in order to reinforce responder understanding of and respect for the scope of risk at such releases.

Meeting attendees identified five courses in the USFA/NFA Hazardous Materials Curriculum that can meaningfully be updated to include accounts of the Jack Rabbit trials and the findings, as part of the overall outreach effort to disseminate the information to the nation's hazardous materials response and preparedness community. These courses are:

- Hazardous Materials Incident Management (R-243)
- Chemistry for Emergency Response (R-233)
- Hazardous Materials Operating Site Practices (R-229)
- Incident Safety Officer
- Advanced Life Support for Hazardous Materials Incident Response (R-247)

The committee recommended detailed revisions and additions to each of the courses. These detailed revision recommendations are listed in full in Appendix E of this report. These recommendations for course revisions will be included in upcoming NFA curriculum revision planning and, pending USFA/NFA management approval, will subsequently be entered into the respective course production and revision cycles as part of the authoring of curriculum updates.

As part of FEMA's overall information dissemination effort for the Jack Rabbit findings, USFA and NFA will also brief appropriate Emergency Management Institute (EMI) hazardous materials and integrated emergency management program training officers on the Jack Rabbit findings summarized in this report so that appropriate areas in the EMI curriculum also at the Emmitsburg campus can be updated as well.

5. Recommendations for Further Study in Jack Rabbit II Trials

It was reported in the meeting that planning is underway for conducting a second round of test releases that are to be called Jack Rabbit II. Meeting attendees were asked to additionally recommend areas of study, supplemental data collection strategies and procedures, possible sources for support and for supplemental test equipment, and any other additions to the Jack Rabbit II tests that would help better address the informational needs of the nation's emergency services.

Tentative plans are that the Jack Rabbit II tests will occur over an extended period of time, with a first round of releases in March or April of 2015 and a second round of releases later. The second round of tests may be conducted as much as a year later, perhaps in March or April of 2016. The purpose of the time lapse between tests is two-fold: (1) it will allow time for after effects from the first round of tests to diminish so that they do not create misleading chemical interactions that might contaminate the results of the second round of tests; and (2) it will allow time for sufficient initial analysis of results of the first round of tests to determine if refinements in test conduct and test measurement procedures are needed in the second round of tests.

As currently planned, the first round of Jack Rabbit II tests will include a variety of improvements and expansions of the Jack Rabbit I effort. Some of the enhancements include:

- Providing containment systems for the releases that mimic more closely the tank car or rail car environment than was used in Jack Rabbit I.
- Providing a release system will mimic impingement situation and a non-obstructed immediate release area.
- Conducting larger volume chlorine field releases of 5, 10, and 20 tons per release.
    - Continuing evolution of higher quantity releases – scaling is non-linear.
    - 20 tons represents 100% of tanker truck transport volume and a large fraction.
- 24 trials, then in following year, as many as 24 trials again. Number of trials is subject to test plan.
- 11-km downwind dispersion data, with vertical sampling for 3-D mass-balance.
- Creating a mock urban testing environment.
- Mock urban test-ban, engineered with terrain and building features.
- Will be doing it at Dugway Proving Ground to be impacted by release cloud.
- Collecting comprehensive source term data: two-phase flow, pooling, rainout, retention, and off-gassing.

- Performing comprehensive experimental characterization of RPT phenomenology.
- Conducting Additional Laboratory Testing.

The meeting attendees made a large number of recommendations and suggestions for the Jack Rabbit II tests. The meeting attendee recommendations are listed in the tables below.

Gap or Study Area	Experiment
Source Terms	
Instruments and experimental design ideas for ground truthing data [validating or revising models]	Important to understand when it first comes out, behavior of gas. Anything that confirms or provides ground truthing data for instruments that would be very helpful. We are currently lacking an experimental idea for measuring the pool size – it sinks into the ground.
	National Geospatial Agency – old Defense Mapping Service. Could pick it up on satellite imagery
	Multiple weather and environmental conditions. Possibility of doing in different seasons.
	Type of surface a transport vehicle is releasing onto – railbed, asphalt, concrete. Some wildcard tests.
Equipment Exposure	
	We would like to attend not just to fundamentals but methods – equipment will be affected by the tox chemicals they are exposed to.
PPE	Carbon filter testing. ECBC work, noted that 10,000 ppm and up, carbon filters in masks began to ignite b/c of oxidation strength of Cl. To know how PPE will perform in this high ppm environment is really important.
Vehicles	Also, vehicles exposed to, e.g., chlorine. First responders are interested in this. If we could have equipment donated and tie exposure to concentration profiles, we will find out their resiliency, how their performance is affected, and long-term performance.
Mannequins	Put them in different spots with different PPE to see how it performs.
Bridges, Railroad ties, Telephone poles, combustibles	Degradation of it. Plywood 2x4. Asphalt shingle.
Tactics	

Gap or Study Area	Experiment
Sheltering in Place	How an incident is addressed with em response procedures. E.g., sheltering in place inside buildings, and also inside vehicles.
Vehicles	Evacuation in a large scale release – will it permeate into a vehicle? And at what rate? How effective is sheltering in place inside a vehicle. We can use donated vehicles and have air monitors inside vehicles as it is exposed, running, not running, etc.
Urban Studies	
Total Impact	Total impact on city or town. Infrastructure, equipment in offices and homes, vehicles, etc. We put a deliverable in our program an urban impact assessment – to explore good studies after Graniteville on urban studies. Can find out who conducted these. Ammonia, flammability, explosiveness
Bridges	How bridges degrade. Telephone poles, combustibles.
Vehicles	Potential donated vehicles. Explore gas-powered combustion engine versus diesel engine. Having video of that. How long can someone last in a vehicle? What is the infiltration rate inside a vehicle – air monitoring. Possible mitigation techniques. Electric Vehicles Buses – public transportation. May try to drive through cloud or evacuate people from contaminated areas.
Building	10x10 buildings – the penetration and value of sheltering in place. Prove or disprove the procedure for that. Redundant meters inside and different technologies. FEMA trailers don't count as houses. Need paint, sheetrock, carpet, furniture. Within building, elevations. Protective measures that may be taken such as lining windows, etc. Validate these procedures.
Degradation of Electronics	Naval warfare found exposure to high ppm was very destructive to them. Longer term studies showed earlier failure also.

Gap or Study Area	Experiment
Infrastructure	Sewer station, telephone components, electrical insulators, transformers, circuit breakers, etc. Power industry would be really interested in this.
Mitigation	
	Israeli's had an inflatable tent. Schools have actually looked at purchasing these for sheltering in place.
Master Streams	Fog or spray over gas cloud to alter direction or dissipate. For example, routing the gas around a congestive area. pH testing of soil would show how much was potentially removed. Evaluate effectiveness of this. This mechanism would be ideal for fixed facility, but transportation releases would not present time to try anything like this. Not limited to the type of response.
Asphalt, concrete	May oxidize
Electric vehicles	How long can someone survive inside a vehicle?
Infrastructure	Electrical insulators, transformers, lose power? Many stakeholders, e.g., power industry would have interest.
Rail Car Tracks	
Detectors	
Electrochemical	
Sampling	
	Draeger, not just the tubes, but vacutainers. Point sampling at different altitudes. Even a snapshot would provide very good ground-truthing. Grab samples along with real-time sampling
	Organics from tape, glue for suite manufacturers claiming that you must use certain types of tape.
	Quadracopters, hand-launched plane UAV
	Go-Pro cameras are HD and very reasonable expensive and we could get quite a bit of them.
Water-Borne Subsurface Release Of Gases	
	Derailments over bridges over water including how a moving water source could absorb ammonia and how fast it would bubble up out of the water?

Appendix A:
Meeting Participants

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Appendix B:
Meeting Agenda and Work Schedules

Agenda

Background

The Jack Rabbit test program was conducted at Dugway Proving Ground, UT, in April/May 2010, sponsored by DHS TSA, with program oversight provided by the Chemical Security Analysis Center. The purpose of the tests was to study and improve understanding of rapid large-scale releases (60-90 tons) of pressurized, liquefied toxic inhalation hazard gases from a railcar.

Initial analyses of test results and the recommendations made by subsequent CSAC and TSA strategy conferences on the subject suggest the need for re-assessment of planning, preparedness, and response protocols for comparable TIH releases, the need for national communication and training strategies to reach the nation's response community with the new information that has been learned from the tests, as well as the possible need for additional tests and study to further refine our understanding of the risks and product behaviors that may be encountered in response to similar large scale TIH releases.

Meeting Goals

1. Review Project Jack Rabbit I field test results and the analysis of the field test results.
2. Assess possible ramifications of the test and test results on current planning, preparedness and response protocols for large scale TIH releases.
3. Develop national communication and training strategies to best reach the nation's emergency preparedness, planning and response communities with the new information, including specific recommendations as appropriate for NFA and other federal hazardous materials training partners. These strategies should be consistent with the strategic communication priorities previously developed by CSAC and TSA for this program.
4. Develop recommendations for consideration regarding the further tests and study that might be needed to refine our understanding of TIH large scale releases and to develop revised response and planning protocols and procedures.

Meeting Work Schedule

Day / Time	Agenda Topic
Day 1, Mon., Feb. 11	
9:00 am	Wayne Yoder, NFA Hazardous Materials Training Specialist presents a brief orientation to Project Jack Rabbit and the reason for this meeting.
9:10 am	Participant Introductions
9:15 am	Shannon Fox, PhD presents an overview of the Jack Rabbit project and the Jack Rabbit 1 field tests.
11:30 am	Lunch
1:00 pm	Dr. Joseph Chang presents an overview of Jack Rabbit 1 field test methods and quantitative results.
2:00 pm	Break
2:15 pm – 4:00 pm	All participants discuss ramifications of Jack Rabbit 1 field test results for emergency preparedness, planning, and response protocols.
Day 2, Tues., Feb. 12	
9:00 am	All participants discuss communication strategies for reaching the nation's emergency preparedness, planning, and response communities.
10:30 am	The group conducts a focused discussion to distill Jack Rabbit 1 field test findings into a discrete list of implications relevant to emergency preparedness, planning, and response protocols.
12:00 pm	Lunch
1:00 pm	All participants develop a list of possible venues and associated points of contact for distribution of a consistent, standardized set of information on Jack Rabbit I findings via the hazardous materials conference circuit.
2:30 – 4:00 pm	All participants develop a list of recommendations for experimental methods and areas for further study in Jack Rabbit II trials.

Day / Time	Agenda Topic
Day 3, Wed., Feb. 13	
9:00 am	Breakout Sessions Group 1 reviews NFA's courses within the hazardous materials curriculum to identify locations within course content where insertion of Jack Rabbit information would be appropriate. Group 2 conducts an open discussion to review and refine the recommendations for experimental methods and areas for further study in the Jack Rabbit II trials. This discussion also served to debrief participants who were absent on Day 2 of the meeting and to provide the opportunity to solicit their input.
12:00 pm	Lunch
1:00 pm – 4:00 pm	Breakout Sessions (continued) Group 1 develops a draft storyboard for the video. Group 2 further refines the plan for controlled distribution of a standardized message to the hazardous materials response community.
Day 4, Thurs., Feb. 14	
9:00 am	Groups 1 and 2 report out on breakout session outcomes.
11:00 am	Meeting adjourns

Appendix C:
Recommended Key Points for Bulletin to Responders

Meeting attendees discussed at length how best to communicate the findings of the Jack Rabbit tests to the nation's emergency response community.

As preamble to the findings, the bulletin should provide a brief, definitive explanation of the program. It should:

- Formally announce that Jack Rabbit occurred.
- Explain that the ERG and other resources have been based on empirical knowledge, and that Jack Rabbit has the goal of providing responders with real scientific analysis of the behaviors of the materials released.
- Explain that the studies will be ongoing and that a second round of tests is already being planned.
- Summarize the key findings of significance to responders.
- Provide directions for responders and others to get more information.

After much discussion, meeting attendees distilled the range of issues and findings into a few key points that should be initially highlighted for responders. They are:

- Initial isolation zone of ERG is validated.
- Wind is validated as the dominate factor affecting dispersion. At low wind, the initial expansion from the release will be in 360 degrees. At moderate to higher winds, the expansion area will be strongly influenced by wind direction.
- The phenomena of some movement of the vapor upwind in low wind conditions was observed and will require additional study to determine factors affecting response.
- ERG calculations for protective actions downwind may need additional critical data, and further study will be required to determine how additional factors such as unusual weather patterns or unusual topography features should affect protective actions downwind.
- The phenomena called Rapid Phase Transitions was observed and will require additional study to determine factors affecting risk assessment and response.

- The phenomena of longer periods of off-gassing in the initial isolation zone area was observed and will require additional study to determine factors affecting risk assessment and response.

Some additional concepts recommended by the meeting attendees that will have resonance with the emergency response community center on grouping the information around the three ideas of:

1. Keep doing what you've been trained to do.
2. What you already know has been validated.
3. There are some possible new phenomena that may need your attention later. "Stay tuned" as more studies are done.

An alternative array of the information that was suggested by meeting attendees divided the material into what we already know and what is new. A draft of that array is below.

(1) Validation of what responders already know:

- Initial isolation zone, consistent with ERG.
- 360 initial dispersion (can move upwind, uphill).
- Vapor density, Venturi effect of the jet is the primary driver of initial flow.
- Low wind speeds and stability can result in extended persistence.
- Terrain/obstacle trapping.

(2) The new phenomena that may be of concern later:

- Rapid Phase Transitions. The meeting attendees recommended consideration of alternative labels in the bulletin to responders, such as "small explosion" or "spontaneous energetic release." In any case, it is recommended that the uncertainty of the mechanism for this phenomenon be clearly acknowledged in the bulletin.

- Vertical concentration gradient, with the caution that it may not apply to other materials besides Chlorine.

- Off-gassing.

Additional contextual information that was discussed in the meeting and that would be of importance in communications to responders includes:

- The testing was done on 2 specific products because they represent 75% of the transported TIH hazards. Make it clear why these two are the current focus.

- Share references of incidents showing the localization of fatalities in the 250-500m range.

Appendix D:
Translation of Jack Rabbit Phenomena and Findings into the National Hazardous Materials GEBMO Model

Concept or Phenomenon in relation to Hazmat GEBMO model	How this concept of phenomenon is demonstrated in emergency services informational materials
Stress	
	Abbreviated discussion that the tanks can be opened in a variety of ways.
	No specific discussion of the mechanisms.
Breach	
	Not a lot of time here. Just note that the breach happens.
	Use existing pictures of incidents – very similar. The puncture at MacDona vs. the fracture at Graniteville, or test results.
Release	
Release rates	Small hole vs. catastrophic damage where all the material is released
Hole location	Top vs. liquid space.
Hole orientation	Large bulk can remain in tank
Auto-refrigeration	Frost line on breached cars. Mark – they do an auto-refrigeration demonstration at SERTC – could easily get videos on that to demonstrate. Bill has the Graniteville pictures.
	Vapor cloud may be super-cooled below boiling point (as low as -70^{o}C). Makes even more dense. Equipment may be impacted. Flash-freezing. Glaze of chorine-water hydrates.
Jet direction	Impingement into the ground vs. vertical (up) direction vs. side (auto-refrigeration once level is reached)
	After auto-refrigeration
Engulf	
Wind is king for cloud migration	Then temperature and humidity
Effects of weather, ambient conditions	On low-wind days, even ammonia can persist.
Models not aligning always with observations	For all compressed, liquefied gases.

Concept or Phenomenon in relation to Hazmat GEBMO model	How this concept of phenomenon is demonstrated in emergency services informational materials
Terrain, obstacles	How the material flows, interacts with these features in the environment. Festus video.
Vertical differences	Concentration profile
Vapor density	Comparison of Cl_2 and NH_3 videos
Large expansion ratio	For liquid to gas
ERG protective actions downwind need additional critical data	Initial isolation zone of ERG validated Showing videos and plume dispersion models—the things they fail to take into account. That additional science needs to be considered to reconcile what models and observations.
Impinge	
Off gassing	Ammonia bubbling. Contaminated mud; hazard that can be brought away from hot zone.
Rapid Phase Transitions	Jet impingement. Clarify that further information is needed to characterize what is going on. The fact that the eruptions may occur is important. Caveat that we aren't sure of its causes definitely. Let them know the working hypothesis but that further study is forthcoming.
Off-gassing of permeated/adsorbed chemical	Demonstration of the low-wind speed case where it can be resident, persistent for extended periods of time. Moving dirt around can cause dangerous enhanced off-gassing. ("Contaminated soil") combined with "off-gassing" of permeated gas. Results in secondary cloud evolution. Even though the cloud is gone, there can still be danger from soil continually releasing trapped chemical.
Longer-term (be careful with term – specify hours) secondary plume	
Soil, vegetation	How long afterward there is still product coming out of the ground. Mud may have continuous off-gassing. Caustic
Chemical properties	In the soil, atmosphere
Harm	
Compressed, liquefied gas hazards	
Different gases will have specific additional hazards	Beyond liquefied gas general hazards (i.e., explosive, flammable, corrosive, etc.)
Toxic load, dosages (concentration x time)	

Appendix E:
Detailed Recommendations for Inclusion of Jack Rabbit Findings into USFA/NFA Curriculum and Programs

The committee identified five courses in the USFA/NFA Hazardous Materials Curriculum that can meaningfully be updated to include accounts of the Jack Rabbit trials and the findings, as part of the overall outreach effort to disseminate the information to the nation's hazardous materials response and preparedness community. These courses are:

- Hazardous Materials Incident Management (R-243)
- Chemistry for Emergency Response (R-233)
- Hazardous Materials Operating Site Practices (R-229)
- Incident Safety Officer
- Advanced Life Support for Hazardous Materials Incident Response (R-247)

The committee recommended detailed revisions and additions to each of the courses, as listed below. These recommendations for course revisions will be included in upcoming NFA curriculum planning and subsequently, pending USFA/NFA management approval, entered into the course production and revision cycles. As part of this information dissemination effort, NFA will also brief appropriate Emergency Management Institute (EMI) hazardous materials and integrated emergency management program training officers on the Jack Rabbit findings summarized in this report so that appropriate areas in the EMI curriculum can be updated as well.

Hazardous Materials Incident Management (HMIM)

The best fit is in unit 3, in the area of decision-making. There is an area that discusses risk-based response, specifically the facts, science and circumstance of the incident.

An option would also be to introduce the course with the information, but there is already an introduction scenario.

Recommendation is that it be conducted as a discussion-based activity at the end of the chapter, outlining that even the best science is still not 100 percent accurate. The situation may change during the incident, and the Incident Commander must continue to look at data and continually update their situational awareness as more information becomes available.

Incident Safety Officer

Unit 5 appears to be the best place because that unit has a hazardous materials component and terrorist attacks.

Slides 5-19, 5-22, 5-23

Safety at selected incident sites; the current course speaks to uphill and upwind. This would be a place to mention that under specific wind conditions the hazardous cloud could move uphill and upwind. It could be changed to Haz Mat /WMD for the title and add at terrorism.

Components to include would be:

Rapid Phase Transitions

Off Gassing

Plume dispersion piece/initial zones may not be safe

The current accepted tactics and strategies may not be appropriate under unique conditions. The safety officer's job is to be aware of those specific hazards.

Chemistry for Emergency Response

Best fit is in Unit 8, Physical and Chemical Properties.

Discussion would be based around the science and specifically what is happening. Rapid Phase Transition is a great part of the discussion as well as the compressed gas phenomena. Also a great part of the discussion would be the reactivity of the oxidizer as it comes into contact with an organic material or other reactive materials.

Recommend that it be conducted as an activity. There are three activities in this unit; one of the activities could be replaced. Liquefied gas should be part of the discussion.

Hazardous Materials Operating Site Practices

Possible areas were considered for inclusion of the material in this course: Unit 2, Unit 4, Unit 8 or Unit 10.

The group felt that one consideration for the material would be in Unit 4, activity 4.1 is Physical Properties/Rapid Assessment Rapid Hazard. This existing activity could be replaced.

Protective Action Criteria is a term that should be used instead of Initial and Secondary Public Protection Actions. There should be a review of how the terms are used in Unit 8 and 10.

Recommend that the material is best placed at the end of the isolation section lecture of Chapter 8, before activity 8.1.

Recommend that the terms also be standardized to reflect verbiage used in the Emergency Response Guide, i.e., Initial Public Protection, and Secondary Public Protection be replaced with Protective Action Criteria or the verbiage out of the ERG.

Advanced Life Support for Response to Hazardous Materials Incidents

The best fit for this course is in Unit 7. This is the Inorganic Non-Salts unit where things like Ammonia and Hydrogen Fluoride are discussed. Although it is not a perfect fit, it is the appropriate place to discuss the toxicity of these gases. Need to add a discussion on how gases are liquefied for shipment and the hazards of liquefied gases.

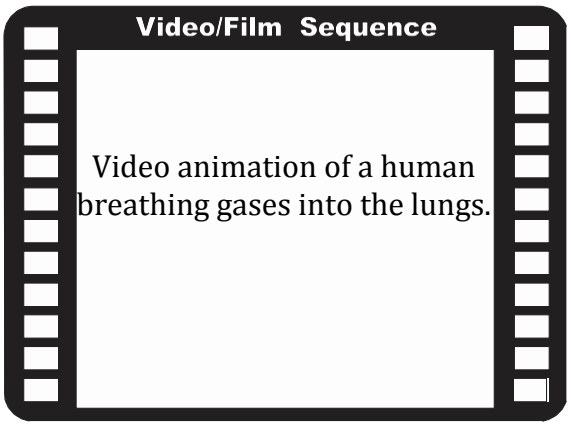
Since this course is currently under revision, it is the group's recommendation that the new information from JR should be utilized in writing the new course.

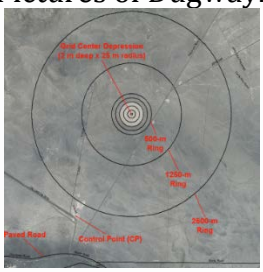
Appendix F:
Sample Draft Script for Presentations to the Nation's Emergency Services Community

	Script	Visuals
1	Rapid Phase Transitions Off-gassing persistence Factors affecting dispersion during a release Inaccuracies in the models (opening to the video)	**Graphic/Photo/Audio Scene** Opening title animation
2	(Narrator reads) Every year, many products are stored and transported around the nation. Some of these products are hazardous in nature and present a problem to responders if a spill or accident occurs. To effectively ship gaseous products, many of these gases are liquefied by cooling or compression to reduce container size and thus shipping costs. Although there is a tremendous savings in transportation and storage costs, the process of liquefying a gas is not without its hazards. The purpose of this video is to review some of those hazards that are well known and to introduce some new phenomena that have been discovered in researching these incidents.	**Video/Film Sequence** Video shots of tank cars and vessels transporting hazardous materials. **Video/Film Sequence** 

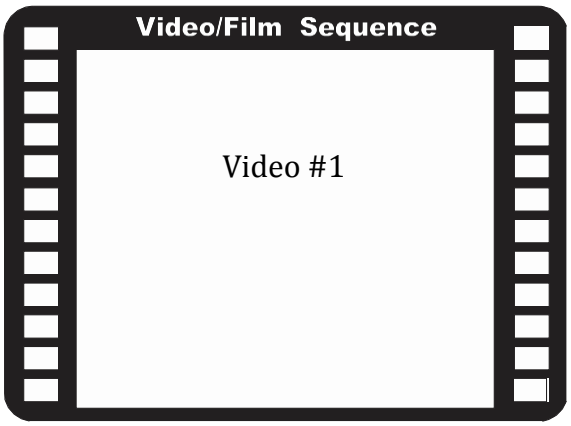
	Script	Visuals
3	(Narrator reads) Although rare, accidents do occur. When they do, communities and responders are potentially exposed to dangers. This video will review some of the lessons learned in recent accidents and the information that responders and community emergency management planners should know to protect themselves and their communities.	**Video/Film Sequence** Switch to screen shots of accidents. 
4	First, let's review the physical laws of nature. Industry takes gaseous products and reduces their volume by compression or cooling to dramatically reduce their volume. The result is that now those products are stored in containers that maintain a certain pressure to keep the products liquefied. If that container is damaged in an accident, there will be a release of the product into the atmosphere around the container. Since many of these products are considered dangerous to the environment and to living things, these accidents carry a very serious consequence. Several accidents over the years have reminded us of those consequences and serve as a great study for planners and responders.	**Video/Film Sequence** Screen shots of industrial storage of compressed liquefied gases. Consider an animation of how gases are liquefied. **Video/Film Sequence** 

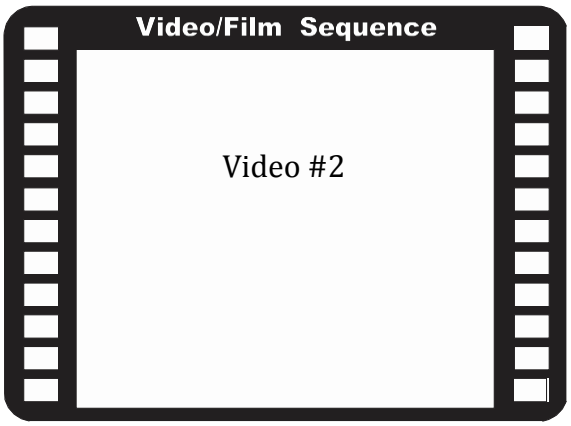
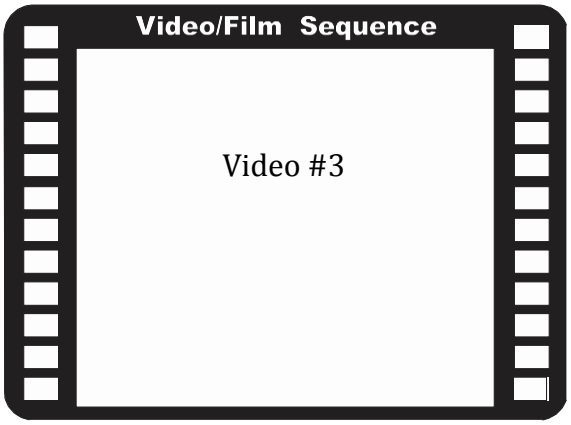
	Script	Visuals
5	By far, the two most common liquefied gases are Chlorine and Anhydrous Ammonia. Although these gases have several specific hazards, the greatest concern is that of inhalation. In fact, they are classified as Toxic Inhalation Hazards (TIH) and have been responsible for many injuries and deaths when involved in accidents.	**Video/Film Sequence** Insert statistics of quantities of gases manufactured in the US every year.
6	The reason for the deadly effect of these gases is twofold. First, the large expansion ratio of a liquid to a gas, and two, the toxic effect of the gas. The large expansion ratio results in extremely high concentrations of the product that expands to great distances from the source or release site. The fact that the products are in a gaseous state means that they are readily inhaled into the body through respiration.	**Video/Film Sequence** Shots of videos showing industrial accidents of Chlorine.
		Video/Film Sequence 

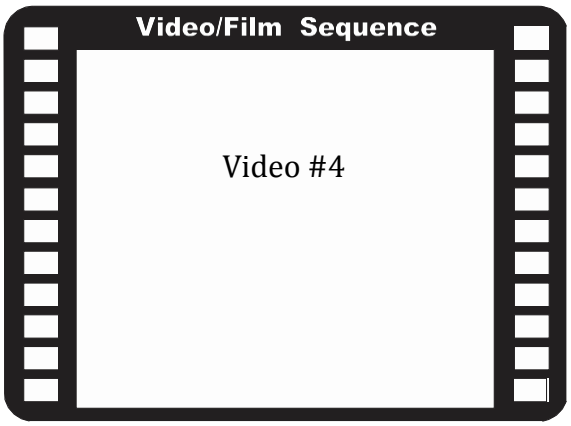
	Script	Visuals
7	As previously stated, accidents are rare. However, when they do occur, victims in the area of a release of a compressed liquefied gas can be exposed, injured or killed. Emergency responders must fully understand the behavior of compressed liquefied gases in order to provide the appropriate protective actions. Historically, emergency managers, investigators and educators have studied the effects of incidents and accidents to see the effects of these accidents and the behavior of the gases released during an accident.	

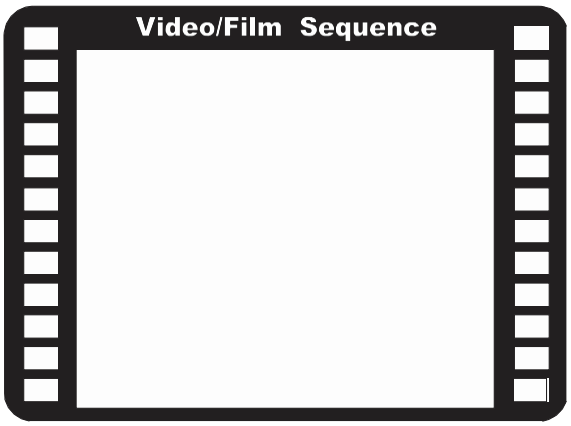
	Script	Visuals
8	One such event was in Graniteville, SC. On January 6th, 2005, at approximately 2:40 am, a Norfolk Southern train derailed and released an estimated 150 tons of liquefied Chlorine, resulting in one of the worst transportation accidents involving liquefied gases in the U.S. 9 people died, 250 were injured and about 5400 people evacuated during the event. Accidents like the Graniteville incident remind emergency planners and responders that they must study and be familiar with the chemical and physical properties of toxic materials and liquefied gases. Each event gives us more information about the proper actions that must be taken to protect the public and emergency responders during an event.	**Video/Film Sequence** Cut to Graniteville Video 
9	In 2010, experiments were conducted at Dugway Proving Grounds in Utah to research some of the observed phenomena at large releases of liquefied gases. These studies are necessary to properly prepare responders so that they may take effective actions to minimize injuries and loss of life.	**Video/Film Sequence** Pictures of Dugway. 

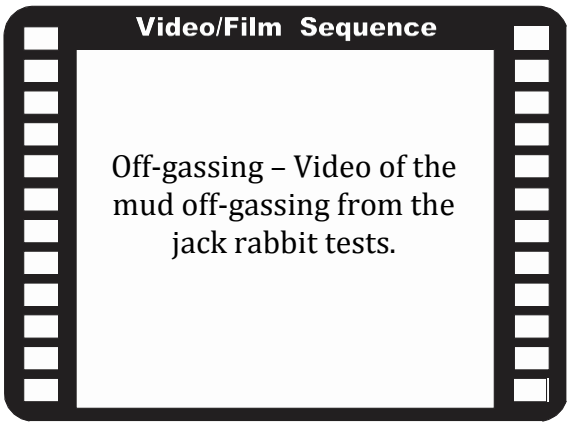
	Script	Visuals
10		Video/Film Sequence Pictures of Jack Rabbit tests. 
11	The Jack Rabbit test was designed to study the effects of large-scale (1-2 tons) releases of compressed liquefied gases (Cl2 & NH3). The findings have driven the need to share certain phenomena with the response community. Predictions such as wind effect, vapor density, and initial isolation zones were validated. Protective measure criteria, terrains effect on the traveling vapor cloud, condensed liquid phenomena (extremely cold liquid, large expansion ratios and the chemical properties of the products) such as unexpected violent reactions need to be researched further in Jack Rabbit II.	Video/Film Sequence Text for video clips needed from Shannon.

	Script	Visuals
12	NH3 and Cl2 side-by-side in high wind conditions and then low wind conditions. This video supports that wind is the most important factor when determining the direction of a dispersing vapor from a hazardous materials release. The initial release expands in a 360-degree fashion and is then affected by the wind. Notice the rate of evaporation and diffusion of vapor concentration is greatly impacted with wind speeds above 10 mph. (High wind video clip at approx. 13.8 mph) Using the low wind speed video, note that the vapor density of Chlorine (~2.5 times heavier than air) is demonstrated compared to Anhydrous Ammonia (~.5 less than air). Discuss why the birds landing within ~10' vertical from the Cl2 release are unaffected.	

	Script	Visuals
13	Cl2 with violent reactions coming from the ground. This video shows some unexpected explosions coming from the ground around the tank, continuing for over an hour after the release. It has been hypothesized that these may be Rapid Phase Transitions caused by the extreme cold of the Cl2 contacting moisture in the ground. Other explanations are also possible driving the need for further research. It is important to note the same reactions were not found with the NH3 trials.	
14	NH3 bubbling through the mud puddles hours after the release. This video shows the soil releasing NH3 into ground water creating a caustic solution of Ammonium Hydroxide. This is important to relay to responders the need to pH any standing water that may have come in contact with Anhydrous Ammonia.	

	Script	Visuals
15	Downwind travel of large-scale releases of compressed liquefied gasses lack critical criteria. (low wind phenomena, product reactivity, terrain, compressed liquefied gasses absorbed into materials cause off-gassing) This video shows footage from Festus MO (terrain), MacDona TX (low wind phenomena where cloud creeps upwind), Graniteville (off-gassing of Cl2 that had absorbed into the ground). It is important to note that these compressed liquefied gasses create specific hazards related to their unique chemical properties (flammable, toxic, corrosive, oxidizer, asphyxiate, etc.)	
16		

	Script	Visuals
17	Case reviews Graniteville, SC (2007 video) Fetus, TX MacDona, TX (2004 Video) Caderock, CO Rail Car on Siding Cl2 Minot, ND NH3 French Video All of these incidents demonstrate how a hazardous product reacts when it escapes its container. Planners and responders are very familiar with the hazards of compressed and liquefied gases. Those hazards include large expansion ratios, oxygen displacement, flammable atmospheres, frostbite, toxic atmospheres, limited visibility, corrosive, oxidizer, and other physical damage to products and living things that the gases come into contact.	
18		

	Script	Visuals
19		
20	Number of deaths regarding the TIH's Chlorine Historic research has shown that all deaths back to the 30s occurred within 500 meters of the release. Citation needed.