From: Belaval, Marcel
Sent: Thursday, November 4, 2021 2:15 PM
To: Driscoll, Keith J NFG NG MAANG (USA) <keith.j.driscoll.nfg@army.mil>
Cc: leonard.pinaud@state.ma.us; Downing, Jane <Downing.Jane@epa.gov>; Springborg, Denise <Springborg.Denise@epa.gov>; Jacobs, Kira <Jacobs.Kira@epa.gov>
Subject: Additional request for information for EPA SSA review on proposed MPMGR

Dear Keith,

Thank you for providing responses to the information request sent from EPA to MAARNG on 10/5/21. EPA has been reviewing information provided by MAARNG in these responses.

EPA understands that MAARNG intends to develop and finalize monitoring plans in the OMMP with input from the EMC in the future. Several MAARNG responses to questions and requests in the "Monitoring" category indicate that information is not yet available and/or will be determined in the future (see MAARNG responses to request numbers 1, 2, 3, 4, and 5). In order to complete the SSA review, a fully developed monitoring plan is required. The monitoring plan as described in the Draft OMMP, including responses to the 10/5/21 information request, is lacking detail in many critical areas.

EPA requires that MAARNG develop an environmental monitoring plan that describes monitoring for each media (soil, subsurface soil, porewater, and groundwater) including, but not limited to sample locations, protocols, depth, frequency, reporting, trigger levels, etc. The monitoring plan may follow the general outline of Section 9.0 in the Draft OMMP; however, it should be a fully developed plan. If modeling is used in any component of the monitoring plan, provide details about the modeling conducted to inform the plan.

The following table provides EPA's current list of questions and information requests based on review of MAARNG responses to the 10/5/21 information request and the Draft OMMP.

Request Number	Question/Request
20211104-01	Provide calculations for ammunition estimates in MAARNG's response to "Design 4" in the 10/5/21 information request. Include annual use calculations. Specify expected number of tracer rounds in ammunition usage estimates.
20211104-02	Provide more details on recycling and storage of harvested rounds ("O&M 1" from 10/5/21 information request). Where is the location of the recycling facilities "outside the reserve"? What are the procedures for compiling and transport within the MPMGR? What are the BMPs that will be used during harvesting, transporting, recycling, and storage to minimize release of contaminants?
20211104-03	More information is needed about how the 90% efficiency ("O&M 2" from 10/5/21 information request) was determined. Provide data and/or reference to calculations which were used to determine the efficiency. What is the fate of the remaining 10% of rounds not recovered?
20211104-04	MAARNG response to "O&M 3" in the 10/5/21 information request indicates that the harvesting frequency described in the Draft OMMP is a placeholder only. How is the appropriate density for projectile harvest determined, and what is the estimate for how often harvesting will occur?

20211104-05	Several MAARNG responses to the 10/5/21 information request reference an upcoming "copper projectile harvest test." Describe the plans for this test including how results will be used in developing/refining range procedures.
20211104-06	If fire suppressing chemicals are needed, will they contain PFAS or other fluorine compounds?
20211104-07	Provide compiled monitoring data collected at Sierra range for soil, subsurface soil, porewater, and groundwater showing results for copper, antimony, lead, and other contaminants of concern over the period when copper ammunition has been in use at the range.
20211104-08	Provide scope of work for investigating environmental impact of tracer rounds proposed for use at MPMGR (as requested by EMC EO).
20211104-09	Provide a timeline for submitting an environmental monitoring plan as described in the paragraphs above.
The following requests should be included within the environmental monitoring plan.	
20211104-10	MAARNG response to "O&M 6" in the 10/5/21 information request refers to modeling conducted to determine soil action levels. Provide details about this modeling, including the modeling methodology and how results were translated into action levels. (This information should be included in the monitoring plan requested above.)
20211104-11	Table 9-2, subsurface soil action levels, is missing from Draft OMMP. Provide missing table. (This information should be included in the monitoring plan requested above.)
20211104-12	Develop a flowchart or series of flowcharts for soil, subsurface soil, porewater, and groundwater which shows each trigger level and the management actions to be initiated when trigger levels are exceeded. (This information should be included in the monitoring plan requested above.)
20211104-13	MAARNG response to "Monitoring 8" in the 10/5/21 information request refers to evaluating trends annually; however, the Draft OMMP states that surface soil sampling will be conducted every 3 years (see sections 9.0 and 9.4). Clarify the frequency of sampling that will be conducted. (This information should be included in the monitoring plan requested above.)

As always, please reach out if you have any questions.

Thank you,

Marcel

Marcel Belaval
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617.918.1239

USEPA
SOLE SOURCE AQUIFER REVIEW
RESPONSE

Massachusetts National Guard

Camp Edwards, MA 02542

In Coordination with the

Environmental Management Commission

22 March 2022

PREFACE

The following information and data provide definition, context, and answers for the USEPA's MPMG Sole Source Aquifer Review inquiry. It addresses monitoring and related issues, projectile recovery efficiency, and projectile harvesting. Definition was provided for terms, structure, and process. The information is provided in the context of the ammunition used, past information and data, lessons learned, and environmental protection. It is our hope that this document provides the answers or a path forward that shows that our primary concerns are being as current as possible with Best Management Practices, regulatory and partner coordination, and environmental protection that will preserve and or improve natural resources, specifically groundwater. Range management activities are coordinated, reviewed, and approved by the Environmental Management Commission Environmental Officer before the proposed range can be active. For the way forward to make timing and other decisions regarding projectile management and environmental monitoring see the following sections below arranged by USEPA Question.

Table of Contents

Preface 1

USEPA Sole Source Aquifer Review Questions.. 4

20211104-01: Provide calculations for ammunition estimates in MAARNG's response to "Design 4" in the 10/5/21 information request. Include annual use calculations. Specify expected number of tracer rounds in ammunition usage estimates. 4

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Table of Contents, continued

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Appendix 1 40

Appendix 2 95

Appendix 3 104

Appendix 4 255

Appendix 5 278

USEPA Sole Source Aquifer Review Questions

20211104-01: Provide calculations for ammunition estimates in MAARNG's response to "Design 4" in the 10/5/21 information request. Include annual use calculations. Specify expected number of tracer rounds in ammunition usage estimates.

Design 4: For each type of ammunition, provide the total number of rounds per day expected to be fired for each weapon (in average use and maximum use scenarios)

Massachusetts Army National Guard (MAARNG) Response:

Estimated 5.56 EPR ammunition per range day:	11,100
Estimated 7.62 EPR ammunition per Range day:	8,800
Estimated Max Ammunition Use (1 Range day):	5.56: 48,400 7.62: 25,600
Estimated Annual use:	5.56: 669,900 7.62: 280,000

Ammunition estimates are based on Army Training Circular (TC) 3-22.240 (7.62) and TC 3-22.9 (5.56) from the number of weapons provided in question Design 2. Please note that this is an estimated maximum use estimation.

Calculation formula for estimated ammunition per range day is (average number of weapons by unit) x (number of rounds required by firer) = total number of rounds.

To calculate EPR Tracer, EPR ratio = Total Rounds Required - (total rounds required / 5)

Calculation for Max use is (Highest Number of Weapons in a Unit) x (Rounds Required)

Calculation for Annual Use is (Total Number of Weapons) x (Rounds Required)

Note: Range activities in the reserve component usually occur Friday through Sunday as needed.

<u>M249 Machine guns (5.56 rounds)</u>:

Average use scenario = 10 x 1,110 = 11,100. 11,100 - 2,220 = 8, 880 EPR Rounds, 2,220 EPR Tracer Rounds

Max use scenario (1 Day) = 44 x 1,100 = 48,400. 48,400 / 5 = 9,768 EPR Tracer, 48,400 – 9,768 = 38,632 EPR Rounds

Annual use Scenario = 609 x 1,100 = 669,900. 669,900 / 5 = 133,980 EPR Tracer, 535, 920 EPR Rounds

<u>M240B Machine gun (7.56 rounds)</u>:

Calculation for M240B average daily use: 11 x 800 = 8,800 rounds. EPR Tracer, EPR mix = 8,800-1,760 = 7,040 EPR Rounds, 1,760 EPR Tracer Rounds

Max use scenario (1 Day) = 32 x 800 = 25,600. 25,600 / 5 = 5,120 EPR Tracer rounds, 20,480 EPR Rounds

Annual use scenario = 350 x 800 = 280,000. 280,000/5 = 56,000 EPR Tracer, 224,000 EPR Rounds

20211104-02: Provide more details on recycling and storage of harvested rounds ("O&M 1" from 10/5/21 information request). Where is the location of the recycling facilities "outside the reserve"? What are the procedures for compiling and transport within the MPMGR? What are the BMPs that will be used during harvesting, transporting, recycling, and storage to minimize release of contaminants?

Storage of projectile material will be outside the Reserve/Training Area. Storage of projectile material will be in approved labeled containers while separation takes place, and if not immediately transported to a recycling facility, the material will be stored in the MAARNG's Qualified Recycling Program yard.

Recycling-receiving facilities are commercial and must be properly licensed.

Berm material is screened with projectile material compiled at the individual target and backstop berms, soil is reused for berm maintenance, and projectile materials are then transported off the range in approved containers to be immediately recycled or stored in the QURP yard until recycling occurs.

BMPs to minimize release of contaminants are: not to conduct separation activities on windy days, soils should be moist, plastic sheeting at the separation area to keep soils and projectile material contained, soils will be used for bullet pocket maintenance, and projectiles will be collected and contained in approved containers for recycling. For further procedures regarding projectile harvesting see review document section for projectile harvesting and periodic metals removal (page 21) for the OMMP.

20211104-03: More information is needed about how the 90% efficiency ("O&M 2" from 10/5/21 information request) was determined. Provide data and/or reference to calculations which were used to determine the efficiency. What is the fate of the remaining 10% of rounds not recovered?

From tests conducted at other ranges, the proposed MPMG range is expected to be within this efficiency range. Our conservative estimate based on the range type is 90% capture and containment at the target and backstop berms with the remaining 10% captured within the range floor just in front of the target berms. From study described below there is approximately 0.183% of unrecoverable overshot. The remaining 9.82% is captured on the range floor. During regular range inspections that occur pre, post, and for general maintenance, bullet pockets are identified for maintenance that can include soil addition and or projectile recovery operations.

At Tango Range (25 meter) the MAARNG conducted a Mass Balance as required by USEPA, MassDEP, and the EMC and found that compared to data on weight of total rounds fired there was a 94.3% projectile recovery rate at Tango Range (2016 USEPA Pilot Period Final Report) (Appendix 1). Given the inherent difficulties of the field measurement (lead rounds that fragment) and the precision of some of the measurements, roughly 94% agreement can be considered excellent recovery. An overshot wall above the berm (STAPP™ system) was erected to determine the amount of overshot on the range. Overshot was closely monitored and individual bullet holes were marked, dated and counted. Calculating the percentage of overshot using the number of rounds fired from the wall erection date to the end of the period, shows 0.183% so roughly 99% of the rounds fired were likely contained in the berm. From both methodologies it is expected that the berm and its supporting components are successful in capturing and containing from 94%-99% of the projectiles fired at the system.

At Echo Range, a pistol range where copper clad lead ammunition is used, several test fires were conducted before this range was active to determine capture, containment, and recovery. Of 100 rounds fired at the last test fire, 95 projectiles were recovered with five rounds believed to be contained within the Dura-Bloc that was protecting the target mechanism (2015 Echo Range Test Fire and Supplemental Test Fire Summaries 13 August 2015) (Appendix 2). This is a 95-100% projectile recovery rate.

At Sierra Range, an analog for the MPMG, a line of sight analysis was conducted to identify projectile distribution and initial dispersion and to aid in identifying appropriate best management practices and pollution prevention procedures for the range (Appendix 3). Two thousand one hundred twenty rounds were used to conduct a live fire exercise to validate Phases I and II of the line of sight analysis. The line of sight methodology was a three-phased operation. Phase I was a geospatial information system (GIS) overview to identify potential issues along Gun Target Lines (GTL) for each Stationary Infantry Target (SIT) location (Figure 1). Phase II utilized laser designation from the point of origin to the point of impact to validate Phase I and identify obstructions to the projectile flight path or the view of SIT locations down range. Phase III was the execution of a live fire exercise; simulating Soldier participation in a modified record fire. The results of this test fire showed that this type of range can be built with projectile capture and containment structures that will capture and contain projectiles and will not affect training requirements. Containment structures need to be built of the proper material to minimize to the maximum extent possible fragmentation and wide and high enough to avoid most overshot and ricochets. Although not a primary part of the test fire, recovery was less than acceptable but the test showed that greater containment can be achieved by applying the lessons learned for range structure. Informal hand screening test have shown approximately a 90% recovery by weight. However some weight was lost due to most of steel penetrators oxidizing away.

See the following sections: Projectile Recovery Efficiency, Projectile Harvesting, and Monitoring.

Projectile Recovery Efficiency Supporting Material

<u>Introduction</u>

Projectile Recovery Efficiency is a function of bullet type, containment media, and fragmentation. In the case of Camp Edwards when referring to bullet type we are referencing lead vs copper projectiles. They both have the same basic structure, bullet core, jacket, and penetrator (Figure 1.) For the purpose of projectile recovery, the main difference is the lead core that is rarely found intact, where with the copper core it is primarily found intact even at the closest targets. In other words, the lead core has an extreme tendency to fragment where the copper core does not and remains largely intact. The jackets are the same; but with the copper round the jacket is more tightly bound to the core and are often found bound together. The lead core and its jacket are most often separate and in pieces due to the fragmenting nature of the lead core. The steel penetrator for both rounds readily oxides away; therefore they are not recoverable, and this must be taken into account for any recovery operations. Containment media is critical to projectile recovery. Containment material must be able to capture a round in a relatively shallow manner, must be as free as possible of material that can cause ricochets or fragmentation, and must be of a nature to capture and reduce fragmentation. The containment media, i.e. berms, must be constructed to the appropriate height and width such that the containment media functions as intended. Finally, reducing fragmentation is very important to projectile recovery; with lead bullets the fragmentation is generally extreme where the lead core and copper jacket are in pieces versus the copper bullets where the copper core and jacket generally remain intact, and if separated, there is almost no fragmentation of the copper core (Figure 2).

Characteristic	M855	EPR
Cartridge Length	2.248 in	No Change
Bullet Weight	62gr	No Change
Tip ID	Green	Bronze from Corrosion Protection
Slug	Lead	Copper
Cup/Jacket	Copper	No Change
Penetrator	Steel	Steel Arrow Head
Corrosion Resistance	None	Yes
Propellant	WC-844	SMP-842
Flash Suppressant	No	Yes
De-Coppering Agent	No	Yes
Velocity	3113 ft/s	Increased
Chamber Pressure	M855 Spec	Increased
Penetration	3/8" Mild Steel @ 160m	3/8" Mild Steel @ 350m
Soft Target	Not Specified	Improved Consistency and Range

Figure 1. Lead vs Copper Ammunition (5.56 and 7.62 mm ammunition), Camp Edwards, Massachusetts

Figure 2. Copper Projectile Fragmentation, Camp Edwards, Massachusetts

A line of sight analysis was conducted on Camp Edwards's 300 meter Modified Record Fire (MRF) Range or Sierra Range to identify projectile distribution and initial dispersion and to aid in identifying appropriate best management practices and pollution prevention procedures for the range (Appendix A). Two thousand one hundred-twenty, of 5,000 authorized, M855, 5.56 ball cartridge, green tip with a steel penetrator and lead core were used to conduct the live fire exercise to validate Phases I and II of the line of sight analysis. The line of sight methodology was a three phased operation. Phase I was a geospatial information system (GIS) overview to identify potential issues along Gun Target Lines (GTL) for each Stationary Infantry Target (SIT) location (Figure 1). Phase II utilized laser designation from the point of origin to the point of impact to validate Phase I and identify obstructions to the projectile flight path or the view of SIT locations down range (Figure 2). Phase III was the execution of a live fire exercise; simulating Soldier participation in a modified record fire qualification table; to validate Phases I and II (Figures 3-6). The line of sight analysis process developed for this project demonstrated that auxiliary structures can be emplaced while not obstructing the line of sight of Soldiers at the firing point, the ability to predict the projectile distribution, initial dispersion, and to show that the range floor would not have to receive projectiles in the operation of Sierra Range. The DefenCells® (bullet capturing rubber block) functioned very well to contain projectiles. However, the best recovery efficiency of projectiles from internal soil media was only 34%. The earthen berm and SIT frontal berms had limited capabilities to contain projectiles on their first point of impact due to three key factors: 1) the angle of repose of frontal berms were conductive to non-containment; 2) the soil media was highly compacted resulting in shallow projectile penetration depths; and 3) the soil was screened to 1/2" minus leaving large pebbles that intensified fragmentation of projectiles limiting recovery efforts.

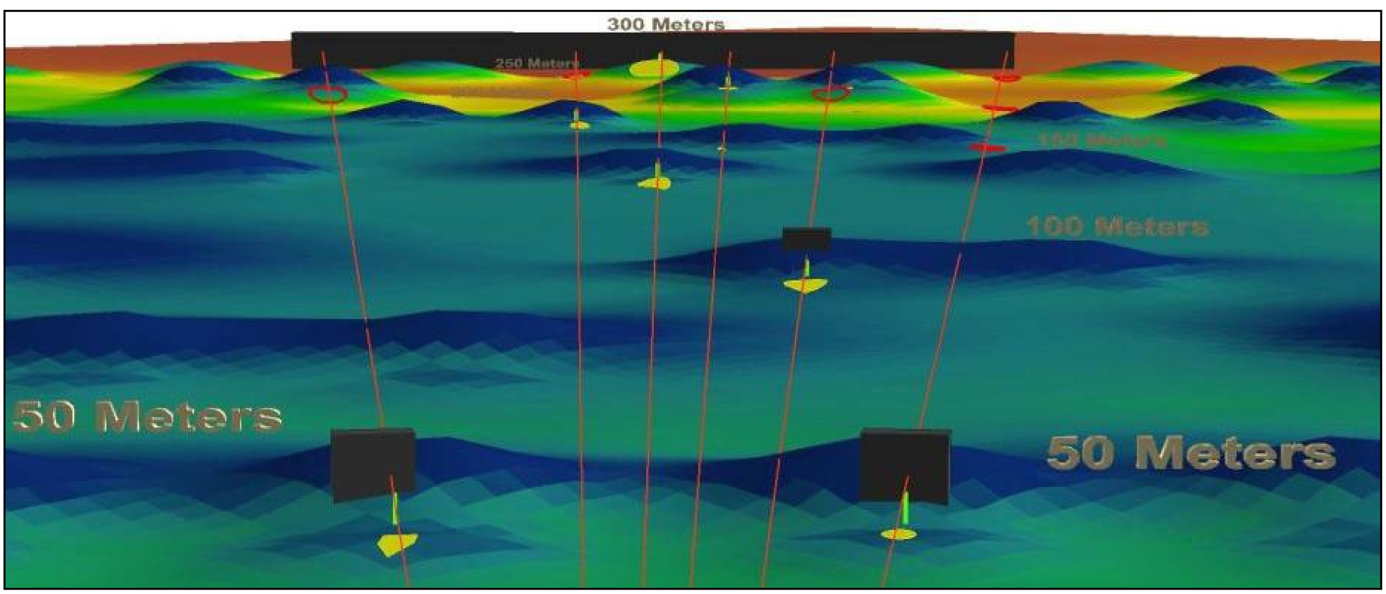

Figure 1. Line of Site, Phase 1, Geospatial Information System, Gun Target Lines (GTL), Stationary Infantry Target (SIT), Sierra Range, Camp Edwards, Massachusetts

Figure 2. Phase 2 Line of Site Laser Analysis Confirming Phase 1 Virtual Line of Site
Sierra Range, Camp Edwards, Massachusetts

Figure 3. Test Fire Set Up to confirm Phases 1 (Virtual) and 2 (Laser), Sierra Range, Camp Edwards, Massachusetts

Figure 4. Fifty Meter Target Berm with Backstop after Test Fire, Sierra Range, Camp Edwards, Massachusetts

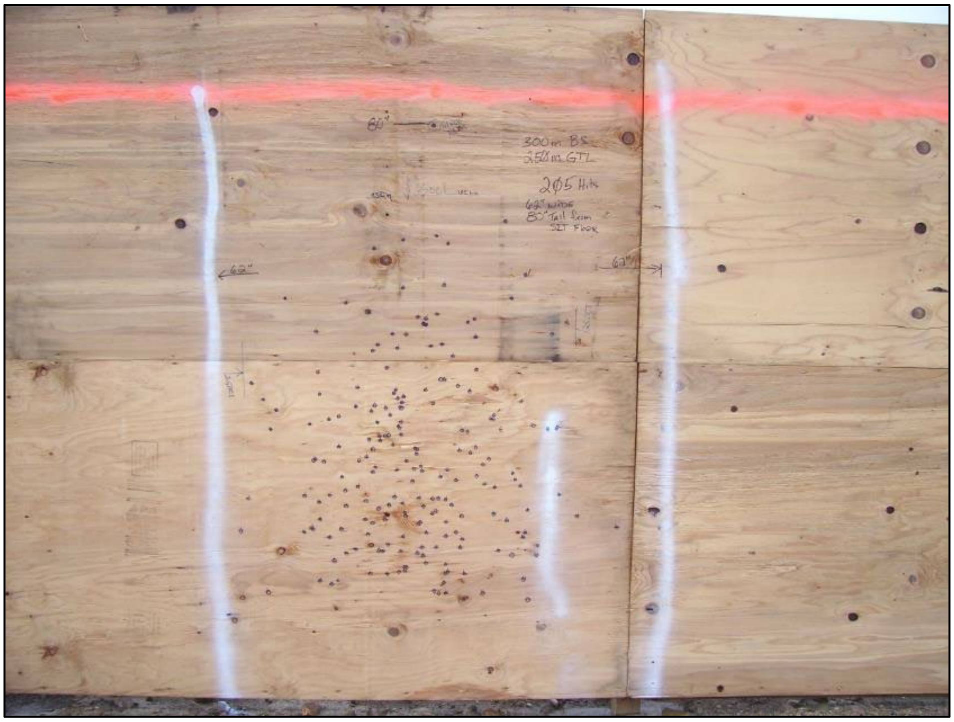

Figure 5. Three Hundred Meter Target Berm Overshot Plywood Telltale after Test Fire
Sierra Range, Camp Edwards, Massachusetts

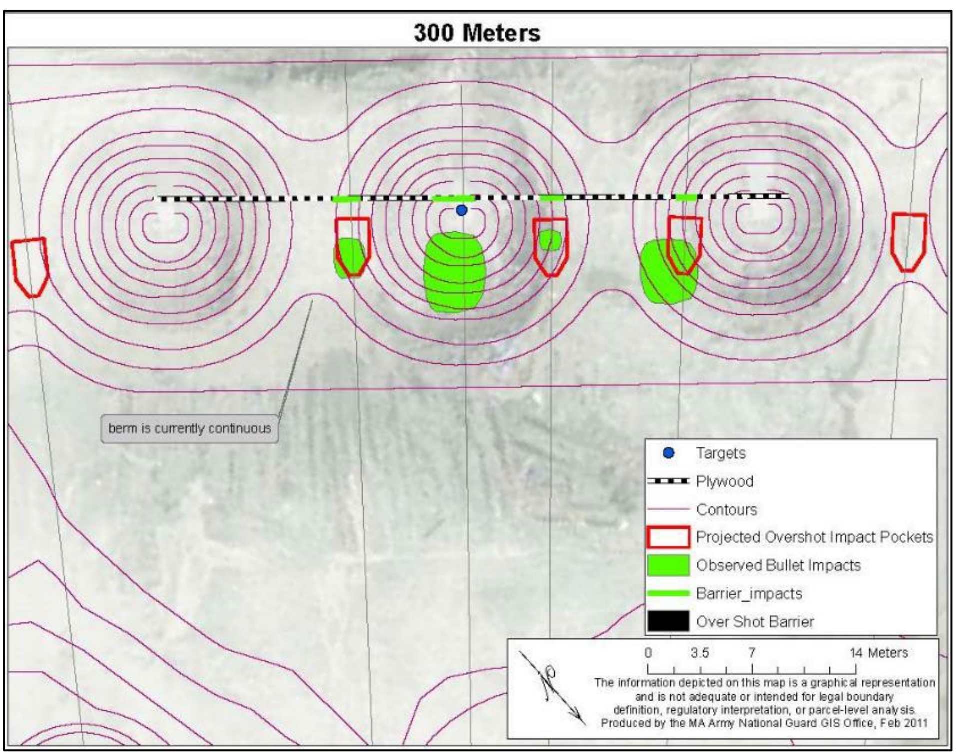

Figure 6. Three Hundred Meter Analysis of Test Fire showing projected and observed projectile impacts, used to develop design and BMPs for current Sierra Range,
Camp Edwards, Massachusetts

The principle **conclusion** is that the Line of Sight Analysis process was able to predict and identify projectile impact distribution and dispersion locations and determine locations to best emplace BMP structures to mitigate strikes to the range floor while not obstructing the view of shooters engaging targets.

This relatively small scale live fire event produced definitive distributions of projectile impact locations.

Each gun target line had clearly identifiable dense projectile impact pockets in both earthen berms and the plywood overshot barriers.

Shooter's deliberate identification and engagement of fixed stationary infantry targets from a fixed firing point produced a repeatable pattern of projectile strikes. These pockets were in locations anticipated by Phases I and II of the Line of Sight Analysis.

It demonstrated the ability to identify and control projectile dispersion and distribution areas from the firing point to the projectile point of impact at earthen structures.

Through the execution of the live fire event the MAARNG has developed lessons learned of the range capabilities and the limitations of the current containment structures.

The LOS aided in identifying the path forward for the MAARNG to develop and propose appropriate Best Management Procedures in support of an Operational, Maintenance and Monitoring Plan (OMMP) specifically designed for Sierra Range.

The Lessons learned (for complete list see Appendix A) and applied to the current Sierra Range, now copper versus lead ammunition, and OMMP are as follows:

Patterns of projectile strikes are uniform from varied distances illustrating that the M855 projectile continues on a generally strait flight path post target strike leaving impact indications at the 300m earthen berm or plywood overshot barrier locations. From this appropriate sized (height and width) and angled target and backstop berms that contain projectiles were developed for the current Sierra Range.

DefenCell® auxiliary berm emplacements were the modular earthen structure utilized during this event to restrict projectile impacts to range floor locations. The size and emplacement of the DefenCell® did not negatively impact the shooter's ability to identify and engage stationary infantry targets during the modified record fire table. From this appropriate sized (height and width) and angled target and backstop berms that contain projectiles were developed for the current Sierra Range that did not impede training and still functioned as intended.

The post-phase III analysis of the former lead bullet-based range test fire illustrated the current capabilities of the range to contain projectiles for hasty and deliberate recovery methodologies and range containment. The range, as constructed, verifiably contained 72.6% of projectiles fired into the DefenCell® auxiliary berms, confirmed via the telltale target covering, but the overall actual material recovery was only 13.2%. Recovery of projectile material within DefenCell® auxiliary berms is difficult due to the nature of the material contained within the DefenCell®. The material caused extensive fragmentation of the lead core rounds which made recovery difficult; also during this test there was overshot that was not recoverable.

The structures utilized during this event to contain projectiles were DefenCell® auxiliary berms, frontal berms covered with 6 inches of screen soil media sifted to ½ minus, 300m earthen berm constructed flush with each 300m stationary infantry target covered with 6 inches of screen soil media sifted to ½ minus and the plywood overshot barrier. The DefenCells® functioned very well to contain projectiles impacting those locations; however, the best recovery efficiency of projectiles from internal soil media was only 34%. The 300m earthen berm and SIT frontal berm had limited capabilities to contain projectiles on their first point of impact due to three key factors: 1) the angle of repose of frontal berms were conductive to non-containment; 2) the soil media was highly compacted resulting in shallow projectile penetration depths; and 3) the soil screened to 1/2" minus intensified fragmentation of projectiles limiting recovery efforts. For the current range the angle of repose was altered so that there is maximum capture of projectiles, soil media (core, sand, top soil) was developed so that projectiles were captured at a shallow depth. The current berm materials do not compact to the extent that can cause excessive fragmentation. The top coat of the current target and backstop berms is ¼" minus top soil.

The 300 meter earthen structure and overshot barrier should be designed in a manner sufficient enough contain small arms projectiles and doesn't need to be constructed flush with the front of each 300 meter SIT location. The containment success in the plywood overshot barrier, a notional earthen structure, should be utilized to maximize the capture projectiles on the first point of impact. For the current Sierra Range the 320 meter backstop berm was constructed to 12' in height to capture projectiles, to include overshot form the original test fire for lead ammunition.

Soil native to the Massachusetts Military Reservation is composed of course sand or gravel resulting in moderate to extreme projectile fragmentation. Material selection for placement in projectile impact locations and use within back stop construction should be based on the ability to reduce the velocity of projectiles without major fragmentation and have chemical properties that reduce lead and metals mobility. For the current Sierra Range where copper only ammunition is used, the material used for the target and backstop berms is made of core material 6" minus, ballistic sand, and then ¼" minus top soil for maximum capture and containment without excessive fragmentation. The nature of the soils at Camp Edwards and used for target and backstop berms impedes the movement of metals through soil by having biding organic material present and elements that impede metals movement such as iron for lead and calcium for copper. Soils are monitored for metals and those substances that may make them mobile in soil (See Monitoring Section)

For the **current** Sierra Range the lessons learned from lead testing were applied to the copper range in the name of environmental protection and best management practices for long-term sustainment of the range. On Sierra Range BMPs are consistently evaluated and updated. A primary example would be berm heights and widths are regularly checked to be sure the structures are adequate to contain projectiles as fired. The primary issues that were taken and applied to the current range were for the purpose of greater containment, reduction in fragmentation, and recovery of projectiles fired. This was done by creating the proper capture berms using ballistically correct materials (see Projectile Recovery Response) adjusting berm heights and widths, and finally the angle of the berms was adjusted to eliminate deflection of projectiles. By applying these lessons learned from the lead test fire the current range is sustainable and projectiles can be contained and recovered. The MAARNG feels that if during the lead test fire with substandard berm structures we had approximately 73% containment then with the current range containment structures and others lessons learned applied we are likely containing a far higher percentage of rounds and recovery should improve. To determine projectile recovery levels at the current range, the MAARNG is to conduct a test harvest of Sierra Range as soon as feasible with concurrence and approval of the EMC Environmental Officer. Please see projectile harvest response for harvest specifics.

20211104-04: MAARNG response to "O&M 3" in the 10/5/21 information request indicates that the harvesting frequency described in the Draft OMMP is a placeholder only. How is the appropriate density for projectile harvest determined, and what is the estimate for how often harvesting will occur?

20211104-05: Several MAARNG responses to the 10/5/21 information request reference an upcoming "copper projectile harvest test." Describe the plans for this test including how results will be used in developing/refining range procedures.

Note: First reading the support material below may be helpful (page 21).

For the questions above -05 is answered first for proper context.

The MAARNG will be planning and expects to execute these tests no later than the spring of 2023.

Test Harvest Plans and Procedures

Describe the plans for this test including how results will be used in developing/refining range procedures.

Each type of range is different in ammunition used, distances fired, target types, and berm sizes and shape. Once a range is constructed and firing validated, which takes in to account condition, # rounds, and visual confirmation of bullet on bullet contact, a recovery schedule will be identified.

The following describes the test harvest plans as requested.

At India Range, three lanes will be test harvested. First the top of the berm (3 inches) and then in between lanes will be harvested to aid in determining bullet overshot and dispersion outside of the primary bullet capture area. After this the bullet pocket proper and lower bullet pockets will be harvested. Knowns for the range are projectiles by range and lane and that the steel penetrators oxidize away in approximately a year depending on exposure. This known weight can then be compared to the harvested weight.

At Sierra Range, two lanes will be test harvested. One high use lane (lanes 1-4), generally the center lanes, and one with a zeroing capacity (Figure 1) will be harvested out to 320 meters. As opposed to India Range, where there is one single large berm across the range, the individual Sierra Range berms will have the full front of the berms harvested. Knowns for the range are projectiles by range and lane and that the steel penetrators oxidize away in approximately a year depending on exposure. This known weight can then be compared to the harvested weight.

Figure 1. Zeroing Lanes in front of 50 meter Target Frontal Berms
Sierra Range, Camp Edwards, Massachusetts.

By comparing the density and arrangement of projectile debris and where outside of the capture structure, if at all, rounds are occurring, a harvest timing can be determined based on the numbers of bullets fired and the time it took to fire these bullets. This test harvest will refine procedures in that it will aid in identifying what target lines need to be harvested first and what the preferred projectile density at each target line will be to determine when harvesting of the target or backstop berm should occur.

How is the appropriate density for projectile harvest determined, and what is the estimate for how often harvesting will occur?

Bullet pockets need to function as intended to capture and contain the projectiles so that they can be harvested.

Data from the harvest test will be used to determine the level of fragmentation and density within a given bullet pocket (pocket area size depth (topsoil depth 12”) vs projectile volume (bullets fired at target). Is there evidence of increased fragmentation and ricochets?

By comparing the density and arrangement of projectile debris and where outside of the capture structure, if at all, rounds are occurring, a harvest timing can be determined based on the numbers of bullets fired and the time it took to fire these bullets. This test harvest will refine procedures in that it will aid in identifying what target lines need to be harvested first and what the preferred projectile density at each target line will be to determine when harvesting of the target or backstop berm should occur.

Based on projectile volume and condition (the further down range the more intact the bullets) within a bullet pocket area, a determination will be made in coordination with the EMC as to when range harvesting needs to occur to keep the target and capture berms in good working capturing condition without ricochets. Harvesting timing may differ among target lines and backstop berms as a result of bullet pocket condition determination.

For the OMMP

9.5 Periodic Metal and Recovery and Recycling

MAARNG will periodically remove projectiles from identified projectile impact areas as inspections identify concerns with the integrity of the berms, or when ricochet or fragmentation issues are a potential concern (Figure 1). The MAARNG, along with the EMC, will inspect the berms and projectile impact areas at least annually to determine when the recovery of metals from the berms will be needed. However, the ranges (bullet pockets) are required to be inspected pre and post firing, by maintenance staff that regularly maintain the range, and when the EMC EO and Camp Edwards Staff are observing range firing. Bullet pockets need to function as intended to capture and contain the projectiles so that they can be harvested and not available to the environment. As one progresses down range bullet fragmentation is reduced and in some cases to where there are whole projectiles within the bullet pocket. It is likely the case that specific target lines will need attention as opposed to a lane or range wide action. Occasional ricochets that result in rounds landing outside of the containment berms is expected and every effort to minimize and correct these occurrences shall be taken, e.g. berm height and width expansion. The frequency of recovery of projectiles will depend on the condition of the range; i.e., if the berms are identified as needing significant repair or reshaping, when the density of projectiles in the bullet pocket(s) suggest increased fragmentation or ricochet may occur, or there are other indicators that ricochet is occurring, such as foreign object build up (rock) or spent projectiles. Based on projectile volume and condition, within a bullet pocket area (pocket area vs projectile volume), a determination will be made as to how often range harvesting needs to occur to keep the target and capture berms in good working condition.

As harvest density and timing are determined the OMMP will be updated to reflect this new information.

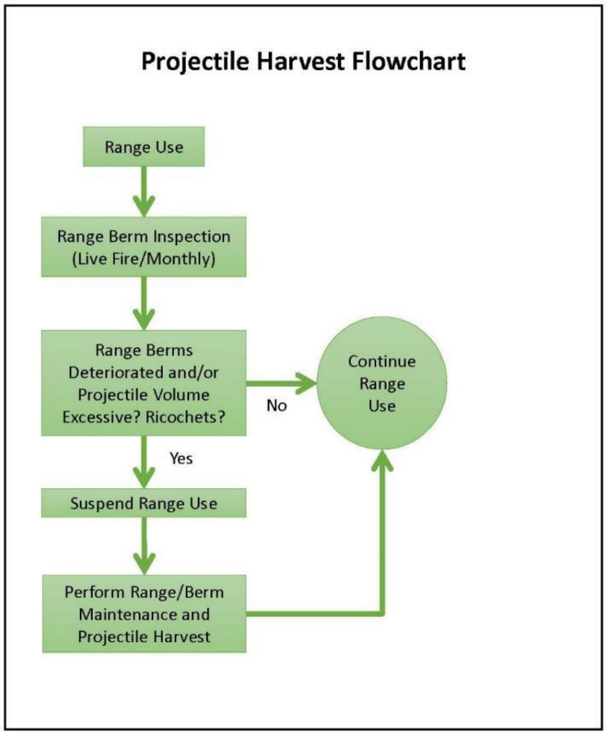

Figure 1. Projectile Harvest Flow Chart, Camp Edwards, Massachusetts

The MAARNG or its representative will excavate and remove projectiles from berms and/or projectile impact areas with appropriate equipment to minimize environmental impact to the surrounding area. The excavated material will then be screened using a 1/4-inch portable soil screener or compatible system that is effective in removing the metal. Storage of projectile material will be outside the Reserve / Training Area. Storage of projectile material will be in approved labeled containers while separation takes place and if not immediately transported to a recycling facility, the material will be stored in the MAARNG's Qualified Recycling Program yard. The screened soil will then be used to reshape/reconstruct the existing berms and/or projectile impact areas as needed.

Best Management Practices to minimize release of contaminants are: not to conduct separation activities on windy days, soils should be moist, plastic sheeting will be used at the separation area to keep soils and projectile material contained, soils will be used for bullet pocket maintenance, and projectiles will be collected and contained in approved containers for recycling.

Prior to work beginning, contractors or in-house personnel conducting this work will coordinate with Range Control, the MAARNG Environmental Office, and the EMC to ensure that the proper environmental protections are in place. Range maintenance is a priority and an ongoing process, major range maintenance activities will be designed, scheduled and implemented to minimize or prevent interruption of training.

Projectile Harvesting Supporting Material

Introduction

When originally constructed, from 1986-89, Sierra Range (also termed the Sierra Range Complex) consisted of two adjacent active operational rifle and machine gun training ranges located on the southern side of Gibbs Road to the north of the Central Impact Area (Figure 1). The two ranges were denoted as the Sierra East (SE) and Sierra West (SW) Ranges. At SE Range there were five firing points and at SW Range there were six firing points. Both ranges had a series of pop-up targets spaced between 110 and 870 yards downrange (800 meter range) from the firing points (Figure 2). Lead ammunition was exclusively used at this range. In 2010 the range was reconfigured into a 300 meter, 10 lane, 9 targets per lane (50, 75, 100, 150, 175, 200, 250, and 300 meters), copper only range (Figure 2). Copper munitions are captured in the target and backstop berms (Figure 3 and 4). Copper ammunition use began in 2012.

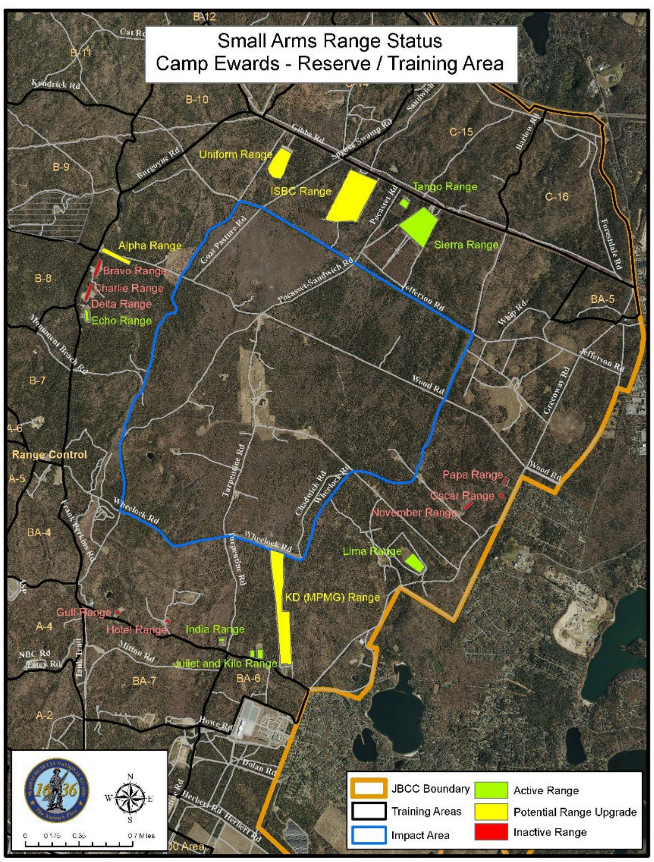

Figure 1. Small Arms Ranges, Camp Edwards, Massachusetts

Figure 2. Sierra Range Complex 2002 and 2018, Camp Edwards, Massachusetts

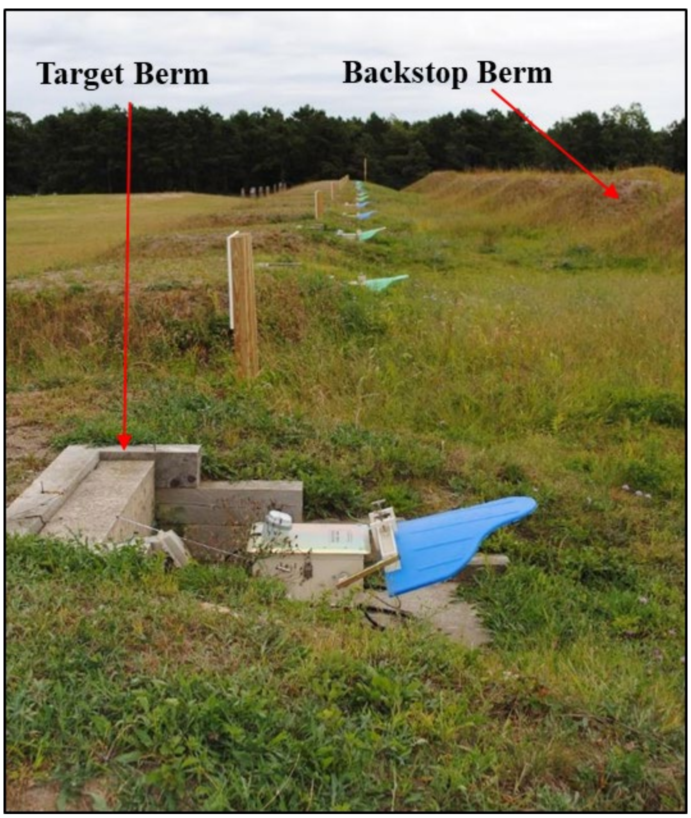

Figure 3. Sierra Range, Across Range (W-E), 50 Meter Targets Berms, and Backstop Berms Camp Edwards, Massachusetts

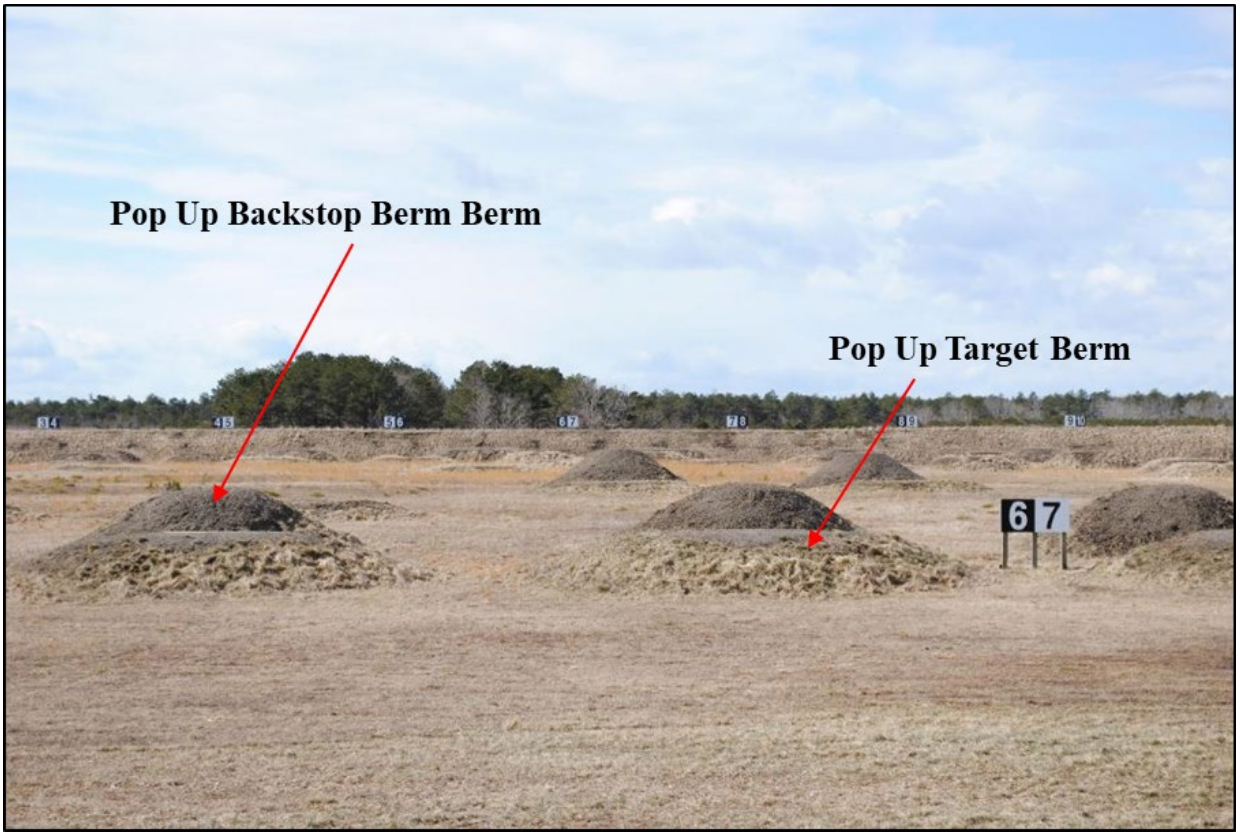

Figure 4. Sierra Range 2018, Down Range, 50, 100, and 320 Meter Pop Up Targets Berms and Backstop Berms in View, Camp Edwards, Massachusetts

USEPA Administrative Order 2, 2012 Sierra Range Investigation Report

After lead ammunition was used for approximately thirty-five years at SE and SW Ranges the Impact Area Groundwater Study Program investigated small arms ranges at Camp Edwards under USEPA Administrative Order 2 and found that the groundwater was not impacted and soil was not significantly impacted from the use of lead ammunition at the SE and SW Range Complex. From the 2012 Sierra Range Investigation report: "… there is no risk to groundwater posed by the analytes detected and no soil or groundwater analytes warrant further evaluation for groundwater protection." The analytes were VOCs, SVOCs, propellants, and metals associated with lead ammunition use. From the 2012 investigation report: Copper has been detected in unfiltered samples in groundwater samples from the range. Copper has been detected at a maximum concentration of 3.2 µg/L in an unfiltered sample and with a Site background level of 1-18.3mg/kg. Antimony and lead have not been detected in any monitoring well associated with this Range. From 2000 to 2012 a series of soil investigations was conduct by the IAWGSP under AO2. Soil samples were collected from a central location along the firing line of SE range immediately after a live firing training exercise to evaluate possible impacts to soil from the airborne deposition. Detected concentrations of metals were consistent with background levels. During a down range Phase IIb soil investigations metals were frequently detected in surface soil samples from SE Range. Antimony was detected in six samples with the maximum concentration (3.2 mg/Kg) reported from a Target Berm and with a MassDEP background level of 1 mg/kg. Copper was detected in all SE Range samples with the maximum concentration (55.2 mg/Kg) reported and with a MassDEP background level of 40mg/kg. Lead was detected in all SE Range samples with the maximum concentration (710 mg/Kg) reported for a Target Berm and with a MassDEP background level of 100mg/kg. At SW Range most of the metals that were analyzed from the SW Range were detected at concentrations comparable to background concentrations. Antimony (2.6 mg/Kg) was detected in the one sample from a Target Berm. Copper was also detected in all of the analyzed samples with a maximum observed concentration of 37.8 mg/Kg. Lead was detected in all of the analyzed samples with the maximum concentration (624 mg/Kg) reported for a target berm. These values are consistent with past small arms range use and remediation was as directed by USEPA.

(2014, January. Final Small Arms Ranges Investigation Report, Impact Area Groundwater Study Program, Camp Edwards, Massachusetts Military Reservation, Cape Cod, Massachusetts. 251 pages.)

OMMP Sampling

From 2012 to 2021 for the current Sierra Range, with copper ammunition only, range sampling of groundwater and soil is consistent with past range use in that metals have shown little to no mobility in soil and have not been found elevated in groundwater from activity at Sierra Range. The maximum detections during OMMP range sampling events were as follows: For soil lead was 17.8 ppm, antimony was 0.93 ppm and copper was 50.6 ppm in soil. For target and auxiliary berms and the associated bullet pockets the following are the maximum detected values for copper in soil at the target berms on Sierra Range. The data was gathered using X-Ray Fluorescence (XRF). Three target berms have been sampled by XRF, 50, 100, and 320 meters. For the 50 meter target there was 186 ppm, for the 100 meter target there was 317 ppm, and for the 320 meter target there was 320 ppm. Most readings have been well under 100 ppm. These numbers are below the OMMP standard for copper in soil (see Monitoring Section page 39). For groundwater lead has been detected at 4.2 ppb, antimony has been detected at 0.46 ppb, and copper has been detected at 12.7 ppb. All below the OMMP action levels (see Monitoring Section page 39).

At Sierra Range from 2012 to 2021, 908,243 of EPR bullets were fired on the range. This equates to 90,824.3 bullets fired per lane and 10,092 bullets fired per target (2021 State of the Reservation Report). Target and backstop berms are constructed in a fashion that will capture projectiles and reduce fragmentation. In general, target and backstop berms are constructed from a core material, three feet of sand, and from 10 to 18 inches of topsoil (Figure 5). The primary capture and containment medium is the top soil layer (Figure 6).

Figure 5. Sierra Range Targets Berms with Core Material (Background), Sand, Top Soil and Erosion Control Matting, Camp Edwards, Massachusetts

Figure 6. India Range, Top Soil Bullet Pocket, Camp Edwards, Massachusetts
(Note: sand visible, needs maintenance to reduce erosion for berm integrity)

To understand range management at Camp Edwards the terms bullet pocket, fragmentation, and ricochet should be defined.

For the term "bullet pocket," the classic description is part of the target or backstop berm that receives the fired bullets. For range management at Camp Edwards bullet pockets have three parts; the upper pocket, the bullet pocket proper and the lower pocket (Figure 7.). The bullet pocket proper is the actual target area or point of aim where fired bullets are received. The upper pocket is the area just above the bullet pocket proper to the berm top and the lower pocket is the area just below the bullet pocket proper to the ground. The bullet pocket proper and lower bullet pocket experience the effects of erosion (bullet pocket drift). Bullet pocket drift is where the bullet pocket proper experiences erosion and where the soil and some projectiles erode down to cover the lower bullet pocket area (Figure 8).

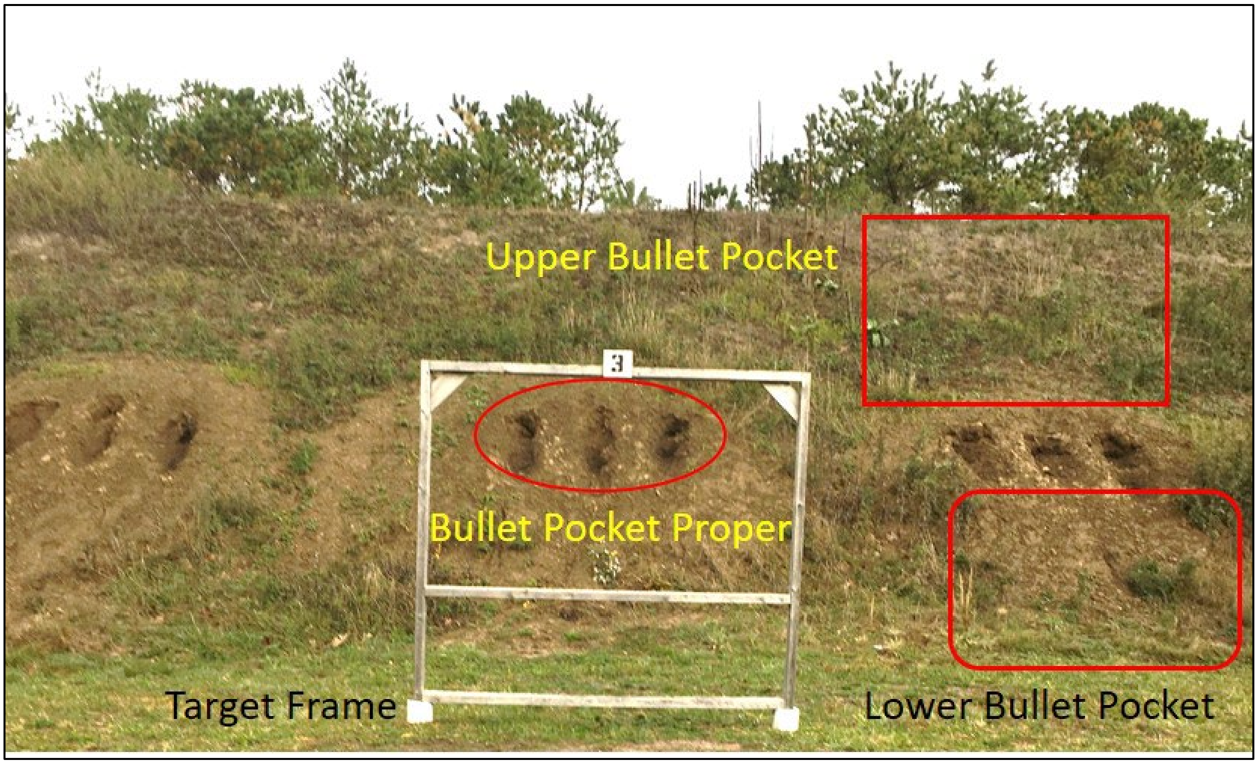

Figure 7. Bullet Pocket Graphic and Photo (India Range), Camp Edwards, Massachusetts.

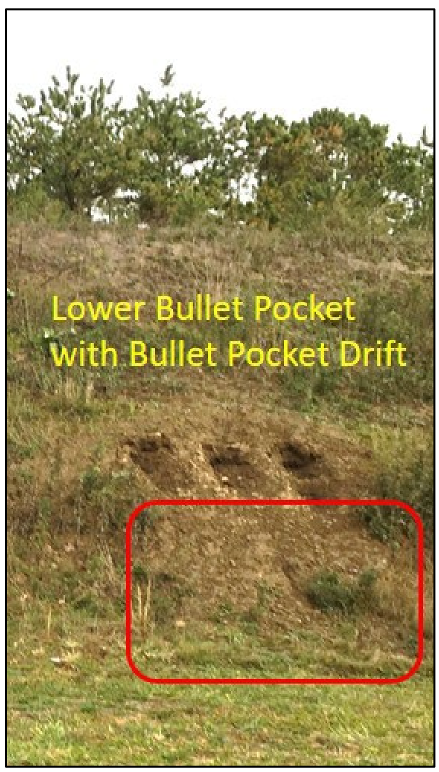

Figure 8. Lower Bullet Pocket with Drift (India Range), Camp Edwards, Massachusetts.

In the context of range management fragmentation refers to the condition of the projectile after being fired into the bullet pocket and thereafter. Each target level has differing 'fragmentation levels" (Figure 9). Targets closest to the firing line receive bullets with the greatest energy and penetration and the projectiles are more likely to fragment. As we progress down range there is obviously less energy when a bullet strikes a target. For example, most bullets within the fifty meter target berm have come apart, i.e. steel penetrator, copper jacket, and copper slug are usually separate (Figure 9). However, the further down range the less fragmentation to the point where when looking at the 320 meter berm we find intact bullets (Figure 9). The secondary but no less important cause of further fragmentation is bullet on bullet impact, which can further fragment projectiles.

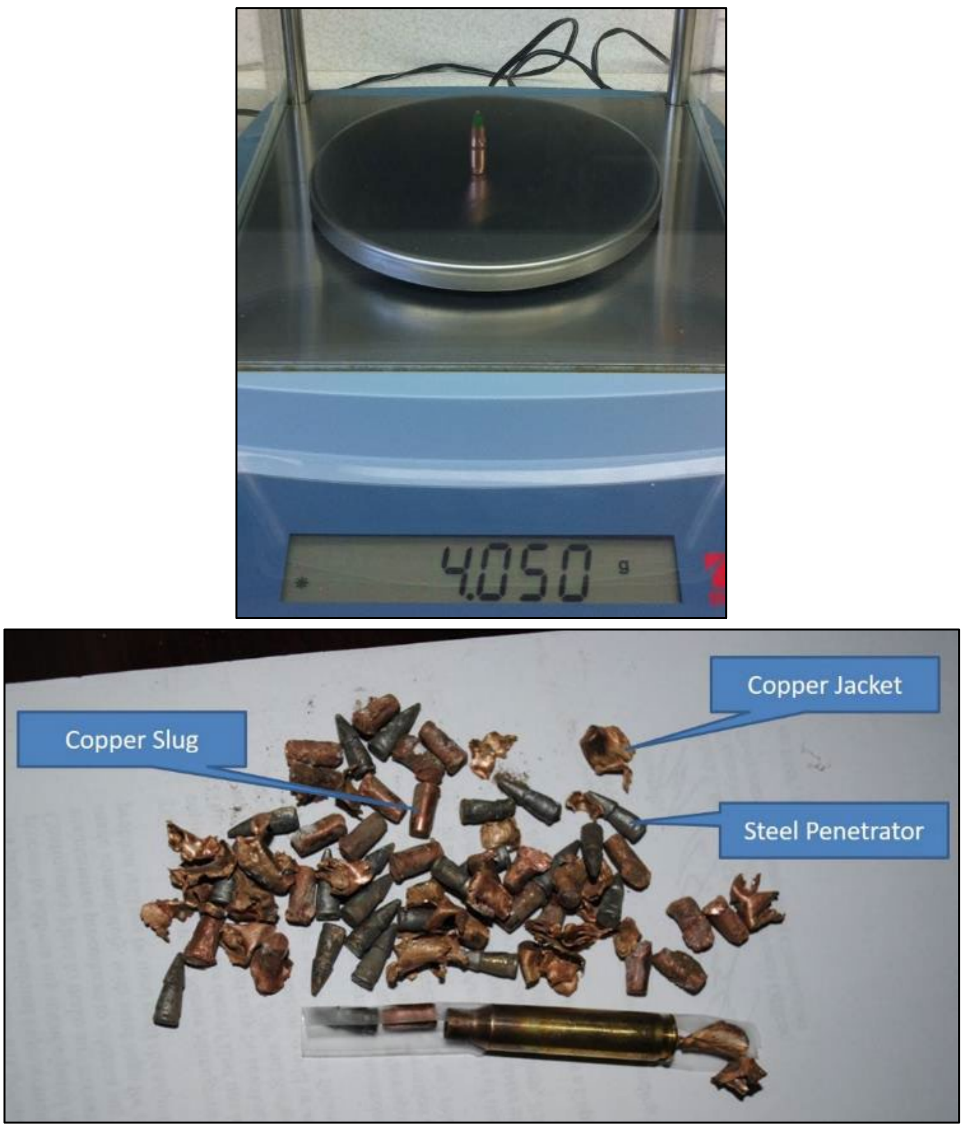

Figure 9. Intact Copper Bullet and Projectile Fragmentation, Camp Edwards, Massachusetts.

The word "ricochet" invokes a picture of a bullet hitting a point and wildly taking off in another direction. Classic ricochets do happen on Sierra Range, but this is not the norm or what is referenced when discussing bullet pocket maintenance and harvest. On any small arms range with earthen target and backstop berms there is a projectile volume limit where "bullet pocket ricochets" will occur. At most public and private shooting ranges this type of ricochet is very common. As bullet pockets at target and backstop berms receive bullets, projectile debris can build to the point where fired bullets hit projectile debris ejecting this debris from the primary bullet pocket. This projectile debris does not fly off wildly but actually "tidily-winks" to the sides and over the top of the target and backstop berms (Figure 10). This affect can cause debris to be far enough away from the berm that projectile debris management will have to harvest from a greater area. This is not an acceptable condition for berm or projectile management at any small arms range.

After considering the information above one must consider the volume and space projectiles and projectile debris occupy. When considering volume, obviously five projectiles equal's five projectiles in volume. However when considering the space a projectile occupies within a bullet pocket fragmentation must be considered. As opposed to whole projectiles fragmented projectiles will occupy more space within a bullet pocket because of the arrangement of fragmented projectiles. Considering the above information and this point further illustrates the need for target line by target line evaluation for bullet pocket harvesting of projectiles and projectile debris.


(1


2)


(3

Figure 10. Projectile Debris, Bullet Pocket Ricochets (Tidily-Wink), Juliet Range behind Backstop Berm 2008, Picture 1 lead pieces with ball point pen, Picture 2 back side of berm with pen inset, Picture 3 clean berm face with snow cover and the location of lead pieces, Camp Edwards, Massachusetts.

20211104-06: If fire suppressing chemicals are needed, will they contain PFAS or other fluorine compounds?

Fire suppressing chemicals will not be used on this range. Prohibition has been coordinated with the Joint Base Cape Cod Fire Department and will be incorporated into range use SOPs and fire response protocols for the MPMG Range.

20211104-07: Provide compiled monitoring data collected at Sierra range for soil, subsurface soil, porewater, and groundwater showing results for copper, antimony, lead, and other contaminants of concern over the period when copper ammunition has been in use at the range.

Soil, porewater, and groundwater data for Sierra range can be found in Appendix 4. In 2019 and 2020 new baseline sampling was conducted for all active ranges at the request and in coordination with the EMC SAC Ad Hoc Committee. The intent was to begin to sample for those things that could make metals mobile in soil. This is now part of the standard sampling suite. There is no subsurface soil data for Sierra Range. Subsurface soil sampling is only conducted (in coordination with the EMC EO) if there is an exceedance or trend in surface soil data that warrants further investigation.

20211104-08: Provide scope of work for investigating environmental impact of tracer rounds proposed for use at MPMGR (as requested by EMC EO).

Tracers were investigated using a different weapons system. The MAARNG will add the tracer component Strontium to its sampling and testing at small arms ranges where in use. See Appendix 5 for Scope of Work and Results

20211104-09: Provide a timeline for submitting an environmental monitoring plan as described in the paragraphs above.

Tentative Dates cannot be given due to the current nature of the process.

USEPA has been provided the draft Sierra Range OMMP. The MAARNG and the EMC have been coordinating to finish the OMMP for the MPMG Range. Final completion of the OMMP is pending construction of the range to ensure consistency with the structures on the ground, to ensure proper monitoring set up and data points, and request approval to implement.

In general the process (timeline) for completing an OMMP is: working with the EMC EO to develop and complete the OMMP; schedule and conduct Community and Science Advisory Council meetings asking for support of MPMG Range: schedule and conduct an Environmental Management Commission meeting asking the commission to give the EMC Environmental Officer the authority for Design and OMMP Approval: MAARNG submits a written request for approval of design and OMMP: EMC responds in writing with approval.

20211104-10 MAARNG response to "O&M 6" in the 10/5/21 information request refers to modeling conducted to determine soil action levels. Provide details about this modeling, including the modeling methodology and how results were translated into action levels. (This information should be included in the monitoring plan requested above.)

Soil Action Levels were set and approved by the EMC, MassDEP, and the USEPA.

Soil Action Levels were determined by the EMC EO using MCP 310 CMR 40.0996 (8) for calculating default UCLs. For Copper there is no way to calculate a UCL standard, so the EMC EO defaulted to the RS-2 (Reporting Standard) level of 10,000mg/kg.

See Monitoring Plan below (page 39).

20211104-11: Table 9-2, subsurface soil action levels, is missing from Draft OMMP. Provide missing table. (This information should be included in the monitoring plan requested above.)

There are no subsurface soil Action Levels for the OMMP.

Subsurface soil sampling is only conducted (in coordination with the EMC EO) if there is an exceedance or trend in surface soil data that warrants further investigation.

20211104-12: Develop a flowchart or series of flowcharts for soil, subsurface soil, porewater, and groundwater which shows each trigger level and the management actions to be initiated when trigger levels are exceeded. (This information should be included in the monitoring plan requested above.)

See Monitoring Plan below (page 39).

20211104-13: MAARNG response to "Monitoring 8" in the 10/5/21 information request refers to evaluating trends annually; however, the Draft OMMP states that surface soil sampling will be conducted every 3 years (see sections 9.0 and 9.4). Clarify the frequency of sampling that will be conducted. (This information should be included in the monitoring plan requested above.)

For all current approved OMMPs monitoring is required annually unless otherwise stated. Discussion had begun and is ongoing with the EMC SAC Ad Hoc Committee where it was determined to sample for those constituents that could make metals mobile in soils and if it would be, based on data to date, appropriate to move sampling to every three years.

See Monitoring Plan below.

<u>Monitoring Plan</u>

As discussed, the Monitoring Plan will be submitted at a later date.

Appendix 1

2016 USEPA Pilot Period Final Report

Pilot Period Final Report

Juliet, Kilo, and Tango Ranges

Camp Edwards, Massachusetts

2016

TABLE OF CONTENTS

Table of Contents ii
List of Tables iii
List of Figures iv
Acronyms and Abbreviations v
1.0 Introduction 1
1.1 Purpose of Report 1
1.2 Scope 1
1.3 Background 1
2.0 Range Descriptions 5
2.1 Initial STAPP™ Evaluation and Firing Demonstrations 9
3.0 Range Use History 11
4.0 Range Operations, Inspections, Maintenance, And Modifications 19
4.1 Range Operations 19
4.2 Range Inspections 20
4.3 Range Maintenance and Modifications 23
5.0 Environmental Monitoring Results 27
5.1 Soil Sampling Results 28
5.2 Porewater Results 29
5.3 Groundwater Results 30
5.4 STAPP™ Water Collection and Analysis 32
6.0 Environmental Management Commission 35
7.0 Changes to the Operations, Maintenance and Monitoring Plan and Lessons Learned 39
7.1 Operations 40
7.2 Inspection and Maintenance 42
7.3 Environmental Monitoring 43
8.0 Summary and Conclusions 45
9.0 References 48

LIST OF TABLES

Table 3-1 Lead Ammunition Use History, Tango Range 12
Table 3-2 Lead Ammunition Use History, Juliet Range 12
Table 3-3 Lead Ammunition Use History, Kilo Range 12
Table 4-1. Pumped STAPP System Water, Before and After Tarps were installed, JKT Ranges, Camp Edwards, Massachusetts. (*Tarps installed September/October 2011) 25
Table 5-1. Current Action Levels for Soil, Porewater, and Groundwater Camp Edwards, Massachusetts. 28
Table 5-2. Maximum Lead Concentrations (mg /Kg) Detected in Soil on Juliet, Kilo, and Tango Ranges Camp Edwards, Massachusetts. 28
Table 5-3. Antimony in Porewater at Juliet, Kilo, and Tango Ranges with background lysimeter data to include the Sierra Range background lysimeter. 29
Table 5-4. Background Lysimeter Results for Tango Range, Camp Edwards, Massachusetts. 30
Table 5-5. Analytical Results for STAPP System Water, Camp Edwards, Massachusetts. 34

LIST OF FIGURES

Figure 1. Training Area and Ranges, Camp Edwards, Massachusetts. 2
Figure 2. Tango (A), Juliet (B), and Kilo (C) Range Site Work and STAPP System Construction Camp Edwards, Massachusetts. 3
Figure 3. Toe-Berm Boxes, Tango Range, Protecting STAPP™ System Base and Internal Reservoir, Camp Edwards, Massachusetts. 5
Figure 4. Lysimeters, Soil Grids, and Monitoring Well on Tango Range Camp Edwards, Massachusetts. 7
Figure 5. Lysimeters, Soil Grids, and Monitoring Well on Juliet Range Camp Edwards, Massachusetts. 8
Figure 6. Lysimeters, Soil Grids, and Monitoring Well on Kilo Range Camp Edwards, Massachusetts. 9
Figure 7. Soldiers from the 182nd Infantry Firing at Juliet Range. 11
Figure 8. Tango Range Lanes 14 and 15, Sorting and Sifting Operation during Mass Balance Work, Camp Edwards, Massachusetts 13
Figure 9. Tango Range Lanes 14 and 15, Re-Installing Rubber Granules After Mass Balance Work, Camp Edwards, Massachusetts 15
Figure 10. Plywood Overshot Telltale Wall, Tango Range, Camp Edwards, Massachusetts. 17
Figure 11. Red Line, Upper Limit of Aiming to Decrease Overshot, Juliet Range Camp Edwards, Massachusetts 17
Figure 12. Bottom Liner Penetrations and Recovered Rounds, Tango Range Camp Edwards, Massachusetts 18
Figure 13. Tango Range Top Cover Inspection, Range Control Camp Edwards, Massachusetts. 20
Figure 14. Tarp Covered STAPP™ Systems at Juliet and Kilo Ranges Camp Edwards, Massachusetts. 22
Figure 15. STAPP™ System Internal Reservoir Access Port Tango Range, Camp Edwards, Massachusetts. 26

ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
CAC	Community Advisory Council
CRREL	Cold Regions Research and Engineering Laboratory
DA	Department of the Army
DOD	Department of Defense
EBC	Environmental Bullet Catcher
ECC	Environmental Chemical Corporation
EMC	Environmental Management Commission
EPA	U.S. Environmental Protection Agency
EOEEA	Executive Office of Energy and Environmental Affairs
E&RC	Environmental and Readiness Center
HDPE	High Density Polyethylene
IAGWSP	Impact Area Groundwater Study Program
ISM	Incremental Sampling Methodology
MANG	Massachusetts National Guard
MassDEP	Massachusetts Department of Environmental Protection
JBCC	Joint Base Cape Cod
NCO	Non Commissioned Officer
OMMP	Operations, Maintenance, and Monitoring Plan
Reserve TA	Upper Cape Water Supply Reserve/Camp Edwards Training Area
SAC	Science Advisory Council
SARWG	Small Arms Range Working Group
SDWA	Safe Drinking Water Act
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
WWTP	Waste Water Treatment Plant
kg	kilograms
mg/Kg	milligrams per kilogram
μg/L	micrograms per liter

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

In July 2007 and January 2009, the U.S. Environmental Protection Agency (EPA) authorized a pilot project under which Massachusetts National Guard (MANG) personnel, and personnel from other military and law enforcement agencies under the MANG's supervision, would be permitted to conduct lead ammunition training at Tango Range, and Juliet and Kilo Ranges, respectively, under specified conditions. The approximately nine-year combined pilot period has allowed an adequate record of use, management, and monitoring to be established to show that these ranges, with appropriate controls, could be managed in an environmentally sound fashion.

The purpose of this report is to provide stakeholders, the EPA, the Environmental Management Commission (EMC) and the Massachusetts Department of Environmental Protection (MassDEP) with a summary of data collected during this Pilot Period. This report also provides a summary to all other members of the Small Arms Range Working Group (SARWG) that includes the MANG Environmental &Readiness Center (E&RC), EPA, MassDEP, the EMC, the Impact Area Groundwater Study Program (IAGWSP), and Camp Edwards staff. The SARWG convenes to discuss and help guide small arms range development on Camp Edwards.

1.2 SCOPE

The MANG was required to complete a Pilot Period Report for the 17-month trial period, August 2007 through December 2008, as part of the EPA's July 2007 limited authorization to conduct lead ammunition training at Tango Range. That report was completed and submitted to the EPA in final form in August 2009. The scope of the present report is to present current information for the Pilot Period relating to Juliet and Kilo Ranges and updating information on Tango Range. The pilot period occurred from 2007 to 2016. This report summarizes the use of the ranges, any operational issues encountered and how they were resolved, all environmental monitoring data, changes made to the systems and the Operations, Maintenance and Monitoring Plan (OMMP), and lessons learned. In addition, Section 7 of this report provides a description of the EMC and the Environmental Performance Standards (EPSs), which govern the use and operation of the ranges under Chapter 47 of the Acts of 2002 for the Commonwealth of Massachusetts.

The Pilot Period was performed in accordance with procedures and policies outlined in the OMMP, for Juliet, Kilo and Tango Ranges (Appendix A). This OMMP has been and will continue to be a dynamic document with changes made to capture lessons learned, to add efficiencies, and to make implementation and compliance easier for the end user: Camp Edwards Range Control and environmental staff with emphasis on staff that does the day-to-day maintenance.

1.3 BACKGROUND

Camp Edwards, located within Joint Base Cape Cod (JBCC), is an important training center for National Guard, Reserve Components, US Coast Guard, and law enforcement agencies throughout the northeastern United States. Training facilities available at Camp Edwards include small arms ranges, training areas, battle positions, observation posts, and maneuver roads and trails (Figure 1). These facilities support a variety of training activities to include small arms training and qualification.

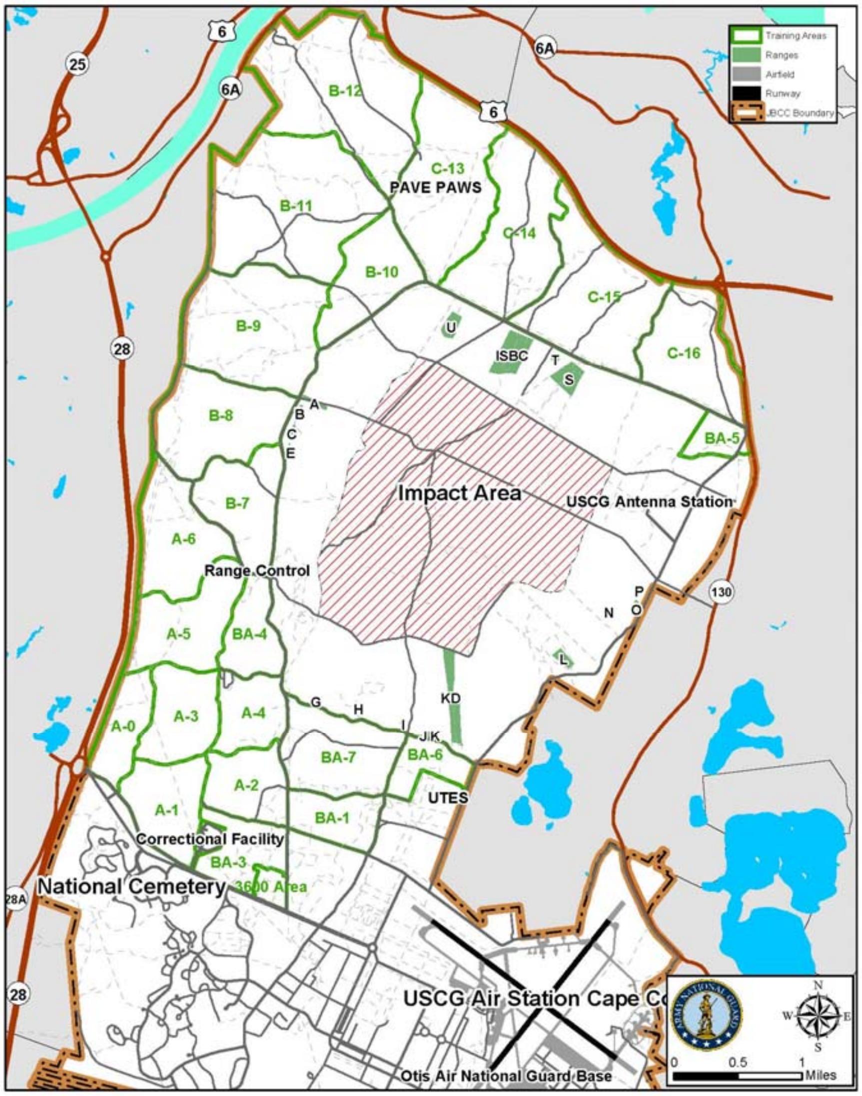

Figure 1. Training Area and Ranges, Camp Edwards, Massachusetts.

In 1997, the use of lead ammunition was suspended at all small arms ranges on Camp Edwards as required by an EPA Administrative Order under the Safe Drinking Water Act (EPA Docket No. SDWA-1-97-1030) (AO2). AO2 explicitly prohibited “all firing of lead ammunition or other ‘live’ ammunition at small arms ranges at or near the Training Range and Impact Area.” AO2 also provided for a process to return to live firing at the small arms ranges (see Paragraph 125 of AO2). The following sections present an explanation why MANG believed a modification to authorize a limited pilot project under the conditions specified was both “necessary and appropriate” under AO2.

In cooperation with the SARWG, the MANG selected Tango Range, an existing small arms range, to receive the STAPP™ system for the Department of the Army demonstration/validation program. Subsequently, Juliet and Kilo Ranges were proposed for use, and funding for STAPP™ systems on these ranges was provided by Congress. Tango, Juliet, and Kilo Ranges were previously-used small arms ranges. Prior to STAPP™ installation, soil on these ranges was sampled and any required mitigation was conducted by the IAGWSP. On June 13, 2007, the MANG requested that the EPA modify the Scope of

Work (SOW) to Administrative Order SDWA I-97-1030 ("AO2") issued pursuant to Section 1431(a) of the Safe Drinking Water Act with respect to the Massachusetts Military Reservation (MMR) (currently Joint Base Cape Cod). On July 23, 2007, EPA responded to this request by adding Appendix B to AO2, which authorized limited firing of lead ammunition at Tango Range through December 2008 and required the MANG to submit to EPA a final report after the conclusion of that pilot project. In January 2009, EPA further modified AO2 by adding Appendix C to the order, which extended the authorization to fire lead ammunition at Tango Range through December 2009 and to allow firing at two additional small arms ranges, Juliet and Kilo.

Soils with pre-existing small arms range contaminant constituents, primarily lead and nitroglycerine, were removed from the reconfigured ranges prior to STAPP™ system installation. An earthen berm was constructed and/or reconstructed on the ranges to receive the STAPP™ systems (Figure 2). On Kilo Range a new berm was constructed to be in line with the berm on Juliet Range so that both ranges could safely be used concurrently. The STAPP™ system was installed on Tango Range June through July 2006 and on Juliet and Kilo Ranges June through September 2008.


(A)


(B)


(C)

Figure 2. Tango (A), Juliet (B), and Kilo (C) Range Site Work and STAPP System Construction Camp Edwards, Massachusetts.

TANGO RANGE

In 2006, as part of the Department of the Army (DA) demonstration/validation testing program on bullet containment systems, a granulated rubber bullet trap system, the STAPP™ bullet containment system, was shipped to Camp Edwards in the spring of 2006. The program goal was to assess how effective the bullet trap system could be in managing tungsten-nylon ammunition, the then-proposed Army replacement for lead ammunition. Prior to completing the evaluation, tungsten was discovered in groundwater (February 2006). The use of tungsten-nylon ammunition was suspended at Camp Edwards.

Beginning in late 2006, there were numerous public notices published and meetings held with the various advisory groups to keep the public, surrounding towns, and regulators apprised throughout the process of bringing small arms firing back to Camp Edwards. Site visits and an open public tour of the range were conducted.

In 2007, the EMC's Science Advisory Council (SAC) and Community Advisory Council (CAC) unanimously voted in support of the requested changes to the EPSs, which made possible the return to lead firing on Tango Range.

Further information about the need and process to resume firing lead ammunition on Tango Range is available in the Tango Range Pilot Study Report, Massachusetts Military Reservation, Cape Cod, Massachusetts, August 2009.

JULIET and KILO RANGES

In 2007 the MANG initiated action requesting the construction of a STAPP™ bullet containment system at Juliet and Kilo Ranges and resuming firing of lead ammunition at the two ranges. A Notice of Project Change was submitted to the Massachusetts Executive Office of Energy and Environmental Affairs (EOEEA) on July 9, 2007. EOEEA issued a Certificate on August 10, 2007 approving the request and establishing several conditions to ensure maximum feasible environmental protection and adequate public involvement.

In a letter submitted to EOEEA during the public comment period on the Notice of Project Change for Juliet and Kilo ranges, the EMC established a requirement for the MANG to prepare a brief summary status update of lessons learned to date on the current STAPP™ bullet trap system installed on Tango Range, with the update describing how the lessons and experiences from the Tango Range might be applied to the design specifications, construction plans, and construction supervision of the proposed bullet containment systems on Juliet and Kilo ranges. The EMC also required the information in the update to be presented to the SARWG, applicable advisory groups (SAC and CAC), and the public. The status update, Camp Edwards/Massachusetts Military Reservation Small Arms Range Working Group Status Update 2 was published summer 2008. The MANG submitted a request to the EMC on July 10, 2008 requesting permission to construct appropriate berms and the STAPP™ system on Juliet and Kilo ranges. The EMC approved the construction request in a letter dated August 6, 2008.

On September 25, 2008, the MANG submitted a letter to EPA asking it to modify AO2 to allow the resumption of firing lead ammunition at Juliet and Kilo ranges using a STAPP™ bullet trap system. A 30-day public comment period was conducted October 23, 2008 through November 24, 2008. EPA received seven sets of written comments from the public during this period and a total of eleven substantive comments. Comments were primarily supportive of the request. After reviewing the MANG's request, conducting a 30-day public comment period, which included a public meeting, EPA approved the MANG's request on January 28, 2009.

2.0 RANGE DESCRIPTIONS

The STAPP™ system on Tango Range consists of a composite lumber frame approximately 100-feet long by 23-feet wide with 15 firing lanes. On Juliet Range the system is 120-feet long by 25 feet wide with 17 lanes. Kilo Range is 200-feet long by 25-feet wide with 29 lanes. Granular rubber was placed on top of the bottom-liner inside the composite frame to a depth of 18 inches. The granular rubber was then capped with a patented "self-closing" top cover. The bullets pass through the top cover and are captured in the granulated rubber layer. This system is designed to capture and contain fired bullets. The system also minimizes potential airborne lead and runoff. The system includes an internal water collection reservoir to capture any water that infiltrates the STAPP™ system. The MANG built and placed toe berm boxes at the base and in front of the systems to protect the framing and water reservoir of the STAPP™ systems from projectiles (Figure 3).

Figure 3. Toe-Berm Boxes, Tango Range, Protecting STAPPTM system Base and Internal Reservoir, Camp Edwards, Massachusetts.

On Tango Range tension lysimeters designed to sample soil pore water for potential contaminants were installed in front of the firing line and between the target line and STAPP™ system. Three lysimeters were installed at a depth of five feet below the ground surface near the target line and three were located at the firing line. In 2008 it was determined that tension lysimeters can provide false sampling results because the materials that they are composed of may bind or release other contaminants. All tension lysimeters were replaced with pan lysimeters that are not known to have the same issue with contaminants seen in tension lysimeters. Three pan lysimeters were installed on Tango Range in 2010 (Figure 4). Each of these is essentially a plastic bucket with a screened lid to allow percolating water into the bucket. Tubes provide access to the collected water which is pumped to the ground surface for sampling. The screens are all placed approximately 2 feet below the ground surface. There is one pan lysimeter in front of the firing line, one in the center of the range floor and one between the target frames and the STAPP™ system.

Three pan lysimeters were installed on Juliet Range in 2010 (Figure 5). The screens are all approximately 2 feet below the ground surface. There is one pan lysimeter in front of the firing line, one at the center of the range floor and one at the west end of the drainage swale between the toe boxes and the STAPP™ system.

Four pan lysimeters were installed on Kilo Range in 2010 (Figure 6). The screens are all approximately 2 feet below the ground surface. There is one pan lysimeter in front of the firing line, one at the center of the range floor and one at each end of the drainage swale between the toe boxes and the STAPP™ system.

Background lysimeters were installed in the area of Kilo, Sierra and Tango Ranges to provide a comparison between porewater conditions on and off the small arms ranges so that the potential impact of small arms firing can be discerned from natural conditions.

In 2016 the EMC's SAC recommended spilt core soil sampling to replace lysimeter use for tracking initial metals movement through soils. Split core soil sampling will be implemented when all agency approvals are received.

To monitor ground water conditions on the STAPP™ ranges monitoring wells were installed to intercept groundwater flow from water that originated from the ranges. The wells were installed by the IAGWSP and are now used to monitor potential contaminants in groundwater at the active STAPP™ Ranges.

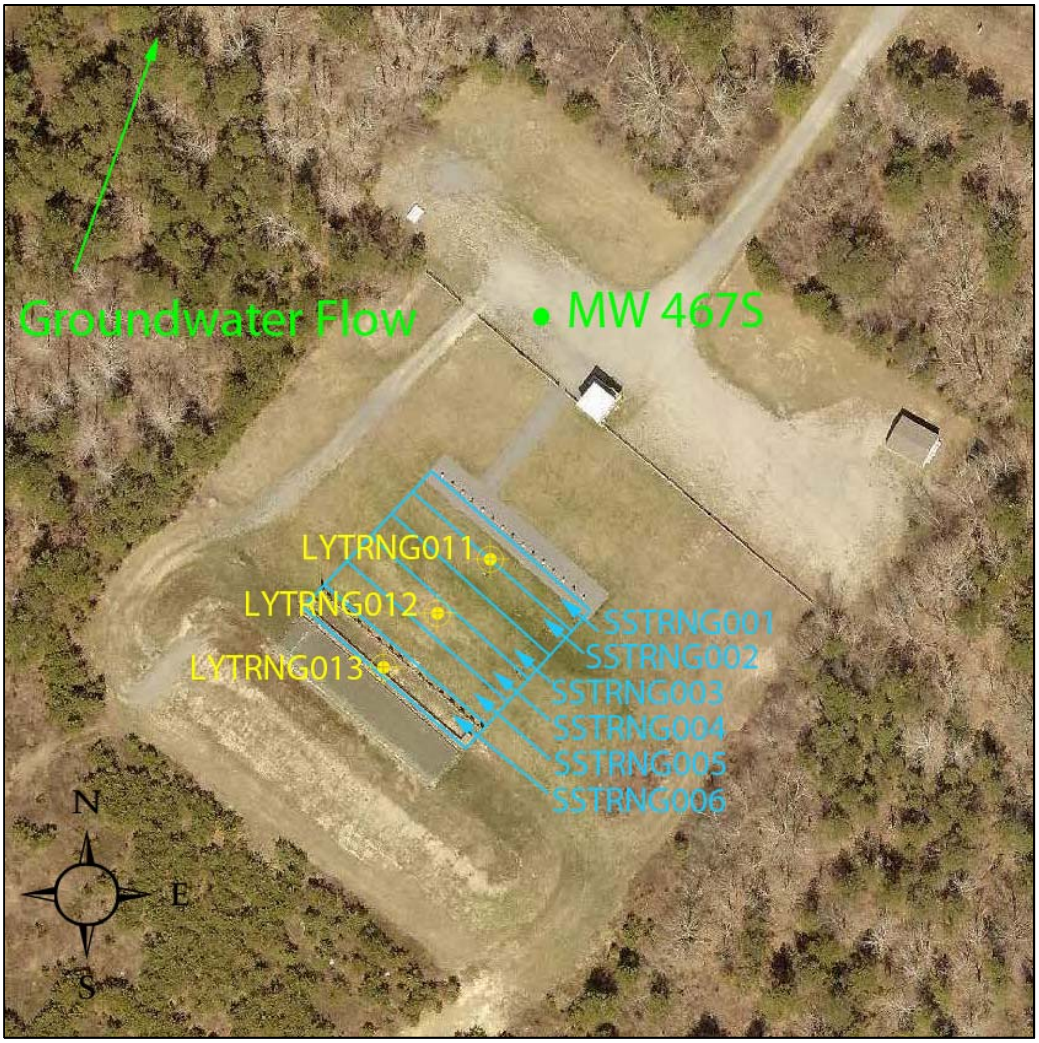

Figure 4. Lysimeters, Soil Grids, and Monitoring Well on Tango Range Camp Edwards, Massachusetts.

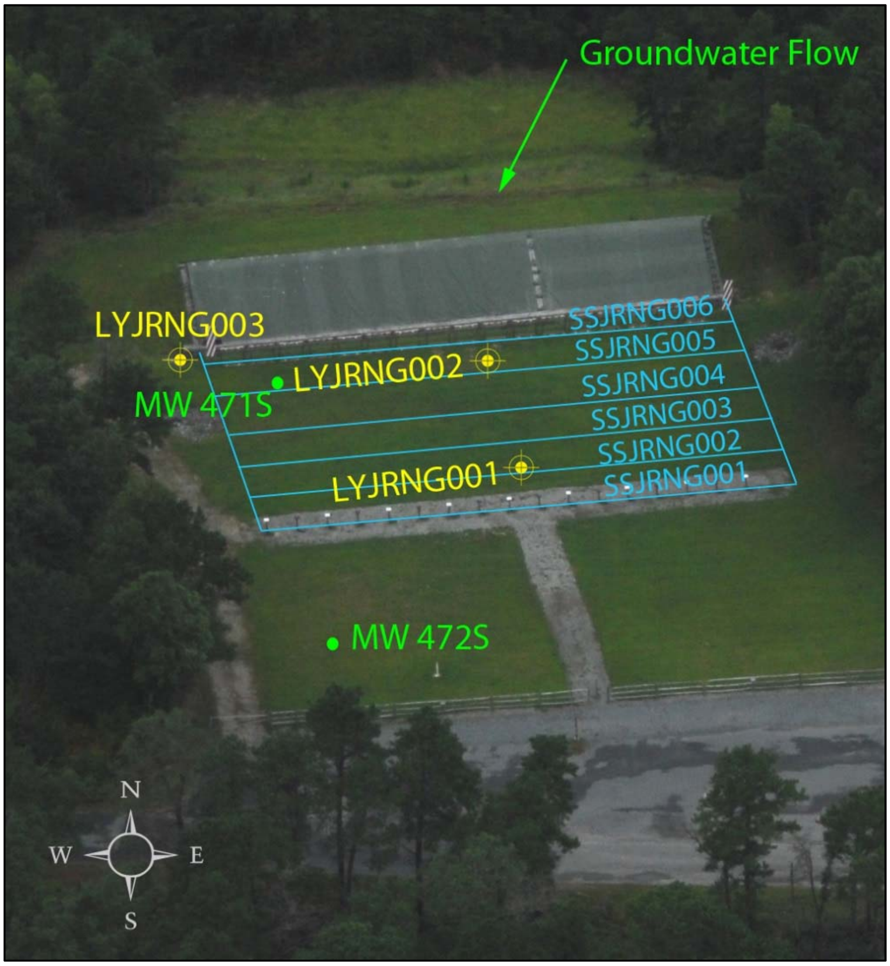

Figure 5. Lysimeters, Soil Grids, and Monitoring Well on Juliet Range Camp Edwards, Massachusetts.

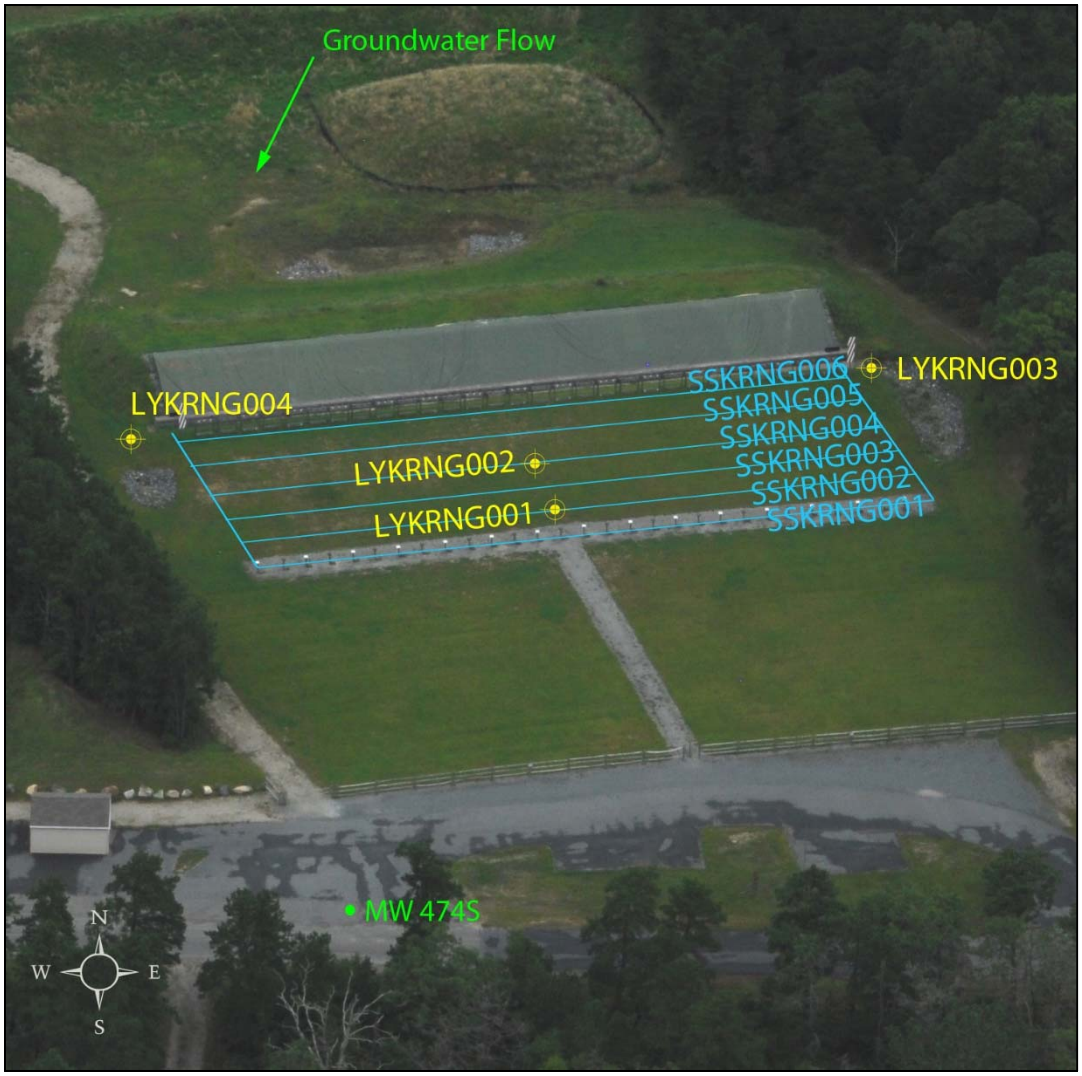

Figure 6. Lysimeters, Soil Grids, and Monitoring Well on Kilo Range Camp Edwards, Massachusetts.

2.1 INITIAL STAPP™ EVALUATION AND FIRING DEMONSTRATIONS

The Tango Range STAPP™ system was structurally evaluated in August and September 2006 prior to any test firing. It was noted that there appeared to be seam failures in the cover, possibly caused by improper gluing techniques. The seams were reported to and repaired by the STAPP™ EBC Company in October 2006. Two firing demonstrations were held during 2007, with approximately 1,700 rounds of 5.56mm lead ammunition fired into the system. The demonstrations showed that the bullets were generally contained within the first three inches of the granular rubber medium. The top cover performed per the manufacturer's literature. During both demonstrations, there was no indication of rounds ricocheting; the target frames and the toe boxes were inspected and there was no evidence of errant rounds.

As part of the initial evaluation, the water collection reservoir inside the STAPP™ system was checked periodically to monitor how much water was collecting. Water collection became a management issue for the STAPP™ systems and is discussed in Section 5.4. The overall quantity and analytical results for water removed from the STAPP™ systems are presented in Section 5.4. There were no validation tests for Juliet and Kilo Ranges as the test at Tango Range served this purpose for STAPP™ system use on Camp Edwards. Juliet and Kilo Ranges also had issues with water collecting within the system that exceeded what was expected by the manufacturer. The water issue at Juliet and Kilo Ranges was not as significant as that at Tango Range but still became an undesirable maintenance and management issue.

3.0 RANGE USE HISTORY

Range users consisted of MANG (Army and Air), U.S. Coast Guard (USCG), Army Reserve units, and various law enforcement agencies and personnel (Figure 7).

Detailed records are kept by Range Control as to the rounds fired, type of round and the lane used. The Army and National Guard are required to track ammunition usage for accountability of resources and to document small arms range throughput (utilization) in accordance with AR 350-19, The Sustainable Range Program. For safety purposes live ammunition usage by specific type must be maintained in various Range Control logs and is a requirements of the OMMP.

Figure 7. Soldiers from the 182nd Infantry Firing at Juliet Range.

The operational firing results for this report cover March 2007 through December 2015. There were two demonstrations at Tango Range in March and April 2007 and 58 operational firing events over the course of its formal Pilot Period, August 2007 through December 2008. Tango Range was used 125 days and Juliet and Kilo Ranges were used for 150 days each since the ranges became operational. As of the end of Training Year 2015 (September 30, 2015), 1,121,332 rounds have been fired on the STAPP™ ranges. The number of rounds fired per range is: 323,331 on Tango Range, 296,599 on Juliet Range, and 499,282 on Kilo Range. The types of ammunition fired were: 5.56mm, 9mm, 40cal, 7.62mm, 2.23cal, 45cal, and 38cal. Out of the total rounds fired: 68.5% were 5.56mm, 21.4% were 9mm, 7.0% were 40cal, 1.2% were 7.62mm, 0.78% were 2.23cal, 0.67% were 45cal, and 0.03% were 38cal. Tables 3-1 to 3-3 provide the number and types of lead ammunition fired on the ranges.

Table 3-1 Lead Ammunition Use History, Tango Range

Training Year	.40 Cal Lead	9 mm Lead	7.62 mm Lead	5.56 mm Lead	.38 Cal Lead	.45 Cal Lead	.233 Cal Lead	Total
2015	0	5,240	0	1,720	0	0	0	6,960
2014	0	0	0	3,220	0	0	0	3,220
2013	1,600	1,800	0	2,000	0	0	4,550	9,950
2012	2,800	7,373	0	1,944	0	0	0	12,117
2011	5,200	6,765	0	25,157	0	0	0	37,122
2010	40,341	2,496	0	41,042	0	6,449	0	90,328
2009	0	31,985	0	105,077	300	0	0	137,362
2008	4,075	9,094	4,556	0	0	0	0	17,725
2007	0	0	0	8,547	0	0	0	8,547
Total	**54,016**	**64,753**	**4,556**	**188,707**	**300**	**6,449**	**4,550**	**323,331**

Table 3-2 Lead Ammunition Use History, Juliet Range

Training Year	.40 Cal Lead	9 mm Lead	7.62 mm Lead	5.56 mm Lead	.38 Cal Lead	.45 Cal Lead	.233 Cal Lead	Total
2015	2,500	24,828	0	36,938	0	1,000	0	65,266
2014	2,400	18,874	9,000	6,663	0	0	0	36,937
2013	2,450	9,260	0	27,286	0	0	1,200	40,196
2012	750	12,819	0	14,457	0	0	3,000	31,026
2011	0	16,911	0	46,630	0	0	0	63,541
2010	0	7,311	0	27,060	0	0	0	34,371
2009	0	4,780	0	11,482	0	0	0	16,262
2008	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0
Total	**8,100**	**94,783**	**9,000**	**170,516**	**0**	**1,000**	**4,200**	**287,599**

Table 3-3 Lead Ammunition Use History, Kilo Range

Training Year	.40 Cal Lead	9 mm Lead	7.62 mm Lead	5.56 mm Lead	.38 Cal Lead	.45 Cal Lead	.233 Cal Lead	Total
2015	0	15,601	0	54,372	0	0	0	69,973
2014	0	31,304	0	49,052	0	0	0	80,356
2013	0	731	0	73,011	0	0	0	73,742
2012	0	7,181	0	52,731	0	0	0	59,912
2011	14,362	9,850	0	100,942	0	0	0	125,154
2010	1,450	7,500	0	51,412	0	0	0	60,362
2009	0	6,675	0	23,108	0	0	0	29,783
2008	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0
Total	**15,812**	**78,842**	**0**	**404,628**	**0**	**0**	**0**	**499,282**

As a requirement of the Tango Range OMMP, the MANG conducted a mass balance of bullets contained in the STAPP™ system. The mass balance was conducted to assess a percentage of rounds captured by weight, measuring the weight of rounds fired versus the weight of the metal collected from the system. The mass balance provides a known percentage of the calculated weight of the bullets fired versus the weight of material recovered that has been contained and not introduced into the environment. This information was reported in the 2009 Pilot Period Report.

The normal objective of the routine bullet pocket maintenance is simply removal of accumulated rounds. Accumulated rounds can be a ricochet hazard to the top cover over time. The maintenance process is done to reduce the overall top cover maintenance requirement. A mass balance on a STAPP™ system had never before been attempted and the weight measurements taken cannot, by the very nature of the materials involved, be a perfectly precise exercise.

An extrapolation approach was used based upon bullet pocket removals within each lane. The bullet pockets in each lane represent the greatest concentration of projectiles in the STAPP™ system. Under normal circumstances the recommended maintenance for bullet pockets is done every three years or 500,000 rounds, but in this case it was determined to perform the manufacturer-recommended maintenance early, in conjunction with the mass balance measurement requirements of the OMMP.

Additionally, two lanes (Lanes 14 and 15) were selected for complete removal of all rubber granules that would be sifted and sorted to obtain projectiles to be weighed (Figure 8). This weight allowed for the extrapolation across the range of the rate of capture of projectiles fired into the STAPP™ system.

Figure 8. Tango Range Lanes 14 and 15, Sorting and Sifting Operation during Mass Balance Work, Camp Edwards, Massachusetts

The rubber granules were returned to the STAPP™ system following the removal and inspection (Figure 9).

On November 17, 2008, the sifting operation began. The sifting process was interrupted after the work was underway due to improper site preparation. As a result of this initial change, it was unknown if Lane 14 was effectively isolated while being screened. Measurement of hot spots was then continued with lanes 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, and 1. It is believed that Lane 14 and 15 bullet pockets were combined during the screening process.

Per the Range Control documented summary of rounds fired, and the individual weights of the types of bullets that were fired, the total weight of spent rounds in Lanes 14 and 15 for the test period is calculated to be 108.45 lbs. compared to a measured weight of 102.49 lbs. This will be discussed in detail at the end of this section.

The actual recovered weight from the complete lane sifting of Lanes 14 and 15 was 68.50 lbs. in Lanes 14 and 15 plus the previously removed bullet pocket weight of 32.00 lbs. The bullet pocket weight is labeled Lane 14, but there is a high probability this includes Lanes 14 and 15 due to the interruption of the bullet pocket measurement. As stated previously, the STAPP™ system has no internal lane divisions.

As an additional check, a 2,000 lb. sample of granular rubber from Lanes 14 and 15 was not returned to the system after the complete lanes sifting and weighing event. This sample volume was subsequently resifted and missed bullets were captured and weighed. The weight of the spent bullets was 0.272lb for this sample volume. To extrapolate the missed spent bullets and fragments found in the resifting exercise of the granular rubber sample from Lanes 14 and 15, the following equation was used:

Weight of spent bullets from resifting			Sample of rubber from Lanes 14 and 15			Rubber weight per lane			Lane 14 and 15			Additional weight of spent bullets from the resifting of Lanes 14 and 15	
0.272	lbs.	/	**2000**	lbs.	X	**7333**	lbs.	X	**2**	lanes	=	**1.99**	lbs.

It is expected that some of the bullets have been pulverized into very small fragments by hitting other bullets/fragments, etc. and would not be possible to account for in this particular procedure.

To determine the total lbs. of weight recovered from Lanes 14 and 15 during the bullet pocket cleanup, complete lane sift and resift of the 2,000 lbs sample, the following equation was used:

Bullet Pocket weight lane14 and likely lane 15			Weight of spent bullets from lane 14 and 15 not including bullet pocket weight			Extrapolated weight from above from resifting lane 14 and 15			Total spent bullets recovered from Lanes 14 and 15	
32.00	lbs.	+	**68.50**	lbs.	+	**1.99**	lbs.	=	**102.49**	Lbs.

Figure 9. Tango Range Lanes 14 and 15, Re-Installing Rubber Granules after Mass Balance Work, Camp Edwards, Massachusetts

Compared to data on weight of total rounds fired per the Range Control log (102.29 lbs./108.45 lbs.) = 94.3%.

Given the inherent difficulties of the field measurement and the precision of some of the measurements, roughly 94% agreement can be considered excellent for this mass balance exercise.

A possible better indicator of system performance than weighing the bullet pockets is an evaluation of the under and overshot data. A visual inspection shows some bullet holes in the overshot wall and toe berm boxes. There are relatively few overshot and these decrease with height. This pattern was readily seen on the plywood overshot wall above the STAPP™ system. This is perhaps a more realistic estimate of system efficiency, i.e. number of rounds fired from Range Control records, less number of bullet holes in plywood and toe box, divided by total number fired.

Over and undershot have been closely monitored. Individual bullet holes have been marked, dated and counted in the toe berm boxes and plywood overshot wall. The percentage (%) of rounds that were over and undershot is calculated at 0.5% per the discussion below. Based on over and undershot data, and assuming no bullets are being purposefully shot high or low, and the known quantity of bullets fired, the recovery rate of the STAPP™ system is calculated to be over 99%.

Range Control personnel thoroughly inspected the toe berm boxes and reported finding 392 bullet holes for the period March 2007 through November 2008. The toe berm boxes have been in place for the entire Pilot Period firing. The calculated percentage of low shots is 0.316% (392 holes/123,787 total rounds fired).

Range Control personnel also inspected the overshot wall above the STAPP™ system and reported finding 187 bullet holes. The wall was erected during the week of February 11, 2008. Calculating the percentage of high shots using the number of rounds fired from the wall erection date to the end of the period, shows 0.183% (187 holes/101,916 rounds fired Feb 11 – Dec 31 2008). The calculated percentage of rounds not contained in the STAPP™ system is 0.5% (619 high and low rounds detected/123,787 total rounds fired). Using the above calculations of bullet holes above and below the STAPP™ system, roughly 99% of the rounds fired were likely contained in the STAPP™ bullet trap. Using this metric, the MANG considers the range configuration highly successful in terms of bullet containment and environmental protection.

From both methodologies it is expected that the STAPP™ system and its supporting components are successful in capturing and containing from 94%-99% of the projectiles fired at the system.

The vast majority of bullets fired on Tango, Juliet, and Kilo Ranges are contained in the STAPP™ system. It has been observed that a small percentage of rounds fired do not make it into the STAPP™ system. The major causes for rounds not penetrating the STAPP™ are rounds ricocheting off target frames and Soldiers firing too high or low, referred to as overshot or undershot. Undershot bullet holes have been found in the toe berm boxes at the base of the system and overshot has made holes in the wood wall above the original Tango Range STAPP™ system. Ricocheting rounds, or those aimed too high, may also hit near the upper edge of the STAPP™ system and "skip" back out of the system. An auxiliary berm to the STAPP™ system berm that extended above the top of the system was originally part of Tango Range when constructed in 2006. It had provided some overshot detection and protection, but was removed as part of the search for the source of water that was entering the STAPP™ system during the 2007 reconstruction effort. In order to evaluate and monitor overshot above the STAPP™ system, a four-foot high plywood wall was installed in February 2008, at the top of the berm after the original top of the berm was removed (Figure 10). The intent was not to capture the ricochets or overshot but to assess a possible percentage of rounds that were not being captured in the STAPP™ system.

A red stripe was painted on the upper portion of the top cover on all STAPP™ ranges to limit overshot (Figure 11). The red line provides for an upper limit of aiming for all range users. This has greatly reduced impacts to the STAPP™ system above the red upper limit line.

Figure 10. Plywood Overshot Telltale Wall, Tango Range, Camp Edwards, Massachusetts.

Figure 11. Red Line, Upper Limit of Aiming to Decrease Overshot, Juliet Range Camp Edwards, Massachusetts.

As part of the Tango Range Pilot Period and as discussed above, an alternative metric of bullet containment was used and a mass balance evaluation was also conducted to identify the percentage of rounds captured within the system. During the mass balance and inspection activities, it was noted that the bottom-liner between Lanes 6 and 7 was perforated by several 7.62mm rounds. The penetrations were investigated by recovering the bullets (Figure 12). The bottom-liner was repaired by STAPP™ and Range Control personnel. The exact cause of the 7.62mm bullet penetrations in these two lanes is not known. It can be speculated that the depth of rubber granules was not sufficient at the location of the penetrations and could be caused by repeated use of the lane by machine gun fire (M240B, 7.62mm). The bottom-liner under the "bullet pocket" of all 15 lanes was inspected during the mass balance work and no penetrations were found other than Lanes 6 and 7. The original OMMP accounted for the potential of penetrations in the bottom-liner and the MANG followed the appropriate procedures: they notified regulators, recovered the rounds, repaired the bottom-liner, and returned to training. To further lower the probability of penetrations, approximately two tons of additional granular rubber material was added during the top cover replacement performed in July 2009.

In general, results of inspections of Tango, Juliet, and Kilo Ranges during the Pilot Period show that the STAPP™ system, when properly operated and maintained, functions to contain bullets, sever exposure pathways and protect the environment.

Figure 12. Bottom Liner Penetrations and Recovered Rounds, Tango Range Camp Edwards, Massachusetts.

4.0 RANGE OPERATIONS, INSPECTIONS, MAINTENANCE, AND MODIFICATIONS

The following sections discuss how the STAPP™ ranges are operated, the maintenance and modifications performed, and range inspections conducted by the MANG, EPA, and the EMC. During the Pilot Period, several modifications to the original range configurations were implemented. All range modifications were discussed and approved at the SARWG meetings and through required regulatory processes. The OMMP has also been modified to reflect changes that were identified and approved.

4.1 RANGE OPERATIONS

Camp Edwards Regulation TAGMA PAM 350-2 outlines extensive rules and procedures for the ranges and training lands on Camp Edwards. The OMMP in sections 4.0 and 7.0 (Appendix A) also outlines extensive rules and procedures for the ranges on Camp Edwards. Range Control personnel are well-versed with these regulations and educate Range Safety Officers (RSOs) during the scheduling and issuance of ranges to using units. Camp Edwards personnel oversee and assist the training conducted on Juliet, Kilo, and Tango ranges and evaluate whether training is conducted in accordance with operational, safety, and environmental requirements. Before occupying Juliet, Kilo, or Tango Range, the unit must designate an RSO who will receive a safety briefing. The briefing informs units of the installation's restricted areas, misfire and malfunction procedures, communication procedures, and environmental considerations such as minimum and maximum firing distances and aiming below the red line painted on the upper portion of the STAPP™ systems.

Range Control is responsible for the oversight of Juliet, Kilo and Tango range operations. They issue and clear the ranges and monitor units on Juliet, Kilo and Tango ranges to support compliance with the OMMP. The Camp Edwards Environmental Office and Range Control schedule all required monitoring and maintenance.

To ensure continuity of operations during military staff transitions, Range Control has hired a civilian range control person. This positions job will be to learn all aspects of range operations, help in directing staff to manage the ranges and again to ensure continuity during military staff transitions.

In accordance with the OMMP, each unit is responsible for completing the Training Facility Utilization Report in Appendix A of the OMMP (Appendix A). This form documents who uses the facility, how many personnel were trained, what they did, the quantity of rounds fired and other information important for tracking the use of the facilities. Each Report is turned in to Range Control at the end of each training day. This information feeds into the detailed inspection log maintained by Range Control. An important aspect of ensuring compliance with the OMMP was communicating and coordinating with personnel using the ranges. Range Control personnel were active in educating users of the specific OMMP requirements in order to maintain compliance.

Over the course of the Pilot Period and as standard practice, Range Control maintains a detailed log for each firing event. Data recorded from each event includes, but is not limited to: unit firing, officer in charge, temperature, weather, the time when the range went hot and cold, and the particular type of round fired on each lane. These records allow the user to query the data by the number of rounds and type fired on each lane.

4.2 RANGE INSPECTIONS

Tango, Juliet, and Kilo Ranges have been the focus of extensive inspections during the Pilot Period (Appendix A). The MANG (Range Control and the E&RC), EMC's Environmental Officer, EPA and MassDEP have all performed inspections before, during and after training events.

The ranges are inspected periodically as described below to ensure that pollution prevention equipment remains in place and is in good working order and to ensure that environmental conditions on the ranges are not degrading.

Before each time a range is used for live firing, a range inspection is conducted by Range Control accompanied by the Non-Commissioned Officer in Charge (NCOIC) or person in charge of the group using the range. This provides a chance to document pre-firing conditions and to acquaint the range users with the facilities and the expectations associated with range use. The inspection includes the firing line, range floor, target line, STAPP™ system, and other important features of the ranges. The parking areas are inspected for general condition and any petroleum, oil, and lubricant stains from vehicles. The toe berm boxes behind the target frames are evaluated to identify deterioration, damage or excessive amounts of undershot. Range Control and range users note the condition of each of these features and any specific deficiencies in need of repair.

The ranges are inspected again after range use is complete to document the post-firing conditions (Figure 13). The form provided in the OMMP (Appendix A) is used to document the pre- and post-range firing inspections and to note any changes or discrepancies.

Figure 13. Tango Range Top Cover Inspection, Range Control Camp Edwards, Massachusetts.

Monthly inspections consist of general range conditions, evaluation of erosion, surface water, vegetation growth, and a visual inspection of the STAPP™ system. Range issues were documented, reviewed with appropriate personnel and addressed by Range Control. Inspections identified issues with the STAPP™

system structure, systems that protect the STAPP™ system, and the administrative record. The following provides several examples of issue identified during inspections.

The toe berm boxes at Juliet and Kilo Ranges were degrading and becoming a major maintenance issue. The box bottoms were collapsing with the protective sand infill spilling from the box. Interim repairs were made by filling the toe berm boxes with sand bags until new boxes could be placed on these ranges. All toe berm boxes on Juliet and Kilo Ranges have been replaced.

Penetration holes, rips greater than 1.5 inches in length with rubber media visible through the rubber membrane cover, and seam failures have been found at the STAPP™ Ranges. Repairs are made prior to subsequent range use. However, there are times where problems identified could not be immediately addressed--most often as a result of weather conditions and or availability of materials. Repairs were made when the weather allowed and orders were made to provide for materials needed to repair the system.

Finally, it was identified that the administrative record was not in order. Issues identified included Utilization Inspection Reports that did not consistently record the requested information; the most up-to-date detailed inspection form and range inspections/clearance checklist were not being used, and these forms did not consistently record the requested information. Also, some post-fire inspections were not recorded, and it was not clear that maintenance was conducted based upon the results of each inspection. Administrative record issues were rectified by meeting with Range Control staff to ensure all current forms are used and, most importantly, that all issues identified and repairs are recorded in the record.

Range Control conducts Detailed Range Inspections monthly. Detailed Range Inspections are also completed within two business days of significant storm events. These inspections determine the condition of pollution prevention equipment and general range conditions. In particular, the conditions of the STAPP™ system and any protective cover are closely monitored. The amount of water accumulated in the STAPP™ system is measured and recorded. The form provided in the OMMP (Appendix A) is used to document the Detailed Range Inspections. During the Detailed Range Inspection conducted each year in March, Range Control takes baseline condition photos every third year of the firing lines, range floors, soil berms, and bullet containment systems while standing at firing positions 4 and 13. These and previous baseline photos help field crews evaluate observed conditions against the baseline and help document the rehabilitation of any reported range deterioration using the baseline condition photos and any rehabilitation photos. This photo log is maintained at Range Control.

The conditions inside the STAPP™ system are inspected and documented when the STAPP™ cover is removed for maintenance and/or during periodic bullet removal. Typically, this is done after 500,000 rounds have been fired on Juliet and Tango Ranges and after 750,000 rounds at Kilo Range unless it is determined in conjunction with the regulatory agencies that removal is not needed. This inspection can also be conducted more frequently if conditions warrant. The form provided in the OMMP (Appendix A) is used to document the detailed STAPP™ inspections.

The internal STAPP™ system was qualitatively assessed in the spring and again in early summer 2016 in support of a Scope of Work development for metals removal from the Juliet Range STAPP™ system. The bullets were observed to be contained within the top 8-12 inches of the system. Consequently, it was determined that the rubber granule material and any contained lead bullets will be removed selectively from the system. The portions of the system containing the greatest concentrations of lead bullets will be disposed of off-site as hazardous waste. New rubber granule material will be added back to the system, and those portions removed from the top and bottom of the system will be re-installed to the same areas in which they were removed. This action is scheduled to be conducted during the summer of 2016. After the rubber granule material is removed, the bottom underlayment, ground liner, and wooden frame will be inspected for damage.

The EMC and EPA have conducted unannounced independent inspections of Juliet, Kilo, and Tango ranges as needed. All personnel, including regulatory personnel, check in with Range Control prior to visiting the ranges. If inspections occur during range use, the inspector identifies themselves to the person in charge at the range and follows all safety procedures and requirements of the range users. EPA and EMC provide the inspection form to Range Control for inclusion in the inspection record. To ensure that all deficiencies identified during an inspection are addressed, Camp Edwards provides a formal response to inspection reports submitted by regulatory agencies within five business days.

Range Control maintains all the inspection logs with hard copies placed in a binder and archived. Range Control compiles data into a table that tracks the maintenance performed, level of effort to perform the maintenance, and supplies required to conduct maintenance. The primary maintenance conducted as a result of the inspection process is patching or seaming the STAPP™ system top cover and removal and disposal of water collected within the STAPP™ system internal reservoir. In an effort to reduce the amount of water accumulating within the system, tarps were placed over the top covers in 2010. Water within the reservoirs of the STAPP™ systems has become less of an issue after the installation of tarps over the STAPP™ systems when not in use (Figure 14). A summary of inspection table can be found within the OMMP (Appendix A).

Figure 14. Tarp Covered STAPP™ Systems at Juliet and Kilo Ranges Camp Edwards, Massachusetts.

EPA issued a letter on March 15, 2011 notifying Camp Edwards of a failure to notify EPA of level 1 and 2 interim action level exceedances and the fact that resampling did not occur as required. On May 3, 2011 the EPA issued a letter notifying Camp Edwards of a failure to comply with the Safe Drinking Water Act through AO2 and its modified SOW to allow for the interim use of Tango, Juliet and Kilo Ranges. Camp Edwards did not comply with the OMMPs for these ranges. Camp Edwards did not sample soil, porewater, and groundwater and did not report the findings as required. Another letter was issued to Camp Edwards on November 7, 2011 for failure to follow the provisions of the approved OMMPs for the above mentioned violations and additionally for not disposing of water that accumulated in the STAPP™ systems on Tango, Juliet and Kilo ranges above established limits within 72 hours and for not notifying EPA within 24 hours that this required action could not be completed.

The EMC also issued a Notice of Violation letter to Camp Edwards on November 7, 2011 informing it that it had not complied with the Small Arms Range EPS (EPS 19) in failing to remove liquid from the STAPP™ bullet capture systems on Tango, Juliet and Kilo ranges on multiple occasions in 2011 within the time period established in the OMMP plans. Camp Edwards submitted a Response Packet to the EPA and EMC in early December 2011.

As a result of these violations, and after extensive consultations, Camp Edwards was fined by EPA $27,500 in August 2012 and also agreed, through a Consent Agreement and Final Order on August 16, 2012 (Appendix D), to conduct a Supplemental Environmental Project (SEP). The project involved removing 14 acres of existing impervious surfaces in the grasslands area of the Cantonment Area, most of it located on Otis Air National Guard Base. The 14 acres were left to seed naturally from the surrounding environment. This allows for native flora to establish itself within the grassland area. It also allows for further recharge of the aquifer by removing impervious surface area. The area will be monitored for invasive plants species and managed to control the density of native pitch pine that can act like an invasive species by growing into a monoculture that is not beneficial to the goal of grassland restoration.

Project status reports on the removal of the 14 acres of impervious surface were submitted to EPA on November 5, 2012, January 10, 2013 and May 7, 2013, with a final report submitted on October 12, 2013 notifying EPA of the project's completion.

As a result of this violation, and as proposed in the Response Packets, the MANG submits a Monthly Report on the status of the STAPP™ Ranges to EPA and also provides it to the EMC. Monthly Sustainable Range Program meetings were also proposed and are being conducted to ensure proper awareness, communications, and management of the STAPP™ and other ranges is occurring. The Response Packet also addressed communications, notification protocols, and that proper funding for STAPP™ range management was in place.

4.3 RANGE MAINTENANCE AND MODIFICATIONS

Camp Edwards conducts periodic maintenance on Juliet, Kilo, and Tango ranges to ensure design features and pollution prevention measures remain in adequate condition to support training requirements and ensure that the BMPs function as intended. To the maximum extent possible, maintenance is conducted during off-peak training periods (between October and April). This preventative maintenance is conducted as needed, regardless of other maintenance schedules.

All maintenance and repairs conducted on Juliet, Kilo, and Tango ranges are documented using a Range Maintenance/ pH testing/Lime Spread Form in the Appendix C of the OMMP (Appendix A) and then filed in the maintenance log at Range Control.

The majority of site maintenance consisted of patching and seaming the STAPP™ system top cover. Other maintenance activities consisted of pumping and disposing of water collected in the STAPP™ system reservoir and grounds keeping.

A range modification was made based on a request by the USCG to utilize the range for transition or reflexive firing training, the OMMP was reviewed to ensure it was protective during this type of use with respect to firing lines, firing lanes, weapons, ammunition types, and target placement. With respect to the firing lines, the reflexive firing training requirement is to fire from several different distances from the target line, between three to 25 yards. In October 2007, the USCG conducted a dry-fire demonstration so members of the SARWG could observe and understand the training aspects of transition firing. To further support this training requirement, the MANG established a maximum and minimum firing distance from the target line along the range floor. The maximum firing distance is 25m, and the minimum firing distance is 2.7m. The maximum and minimum distances are within the Surface Danger Zone (SDZ) for the bermed range and are within the capabilities of the STAPP™ system. The current design and construction of STAPP™ could support rounds fired directly on the upper membrane without compromising the integrity of the trap; however, weapons training does not authorize or require point blank firing at the STAPP™ system.

At Tango Range pre-existing elevated machine gun mounds located behind the firing line were knocked down, as they served no useful purpose. During the week of April 19, 2008, the mounds were knocked down and used to raise the height of the 25 meter firing line by approximately two feet, creating an improved angle of fire that decreases overshot.

Range floor drainage was an issue on Juliet and Kilo Ranges. The lack of adequate drainage on this range was threatening the integrity of the base of the STAPP™ system and Soldiers were forced to conduct their training by laying in the water to fire on the range. In 2010, a project was initiated and completed that re-graded the range floor and installed drainage systems to correct this issue on Juliet and Kilo Ranges.

An additional modification to Tango Range was the installation of a wooden plywood wall located above the STAPP™ system on the berm. The wall was installed to help evaluate how many rounds fired high may be missing the STAPP™ system. A broad red stripe was placed near the top of the STAPP™ systems on Juliet, Kilo, and Tango Ranges to aid in preventing overshot at these ranges. The stripe provides the shooter with a visible mark to avoid aiming the weapon above this stripe thereby helping to prevent overshot.

Prior to full-scale training, initial checks on the STAPP™ systems showed that larger than expected amounts of water was collecting inside the systems. To help assess potential causes of the water collection, a detailed dismantling and inspection of the Tango Range STAPP™ system was planned prior to full-scale training on the range. The STAPP™ contractor deconstructed the system in July 2007. Just prior to dismantling the system, an additional 300 gallons of water was removed.

As part of the inspection process, the system was taken apart and all aspects of the construction were reviewed: the framework was intact, the bottom-liner was not ripped or perforated, the depth of rubber granules was correct, and the top cover did not have any visible holes other than the above-mentioned seam failures/tears. However, it was noted that there was some silt inside the center section of the system. The moist silt indicated a potential mechanism or pathway for the excess water entering the STAPP™ system. The silt and water may have entered the STAPP™ system by flowing between the bottom-liner and the top cover where they are attached to the frame at the highest point of the system. To remedy this potential cause of water infiltration, the apex of the earthen berm extending higher than the Tango Range STAPP™ system was removed to reduce the amount of precipitation running down and over the face of the STAPP™ system. Additionally, a minor modification was made to the method of securing the bottom-liner and top cover to the frame along the top edge of the system. The bottom-liner of the system was free of any bullet holes, and the 1,700 bullets fired during the demonstrations were contained within the rubber granular medium.

Overall, the system appeared to be installed correctly with the exception of concerns that the original gluing of the seams was not done in strict compliance with recommendations of the glue manufacturer. The STAPP™ system was re-constructed with a new bottom-liner as the original bottom-liner was damaged when the system was dismantled. As an additional protective measure, a felt fabric material was placed between the soil and the bottom-liner. The original rubber granules and top cover were used and the re-constructed Tango Range STAPP™ system was made available for small arms range training in August 2007.

On Juliet and Kilo Ranges water within the system was also an issue but not to the extent that occurred at Tango Range. Like Tango Range, all aspects of the systems were checked and were found to be sound in their structure and function. During the spring of 2015 STAPP™ EBC came to Camp Edwards to try and remedy the water collection issue at Juliet and Kilo Ranges. Their efforts included removing and replacing framing members while tightening the top cover and placing bottom liner material from the top of the system to the ground behind the system. In theory it was to shed water from running under the system or between the bottom liner and the top cover. The repair was not successful in reducing the amount of accumulating within the system. To remedy water build up on all STAPP™ ranges the STAPP™ systems were recovered with tarps to protect from precipitation. This action proved to be extremely effective in reducing the water issue with the STAPP™ systems. Water is still found within the reservoir but not the volumes seen before the using traps to cover the STAPP systems. Table 4-1 shows pumped STAPP™ system water prior to and after tarps were used to cover the STAPP™ systems.

Table 4-1. Pumped STAPP™ System Water, Before and After Tarps Were Installed, JKT Ranges, Camp Edwards, Massachusetts. (*Tarps installed September/October 2011)

Training Year	Tango Range	Juliet Range	Kilo Range
2007	1,420	--	--
2008	1,870	--	--
2009	4,570	0	0
2010	700	130	140
***2011**	2,465	815	1,545
2012	115	62	128
2013	8	70	155
2014	115	100	71
2015	480	630	95
Total	**11,743**	**1,807**	**2,134**

Another modification to the STAPP™ systems was the incorporation of a view/extraction port for the internal water collection reservoir (Figure 15). Initially, the internal reservoir was only accessible by unbolting and peeling back the top cover. Range Control installed an external port to allow for the viewing and removal of collected water. The riser pipe was extended and a round hole was cut into the top cover, a sealed rubber boot was applied and top cap was installed. This modification saves time and effort in evaluating the internal water collection reservoir. This modification was implemented at Tango, Juliet, and Kilo Ranges. The port on Tango Range is located in the lower right hand corner facing the system, on Juliet Range it is in the lower left hand corner, and on Kilo Range there is a port at both the lower right and left hand sides of the system.

Figure 15. STAPP™ System internal Reservoir Access Port Tango Range, Camp Edwards, Massachusetts.

5.0 ENVIRONMENTAL MONITORING RESULTS

Camp Edwards monitors surface soils, pore water, and groundwater at Juliet, Kilo and Tango ranges on a rotating schedule (Appendix A) for the metals antimony, copper, and lead. There is a potential for these metals to occur and move within the environment after projectiles that are fired onto the range are oxidized, abraded, and further exposed to the environment. The goal of the monitoring is to determine when range maintenance activities are needed to protect the environment and promote range sustainability. Data validation is completed at the Tier I[1] and Tier II[2] level for all data. Ten percent of the data is validated at the Tier III level. Unvalidated (i.e. draft) data is forwarded to the regulatory agencies within two business days of receipt by the MANG.

The results of sampling are compared to the action levels presented in Table 5-1. Any increase in concentrations are noted in the results submittal. If an unexpected result exceeds an Action Level, resampling may be conducted to confirm the result. Any concentrations exceeding the action levels are noted in the results submittal and a proposed plan for re-sampling, if needed to confirm an exceedance, is included pending data validation. Validated data is forwarded to the regulatory agencies as soon as feasible within seven business days of receipt. Validated data is normally received by the MANG 4-6 weeks after sampling occurs.

Action Levels for contaminants associated with small arms firing were established for soil, porewater, and groundwater based upon comments from the SARWG and members of the SAC. Initially (May 2007), there were two levels for porewater and groundwater and one level for soil. The matrix of Action Levels was simplified such that there is currently one action level for each potential contaminant (antimony, lead, copper) for each sampling media (soil, porewater, and groundwater). With approval from the EPA and the EMC, tungsten, zinc, and nitroglycerin are no longer part of the analysis. For tungsten, the source area at each range where tungsten bullets were used was removed so that further sampling for tungsten on the STAPP™ ranges was no longer required. As for nitroglycerin, a study was conducted in 2010, Adsorption/Desorption Measurements of Nitroglycerin and Dinitrotoluene in Camp Edwards, Massachusetts Soils. This study found that unfired and fired propellant tests suggest that nitroglycerin and dinitrotoluene is not completely available for dissolution, and tests with weathered soils indicate none of the nitroglycerin is available, although analysis shows nitroglycerin is still present in the soil. Therefore it was found that nitroglycerin was not a threat to the groundwater and was no longer needed to be analyzed for at the STAPP™ ranges.

The surface soil action levels for lead, copper, and antimony are set using selected concentrations from the Massachusetts Contingency Plan. These values are not necessarily directly applicable to active small

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[1] Tier I Data Validation will include a general review of sample receipt, analysis, and the ability of the instruments to recover the elements or compounds that were analyzed. The main components of a Tier I Data Validation include: assessing the technical holding times, surrogate recoveries, matrix spike/matrix spike duplicates, laboratory control samples, and method blanks.

[2] Tier II Data Validation will include all of the parameters assessed during the Tier I Data Validation as well as the following parameters: Metals (6010C and 6020A): Mass spectrograph tuning; initial calibration; Continuing calibration; internal standards; Target compound identification. Tentatively Identified Compounds (TICs): TICs will only be addressed in Tier II Data Validations and are generally evaluated only for ground water recovery results. Initial and continuing calibration; Duplicates; Metals spikes and LCS recovery; Assessment of Interferences; Mass tuning (6020A). These parameters primarily deal with instrument calibration and analysis sensitivity. Additionally, Tier II Data Validation includes several methods that are not, or are only generally, addressed in the Tier I Data Validation Checklist.

arms ranges, but they provide a framework for comparison to concentrations that are considered potentially hazardous in some situations. Porewater action level numbers are based on drinking water standards because the porewater is monitored as an early warning of potential groundwater impacts. Drinking water standards are not applicable to porewater but they provide a framework for comparison to concentrations that are potentially hazardous if they were to migrate all the way to the aquifer. Groundwater action levels are set equal to one half of the drinking water standard because a detection of range-related metals in groundwater at these concentrations would indicate a potentially significant and unexpected occurrence and response actions should be taken before concentrations exceeding safe drinking water concentrations occur. The current Action Levels are summarized in Table 5-1.

Table 5-1. Current Action Levels for Soil, Porewater, and Groundwater
Camp Edwards, Massachusetts.
Surface Soil

Action Levels			
	Lead	**Antimony**	**Copper**
Surface Soil	3,000 mg/Kg	300 mg/Kg	10,000 mg/Kg
Porewater	15 ug/L	6 ug/L	1,300 ug/L
Groundwater	7.5 ug/L	3 ug/L	650 ug/L

5.1 SOIL SAMPLING RESULTS

Soil analytical results are discussed in detail in the Annual Environmental Sampling Reports (Appendix B). All soil analytical results collected during the Pilot Period are summarized in those reports.

The soil sampling at Juliet, Kilo, and Tango Ranges is performed using an incremental sampling methodology (ISM) from six sample areas on each range on alternating years. The sample areas are laid out in strips across the width of the ranges from the firing lines to the backstop berms so that the impact of metals deposition at the firing lines, the target areas, and the areas in between could be separately quantified (Figures 4, 5, and 6).

One hundred-point composite samples are collected from each sample area from a depth of 0 to 3 inches below ground surface (bgs). All samples are ground and processed in accordance with EPA Method 8330B. Soil samples are currently analyzed for antimony, lead, and copper. Table 5-2 provides the maximum lead concentrations detected on Juliet, Kilo, and Tango Ranges since 2010. See Annual Environmental Sampling Reports for specific sampling data (Appendix B)

Table 5-2. Maximum Lead Concentrations (mg /Kg) Detected in Soil on Juliet, Kilo, and Tango Ranges
Camp Edwards, Massachusetts.

	OCT-10	MAY-11	OCT-11	SEP-12	JUL-13	AUG-14	AUG-15
Juliet Range	54.6	192	106	43.3	Not Sampled	58.4	Not Sampled
Kilo Range	28.2	30	35.5	Not Sampled	28.1	Not Sampled	34.4
Tango Range	1090	522	439	Not Sampled	351	Not Sampled	98.9

These values represent the maximum lead concentrations detected in the six soil sampling areas on each range floor. No consistent trends are apparent in the data at Juliet or Kilo ranges which indicates that lead concentrations are not increasing with continued use of the ranges. However, at Tango Range there is a decreasing trend in the maximum concentration of lead within the sampling areas. This trend may be a result of the lack of deposition and the adsorption of lead to soil at Tango Range. During the nine year pilot period no Action Levels for soil have been exceeded at Tango, Juliet, or Kilo Ranges.

5.2 POREWATER RESULTS

Porewater analytical results for Tango, Juliet, Kilo, and background lysimeters are discussed in detail in the Annual Environmental Sampling Reports (Appendix B). All porewater analytical results collected during the Pilot Period are summarized in the reports.

TANGO RANGE

Only antimony has been detected in porewater at Tango Range at concentrations above the Action Level (Table 5-3). This has occurred on two occasions (August 2014, 2015) at one location (LYTRNG013, Figure 4) at the center base of the STAPP™ system. Lead and copper concentrations remain well below the Action Levels. These detections are further discussed below.

Table 5-3. Antimony in Porewater at Juliet, Kilo, and Tango Ranges with Background Lysimeter Data to Include the Sierra Range Background Lysimeter.

Range	Lysimeter	Oct-10	May-11	Oct-11	Sep-12	Nov-12*	Feb-13*	Jul-13	Aug-14	15-Aug
Juliet	LYJRNG003	0	0	0	**11.4**	**32.8**	**43**	**36**	**54.1**	**70.75**
Kilo	LYKRNG003	0	0	0	**6.9**	**9.6**	**12**	**11.6**	**26.2**	**37.1**
	LYKRNG004	0	0	0	**7**	**12.1**	**15**	**11.5**	**17.3**	**35.7**
BG	LYKRBGD01	-	-	-	-	-	Not sampled	No sample /dry	0.43	No sample /dry
Tango	LYTRNG013	0	0	0	4	*4*	5.1	4.3	**11**	**15.2**
BG	LYTRBGD01	-	-	-	1.5	0.18	0.35	0.074	ND	ND
Sierra BG	LYSRBGD01	-	-	-	-	-	Not sampled	No sample /dry	No sample /dry	0.92

BG = Background
ND = Nondetect
*Resample

JULIET RANGE

Antimony has been detected in one porewater lysimeter (JRNGLY003) at Juliet Range at concentrations above the Action Level (Table 5-3). This has occurred in several sampling events. The location is near the STAPP™ system. Lead and copper concentrations remain below the Action Levels. These detections are further discussed below.

KILO RANGE

Antimony has been detected in the two porewater lysimeters (KRNGLY003 and KRNGLY004) at Kilo Range at concentrations above the Action Level (Table 5-3). This has occurred in several sampling events. These lysimeters are both in the drainage swale near the STAPP™ system. Lead and copper concentrations remain below the Action Levels. These detections are further discussed below.

BACKGROUND LYSIMETERS

In 2012 background lysimeters were installed in the vicinity of Tango and Kilo Ranges. They were installed to provide a comparative data set for the background occurrence in porewater of antimony, copper, and lead. The Tango Range background lysimeter is the only background lysimeter that was able to be consistently sampled since installation (Table 5-4). The Kilo Range lysimeter was only sampled in 2014 as it has been dry during all other sampling events. Although not sampled this cycle, the analysis of four rounds of background porewater sampling near Tango Range indicate antimony concentrations as high as 1.5 ppb, copper as high as 1.6 ppb, and lead as high as 0.53 ppb. At Kilo Range in 2014 porewater sampling indicated antimony concentrations of 0.43 ppb (Table 5-3), copper of 0.79 ppb, and lead of 0.084 ppb. Similar concentrations of these metals detected in lysimeters on the ranges may tentatively be expected to be background concentrations.

Table 5-4. Background Lysimeter Results for Tango Range, Camp Edwards, Massachusetts.

Year	Antimony	Copper	Lead
2012	1.5	1.6	0.079
2013	0.74	1.1	0.13
2014	ND	3.2	0.53
2015	ND	ND	ND

ND = Non-Detect.

The source of the antimony detected in the lysimeters near the firing berms at the three ranges is suspected to be from legacy range soils. At all three ranges, the soils comprising the berms were reshaped from previously used, on-site, range berm soil. The dissolution and movement of antimony may be exacerbated by the phosphate-based soil amendments that were used on and in the original berms to minimize dissolution of and migration of lead during the initial pollution prevention actions under AO2. Research has shown that antimony becomes mobilized in soil in the presence of phosphates.

It should also be noted that on Juliet and Kilo Ranges water runoff is directed from the range berm and floor into a drainage swale(s) thereby concentrating range runoff into a single sampling point. Along with the phosphate amendments, this process could be a contributing factor in concentrating antimony at the sampling points (porewater) which have exceeded the prescribed action level for antimony. Annual monitoring of porewater and groundwater at the ranges will continue including sampling for antimony so that the concentrations can be monitored and groundwater can be protected. Through the recommendation EMC's SAC (Section 6.0) monitoring porewater or the use of lysimeters will be replaced by using split core soil sampling when approved. The SAC voiced that they believe that the use of lysimeters and the results is not representative of how metals are moving through soils. They have stated that there is too much sampling bias; for example water has preferential pathways as it moves through soils along with the potential for the lysimeters themselves to be contaminated with soil material that may be affecting samples due to prolonged contact time.

5.3 GROUNDWATER RESULTS

Groundwater analytical results are discussed in detail in the Annual Environmental Sampling Reports (Appendix B). All groundwater analytical results collected during the Pilot Period are summarized in those reports.

TANGO RANGE

Groundwater beneath Tango Range flows from south to north (Figure 4). Tango Range has one groundwater monitoring well that is sampled annually, MW-467S. Monitoring well MW-467S is north of the firing line in a down-gradient position. The location and screen height of MW-467S was selected to intercept any Contaminants of Concern (COCs) emanating from Tango Range. Monitoring well MW-489S was also sampled in the past; however, it was discontinued for active monitoring under the OMMP because it is located south of the STAPP™ berm in an up-gradient location. Unfiltered groundwater samples are currently analyzed for lead, copper, and antimony using EPA Method SW6020A.

Results from sampling groundwater wells on Tango Range indicate that there are generally no concentrations of lead, copper, or antimony above the action levels in groundwater. The one exception was the 24.1 ppb result from a sample collected from MW467S in 2015. Low water levels within the well necessitated the use of a bailer to retrieve a sample from this well. In accordance with the OMMP the well was resampled and the results were 4.1 ppb for lead which is below the action level for lead in groundwater as set forth by the OMMP. Upon resampling the well still had low water levels but the samplers were able to collect a single sample.

The groundwater metals results obtained during the Tango Range Pilot Period are consistent with conclusions made in a report titled: The Environmental Assessment of Lead at Camp Edwards, Massachusetts Small Arms Ranges, May 9, 2007, Prepared by Jay L. Clausen, Biogeochemical Sciences Branch, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire (CRREL Lead Report). Conclusions made in the CRREL Lead Report indicate that lead has not migrated to groundwater at any small arms ranges monitored on Camp Edwards including some small arms ranges with decades of training using lead ammunition.

Like other propellants, nitroglycerine was thought to be a threat to groundwater. Groundwater sampling results for propellant related compounds, primarily nitroglycerine, are also consistent with conclusions made the report titled: Adsorption/Desorption Measurements of Nitroglycerine and Dinitrotoluene in Camp Edwards Soil, February 2010, prepared by CRREL. Based on the scientific studies to evaluate the fate and transport of propellants, one of the conclusions of this report states that the groundwater is not expected to be impacted by propellant residue associated with small arms range training. With approval from the EPA and the EMC, nitroglycerin is no longer required to be analyzed for when sampling groundwater at the small arms ranges.

JULIET RANGE

Groundwater beneath Juliet Range flows from northeast to southwest (Figure 5). Juliet Range has two groundwater monitoring wells that are sampled annually, MW-471S and MW-472S. Monitoring well MW-471S is downgradient of the STAPP™ system and MW-472S is downgradient of the range floor and firing line. The locations and screen elevations were selected to intercept any contaminants, primarily lead, antimony, and copper, emanating from Juliet Range. The source of lead and antimony being the projectile and the bullet primer that contains lead styphnate--another source of lead.

Results from groundwater wells on Juliet Range indicate that there are no concentrations of lead, copper, or antimony above the action levels in groundwater.

The groundwater metals results obtained during the Juliet Range Pilot Period are consistent with conclusions made in CRREL lead report.

The groundwater results for propellant related compounds, primarily nitroglycerine, are also consistent with conclusions made in the CRREL nitroglycerine report.

KILO RANGE

Groundwater beneath Kilo Range flows from northeast to southwest (Figure 6). Kilo Range has one groundwater monitoring well that is sampled annually, MW-474S. The location and screen elevation were selected to intercept any contaminants emanating from the range floor and firing line at Kilo Range. Well MW-473S was also previously sampled but was eliminated from the OMMP because it is not located appropriately to monitor for contaminants resulting from the range as currently configured.

As per the OMMP, groundwater samples are currently analyzed for lead, copper, and antimony using method SW6020A. Results from groundwater wells on Kilo Range indicate that there are no concentrations of lead, copper, or antimony above the action levels in groundwater. Samples were also previously analyzed for nitroglycerine and tungsten. In coordination with the regulatory community Tungsten was no longer sampled for as result of source removal at the range.

The groundwater metals results obtained during the Kilo Range Pilot Period are consistent with conclusions made in the CRREL lead report.

The groundwater results for propellant related compounds, primarily nitroglycerine, are also consistent with conclusions made in the CRREL nitroglycerine report.

Studies and data submitted by MANG indicate that the geochemistry of the soil serves to retard the migration of lead, and the depth to groundwater is deep, and substantial intervening soil acts as an absorbent. Data suggests that lead in soil will take a long time to significantly impact the groundwater. The models predict that it could take anywhere from several hundred to over a thousand years for groundwater to exceed drinking water standards. Further, any dissolved form of lead would be rapidly removed from porewater primarily via adsorption processes. Lysimeter results obtained during the Pilot Period support this conclusion as lead levels in porewater have either dropped or have remained consistent through the Pilot Period.

5.4 STAPP™ WATER COLLECTION AND ANALYSIS

During the course of the Pilot Period, water has been collected from the STAPP™ system internal reservoirs at Tango, Juliet, and Kilo Ranges in accordance with the OMMP. This process has resulted in the collection, storage, and disposal of the water according to state and federal regulations and law. Table 4-1 reflects the amount of water removed from the STAPP™ systems to date.

Upon completion of the installation of the STAPP™ system at Tango Range an unanticipated buildup of water was identified in the system. This reoccurring buildup of water was determined to be a result of condensation, as well as infiltration of precipitation into the system. This water was analyzed in March, April, and November 2007 for the MANG by Environmental Chemical Corp. (ECC) under contract with the US Army Corps of Engineers. The results of these sampling events identified the water as non-hazardous, however, elevated levels of antimony and zinc were detected above drinking water limits. In late November 2007, the existing analytical data was reviewed by the 102nd Intelligence Wing Waste Water Treatment Plant (WWTP) manager and the Massachusetts Army National Guard, in coordination with the Massachusetts Air National Guard, successfully introduced 840 gallons to the WWTP for treatment/disposal. Additional accumulated water was sampled in December 2007 by ECC and again in April 2008. The April 2008 analysis, conducted by TMC Services Inc., under Massachusetts Army

National Guard contract, was used to create a waste profile sheet for the disposal of 827 gallons of non-hazardous waste water at an off-site treatment facility in June 2008. In November 2008, the Massachusetts Army National Guard conducted sampling and analysis of the Tango Range STAPP™ water to be included as part of a formal request made to the WWTP to accept all water generated from the STAPP™ system. This request was verbally denied in a meeting with Massachusetts Army National Guard and Massachusetts Air National Guard personnel. In December 2008, using the profile created in June 2008, an additional 2,470 gallons of STAPP™ water was shipped off-site for proper treatment/disposal. It should be noted that before firing occurred at Tango, Juliet and Kilo Ranges the STAPP™ system water analysis showed elevated levels of metals.

In March 2009, the construction of the Kilo Range STAPP™ system was completed and the range came online. In April and June 2009, two additional disposal events for only Tango Range STAPP™ water were conducted, resulting in the disposal of 1,500 gallons and 850 gallons respectively. In August 2009, construction of Juliet Range was completed and by the end of August both new systems had begun to accumulate water resulting from condensation, as well as precipitation. Before the end of August 2009 water was collected separately from Juliet and Kilo ranges and analyzed for Resource Conservation and Recovery Act metals. The results from this sampling event were compared to previous Tango Range results. The August 2009 analysis of water from Juliet and Kilo ranges indicated similar levels of analytes with respect to the previous Tango Range results utilized for off-site treatment and disposal. Therefore, all subsequent off-site treatment and disposal of STAPP™ water from Tango, Juliet, and Kilo ranges, to include January 2010 (1,020 gallons), April 2010 (525 gallons), and December 2010 (1,170 gallons) were shipped off-site utilizing the existing profile sheet generated in June 2008. In 2015, water from the STAPP™ systems was analyzed and found to be consistent with past sampling events where elevated levels of antimony and zinc were found (Table 5-3). Based on the STAPP™ System Water Analytical profiles all STAPP™ water continues to be shipped to an offsite disposal facility as a non-hazardous waste water.

Analytical results for metals were below the MassDEP GW-1 standard and EPA maximum containment levels for all analytes except antimony (Table 5-5). Antimony results range from 13.1 µg/L to 255 µg/L. The MassDEP GW-1 standard and EPA maximum containment levels for antimony are 6.0 µg/L. The waste profile results for the water removed from the STAPP™ indicate that all water removed has been non-hazardous.

Table 5-5. Analytical Results for STAPP System Water, Camp Edwards, Massachusetts.

Sample Identification	Client Project #	Matrix	Collection Date/Time	Received
Range Water SC05514-01	F20-16776	Waste Water	06-Apr-15 10:00	07-Apr-15

CAS No.	Analyte(s)	Result	Flag	Units	*RDL	MDL	Dilution	Method Ref.	Prepared	Analyzed	Analyst	Batch	Cert.
Total Metals by EPA 6000/7000 Series Methods													
7440-22-4	Silver	< 0.0050		mg/l	0.0050	0.0012	1	SW846 6010C	14-Apr-15	15-Apr-15	edt	1506878	
7440-38-2	Arsenic	< 0.0040		mg/l	0.0040	0.0027	1	"	"	"	"	"	
7440-41-7	Beryllium	< 0.0020		mg/l	0.0020	0.0001	1	"	"	"	"	"	
7440-43-9	Cadmium	< 0.0025		mg/l	0.0025	0.0002	1	"	"	"	"	"	
7440-47-3	Chromium	**0.0050**		mg/l	0.0050	0.0010	1	"	"	"	"	"	
7440-50-8	Copper	**0.0189**		mg/l	0.0050	0.0035	1	"	"	"	"	"	
7440-02-0	Nickel	**0.0223**		mg/l	0.0050	0.0014	1	"	"	"	"	"	
7439-92-1	Lead	**0.0292**		mg/l	0.0075	0.0020	1	"	"	"	"	"	
7440-36-0	Antimony	**0.255**	V11	mg/l	0.0060	0.0025	1	"	"	"	"	"	
7782-49-2	Selenium	< 0.0150		mg/l	0.0150	0.0036	1	"	"	"	"	"	
7440-28-0	Thallium	< 0.0050		mg/l	0.0050	0.0016	1	"	"	"	"	"	
7440-66-6	Zinc	**20.6**	GS1, D	mg/l	0.0500	0.0056	10	"	"	16-Apr-15	"	"	
Total Metals by EPA 200 Series Methods													
7439-97-6	Mercury	< 0.00020		mg/l	0.00020	0.00009	1	EPA 245.1/7470A	14-Apr-15	14-Apr-15	YR	1506879	X
General Chemistry Parameters													
	pH	**6.70**	pH	pH Units			1	ASTM D 1293-99B	08-Apr-15 12:00	13-Apr-15 14:08	CAA	1506536	X

The water removed from the STAPP™ system was initially treated at the 102nd WWTP as approved by the MassDEP. Subsequent disposals of the STAPP™ water were and are taken offsite to a licensed recycling facility.

As indicated in other sections of this report, the STAPP™ systems were covered with tarps to limit the amount of water entering the systems. This practice has greatly reduced the amount of water accumulating within the STAPP™ systems.

6.0 ENVIRONMENTAL MANAGEMENT COMMISSION

Through the recommendations of the Community Working Group, the MANG, and through the actions of the Governor and the State Legislature, Chapter 47 of the Acts of 2002 established the EMC, consisting of the Commissioner of the Department of Fish and Game (DFG), the Commissioner of MassDEP, and the Commissioner of the Department of Conservation and Recreation (DCR). The EMC oversees compliance with and enforcement of the EPSs in the Upper Cape Water Supply Reserve/Camp Edwards Training Area (Reserve TA), coordinates the actions of environmental agencies of the Commonwealth of Massachusetts in the enforcement of environmental laws and regulations in the Reserve TA, as appropriate, and facilitates an open and public review of all activities in the Reserve TA. The legislation also states that the environmental agencies of the EMC retain all their respective, independent enforcement authority.

Chapter 47 of the Acts of 2002 also directed that the EMC be assisted by two advisory councils. The CAC, consisting of 15 members, assists the EMC by providing the communities concerns and advice on issues related to the protection of the water supply and wildlife habitat within the Reserve TA. The SAC, consisting of up to 9 members, assists the EMC by providing scientific and technical advice relating to the protection of the drinking water supply and wildlife habitat within the Reserve TA. The Act also established an Environmental Officer for JBCC. In this capacity, the Environmental Officer provides monitoring of military and civilian activities on and uses of the Reserve TA and the impact of those activities and uses on the water supply and wildlife habitats. Working directly for the EMC, the Environmental Officer has unrestricted access to all data and information from the various environmental and management programs in the Reserve TA. The Environmental Officer has full access to all points in the Reserve TA and conducts inspections at any time in order to monitor, oversee, evaluate, and report to the EMC on the environmental impact of military training and other activities. His on-site monitoring occurs prior to, during, and immediately following training and other activities. The Environmental Officer's monitoring activities include but are not limited to: training sites, pollution prevention and habitat protection activities for both military and military contractors in the Reserve TA, as well as coordinating with and consulting with the E&RC on various projects, initiatives, and issues.

The Environmental Officer acts as a liaison between the EMC, SAC, CAC, military, general public, and various state agencies. The Environmental Officer identifies and monitors ongoing issues regarding training procedures and the environment in the Reserve TA and keeps the EMC, SAC and CAC apprised of the progress of these issues in addition to bringing issues to the E&RC for resolution. He also participates in community outreach activities with the E&RC and facilitates the EMC, SAC and CAC public meetings under the legislation.

In general the EMC, SAC, and CAC meet twice a year. However, meetings can be scheduled as needed. The meetings are open to public with meeting notices and agendas provided to the Secretary of State's Office as required under the open meeting law for Massachusetts. These meetings are advertised online at http://www.thenationsfirst.org/ERC/index.htm and ads are placed in the local Enterprise Newspapers. Meeting topics include but are not limited to personnel changes, Natural Resource actions, training area venue and range updates, and finally other Reserve TA activities such as Eversource and National Grid work in the area is briefed.

For small arms range development, the use of simulated munitions (projectile based and pyrotechnic devices) and blank use, the EPSs provide for a rigorous review, management, and oversight process. Currently the EMC's Environmental Officer has oversight of the STAPP™ system ranges (Juliet, Kilo, and Tango Ranges), the Enhanced performance Round (copper) ranges (India and Sierra Ranges), and the M320 40mm grenade range (Lima Range). The following is a summary of the range development process.

Proposed small arms range development, simulated munition (projectile based and pyrotechnic devices) and blank ammunition use on Camp Edwards are regulated by Chapter 47, the Acts of 2002 and its associated EPSs. As the ranges and training aids are proposed for use they are brought before the EMC for evaluation for compliance with the EPSs and compatibility with the habitat and groundwater per the tenants of Chapter 47, the Acts of 2002. In general the proposal is brought to the SAC and CAC for their input and recommendation to the Commissioners that sit on the EMC. If the proposal is supported by the commission then they authorize the Environmental Officer to approve the range in accordance with the EPSs. The Environmental Officer then ensures the tenants of the EPSs are followed to complete the process.

The specific standards are the General Performance Standards and EPS 19. The standards are as follows:

General Performance Standards:

"**Limitations on the use of small arms ammunition and live weapon fire fall into the following two categories:**

> Live weapon fire is prohibited outside of established small arms ranges. Live weapon fire is not allowed on established small arms ranges except in accordance with Environmental Performance Standard 19,other applicable Performance Standards, and a range-specific plan approved through the Environmental Management Commission (EMC).
>
> Blank ammunition for small arms and simulated munitions may be used in areas outside of the small arms ranges, using only blank ammunition and simulated munitions identified on an approved list of munitions. Joint review and approval for inclusion on the list shall be through by the Environmental & Readiness Center (E&RC) and the EMC."

"Pollution prevention and management of the Camp Edwards training ranges will focus on and include the following:

> The Camp Edwards Training Area, including the Small Arms Ranges (SAR) and their associated "Surface Danger Zones," and any areas where small arms or other munitions or simulated munitions are used, shall be managed as part of a unique water supply area under an adaptive management program that integrates pollution prevention, and best management practices (BMP), including the recovery of projectiles. This will be done through individual range-specific plans that are written by the Massachusetts National Guard and approved for implementation through the EMC and any other regulatory agency having statutory and/or regulatory oversight. Adaptive, in this context, means making decisions as part of a continual process of monitoring, reviewing collected data, evaluating advances in range monitoring, design and technology, and responding with management actions as dictated by the resulting information and needs of protecting the environment while providing compatible military training within the Upper Cape Water Supply Reserve.

A range plan shall be designed and followed to reduce the potential for an unintended release to the environment outside of the established containment system(s) identified in the range-specific plans. All users must be aware of, and comply with, the Environmental Performance Standards that are applicable to all SAR activities. Any range specific requirements will be coordinated through the E&RC with the EMC, incorporating those specific requirements into the appropriate range-specific plans and range information packets. Camp Edwards SAR Pollution Prevention Plan shall be followed to prevent or minimize releases of metals or other compounds related to the normal and approved operation of each SAR. The adaptive SAR management program components required in each range-specific plan shall include:

- Consultation with applicable agencies with oversight of the training area before undertaking any actions that are subject to state and/or federal regulatory requirements.

- Specific recovery plans for the removal and proper disposition of spent projectiles, residues and solid waste associated with the weapons, ammunition, target systems, and/or their operation and maintenance.

- Reduction of adverse impacts to the maximum extent feasible, including consideration for the design/redesign and/or relocation of the activity or encouraging only those activities that result in meeting the goal of overall projectile and/or projectile constituent containment. ·

- Internal and external coordination of documentation for the Camp Edwards range management programs and other related Camp Edwards management programs including: the Integrated Training Area Management Program, Range Regulations, Camp Edwards Environmental Management System, Civilian Use Manual, and Standard Operating Procedures.

- Long-term range maintenance, monitoring and reporting of applicable parameters and analysis.

The Massachusetts National Guard shall ensure that all training areas where munitions or simulated munitions are used or come to be located, including range areas, range surface danger zones, and any other areas within the Upper Cape Water Supply Reserve that are operational ranges are maintained and monitored following approved management plans that include planning for pollution prevention, sustainable range use and where applicable, restoration."

EPS 19. Range Performance Standards:

"19.1. All operational ranges including but not limited to small arms ranges (SAR) shall be managed to minimize harmful impacts to the environment within the Upper Cape Water Supply Reserve. Range management at each range shall include to the maximum extent practicable metal recovery and recycling, prevention of fragmentation and ricochets, and prevention of sub-surface percolation of residue associated with the range operations. Camp Edwards shall be held responsible for the implementation of BMPs by authorized range users, including collection and removal of spent ammunition and associated debris.

19.2. Small arms ranges shall only be used in accordance with approved range plans. These plans shall be designed to minimize to the maximum extent practicable the release of metals or other contaminates to the environment outside of specifically approved containment areas/systems. Occasional ricochets that result in rounds landing outside of these containment areas is expected and every effort to minimize and correct these occurrences shall be taken. Failure to follow the approved range plans shall be considered a violation of this EPS.

19.3. All operational SARs shall be closely monitored by the Massachusetts National Guard to assess compliance of the approved range plans as well as the implementation and effectiveness of the range specific BMPs.

19.4. Camp Edwards / Massachusetts National Guard Environmental and Readiness Center shall staff and request appropriate funding to support its SAR management plans.

19.5. All users must use and follow Camp Edwards' Range Control checklists and procedures to:

- Minimize debris on the range (e.g. shell casings, used targets)
- Minimize or control residues on the ranges resulting from training (e.g., unburned constituents, metal shavings from the muzzle blast)
- Ensure the range is being used for the designated purpose in accordance with all applicable plans and approvals

19.6. Camp Edwards is responsible for following range operation procedures and maintaining range pollution prevention systems. Range BMPs shall be reviewed annually for effectiveness and potential improvements in their design, monitoring, maintenance, and operational procedures in an effort to continually improve them. Each year the annual report shall detail the range-specific activities including, but not limited to, the number of rounds fired, number of shooters and their organization, and the number of days the range was in use. The annual report will also detail active SAR groundwater well and lysimeter results, as well as any range maintenance/management activities that took place that training year and the result of such activities, i.e. lbs. of brass and projectiles recovered and recycled, etc. The Massachusetts National Guard shall provide regular and unrestricted access for the EMC to all its data and information, and will provide immediate access to environmental samples from the range, including range management and monitoring systems and any other applicable activities operating on the ranges.

19.7. Range plans and BMPs for training areas shall be reviewed and/or updated at least every three years. Management plans for new and upgraded ranges shall be in place prior to construction or utilization of the range. Range plans, at a minimum, will address long-term sustainable use, hydrology and hydrogeology, physical design, operation, management procedures, record keeping, pollution prevention, maintenance, monitoring, and applicable technologies to ensure sustainable range management. Range plans shall be integrated with other training area planning processes and resources.

19.8. The Massachusetts National Guard shall establish procedures for range maintenance and where applicable, maintenance and/or clearance operations to permit the sustainable, compatible, and safe use of operational ranges for their intended purpose within the Upper Cape Water Supply Reserve. In determining the frequency and degree of range maintenance and clearance operations, the Massachusetts National Guard shall consider, at a minimum, the environmental impact and safety hazards, each range's intended use, lease requirements, and the quantities and types of munitions or simulated munitions expended on that range."

See Appendix C for a complete version of Chapter 47 of the Acts of 2002 and the Environmental Performance Standards.

7.0 CHANGES TO THE OPERATIONS, MAINTENANCE AND MONITORING PLAN AND LESSONS LEARNED

It is acknowledged that the OMMP should be a "living document," one that changes over time as more information becomes available, technology advances, and lessons are learned. Initially the OMMPs for Tango, Juliet, and Kilo Ranges were separate documents. All STAPP™ Range OMMPs (Tango, Juliet, and Kilo) have been combined into a single document. To illustrate the adaptive and dynamic nature of the OMMP as a living document, revisions to the OMMPs for Tango, Juliet, and Kilo Ranges occurred on June 2007, December 2007, October 2008, and January 2009. The OMMPs were consolidated into a single document in September 2012. The OMMP was again updated April, June, October, and November 2014. Finally the OMMP was updated and approved again in July 2015.

Several major changes to the OMMP include: establishing Interim Action Levels for contaminants in soil, porewater, and groundwater, establishing corrective actions if Action Levels are exceeded, and defining the communications and providing for continuity as personnel leave and are replaced. Specific changes to the OMMP included the following: consolidation of the three plans into one plan for all three ranges; deletion of extraneous information that is not related to protection of the environment; reorganization of the plan so that important tasks have their own primary section and aren't buried in various sub-sections making the document more user friendly; simplification of the range inspection procedures; streamlined environmental monitoring that accounts for lessons learned since the original OMMPs were written, while still ensuring protection of the environment, and, finally, a simplified action level process for soil, porewater and groundwater monitoring results to ensure environmental protection.

For soil the initial action level was based on the modeled potential for leaching to groundwater and if exceeded, required sample validation, resampling, cause evaluation and potentially the alteration of the conceptual site model. The current action level is based on the Massachusetts Contingency Plan. Initially for porewater and groundwater there were two action levels, a level 1 and a level 2. These levels were based on the relative drinking water standard. For porewater if the action level 1 was exceeded a Focused Reassessment was called for where resampling, modification of the conceptual site model, or maintenance could occur. If a level 2 action level was exceeded for porewater then some sort of Range Maintenance was required such as soil removal, resampling, and a ceasefire until the issue could be rectified after coordinating with regulatory stakeholders. For groundwater there was also a level 1 and 2 action level. The difference between the porewater and groundwater action levels is in the level 2 process. For groundwater if the level 2 action level was exceeded then a cease fire was imposed, stake holder coordination took place, and finally, range maintenance and a reassessment of the pollution prevention program would have been required. Currently there is only one action level for porewater and groundwater. For porewater the level is based on the drinking water standard and for groundwater it is one half the drinking water standard. If action levels are exceeded for these standards stakeholder coordination and resampling is required. Communications and continuity among and with staff was identified as an issue that could be problematic with long-term management of the STAPP™ ranges. Actions taken toward this end were the creation of a reporting matrix, Figure 12-1 of the current OMMP (Appendix A).

Inspection checklists were revised to incorporate SARWG suggested improvements. Sections B and C of the checklists were combined for added clarity and the sketch was appropriately updated to show the placement of the toe berm boxes. Other changes included adding further written directions within the sheets such that day to day users could understand what was expected within each form.

Another change consisted of establishing maximum (25m) and minimum (2.7m) firing distances from the target line along the range floor to facilitate transition firing. This allowed personnel to move forward of the 25m firing line and fire at targets. With the increased area available for firing and potential deposition of contaminants, the soil sampling plan was modified to include six sampling units instead of the original two.

The OMMP now references a red stripe that was painted on the upper portion of the top cover on all STAPP™ ranges to limit overshot (Figure 11). The red line provides for an upper limit of aiming for all range users. This has reduced overshot and impacts to the STAPP™ system above the red upper limit line.

As expressed in Sections 5.2 and 7.3, pan lysimeters are thought to be a better tool for monitoring porewater. The MANG revised the OMMP to require all pan lysimeters on the ranges.

The MANG is committed to keeping the OMMP updated to allow efficient and appropriate operations and monitoring of the STAPP™ Ranges. The MANG will continue to make changes as needed, are appropriate, and approved.

Based on observations and use of the STAPP™ systems there have been lessons learned. The lessons learned have been discussed with members of the SARWG and incorporated in the most current version of the OMMP as required and approved. The lessons learned included are grouped into three categories: Operations, Inspections and Maintenance, and Environmental Monitoring.

7.1 OPERATIONS

Management Controls

The MANG has developed management controls to support compliance with the Small Arms Range OMMPs. Incorporating these management controls into the OMMP would allow the Revised Combined OMMP to act as an overall operating guide and provide built-in redundancy and ensure safeguards are in place, see Section 12 of the current OMMP (Appendix A)

In 2011 management controls that were added to the OMMP that included: 1) a Notification Protocol should the MANG not be able to comply with a requirement of the OMMPs; 2) a STAPP™ Range Tarp Cover Project Description where the STAPP™ systems are covered with a tarp to reduce water build up within the STAPP™ system; 3) Water Removal Contracting and Budgeting provisions to ensure funding is available to dispose of the STAPP™ water and to conduct annual environmental sampling as required; 4) creation of a Camp Edwards Sustainable Range Program Working Group that meets monthly to ensure the OMMP is being complied with and to discuss other Camp Edwards range issues and future range development; and 5) a Standard Operating Procedure for STAPP ™System Range Maintenance Procedures and Inspections.

In order to better understand the time and effort to accomplish routine maintenance on the STAPP™ system, Range Control kept an ongoing log of personnel and time required to perform maintenance. Over the duration of the Pilot Period, it is estimated that patching and/or seaming maintenance work required two personnel an average of four hours per training event. It was noted that as training activities increased so did the required level of effort to properly maintain the top cover.

At the beginning of the Pilot Period, routine maintenance was expected in the form of top cover patching. Repetitive seam failures and frequent water removal were not anticipated (beyond routine maintenance) that could potentially expose personnel to lead residue from spent rounds inside the STAPP™ system. The risk of exposure from opening a corner of the system to remove the excess water was reduced when a water inspection port was installed, allowing staff to conduct OMMP-required water level inspections and remove water from the system without removing the STAPP™ system top cover (Figure 9). Because of the frequency and scale of repairs during the first year of operations at Tango Range, a worker health study was coordinated through the MANG Safety Office to determine if personnel were at risk of exposure to lead and to determine the appropriate level of protective equipment required during maintenance activities. Results of the worker health study identified that personnel were not at risk, and typical health and safety practices such as no eating and drinking during maintenance activities and washing hands before eating were sufficient to protect personnel performing maintenance tasks on the STAPP™ system.

Ricochets have not caused problems to the system or personnel.

On Tango Range raising the 25-meter firing line improved the angle of firing for training and reduced the number of overshot.

The toe berm boxes appear to function well in protecting the base of the STAPP™ system from bullet penetrations. The placement of the toe boxes behind the target frames and within two to three feet of the STAPP™ system allows easier and safer access to the targets and provides greater protection of the framework from errant or ricochet rounds. In 2015 and 2016 the toe berm boxes were replaced at Juliet and Kilo Ranges respectively. The replacement boxes were constructed in a similar fashion to those that have been used on Tango Range. The Tango Range boxes were constructed using 6” x 6” timbers and have been very affective in protecting the base of the STAPP system from undershot.

The Tango Range top cover was replaced due to incorrect installation causing multiple operational issues, e.g. seam failure and water build up.

Rounds can ricochet off of the ground surface, toe boxes, and target frames and tumble entering the system. Tumbling projectiles can cause larger than expected holes in the top cover. This in turn causes greater maintenance.

Hollow point bullets need to be cleared with Range Control and require greater maintenance as they cause larger holes similar to tumbling rounds.

Tracer rounds were demonstrated to function acceptably within the STAPP™ system. Wear and tear above acceptable levels was not observed during demonstrations and inspections with tracer rounds. However on Tango Range there was an instance where tracer rounds bounced back towards the firing line. Range Control has since had a moratorium on using tracer rounds on STAPP™ ranges. Those wanting to use tracer rounds must coordinate with a Range Control Officer before they are approved for use at the STAPP™ system ranges.

Based on lane sampling and extrapolation approximately 94-99% of all rounds fired at the STAPP™ system are captured.

As discussed in Section 3.0, seven 7.62mm rounds penetrated the STAPP™ system bottom-liner. The lessons learned with regards to the 7.62mm rounds is that regular maintenance is critical. The granular rubber depth at 18 inches must be maintained and is crucial to using larger caliber weapons (7.62mm) and to avoid bottom-liner perforations on STAPP™ system small arms ranges. Though a few rounds did penetrate the bottom-liner, and they were recovered, the soil area below the STAPP™ system is not exposed to weathering conditions; thus it is expected that there was no risk to the environment.

Target frames and each firing lane should be located such that the center of each target is lined up on the center of an appropriate panel of the STAPP™ top cover. It is better to have bullets go through the middle of a top cover panel than to cause extra stress on seams between panels.

Inspection and management of the water collecting inside the STAPP™ system was also an ongoing task. Removal of the collected STAPP™ system water generally required two personnel from Range Control an average of three hours per event. Rain event inspections generally required one individual an average of one hour per event. The effort for water collection and monitoring is significantly less since Range Control started the use of tarps to cover the STAPP™ systems. By covering the STAPP™ systems water accumulation within the STAPP™ systems has been significantly reduced, Table 4-1.

Finally, Camp Edwards has hired a civilian Range Control employee to ensure consistency during transition of military and civilian staff. This position's job will be to learn all aspects of range operations, help in directing staff to manage the ranges, and to ensure continuity during military staff transitions.

7.2 INSPECTION AND MAINTENANCE

Initially, bi-weekly inspections were conducted as part of the ongoing training cycle. Inspections are now monthly per an approved change in the OMMP.

All maintenance work on the STAPP™ system should be done with appropriate containment, personal protective equipment and training for site workers.

Walking on the top cover can put pressure on the panel seams and potentially cause seams to fail. Not a current issue.

In the early stages of the program, the top cover patches were square. It was determined through inspections that the lips of the patches were collecting water along with sand. Range Control began designing round or oval patches to allow water and windblown sand to migrate down the face of the STAPP™ system. Top cover repairs now consist of using only glue when possible to fill cuts, slashes, and some holes. Patches are still required where using only glue is not sufficient for repair.

It was found that the product (Loctite 401) used by STAPP™ personnel to glue the seams did not hold up to weather conditions at Camp Edwards. Camp Edwards has found that Loctite 5510 elastic adhesive caulking is the best way to repair holes and seam failures.

Results of air sampling during the bullet sifting activities performed showed that respirators were not required.

Covering the STAPP™ systems with tarps precludes most water build up within the system. Less pumping, sampling, and disposal equals reduced operational cost and, most importantly, further environmental protection.

A Training Facility Utilization Report is generated for each firing event. Range Control expanded on this report to account for quantity and type of round fired on each lane. This data can be used to assess the overall wear and tear from rounds impacting the system's top cover, to include projected schedule for top cover replacement.

By observing range firing, it can be determined which type of ammunition or training will cause an increase in maintenance, specifically more patching of the top cover. The use of the 7.62mm (M240B) and/or firing the 5.56mm (M249 SAW) weapons, machine guns with heavy rates of fire that create beaten zones, and .40 cal hollow points were observed to cause increased wear.

Construction of STAPP™ and any bullet containment system should follow pre-established construction plans. The construction plans should include all pertinent Quality Control/Quality Assurance (QA/QC) steps necessary to ensure an acceptable end product. This is considered a lesson learned based on some of the maintenance required on the Tango Range STAPP™ system. It is speculated that top cover maintenance during the pilot program would have been less if more rigid QA/QC procedures were followed on the STAPP™ system installations.

7.3 ENVIRONMENTAL MONITORING

Based on soil sampling data from the range floor that has shown no apparent trend for lead deposition as a result of the bullet propellant, and the fact that the groundwater has not been impacted by lead from small arms ranges, soil sampling at Juliet, Kilo, and Tango Ranges is now performed at each range on alternating years.

Results from sampling groundwater wells on Tango Range indicate that there are generally no concentrations of lead, copper, or antimony above the action levels in groundwater. The one exception was the 24.1 ppb result from a sample collected from MW467S in 2015. Low water levels within the well necessitated the use of a bailer to retrieve a sample from this well. In accordance with the OMMP the well was resampled and the results were 4.1 ppb for lead which is below the action level for lead in groundwater as set forth by the OMMP. Upon resampling the well still had low water levels but the samplers were able to collect a single sample. Based on this experience groundwater samples should only be taken if appropriate water levels are present within the well and well screens.

Use of legacy soils in constructing the ranges can be problematic when it comes to soil contaminants such as metals. It is thought that the likely source of elevated antimony detections in pore water were from the use of legacy soils on the range. Maectite™ (phosphate) was used to immobilize lead in legacy soils during a 1998 berm treatment process for stabilizing lead in soil. Research has shown that phosphate can cause antimony to become more mobile in soil.

The soils of Camp Edwards do not need to have the pH adjusted as the native soil's pH is appropriate to avoid metals mobility at the small arms ranges.

Tension lysimeters are not appropriate for monitoring the soil porewater on small arms ranges. Materials within the tension lysimeters such as the ceramic cup and metal components can adsorb or release metals. As stated earlier in the report, these materials could cause false positive and negative readings in metals analysis.

Pan Lysimeters are now in use for soil porewater monitoring on STAPP™ Ranges. High Density Polyethylene (HDPE) is now used in lysimeters intended to sample soil porewater for metals as HDPE does not have the property of adsorbing metals.

With regards to lysimeters the EMCs SAC advised that a better methodology for tracking metals through soil as an early warning system for protecting groundwater would be to conduct spilt core soil sampling. This sampling will be implemented if it is approved. This was advised based on the fact that water can have preferential pathways, lysimeters only provide a point sample, and the residence time of water within the lysimeter where sediment and the lysimeter materials themselves can have affect the analysis of porewater.

If changes in training are approved and implemented at the small arms ranges, monitoring specified by the OMMP should be reviewed to ensure that it is appropriate for monitoring the change in training. As an example, when transition firing (where shooters advance forward of the 25m firing line) was approved the soil sampling specified by the current OMMP was changed to include a larger area of potential impact.

8.0 SUMMARY AND CONCLUSIONS

The Pilot Period for Tango Range began in August 2007 and in August 2008 for Juliet and Kilo Ranges. The objective of the Pilot Period was to assess the Tango, Juliet, and Kilo OMMP and the effectiveness of the STAPP™ system installed on these ranges. The Pilot Period most importantly gave the regulatory agencies a chance to review the effectiveness of range management and the MANG's ability to meet its commitment in operating small arms ranges at Camp Edwards in an environmentally sound fashion, i.e. no impacts to groundwater.

Approximately 16,968 individuals were trained over 425 total days of use on the STAPP™ ranges, using lead ammunition during the Pilot Period for Tango, Juliet, and Kilo Ranges. All firing events were monitored with inspections before, during and after training events as per the OMMP. Mass Balance and overshot analysis shows that approximately 94-99% of the bullets fired during training events were captured by the STAPP™ system and effectively isolated from the environment.

More maintenance was required on the STAPP™ system than was anticipated, particularly on the top cover and to remove water collected in the internal reservoir. However, the STAPP™ system is considered an effective system design to capture most of the bullets fired and isolate them from the environment.

The Conceptual Site Model with contaminant potential exposure pathways for the STAPP™ ranges was detailed in the OMMP. For lead, relevant literature including the CRREL Lead Report indicate that lead mobilization at small arms ranges occurs mainly by wind and surface water erosion and to a lesser extent through dissolution and leaching through soil. Lead is less mobile in soil at a neutral pH. Best Management Practices (BMPs) were implemented at Tango, Juliet and Kilo Ranges to minimize any potential environmental impact. Bullets captured within the STAPP™ system are effectively isolated from the wind and are not in contact with surface waters of the range. Based on the Conceptual Site Model, this removes the most likely migration pathways for lead and other metals. Based on annual range sampling of the firing line and range floor there has been no evident trend of lead deposition from propellants within the bullet primer.

Antimony has become a metal to monitor as OMMP action levels have been exceeded for porewater on Tango, Juliet, and Kilo Ranges. Elevated detections of antimony at concentrations exceeding the Action Level in several of the lysimeters have now been confirmed in several consecutive sampling rounds. It was thought that pH might be a contributing factor to the increased level of antimony in porewater. Liming of the ranges was put on hold in 2013 to determine if adjusting the pH could be a contributing factor to the increased levels of antimony in porewater. It appears that this is not the case based on porewater sampling results--levels have continued to rise. Another possibility causing an increase in antimony in porewater is that the lysimeters have sediments within the collection bucket where porewater can remain in contact with these sediments for an extended timeframe. Sediment contact time could be responsible for elevated antimony levels in pore water. It should be noted that the EMC's SAC has on multiple occasion suggested that this residence time of porewater in contact with sediments within the lysimeters can be problematic affecting sampling result. For this reason, the MANG will be analyzing both filtered and unfiltered pore water samples. Efforts will again be made to determine if there is sediment present within the lysimeters. If so, they will be purged of sediment. Another potential cause of elevated antimony in porewater can be phosphates, which were added to the range soils during the berm maintenance project of 1998. A phosphate-based amendment was added to range soils to decrease the mobility of lead. Unfortunately, phosphates can mobilize antimony. With time, phosphate levels will diminish, and so monitoring of antimony levels will continue along with close coordination with the regulatory community in regards to antimony in porewater. The two potential causes of elevated antimony levels, phosphate and sediment within the lysimeters, are not mutually exclusive and both could be contributing to this issue. An additional concern is that the lysimeters on both Juliet and Kilo Ranges are located within the drainage system of the ranges where storm water is collected from most of the range footprint. Therefore antimony may be concentrating within the lysimeter located within the system.

Careful monitoring of porewater should continue and continued consultation with experts in the field of metals mobility will be undertaken. Porewater sampling maybe replaced with split core soil sampling, as advised by the SAC, to more accurately track metals through soil. When the specifics for this type of sampling is determined and when approved, the MANG will implement this new protocol during the next sampling cycle.

The OMMP included broad monitoring to assess potential environmental impacts. Methods used for environmental monitoring included soil sampling for COCs, monitoring soil pH, sampling soil pore water via lysimeters, and sampling groundwater immediately down-gradient of the range. The results of the environmental monitoring during the Pilot Period shows that COCs are not migrating from the range but do need close scrutiny to assure no environmental impacts are imminent or occurring.

The BMPs and robust environmental monitoring implemented at the STAPP™ Ranges demonstrates the MANG's commitment to provide small arms range training at Camp Edwards all while being protective of natural resources, especially groundwater. The MANG has reviewed and evaluated all data generated during the Pilot Period. The MANG has considered conclusions in the CRREL Lead Report, ongoing studies on fate and transport of antimony and propellant related small arms range compounds and IAGWSP reports that investigated small arms ranges at Camp Edwards.

The MANG believes that EPA's issues as identified in AO2 and the approval letters for the STAPP™ ranges (Juliet, Kilo, and Tango Ranges) have and will be continually addressed to be protective of the Camp Edwards Training Area/Upper Cape Water Supply Reserve. Specific tasks completed and issues addressed include:

- Lead and lead contaminated soil was removed from impact berms as a mitigation measure and further removal has been conducted as identified in the Decision Document, Small Arms Range Operable Unit, and (September 2015).
- Research was conducted into the use of projectile capturing material and nontoxic ammunition. The MANG has three ranges using a STAPP™ Bullet Catcher System and two ranges that are utilizing nontoxic ammunition, i.e. copper projectiles.
- The MANG now uses lead bullets on ranges that have a system in place to capture the projectiles or the range is managed through an OMMP.
- The Department of the Army and the MANG are transitioning to copper rounds, namely the Enhanced Performance Round currently used on India and Sierra ranges at Camp Edwards.
- OMMPs are created for all approved ranges and devices. These plans have been developed in partnership with EPA, MassDEP, and the EMC. The goal of these plans is to avoid any releases or damage to the environment that may cause harm to the Camp Edwards Training Area/Upper Cape Water Supply Reserve's groundwater resources. These plans provide for the monitoring of environmental media that includes soil, porewater, and groundwater. Monitoring data show that current small arms range training activities at the STAPP™ ranges, when properly

operated and maintained, can be conducted without causing unacceptable contamination levels in the groundwater.

- Through the last nine years of the Pilot Period, the MANG successfully operated, managed, and funded the active ranges at Camp Edwards. Although there have been unanticipated problems with the STAPP™ systems, the MANG has been diligent in investigating, researching, and implementing solutions to problems as they are discovered.

Working closely with EPA, MassDEP, the EMC, stakeholders and the public over the past nine years, the MANG has successfully implemented training with lead ammunition.

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Appendix 2

2015 Echo Range Test Fire and Supplemental Test Fire Summaries

13 August 2015

Echo Range Combat Pistol Range Test Fire

And

Supplemental Test Fire Summaries

Camp Edwards Training Site, Massachusetts Army National Guard

A test fire was conducted on Lane 4 at Echo Range (Figures 1 and 2) on 19 June 2015 to determine if the Line of Sight Analysis was valid and if the information gathered could be used to determine the initial design of Echo Range, which can be protective of the environment while meeting regulatory requirements and training standards. The test fire was conducted to determine if an angle of fire can be established such that most projectiles will be captured in a band across the back berm thereby eliminating the range floor as the main capture medium for fired projectiles. It is assumed that due to the varying skills of shooters using the range, there will be low shots that will be captured by the SIT frontal materials such as sand and Dura-Block.

Figure1. Echo Range, Camp Edwards, Massachusetts

Figure 2. Echo Range, Lane 4, Camp Edwards, Massachusetts

In attendance were Jane Dolan, US Environmental Protection Agency (USEPA), Mark Begley, Environmental Management Commission (EMC), Len Pinaud, Massachusetts Department of Environmental Protection (MassDEP), Michael Ciaranca, MAJ Jerrime Oliver, CPT Alex McDonough, SFC Kenneth Moreira, SGT John Slager, Jason Obrebski, and other support staff from Camp Edwards. Also in attendance were contractors John Bean from Leidos Engineering and David Harris from OMR Architects.

The test fire was conducted at Lane 4. Each lane contains seven SITs (Figure 2). Lane 4 was prepared by excavating the firing line to 20 inches in depth for approximately 14 feet from just behind the firing line. The eastern back berm was prepared by placing 12 inches or more of 1/8th inch minus sand on the total of the slope behind Lane 4. As the angle of fire is not direct, the sand was extended to the north and south approximately half way in between the next targets to capture projectiles that may strike outside of Lane 4.

A total of 107 projectiles were fired during this test fire. Three Combat Pistol Qualification Course courses of fire were conducted along with one set of firing using an inexperienced, shorter-in-stature shooter to determine the impacts of lowering or raising the targets on projectile disposition. As a result of raising and lowering the targets, along with using an inexperienced, shorter-in-stature shooter, shots were lower on the back berm and there was a single shot that hit one of the target frontal berms. Ten shots were fired into Dura-Bloc to determine if projectiles would penetrate this material. This firing was conducted based on the observation that there was a Dura-Bloc pass through during one of the courses of fire. It was determined that the Dura-Bloc was arranged incorrectly, placed on end versus on its side (Figure 3). When placed correctly, the Dura-Bloc was effective at stopping all 10 projectiles fired into the block (Figure 4).

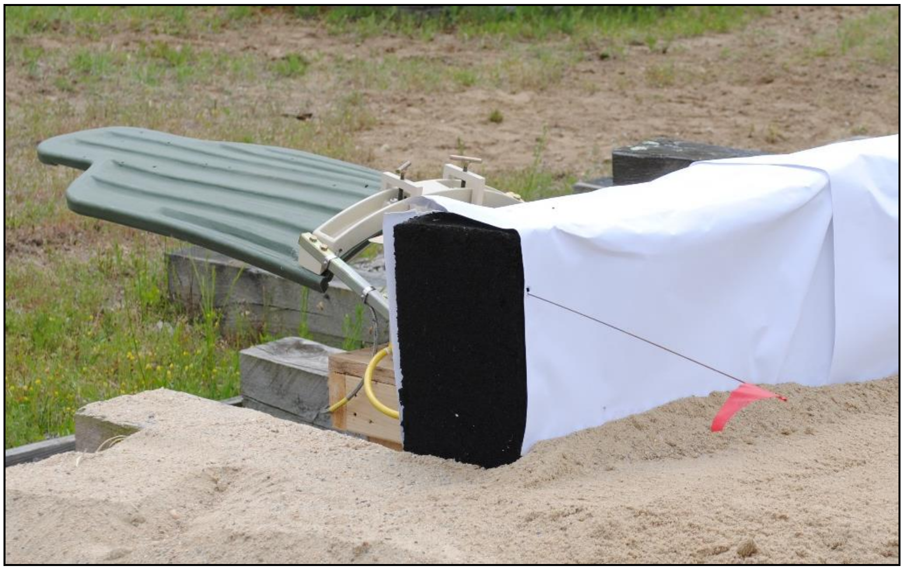


Figure 3. Dura-Bloc on end with flagged projectile pass through, Camp Edwards, Massachusetts

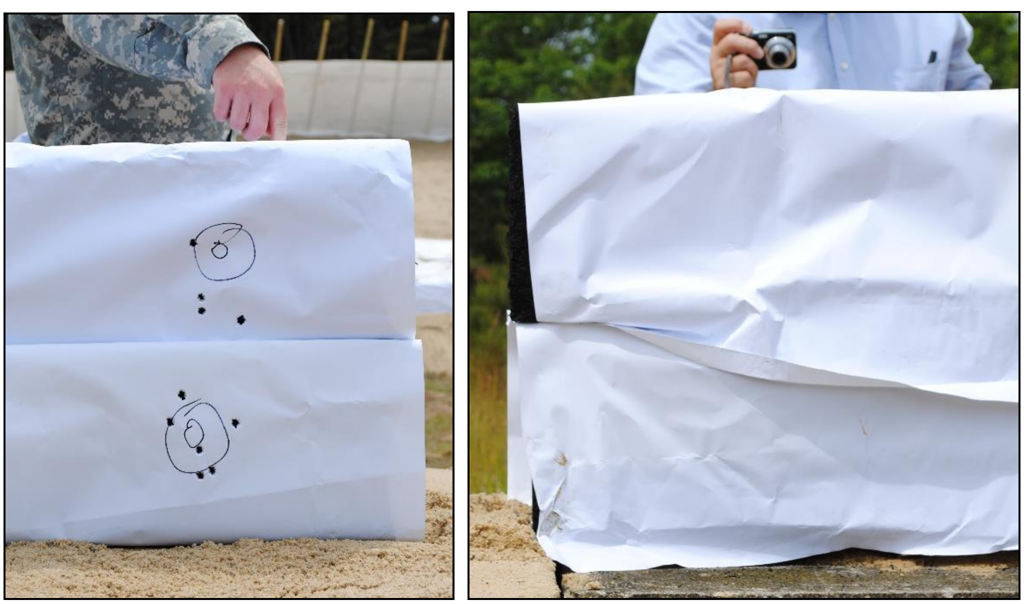


Figure 4. Dura-Bloc arranged correctly and showing that projectiles do not pass through in this configuration, Camp Edwards, Massachusetts

As was illustrated through the Line of Site Analysis, the results of the test fire confirmed the objective that projectiles could be captured across the back berm and that the back berm could be used as the main capture medium for Echo Range (Figure 5). The back berm was effective at capturing the projectiles. However, given the gentle slope of the back berm there were "skip ups," or ricochets, that penetrated the back berm overhang telltale.

A

B

Figure 5. A) Line of Site Analysis theoretical projectile locations, B) Actual Test Fire Projectile Locations, Echo Range, Camp Edwards, Massachusetts

Of 107 rounds fired, 63 projectiles were recovered, 11 rounds passed through the back berm overhang telltale and were not recovered, 10 were contained within the Dura-Bloc, and 23 were not accounted for, i.e. still within the back berm or ricocheted. This provides for approximately a 73% projectile recovery rate. It should be noted that projectiles were recovered by hand with a metal detector so level of effort must be accounted for when considering this information.

In summary, the test fire did confirm the test fire objective that the Line of Sight Analysis was validated-that an angle of fire can be established such that most projectiles will be captured in a band across the back berm thereby eliminating the range floor as the main capture medium for fired projectiles.

Echo Range Combat Pistol Range Supplemental Test Fire Summary

A supplemental test fire was conducted on Lane 4 at Echo Range (Figures 1 and 2) on 31 July 2015 to determine if a back berm with a slope as close to 2:1 as possible would be sufficient to capture projectiles and avoid ricochets through the overhang telltale at the top and sides of the back berm. Also, would projectile recovery rates improve as a result of the increased back berm slope? Like the information gathered from the initial test fire, the supplemental information could be used to aid in the initial design of Echo Range so that the range can be protective of the environment while meeting regulatory requirements and training standards.

In attendance was Len Pinaud, MassDEP/EMC, Michael Ciaranca, MAJ Nathan Wilder, MAJ Jerrime Oliver, CW2 Justin Smith, 1SGT Michael Andersen, SFC Charles LaFlame, SGT John Slager, and other support staff from Camp Edwards.

The test fire was conducted at Lane 4 with rounds fired at the last target within the lane (Figure 6). The eastern back berm was prepared by placing sand from the toe of the existing berm to a height of approximately 7 feet (Figure 7). This created the desired slope of approximately 2:1. The slope was then covered with approximately 4 inches of loam. A telltale overhang along with side wall was placed on the back berm. The overhang was constructed using 4x4 timbers covered with paper. Dura-Bloc was again placed in front of the target mechanism for low shot protection.

Figure 6. Last target in Lane 4, Echo Range Camp Edwards, Massachusetts

Figure 7. Eastern Backstop Berm Supplemental Test Fire 2:1 Slope Echo Range Camp Edwards, Massachusetts

A total of 100 projectiles were fired through four courses of fire. Two courses of thirty and twenty shots were fired respectively. The last twenty were fired with purposeful “bad,” or off target shots, to determine if high and side shots would react to striking the berm differently. All shots reacted similarly and were contained by the back berm with no ricochets or “skip-ups” (Figure 7). The Dura-Bloc did again protect the target mechanism. It is thought that five low shots entered the Dura-Bloc with three others grazing the top of the block during the test fire. The telltale paper covering the Dura-Bloc showed the projectile strikes (Figure 7).

Figure 7. Dura-Bloc, Target, and Overhang Telltale, Echo Range, Camp Edwards, Massachusetts

The results of the test fire confirmed the objective that the back berm with a slope as close to 2:1 as possible would be sufficient to capture projectiles and avoid ricochets through the overhang telltale at the top of the back berm. The results also confirmed that projectile recovery rates could be improved as a result of the increased back berm slope. The back berm was effective at capturing the projectiles and did increase recovery rates. Of 100 rounds fired, 95 projectiles were recovered with five rounds believed to be contained within the Dura-Bloc that was protecting the target mechanism (Figures 7 and 8). This is a 95% projectile recovery rate.

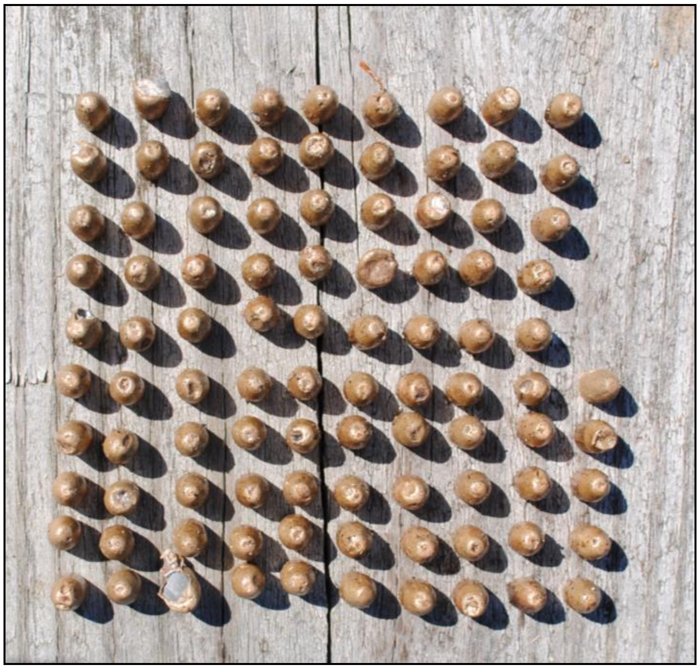


Figure 8. Recovered projectiles (n=95), Echo Range, Camp Edwards, Massachusetts

In summary, the test fire did confirm the test fire objective that the back berm with a slope as close to 2:1 as possible would be sufficient to capture projectiles and avoid ricochets through the overhang telltale at the top of the back berm. The results also confirmed that projectile recovery rates, 95% vs 73% from the initial test fire, could be improved as a result of the increased back berm slope.

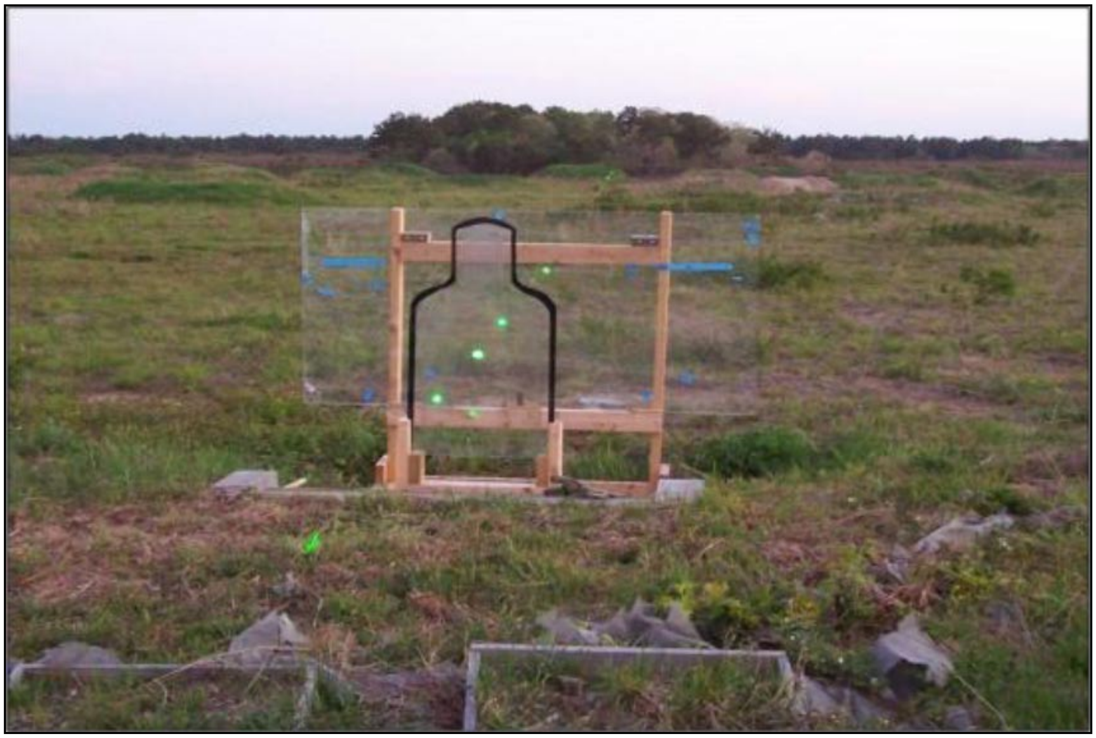
Appendix 3

Line of Site Analysis

March 2011

300 METER MODIFIED RECORD FIRE RANGE
LINE OF SIGHT ANALYSIS
MASSACHUSETTS MILITARY RESERVATION

Draft March 2011



RANGE CONTROL OPERATIONS CENTER, CAMP EDWARDS, MA
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CONSTRUCTION & FACILITIES MANAGEMENT OFFICE, JOINT FORCE HEADQUARTERS, MILFORD, MA

ABSTRACT

A line of sight analysis was conducted on the Massachusetts Military Reservation's 300 meter Modified Record Fire (MRF) Range or Sierra Range to identify projectile distribution and initial dispersion and to aid in identify appropriate best management practices and pollution prevention procedures for the range. Two thousand one hundred-twenty of 5000 authorized M855, 5.56x45mm 62-grain FN SS109 ball cartridge, green tip with a steel penetrator and lead core were used to conduct the live fire exercise to validate Phases I and II of the line of sight analysis. The line of sight methodology was a three phased operation. Phase I was a geospatial information system (GIS) overview to identify potential issues along Gun Target Lines (GTL) for each Stationary Infantry Target (SIT) location. Phase II utilized laser designation from the point of origin to the point of impact to validate Phase I and identify obstructions to the projectile flight path or the view of SIT locations down range. Phase III was the execution of a live fire exercise; simulating Soldier participation in a modified record fire qualification table; to validate Phases I and II. The line of sight analysis process developed for this project demonstrated that auxiliary structures can be emplaced while not obstructing the line of sight of Soldiers at the firing point, the ability to predict the projectile distribution, initial dispersion, and to show that the range floor would not have to receive projectiles in the operation of Sierra Range.

CRITICAL DEFINITIONS

Distribution: describes the number of projectile impact locations for a particular GTL.

Dispersion: describes the dimensions of a particular projectile impact location.

Contained: describes projectiles or fragments located at the projectile point of impact location.

Terminal Ballistics: the behavior of a projectile when it strikes an object.

INTRODUCTION

***Current Situation*:** Camp Edwards does not currently have an approved automated 300m Modified Record of Fire Range required to train, sustain, improve and qualify Soldiers in individual marksmanship proficiency tasks. The modified record fire range is used to train and test individual Soldiers on the skills necessary to identify, engage, and defeat SIT for day/night qualification requirements with M16- and M4-series weapons. This range combines the capabilities of the automated field fire, automated record fire, and auto-mated night fire ranges to reduce land and maintenance requirements and increase efficiencies.

Defining the Problem: Pursuant to the U.S. Environmental Protection Agency's (EPA) Administrative Order SDWA I-97-1-030 ("AO2") the Massachusetts Army National Guard (MAARNG) suspended small arms range firing on Camp Edwards in 1997. This order was issued based on findings related to potential environmental impact of lead mobility from the range to groundwater, a sole source aquifer. The current 300m MRF Range-Sierra Range on Camp Edwards will not receive EPA/DEP/EMC approval to return to live fire with lead ammunition without the implementation of an approved best management practices and pollution prevention plan (BMP/P2) to operate and maintain the range and sustain environmental conditions in accordance with the requirements of USEPA AO2 and the Environmental Performance Standards as set by Chapter 47 the Acts of 2002 for the state of Massachusetts. As part of a draft alternative analysis, a feasibility study was needed to establish the limitations in size and scope of particular containment strategies which would be determined by a Line of Sight Analysis.

The Path Forward: A primary requirement to receive the regulatory agencies' approvals is the completion of the Alternatives Analysis of Best Management Practices/ Pollution Prevention (BMP/P2) methodologies appropriate for this range. The MAARNG has initiated the required Alternatives Analysis and has proposed a Range Adaptive Management Process (RAMP) strategy to resume live fire training. This paper is intended to describe the process used for the execution of the Line of Sight analysis, required in the RAMP, to predict the projectile distribution and initial dispersion on the range that will aid in determining appropriate BMP/P2 technologies to implement at each identified SIT location.

Typically, LOS analysis for small arms ranges is confined to the issue of target visibility from the firing line. TC 25-8 Army Ranges is the guidance on range design and operational requirements. Chapter 5, Range Development, covers the requirements for designing target areas, GTL and target visibility of direct fire ranges like Sierra range. Paragraph 5-17, Target Visibility, specifies that 90% of each target must be visible from the firing point, in order to meet training requirements. Further, the key is to provide an environment in which correct marksmanship techniques can be exercised using realistic battlefield terrain and target exposure speeds.

The Sierra Range LOS Analysis calls for a three phase analytical process in order to best predict and confirm the projectile distribution and initial dispersion on the range. The intent is to support preemptive implementation of BMP/P2 plans where projectiles are anticipated to impact and to use BMP/P2 methodologies which can be adapted to the observed projectile dispersion within the impact locations.

Prior to the LOS Analysis; MAARNG coordinated with agencies, such as, US Army Corp of Engineers, Huntsville AL, Installation Support Center of Expertise (ISCX), Ranges and Training Lands Program (RTLP) and Picatinny Arsenal, The Armament Research, Development and Engineering Center (ARDEC) to determine what data was available on general marksmanship proficiency, LOS studies on small arms range projectile distribution and dispersion patterns, and the availability for analysis of site specific LOS/projectile dispersion prediction on Sierra Range. This information was determined not to be available for the very specific questions related to the Sierra Range LOS.

LINE OF SIGHT ANALYSIS - PHASE I

Paper and computer based assessments of anticipated LOS/projectile distribution and dispersion patterns were conducted using the Range Managers Tool Kit (RMTK), a GIS based application, which is used to generate range Surface Danger Zone (SDZ) templates for Army live fire ranges. Using RMTK, plan view maps were generated by lane by target to depict GTLs (9 targets per lane x 10 lanes = 90 separate plans). These GTLs rep-resent the expected projectile flight path distribution in the X axis and are a good indicator of which target(s) will not be obscured by implementation of any BMP/P2 structures. Individual targets were evaluated for line of sight issues or identified as to whether a LOS issue may be created by the implementation of further BMP/P2 structures. Once individual GTL plans were printed; several Sierra range site visits were required to apply visual observation of the range topography to the GTL plans and to draft/sketch areas of concern on the plans which required additional review and planning to construct appropriate BMP/P2 methods.

In April of 2010, a preliminary range visit with members of Range Control, Mass DEP, EPA and the EMC met to sketch areas of concern on the GTL plans and discuss the use of the range, marksmanship techniques and LOS methodologies; specifically individuals with small arms weapons and marksmanship training to apply their experience to the process.

LINE OF SIGHT ANALYSIS - PHASE II

Range Control conducted an extensive projectile distribution and initial dispersion analysis using laser target designators to predict and replicate point of aim and point of impact characteristics of projectile flight. Two visible light target designator systems were utilized for this exercise (Figure 1.). The AN/PEQ-15 Advanced Target Pointer Illuminator Aiming Light (DBAL-2/ ATPIAL) which is a visible light target designating laser that is attached to a small arms weapon system. The Beamshot, GreenBeam 2200 GreenBlaster (GBII) is a visible light target designator that can be attached to a weapon system or operated as a hand held unit.

Figure 1. Laser Target Designators: AN/PEQ-15 Advanced Target Pointer Illuminator Aiming Light (Red) and the Beamshot, GreenBeam 2200 GreenBlaster (Green)

During the LOS Analysis Phase 2; the MAARNG mounted a GB II on a tripod located at the firing point on each lane and systematically "engaged" each target at the various distances (50-300m) for each lane in accordance with the modified record fire qualification table. Temporary targets simulating the actual size of targets and the height of exposure were placed at each SIT position and a temporary 4' x 8' clear Plexiglas "backstop" was erected at each SIT location to provide a surface to mark laser "impacts" according to a hypothesized target distribution and dispersion patterns (Figure 2.). The laser was additionally used to indicate potential projectile impact locations on the range floor or other SIT positions down range. This information produced the predicted projectile distribution and initial dispersion for each GTL. Projectile impact locations identified to potentially strike the range floor were mitigated by strategically placing backstops (n=17) to capture the projectile prior to impacting in an unrecoverable location.

Figure 2. Temporary Plexiglas Targets and Backstops erected at each SIT location to provide a surface to mark laser "impacts" according to a hypothesized target distribution and dispersion patterns.

LINE OF SIGHT ANALYSIS - PHASE III

The objective of the Phase III test fire is to conduct a comprehensive live fire on Sierra Range in order to validate the methodology utilized in Phase I and II of the Line of Sight Analysis. Specifically, the live fire event was designed to demonstrate that structures can be emplaced to mitigated undesirable range floor strikes while not obstructing the line of sight of Soldiers at the firing point. Additionally, the line of sight analysis demonstrated the ability to contain projectiles in the strategically emplaced structures and the recoverability of projectiles from those structures.

Sierra Range, prior to modification, was prone to projectile ricochets into the impact area resulting in the inability to contain projectiles for future recovery. The concerns for the Modified Record Fire range were range floor strikes, auxiliary berm functionality, and the result of berm emplacement on shooter's line of sight. Senior Range Control leadership at Camp Edwards designed deliberate backstop emplacements to contain and reduce undesirable projectile distribution. The measure of a successful line of sight is based on projectiles landing in the predicted impact location and not landing in an undesirable impact location.

Members of the Small Arms Range Working Group met and discussed the terms of the live fire exercise and produced an approved project note which outlined the background, objective, site description, site preparation, test fire execution and the evaluation of results. The MAARNG recommended this demonstration in order to test and verify the predictions produced in Phases I and II of the LOS analysis. Lane 6 was identified as the test lane due to the topography and the high potential of range floor strikes. Refer to Appendix A to review the accepted Project Note.

Prior to the execution of the live fire exercise; Lane 6 was prepared in accordance with the Range Adaptive Management Plan core elements (Figure 3.). Refer to Appendix B for the construction specifications associated with the design Sierra Range modifications. Site preparation was conducted as follows:

Figure 3. Lane 6 Prepared for Live Fire Demonstration for Phase III of the Line of Sight Analysis.

1. At the 300 meter berm; the area between the SIT positions of lanes five and six and six and seven was in-filled with clean fill to provide a base for a secondary berm structure and to capture projectiles which travel lower and between the existing SIT berms.

2. A tell tale plywood backstop was constructed on top of the end 300 meter berm, approximately 302 meters from the firing point, which was approximately 7 feet in height starting from the base of the SIT and approximately 130 feet long.

3. The exposed face of the 300 meter earthen berm was covered with soil screened 1/2 inch minus and to a minimum of 6" deep with clean fill.

4. Three backstop berms were constructed offset behind the 50 meter alpha, 50 meter bravo and the 100 meter targets positions. These backstop berms were constructed of a screened earth/sand fill contained

within a geo-textile revetment type material (i.e. DefenCell®) to eliminate projectile impacts down range on the range floor.

5. Berm soil for every target SIT was screened to 1/2 inch minus and to a minimum of 6" deep with clean fill and one 50 meter SIT (Alpha) screened to 18” as a projectile penetration prove out.

6. At anticipated projectile impact areas, as predicted by Phase 1 and 2 of the LOS analysis, which are outside of the scope of the live fire site preparation delineated above (i.e. lane 6 100m target is expected to have target strikes through which projectiles continue down range to the lane 7 250m frontal berm) had the existing vegetation closely mowed and tell tale marker fabric was laid down to capture indications of projectile impacts and the possible dispersion and distribution for each GTL.

7. A firing platform, constructed of plywood and 2”x4” frame, was placed at the firing point of lane 6 where the Beamshot laser “engaged” the targets to maintain continuity of the line of sight and allow Soldiers to qualify on a level surface (Figure 4.).

8. Each distribution location for each GTL of lane 6 was proofed with a VMH3CS Mine Detector. A note to this operation; it was discovered that rocks with high iron content set off the metal detector indicating that there was a metal object concealed below the surface giving a false positive. Additionally, the fill used on the SIT frontal berms contained some metal debris. This eliminated the utilization of the “All Metals” detector during post Phase III recovery operations.

Figure 4. Firing platform, Constructed of Plywood and 2”x4” Frame

The Live Fire Exercise was authorized to use but was not to exceed five thousand rounds of M855 is a 5.56x45mm 62-grain ball cartridge with a green tip, steel penetrator and a lead core. 5000 rounds is the equivalent to 125 Soldiers qualifying with the required 40 rounds of ammunition. The project note outlines a caveat which stated there was no specific requirement to fire all the ammunition if the observed projectile dispersion and distribution remained constant throughout the live fire event.

Portable Tactical Targets were set up on the range to conduct the standard modified record fire qualification table. A sample group of shooters representing a cross section of Massachusetts Army National Guardsmen with varied proficiency and experience levels were used to conduct the modified record fire qualification table. **NOTE**: Refer to Appendix C & D to visualize the differences in order of target engagement between Version I and Version II.

Line of sight specific duties and responsibilities were designated as follows:

1. Portable Tactical Target Manager: A Range Control technician was responsible for the connectivity and actuation of the portable tactical target system in accordance with the Modified Record Fire qualification table or the alternative qualification table.

2. Projectile Impact Observers: Two personnel were assigned to specifically observe and record the impact locations throughout the live fire exercise. Observers were equipped with a spotting scope and data sheets to record each course of fire. Both personnel observed projectile impacts and recorded either the location that the projectile hit or that it was not observed. Refer to Appendix C for specific data sheet information.

3. Marksmanship Observer: One individual was assigned to observe target strikes in order to record marksmanship statistics. The statistics were recorded directly into a Microsoft Excel spreadsheet built for the specified course of fire. Refer to Appendix D for individual and cumulative marksmanship data.

Massachusetts Army National Guard executed Phase III of the Line of Sight analysis with two versions of the qualification table. Version I is the Modified Record Fire qualification table in accordance with FM 3-22.9 Rifle Marksmanship. Version II is a modified version of the qualification table where targets were engaged sequentially but keep the integrity of the number of exposures per qualification iteration. The benefit from executing the alternate qualification table was the systematic execution, observation and tabulation of projectile impact locations with the projectile dispersion and distribution patterns could be quickly identified. The disadvantage the alternate qualification table produced was a less accurate depiction of the dispersion and distribution pattern than the actual Modified Record Fire qualification table.

Phase III began on 25 October 2010. The live fire event began with 20 iteration of Version II, the alternated qualification table. Multiple range walks were conducted to observe the initial patterns of the dispersion and distribution of projectile impact location. The 20 iteration were executed without significant deviation to the anticipated results with one caveat. The 100 meter DefenCell® back stop was observed to be potentially creating projectile ricochets due to the manner in which they struck the back stop. Six more iteration were executed utilizing Version I, the Modified Record Fire qualification table. By the end of the day, Soldiers participating in the event fired 1040 rounds (26 iterations) with no significant deviations to Phases I and II of the LOS Analysis. Representatives from the US Environmental Protection Agency, Massachusetts Department of Environmental Protection, and the Environmental Management Commission, concurred with the MAARNG that the projectile distribution and dispersion appeared to be consistent with the predictions made with Phase I and II of the LOS analysis. The expectation, at the end of the day, was that the MAARNG was going to continue firing on 26 October 2010, but would only need to fire another 1,000 rounds due to the preliminary results of the LOS Phase III to complete the LOS Analysis.

On 26 October 2010, the MAARNG fired another 1080 rounds (27 iterations) in accordance with Version I, the Modified Record Fire qualification table, for a total of 2120 rounds (53 iterations). The results from the second day of the live fire exercise reproduced the previous day's results with only a minor increase to projectile dispersion. MAARNG personnel and representatives from the regulatory agencies conducted multiple range walks throughout lane six. The review of the overall projectile dispersion and distribution associated with lane six demonstrated that the final results indicate that the predictions made through Phase I and II appeared to closely represent the results of the Phase III. All parties, present through the event, concurred that Phase III of the LOS should conclude and that the MAARNG should initiate the Post-Phase III validation and analysis.

The Post-Phase III analysis took place from 27 October 2010 through 05 November 2010. Dispersion and distribution of projectiles was measured and quantified; a GIS overlay was plotted and drafted; bullet impacts in the telltale back stop were counted and measured; and lead and copper fragments and steel penetrators were sifted and recovered.

EVALUATION OF RESULTS

A Geographic Information System overlay was developed to depict anticipated and actual projectile impact locations. The Camp Edwards GIS Manager plotted each projectile impact location with a GPS and transferred the Meta Data to the specified overlay. Refer to Appendix E, Figures 1-8, to review the results of the Line of Sight execution.

Projectile Impact Observations: Observations of projectile terminal ballistics were determined by visually observing the real time projectile strike and the evidence left as a result of the strike. Visual observations during Phase III were tabulated on "Phase III LOS Analysis Composite Worksheets." Two versions of the worksheet were developed for each version of the qualification tables utilized during the live fire execution. Version I is the primary methodology where the actual Modified Record Fire qualification table is employed which represents the same stresses Soldiers experience during record fire qualification. Version II was the alternate methodology where targets are engaged sequentially with the same number of target exposures. Refer to Appendix C, Sections 1 and 2 for Phase III LOS Analysis Composite Worksheets and Section Three for data totals.

Marksmanship Proficiency: An important metric of this line of sight analysis is Soldier marksmanship proficiency. Soldier's marksmanship proficiency determines the validity of this modified record fire qualification event by determining if each shooter is deliberately aiming and engaging each target; essentially, allowing the projectile to end up at a pre-determined location.

Table 1 shows the Probability of Hits based on 53 qualification iterations completed in accordance with standards set by Rifle Marksmanship FM 3-22.9, Chapter 6, Section 66. The table breaks down target strikes by an anticipated performance rate determined by the Army qualification skill levels of Marksman (23/40), Sharp-shooter (32/40), and Expert (37/40).

Table 1. Anticipated Marksmanship Probability of Hit Based on 57 Iterations.

Table 1. Probability of Hit (PH) Per Target Exposure Based on Soldier Proficiency n=2120							
RANGE (m)	EXPOSURES	Low PH	Low Hit Score	Ave PH	Ave Hit Score	High PH	High Hit Score
50A	192	0.8	154	0.95	182	0.98	188
50B	126	0.8	101	0.95	120	0.98	123
100	424	0.7	297	0.9	382	0.95	403
150	583	0.65	379	0.9	525	0.95	554
200	371	0.45	167	0.7	260	0.9	334
250	265	0.35	93	0.6	159	0.85	225
300	159	0.25	40	0.5	80	0.8	127
Total	2120	0.58	1230	0.81	1707	0.92	1955
			23		32		37

Table 2 describes the number of observed target strikes versus the number of target exposures. This table breaks down the marksmanship proficiency for each particular target which can then be related back to the previous table in order to determine the overall Soldier proficiency for this live fire event.

Table 2. Actual Marksmanship Rates Based on 57 Iterations.

Table 2. OBSERVED TARGET STRIKES VS. TARGET EXPOSURE				
RANGE (m)	**EXPOSURES**	**TOTAL STRIKES**	**PERCENT HITS**	
50A	192	171	89%	
50B	126	119	94%	
100	424	346	82%	
150	583	378	65%	
200	371	202	54%	
250	265	104	39%	
300	159	58	36%	**AVERAGE HITS**
TOTALS	***2120***	***1378***	***65%***	***26.00***

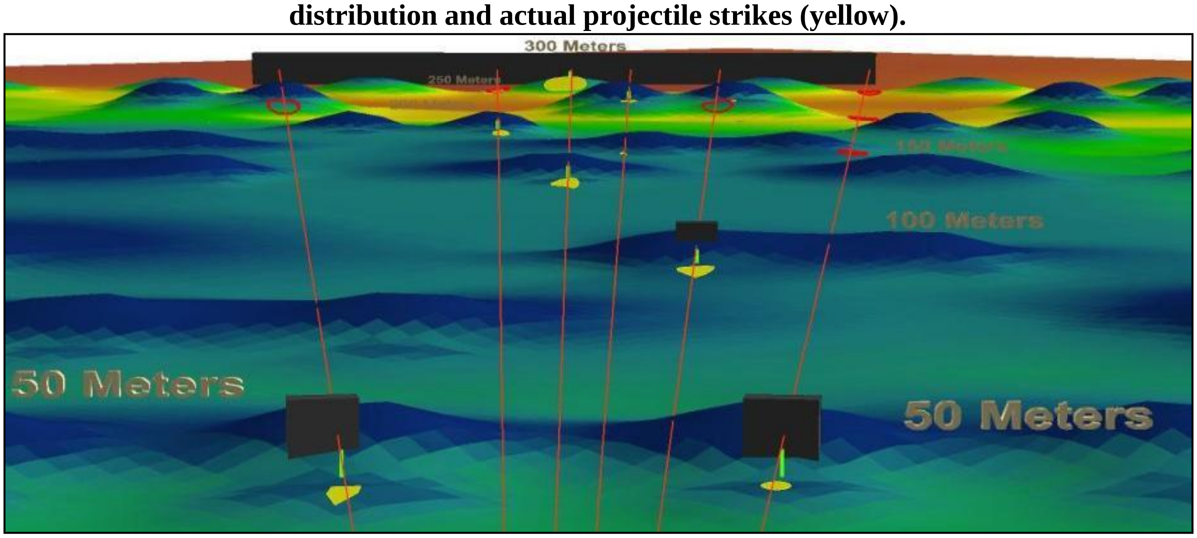
The average overall marksmanship performance for this event was an average 26 target strikes for the 40 target exposures. This falls in the category of a low probability of hit but is within adequate performance rate in accordance with Rifle Marksmanship FM 3-22.9 and therefore validated the initial dispersion and distribution of projectiles through each GTL.

Terminal Ballistics: The LOS analysis needed to answer some critical questions: 1) Did the projectiles proceed down range as predicted (flight path); 2) Did secondary berms function to contain the projectiles; 3) Were targets obscured by backstop berm emplacements; 4) Were there any range floor projectile impacts? In preparation for this live fire exercise; the MAARNG developed and emplaced berm modifications to eliminate undesirable range floor strikes which would result in ricochets or develop a projectile dispersion area too large to identify impact locations which would reduce the ability to recapture lead projectiles fired.

The bottom line up front is that the first two phases of the LOS Analysis, identifying GTLs and emplacing mitigation structures, were validated by the execution of the live fire event or the LOS Phase III. Each GTL can be predicted allowing for the determination of proper range adaptive management planning and procedures to be implemented at Sierra Range.

This GIS image (Figure 5.) is a graphic that shows the plotted projectile strikes and the anticipated projectile distribution areas. There is little to no deviation of projectiles from the GTLs.

Figure 5. Geographical Information System Image showing the anticipated (Red) projectile distribution and actual projectile strikes (yellow).



One area of concern that developed was the distribution of projectiles to the 100 meter GTL. The DefenCell® back stop was specifically designed to contain projectiles that would potentially impact the range floor but allow the rest of the projectiles to travel to the 300 meter berm. Projectile "grazing" across the top of the berm observed during the live fire event raised doubts to the terminal ballistics of that particular GTL (Figure 6.).

Figure 6. Projectile "Grazing" Across Backstop Berm 100 meter GTL.

50 meter Alpha Gun Target Line:

The 50 meter Alpha Stationary Infantry Target on Lane Six was the first location determined to need an auxiliary berm emplacement in order to avoid range floor strikes due to the range design and rolling topography. Through the Phase I and II LOS analysis; projectiles were anticipated to strike the 50m Alpha frontal berm, 250m frontal berm in Lane 5 and the range floor near the 300m berm in Lane 5. To improve containment of projectiles; a 60" (w) x 45" (h) DefenCell® back stop offset by 9" to be centered with the line of sight to the firing point was constructed behind the Stationary Infantry Target with the intent to eliminate strikes to the 250m and 300m locations.

The emplacement of this back stop did not restrict the view or line of sight of Soldiers engaging targets further down the range throughout the qualification table.

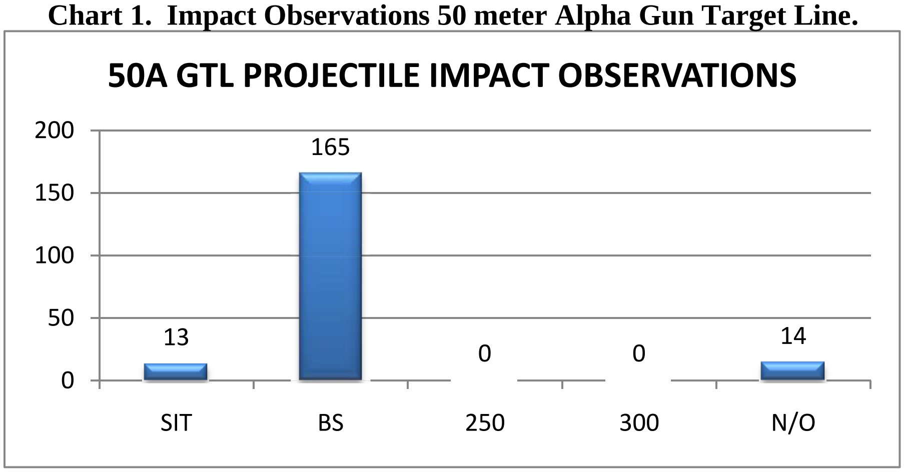
During 53 iterations; this target was exposed 192 times and had 171 strikes. This is an 89.1% hit rate which is slightly below average but not out of expectations. Refer to Table 3. for the anticipated and actual marksmanship rate for the 50 meter Alpha target.

Table 3. Marksmanship proficiency 50 meter Alpha Gun Target Line.

50 Meter ALPHA Gun Target Line		
	EXPOSURES	192
METRIC OF PROFICIENCY	TOTAL STRIKES	PERCENT HIT
LOW	154	80.2%
AVERAGE	182	94.8%
HIGH	188	97.9%
ACTUAL	**171**	**89.1%**

Real time observations during the event indicate that 13 projectiles hit the frontal berm, 165 projectiles hit the back stop and 14 projectiles were not observed. The projectiles proceeded to the 50 meter target with no observable deviation from its vector after the target strike. Any affect from target strikes were masked due to the close proximity of the auxiliary berm which was a distance of approximately 1 meter; however, a dense pattern of projectile strikes in the DefenCell® plastic cover emerged indicating that a projectiles striking targets had no observable effect. Refer to Chart 1. for the tabulated real time observations.

Chart 1. Impact Observations 50 meter Alpha Gun Target Line.



During post Phase III analysis of this target location; projectile strikes were observed as hitting the frontal berm, the target and the DefenCell® bask stop. There were no other observed projectile strikes at the 250m frontal berm or 300m earthen berm location during range walks, which indicate that the DefenCell® worked as intended to protect the range floor from projectile strikes.

During the analysis of the frontal berm plastic cover; multiple penetrations were observed. The exact count of these penetrations is masked because of the tearing in the fabric and what seem to be projectiles weaving in and out of the fabric toward the back stop. The visual indications in the fabric support the real time observations where 13 projectiles struck the frontal cover. Refer to Figure 7. for projectile impact indications to the 50m Alpha frontal berm.

Figure 7. 50 Meter Alpha Frontal Berm and Cover.

Note: Colors were adjusted to increase the visualization of the image.

Observations of the DefenCell® back stop indicate 189 penetrations in the plastic cover. These penetrations were manually counted and the plastic covers were retained as visual aids. The back stop appeared to function, as designed, to contain projectiles as there were entry penetration holes and no exit holes. Refer to Figure 8. for projectile impact observations to the 50m Alpha DefenCell.

Figure 8. 50 Meter Alpha Stationary Infantry Target and Backstop Berm

The frontal berm, however, did not function to contain all the projectiles. Projectiles hitting closer to the top of the frontal berm appeared to continue to the back stop while projectiles closer to the bottom seemed to penetrate into the frontal berm. This is most likely due to the slope of the frontal berm. Of the 13 projectiles that struck the frontal berm; 10 rounds still continued to the DefenCell® back stop. The intent of the frontal berm's functionality should be evaluated as part of future best management practices.

The remaining three projecitles which are not contained in the DefenCell® back stop are assumed to be in the frontal berm due to indications in the frontal cover and there are no other locations projectile impact indications exist at this gun target line. This cannot be definitively answered because the recovery process could not validate this assumption.

The dispersion area to this target location is approximately 23 5/8" (w) x 39 1/4" (h) (+). This projectile pocket dimension can be retained to aid in the design of future BMP structures at a range of 50 meters.

50 meter Bravo Gun Target Line:

The 50 meter Bravo Stationary Infantry Target on Lane Six was the next location determined to need an auxiliary berm emplacement in order to avoid range floor strikes. Through Phase I and II analysis; projectiles were anticipated to strike the 50m Bravo frontal berm, and the range floor near the 175m, 250m and 300m SIT locations in Lane 7. To improve containment of projectiles; a 60” (w) x 45” (h) DefenCell® back stop offset by 9” to be centered with the line of sight to the firing point was constructed behind the Stationary Infantry Target with the intent to eliminate strikes to the 175m, 250m and 300m locations.

The emplacement of this back stop did not restrict the view or line of sight of Soldiers engaging targets throughout the qualification table.

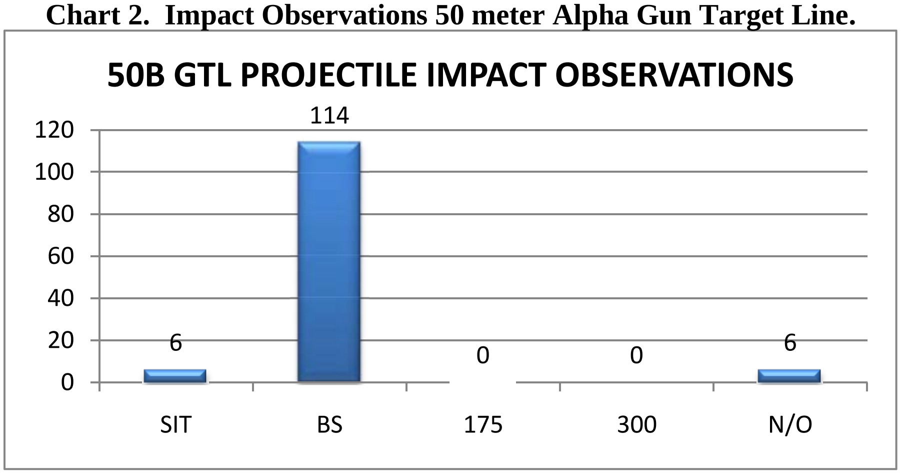
During 53 iterations; this target was exposed 126 times and had 119 strikes. This is a 94% hit which is slightly below average but not out of expectations. Refer to Table 4. for the anticipated and actual marksmanship rate for the 50 meter Alpha target.

Table 4. Marksmanship Proficiency 50 Meter Bravo Gun Target Line.

50 Meter BRAVO Gun Target Line		
	EXPOSURES	126
METRIC OF PROFICIENCY	TOTAL STRIKES	PERCENT HIT
LOW	101	80%
AVERAGE	120	95%
HIGH	123	98%
ACTUAL	**119**	**94%**

Real time observations during the event indicate that 6 projectiles hit the frontal berm, 114 projectiles hit the back stop and 6 projectiles were not observed. The projectiles proceeded to the 50 meter target with no observable deviation from its vector after the target strike. Any affect from target strikes were masked due to the close proximity of the auxiliary berm which was a distance of approximately 1 meter; however, a dense pattern of projectile strikes in the DefenCell® cover emerged indicating that a projectiles striking targets had no observable effect. Refer to Chart 2. for the tabulated real time observations.

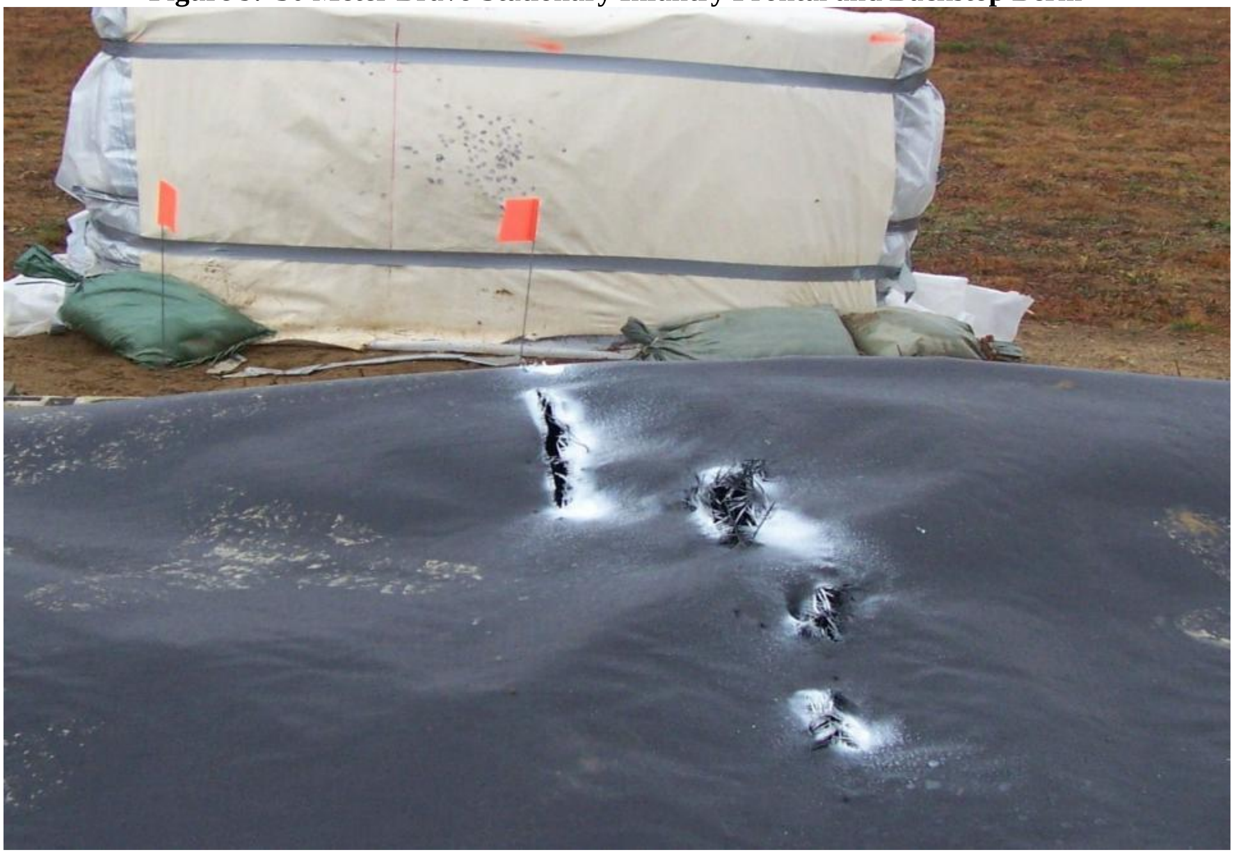
Chart 2. Impact Observations 50 meter Alpha Gun Target Line.



During post Phase III analysis of this target location; projectile strikes were observed as hitting the frontal berm, the target and the DefenCell® bask stop. There were no other observed projectile strikes at the 175m, 250m or 300m berm locations during range walks, which indicate that the DefenCell® worked as intended to protect the range floor from projectile strikes.

During the analysis of the frontal berm plastic cover; multiple penetrations were observed. The exact count of these penetrations is masked because of the tearing in the fabric and what seem to be projectiles weaving in and out of the fabric toward the back stop. The visual indications in the fabric support the real time observations where 6 projectiles struck the frontal cover. Refer to Figure 9. for the observations of the 50m Bravo frontal berm.

Figure 9. 50 Meter Bravo Stationary Infantry Frontal and Backstop Berm



Note: Red survey flags indicate the board of projectile impact locations to the frontal berm.

Observations of the DefenCell® back stop indicate approximately 119 penetrations in the plastic cover. These penetrations were manually counted and the plastic covers were retained as visual aids. The back stop appeared to function as designed to contain projectiles as there were penetrating holes and no exit hole.

The frontal berm, however, did not function to contain all the projectiles. Projectiles hitting closer to the top of the frontal berm seemed to continue to the back stop while projectiles hitting closer to the bottom seemed to penetrate into the frontal berm. This is most likely due to the slope of the frontal berm. An exact number of frontal berm hits cannot be definitively determined due to the condition of the plastic cover but the indications illustrate a combination of projectiles skimming the top of the frontal berm and penetrating into the frontal berm. The intent of the frontal berm's functionality should be evaluated as part of future best management practices.

The remaining seven projectiles which are not contained in the DefenCell® back stop are assumed to be in the frontal berm because that is the only other location projectile impact indications exist at this gun target line. This cannot be definitively answered because the recovery process could not validate this assumption and the projectile impact indications on frontal berm cover have large tears.

The dispersion area to this target location is approximately 20 1/2" (w) x 25" (h) (+). This projectile pocket dimension can be retained to aid in the design of future BMP structures at a range of 50 meters.

100 meter Gun Target Line:

The 100 meter Stationary Infantry Target on Lane Six was the last location on Lane Six determined to need an auxiliary berm emplacement in order to avoid range floor strikes. Through Phase I and II analysis; projectiles were anticipated to strike the 100 frontal berm and 250m frontal berm in Lane Six and the 300m berm in Lane Seven. To improve containment of projectiles; a 60" (w) x 36" (h) DefenCell® back stop offset by 12" centered with the line of sight from the firing point to the target was constructed behind the Stationary Infantry Target with the intent to eliminate range floor strikes but allow projectiles to proceed to the 250m and 300m berm location.

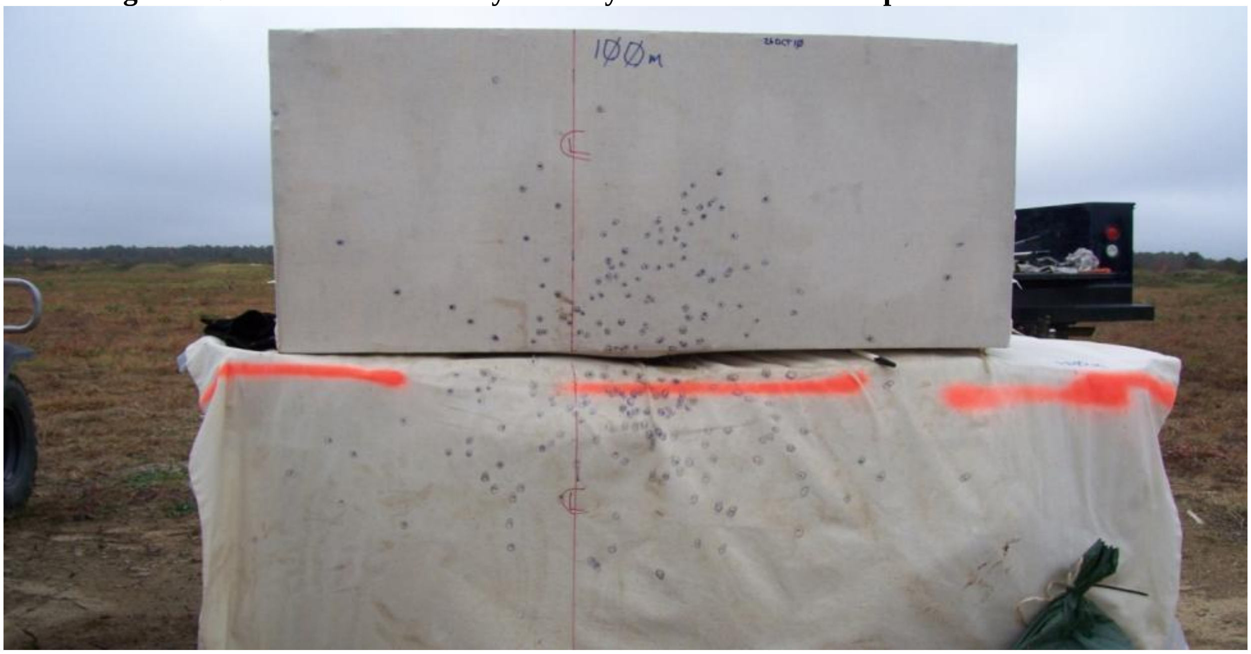
The emplacement of this back stop did not restrict the view or line of sight of Soldiers engaging targets throughout the qualification table.

On the first day of the Phase III analysis, this target was exposed 208 times. Initial projectile indications in the DefenCell®, as designed, illustrate multiple projectile strikes to the top of the berm which caused an unknown effect on the projectiles and uncertainty to their final disposition. Refer to Figure 10.

Figure 10. 100 Meter Stationary Infantry DefenCell® back stop on 25 October 2010

As a result of onsite discussions regarding the unfavorable condition; a plywood extension, similar to the 300 meter plywood tell tale barrier with a sandbag barrier, was emplaced to simulate a larger DefenCell® back stop. Refer to figure 11.

Figure 11. 100 Meter Stationary Infantry DefenCell® back stop on 28 October 2010



Note: The extension to 100m DefenCell® did not restrict the line of sight or view of targets further down the range.

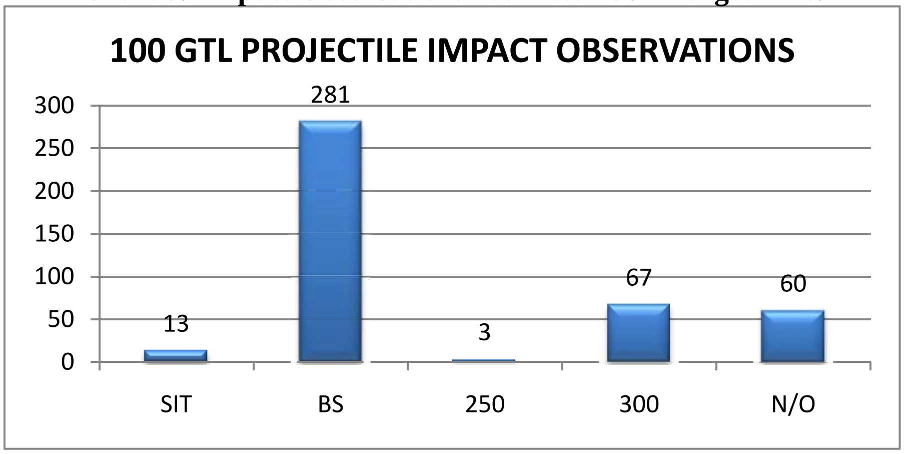
During 53 iterations; this target was exposed 424 times and had 346 strikes. This is an 82% hit which is slightly below average but not out of expectations. Refer to Table 5. for the anticipated and actual marksmanship rate for the 50 meter Alpha target.

Table 5. Marksmanship Proficiency 100 Meter Gun Target Line.

100 meter Gun Target Line		
	EXPOSURES	424
METRIC OF PROFICIENCY	TOTAL STRIKES	PERCENT HIT
LOW	297	70%
AVERAGE	382	90%
HIGH	403	95%
ACTUAL	**346**	**82%**

Real time observations during the event indicate that 13 projectiles hit the frontal berm, 281 projectiles hit the back stop, 3 projectiles hit the 250m frontal berm, 67 projectiles hit the 300m earthen berm and 60 projectiles were not observed. The projectiles not observed are assumed to be the projectiles penetrations in the 300m plywood barrier, which would be difficult to observe without a visual indication such as a duct cloud when the projectile hits earth. The projectiles proceeded to the 100 meter target with no observable deviation from its vector after a target strike. Any affect from target strikes were masked due to the close proximity of the auxiliary berm which was a distance of approximately 1 meter; however, a dense pattern of projectile strikes in the DefenCell® and plywood extension plastic covers emerged indicating that projectile striking this target had no observable effect. Refer to figures 10 and 11. for projectile strike observations. Refer to Chart 3. for the tabulated real time observations.

Chart 3. Impact Observations 100 meter Gun Target Line.



During post Phase III analysis of this target location; projectile strikes were observed as hitting the frontal berm, the target, the DefenCell® bask stop, the 250m frontal berm, 300 meter earthen berm and the 300m plywood overshot barrier. There were no observed projectile strikes or indications on the range floor or other locations during range walks, which indicate that at a minimum the DefenCell® worked as intended to protect the range floor from projectile strikes. Unfortunately, the DefenCell® design had an unintended effect when the projectiles struck the top of the berm which introduced doubt to the final location of these rounds.

During the analysis of the frontal berm plastic cover; multiple penetrations were observed. The exact count of these penetrations is undeterminable because of environmental conditions in which wind blew the frontal berm cover out of place during the event. Indications in the frontal cover fabric; however, illustrate the frontal berm was struck as many as 13 times. Refer to Figure 12. for frontal berm observations.

Figure 12. 100 Meter GTL (Plastic Frontal Cover) on 26 October 2010

Observations of the DefenCell® back stop indicate atleast 225 penetrations in the plastic cover. These penetrations were manually counted and the plastic covers were retained as visual aids. Aside from the original DefenCell® design methodology; the back stop appeared to function to contain projectiles as there were penetrating holes and no exit hole. Additionally, a manual count cannot determine the number of projectiles which struck the top of the DefenCell® berm.

The frontal berm, however, did not function to contain all the projectiles. Projectiles hitting closer to the top of the frontal berm seemed to continue to the back stop while projectiles hitting closer to the bottom seemed to penetrate into the frontal berm. This is most likely due to the slope of the frontal berm. An exact number of frontal berm hits cannot be definitively determined due to the condition of the plastic cover but the indications illustrate a combination of projectiles skimming the top of the frontal berm and penetrating into the frontal berm. The intent of the frontal berm's functionality should be evaluated as part of future best management practices.

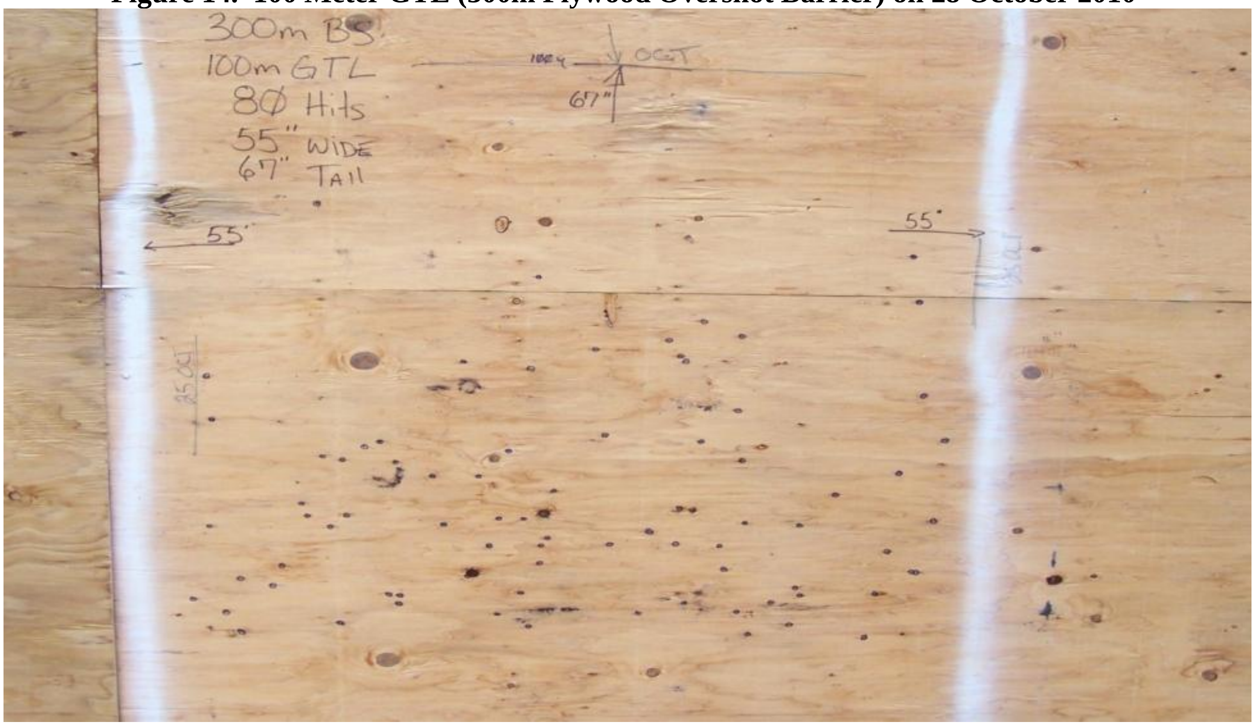
The 300m earthen berm, also, did not function to contain all the projectiles. In the same conditions as the SIT frontal berms; projectiles hitting closer to the top of the frontal berm, where the slope is closer to zero, seemed to continue to the plywood back stop while projectiles hitting closer to the bottom seemed to penetrate into the berm. Additionally, copper fragmentation was observed hitting but not penetrating in the plywood overshot barrier. This is most likely due to the slope of the frontal berm and the level of compaction of the soil material. An exact number of earthen berm hits cannot be definitively determined because the geo-textile cover was removed due to high wind conditions; however, the boarder was marked with red survey flags to delineate the magnitude of the projectile impact location. The intent of the 300m berm's functionality should be evaluated as part of future best management practices. Refer to the figure 13. for 300m earthen berm observations.

Figure 13. 100 Meter GTL (300m Earthen Berm) on 25 October 2010

Note: The red survey flags indicate the boarder of the projectile impact location. Additionally, due to high wind conditions; the earthen berm covers blew out of place during the live fire event.

Out of the 424 projectiles fired; 305 have been definitively contained at the DefenCell® or plywood overshot barrier. The remaining 119 projectiles which are not contained in the DefenCell® back stop or plywood overshot barrier are assumed to be in the 100m, 250m or 300m frontal berms because they are the only other locations projectile impact indications exist at this gun target line which is not outside the projectile impact locations identified during Phase I and II of the LOS analysis. This cannot be definitively answered because the recovery process could not validate this assumption; the 300m earthen berm cover was removed due to high winds and the uncertainty imposed by the original DefenCell® design. Refer to Figure 14 for plywood overshot barrier observations.

Figure 14. 100 Meter GTL (300m Plywood Overshot Barrier) on 28 October 2010



Projectile accountability for the 100m Gun Target Line cannot be definitively measured but the visual indications left behind illustrate that projectiles appeared to impact anticipated locations as determined by Phase I and II of the LOS analysis. Observations during range walks and the visual indications left behind after the live fire execution do not present any evidence which projectiles landed outside of anticipated locations. Additionally, the redesign of the 100m DefenCell back stop will eliminate projectiles impacting past the 100m Stationary Infantry Target.

The dispersion areas to this target location are as follows:

a. The 100 meter DefenCell® back stop is 43" (w) x 21" (h) plus approximately 20".
b. The 250 meter frontal berm is insignificant.
c. The 300 meter Plywood over shot barrier is 55" (w) x 67" (h).
d. The 300 meter earthen berm was, approximately, 55" (w) x 72" (h) (vertical drop, not hypotenuse).

200 meter Gun Target Line:

The 200 meter Stationary Infantry Target, on Lane Six, was determined to not need an auxiliary berm to contain projectiles. This gun target line methodology, after the Phase I and II analysis, was to attempt to contain projectiles at its anticipated projectile impact locations; the 200m frontal berm, the 300m earthen berm and the plywood overshot barrier.

The view and line of site to this target was not obscured by any of the DefenCell® auxiliary berm emplacements.

During 53 iterations; this target was exposed 371 times and had 202 strikes. This is a 54% hit which is below average but not out of expectations. Refer to Table 6. for the anticipated and actual marksmanship rate for the 200m target.

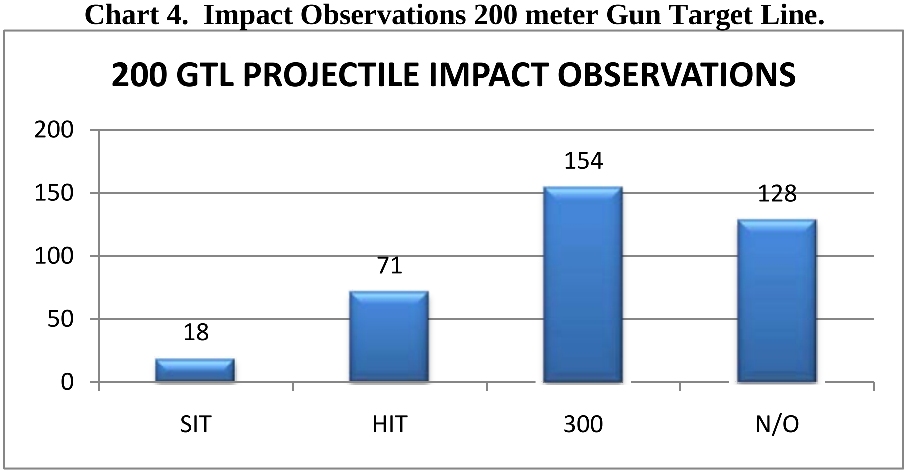
Table 6. Marksmanship Proficiency 200 Meter Gun Target Line.

200 meter GTL		
	EXPOSURES	371
METRIC OF PROFICIENCY	TOTAL STRIKES	PERCENT HIT
LOW	167	45%
AVERAGE	260	70%
HIGH	334	90%
ACTUAL	**202**	**54%**

Real time observations during the event indicate that 18 projectiles hit the frontal berm, 154 projectiles hit the 300m earthen berm, 128 projectiles were not observed and 71 projectiles were marked as a “Hit”. The inclusion of the term “hit” as a projectile impact location has caused confusion in the classification of real-time visual data. Visual indications of projectile strikes to the 300m earthen berm were illustrated but not conclusive due to the removal of tell tale fabric because of high wind conditions.

The projectiles proceeded to the 200 meter target with no observable deviation from its vector after a target strike, which is indicated by the dense pattern of projectile impacts to the 300m earthen berm and plywood overshot barrier. The 200m Gun Target Line offers a particular analysis of the projectile target strikes and the observable affects on flight paths. In the 100 meters between the 200 meter target and the 300 meter plywood overshot barrier; no distinguishable patterns were noticed to acknowledge that the projectile striking the plastic target significantly altered the flight path. Refer to Chart 4. for real time observations.

Chart 4. Impact Observations 200 meter Gun Target Line.



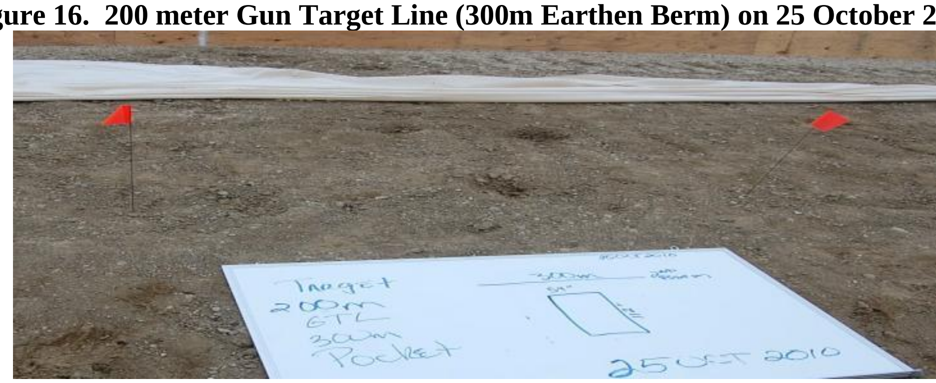
During post Phase III analysis of this target location; projectile strikes were observed as hitting the frontal berm, the target, the 300m earthen berm and the 300m plywood overshot barrier. There were no other projectile strikes observed during range walks.

During the analysis of the frontal berm geo-textile cover; multiple penetrations were observed. The exact count of these penetrations is masked because of the tearing in the fabric and what seem to be projectiles weaving in and out of the fabric toward the back stop. Figure 15 illustrates the visual indications in the fabric support the real time observations where 18 projectiles struck the frontal cover.

Figure 15. 200 meter Gun Target Line (200m SIT) on 26 October 2010.

During the analysis of the 300m earthen berm; multiple penetrations were observed. The exact count of these penetrations cannot be determined because during the event the tell tale fabric was removed due to high wind conditions and any analytical value the fabric presented when the fabric blew out of place. However, the boarders of the projectile impact location on the 300m earthen berm was marked with red survey flags to delineate the magnitude of that particular impact location. Refer to Figure 16.

Figure 16. 200 meter Gun Target Line (300m Earthen Berm) on 25 October 2010.



Observations of the 300m overshot barrier indicate 250 penetrations in the plywood. These penetrations were manually counted and each penetration was highlighted with black permanent marker to aid in visualizing the pattern of penetrations. Refer to Figure 17.

Figure 17. 200 meter Gun Target Line (300m Plywood Overshot Barrier) on 28 October 2010.

The dispersion area to the 200 meter Stationary Infantry Target is as follows:

a. The 200m frontal berm is 38" (w) x approximately 36" (h)
b. The 300m earthen berm is 72" (w) x approximately 24" (h) down from the top of the earthen berm
c. The plywood overshot barrier is 72" (w) x 78" (h) up from the top of the earthen berm

250 meter Gun Target Line:

The 250 meter Stationary Infantry Target, on Lane Six, was determined to not need an auxiliary berm to contain projectiles. This gun target line methodology, after the Phase I and II analysis, was to attempt to contain projectiles at its anticipated projectile impact locations; 175m frontal berm, the 250m frontal berm, the 300m earthen berm and the plywood overshot barrier.

The view and line of site to this target was not obscured by any of the DefenCell® auxiliary berm emplacements.

During 53 iterations; this target was exposed 265 times and had 104 strikes. This is a 39% hit which is below average but not out of expectations. Refer to Table 7. for the anticipated and actual marksmanship rate for the 200m target.

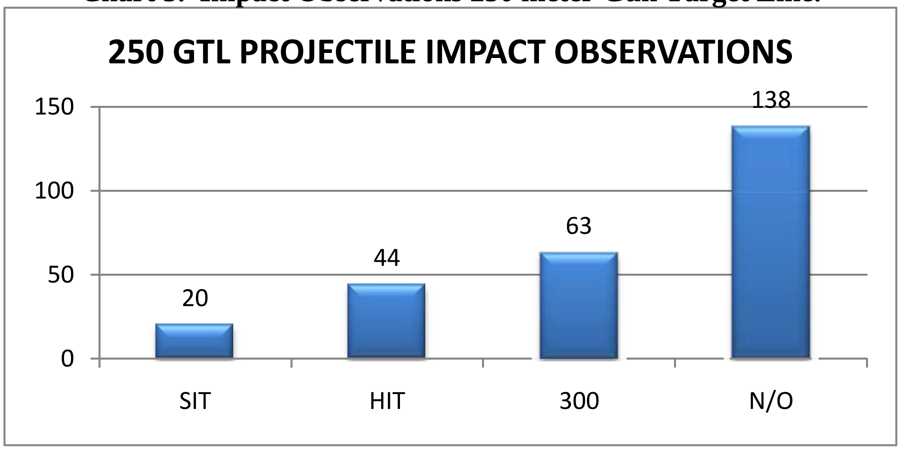
Table 7. Marksmanship Proficiency 250 Meter Gun Target Line.

250 meter Gun Target Line		
	EXPOSURES	265
METRIC OF PROFICIENCY	TOTAL STRIKES	PERCENT HIT
LOW	93	35%
AVERAGE	159	60%
HIGH	225	85%
ACTUAL	**104**	**39%**

Real time observations during the event indicate that 20 projectiles hit the frontal berm, 63 projectiles hit the 300m earthen berm and 138 projectiles were not observed and 44 projectiles were marked as a “hit”. Again, the inclusion of the term “hit” as a projectile impact location has caused confusion in the classification of real-time visual data. Visual indications of projectile strikes to the 300m earthen berm were illustrated as disturbed earth on the graded earthen berm but not conclusive due to the removal of tell tale fabric because of high wind conditions. Refer to Chart 1. for the tabulated real time observations.

The projectiles proceeded to the 250 meter target with no observable deviation from its vector after the target strike. A dense pattern of projectile strikes in the 300m earthen berm and plywood overshot barrier indicate that projectiles striking targets had no observable effect to flight path.

Chart 5. Impact Observations 250 meter Gun Target Line.



During post the Phase III analysis of this target location; projectile strikes were observed as hitting the 250m frontal berm, the target, 300m earthen berm, plywood overshot barrier and the 175m earthen berm.

Observations of the projectile penetrations in the 175m earthen berm indicate a better capability to contain projectiles impacting that location. Visual indications illustrated approximately six projectiles impacted the earthen berm. The vegetative cover aided in the capture of these projectiles as 15.36g of projectiles were recovered out of approximately 24.12g. The number of projectile impacts to this location is not definitive due to the inability to identify individual and specific projectile impacts. Refer to figure 18.

Figure 18. 250 Meter Stationary Infantry Target (175m Frontal Berm) on 26 October 2010

During the analysis of the 250m frontal berm geo-textile cover; multiple penetrations were observed. The exact count of these penetrations is not definitive because high winds blew part of the tell-tale fabric out of place during the live fire event. The visual indications in the fabric support the real time observations where at least 20 projectiles struck the frontal berm. Refer to the Figure 19 for 250m frontal berm impacts.

Figure 19. 250 Meter Stationary Infantry Target (250m Frontal Berm) on 26 October 2010

Out of the 265 projectiles fired; 205 have been definitively contained at the plywood overshot barrier. The remaining 60 projectiles which are not contained in the plywood overshot barrier are assumed to be in the 175m, 250m or 300m frontal berms because they are the only other locations projectile impact indications exist for this gun target line which is not outside the projectile impact locations identified during Phase I and II of the LOS analysis. This cannot be definitively answered because the recovery process could not validate this assumption and the 250m and 300m earthen berm covers were removed due to high winds conditions. Refer to Figure 20.

Figure 20. 250 Meter Stationary Infantry Target (300m Plywood Overshot Barrier) on 28 October 2010

The dispersion area to the 250 meter Stationary Infantry Target is as follows:

a. The 175m frontal berm is 6" (w) x approximately 6" (h) vertical distance.
b. The 250m frontal berm is 46" (w) x approximately 30" (h)
c. The 300m earthen berm is 48" (w) x approximately 28" (h) down from the top of the earthen berm
d. The plywood overshot barrier is 72" (w) x 78" (h) up from the top of the earthen berm

150/300 meter Gun Target Line:

The 150 and 300 meter gun target lines overlap each other making it impossible to distinguish between the dispersion areas at the 300 meter earthen berm and plywood telltale overshot barrier (Figure 26). The 150/ 300 meter Gun Target Line, on Lane Six, was determined to not need an auxiliary berm to contain projectiles. This gun target line methodology, after the Phase I and II analysis, was to attempt to contain projectiles at its anticipated projectile impact locations; 150m frontal berm, the 300m frontal berm, the 300m earthen berm and the plywood overshot barrier. Refer to figure 21.

Figure 21. 150/ 300 Target Gun Target Line with Overshot Barrier

The view and line of site to this target was not obscured by any of the DefenCell® auxiliary berm emplacements.

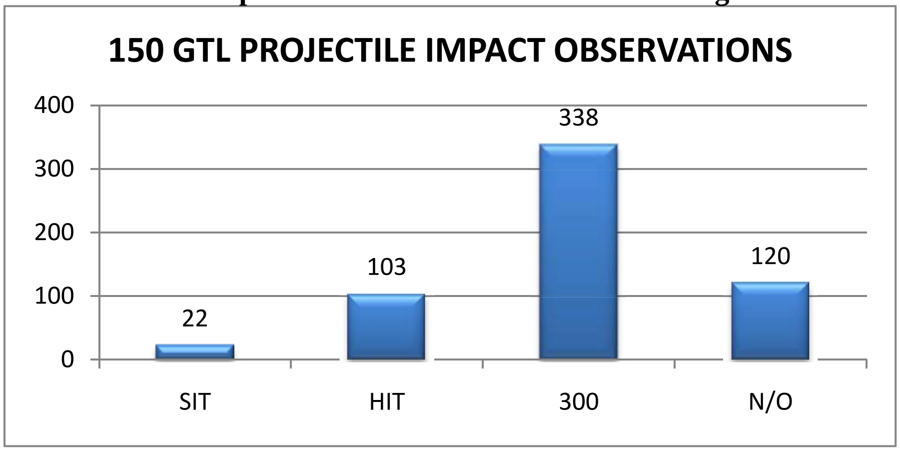
During 53 iterations; the 150 meter target was exposed 583 times and had 378 strikes. This is a 65% hit which is below average but not out of expectations. The low average is due to IT issues with the targets registering a hit which was adjusted on day one. Additionally, the 300 meter target was exposed 159 times and had 58 strikes. This is a 36% hit which is below average but not out of expectations. Refer to Table 8. for the anticipated and actual marksmanship rate for the 150/ 300m target.

Table 8. Marksmanship Proficiency 150 / 300 Meter Gun Target Lines.

150 Meter Gun Target Line			**300 Meter Gun Target Line**		
METRIC OF	EXPOSURES	583	*METRIC OF*	EXPOSURES	159
PROFICIENCY	TOTAL STRIKES	PERCENT HIT	*PROFICIENCY*	TOTAL STRIKES	PERCENT HIT
LOW	379	65%	*LOW*	40	25%
AVERAGE	525	90%	*AVERAGE*	80	50%
HIGH	554	95%	*HIGH*	127	80%
ACTUAL	**378**	**65%**	***ACTUAL***	**58**	**36%**

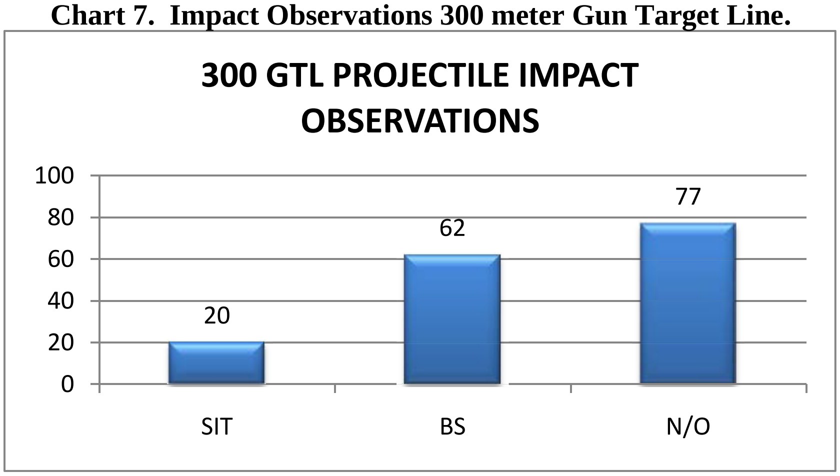
Real time observations, of the 150m GTL, during the live fire event indicates that 22 projectiles hit the frontal berm, 338 projectiles hit the 300m earthen berm, 120 projectiles were not observed and 103 projectiles were marked as a "Hit" which is confusing. The projectiles proceeded to the 300 meter berm location with no observable deviation from its vector after the target strike. Refer to Chart 6. for the tabulated real time observations.

Chart 6. Impact Observations 150 meter Gun Target Line.



Real time observations, of the 300m GTL, during the live fire event indicates that 20 projectiles hit the frontal berm, 62 projectiles hit the 300m plywood back stop, and 77 projectiles were not observed. The projectiles proceeded to the 300 meter berm location with no observable deviation from its vector after the target strike. Refer to Chart 7. for the tabulated real time observations.

Chart 7. Impact Observations 300 meter Gun Target Line.



Observations made when Soldiers engaged the 150 meter or 300 meter targets are that the projectile dispersion density at the plywood backstop belongs equally to the 150m and 300m target and the projectile impacts to the 300 meter earthen berm primarily belong to the 150 meter target. There was little to no deviation to the vector of the projectiles hitting either target, and there were observations of hitting two targets with one projectile when the 150 and 300 meter target popped up, simultaneously.

During post Phase III analysis of this target location; projectile strikes were observed as hitting the 150m frontal berm, the 150m target, the 300m earthen berm, the 300m target, and the 300m plywood overshot barrier. There were no other observed projectile strikes at any other location observed during range walks and post Phase III analysis which indicate that the 150/ 300 meter gun target line, as is, protected the range floor from projectile strikes.

During the analysis of the 150m frontal berm geo-textile cover; multiple penetrations were observed. The exact count of these penetrations is masked because of the tearing in the fabric and what seem to be projectiles weaving in and out of the fabric toward the back stop. The visual indications in the fabric support the real time observations where 22 projectiles struck the frontal cover. Refer to Figure 22 for 150m frontal berm impact observations.

Figure 22. 150 Meter Stationary Infantry Target Gun Target Line

Observations of the 300m frontal berm earthen berm indicated numerous projectile impacts. The exact count of these penetrations is masked because of the tearing in the fabric and what seem to be projectiles weaving in and out of the fabric toward the back stop. The visual indications in the fabric support the real time observations where approximately 400 projectiles struck the 300m earthen berm. Refer to Figures 23, 24 and 25.

Figure 23. 300 Meter Stationary Infantry Target Gun Target Line with Overshot Barrier on 25 October 2010

Figure 24. 300 Meter Gun Target Line Earthen Berm and Cover on 25 October 2010

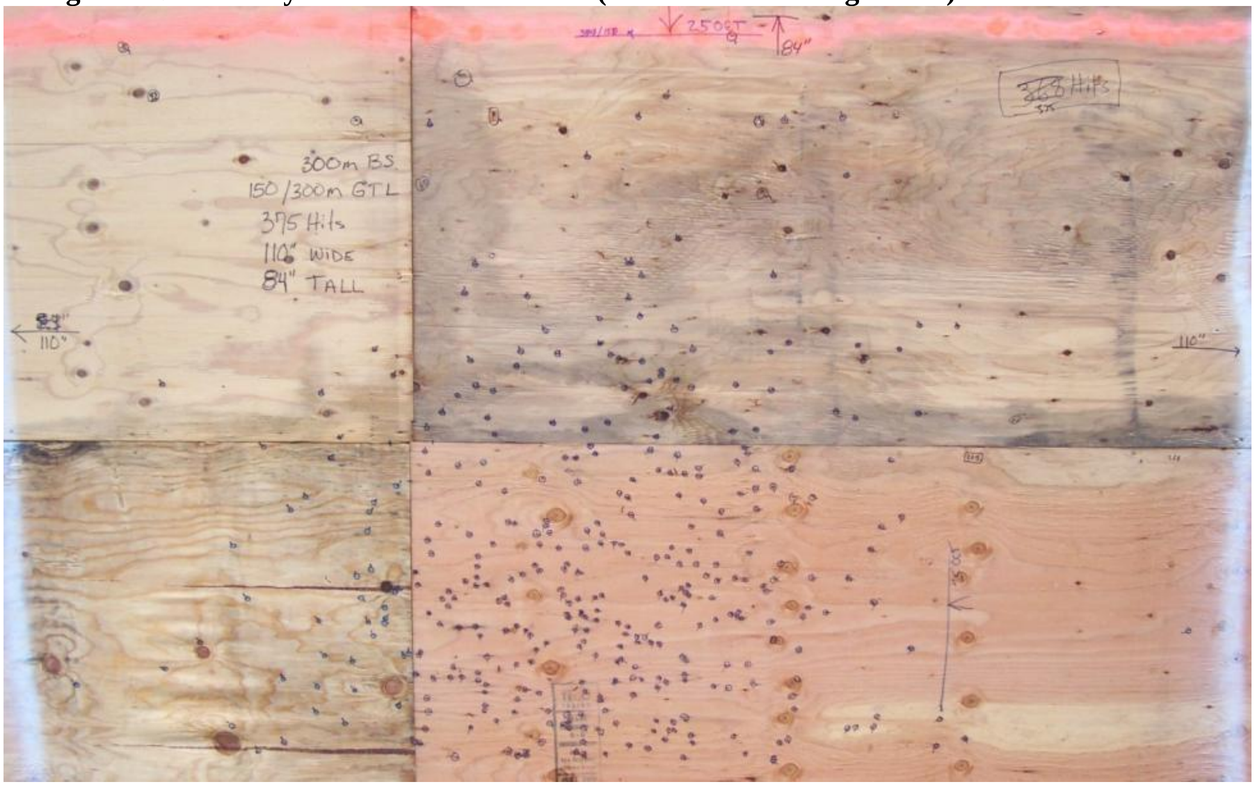
Note: fabric condition provided inconclusive count of projectile impacts.

Figure 25. 300 Meter Stationary Infantry Target Gun Target Line with Overshot Barrier on 26 October 2010

Note: Red Survey Flag indicate the projectile impact dispersion area.

Observations of the 300m overshot barrier indicated 375 definitive penetrations in the plywood. These penetrations were manually counted and highlights with black permanent marker to aid in visualization of projectile dispersion patterns. There are more than double the penetrations in the plywood then which were fired at the 300 meter target alone, indicating that the dispersion area of the 150 meter target is the largest of all gun target lines. Refer to Figure 22, 25 and26 for the distribution of projectiles to the 150/300m Gun Target Line.

Figure 26. 300m Plywood Overshot Barrier (150/300m Gun Target Line) on 28 October 2010



The dispersion area to the 250 meter Stationary Infantry Target is as follows:

a. The 150 meter frontal berm is 55" (w) x approximately 38" (h) vertical distance from the top of the SIT.
b. The 300 meter earthen berm was, approximately, 110" (w) x approximately 100" (h) (vertical drop, not hypotenuse).
c. The 300 meter Plywood over shot barrier is 110" (w) x 84" (h).

POST-PHASE III ANALYSIS

RECOVERY

Following the execution of the Line of Sight live fire exercise, the last aspect of the evaluation was projectile recovery. Projectile recovery from impact pockets measured the effectiveness of auxiliary berm emplacements and earthen berms to contain projectile fragmentation. The intent of this recovery was to separate intact projectiles and fragmentation from soils and rocks. A cumulative weight measurement in grams was taken to determine to overall recovery efficiency. As a note; the recovery method utilized during this event was a hasty technique to aid in the identification and verification of projectile impact locations. The data and information obtained from this live fire exercise will aid in the development of Operational, Maintenance and Monitoring Plans (OMMP) in order to enable the Massachusetts National Guard meet established environmental standards and best management practices to contain the maximum number of projectiles possible.

The Recovery Process:

Recovery of projectiles and fragmentation during the post-phase III analysis was executed by sifting soil media from identified projectile impact locations and extracting projectile fragments as they are observed. The recovery methodology utilized to separate projectile fragments was a two step screening process; screening to 1/4" diameter to remove larger fragmentation then screen to 1/8" diameter smaller fragmentation. After screening soils; the sieve was emptied on a separating table and personnel would visually identify and manually extract projectile residue.

During the execution of the post-phase III analysis, inclement weather created less than ideal conditions to visually identify and extract projectile fragments. In reaction to the poor ability to identify projectile residue; an additional step was integrated to aid in the identification process. Soil was collected in a secondary sieve constructed with lumber and a 1/8" diameter galvanized mesh where it was submerged in a bath which was constructed of plywood with a tarp liner and filled with 5 gallons of water. Refer to Figure 27 to view the recovery methodology.

Figure 27. Projectile Recovery Methodology

The Recovery Observations

The surface soil on the frontal berm locations and the fill in the DefenCell® back stop were obtained from the Unit Training Equipment Site which was top soil that was removed and stockpiled after the installation of the tactical training base at the 3600 Area on the Massachusetts Military Reservation. The soil characteristics on Sierra Range were determined during a sieve analysis conducted by Barbato Construction as Gravelly Sand. Refer to Appendix B for sieve results and refer to Figure 28.

Figure 28. Screened soils from Sierra Range.

During the recovery; it was observation was that the M855 projectile penetrated approximately 6 inches into the DefenCell® backstop at 50m (Figure 15.). This penetration corresponds approximately to a projectile velocity of 2,930 feet per second at 50m. Projectiles recovered from between 50-150 meters were highly fragmented making it difficult to distinguish from the soil media. Refer to figure ## and 29.

Figure 29. DefenCell® Backstop, 25 meters, 6 inch Projectile Penetration.

Projectile fragmentation at the 300m earthen berm was more easily identified. The projectiles, much of the time, had minimal fragmentation. Penetration depths were generally observed to be between 1-3 inches. This penetration depth corresponds to a projectile velocity of approximately 2,115 feet per second. Refer to Chart 8. The transfer of kinetic energy from the projectile to the surface soil seemed too dissipate across a wider surface area than in the DefenCell® backstop locations. The repose of the 300m earthen berm, compaction of the surface soil and projectile velocity are key factors directly influencing the amount of fragmentation and penetration. Refer to figures 30 and 31 for fragmentation observations.

Figure 30. Projectile impact at 300 meter earthen berm showing minimal fragmentation

Figure 31. Projectile impact at 300m earthen berm showing maximum fragmentation

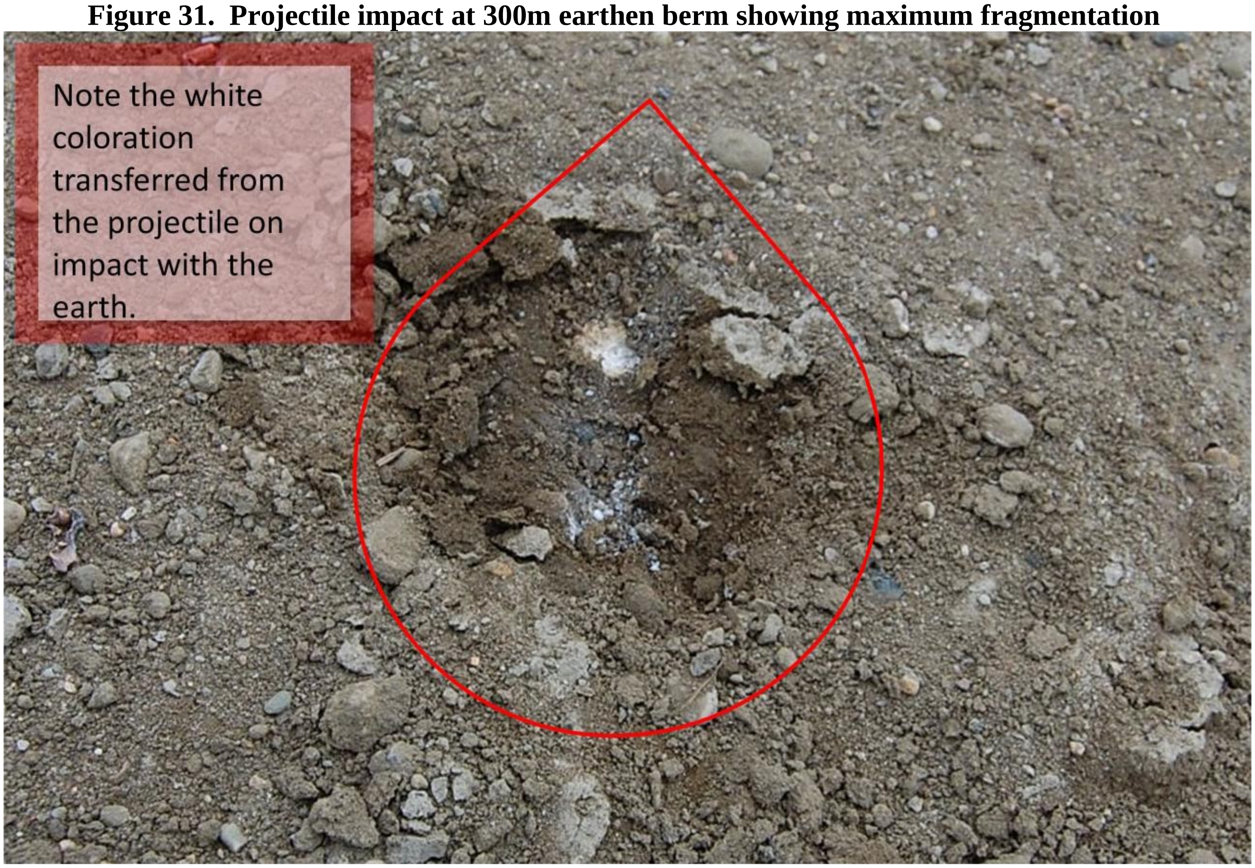
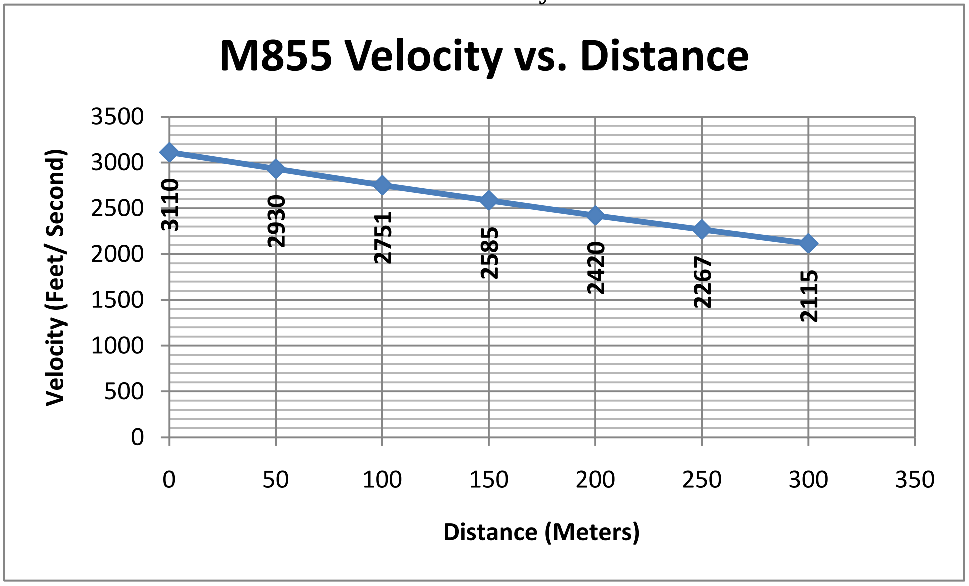


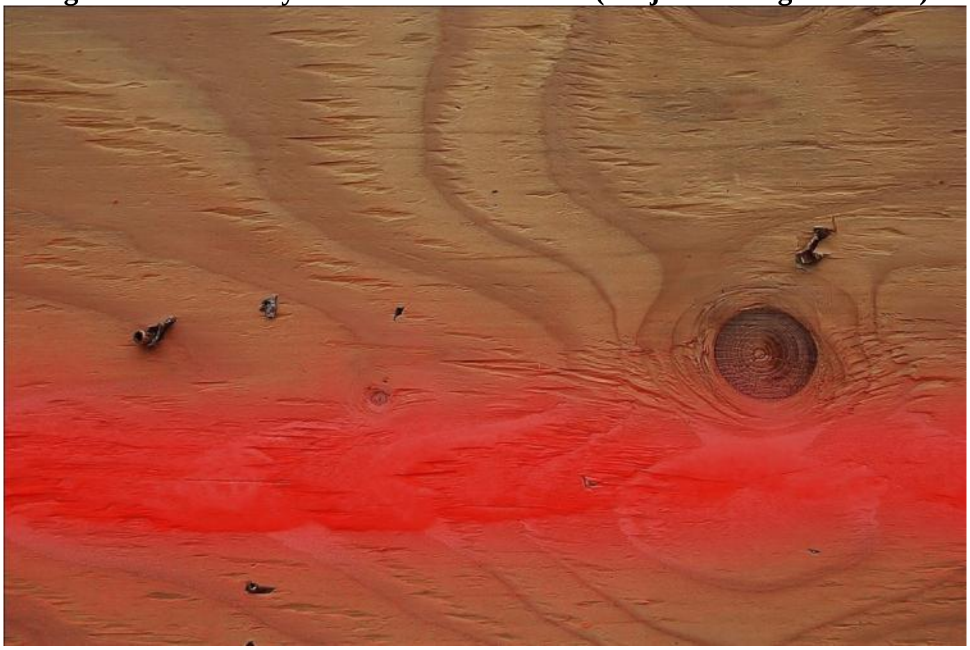
Chart 8. M855 Velocity vs. Distance



Note: M855 velocity information is based on Aberdeen Proving Ground Data obtained from http://www.ak-47.net/ammo/ss109.txt

Observations of the 300m Plywood Overshot Barrier indicate the non-capture of projectiles striking the 300m earthen berms and possibly other locations for specified gun target lines. Fragmentation appeared to form a belt higher on the plywood overshot barrier but the dispersion in the plywood was not limited to upper locations. The 300m plywood overshot barrier appeared to function as both a primary and secondary containment strategy. Additionally, there was fragmentation located on the surface of the soil throughout the 300m earthen berm dispersion area. This indicates a poor ability to capture projectiles on the first point of impact at the 300m earthen berm. Refer to Figure 32.

Figure 32. 300m Plywood Overshot Barrier (Projectile Fragmentation)



Note: The Orange spray paint highlights the 7' high mark from the base of the 300m SIT.

Observations of the 50m Alpha, Bravo and 100m DefenCell® back stop locations indicate that projectile impacts into the geo-textile auxiliary berms were contained. There are no exit penetrations in the berm and though excavations of the interior soil media indicate penetration depths of approximately 6 inches; therefore the projectiles striking the DefenCell® are definitively contained. Additionally, as per the project note, projectiles passing through the 300m back stop tell tale barrier were determined as accounted for and contained. Of the 2120 projectile fired; a sum of 1443 (68.1%) projectiles were immediately contained in either DefenCell® auxiliary berms or the 300m plywood overshot barrier which would result in rapid and expeditious recovery. The remaining projectiles are located at earthen berms or other locations throughout lane six which require more deliberate and time consuming validation. Through the recovery process, 384.10g (4.5%) of projectile residue was recovered from earthen berm locations to validate the containment of projectiles at their point of impact; leaving 27.4% of projectiles fired to be verified of their final disposition. Refer to Table 9.

Table 9. Projectile Containment Observations.

PROJECTILE CONTAINMENT OBSERVATIONS		
TOTAL FIRED (#)	2120	
TOTAL WEIGHT (g)	8504.17	
DEFINITIVE CONTAINMENT (#)[1]	5788.46	68.1%
DefenCell® & 300m Overshot Barrier Impacts (#)	1443	
VERIFIED CONTAINMENT (g)[2]	384.10	4.5%
UNVERIFIED CONTAINMENT (g)[3]	2261.88	27.4%
NOTE: 1) Sum of rounds fired into DefenCell berm emplacements and the 300 meter plywood telltale overshot barrier. (50 meter A (189 rds), 50 meter B (119 rds), 100 meter (305 rds), 200 meter (250 rds), 250 meter (205 rds) and the 150/300 meter (375). 2) Sum of projectile residue recovered from earthen berm locations which were verified to be contained at the projectile point of impact. 3) Sum of projectile residue remaining to be verified as contained.		

The Sierra Range design in accordance with project note specifications annotated that the soil needed to be screen to ½” minus. Observations of the range design show that Stationary Infantry Target frontal berms have slopes that are conducive to ricochets. Additionally, the 300m earthen berm is highly compacted which attributes to a low penetration depth in the 300m berm and possibly projectile ricochets. Future designs should incorporate three factors; 1) increase the slope of frontal berms, 2) Screen soil media to 1/8” minus and 3) Reduce the level of compaction to soil media covering the frontal berms.

The Recovery Results

The recovery process utilized to remove fragmentation from frontal and earthen berms could not recover all fragmentation due to three factors: 1) the methodology to find and extract fragmentation is based on the ability to visually identify projectile residue; 2) the screening methodology only recovers fragmentation that is greater than 1/8” in diameter, and 3) the soil media was a less than desirable material (i.e. ballistically sound substrate) which was course, insufficiently sloped and compacted resulting in non-containment. However, the results from the recovery procedures utilized demonstrate a baseline metric to develop a primary Operational, Maintenance and Monitoring Plan (OMMP) and indicates secondary and tertiary OMMP recovery strategies or better ballistic materials should be implemented to meet recovery efficiencies.

Projectile recovery efficiency is based on the number of projectiles fired (in grams) versus the weight (in grams) of projectile’s recovered in the form of lead and copper fragmentation and steel penetrators. The recovered projectile residue was separated by gun target line and additionally separated by projectile impact location in order to differentiate the dispersion and distribution across lane six as a whole.

Fragmentation extracted from the 300m plywood overshot barrier was added to the 300m berm Ziploc bags. The fragmentation contained in Ziploc bags were retained as a visual reference. The weight in grams was measured utilizing an Ohaus Analytical Balance with a precision of a 1000th of a gram. Refer to the Table 10 for the projectile recovery breakdown.

Table 10. Projectile Recovery Summary by Gun Target Line.

GUN TARGET LINE	RECOVERED WEIGHT PER PROJECTILE IMPACT LOCATION (g)			TOTAL RECOVERED WEIGHT (g)
50A	50A Frontal Berm	50A DefenCell®		**263.81g**
	0.66g	**263.15g**		
50B	50B Frontal Berm	50B DefenCell®		**126.55g**
	0.64g	**125.91g**		
100	100M Frontal Berm	100M DefenCell®	300M Earthen Berm	**403.29g**
	2.56g	**349.27g**	**51.46g**	
150	150M Frontal Berm			**2.34g**
	2.34			
200	200M Frontal Berm	300M Earthen Berm		**57.52g**
	3.02g	**54.5g**		
250	175M Frontal Berm	250M Frontal Berm	300M Earthen Berm	**49.49g**
	15.36g	**31.67g**	**2.46g**	
300	300M Earthen Berm			**219.43g**
	219.43g			
			TOTAL RECOVERED WEIGHT	**1122.43g**

The M855 NATO round has a 62 grain projectile consisting primarily of lead, copper and steel which converts to a weight of 4.017 grams. If multiplied by 2120 projectiles, the number of projectiles expended, it would equate to 8,502.17 grams.

<u>Individual Projectile Weight Conversion:</u> $M855 = \frac{62 grains}{M855} \times \frac{.0647 grams}{grain} = 4.0114 grams$

<u>Sum of Projectiles Fired:</u> $2{,}120 \times \frac{62 grains}{M855} \times \frac{.0647 grams}{grain} = 8{,}504.17 grams$

The projectile weight was verified utilizing a control projectile which was measured to verify the conversion data. The control projectile was measured at the same time as the projectile residue utilizing the Ohaus Analytical Balance. The control projectile was measured at 4.05 grams verifying the weight; but, due to inability to measure all the projectiles; the historically based 4.0114 grams was utilized for all calculations.

The unadjusted overall recovery efficiency was **13.2%**. When adjusted to take the unrecoverable projectiles into consideration, the recovery efficiency was **23.1%.** The unrecoverable weight was produced by counting the projectile penetrations (910 penetrations) in the 300 meter plywood overshot barrier and deducting that number from total number of projectiles fired during the live fire exercise in accordance with the project note. Refer to Table 11 and the equations below.

Table 11. Recovery Efficiency.

PROJECTILE RECOVERY BREAKDOWN		
TOTAL FIRED (#)	2120	
WEIGHT (g)	8504.17	
PASSED THROUGH 300M OVERSHOT BARRIER (#)[1]	910	
WEIGHT (g)	3650.38	42.9%
RECOVERED WEIGHT >1/8" (g)[2]	1122.43	13.2%
UNRECOVERED (g)[3]	3731.36	43.9%
ADJUSTED PROJECTILE RECOVERY[4]		
ADJUSTED RECOVERED WEIGHT (g)	1122.43	23.1%
ADJUSTED UNRECOVERED (g)	3731.36	76.9%

NOTE:
1) Sum of projectile penetrations in the 300 meter plywood telltale overshot barrier. (100 meter (80 rds), 200 meter (250 rds), 250 meter (205 rds) and 150/300 meter (375 rds)).
2) Sum of projectile residue recovered at all locations.
3) Weight remaining to be recovered (total fired - plywood backstop penetrations - recovered projectile residue = remaining weight).
4) The adjusted projectile recovery rate is the deduction of the projectiles which passed through the 300m Plywood overshot barrier to account for the recoverable projectiles, only.

Overall Recovery Efficiency: $\frac{1{,}122.43\,grams(recovered)}{8{,}504.17\,grams(total)} \times 100 = \boxed{13.2\%}$

Unrecoverable Weight Conversion: $910\,M855 \times \frac{62\,grains}{M855} \times \frac{.0647\,grams}{grain} = \boxed{3{,}650.37\,grams}$

Adjusted Weight Calculation:

$$8{,}504.17\,grams(total) - 3{,}650.37\,grams(unrecoverable) = \boxed{4{,}853.79\,grams(recoverable)}$$

Adjusted Recovery Efficiency: $\frac{1122.43\,g(recovered)}{4{,}853.79\,g(recoverable)} \times 100 = \boxed{23.1\%}$

The individual adjusted recovery rates for each gun target line ranged from 11.8% to 34.3%. These results from the recovery operations show the abilities in the current recovery methodology and identify containment capabilities of the current earthen structures utilized for this event.

Key observations of the recovery methodology limitations are in reference to the DefenCell® auxiliary berms. Soil media in the earthen berm was removed and screened in accordance with the identified recovery process. The 50m Alpha DefenCell® contained 189 projectile penetrations with no observable exit holes; leading to the assumption that projectiles are contained at their respective points of impact. The recovery process only recovered 263.81 grams of projectile residue out of 758.15 grams identified as contained which is a 34.7% recovery efficiency. The 50m Alpha gun target line represents the best recovery efficiency of all the gun target lines.

Table 12 describes the individual recovery rates for each GTL. As a note the 150 meter and 300 meter recovery data was compiled into a composite data table.

Table 12. Individual Containment & Recovery Rates per Gun Target Line

50 meter Alpha GTL		
NUMBER OF PROJECTILES FIRED	*192*	
WEIGHT (g)	770.19	
PROJECTILE CONTAINMENT		
DEFINITIVE CONTAINMENT (g)	758.15	98.4%
DefenCell® Impacts (#)	*189*	
VERIFIED CONTAINMENT (g)	0.66	0.1%
50 meter Alpha Frontal Berm (g)	*0.66*	
UNVERIFIED CONTAINMENT(g)	11.37	1.5%
PROJECTILE RECOVERY		
300 METER OVERSHOT BARRIER (g)	NONE	
TOTAL RECOVERED WEIGHTS >1/8" (g)	263.81	34.3%
50 meter Alpha Frontal Berm (g)	*0.66*	
50 meter Alpha Back Stop (g)	*263.15*	
UNRECOVERED (g)	506.38	65.7%
ADJUSTED RECOVERED WEIGHT (g)	*263.81*	*34.3%*
ADJUSTED UNRECOVERED WEIGHT (g)	*506.38*	*65.7%*

50 meter Bravo GTL		
NUMBER OF PROJECTILES FIRED	*126*	
WEIGHT (g)	505.44	
PROJECTILE CONTAINMENT		
DEFINITIVE CONTAINMENT (g)	477.36	94.4%
DefenCell® Impacts (#)	*119*	
VERIFIED CONTAINMENT	3.02	0.6%
50 meter Bravo Frontal Berm (g)	*3.02*	
UNVERIFIED CONTAINMENT(g)	25.06	5.0%
PROJECTILE RECOVERY		
300 METER OVERSHOT BARRIER (g)	NONE	
TOTAL RECOVERED WEIGHT >1/8" (g)	126.55	25.0%
50 meter Bravo Frontal Berm (g)	*3.02*	
50 meter Bravo Back Stop (g)	*125.91*	
UNRECOVERED (g)	378.89	75.0%
ADJUSTED RECOVERED WEIGHT (g)	*126.55*	*25.0%*
ADJUSTED UNRECOVERED WEIGHT (g)	*378.89*	*75.0%*

100 meter GTL		
NUMBER OF PROJECTILES FIRED	*424*	
WEIGHT (g)	1700.83	
PROJECTILE CONTAINMENT		
DEFINITIVE CONTAINMENT (g)	1223.48	71.9%
DefenCell 300m Overshot Barrier Impacts (#)	*305*	
VERIFIED CONTAINMENT	54.02	3.2%
100 meter Frontal Berm (g)	*2.56*	
300 meter Earthen Berm (g)	*51.46*	
UNVERIFIED CONTAINMENT(g)	423.34	24.9%
PROJECTILE RECOVERY		
300 METER OVERSHOT BARRIER (g)	320.91	18.9%
TOTAL RECOVERED WEIGHTS >1/8" (g)	403.29	23.7%
100 meter Frontal Berm (g)	*2.56*	
100 meter Back Stop (g)	*349.27*	
200 meter Frontal Berm (g)	*0.00*	
300 meter Earthen Berm (g)	*51.46*	
UNRECOVERED (g)	976.63	57.4%
ADJUSTED RECOVERED WEIGHT (g)	*403.29*	*29.2%*
ADJUSTED UNRECOVERED WEIGHT (g)	*976.63*	*70.8%*

200 meter GTL		
NUMBER OF PROJECTILES FIRED	*371*	
WEIGHT (g)	1488.23	
PROJECTILE CONTAINMENT		
DEFINITIVE CONTAINMENT (g)	1002.85	67.4%
300m Overshot Barrier Impacts (#)	*250*	
VERIFIED CONTAINMENT	57.52	3.9%
200 meter Frontal Berm (g)	3.02	
300 meter Earthen Berm (g)	54.5	
UNVERIFIED CONTAINMENT(g)	427.86	28.7%
PROJECTILE RECOVERY		
300 METER OVERSHOT BARRIER (g)	1002.85	67.4%
TOTAL RECOVERED WEIGHTS >1/8" (g)	57.52	3.9%
200 meter Frontal Berm (g)	3.02	
300 meter Earthen Berm (g)	54.50	
UNRECOVERED (g)	427.86	28.7%
ADJUSTED RECOVERED WEIGHT (g)	*57.52*	*11.9%*
ADJUSTED UNRECOVERED WEIGHT (g)	*427.86*	*88.1%*

250 meter GLT		
NUMBER OF PROJECTILES FIRED	*265*	
WEIGHT (g)	1063.02	
PROJECTILE CONTAINMENT		
DEFINITIVE CONTAINMENT (g)	822.34	77.4%
300m Overshot Barrier Impacts (#)	*205*	
VERIFIED CONTAINMENT (g)	49.49	4.7%
175 meter Frontal Berm (g)	*15.36*	
250 meter Frontal Berm (g)	*31.67*	
300 meter Earthen Berm (g)	*2.46*	
UNVERIFIED CONTAINMENT(g)	191.19	18.0%
PROJECTILE RECOVERY		
300 METER OVERSHOT BARRIER (g)	822.34	77.4%
175 meter Frontal Berm (g)	*15.36*	
250 meter Frontal Berm (g)	*31.67*	
300 meter Earthen Berm (g)	*2.46*	
TOTAL RECOVERED WEIGHTS >1/8" (g)	49.49	4.7%
UNRECOVERED (g)	191.19	18.0%
ADJUSTED RECOVERED WEIGHT (g)	*49.49*	*20.6%*
ADJUSTED UNRECOVERED WEIGHT (g)	*191.19*	*79.4%*

300/150 meter GLT Composite		
NUMBER OF PROJECTILES FIRED	*742*	
150 meter Gun Target Line	*583*	
300 meter Gun Target Line	*159*	
WEIGHT (g)	2976.46	
PROJECTILE CONTAINMENT		
DEFINITIVE CONTAINMENT (g)	1504.28	50.5%
300m Overshot Barrier Impacts (#)	*375*	
VERIFIED CONTAINMENT (g)	220.09	7.4%
150 meter Frontal Berm (g)	*0.66*	
300 meter Earthen Berm (g)	*219.43*	
UNVERIFIED CONTAINMENT(g)	1252.09	42.1%
PROJECTILE RECOVERY		
300 METER OVERSHOT BARRIER (g)	1504.28	50.5%
TOTAL RECOVERED WEIGHTS >1/8" (g)	221.77	7.5%
150 meter Frontal Berm (g)	*2.34*	
300 meter Earthen Berm	*219.43*	
UNRECOVERED (g)	1250.41	42.0%
ADJUSTED RECOVERED WEIGHT (g)	*221.77*	*15.1%*
ADJUSTED UNRECOVERED WEIGHT (g)	*1250.41*	*84.9%*

General interpretations of this data should focus on the recovery strategy as the limiting factor. The projectile residue was contain in a relatively dense location and easily accessible. Observations of the recovered projectile residue indicate a high level of fragmentation. The recovery process removed residue 1/8" or greater; leaving the remaining residue with the screen soil media.

Key observations of frontal berms identify projectile impacts locations which can be validated by real time observations. Indications on the frontal berms show projectile containment toward the top of the earthen berms to be relatively low and projectile strikes lower on the frontal berms have more indications of frontal berm containment. Low recovery rates at frontal berm locations indicate both an inability to recovery projectiles with the current screening methodology and compounded by an inability to contain projectiles on the first point of impact due to SIT frontal berm slope and poor soil structure at recovery locations.

LESSONS LEARNED

Observations made during and after the execution of the live fire exercise indicate that projectile strikes to targets have no significant effect to projectile trajectory from distances up to 300m. Patterns of projectile strikes are uniform from varied distances illustrating that the M855 projectile continues on a generally strait flight path post target strike leaving impact indications at the 300m earthen berm or plywood overshot barrier locations.

DefenCell® auxiliary berm emplacements were the modular earthen structure utilized during this event to restrict projectile impacts to range floor locations. The size and emplacement of the 50m Alpha, 50m Bravo and 100m DefenCell® did not negatively impact the shooter's ability to identify and engage stationary infantry targets during the modified record fire table.

The post-phase III analysis illustrated the current capabilities of the range to contain projectiles for hasty and deliberate recovery methodologies and range containment. The range, as constructed, verifiably contained 72.6% of projectiles fired during the line of sight analysis, but the overall recovery efficiency was 13.2%.

The structures utilized during this event to contain projectiles were DefenCell® auxiliary berms, frontal berms covered with 6 inches of screen soil media sifted to ½ minus, 300m earthen berm constructed flush with each 300m stationary infantry target covered with 6 inches of screen soil media sifted to ½ minus and the plywood overshot barrier. The DefenCells® functioned very well to contain projectiles impacting those locations; however, the best recovery efficiency of projectiles from internal soil media was only 34%. The 300m earthen berm and SIT frontal berm had limited capabilities to contain projectiles on their first point of impact due to three key factors: 1) the angle of repose of frontal berms were conductive to non-containment; 2) the soil media was highly compacted resulting in shallow projectile penetration depths; and 3) the soil was screen to 1/2" minus intensified fragmentation of projectiles limiting recovery efforts.

The 100m SIT location had multiple projectile strikes to the top of the berm (Refer to Figure 10). As a result a plywood extension, similar to the 300 meter plywood tell tale barrier with a sandbag barrier, was emplaced to simulate a larger DefenCell® back stop (Refer to figure 11). As a result, all auxiliary berms utilized throughout Sierra Range should be evaluated for this affect and adjusted in height accordingly.

Real time visual observations cross referenced with post phase III impact analysis indicate that projectile strikes on frontal berms were not contained at the initial point of impact; but, retained in DefenCells® or berm locations. This observation was uniform for all frontal berm impacts.

The 300 meter earthen structure and overshot barrier should be designed in a manner sufficient enough contain small arms projectiles and doesn't need to be constructed flush with the front of each 300 meter SIT location. The containment success in the plywood overshot barrier, a notional earthen structure, should be utilized to maximize the capture projectiles on the first point of impact.

The deepest penetration of an M855 round in a vertical back stop was approximately 6 inches at the 50 meter and 100 meter targets, which suggests that anything significantly larger than that would not be needed. Note: 6 inches of penetration is based on the current soil characteristics which should be revisited pending any ballistic material changes and describes the length of penetration; not the thickness of top soil.

The angle of repose or slope on stationary infantry target frontal berms and the 300 meter earthen berm should be increased to result in projectile containment on the first point of impact and reduce projectile ricochets.

Soil native to the Massachusetts Military Reservation is composed of course sand or gravel resulting in moderate projectile fragmentation. Material selection for placement in projectile impact locations and use within back stop construction should be based on the ability to reduce the velocity of projectiles without major fragmentation and have chemical properties that reduce lead mobility.

CONCLUSIONS

This report has assessed the terminal ballistics of the projectiles fired in accordance with the modified record fire qualification table at Camp Edwards on Sierra Range. The principle conclusion is that the Line of Sight Analysis process was able to predict and identify projectile impact distribution and dispersion locations and determine locations to best emplace BMP structures to mitigate strikes to the range floor while not obstructing the view of shooters engaging targets.

This relatively small scale live fire event produced definitive distributions of projectile impact locations. Each gun target line had clearly identifiable dense projectile impact pockets in both earthen berms and the plywood overshot barriers. Shooter's deliberate identification and engagement of fixed stationary infantry targets from a fixed firing point produced a repeatable pattern of projectile strikes over the course of two days and through two separate qualification tables. These pockets were in locations anticipated by Phases I and II of the Line of Sight Analysis.

The Massachusetts Army National Guard has demonstrated the ability to identify and control projectile dispersion and distribution areas from the firing point to the projectile point of impact at earthen structures. Through the execution of the live fire event the MAARNG has developed lessons learned of the range capabilities and the limitations of the current containment structures. The LOS aided in identifying the path forward for the MAARNG to develop and propose appropriate Best Management Procedures in support of an Operational, Maintenance and Monitoring Plan specifically designed for Sierra Range.

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APPENDIX A

Environmental and Readiness Center Camp Edwards, Massachusetts	PROJECT NOTE
Confirmation of ☐ ☐ ☐	Date Held: Not applicable Location: Not applicable Date Issued: 16 September 2010 Recorded By
Subject **SIERRA RANGE LIVE (TEST) FIRE LINE OF SITE VALIDATION**	Issued By MAARNG

Item		Action Required By
1.0	**INTRODUCTION** Pursuant to the U.S. Environmental Protection Agency's (EPA) Administrative Order SDWA I-97-1-030 ("AO2") issued in 1997 the MAARNG suspended small arms range firing on Camp Edwards. This order was issued based on findings related to potential environmental impact to groundwater. In May 1998, the Massachusetts National Guard in coordination with the Commonwealth suspended all live fire small arms training and the construction of new small arms ranges out of similar concerns for protection of the environment. Camp Edwards does not currently have an approved automated 300m pop-up range Modified Record Fire (MRF) required to qualify Soldiers in marksmanship proficiency. The existing state of the current MRF Range, Sierra Range, on Camp Edwards will not receive EPA, Environmental Management Commission (EMC) approval or MassDEP support to return to live fire without the implementation of approved BMPs to operate and maintain the range and to provide for pollution prevention. Sierra range was upgraded during FY2006 to a 10 lane, 90 target, MRF, FCC 17806 Range. This range consists of 90 pop up targets at various distances, ranging from 50 to 300 meters as opposed to a row of targets at a fixed distance such as the 25 meter ranges Juliet, Kilo and Tango. As constructed the range is uneven, has patchy vegetation and a rocky range floor. The individual target locations have acceptable vegetation but have large amounts of rocks in the surface soils. In order to return the range to active status, the requirements of AO2 and Chapter 47 the Acts of 2002 associated Environmental Performance Standards requires a comprehensive Best Management Practice/ Pollution Prevention (BMP/P2) plan and review of available P2 technologies be completed for Sierra Range. The Range Performance Standard in the EPS requires "Range management at each range shall include to the maximum extent practicable metal recovery and recycling, prevention of fragmentation and ricochets, and prevention of sub-surface percolation of residue associated with the range operations." Development of BMPs for this complex range requires a line of sight analysis to determine the deposition of bullets. The Line Of Sight (LOS) analysis consists of three phases; Phase 1 was computer-based analysis, Phase 2 was a laser-based analysis, and Phase 3 will be a live fire demonstration (up to 5,000 rounds). The MANG is proposing to conduct phase three of the LOS analysis during Fall 2010.	

2.0 OBJECTIVE

The objective of the proposed test firing is to conduct a comprehensive live fire on Sierra Range to validate phases 1 and 2 of the LOS. Specifically, the test fire will demonstrate that BMP structures can be designed so as not to obstruct the line of sight of the soldier. The live fire is also being conducted to demonstrate that projectiles can be contained within BMP structures on the range and will determine potential effectiveness of projectile recovery. The information gathered will aid in developing base line BMP(s), the design of Sierra Range, and the final OMMP plan for this range.

3.0 SITE DESCRIPTION

Sierra Range is located at Camp Edwards on Cape Cod, an environmentally sensitive region, and contains threatened and endangered wildlife species and culturally sensitive areas. The Camp sits on top of the Sagamore lens of Cape Cod's aquifer, which is 30–76 m thick and supplies water to off-site as well as on-site populations. The aquifer is a sole source of drinking water for Cape Cod. The northern 15,000 acres of Camp Edwards, the Upper Cape Water Supply Reserve/Camp Edwards Training Area, are located within a recharge area of the aquifer. The nearest drinking water supply wells, WS-2 and WS-3 for the Upper Cape Water Cooperative, are approximately 1,524 m northeast of Sierra Range. Groundwater flows to the north and Sierra Range is hydraulically up gradient of these public water supply wells. The potential receptors of water supplied by these public wells include the populations of the Upper Cape town's of Bourne, Falmouth, Mashpee, and Sandwich, as well as the town of Barnstable, the Barnstable County Correctional Facility, and the Massachusetts Military Reservation.

Sierra Range covers approximately 16 acres south of Gibbs Road at Camp Edwards. In general it has flat topography with an elevation change of approximately 6 ft across the 300 m long range floor, with a slope from the firing line toward the back of the range (northeast to southwest). The range is surrounded by trees on the northeast, northwest, and southeast sides of the range floor. On the northwest and southeast sides of the range floor, the tree line is within 20 ft of the elevated firing line and gradually extends away from the range floor moving downrange. This is due to the previous configuration of the Sierra East and Sierra West Ranges in a V-shaped pattern emanating from the firing lines. On the southwest side (downrange boundary of the range, beyond the 300-m targets), trees are located in the four center lanes only. The other lanes on Sierra Range have no trees between 300 and 800 m.

Distinct features of Sierra Range include an access road, a parking lot, a range tower, a range shed, a covered mess area, covered bleachers, the range floor, and soil berms that protect the 90 Stationary Infantry Targets (SIT) and the old SIT soil berms out to 800 m.

The current range has 10 firing lanes and 90 automated pop-up targets arranged over approximately a 300 × 200-m area. The firing line is about 6 ft above the range floor. There are nine stationary, pop-up targets in each firing lane. The targets are located at 50 m, 75 m, 100 m, 150 m, 175 m, 200 m, 250 m, and 300 m. There are two targets at the 50 m distance and one each at the other distances.

4.0 SITE PREPARATION

The site preparation described below is primarily intended for the live fire LOS validation. Final site preparation will be specified in the approved design and may include some of the components described below.

Sierra range is a live fire 300m 10 lane record qualification range. It has recently (FY2006) been upgraded to a 10 lane, 90 target MRF, FCC 17806 Range. As constructed the range is uneven, has patchy vegetation, and a rocky range floor. In order to validate the line of sight analysis a live fire demonstration (up to 5000 rounds) needs to be conducted using one lane. The MAARNG proposes to mainly use lane six (from left to right) to conduct the larger live fire.

Beginning at the 300 meter line, the area between the SIT berms for lanes five and six and six and seven would be in-filled with clean fill to provide a base for a secondary berm/ structure and to capture projectiles which travel lower and between the existing SIT berms. The exposed face of the end berm will be covered with soil screened to ½" minus and to a minimum of 6" deep. A backstop tell tale will be constructed on top of the end berm and will be approximately 7 feet in height from the base of the SIT and approximately 130 feet long. This backstop tell tale will be constructed of plywood for this live fire validation.

Three backstop berms will be constructed. At the 100 meter SIT a backstop berm 60"x36" would be constructed and at the 50 meter SITs two backstop berms would be constructed each being 60"x45". All backstop berms would be constructed off center of/and approximately 6 feet behind the SITs to accommodate for the angle of fire from the firing point through the target, known as the Gun Target Line (GTL). This will increase the area of the backstop berm exposed to the dispersion of projectiles while decreasing the LOS impacts on down range target locations as determined by the LOS analysis. These backstop berms will be constructed of a screened earth/sand filled geotextile revetment type material (i.e. DefenCell ®). All SIT berm soil would be screened to ½" minus to a minimum of 6" deep with one 50 meter SIT screened to 18" as a round penetration prove out. As necessary, additional measures may be added to aid in confirming projectile deposition such as the addition of Tyvek® paper as a tell tale marker.

At anticipated projectile impact areas, as predicted by Phase 1and 2 of the LOS analysis, which are outside of the scope of the live fire site preparation delineated above (i.e. lane 6 100m target is expected to have target strikes through which projectiles continue down range to the lane 7 250m frontal berm) will have the existing vegetation closely mowed to allow the temporary installation of a tell tale marker such as Tyvek® paper or other fabric like material. This material will be used to capture indications of projectile impacts and the possible dispersion area size at each location.

In the event that the new M855A1 LFS copper ammunition is available for use during this test fire event, it will be necessary for Soldiers to "zero" their individual weapons prior to shooting on Sierra Range. The process to zero a weapon requires Soldiers to fire on a 25 meter range, such as Tango Range which is equipped with a STAPP® bullet capture system. Because of the designed improvements to the battlefield performance of the M855A1 LFS it is unknown what effects if any the new round may have on the STAPP system (i.e. top cover, penetration of bottom liner, etc.). The MANG is proposing to construct a demonstration STAPP® system to the east of the existing STAPP® on the current earth berm for the purposes of zeroing weapons if using the new ammunition.

The proposed demonstration STAPP® system will be constructed of similar materials and specifications as the existing system (i.e. synthetic lumber frame, bottom liner material, granulated rubber fill, and a rubber top cover). The approximate size of the demonstration STAPP® system is to be 4' wide by 8' long.

5.0 TEST FIRE EXECUTION

As stated in Item 2.0 Objective, the goal of this live fire event is to validate phase 1 and 2 of the LOS analysis to date. This phase of the line of sight analysis will demonstrate the effects, if any, that projectile strikes on targets had on the final dispersion of the projectile down range, whether the backstop berms function to contain projectiles and whether any projectiles strike the range floor.

A properly trained and designated range Officer In Charge (OIC) will be responsible to make all safety related decisions and for the safe conduct of the live fire test. All participants on the range will observe the commands from the range OIC.

All test firing will be conducted in accordance with the operation of a Modified Record Fire Range for Record Fire (Qualification), IAW Army FM 3-22.9 Rifle Marksmanship. Each shooter would fire 40 rounds per iteration with the expected round distribution per target exposure per iteration and for the overall test according to table 1.

Table 1. MRF Range Round Distribution per Target.

Target (m)	Rounds / Target	Total / Target
50	3	375
50	3	375
75	N/A	N/A
100	8	1000
150	11	1375
175	N/A	N/A
200	7	875
250	5	625
300	3	375
Total	**40**	**5000**

A computer based application will be used to run the wireless target lifters following the required timed and exposure sequence of the Record Fire Scorecard, DA Form 3595-R. Each firer will complete three Tables; Table 1, 20 rounds prone supported; Table 2, 10 rounds prone unsupported and Table 3, 10 rounds kneeling. The software used is capable of tracking the number of target exposures and number of target strikes (hits).

As each Soldier fires, observers will be used to spot projectile impacts on SIT berm faces (low miss) and down range berms (left/right or high miss). If soil conditions don't allow observation of projectile impacts, then a tell tale marker will be used to document projectile impacts. This data will be recorded on individual data sheets to validate the observed projectile impacts against the anticipated projectile impact pockets as determined through Phase 1 and 2 of the LOS analysis.

During the test fire event, it may be required to periodically halt the firing event between shooters for safety issues, to evaluate and adjust the data capture process, to evaluate the projectile dispersion down range, or for other productive reasons. Natural pauses during the test fire such as after first 200 rounds (5 firers) or 400 rounds (10 firers) or at other times may be inserted during the test fire to ensure the quality and effectiveness of the live fire event.

In the event that substantial deviation(s) from the anticipated projectile performance, as determined by Phase 1 and 2 LOS analysis, are observed it may be necessary to halt, suspend, or to reschedule the remainder of the test fire event until acceptable accommodation(s) for the deviation(s) can be agreed to, designed and or modified and implemented. Further, there is no requirement to fire all 5,000 rounds of ammunition if the observed projectile performance remains consistent throughout the test fire and all parties agree that the observed live fire data supports the conclusions of the Phase 1 and 2 LOS analysis.

For the test fire, the ammunition to be used would be M855 5.56 lead ball ammunition or preferably, if available, M855A1 lead free slug 5.56 ball ammunition.

If approved, test firing would be scheduled for Fall 2010.

6.0 EVALUATION OF RESULTS

Results of the LOS validation live fire would be evaluated to determine the following:

1) LOS Analysis
    a. did the projectiles proceed down range (flight path) as predicted in the LOS phases 1 and 2
    b. did secondary berms function to contain projectiles
    c. were there range floor projectile impacts or overshot
    d. were targets obscured by backstop berms
2) Measure the marksmanship rates of the test fire compared to the anticipated Probability of Hit (PH) from FM 3-22.9
3) Recover projectiles from impact pockets to measure backstop berm containment (environmental) effectiveness

Before phase 3 is initiated, the MANG will develop a composite projectile disposition graphic which will depict anticipated projectile impact areas for lane 6 for each SIT target. Post firing, the observed results will be compiled into the composite projectile disposition graphic for aiding in determining LOS validation. The MANG will recover the rounds from each impact area and will keep record of location and will produce a cumulative report on the number of rounds recovered from the test fire by weight. One of the goals of this effort is to determine the overall projectile impact area dimensions in each location. This will be measured by visual observation of the impact area and use of an "all" metals detector to delineate the boundary for each impact area. During firing, observers will indicate impacts on the range floor, if any, using the observation form. Post firing, a range walk will be conducted to look for impacts on the range floor.

Feedback from the firers will be used to determine if there were significant impacts to the shooter's line of sight caused by BMP structures on the range.

The utilization of the automated software for the range will keep track of the number of target exposures versus the number of target strikes. This data will be used to determine overall marksmanship rates during the test fire, compared to anticipated marksmanship proficiencies per FM 3.22.9 (probability of hits).

Projectile recovery from impact areas will be accomplished by screening the soils using various methods with the intent of separating intact projectiles and fragments from soils and rocks. A cumulative weight measurement will be taken to determine the overall recovery efficiencies. Bullets passing through the 300m backstop tell tale will be counted and deducted from the mass weight recovered but as accounted for and contained. The projectiles impacting the backstop berms at the 100 and 50m berms will be recovered and added to the mass weight and accounted for as contained. At all SIT berms, projectiles will be recovered from frontal cover impact areas and added to the mass weight and accounted for as contained.

The MANG will prepare a Tech Memo which will describe and present the results of the phases of the LOS analysis. This memo will include a description, summary, and conclusions of the Line of Site Analysis Phases 1-3 and all relevant data.

7.0 SCHEDULE AND NEXT STEPS

With approval of this PN, the MAARNG will begin to set up Sierra Range Lane six for live fire validation of the LOS during Fall 2010. The regulatory community will be regularly updated on the progress of the set up, of securing the M855A1 ammunition for the test fire, and contacted to determine the best dates for conducting the requested live fire validation (test) on Sierra Range.

8.0 CONCURRENCE

Concurrence with the activities presented in this project note is represented by the signatures below:

[signature] 16 Sept 2010
USEPA

MassDEP

EMC

[signature], LTC 16 SEP 10
MAARNG

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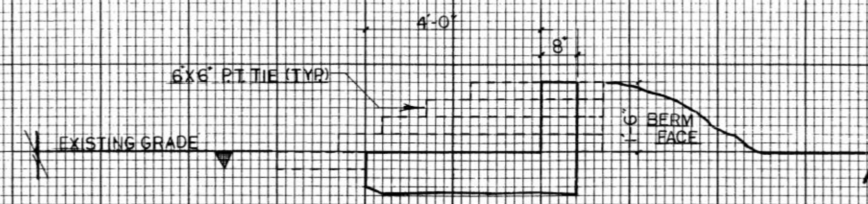
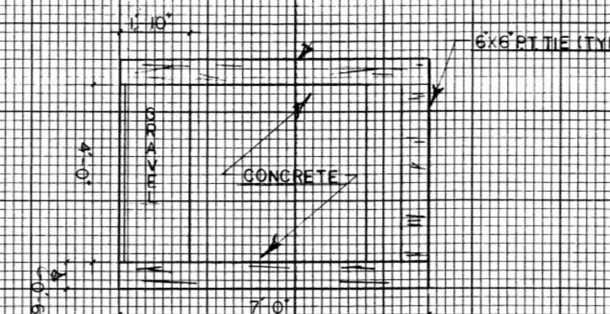
APPENDIX B

GENERAL NOTES:

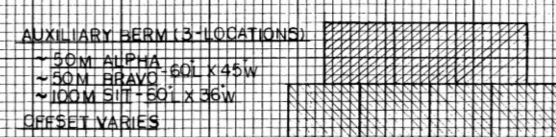
1. SUBSURFACE UTILITIES ARE NOT SHOWN HEREON AND MAY EXIST ON-SITE. PRIOR TO ANY CONSTRUCTION, CONTACT DIG-SAFE
   - ~BASE CE, MR.ROBERT DRAKE 508-968-4724
   - ~1-888-DIG-SAFE
2. ALL DISTURBED AREAS SHALL BE RESTORED TO THEIR ORIGINAL CONDITION. (AS REQUIRED)
3. GOVERNMENT SUPPLIED FILL; LOCATED AT UNIT TRAINING EQUIPMENT SITE (UTES). SEE ATTACHED HAUL ROUTE PLAN.
4. PLYWOOD OVERSHOT BARRIER SHALL BE INSTALLED PLUMB AND LEVEL. THERE SHALL BE NO VOID BETWEEN THE EARTHEN BERM AND PLYWOOD FACE.
5. NOTED ELEVATIONS ARE APPROXIMATE (HISTORICAL DATA). CONTRACTOR SHALL FIELD VERIFY ALL ELEVATIONS. LAYOUT AND CONTROL IS THE RESPONSIBILITY OF THE CONTRACTOR.

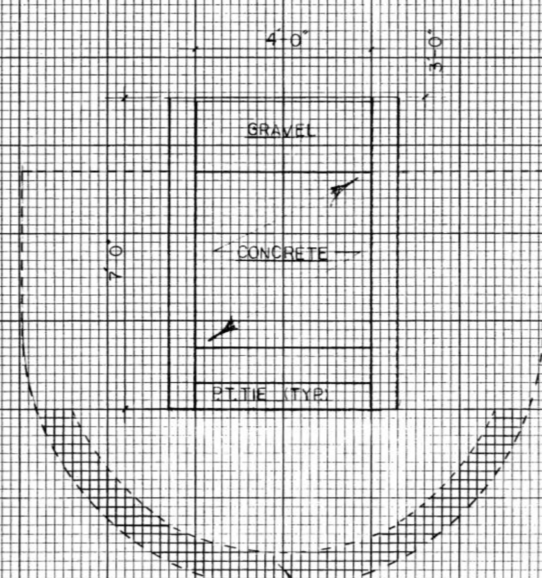


TYPICAL SIT LOCATION
SECTION
N.T.S.

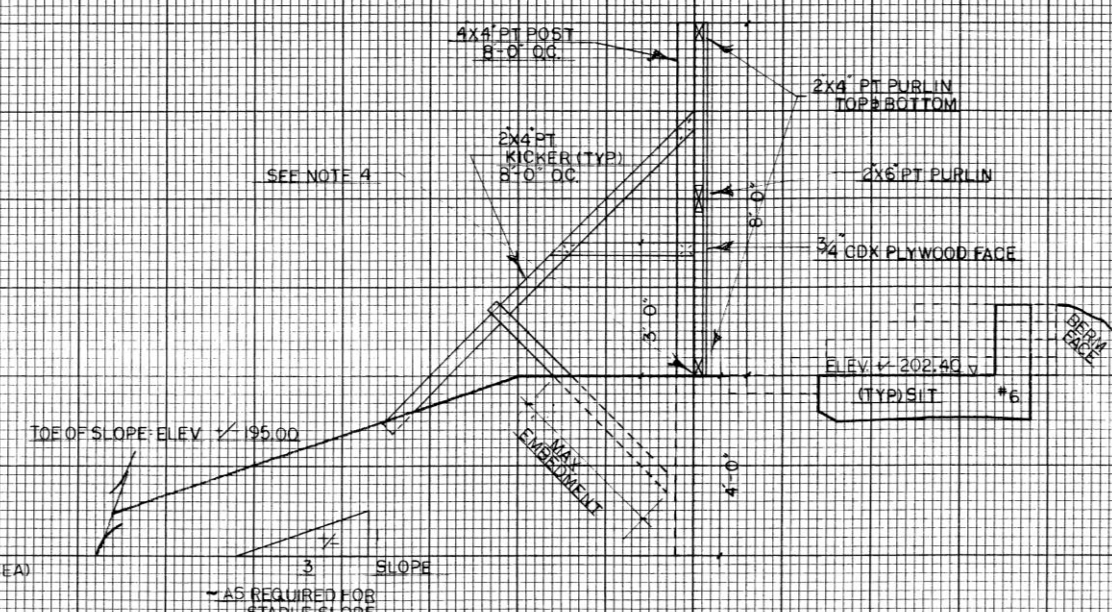


TYPICAL SIT LOCATION
PLAN VIEW
N.T.S.





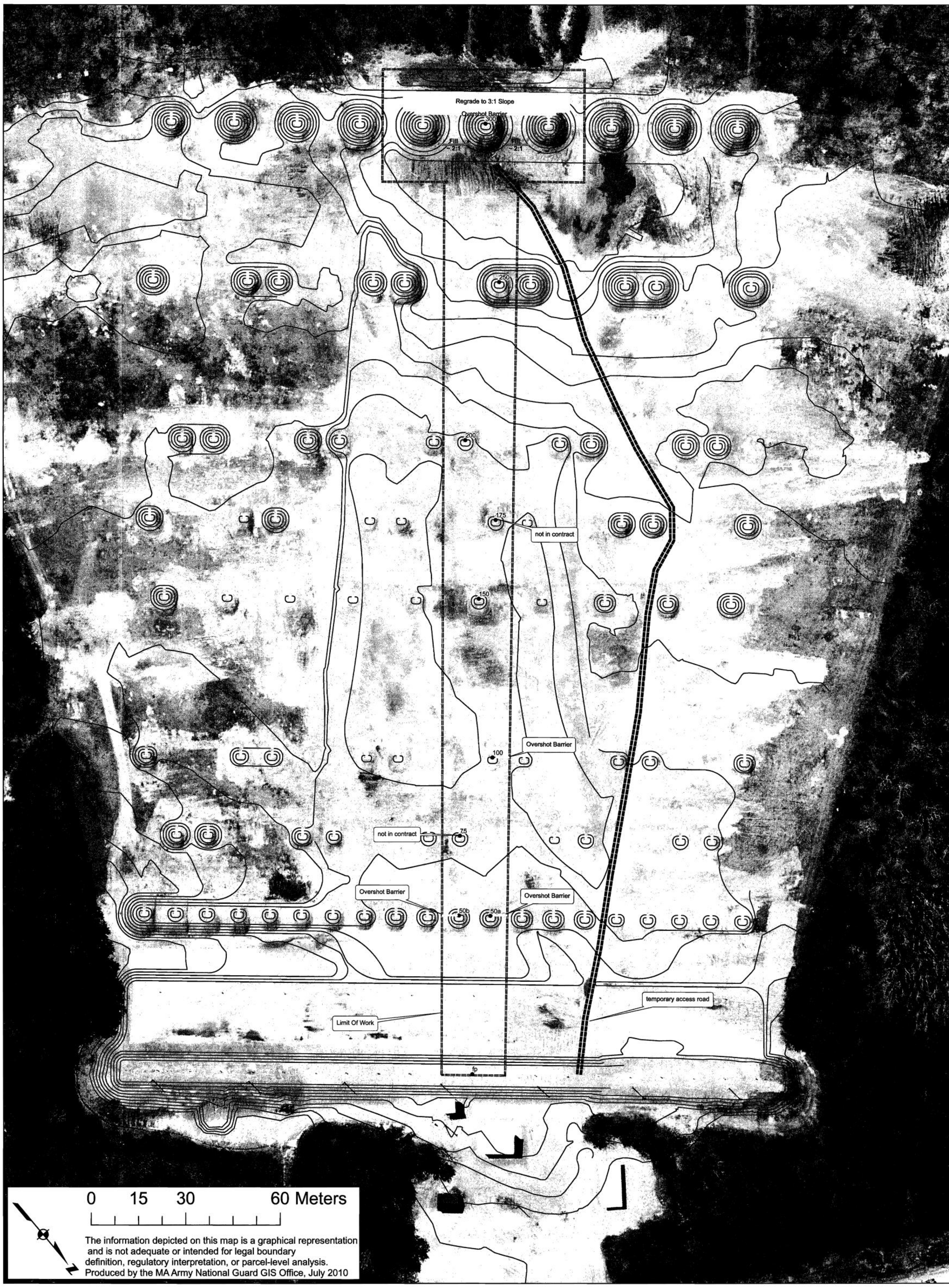
TYPICAL SIT
PLAN VIEW
N.T.S.



SECTION
300-METER BERM W/OVERSHOT BARRIER
N.T.S.

SIERRA RANGE IMPROVEMENTS
DATE: 06 JULY 2010
PROJECT NO. 985146
DRAWN BY: S.PERRY
SCALE: N.T.S.

K&L 10 X 10



Regrade to 3:1 Slope
Overshot Barrier
300
Fill
~ 2:1
Fill
~ 2:1
250
200
175
not in contract
150
Overshot Barrier
100
not in contract
75
Overshot Barrier
50b
50a
Overshot Barrier
temporary access road
Limit Of Work
fp
0 15 30 60 Meters
The information depicted on this map is a graphical representation
and is not adequate or intended for legal boundary
definition, regulatory interpretation, or parcel-level analysis.
Produced by the MA Army National Guard GIS Office, July 2010

APPENDIX C

APPENDIX C. REAL TIME PROJECTILE IMPACT OBSERVATIONS

VERSION 2 MASTER SHEET							
RND	RND	TGT	1	2	3	4	5
1	1	50A	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
2	2		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
3	3		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
4	1	50B	SIT FRONTAL	BACK STOP	175 BERM	300 BERM	NOT OBSERVED
5	2		SIT FRONTAL	BACK STOP	175 BERM	300 BERM	NOT OBSERVED
6	3		SIT FRONTAL	BACK STOP	175 BERM	300 BERM	NOT OBSERVED
7	1	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
8	2		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
9	3		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
10	4		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
11	5		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
12	6		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
13	7		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
14	8		SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
15	1	150	SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
16	2		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
17	3		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
18	4		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
19	5		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
20	6		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
21	7		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
22	8		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
23	9		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
24	10		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
25	11		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
26	1	200	SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
27	2		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
28	3		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
29	4		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
30	5		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
31	6		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
32	7		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
33	1	250	SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
34	2		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
35	3		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
36	4		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
37	5		SIT FRONTAL	HIT	300 BERM	NOT OBSERVED	
38	1	300	SIT FRONTAL	BACK STOP	NOT OBSERVED		
39	2		SIT FRONTAL	BACK STOP	NOT OBSERVED		
40	3		SIT FRONTAL	BACK STOP	NOT OBSERVED		

VERSION 2 TOTALS											
RND	TGT	1		2		3		4		5	
1	50A	SIT	0	BS	18	250	0	300	0	N/O	2
2		SIT	1	BS	17	250	0	300	0	N/O	2
3		SIT	0	BS	17	250	0	300	0	N/O	3
4	50B	SIT	0	BS	19	175	0	300	0	N/O	1
5		SIT	0	BS	19	175	0	300	0	N/O	1
6		SIT	0	BS	19	175	0	300	0	N/O	1
7	100	SIT	0	BS	13	250	0	300	5	N/O	2
8		SIT	0	BS	10	250	0	300	9	N/O	1
9		SIT	0	BS	9	250	1	300	8	N/O	2
10		SIT	0	BS	12	250	1	300	6	N/O	1
11		SIT	0	BS	13	250	0	300	5	N/O	2
12		SIT	0	BS	11	250	0	300	7	N/O	2
13		SIT	0	BS	12	250	0	300	7	N/O	1
14		SIT	1	BS	9	250	1	300	6	N/O	3
15	150	SIT	0	HIT	10	300	4	N/O	6		
16		SIT	0	HIT	9	300	3	N/O	8		
17		SIT	0	HIT	9	300	4	N/O	7		
18		SIT	0	HIT	9	300	3	N/O	8		
19		SIT	0	HIT	13	300	4	N/O	3		
20		SIT	0	HIT	7	300	7	N/O	6		
21		SIT	0	HIT	9	300	7	N/O	4		
22		SIT	0	HIT	11	300	4	N/O	5		
23		SIT	0	HIT	9	300	6	N/O	5		
24		SIT	0	HIT	11	300	6	N/O	3		
25		SIT	0	HIT	6	300	8	N/O	6		
26	200	SIT	0	HIT	7	300	3	N/O	10		
27		SIT	0	HIT	11	300	1	N/O	8		
28		SIT	0	HIT	8	300	4	N/O	8		
29		SIT	0	HIT	10	300	2	N/O	8		
30		SIT	0	HIT	10	300	3	N/O	7		
31		SIT	0	HIT	12	300	2	N/O	6		
32		SIT	0	HIT	13	300	1	N/O	6		
33	250	SIT	0	HIT	10	300	0	N/O	10		
34		SIT	1	HIT	7	300	0	N/O	12		
35		SIT	2	HIT	7	300	0	N/O	11		
36		SIT	0	HIT	8	300	2	N/O	10		
37		SIT	2	HIT	12	300	0	N/O	6		
38	300	SIT	1	BS	6	N/O	13				
39		SIT	2	BS	6	N/O	12				
40		SIT	1	BS	5	N/O	14				

		1					**2**					**3**				
RND	TGT	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1			1					1					1			
2	50A		1					1					1			
3			1					1					1			
4			1					1					1			
5	50B		1					1					1			
6			1					1					1			
7			1					1							1	
8			1					1							1	
9			1					1							1	
10			1							1					1	
11	100		1					1							1	
12			1					1							1	
13			1					1							1	
14			1					1							1	
15					1			1					1			
16					1			1							1	
17					1				1						1	
18					1			1							1	
19					1			1					1			
20	150				1				1					1		
21					1			1					1			
22					1			1					1			
23				1				1							1	
24				1				1							1	
25					1			1						1		
26			1							1					1	
27			1					1					1			
28			1					1					1			
29	200		1					1					1			
30					1			1					1			
31			1					1					1			
32			1					1					1			
33			1							1					1	
34					1			1							1	
35	250				1			1					1			
36			1							1			1			
37					1			1					1			
38				1				1						1		
39	300			1				1						1		
40				1					1				1			
		4					**5**					**6**				
RND	TGT	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5

1			1					1					1			
2	50A		1								1		1			
3			1					1					1			
4			1					1					1			
5	50B		1					1					1			
6			1					1					1			
7			1					1							1	
8			1							1					1	
9				1						1						1
10	100			1						1			1			
11			1					1							1	
12			1					1					1			
13			1					1					1			
14				1				1								1
15					1			1					1			
16					1					1			1			
17			1							1			1			
18			1							1			1			
19			1							1			1			
20	150				1			1						1		
21					1				1				1			
22			1					1					1			
23					1				1				1			
24			1					1					1			
25			1						1					1		
26			1							1					1	
27					1			1					1			
28					1					1			1			
29	200				1			1					1			
30					1			1							1	
31			1					1							1	
32					1			1							1	
33					1			1							1	
34					1			1							1	
35	250				1					1					1	
36					1			1					1			
37					1			1					1			
38				1				1						1		
39	300			1					1				1			
40				1					1				1			

		7					8					9				
RND	TGT	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1								1		1			
2			1					1					1			

3			1					1					1			
4			1					1					1			
5	50B		1					1					1			
6			1					1					1			
7					1			1								1
8			1					1					1			
9			1					1							1	
10	100		1							1			1			
11			1							1			1			
12			1					1					1			
13					1			1					1			
14			1					1							1	
15					1				1				1			
16					1			1					1			
17			1					1							1	
18					1			1					1			
19			1						1				1			
20	150		1						1					1		
21			1						1					1		
22					1				1				1			
23					1			1					1			
24			1						1					1		
25					1				1				1			
26					1				1					1		
27					1				1				1			
28					1				1					1		
29	200		1						1						1	
30					1				1				1			
31			1					1							1	
32			1					1							1	
33					1			1					1			
34					1		1						1			
35	250				1			1							1	
36					1			1							1	
37					1		1						1			
38				1			1							1		
39	300			1					1					1		
40				1					1					1		
				10					**11**					**12**		
RND	TGT	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1			1					1					1			
2	50A		1					1					1			
3			1					1					1			
4	50B		1					1					1			

5			1					1					1			
6			1					1					1			
7	100		1					1					1			
8					1					1					1	
9			1							1			1			
10					1			1							1	
11			1					1					1			
12					1			1							1	
13					1					1					1	
14					1					1			1			
15	150			1				1					1			
16			1						1				1			
17				1					1				1			
18				1				1					1			
19			1					1					1			
20			1							1			1			
21			1					1					1			
22				1				1					1			
23				1				1						1		
24				1				1							1	
25				1						1			1			
26	200				1					1					1	
27			1					1							1	
28			1					1							1	
29			1					1							1	
30			1					1							1	
31			1							1			1			
32				1				1					1			
33	250		1					1							1	
34			1					1							1	
35			1							1			1			
36			1					1							1	
37			1					1							1	
38	300		1					1						1		
39			1					1						1		
40			1					1						1		
		13					**14**					**15**				
RND	TGT	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2			1					1					1			
3			1					1								1
4	50B		1					1					1			
5			1					1					1			
6			1					1					1			

7	100		1					1					1			
8					1			1					1			
9					1					1			1			
10			1					1					1			
11			1					1					1			
12					1					1			1			
13			1					1					1			
14			1				1						1			
15	150				1				1				1			
16					1				1				1			
17			1					1					1			
18					1			1					1			
19				1				1						1		
20			1						1					1		
21				1					1					1		
22				1					1				1			
23				1				1					1			
24			1					1					1			
25					1			1						1		
26	200		1						1				1			
27					1			1					1			
28					1				1				1			
29					1			1					1			
30				1				1					1			
31			1					1					1			
32			1					1					1			
33	250		1					1					1			
34					1			1					1			
35					1			1				1				
36			1						1					1		
37			1					1				1				
38	300			1					1				1			
39			1					1				1				
40				1					1			1				

		16					17					18				
RND	TGT	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A					1		1					1			
2						1		1					1			
3						1					1		1			
4	50B					1		1					1			
5						1		1					1			
6						1		1					1			
7	100					1		1							1	
8						1		1							1	

9						1		1							1	
10						1		1					1			
11						1				1					1	
12						1					1				1	
13						1		1							1	
14						1					1				1	
15	150				1					1			1			
16					1					1				1		
17					1					1				1		
18					1					1				1		
19					1				1				1			
20					1			1							1	
21					1			1						1		
22					1					1			1			
23					1			1							1	
24					1			1					1			
25					1			1						1		
26	200				1			1							1	
27					1			1							1	
28					1					1				1		
29					1					1				1		
30					1			1						1		
31					1				1					1		
32					1			1							1	
33	250				1					1					1	
34					1					1					1	
35					1		1						1			
36					1					1					1	
37					1			1					1			
38	300			1				1						1		
39				1					1			1				
40				1				1						1		

		19					**20**				
RND	TGT	1	2	3	4	5	1	2	3	4	5
1	50A		1					1			
2		1						1			
3			1					1			
4	50B		1					1			
5			1					1			
6			1					1			
7	100		1							1	
8			1							1	
9			1							1	
10			1					1			

11			1								1
12			1							1	
13					1			1			
14			1							1	
15			1						1		
16			1					1			
17			1							1	
18				1						1	
19			1					1			
20	150		1							1	
21			1							1	
22			1							1	
23			1						1		
24				1					1		
25				1						1	
26			1					1			
27					1					1	
28			1							1	
29	200				1					1	
30					1			1			
31					1					1	
32			1							1	
33			1							1	
34					1					1	
35	250				1					1	
36					1					1	
37					1			1			
38				1					1		
39	300			1					1		
40				1					1		

RND	TARGET	VERSION 1 MASTER SHEET				
		1	2	3	4	5
1	50A	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
2	200	SIT FRONTAL	300 BERM	NOT OBSERVED		
3	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
4	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
5	300	SIT FRONTAL	BACK STOP	NOT OBSERVED		
6	250	SIT FRONTAL	300 BERM	NOT OBSERVED		
7	50B	SIT FRONTAL	BACK STOP	175 BERM	300 BERM	NOT OBSERVED
8	200	SIT FRONTAL	300 BERM	NOT OBSERVED		
9	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
10	250	SIT FRONTAL	300 BERM	NOT OBSERVED		
11	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
12	200	SIT FRONTAL	300 BERM	NOT OBSERVED		
13	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
14	300	SIT FRONTAL	BACK STOP	NOT OBSERVED		
15	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
16	250	SIT FRONTAL	300 BERM	NOT OBSERVED		
17	200	SIT FRONTAL	300 BERM	NOT OBSERVED		
18	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
19	50A	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
20	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
21	200	SIT FRONTAL	300 BERM	NOT OBSERVED		
22	250	SIT FRONTAL	300 BERM	NOT OBSERVED		
23	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
24	300	SIT FRONTAL	BACK STOP	NOT OBSERVED		
25	200	SIT FRONTAL	300 BERM	NOT OBSERVED		
26	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
27	200	SIT FRONTAL	300 BERM	NOT OBSERVED		
28	250	SIT FRONTAL	300 BERM	NOT OBSERVED		
29	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
30	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
31	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
32	50A	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
33	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
34	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
35	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
36	50B	SIT FRONTAL	BACK STOP	175 BERM	300 BERM	NOT OBSERVED
37	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
38	150	SIT FRONTAL	300 BERM	NOT OBSERVED		
39	50A	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED
40	100	SIT FRONTAL	BACK STOP	250 BERM	300 BERM	NOT OBSERVED

NOTE: RED FILL COLOR INDICATES TARGETS INITIATED SIMULTANEOUSLY.

RND	TARGET	VERSION 1 TOTALS									
		1		2		3		4		5	
1	50A	SIT	1	BS	32	250	0	300	0	N/O	0
2	200	SIT	4	300	20	N/O	9				
3	100	SIT	0	BS	31	250	0	300	2	N/O	0
4	150	SIT	2	300	20	N/O	11				
5	300	SIT	5	BS	13	N/O	15				
6	250	SIT	3	300	8	N/O	22				
7	50B	SIT	2	BS	31	175	0	300	0	N/O	0
8	200	SIT	1	300	15	N/O	17				
9	150	SIT	0	300	22	N/O	11				
10	250	SIT	4	300	12	N/O	17				
11	100	SIT	2	BS	27	250	0	300	2	N/O	2
12	200	SIT	2	300	25	N/O	6				
13	150	SIT	3	300	28	N/O	2				
14	300	SIT	4	BS	19	N/O	10				
15	100	SIT	1	BS	28	250	0	300	1	N/O	3
16	250	SIT	2	300	10	N/O	21				
17	200	SIT	2	300	18	N/O	13				
18	150	SIT	2	300	26	N/O	5				
19	50A	SIT	2	BS	30	250	0	300	0	N/O	1
20	100	SIT	0	BS	26	250	0	300	0	N/O	7
21	200	SIT	4	300	20	N/O	9				
22	250	SIT	3	300	14	N/O	16				
23	150	SIT	1	300	26	N/O	6				
24	300	SIT	7	BS	13	N/O	13				
25	200	SIT	2	300	22	N/O	9				
26	150	SIT	1	300	29	N/O	3				
27	200	SIT	3	300	18	N/O	12				
28	250	SIT	3	300	17	N/O	13				
29	150	SIT	1	300	29	N/O	3				
30	150	SIT	2	300	24	N/O	7				
31	150	SIT	3	300	28	N/O	2				
32	50A	SIT	3	BS	27	250	0	300	0	N/O	3
33	100	SIT	2	BS	19	250	0	300	4	N/O	8
34	150	SIT	5	300	25	N/O	3				
35	100	SIT	2	BS	19	250	0	300	2	N/O	10
36	50B	SIT	4	BS	26	175	0	300	0	N/O	3
37	100	SIT	2	BS	18	250	0	300	2	N/O	11
38	150	SIT	2	300	25	N/O	6				
39	50A	SIT	6	BS	24	250	0	300	0	N/O	3
40	100	SIT	3	BS	24	250	0	300	1	N/O	5

		21					22					23				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1				1						1			
2	200	1						1					1			
3	100				1			1					1			
4	150		1					1					1			
5	300			1					1					1		
6	250			1				1						1		
7	50B		1					1					1			
8	200			1					1				1			
9	150		1					1						1		
10	250			1				1					1			
11	100		1					1							1	
12	200		1					1					1			
13	150		1					1					1			
14	300			1					1				1			
15	100		1					1					1			
16	250			1					1					1		
17	200			1					1				1			
18	150		1						1				1			
19	50A		1					1					1			
20	100		1					1					1			
21	200			1			1						1			
22	250		1					1						1		
23	150		1					1						1		
24	300			1					1					1		
25	200			1				1						1		
26	150		1					1						1		
27	200			1					1				1			
28	250			1				1					1			
29	150		1					1					1			
30	150		1						1				1			
31	150			1				1					1			
32	50A					1	1						1			
33	100		1							1					1	
34	150	1					1							1		
35	100				1						1				1	
36	50B					1		1					1			
37	100		1								1				1	
38	150			1				1					1			
39	50A					1	1									1
40	100		1								1				1	

		24					25					26				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200		1					1						1		
3	100		1					1							1	
4	150			1					1					1		
5	300			1					1				1			
6	250			1					1				1			
7	50B		1					1					1			
8	200			1					1				1			
9	150		1					1						1		
10	250			1					1				1			
11	100		1					1							1	
12	200		1					1					1			
13	150		1						1				1			
14	300		1						1				1			
15	100		1					1					1			
16	250		1						1					1		
17	200		1					1					1			
18	150		1					1					1			
19	50A		1					1					1			
20	100					1		1					1			
21	200		1						1					1		
22	250		1						1				1			
23	150		1					1					1			
24	300		1						1				1			
25	200		1						1				1			
26	150		1					1					1			
27	200			1					1				1			
28	250			1				1						1		
29	150		1						1				1			
30	150		1						1				1			
31	150		1					1					1			
32	50A		1								1		1			
33	100		1							1			1			
34	150		1						1				1			
35	100		1					1				1				
36	50B		1								1		1			
37	100		1				1						1			
38	150			1					1					1		
39	50A		1					1								1
40	100		1					1				1				

		27					28					29				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200		1				1						1			
3	100		1					1					1			
4	150	1						1					1			
5	300		1						1					1		
6	250		1						1					1		
7	50B	1						1					1			
8	200		1					1					1			
9	150		1					1					1			
10	250			1					1					1		
11	100		1					1					1			
12	200	1							1					1		
13	150		1					1					1			
14	300	1						1					1			
15	100		1					1					1			
16	250			1				1						1		
17	200			1					1					1		
18	150	1						1					1			
19	50A	1						1					1			
20	100		1					1					1			
21	200	1							1				1			
22	250			1				1						1		
23	150		1						1				1			
24	300			1					1				1			
25	200		1						1					1		
26	150		1					1					1			
27	200			1				1						1		
28	250		1						1					1		
29	150			1				1					1			
30	150		1						1				1			
31	150	1						1					1			
32	50A	1						1					1			
33	100		1							1			1			
34	150		1					1					1			
35	100		1					1								1
36	50B		1					1					1			
37	100		1					1					1			
38	150		1					1					1			
39	50A	1						1					1			
40	100	1						1					1			

		30					31					32				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200			1					1				1			
3	100		1					1					1			
4	150		1						1					1		
5	300			1				1						1		
6	250			1					1					1		
7	50B		1					1					1			
8	200			1					1					1		
9	150		1					1						1		
10	250	1							1					1		
11	100		1				1						1			
12	200		1					1					1			
13	150		1					1					1			
14	300	1							1				1			
15	100		1							1			1			
16	250			1					1					1		
17	200	1						1						1		
18	150		1					1					1			
19	50A		1					1					1			
20	100					1		1					1			
21	200			1				1					1			
22	250		1						1					1		
23	150		1					1					1			
24	300	1							1					1		
25	200		1					1						1		
26	150		1					1					1			
27	200		1					1					1			
28	250			1				1					1			
29	150		1					1					1			
30	150	1						1					1			
31	150		1					1					1			
32	50A		1					1					1			
33	100					1		1					1			
34	150		1					1						1		
35	100					1		1					1			
36	50B	1						1					1			
37	100		1								1		1			
38	150		1					1					1			
39	50A		1					1					1			
40	100		1					1					1			

RND	TARGET	33					34					35				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200			1					1			1				
3	100		1					1					1			
4	150		1						1				1			
5	300			1					1			1				
6	250			1					1			1				
7	50B		1					1					1			
8	200			1					1				1			
9	150		1						1				1			
10	250			1				1					1			
11	100		1				1						1			
12	200		1					1						1		
13	150		1					1					1			
14	300		1						1				1			
15	100		1					1					1			
16	250		1						1					1		
17	200		1					1						1		
18	150			1				1						1		
19	50A		1					1					1			
20	100		1					1								1
21	200		1						1				1			
22	250			1					1					1		
23	150		1						1				1			
24	300		1					1					1			
25	200		1					1					1			
26	150		1					1					1			
27	200		1					1						1		
28	250		1					1						1		
29	150		1					1					1			
30	150		1					1						1		
31	150		1				1						1			
32	50A		1					1					1			
33	100		1					1				1				
34	150		1					1					1			
35	100					1		1								1
36	50B		1					1					1			
37	100		1					1								1
38	150		1					1					1			
39	50A		1					1					1			
40	100		1					1								1

		36					37					38				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200		1				1							1		
3	100		1					1					1			
4	150		1					1						1		
5	300		1				1							1		
6	250			1				1						1		
7	50B		1					1					1			
8	200			1				1						1		
9	150		1					1						1		
10	250			1				1						1		
11	100		1					1					1			
12	200		1					1					1			
13	150		1				1						1			
14	300			1				1						1		
15	100					1		1					1			
16	250			1				1						1		
17	200		1					1						1		
18	150		1					1					1			
19	50A		1					1					1			
20	100		1					1					1			
21	200		1					1					1			
22	250		1				1						1			
23	150		1					1					1			
24	300		1					1						1		
25	200		1					1						1		
26	150		1					1					1			
27	200		1					1					1			
28	250		1						1				1			
29	150		1					1					1			
30	150		1					1					1			
31	150		1					1					1			
32	50A		1					1				1				
33	100					1					1		1			
34	150		1				1						1			
35	100					1					1		1			
36	50B		1				1						1			
37	100					1					1		1			
38	150		1					1					1			
39	50A		1					1					1			
40	100					1					1		1			

		39					40					41				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200		1						1				1			
3	100		1					1					1			
4	150	1							1				1			
5	300	1						1						1		
6	250			1					1					1		
7	50B		1					1					1			
8	200		1						1					1		
9	150		1						1				1			
10	250	1							1					1		
11	100					1		1					1			
12	200		1						1				1			
13	150		1						1				1			
14	300		1						1			1				
15	100					1	1						1			
16	250			1					1				1			
17	200			1					1				1			
18	150		1					1					1			
19	50A		1					1					1			
20	100					1		1					1			
21	200		1						1				1			
22	250		1					1						1		
23	150		1					1					1			
24	300	1							1				1			
25	200		1						1			1				
26	150		1					1					1			
27	200			1				1				1				
28	250			1					1				1			
29	150		1					1					1			
30	150		1						1				1			
31	150		1					1					1			
32	50A		1					1								1
33	100					1					1		1			
34	150		1				1					1				
35	100		1					1					1			
36	50B		1				1						1			
37	100					1		1								1
38	150		1					1					1			
39	50A		1				1						1			
40	100		1					1					1			

		42					43					44				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200		1					1					1			
3	100		1					1					1			
4	150			1				1					1			
5	300		1					1					1			
6	250			1					1					1		
7	50B		1					1					1			
8	200			1				1						1		
9	150			1					1				1			
10	250			1				1						1		
11	100		1					1					1			
12	200		1					1					1			
13	150		1					1					1			
14	300		1				1						1			
15	100		1					1					1			
16	250			1					1				1			
17	200			1				1					1			
18	150			1				1					1			
19	50A		1				1						1			
20	100		1					1					1			
21	200		1					1					1			
22	250			1				1						1		
23	150		1					1					1			
24	300	1					1					1				
25	200		1					1					1			
26	150		1					1					1			
27	200		1					1						1		
28	250		1				1					1				
29	150		1					1					1			
30	150		1					1					1			
31	150		1					1					1			
32	50A		1					1					1			
33	100					1		1				1				
34	150		1					1					1			
35	100		1					1					1			
36	50B		1					1					1			
37	100					1		1				1				
38	150		1					1				1				
39	50A		1					1				1				
40	100		1					1					1			

		45					46					47				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200			1				1						1		
3	100		1					1					1			
4	150		1						1				1			
5	300	1							1			1				
6	250	1							1					1		
7	50B		1					1				1				
8	200		1					1						1		
9	150		1						1				1			
10	250		1					1				1				
11	100		1					1					1			
12	200		1					1				1				
13	150		1					1					1			
14	300		1					1						1		
15	100		1					1					1			
16	250		1				1						1			
17	200			1					1				1			
18	150		1					1					1			
19	50A		1					1					1			
20	100		1					1					1			
21	200		1					1						1		
22	250	1							1					1		
23	150			1					1			1				
24	300			1				1				1				
25	200			1				1					1			
26	150			1					1			1				
27	200	1							1					1		
28	250	1						1					1			
29	150		1					1					1			
30	150		1						1				1			
31	150		1					1					1			
32	50A		1					1					1			
33	100					1		1					1			
34	150		1					1					1			
35	100	1						1								1
36	50B		1					1								1
37	100					1					1		1			
38	150	1							1				1			
39	50A	1						1					1			
40	100	1						1					1			

RND	TARGET	48					49					50				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200		1					1					1			
3	100		1					1					1			
4	150		1					1					1			
5	300			1				1					1			
6	250		1					1					1			
7	50B		1					1					1			
8	200		1					1				1				
9	150			1				1					1			
10	250			1				1					1			
11	100		1					1					1			
12	200			1				1					1			
13	150		1					1					1			
14	300		1					1					1			
15	100		1					1					1			
16	250			1				1						1		
17	200		1				1						1			
18	150		1					1						1		
19	50A		1					1					1			
20	100		1					1					1			
21	200			1				1					1			
22	250		1					1				1				
23	150		1					1						1		
24	300		1						1					1		
25	200		1					1					1			
26	150		1					1					1			
27	200		1					1					1			
28	250		1						1					1		
29	150			1				1					1			
30	150		1					1					1			
31	150		1					1				1				
32	50A		1					1					1			
33	100		1					1					1			
34	150		1					1					1			
35	100					1		1					1			
36	50B		1					1					1			
37	100		1					1					1			
38	150			1				1					1			
39	50A		1					1				1				
40	100		1					1					1			

APPENDIX C. REAL TIME PROJECTILE IMPACT OBSERVATIONS

		51					52					53				
RND	TARGET	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	50A		1					1					1			
2	200		1					1					1			
3	100		1					1					1			
4	150			1				1					1			
5	300		1					1					1			
6	250			1				1				1				
7	50B		1					1					1			
8	200		1						1				1			
9	150		1					1						1		
10	250	1						1						1		
11	100					1		1					1			
12	200		1					1						1		
13	150		1				1					1				
14	300		1					1						1		
15	100		1					1								1
16	250		1				1							1		
17	200		1					1					1			
18	150		1				1						1			
19	50A		1					1								1
20	100					1					1					1
21	200	1						1				1				
22	250			1				1						1		
23	150		1					1					1			
24	300	1						1					1			
25	200		1				1						1			
26	150		1					1					1			
27	200			1			1						1			
28	250		1					1						1		
29	150		1				1						1			
30	150			1			1						1			
31	150		1					1						1		
32	50A		1					1					1			
33	100					1		1					1			
34	150		1					1					1			
35	100					1		1					1			
36	50B		1				1						1			
37	100		1							1						1
38	150		1					1					1			
39	50A		1					1					1			
40	100					1		1					1			

OBSERVED PROJECTILE IMPACT PER LOCATION - VERSION 1

50A		50B		100		150		200		250		300	
SIT	12	SIT	6	SIT	12	SIT	22	SIT	18	SIT	15	SIT	16
BS	113	BS	57	BS	192	*HIT*	*N/A*	*HIT*	*N/A*	*HIT*	*N/A*	BS	45
250	0	175	0	250	0	300	282	300	138	300	61	N/O	38
300	0	300	0	300	14	N/O	59	N/O	75	N/O	89		
N/O	7	N/O	3	N/O	46								

OBSERVED PROJECTILE IMPACT PER LOCATION - VERSION 2

50A		50B		100		150		200		250		300	
SIT	1	SIT	0	SIT	1	SIT	0	SIT	0	SIT	5	SIT	4
BS	52	BS	57	BS	89	*HIT*	*103*	*HIT*	*71*	*HIT*	*44*	BS	17
250	0	175	0	250	3	300	56	300	16	300	2	N/O	39
300	0	300	0	300	53	N/O	61	N/O	53	N/O	49		
N/O	7	N/O	3	N/O	14								

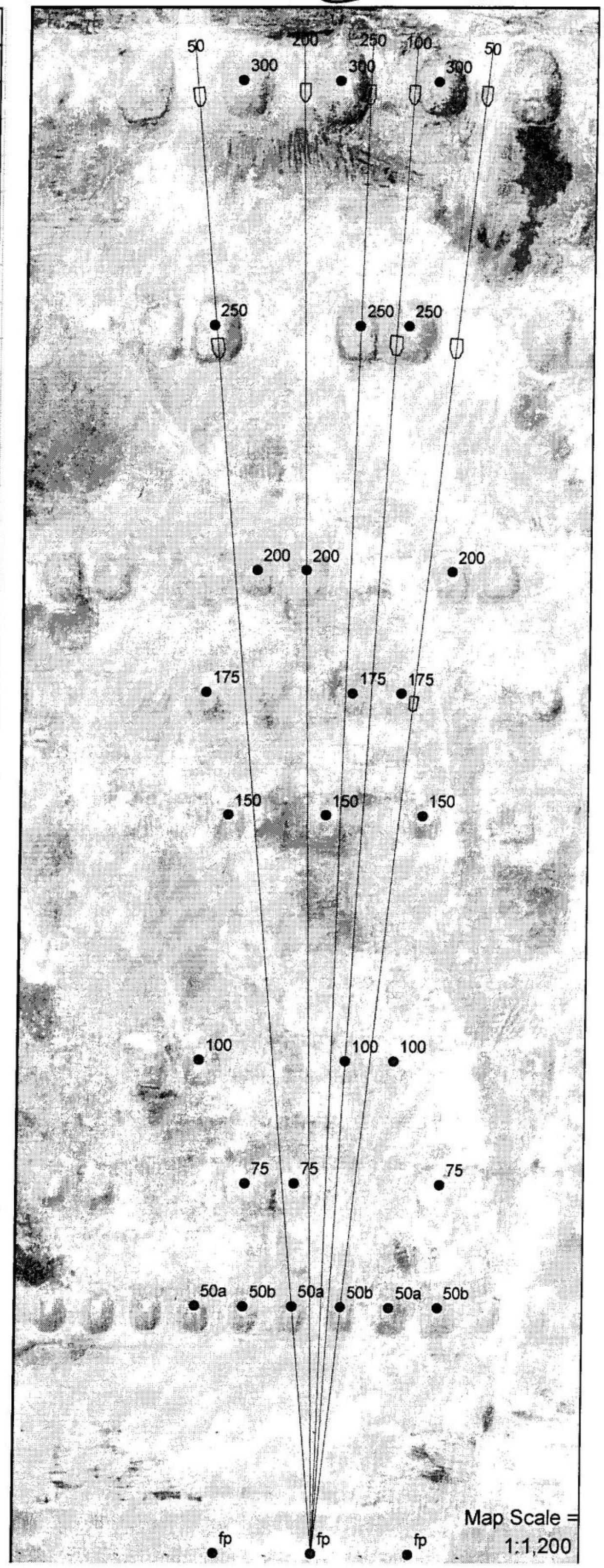
TOTAL OBSERVED PROJECTILE IMPACT PER LOCATION

50A		50B		100		150		200		250		300	
SIT	13	SIT	6	SIT	13	SIT	22	SIT	18	SIT	20	SIT	20
BS	165	BS	114	BS	281	HIT	103	HIT	71	HIT	44	BS	62
250	0	175	0	250	3	300	338	300	154	300	63	N/O	77
300	0	300	0	300	67	N/O	120	N/O	128	N/O	138		
N/O	14	N/O	6	N/O	60								

Lane 6 Phase 3 LOS Analysis Composite Worksheet (21) Firer SFC MOREIRA

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m	N/A		
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m	N/A		
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m	N/A		
32	50b	SIT	BS	175m	300m	N/A
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	N/A
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			N/A
39	50b	SIT	BS	175m	300m	N/A
40	100	SIT	BS	250m	300m	

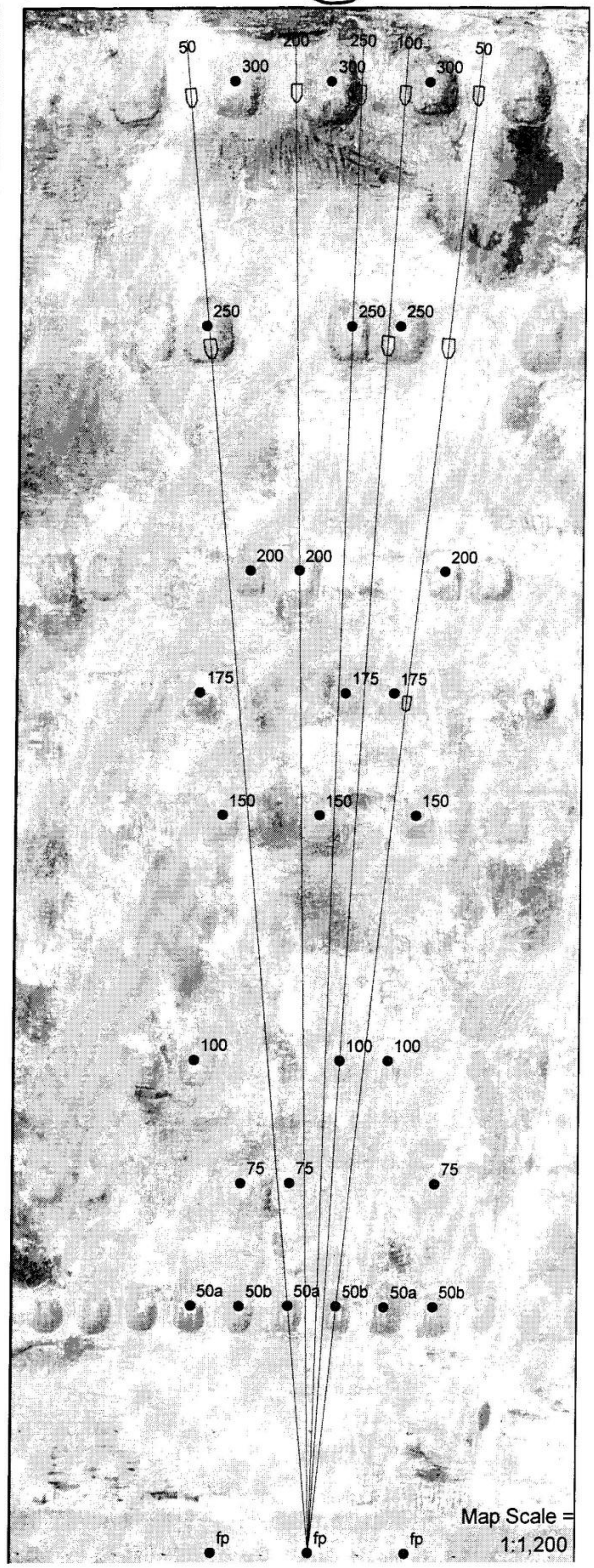
SIT = target frontal berm, BS = backstop berm



Lane 6 Phase 3 LOS Analysis Composite Worksheet (22) Firer PFC Scott

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS	N/A		
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m	N/A		
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m	N/A		
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	N/A
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	N/A

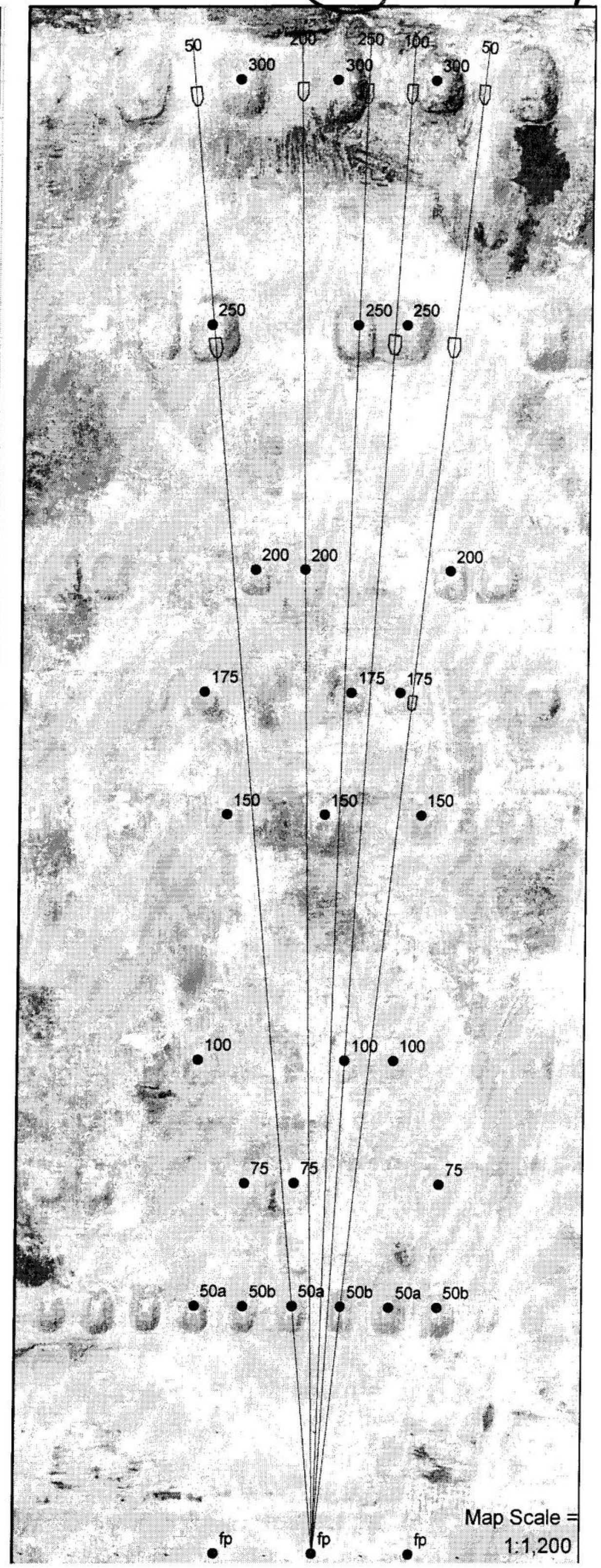
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (23) Firer SGT Dunlap

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m	N/A		
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m	N/A		
24	300	SIT	BS	N/A		
25	200	SIT	300m	N/A		
26	150	SIT	300m	N/A		
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m	N/A		
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	N/A
40	100	SIT	BS	250m	300m	

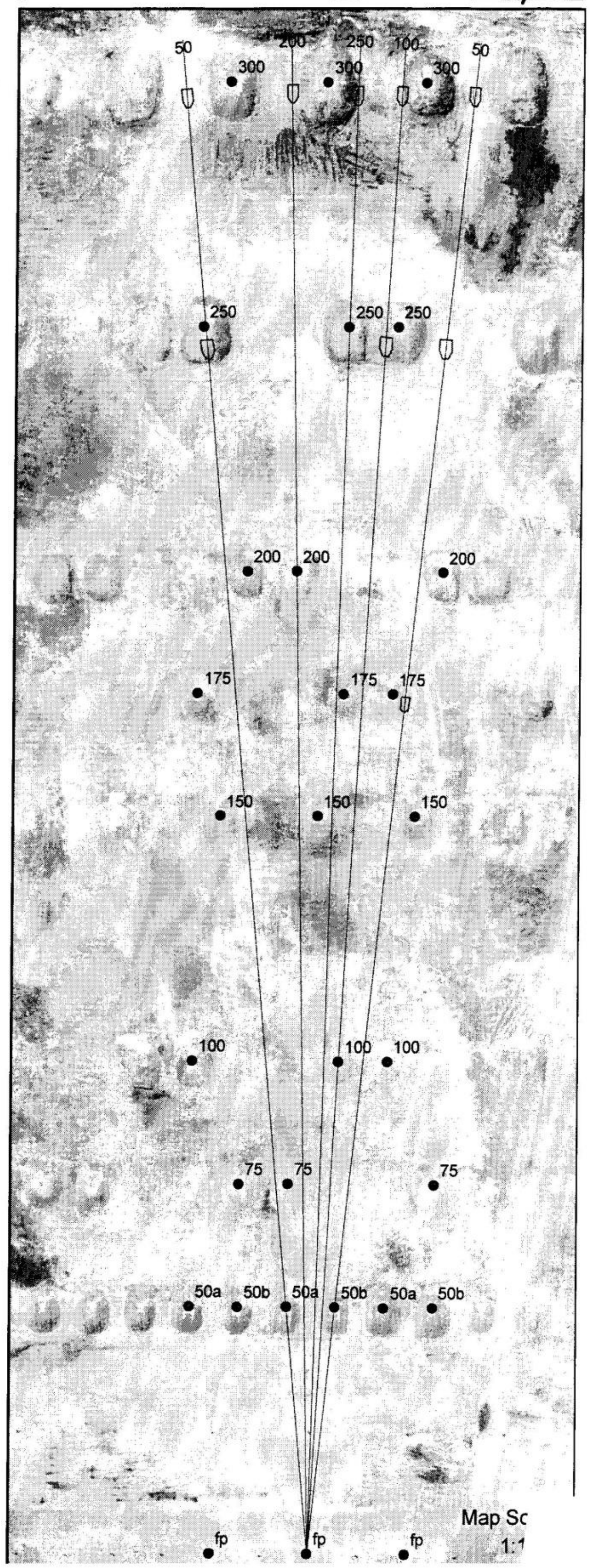
SIT = target frontal berm, BS = backstop berm



Lane 6 — Phase 3 LOS Analysis Composite Worksheet

(24) Firer SFC TAYLOR

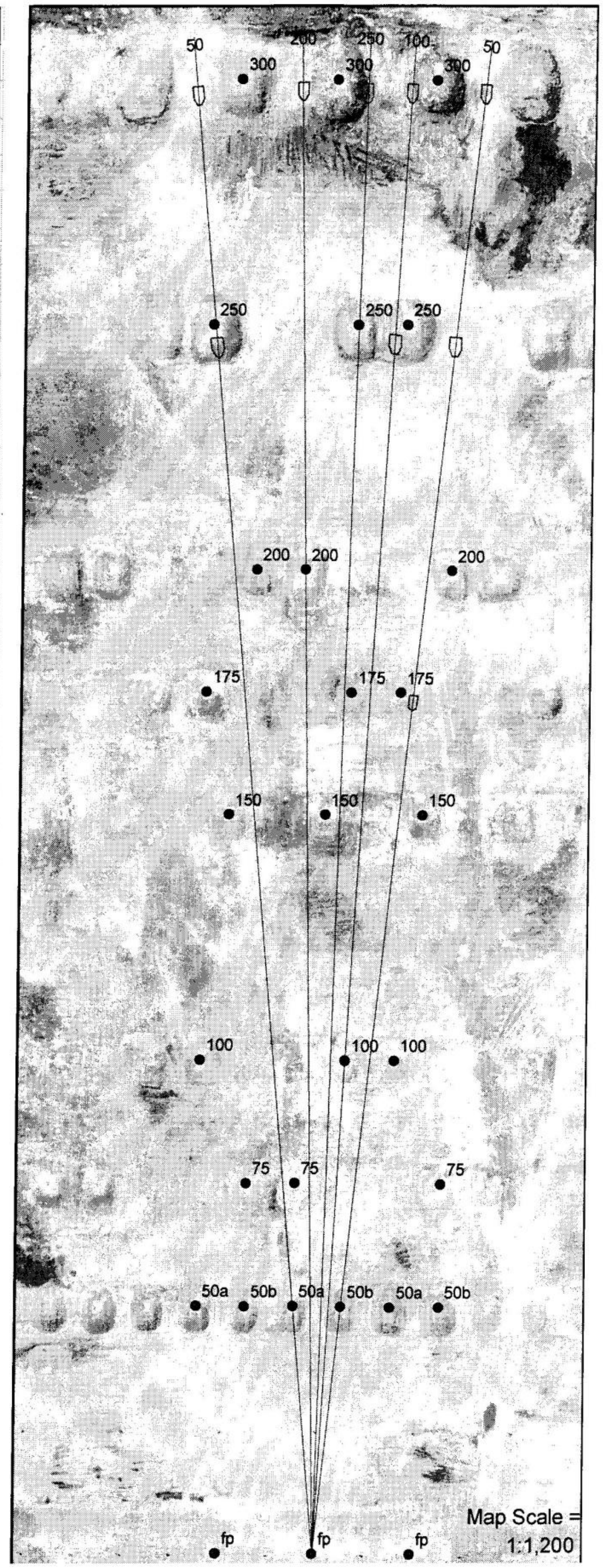
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	N/A
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m	N/A		
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	



SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (25) **Firer** SGT. WALSH

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m	N/A		
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m	N/A		
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m	N/A		
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m			
29	150	SIT	300m	N/A		
30	150	SIT	300m	N/A		
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	N/A
33	100	SIT	BS	250m	300m	
34	150	SIT	300m	N/A		
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	N/A
37	100	SIT	BS	250m	300m	
38	150	SIT	300m	N/A		
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

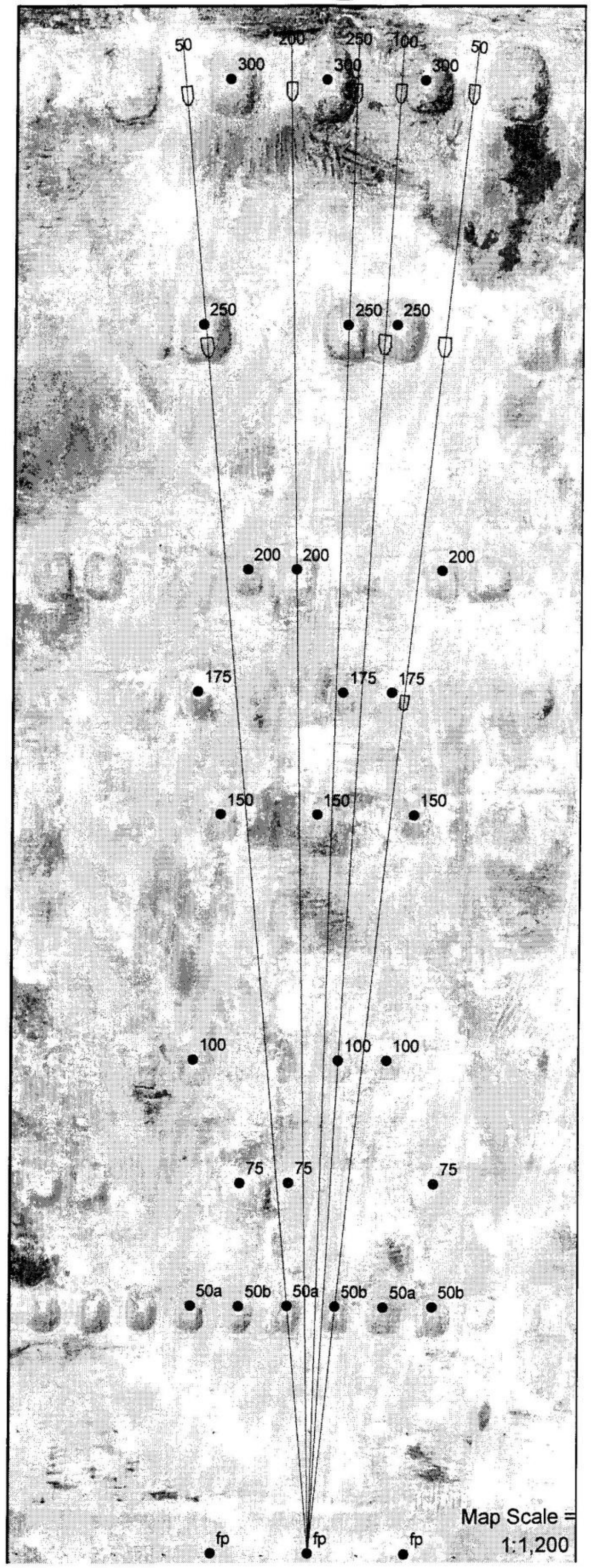


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (26) **Firer** SGT. MOSHER

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m	N/A		
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m	N/A		
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m	N/A		
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m	N/A		
39	50b	SIT	BS	175m	300m	N/A
40	100	SIT	BS	250m	300m	

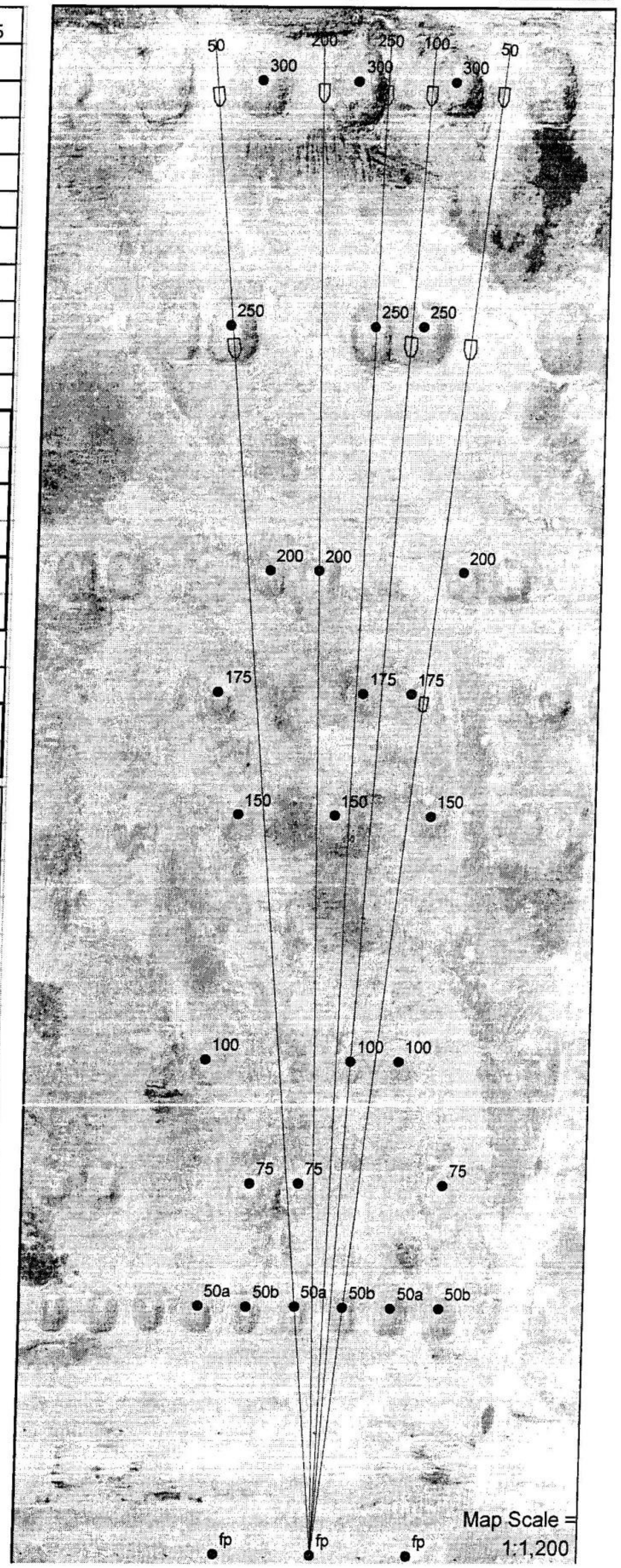
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (27) **Firer** SSG CAlis

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m			
29	150	SIT	300m	N/A		
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

SIT = target frontal berm, BS = backstop berm

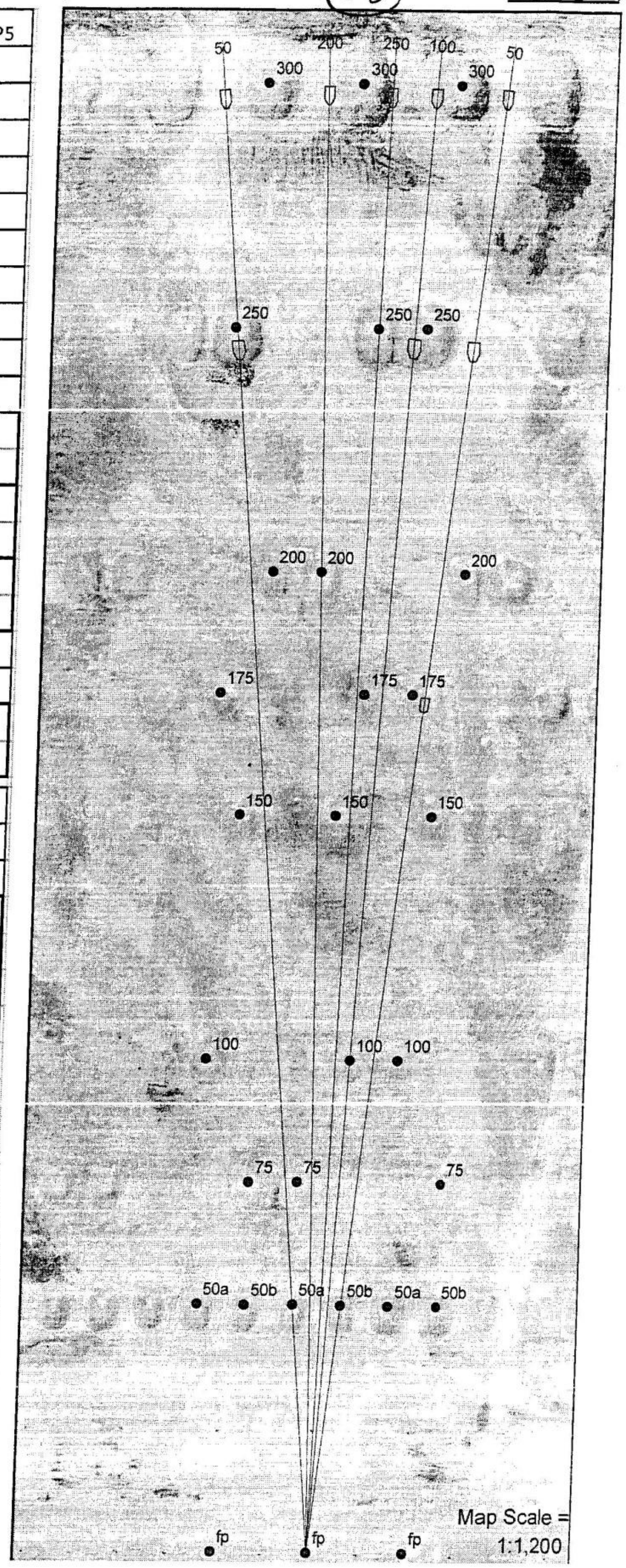


SFC

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (58) **Firer** MORRE.RA

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m	N/A		
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m	N/A		
22	250	SIT	300m			
23	150	SIT	300m	N/A		
24	300	SIT	BS	N/A		
25	200	SIT	300m	N/A		
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m	N/A		
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

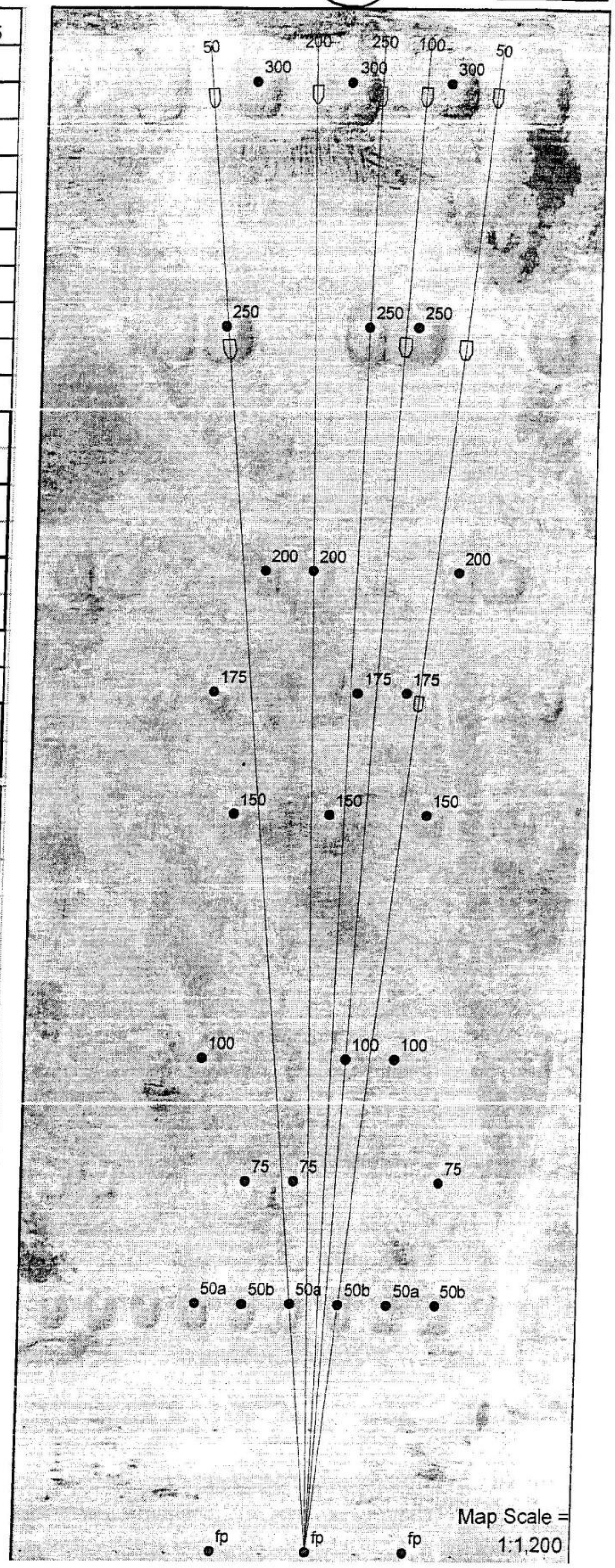
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (29) **Firer** LT. SMITH

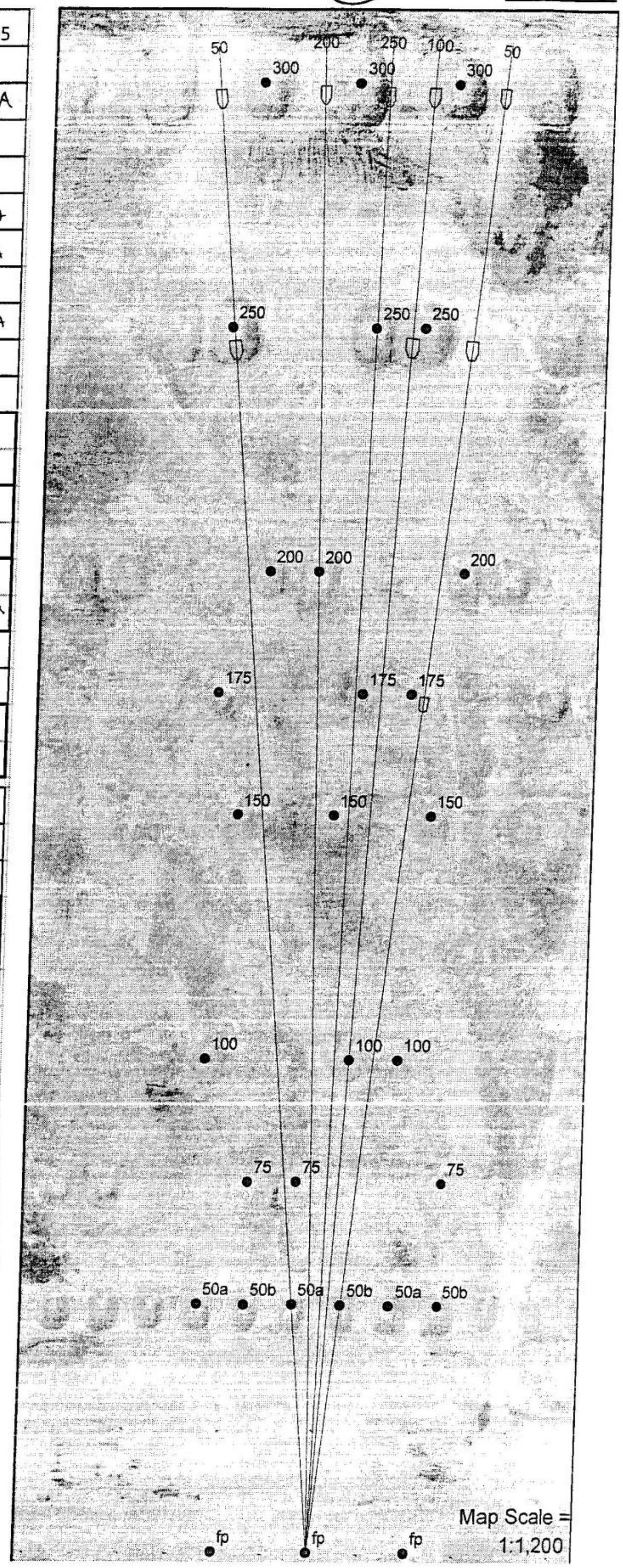
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m	N/A		
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m	N/A		
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	N/A
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (30) **Firer** SFC [illegible]

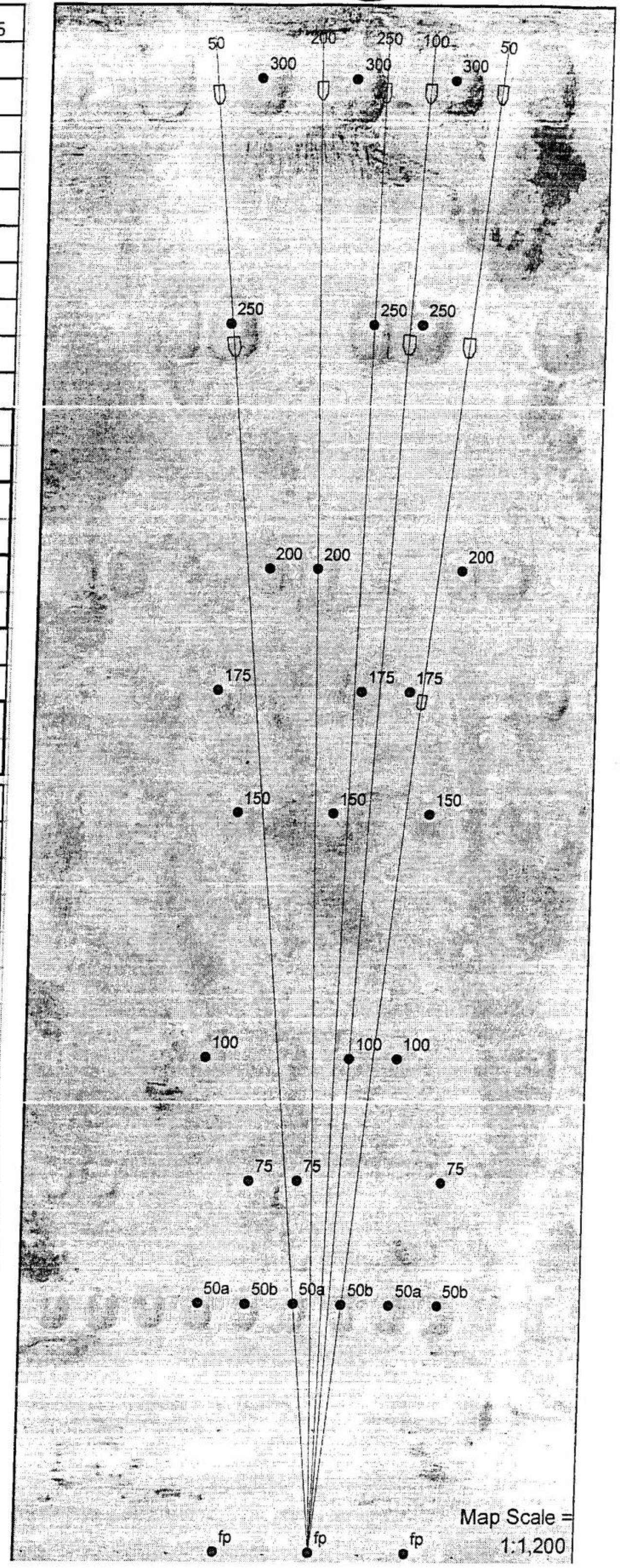
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			NA
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			NA
6	250	SIT	300m			NA
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			NA
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			NA
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	NA
21	200	SIT	300m			NA
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			NA
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	NA
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	NA
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	



SIT = target frontal berm, BS = backstop berm

Lane 6 — Phase 3 LOS Analysis Composite Worksheet — (31) — Firer SGT. WALSH

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m	N/A		
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS			
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

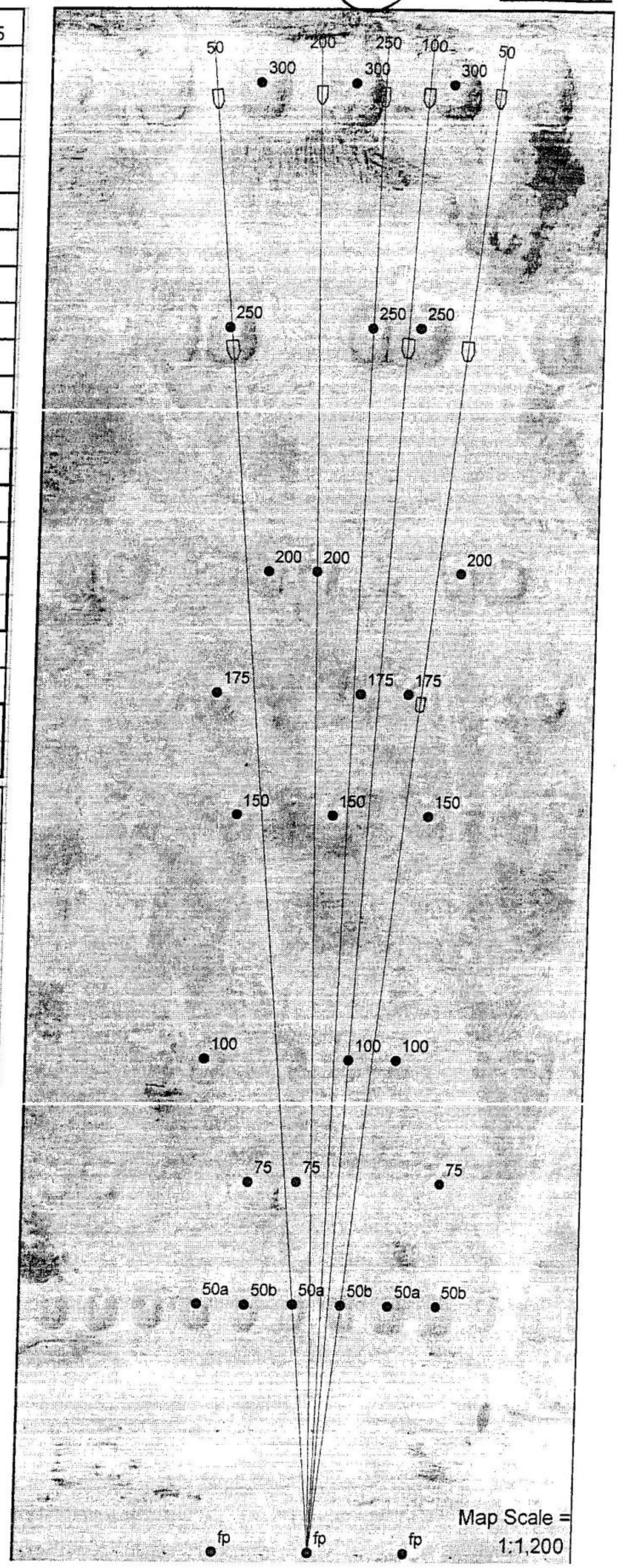


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (32) **Firer** SGT. Dunlap

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m	N/A		
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m	N/A		
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m	N/A		
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

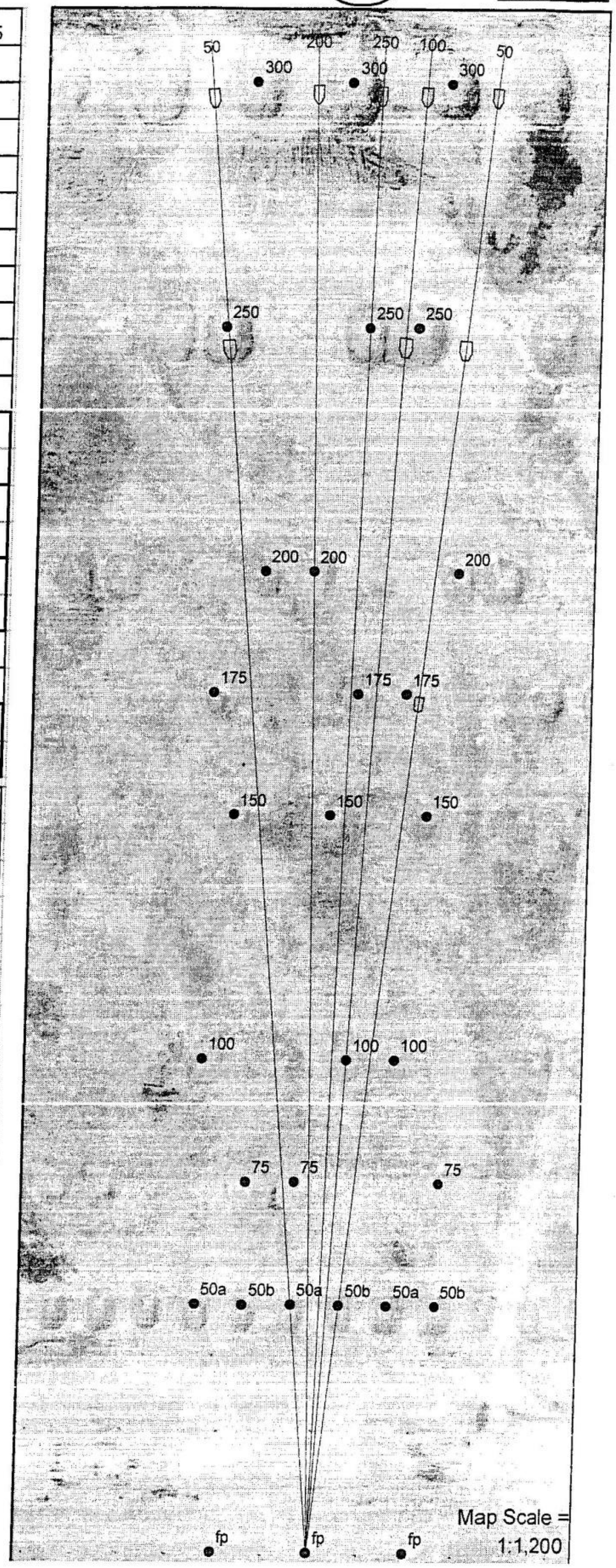
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (33) Firer SGT. MOSHER

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m	N/A		
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m	N/A		
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m	^		
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	N/A
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

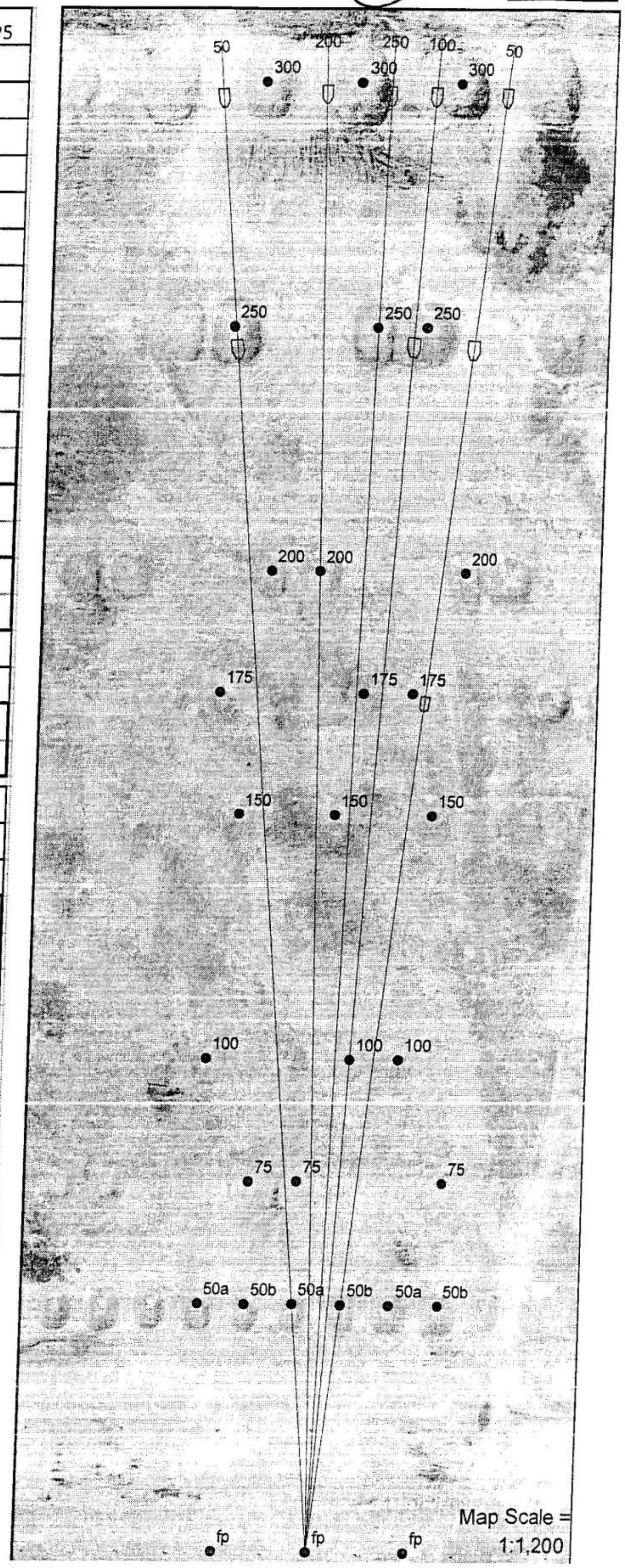
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (34) **Firer** SGT. Dunlap

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m	N/A		
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m	N/A		
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m	N/A		
22	250	SIT	300m	N/A		
23	150	SIT	300m	N/A		
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

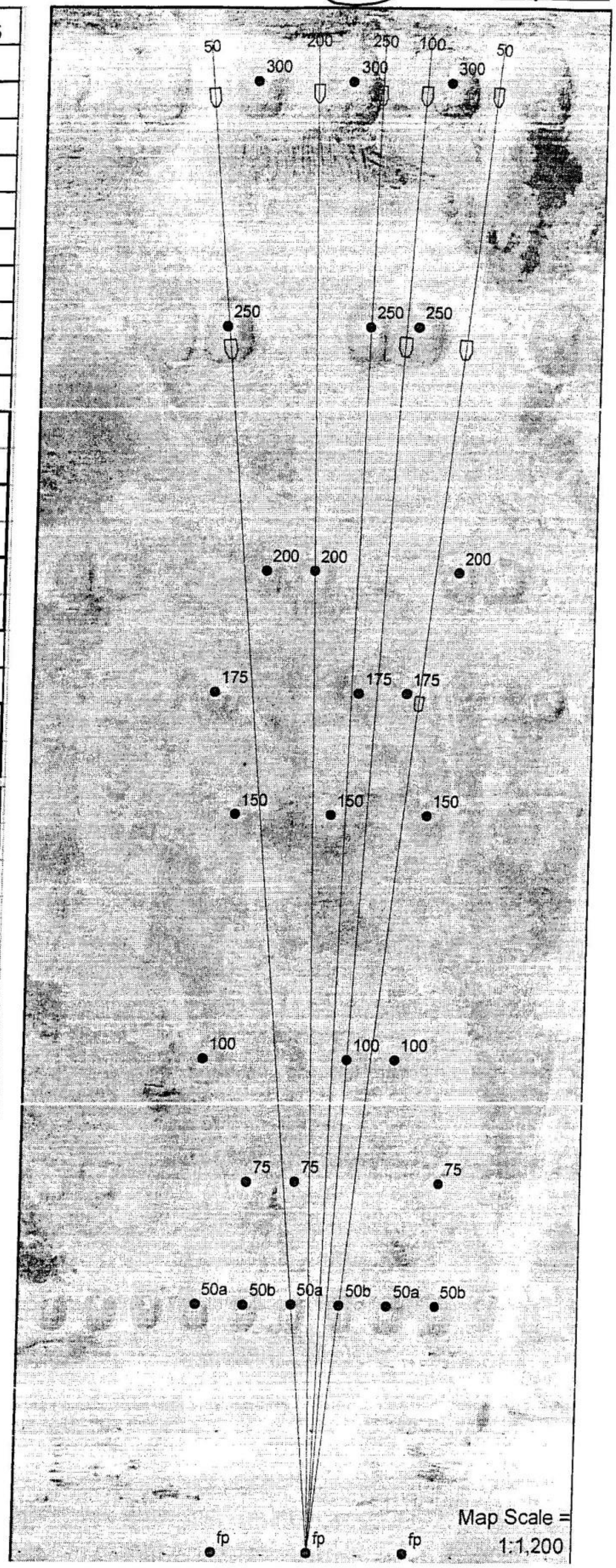
SIT = target frontal berm, BS = backstop berm



Lane 6 Phase 3 LOS Analysis Composite Worksheet (35) Firer SGT. D. PASQUALE

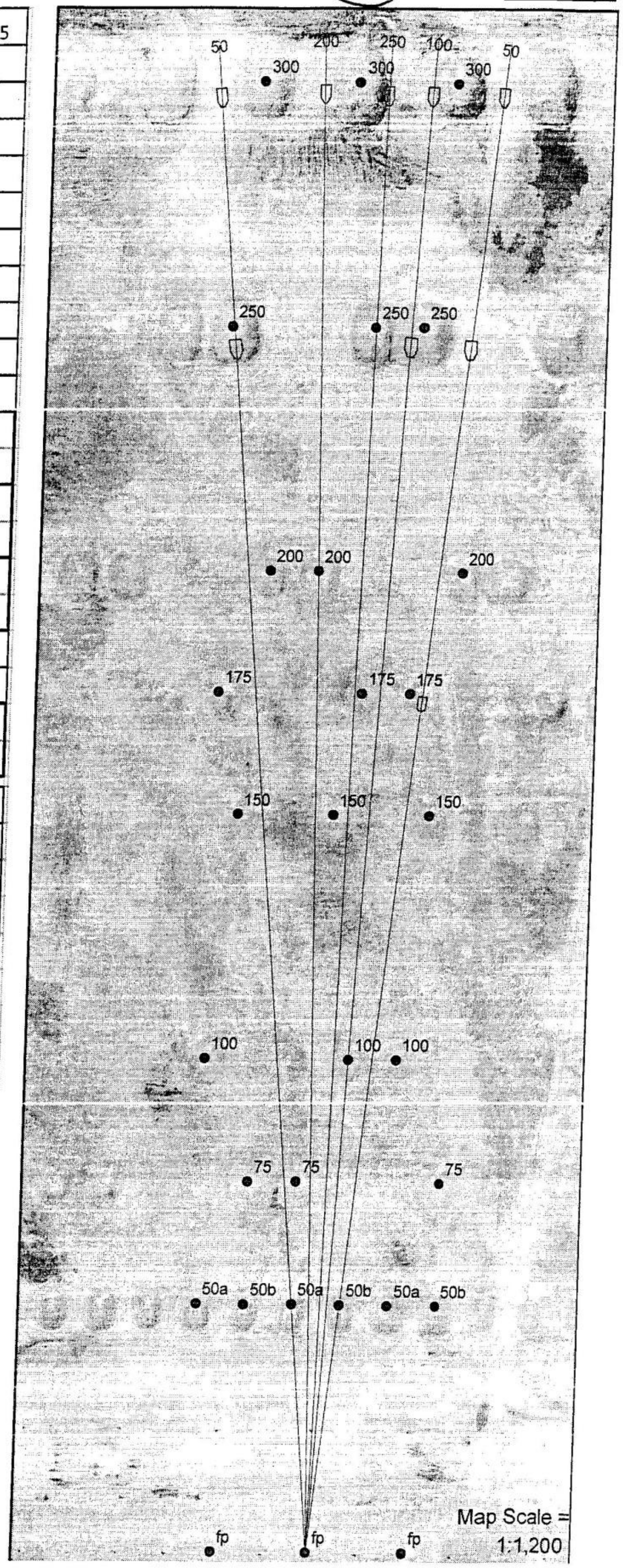
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m	N/A		
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m	N/A		
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	N/A
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m	N/A		
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	N/A
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	N/A

SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (36) **Firer** SFC MOREIRA, R.A.

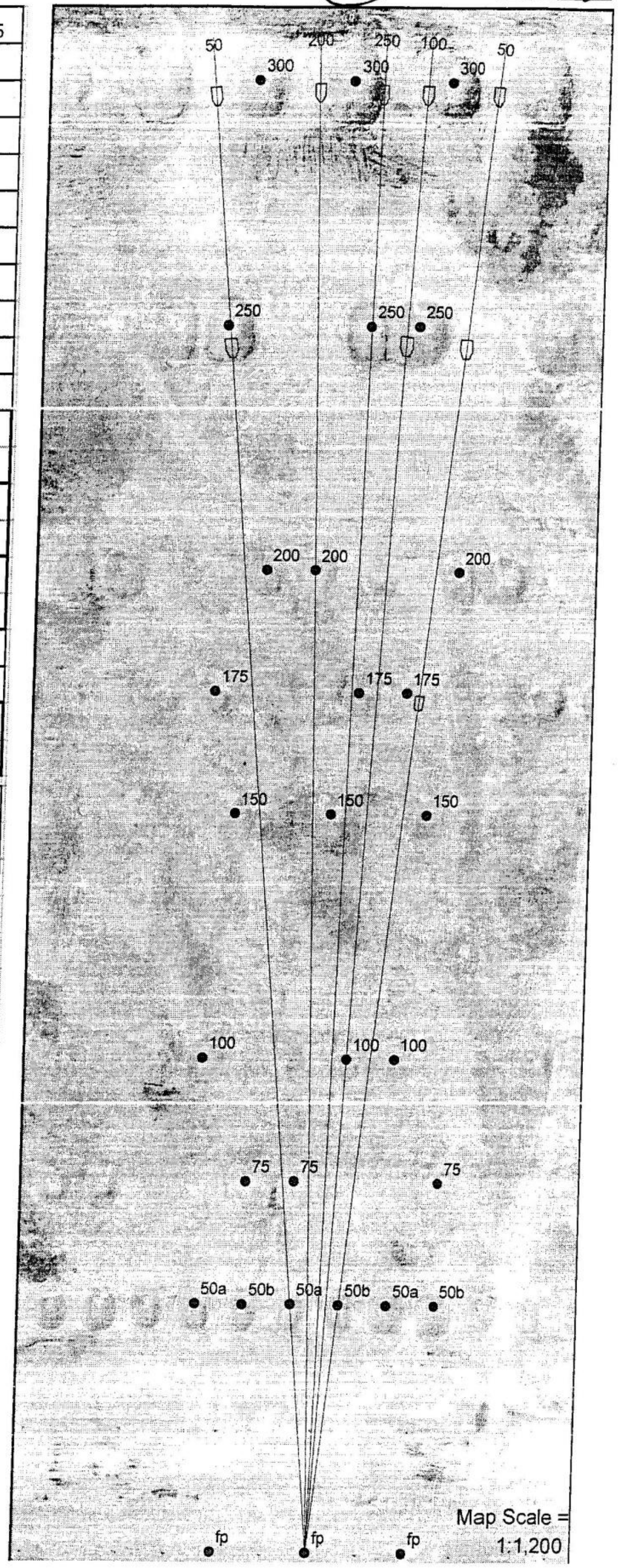
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	N/A
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	N/A
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	N/A
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	N/A



SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (37) **Firer** SSG CALI S

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	N/A
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	N/A
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	N/A

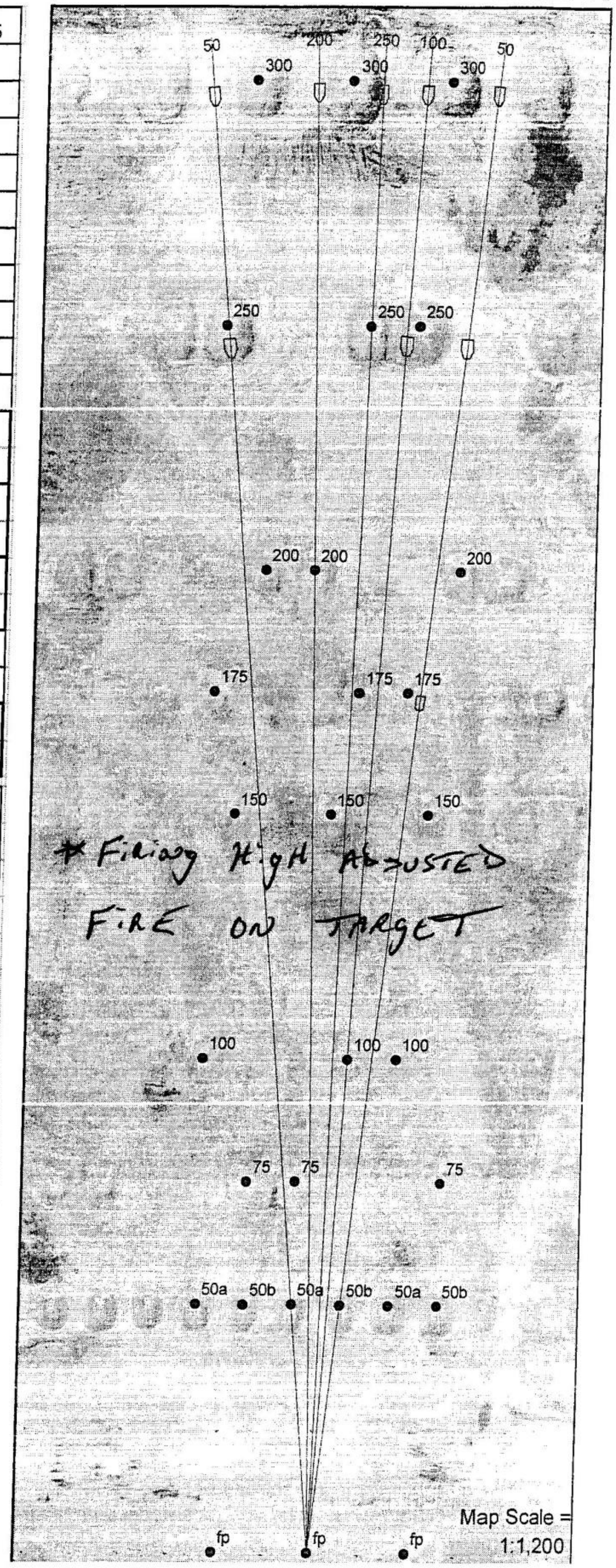


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (38) **Firer** SGT. DUNLAP

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m	N/A		
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m	N/A		
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m	N/A		
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

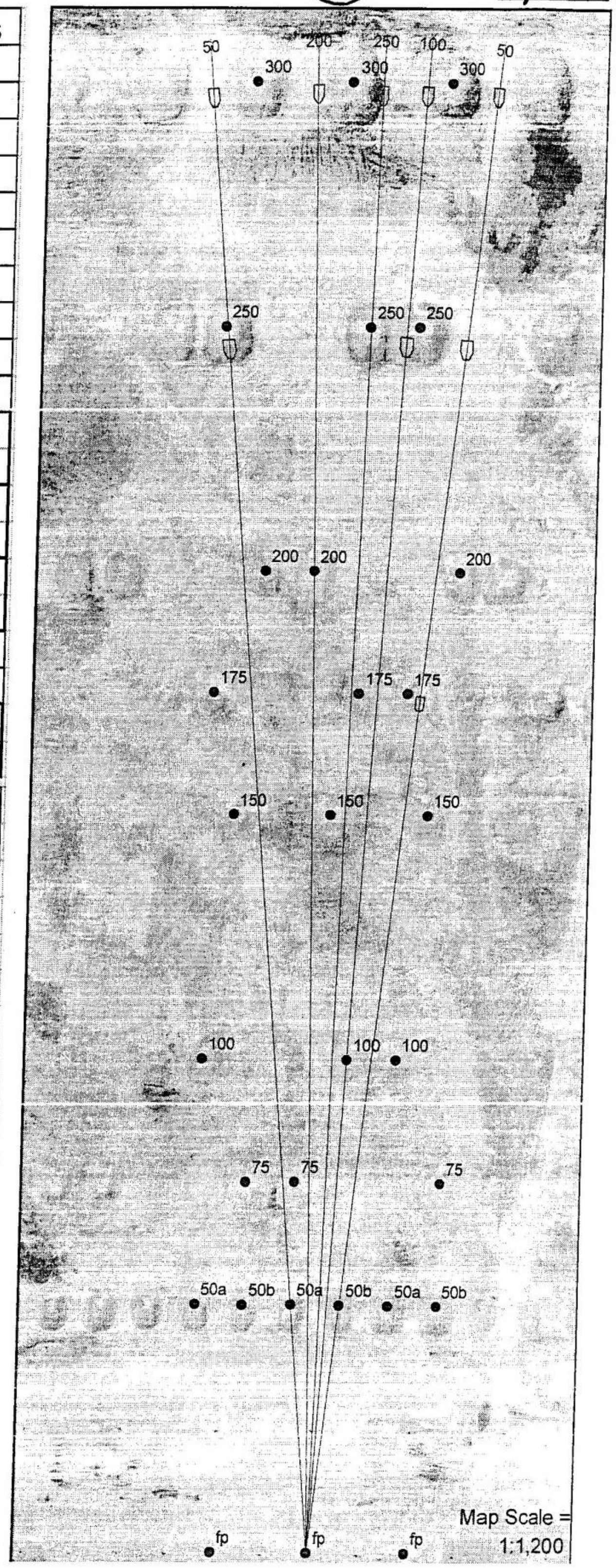
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (39) **Firer:** SGT. PASQUALE

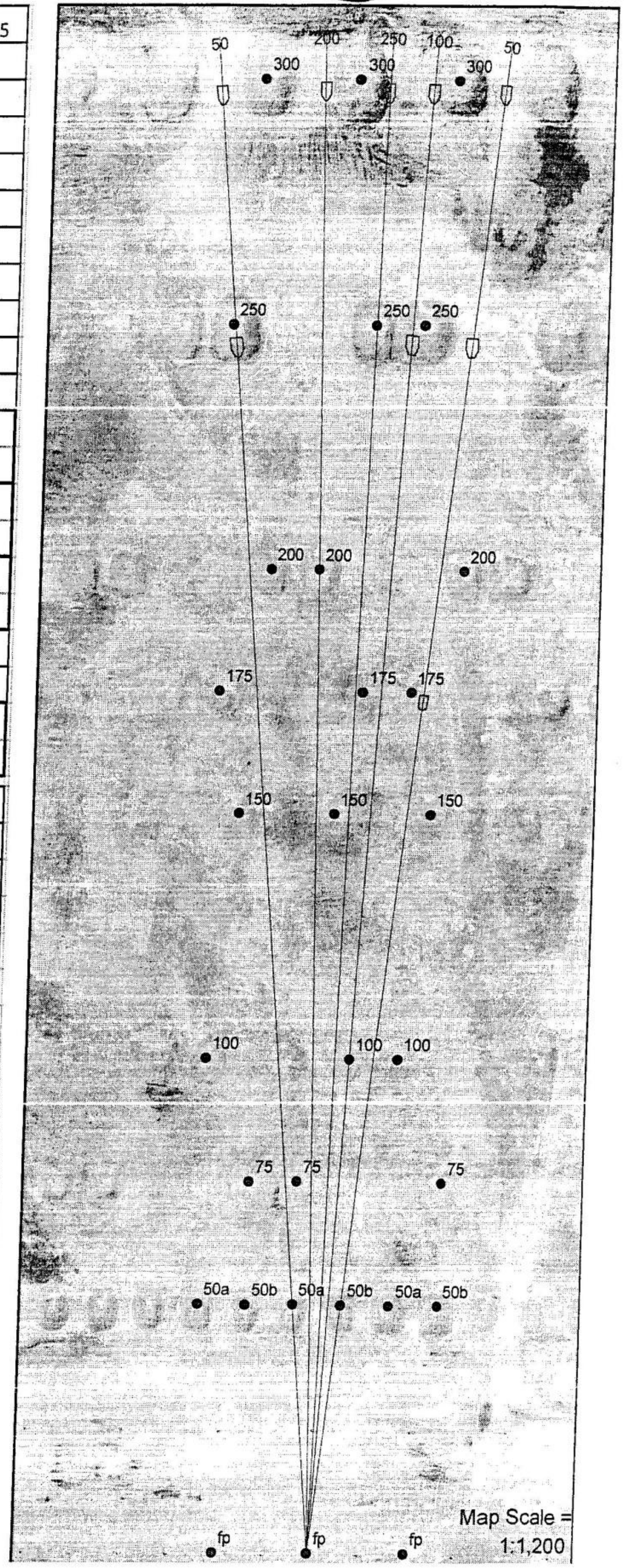
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	N/A
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	N/A
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	N/A
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	N/A
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (40) **Firer** SGT. Armstrong

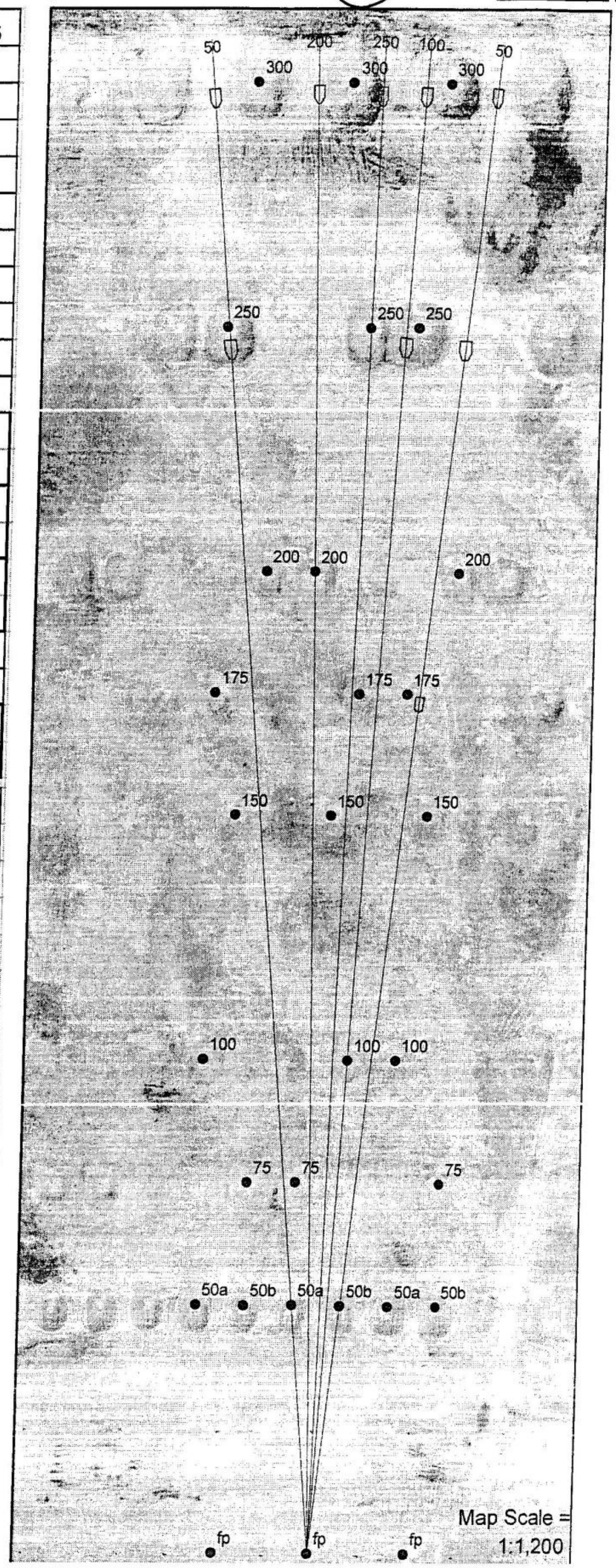
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m	N/A		
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS			
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m	N/A		
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m	N/A		
13	150	SIT	300m	N/A		
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m	N/A		
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m	N/A		
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m	N/A		
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	N/A
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	



SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (41) Firer SFC MORREIRA

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	N/A
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

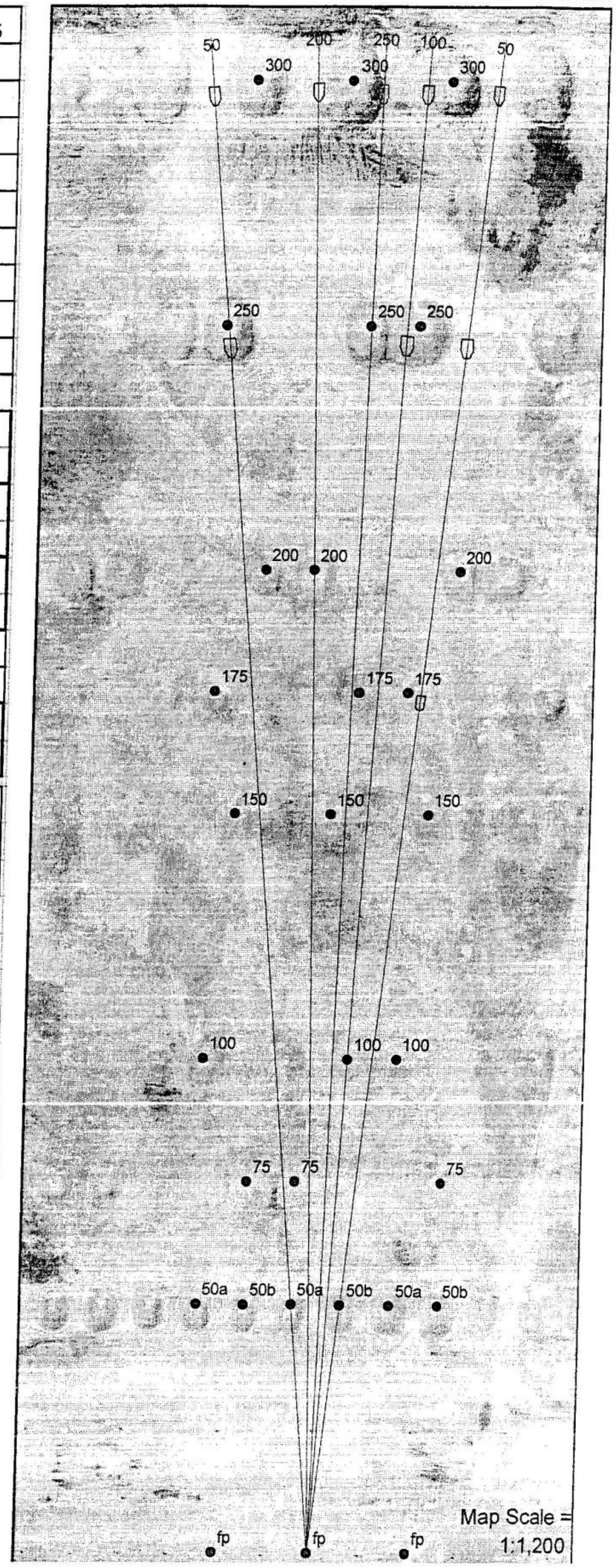


SIT = target frontal berm BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (42) **Firer** SGT. [illegible]

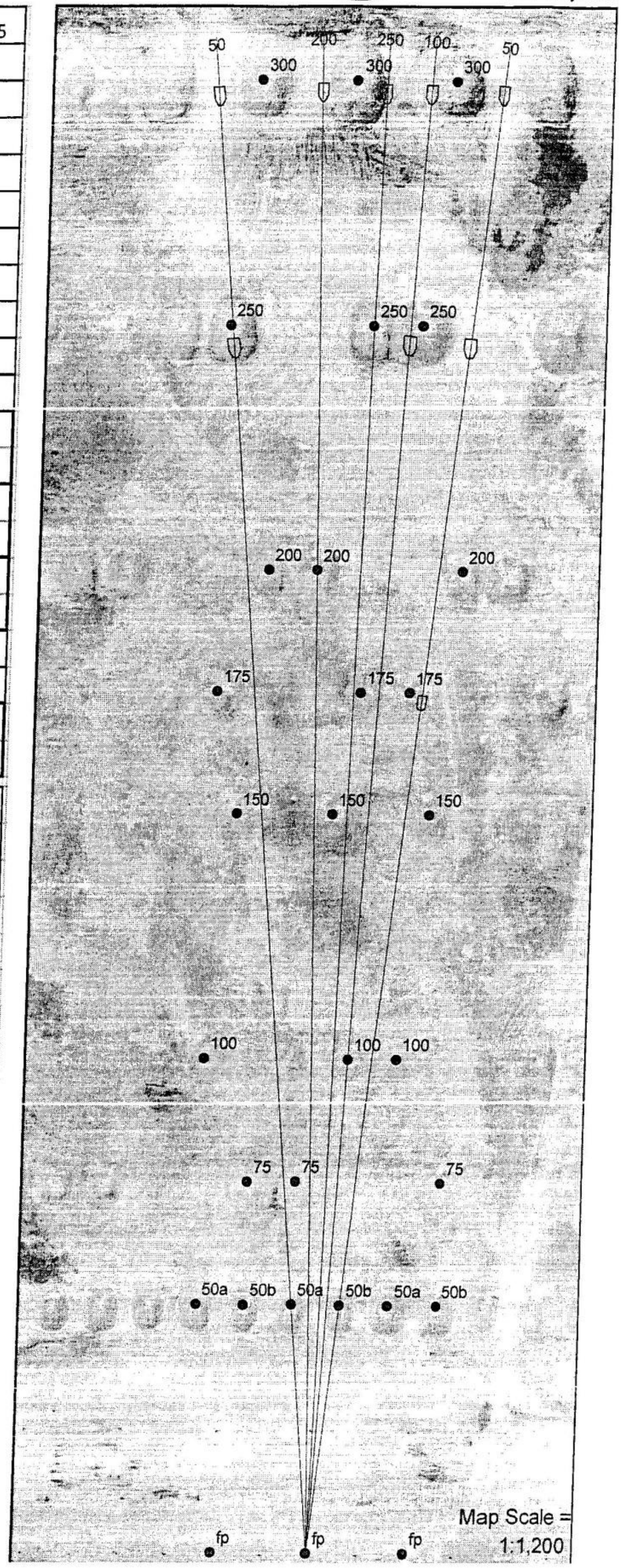
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS			
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m	N/A		
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m	N/A		
18	150	SIT	300m	N/A		
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	N/A
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

SIT = target frontal berm, BS = backstop berm



Lane 6 Phase 3 LOS Analysis Composite Worksheet (43) Firer SFC BEY

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m	N/A		
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

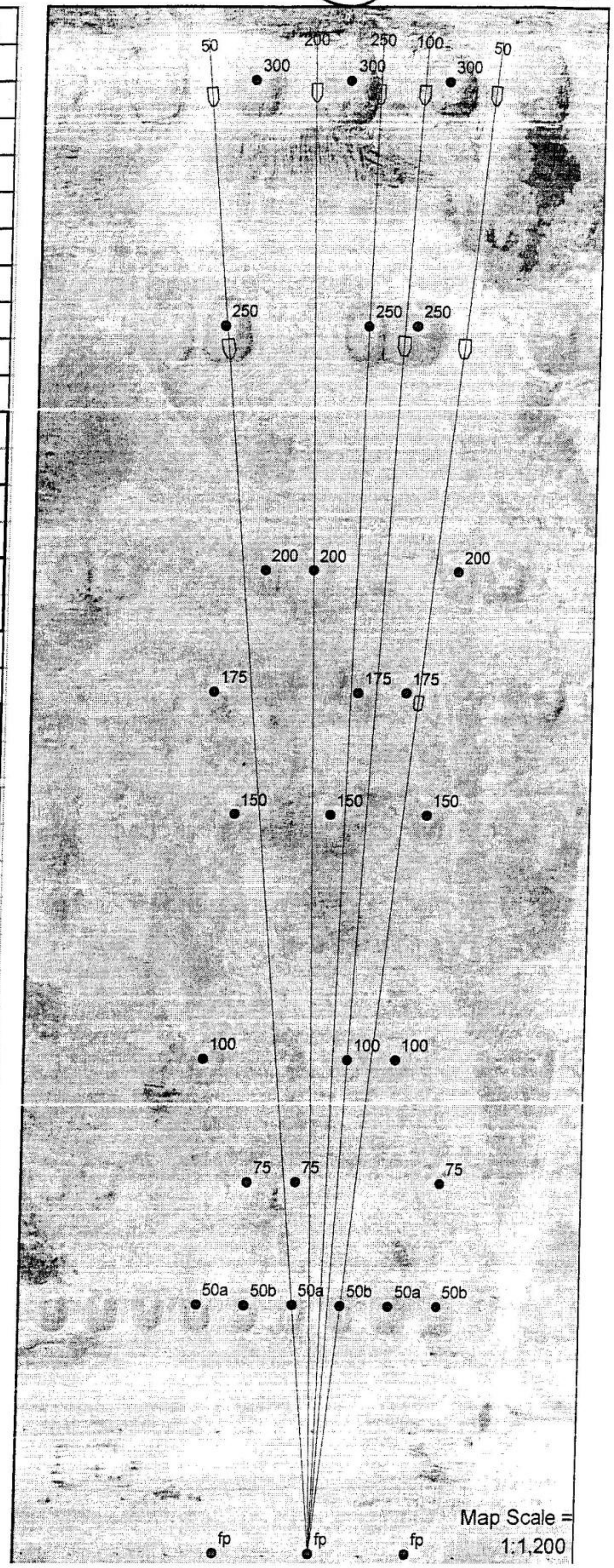


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (44) **Firer** SSG CAL, S

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	N/A		
9	150	SIT	300m			
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

SIT = target frontal berm, BS = backstop berm

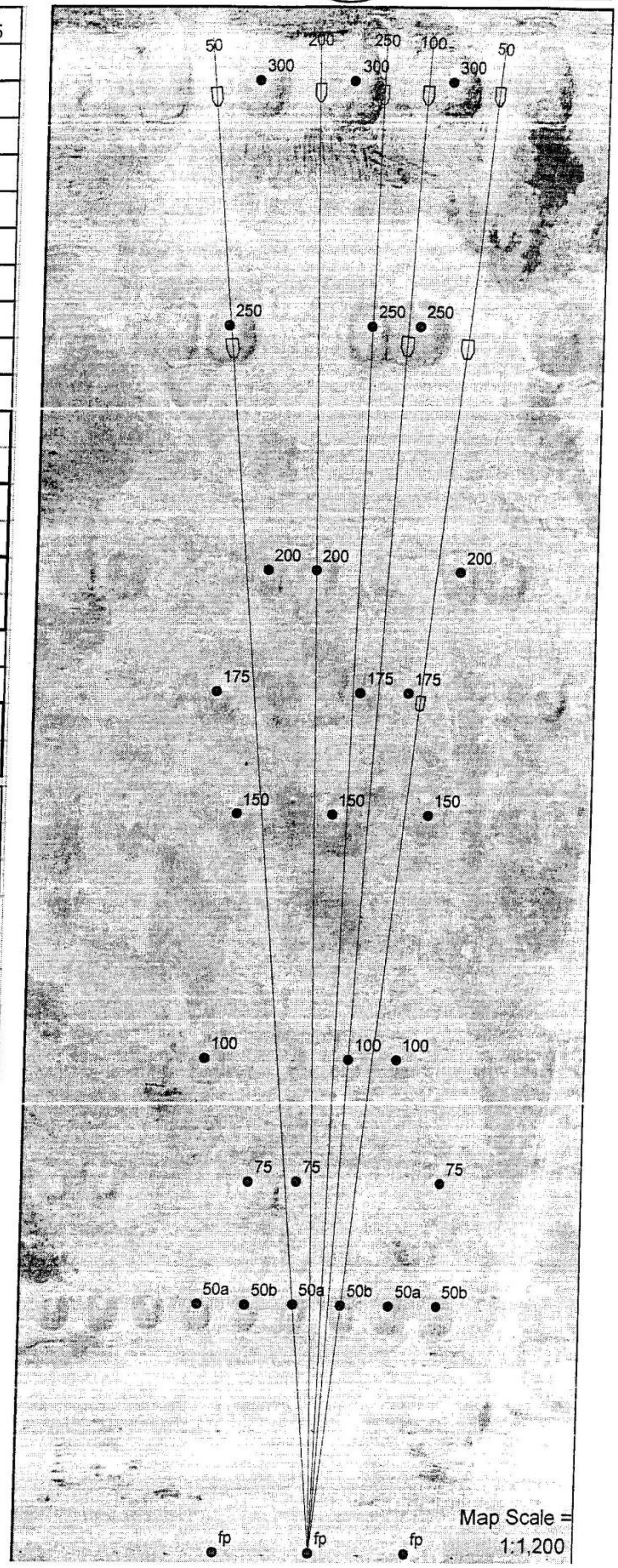


56 T.

Lane 6 Phase 3 LOS Analysis Composite Worksheet (45) Firer D. PASQUALE

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m	N/A		
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS?	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m	N/A		
24	300	SIT	BS	N/A		
25	200	SIT	300m	N/A		
26	150	SIT	300m	N/A		
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	N/A
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

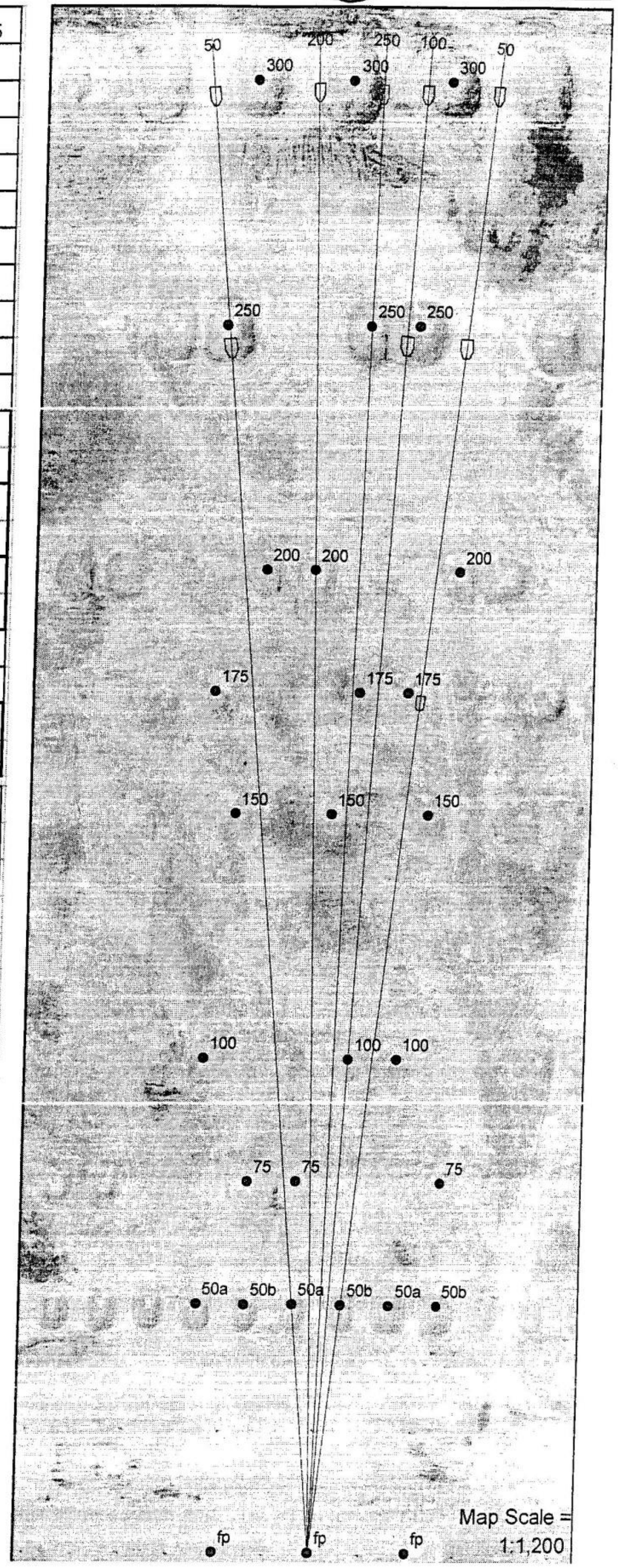
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (46) **Firer** SGT WALSH

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS	N/A		
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m	N/A		
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m	N/A		
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m	N/A		
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m	N/A		
27	200	SIT	300m	N/A		
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m	N/A		
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m	N/A		
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

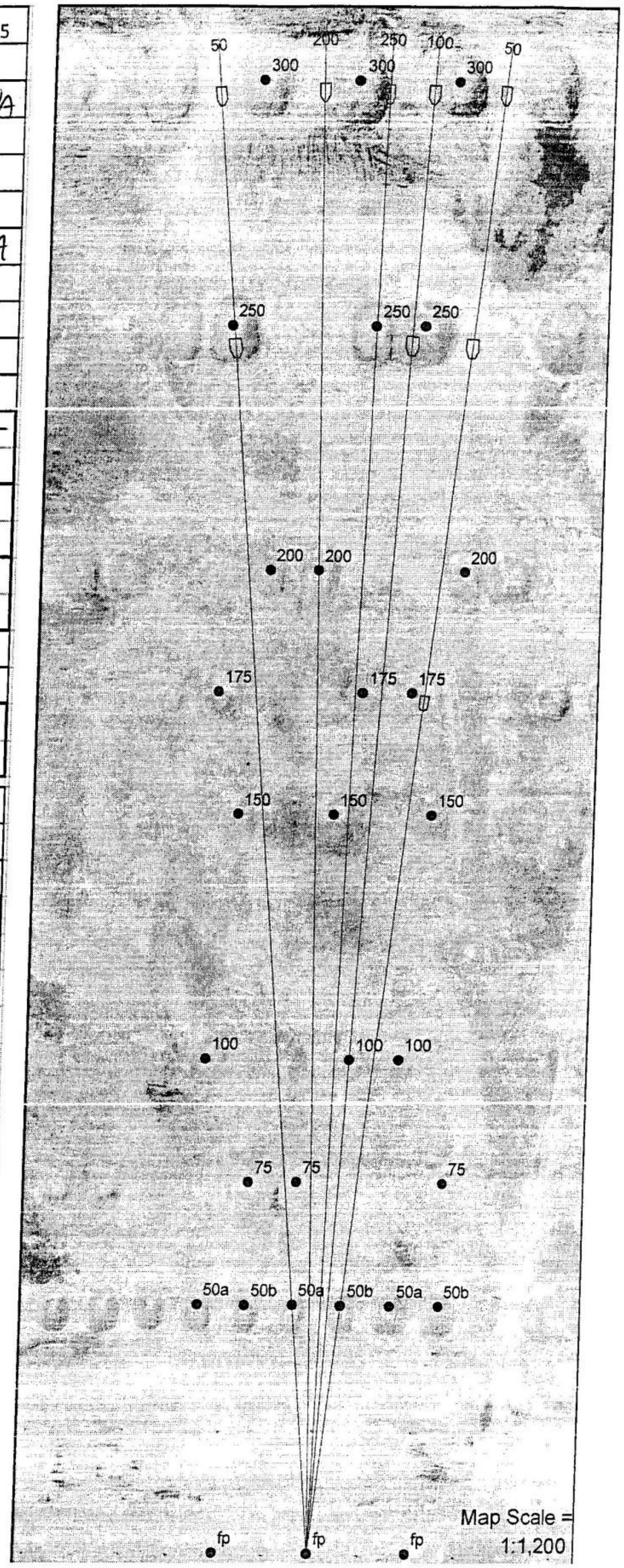
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (47) **Firer** SFC Eklund

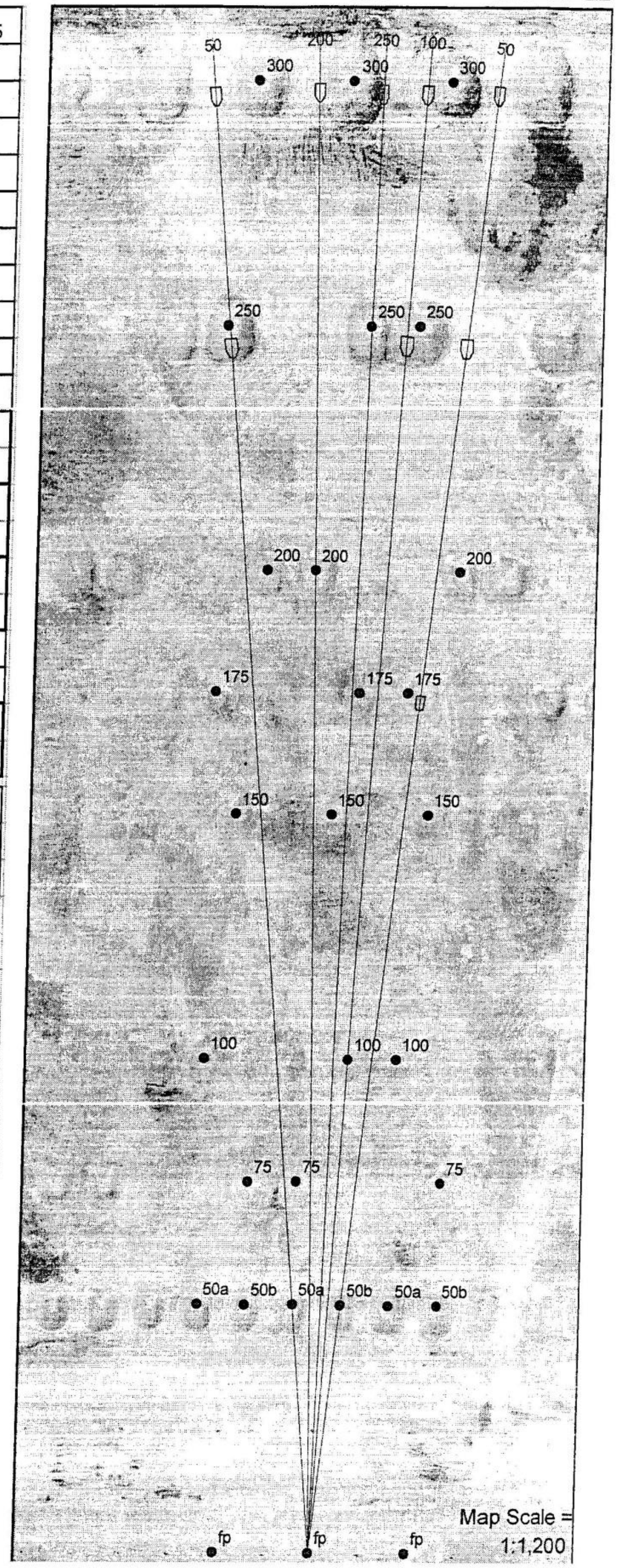
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			N/A
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			NA
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			NA
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	NA
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			NA
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			NA
22	250	SIT	300m			NA
23	150	SIT	300m			
24	300	SIT	[illegible]			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			NA
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	NA
36	50a	SIT	BS	250m	300m	NA
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (18) **Firer** SGT. MOSHER

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS	N/A		
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m	N/A		
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m	N/A		
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m	N/A		
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m	N/A		
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	N/A
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			N/A
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

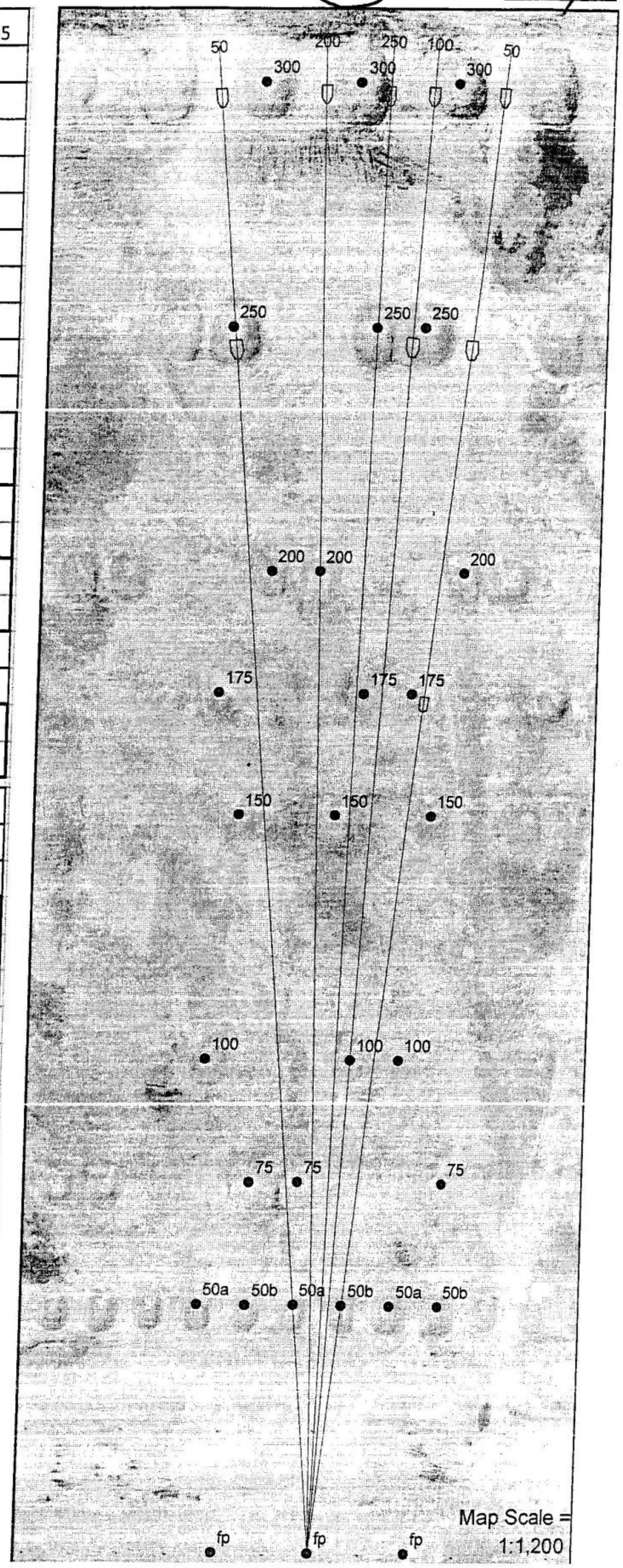


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (49) **Firer** SFC BEY

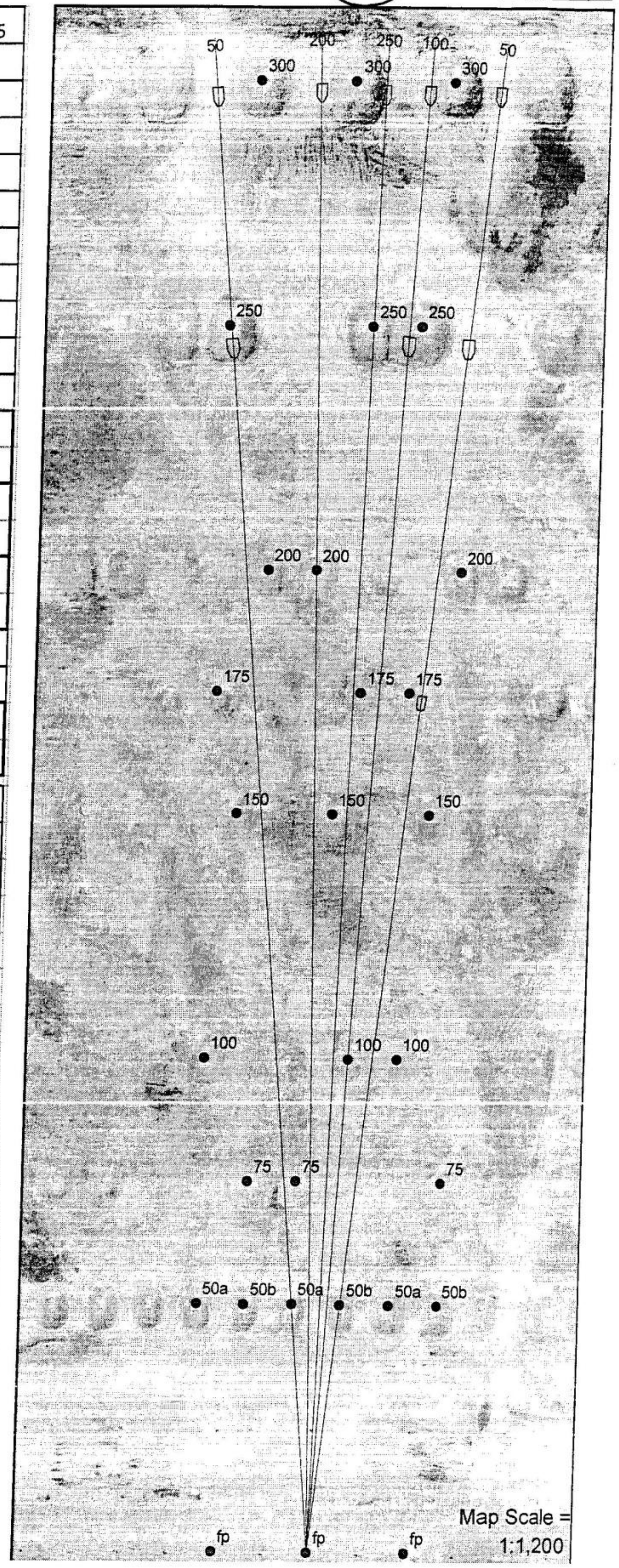
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS	N/A		
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (50) **Firer** SSG Calis

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m	N/A		
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m	N/A		
24	300	SIT	BS	N/A		
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	



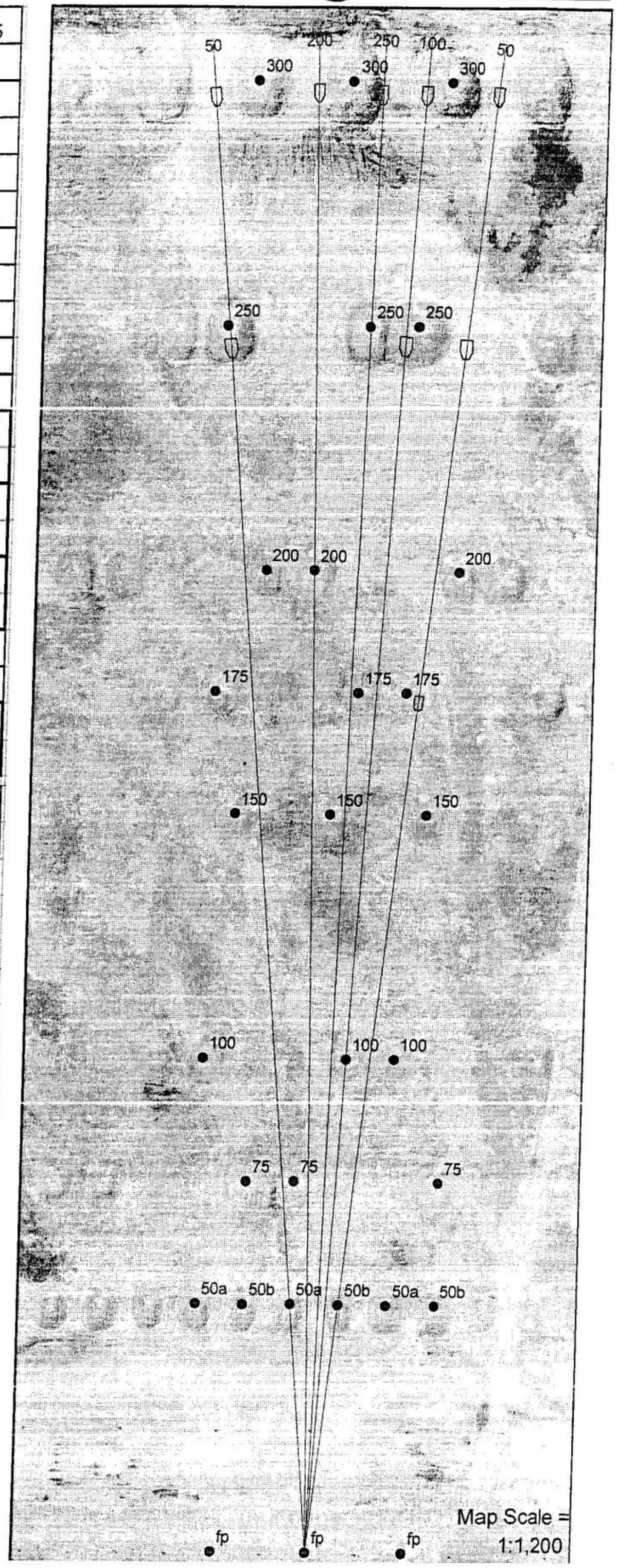
SIT = target frontal berm, BS = backstop berm

MAJ

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (51) **Firer** BENNAKATO

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m	N/A		
5	300	SIT	BS			
6	250	SIT	300m	N/A		
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	N/A
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	N/A
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m	N/A		
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m	N/A		
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	N/A
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	N/A
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	N/A

SIT = target frontal berm, BS = backstop berm

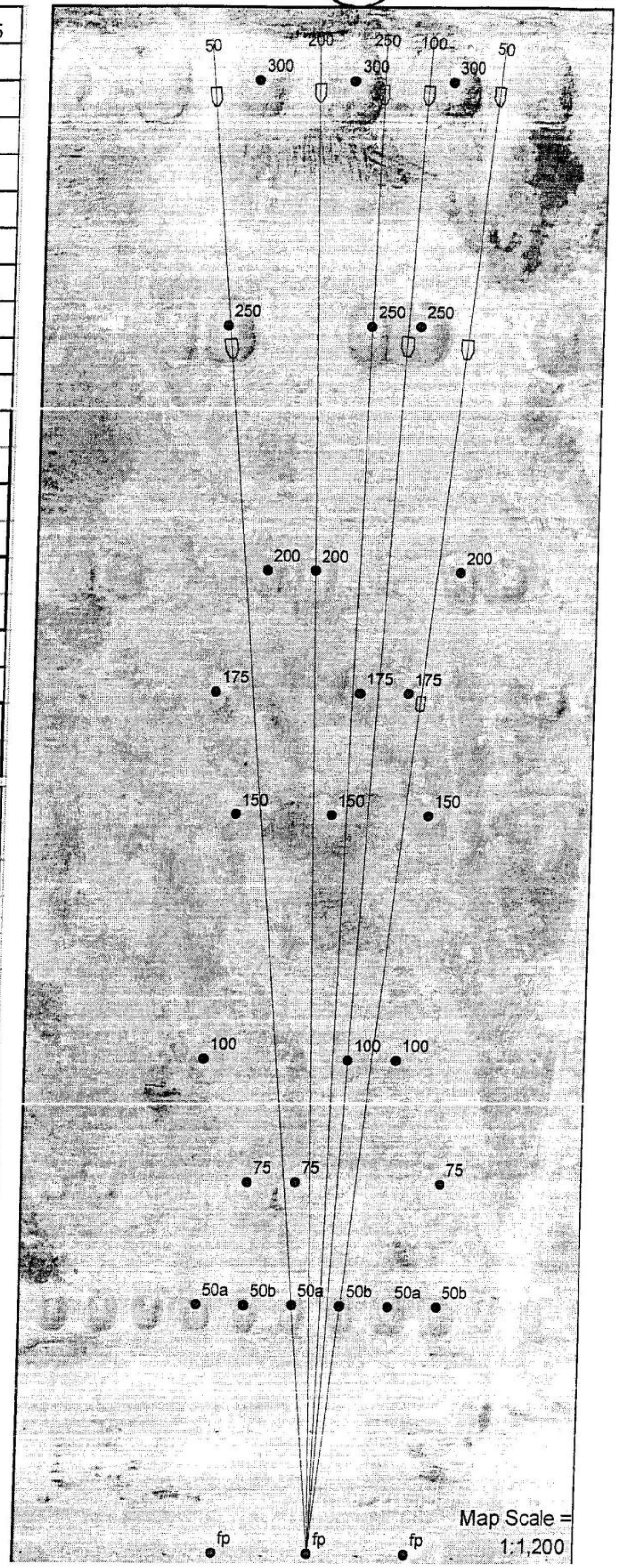


SFC

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (52) Firer Eklund

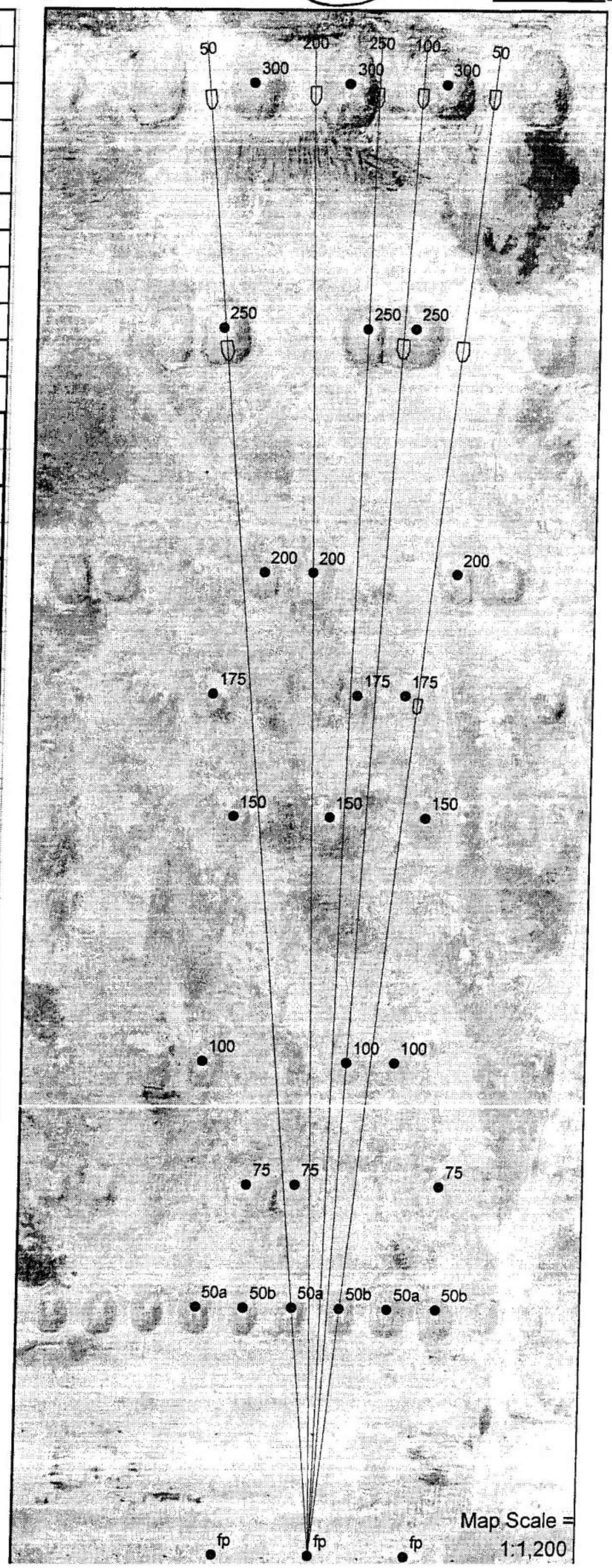
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m	NA		
9	150	SIT	300m			
10	250	SIT	300m			
11	100	SIT	BS	250m	300m	
12	200	SIT	300m			
13	150	SIT	300m			
14	300	SIT	BS			
15	100	SIT	BS	250m	300m	
16	250	SIT	300m			
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	
20	100	SIT	BS	250m	300m	NA
21	200	SIT	300m			
22	250	SIT	300m			
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m			
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m			
32	50b	SIT	BS	175m	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50a	SIT	BS	250m	300m	
37	100	SIT	BS	250m	300m	
38	150	SIT	300m			
39	50b	SIT	BS	175m	300m	
40	100	SIT	BS	250m	300m	

SIT = target frontal berm, BS = backstop berm



Lane 6 Phase 3 LOS Analysis Composite Worksheet (53) Firer SGT. D.PASQUALE

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	200	SIT	300m			
3	100	SIT	BS	250m	300m	
4	150	SIT	300m			
5	300	SIT	BS			
6	250	SIT	300m			
7	50b	SIT	BS	175m	300m	
8	200	SIT	300m			
9	150	SIT	300m	N/A		
10	250	SIT	300m	N/A		
11	100	SIT	BS	250m	300m	
12	200	SIT	300m	N/A		
13	150	SIT	300m			
14	300	SIT	BS	N/A		
15	100	SIT	BS	250m	300m	N/A
16	250	SIT	300m	N/A		
17	200	SIT	300m			
18	150	SIT	300m			
19	50a	SIT	BS	250m	300m	N/A
20	100	SIT	BS	250m	300m	N/A
21	200	SIT	300m			
22	250	SIT	300m	N/A		
23	150	SIT	300m			
24	300	SIT	BS			
25	200	SIT	300m			
26	150	SIT	300m			
27	200	SIT	300m			
28	250	SIT	300m	N/A		
29	150	SIT	300m			
30	150	SIT	300m			
31	150	SIT	300m	N/A		
32	50a	SIT	BS	~~175m~~ 250	300m	
33	100	SIT	BS	250m	300m	
34	150	SIT	300m			
35	100	SIT	BS	250m	300m	
36	50b	SIT	BS	~~250m~~ 175	300m	
37	100	SIT	BS	250m	300m	N/A
38	150	SIT	300m			
39	50a	SIT	BS	~~175m~~ 250	300m	
40	100	SIT	BS	250m	300m	

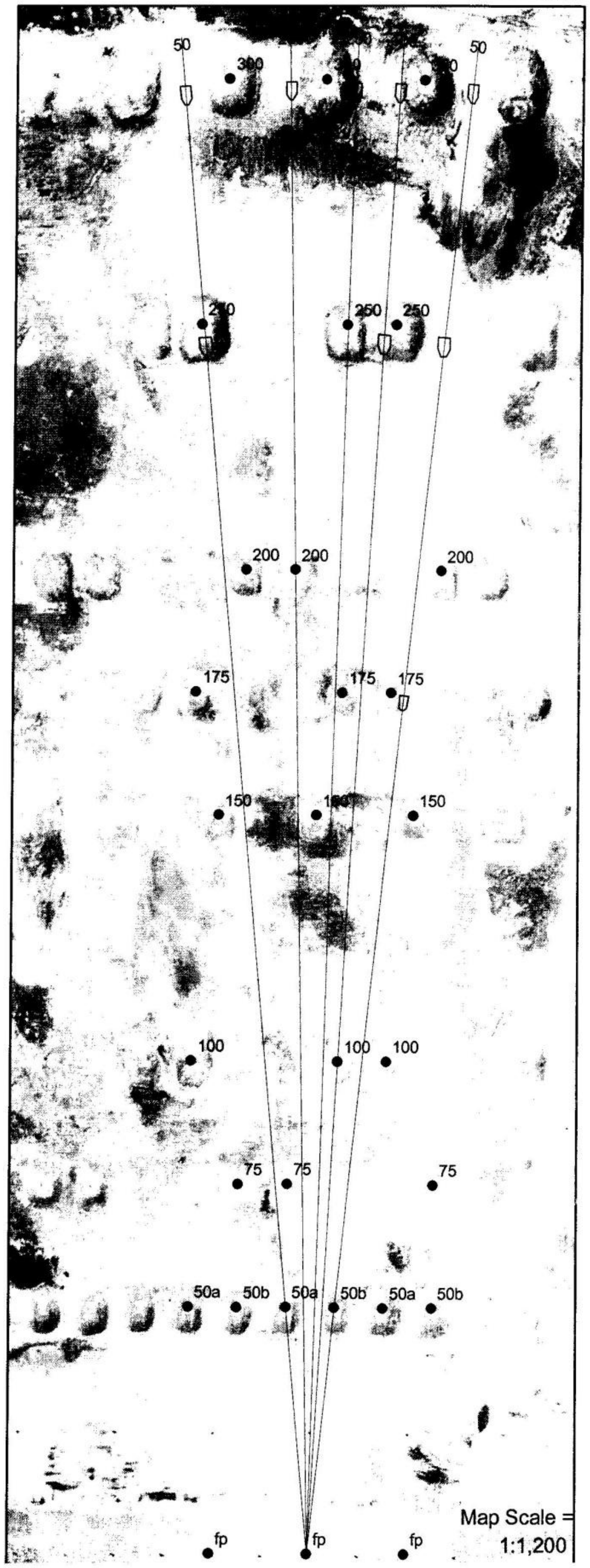


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (1) **Firer** MAJ. KOSK.

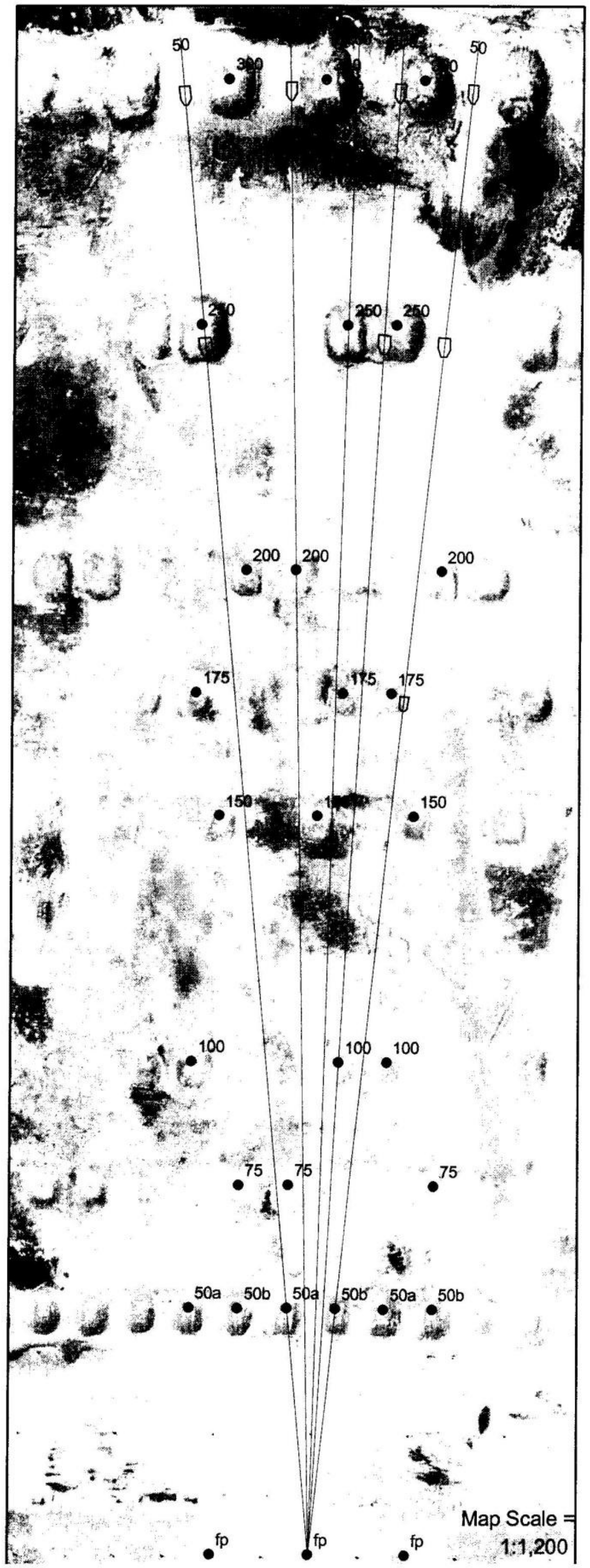
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		N/A
16	150	SIT	HIT	300m		N/A
17	150	SIT	HIT	300m		N/A
18	150	SIT	HIT	300m		N/A
19	150	SIT	HIT	300m		N/A
20	150	SIT	HIT	300m		N/A
21	150	SIT	HIT	300m		N/A
22	150	SIT	HIT	300m		N/A
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		N/A
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		N/A
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		N/A
38	300	SIT	BS			N/A
39	300	SIT	BS			N/A
40	300	SIT	BS			N/A

SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (5) **Firer** SGT. SIAGER

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		N/A
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		N/A
34	250	SIT	HIT	300m		
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m		N/A
37	250	SIT	HIT	300m		
38	300	SIT	BS			
39	300	SIT	BS			
40	300	SIT	BS			N/A

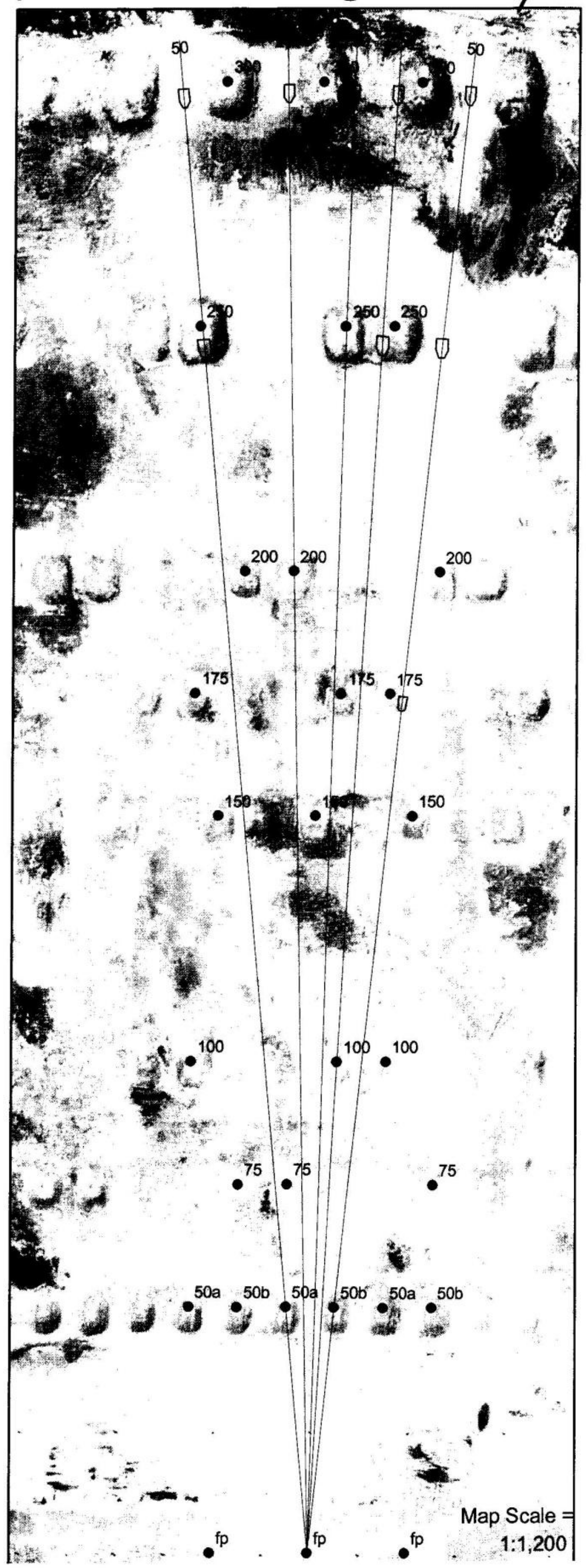


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (3) **Firer** SFC TAYLOR

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		[illegible]
16	150	SIT	HIT	300m		N/A
17	150	SIT	HIT	300m		N/A
18	150	SIT	HIT	300m		N/A
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		N/A
24	150	SIT	HIT	300m		N/A
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		N/A
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		N/A
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			N/A
39	300	SIT	BS			N/A
40	300	SIT	BS			

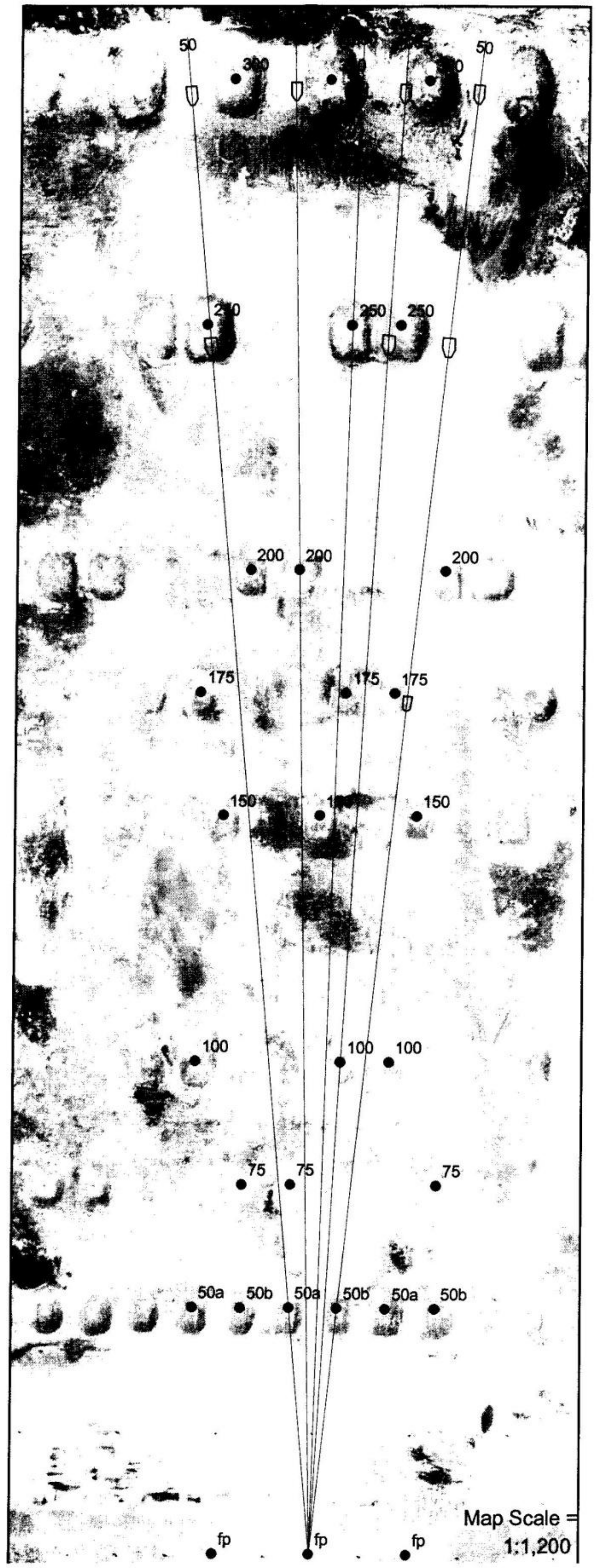
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (4) **Firer** PFC Scott

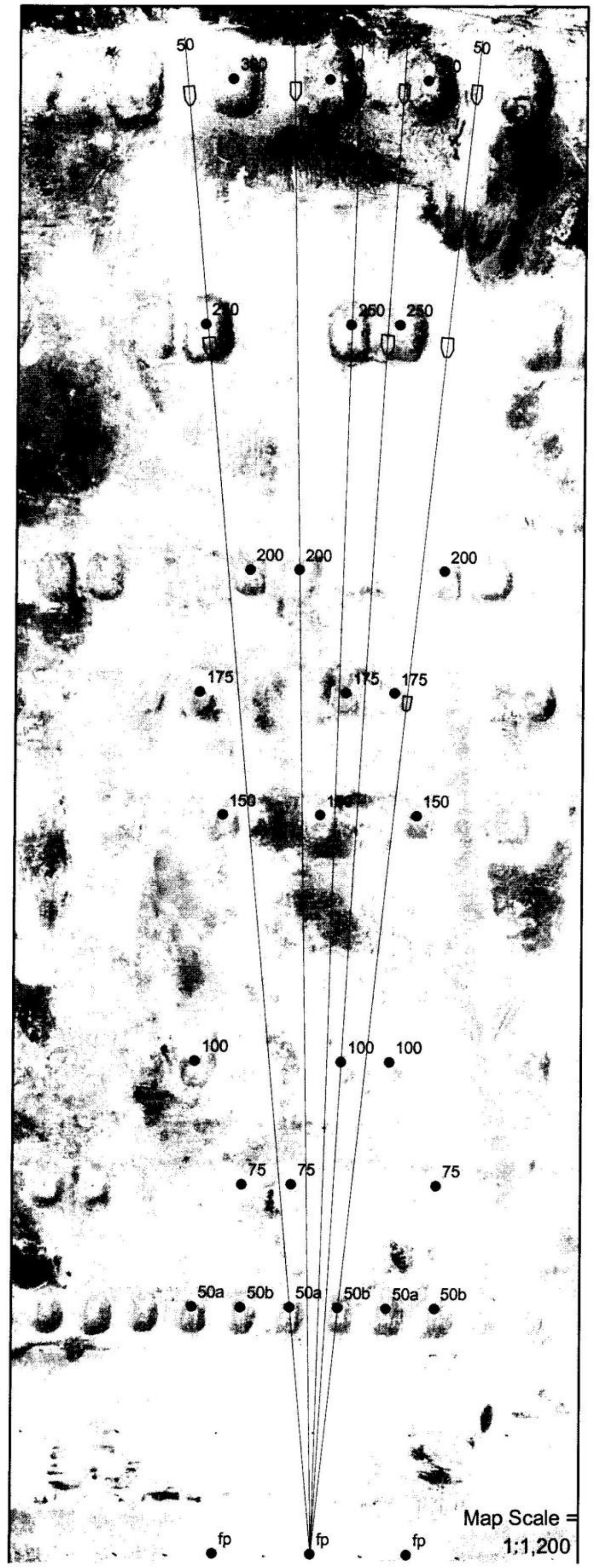
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		N/A
16	150	SIT	HIT	300m		N/A
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		N/A
21	150	SIT	HIT	300m		N/A
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		N/A
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		N/A
28	200	SIT	HIT	300m		N/A
29	200	SIT	HIT	300m		N/A
30	200	SIT	HIT	300m		N/A
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		N/A
33	250	SIT	HIT	300m		N/A
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		N/A
37	250	SIT	HIT	300m		N/A
38	300	SIT	BS			N/A
39	300	SIT	BS			N/A
40	300	SIT	BS			N/A

SIT = target frontal berm, BS = backstop berm



Lane 6 Phase 3 LOS Analysis Composite Worksheet (5) Firer 556 S:/VA

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	N/A
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		N/A
17	150	SIT	HIT	300m		N/A
18	150	SIT	HIT	300m		N/A
19	150	SIT	HIT	300m		N/A
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		N/A
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		N/A
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			
39	300	SIT	BS			N/A
40	300	SIT	BS			N/A

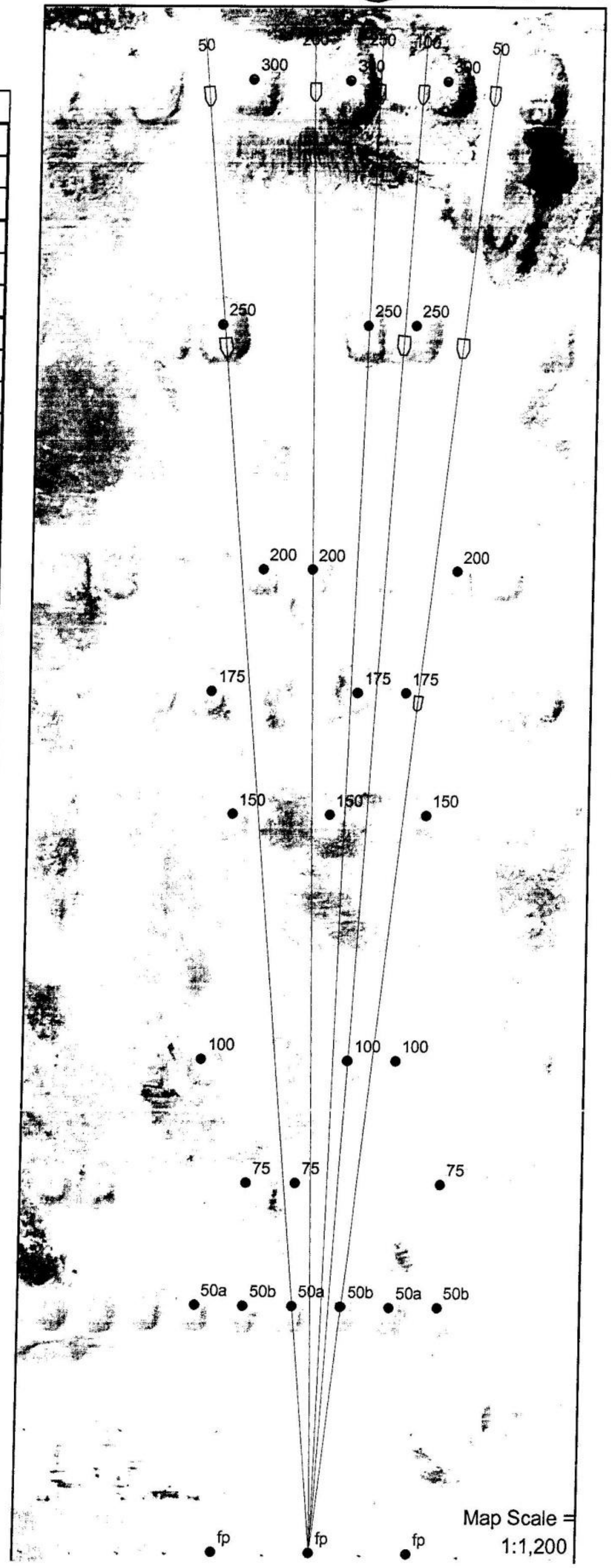


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (6) **Firer** SGT. DUNLAP

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	N/A
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	N/A
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		N/A
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		N/A
31	200	SIT	HIT	300m		N/A
32	200	SIT	HIT	300m		N/A
33	250	SIT	HIT	300m		N/A
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			N/A
39	300	SIT	BS			
40	300	SIT	BS			

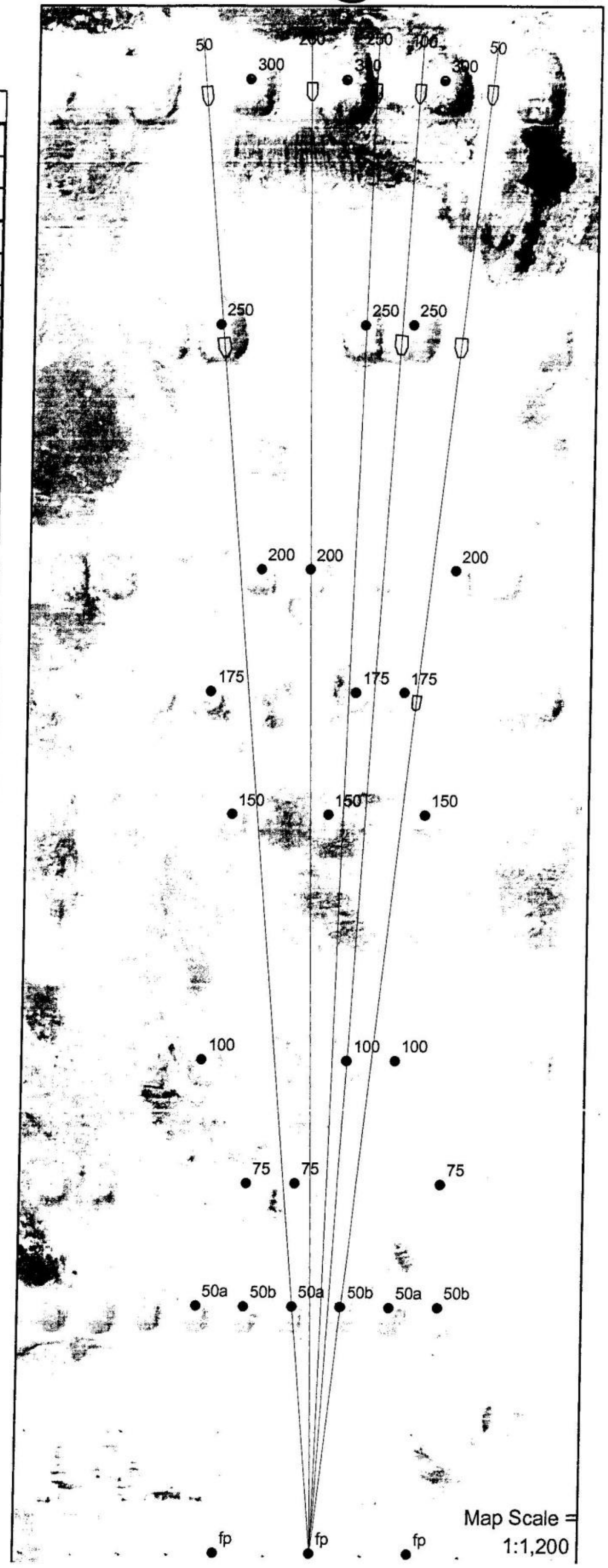
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (7) **Firer** SGT. WALSH

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		N/A
16	150	SIT	HIT	300m		N/A
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		N/A
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		N/A
23	150	SIT	HIT	300m		N/A
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		N/A
26	200	SIT	HIT	300m		N/A
27	200	SIT	HIT	300m		N/A
28	200	SIT	HIT	300m		N/A
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		N/A
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		N/A
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		N/A
37	250	SIT	HIT	300m		N/A
38	300	SIT	BS			N/A
39	300	SIT	BS			N/A
40	300	SIT	BS			N/A

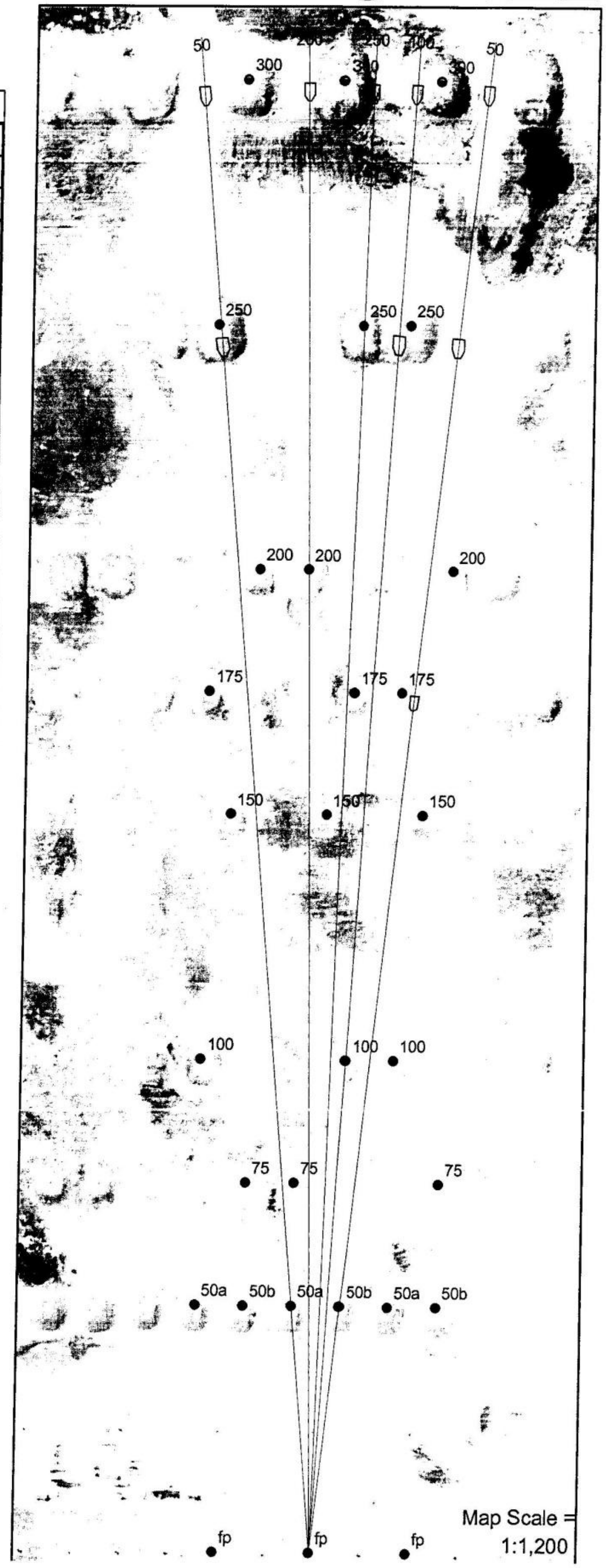
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (8) **Firer** CALIS 55G

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	N/A
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	3[illegible]		
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			
39	300	SIT	BS			N/A
40	300	SIT	BS			N/A

SIT = target frontal berm, BS = backstop berm

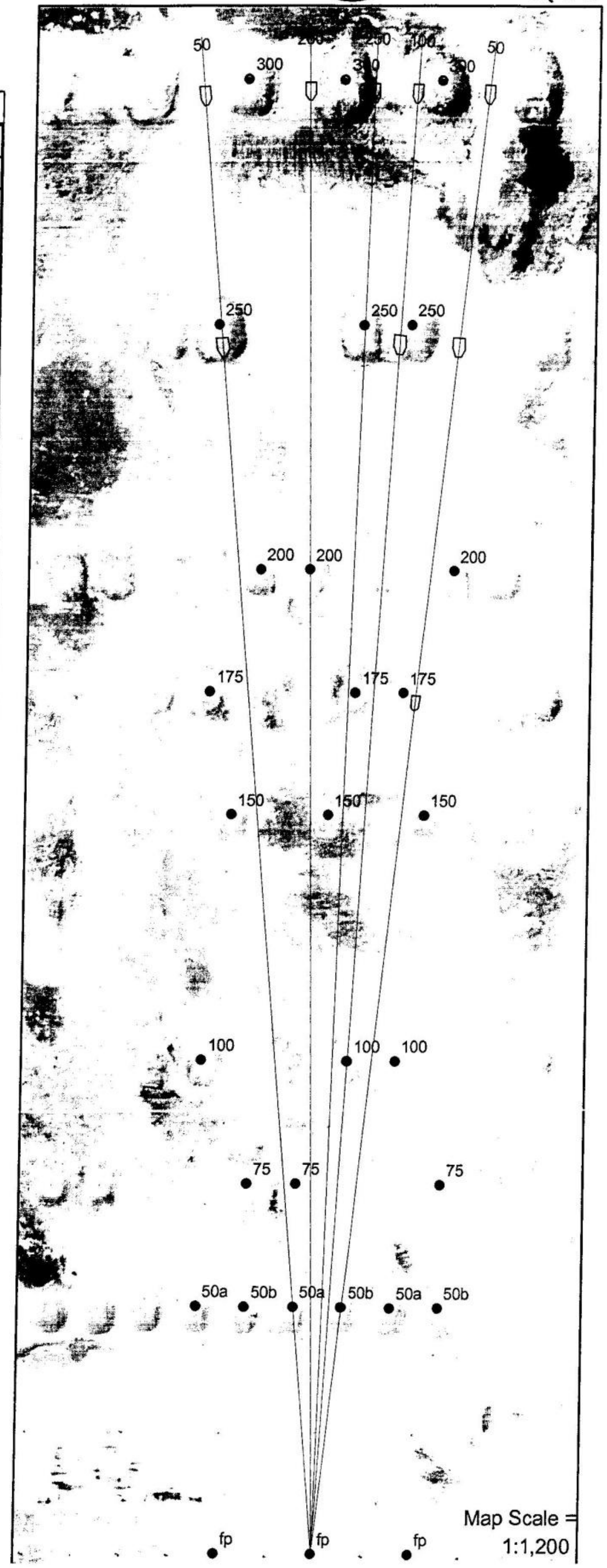


Lane 6 EK

Phase 3 LOS Analysis Composite Worksheet

(9) **Firer** SFC [illegible]

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	✓
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m	✓	
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m	✓	
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m	✓	
32	200	SIT	HIT	300m	✓	
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		
35	250	SIT	HIT	300m	✓	
36	250	SIT	HIT	300m	✓	
37	250	SIT	HIT	300m		
38	300	SIT	BS		✓	
39	300	SIT	BS		✓	
40	300	SIT	BS		✓	

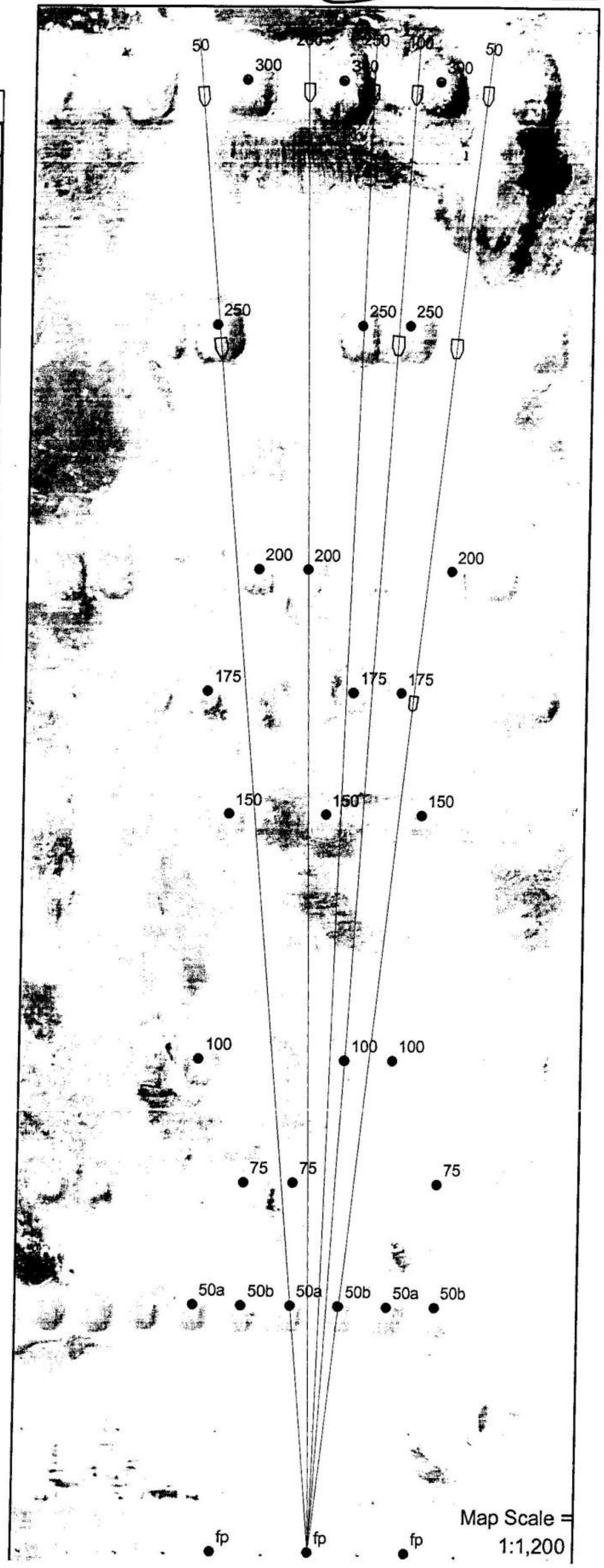


SIT = target frontal berm, BS = backstop berm

Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (10) **Firer** SGT SINGER

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		N/A
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			
39	300	SIT	BS			
40	300	SIT	BS			

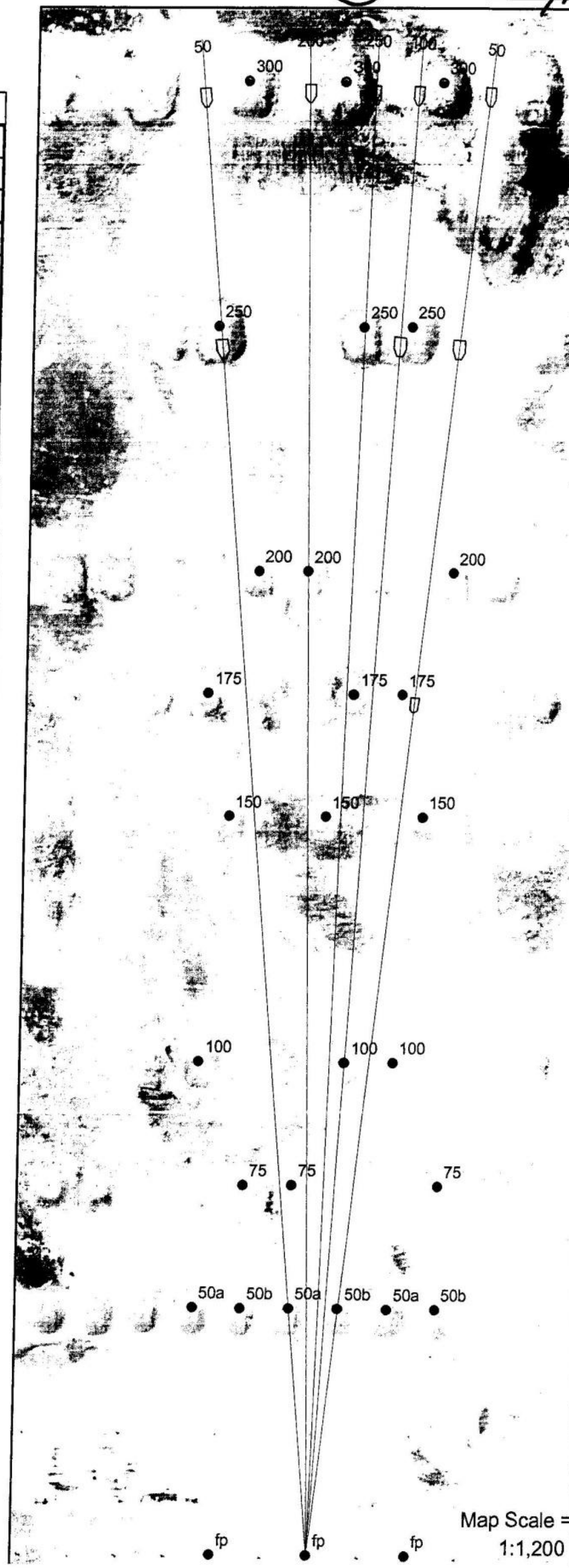
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (11) **Firer** SFC TAYLOR

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		N/A
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		N/A
26	200	SIT	HIT	300m		N/A
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		N/A
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			
39	300	SIT	BS			
40	300	SIT	BS			

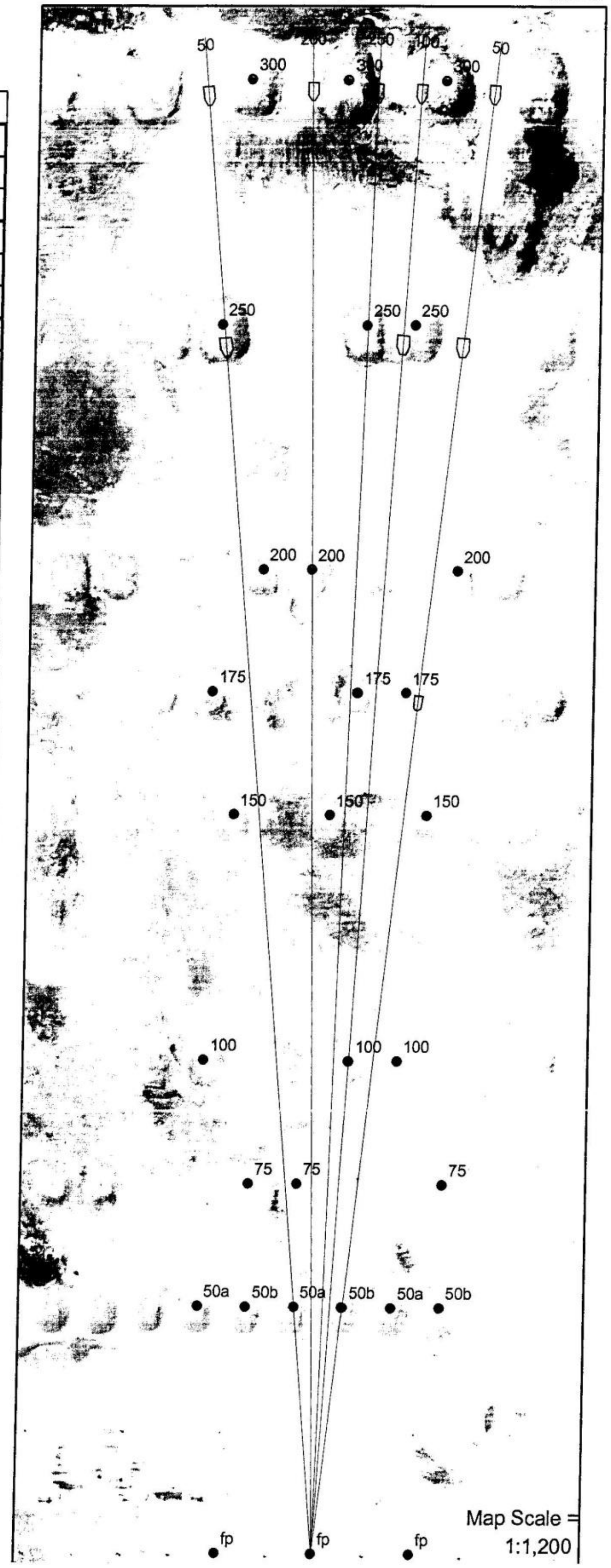
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (12) **Firer** PFC Scott

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		N/A
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		N/A
27	200	SIT	HIT	300m		N/A
28	200	SIT	HIT	300m		N/A
29	200	SIT	HIT	300m		N/A
30	200	SIT	HIT	300m		N/A
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		N/A
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m		N/A
37	250	SIT	HIT	300m		N/A
38	300	SIT	BS			N/A
39	300	SIT	BS			N/A
40	300	SIT	BS			N/A

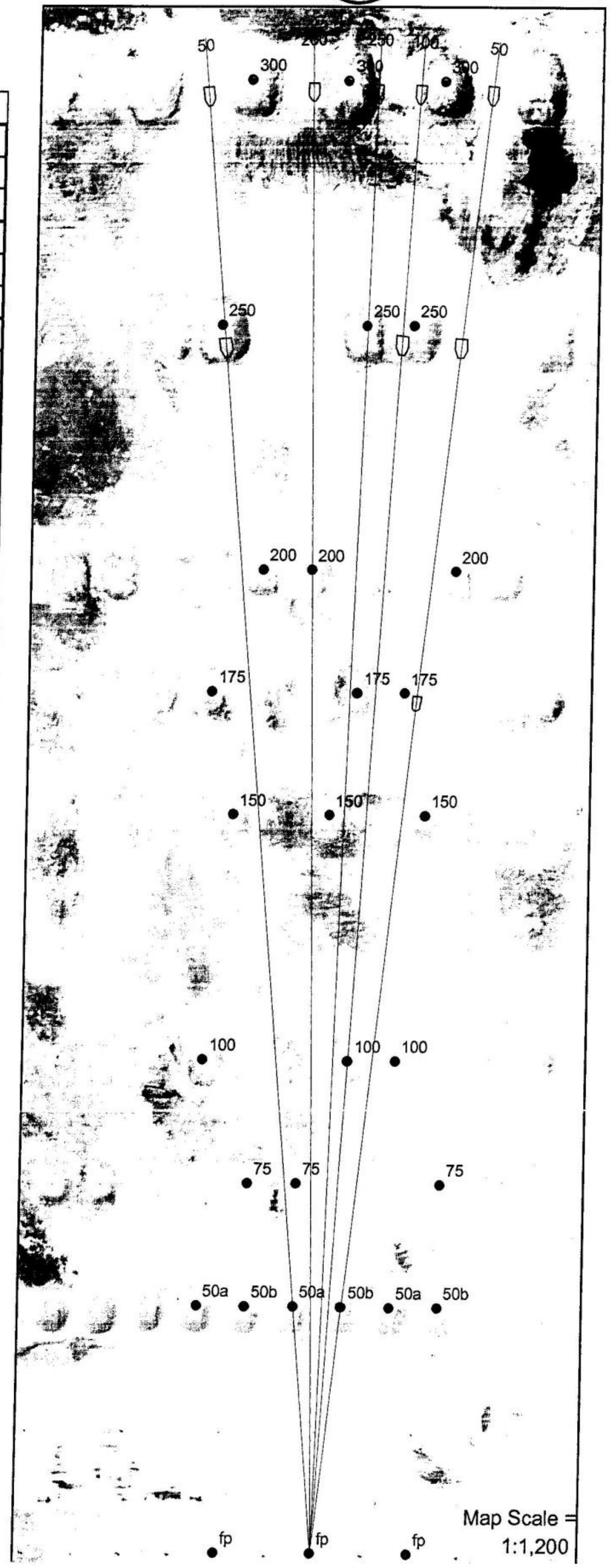
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (13) **Firer** SSG S:lvA

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		N/A
16	150	SIT	HIT	300m		N/A
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		N/A
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		N/A
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		N/A
28	200	SIT	HIT	300m		N/A
29	200	SIT	HIT	300m		N/A
30	200	SIT	HIT	300m		
31	200	[illegible]	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			N/A
39	300	SIT	BS			
40	300	SIT	BS			N/A

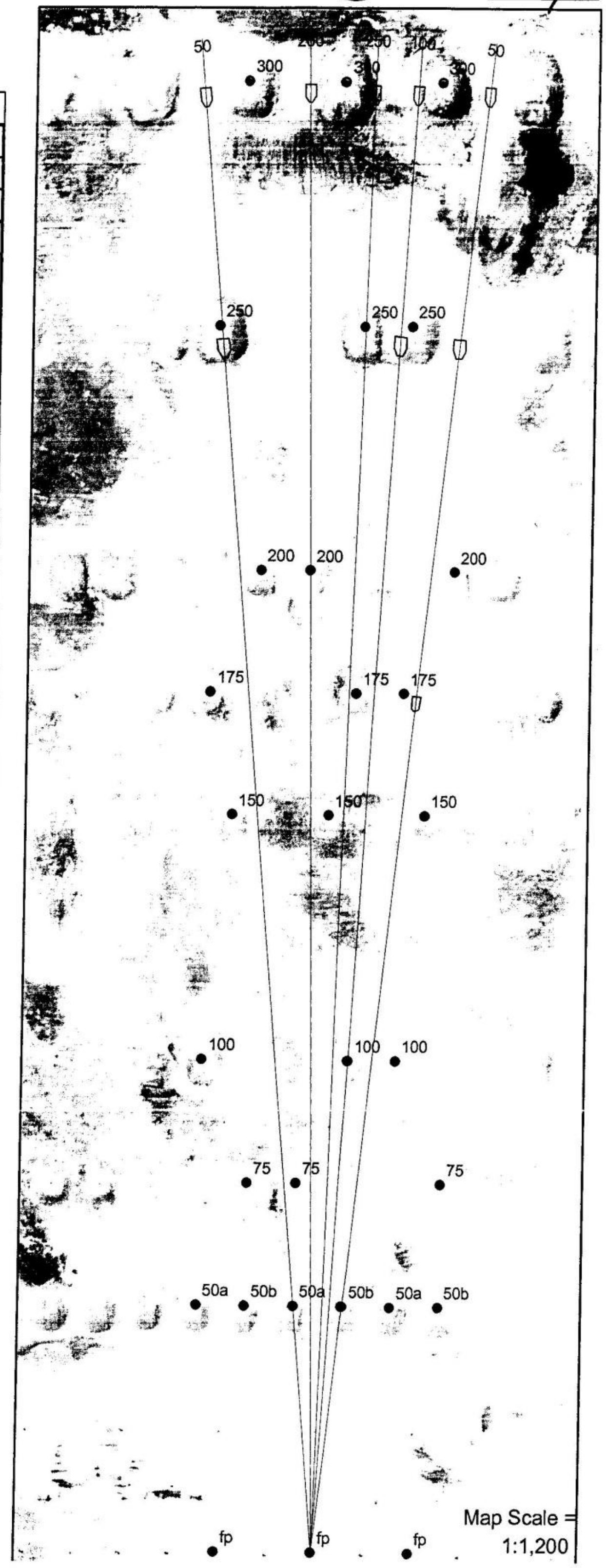
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (14) **Firer** SFC BEY

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			N/A
39	300	SIT	BS			
40	300	SIT	BS			N/A

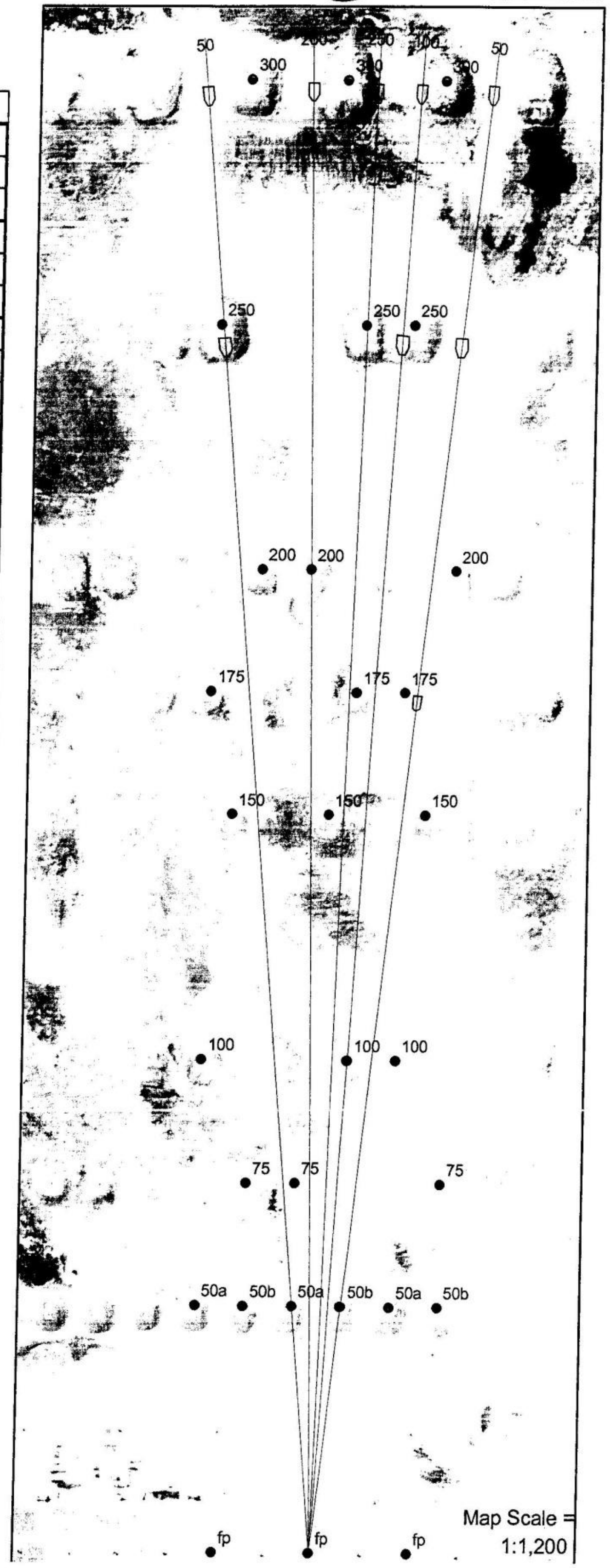
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (15) Firer SSG CALIS

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	N/A
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			
39	300	SIT	BS			
40	300	SIT	BS			

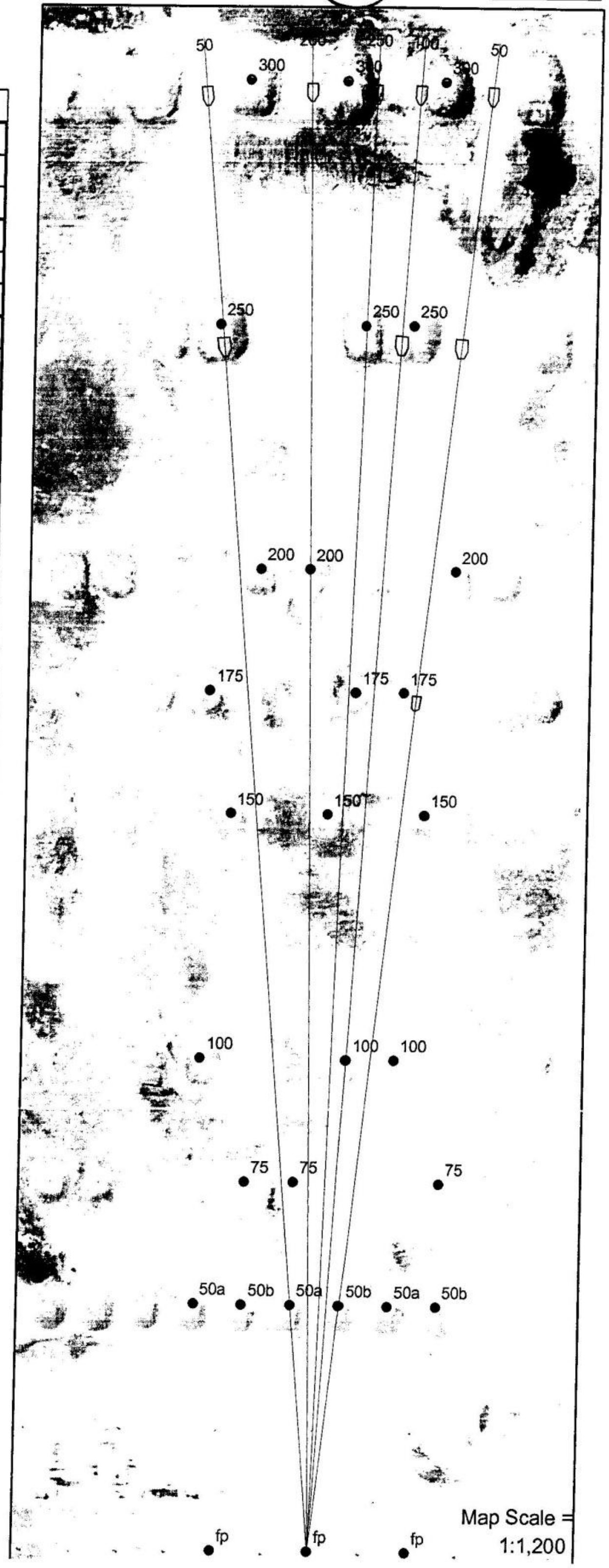
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (16) **Firer** SSG Silva

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m		
37	250	SIT	HIT	300m		
38	300	SIT	BS			
39	300	SIT	BS			
40	300	SIT	BS			

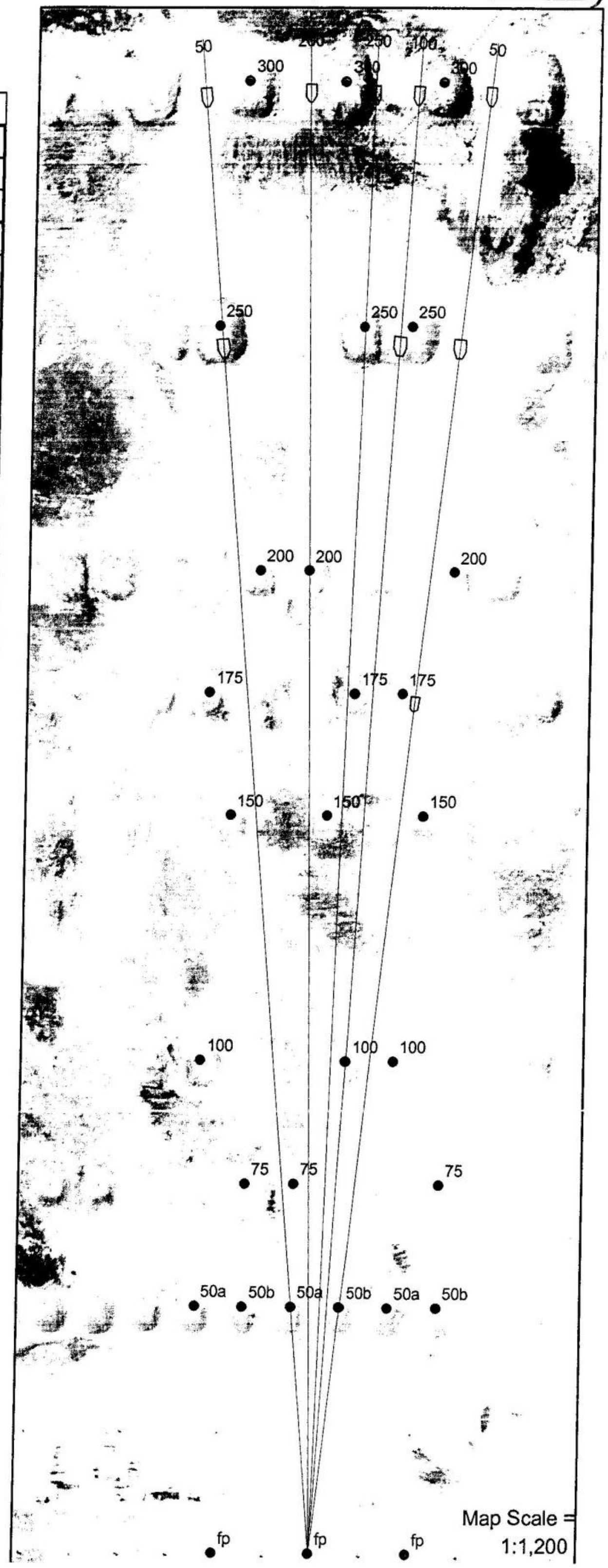
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** 17 **Firer** 56+ Armstrong

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	NA
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	NA
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	NA
15	150	SIT	HIT	300m	NA	
16	150	SIT	HIT	300m	NA	
17	150	SIT	HIT	300m	NA	
18	150	SIT	HIT	300m	NA	
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m	NA	
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		
28	200	SIT	HIT	300m	NA	
29	200	SIT	HIT	300m	NA	
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m	NA	
33	250	SIT	HIT	300m	NA	
34	250	SIT	HIT	300m	NA	
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m	NA	
37	250	SIT	HIT	300m		
38	300	SIT	BS			
39	300	SIT	BS		NA	
40	300	SIT	BS			

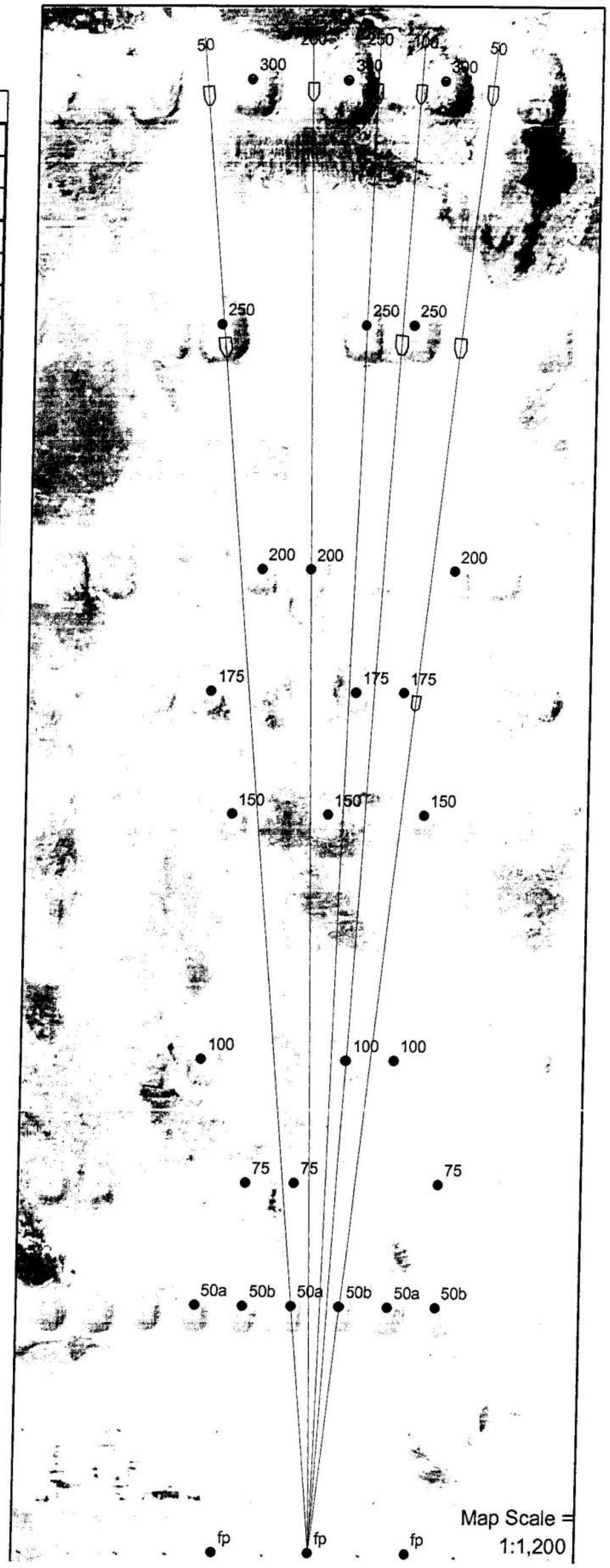
SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** 18 **Firer** S36 Eklen

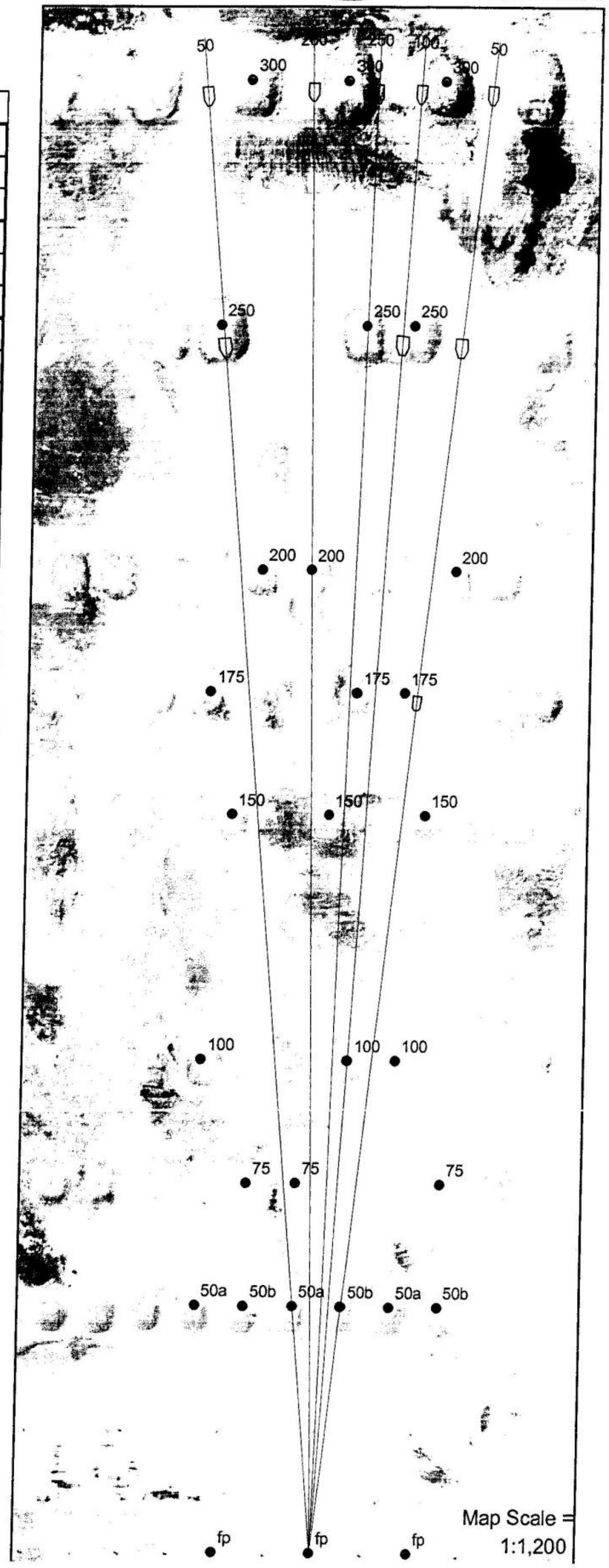
rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m	NA	
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m	NA	
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m	NA	
27	200	SIT	HIT	300m	NA	
28	200	SIT	HIT	300m		
29	200	SIT	HIT	300m		
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		
32	200	SIT	HIT	300m	NA	
33	250	SIT	HIT	300m	NA	
34	250	SIT	HIT	300m	NA	
35	250	SIT	HIT	300m		
36	250	SIT	HIT	300m	NA	
37	250	SIT	HIT	300m		
38	300	SIT	BS	NA		
39	300	SIT	BS			
40	300	SIT	BS	NA		

SIT = target frontal berm, BS = backstop berm



Lane 6 **Phase 3 LOS Analysis Composite Worksheet** (19) **Firer** PFC Scott

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		
18	150	SIT	HIT	300m		
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		
21	150	SIT	HIT	300m		
22	150	SIT	HIT	300m		
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		N/A
28	200	SIT	HIT	300m		/
29	200	SIT	HIT	300m		N/A
30	200	SIT	HIT	300m		N/A
31	200	SIT	HIT	300m		N/A
32	200	SIT	HIT	300m		
33	250	SIT	HIT	300m		
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		N/A
37	250	SIT	HIT	300m		N/A
38	300	SIT	BS			N/A
39	300	SIT	BS			N/A
40	300	SIT	BS			N/A



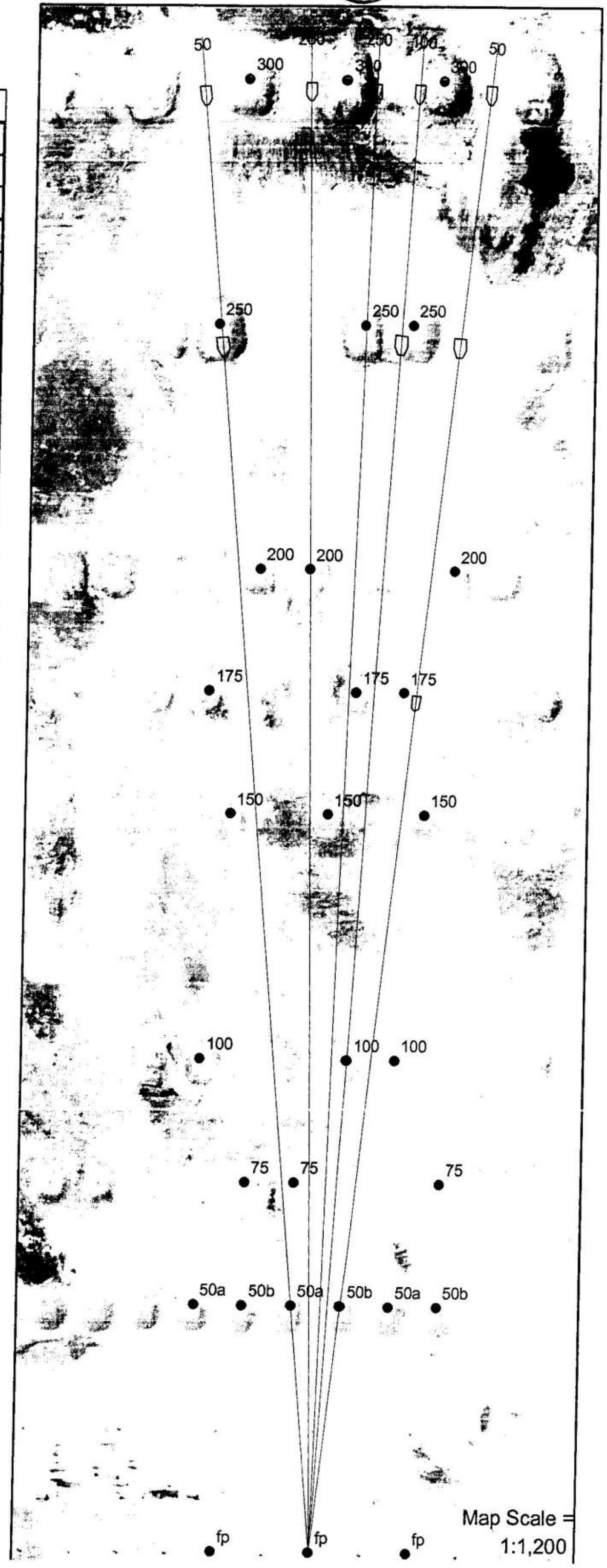
SIT = target frontal berm, BS = backstop berm

SSG

Lane 6 Phase 3 LOS Analysis Composite Worksheet (20) Firer Silva

rnd	target	PP1	PP2	PP3	PP4	PP5
1	50a	SIT	BS	250m	300m	
2	50a	SIT	BS	250m	300m	
3	50a	SIT	BS	250m	300m	
4	50b	SIT	BS	175m	300m	
5	50b	SIT	BS	175m	300m	
6	50b	SIT	BS	175m	300m	
7	100	SIT	BS	250m	300m	
8	100	SIT	BS	250m	300m	
9	100	SIT	BS	250m	300m	
10	100	SIT	BS	250m	300m	
11	100	SIT	BS	250m	300m	N/A
12	100	SIT	BS	250m	300m	
13	100	SIT	BS	250m	300m	
14	100	SIT	BS	250m	300m	
15	150	SIT	HIT	300m		
16	150	SIT	HIT	300m		
17	150	SIT	HIT	300m		N/A
18	150	SIT	HIT	300m		N/A
19	150	SIT	HIT	300m		
20	150	SIT	HIT	300m		N/A
21	150	SIT	HIT	300m		N/A
22	150	SIT	HIT	300m		N/A
23	150	SIT	HIT	300m		
24	150	SIT	HIT	300m		
25	150	SIT	HIT	300m		N/A
26	200	SIT	HIT	300m		
27	200	SIT	HIT	300m		N/A
28	200	SIT	HIT	300m		N/A
29	200	SIT	HIT	300m		N/A
30	200	SIT	HIT	300m		
31	200	SIT	HIT	300m		N/A
32	200	SIT	HIT	300m		N/A
33	250	SIT	HIT	300m		N/A
34	250	SIT	HIT	300m		N/A
35	250	SIT	HIT	300m		N/A
36	250	SIT	HIT	300m		N/A
37	250	SIT	HIT	300m		
38	300	SIT	BS			N/A
39	300	SIT	BS			N/A
40	300	SIT	BS			N/A

SIT = target frontal berm, BS = backstop berm



APPENDIX D

1		1	
2	50A	2	
3		3	
4		1	
5	50B	2	
6		3	
7		1	
8		2	
9		3	
10	100	4	
11		5	
12		6	
13		7	
14		8	
15		1	
16		2	
17		3	
18		4	
19		5	
20	150	6	
21		7	
22		8	
23		9	
24		10	
25		11	
26		1	
27		2	
28		3	
29	200	4	
30		5	
31		6	
32		7	
33		1	
34		2	
35	250	3	
36		4	
37		5	
38		1	
39	300	2	
40		3	

TARGET	HITS	EXPOSURES	PERCENT
50A	57	60	95%
50B	59	60	98%
100	152	160	95%
150	167	220	76%
200	88	140	63%
250	49	100	49%
300	22	60	37%
TOTAL	594	800	74%

AVERAGE QUALIFICATION	29.70

NOTE:

20 iterations of Version 2 were conducted. Each iteration consisted of 40 target engagement opportunities, as follows:

EXPOSURES:

50 meter Alpha target: 3 exposures per iteration
50 meter Bravo target: 3 exposures per iteration
100 meter target: 8 exposures per iteration
150 meter target: 11 exposures
200 meter target: 7 exposures
250 meter target: 5 exposures
300 meter target: 3 exposures

COLOR	NONENCLATURE	HITS / ITERATION
	EXPERT	36-40
	SHARPSHOOTER	29-35
	MARKSMAN	23-28
	DID NOT QUALIFIED	0-22

rd	rd	TARGET	ITERATION 1	2	3	4	5	6	7
1	1	50a	1	1	1	1	1	1	1
2	2	50a	1	1	1	1		1	1
3	3	50a	1	1	1	1	1	1	1
4	1	50b	1	1	1	1	1	1	1
5	2	50b	1	1	1	1	1	1	1
6	3	50b	1	1	1	1	1	1	1
7	1	100	1	1	1	1	1	1	1
8	2	100		1	1	1	1	1	1
9	3	100	1	1	1	1	1		1
10	4	100	1	1	1	1	1	1	1
11	5	100	1	1	1	1	1	1	1
12	6	100	1	1	1	1	1	1	1
13	7	100	1	1	1	1	1	1	1
14	8	100	1	1	1	1	1		1
15	1	150	1	1	1		1	1	
16	2	150	1	1				1	
17	3	150	1	1		1		1	1
18	4	150	1	1		1		1	
19	5	150	1	1	1	1		1	1
20	6	150	1		1		1	1	1
21	7	150	1		1		1	1	1
22	8	150	1		1	1	1	1	
23	9	150	1				1	1	
24	10	150	1			1	1	1	1
25	11	150			1	1	1	1	
26	1	200	1		1	1			
27	2	200	1	1	1		1	1	
28	3	200	1	1	1			1	
29	4	200	1	1	1		1	1	1
30	5	200	1	1	1		1		
31	6	200	1	1		1	1		1
32	7	200	1	1			1		1
33	1	250	1				1		
34	2	250		1	1		1		
35	3	250		1	1				
36	4	250	1		1		1	1	
37	5	250			1		1	1	
38	1	300		1			1		
39	2	300	1	1				1	
40	3	300	1	1	1			1	
TOTAL			34	30	30	22	30	30	22

rd	rd	TARGET	ITERATION						
			8	**9**	**10**	**11**	**12**	**13**	**14**
1	1	50a		1	1	1	1	1	1
2	2	50a	1	1	1	1	1	1	1
3	3	50a	1	1	1	1	1	1	1
4	1	50b	1	1	1	1	1	1	1
5	2	50b	1	1	1	1	1	1	1
6	3	50b	1	1	1	1	1	1	1
7	1	100	1		1	1	1	1	1
8	2	100	1	1	1	1	1	1	1
9	3	100	1	1	1	1	1	1	1
10	4	100	1	1	1	1	1	1	1
11	5	100	1	1	1	1	1	1	1
12	6	100	1	1	1	1	1	1	1
13	7	100	1	1	1	1	1	1	1
14	8	100	1	1	1	1	1	1	1
15	1	150	1	1	1	1	1		1
16	2	150	1	1	1	1	1	1	1
17	3	150	1		1	1	1		1
18	4	150	1	1	1	1	1		1
19	5	150	1	1	1	1	1	1	1
20	6	150	1	1	1		1	1	1
21	7	150	1	1	1	1	1	1	1
22	8	150	1	1	1	1	1	1	1
23	9	150	1	1	1	1		1	1
24	10	150	1	1	1	1		1	1
25	11	150	1	1	1		1		1
26	1	200	1	1				1	1
27	2	200	1	1	1	1			1
28	3	200	1	1	1	1			1
29	4	200	1		1	1			1
30	5	200	1	1	1	1		1	1
31	6	200	1				1	1	1
32	7	200	1		1	1	1	1	1
33	1	250	1	1	1	1		1	1
34	2	250		1	1	1			1
35	3	250	1		1	1	1		1
36	4	250	1		1			1	1
37	5	250		1	1	1		1	1
38	1	300	1		1	1			
39	2	300			1	1		1	1
40	3	300			1	1			
TOTAL			35	30	38	35	26	29	38

rd	rd	TARGET	ITERATION 15	16	17	18	19	20
1	1	50a	1	1	1	1	1	1
2	2	50a	1	1	1	1	1	1
3	3	50a	1	1		1	1	1
4	1	50b	1	1	1	1	1	1
5	2	50b	1	1	1	1	1	1
6	3	50b		1	1	1	1	1
7	1	100	1	1	1	1	1	1
8	2	100	1	1	1	1	1	1
9	3	100	1	1	1	1	1	1
10	4	100	1	1	1	1	1	1
11	5	100	1	1		1	1	
12	6	100	1	1		1	1	1
13	7	100	1	1	1	1	1	1
14	8	100	1	1		1	1	1
15	1	150	1	1		1	1	1
16	2	150	1	1			1	1
17	3	150	1				1	
18	4	150	1	1		1	1	
19	5	150	1		1	1	1	1
20	6	150	1	1	1		1	
21	7	150	1	1	1	1	1	
22	8	150	1	1		1	1	1
23	9	150	1	1	1		1	1
24	10	150	1	1	1	1	1	
25	11	150	1	1	1	1	1	
26	1	200	1	1	1		1	1
27	2	200	1		1			
28	3	200	1	1		1	1	
29	4	200	1	1		1		
30	5	200	1	1	1			
31	6	200	1	1	1	1		
32	7	200	1				1	
33	1	250	1				1	
34	2	250	1	1				
35	3	250		1		1		
36	4	250	1					
37	5	250	1		1	1		1
38	1	300	1		1			
39	2	300				1		
40	3	300			1			
TOTAL			36	30	23	27	29	20

VERSION 1. TOTALS		
rd	**TARGET**	**TOTAL**
1	50a	31
2	200	20
3	100	31
4	150	17
5	300	12
6	250	8
7	50b	32
8	200	13
9	150	19
10	250	11
11	100	27
12	200	16
13	150	27
14	300	14
15	100	29
16	250	13
17	200	17
18	150	19
19	50a	29
20	100	23
21	200	18
22	250	8
23	150	21
24	300	10
25	200	16
26	150	25
27	200	14
28	250	15
29	150	26
30	150	20
31	150	12
32	50a	29
33	100	22
34	150	15
35	100	19
36	50b	28
37	100	19
38	150	10
39	50a	25
40	100	24

VERSION 1. ACTUAL MARKSMANSHIP RATE			
TARGET	HITS	EXPOSURES	PERCENT
50a	114	132	86%
50b	60	66	91%
100	194	264	73%
150	211	363	58%
200	114	231	49%
250	55	165	33%
300	36	99	36%
TOTAL	784	1320	59%

AVERAGE QUALIFICATION	**23.76**

NOTE:

20 iterations of Version 2 were conducted. Each iteration consisted of 40 target engagement opportunities, as follows:

EXPOSURES:

50 meter Alpha target: 4 exposures per iteration
50 meter Bravo target: 2 exposures per iteration
100 meter target: 8 exposures per iteration
150 meter target: 11 exposures
200 meter target: 7 exposures
250 meter target: 5 exposures
300 meter target: 3 exposures

The Red Fill Color indicated targets initiated simultaneously.

COLOR	NONENCLATURE	HITS / ITERATION
(green)	EXPERT	36-40
(yellow)	SHARPSHOOTER	29-35
(red)	MARKSMAN	23-28
(black)	DID NOT QUALIFIED	0-22

rd	TARGET	ITERATION						
		21	**22**	**23**	**24**	**25**	**26**	**27**
1	50a	1		1	1	1	1	1
2	200	1	1	1	1			
3	100		1	1	1	1		1
4	150	1	1	1			1	1
5	300						1	1
6	250		1				1	1
7	50b	1	1	1	1	1		1
8	200			1			1	
9	150		1		1	1		1
10	250		1		1		1	1
11	100		1	1	1	1	1	1
12	200			1	1		1	1
13	150	1	1	1	1		1	1
14	300				1		1	
15	100		1	1	1	1	1	1
16	250				1			
17	200	1		1	1		1	
18	150	1		1	1	1	1	
19	50a	1		1	1	1	1	
20	100		1	1		1	1	
21	200		1	1	1			
22	250	1	1		1			
23	150	1			1	1	1	1
24	300				1		1	
25	200		1		1		1	
26	150	1	1		1	1	1	1
27	200			1			1	
28	250		1	1		1		
29	150	1	1	1	1			
30	150	1		1			1	
31	150		1	1	1		1	1
32	50a		1	1	1		1	
33	100	1	1	1	1		1	1
34	150	1					1	1
35	100				1	1	1	1
36	50b		1	1	1		1	1
37	100	1		1	1		1	1
38	150		1					1
39	50a				1	1		1
40	100	1			1			1
TOTAL		17	22	24	30	14	28	23

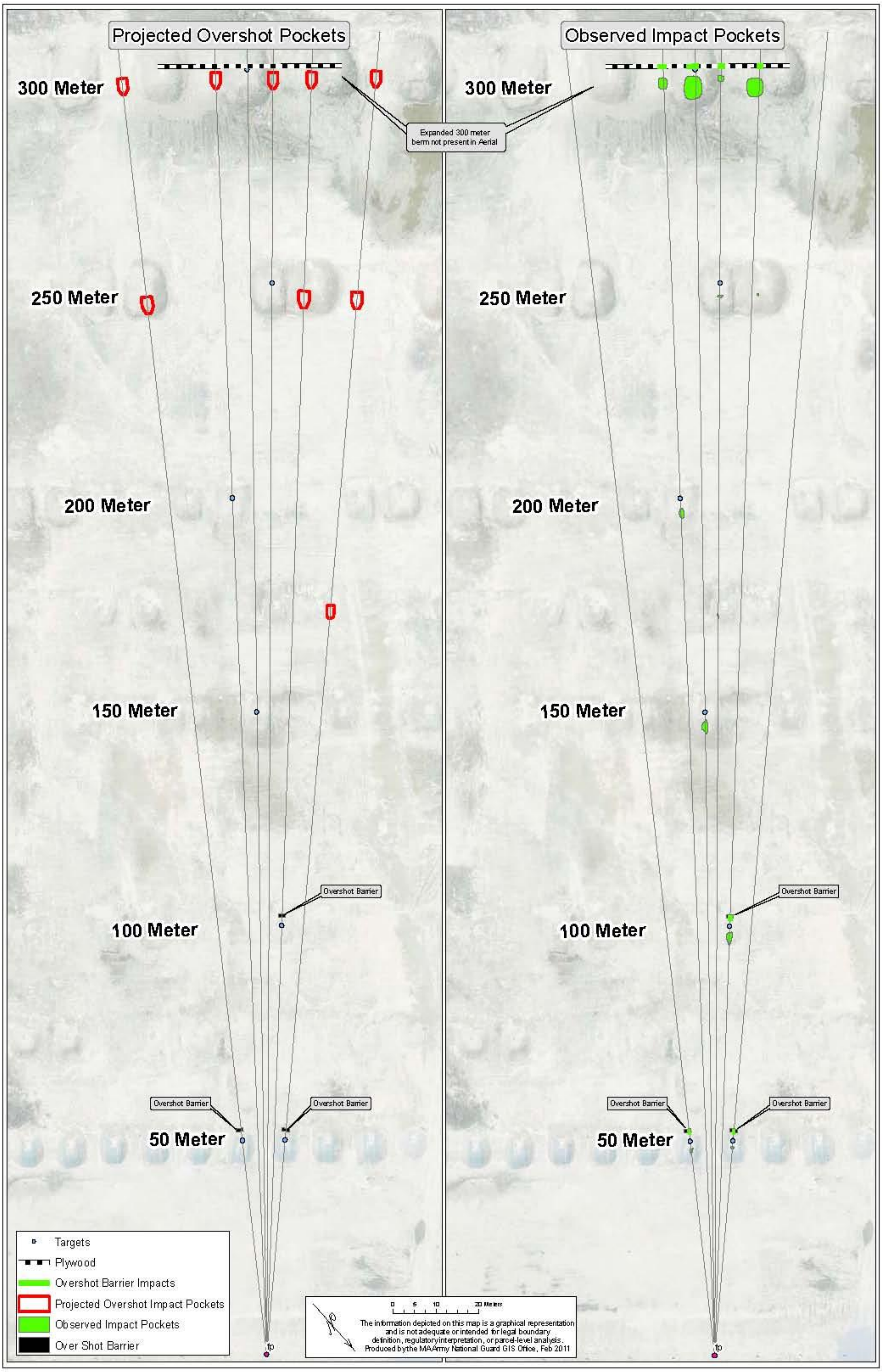
rd	TARGET	ITERATION						
		28	29	30	31	32	33	34
1	50a	1	1	1	1	1	1	1
2	200		1			1		
3	100	1	1	1	1	1	1	1
4	150	1	1	1			1	
5	300				1			
6	250							
7	50b	1	1	1	1	1	1	1
8	200	1	1					
9	150	1		1	1		1	
10	250							1
11	100	1	1	1			1	1
12	200			1			1	1
13	150	1	1	1	1	1	1	
14	300	1	1			1	1	
15	100	1	1	1	1	1	1	1
16	250	1			1		1	
17	200			1	1		1	
18	150	1	1	1		1		
19	50a	1	1	1	1	1	1	1
20	100	1	1			1	1	1
21	200		1		1	1	1	
22	250	1						
23	150		1		1	1	1	
24	300				1		1	1
25	200						1	
26	150	1	1	1	1	1	1	1
27	200	1				1	1	1
28	250		1			1	1	
29	150	1		1	1	1	1	1
30	150		1		1	1		1
31	150	1	1			1		
32	50a	1	1	1	1	1	1	1
33	100		1		1	1	1	1
34	150		1					
35	100	1			1			1
36	50b	1	1	1	1	1	1	1
37	100	1	1	1		1	1	1
38	150	1		1	1	1		
39	50a	1	1	1	1	1	1	1
40	100	1	1	1	1	1	1	1
TOTAL		26	26	20	23	25	28	21

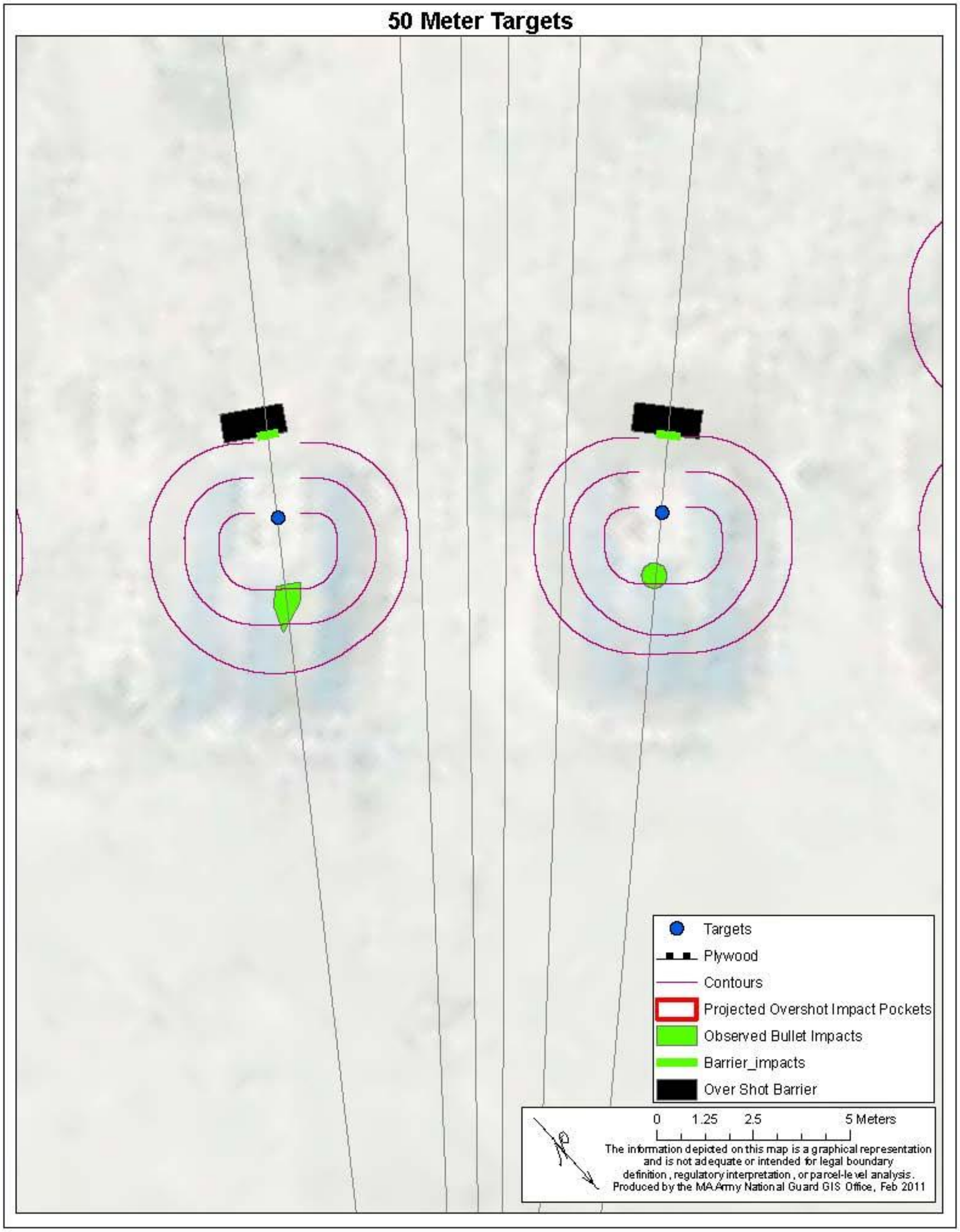
rd	TARGET	ITERATION						
		35	36	37	38	39	40	41
1	50a	1		1	1	1	1	1
2	200	1	1	1		1		
3	100	1	1	1	1	1	1	1
4	150	1		1				1
5	300						1	
6	250			1				
7	50b	1	1	1	1	1	1	1
8	200	1				1		
9	150	1	1	1				1
10	250	1				1		
11	100	1	1	1	1	1	1	1
12	200		1	1				1
13	150		1	1	1	1		1
14	300	1				1		
15	100	1		1	1		1	1
16	250			1				1
17	200	1	1	1				1
18	150	1		1	1			1
19	50a	1	1	1	1	1	1	1
20	100		1		1			1
21	200	1	1		1	1		1
22	250		1		1			
23	150	1	1	1	1		1	1
24	300		1					1
25	200		1	1		1		
26	150			1	1		1	1
27	200		1	1	1			
28	250		1		1			1
29	150	1	1	1	1	1	1	1
30	150		1	1	1			1
31	150			1				
32	50a	1	1	1	1	1	1	
33	100				1			1
34	150	1		1		1	1	
35	100				1	1	1	1
36	50b	1	1		1	1		1
37	100				1		1	
38	150	1						
39	50a	1	1	1	1	1		1
40	100				1	1	1	1
TOTAL		22	22	25	24	19	15	26

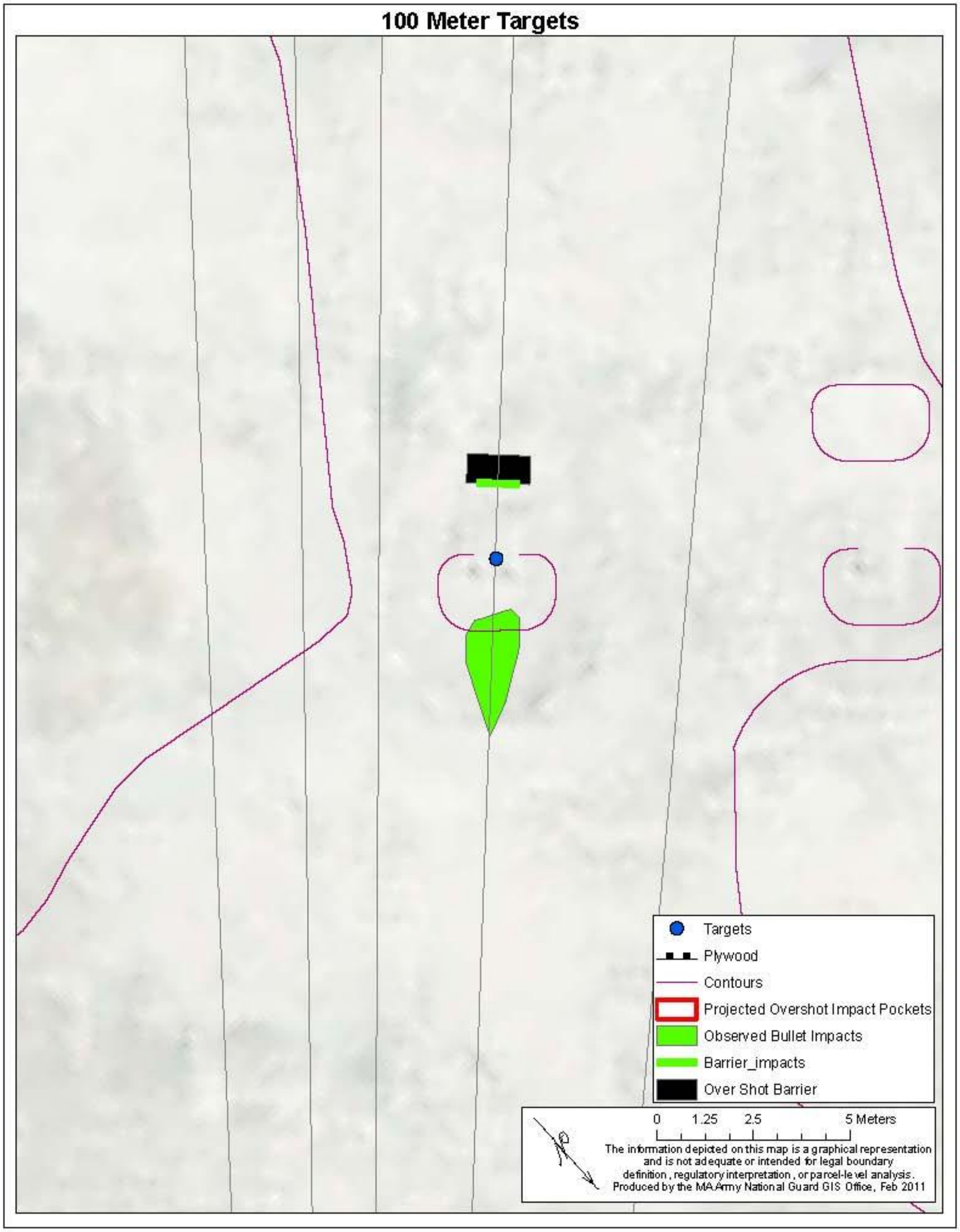
rd	TARGET	ITERATION						
		42	43	44	45	46	47	48
1	50a	1	1	1	1	1	1	1
2	200	1	1	1		1		1
3	100	1	1	1	1	1	1	1
4	150		1	1			1	
5	300	1	1	1				
6	250							1
7	50b	1	1	1	1	1	1	1
8	200		1		1	1		1
9	150			1	1		1	
10	250		1		1			
11	100	1	1	1		1		1
12	200	1		1		1		
13	150		1	1	1	1	1	1
14	300				1	1		1
15	100	1	1	1	1	1	1	1
16	250	1	1	1	1			
17	200		1	1				1
18	150		1	1	1			1
19	50a	1		1	1	1	1	1
20	100	1	1	1	1	1	1	1
21	200	1	1	1		1		
22	250		1					1
23	150	1	1				1	1
24	300					1		1
25	200	1	1	1			1	1
26	150	1	1	1				1
27	200	1	1			1		1
28	250	1				1	1	1
29	150	1	1	1	1	1	1	
30	150	1	1	1	1		1	1
31	150						1	
32	50a	1	1	1	1	1	1	1
33	100		1	1		1	1	1
34	150		1	1	1			
35	100	1	1	1		1		
36	50b	1	1	1	1	1		1
37	100		1				1	1
38	150						1	
39	50a	1	1			1	1	1
40	100	1	1		1	1	1	1
TOTAL		24	31	26	19	23	21	28

rd	TARGET	ITERATION 49	50	51	52	53
1	50a	1	1	1	1	1
2	200	1	1	1	1	1
3	100	1	1	1	1	1
4	150	1	1			
5	300	1	1	1	1	1
6	250	1	1		1	
7	50b	1	1	1	1	1
8	200	1		1	1	
9	150	1	1	1	1	
10	250	1	1			
11	100	1	1		1	1
12	200	1	1	1		
13	150	1	1	1	1	
14	300	1	1	1		
15	100	1	1	1	1	
16	250	1	1	1		
17	200		1		1	1
18	150	1		1		
19	50a	1	1	1	1	
20	100	1	1		1	1
21	200	1	1			
22	250					
23	150			1	1	
24	300			1		
25	200	1	1	1	1	
26	150	1	1	1	1	
27	200	1				
28	250			1	1	
29	150	1	1		1	
30	150	1		1	1	
31	150			1	1	
32	50a	1	1	1	1	1
33	100	1	1		1	1
34	150	1	1		1	1
35	100	1	1		1	1
36	50b	1	1	1	1	1
37	100	1	1	1		
38	150	1	1			
39	50a	1		1	1	1
40	100	1	1		1	1
TOTAL		34	30	25	28	15

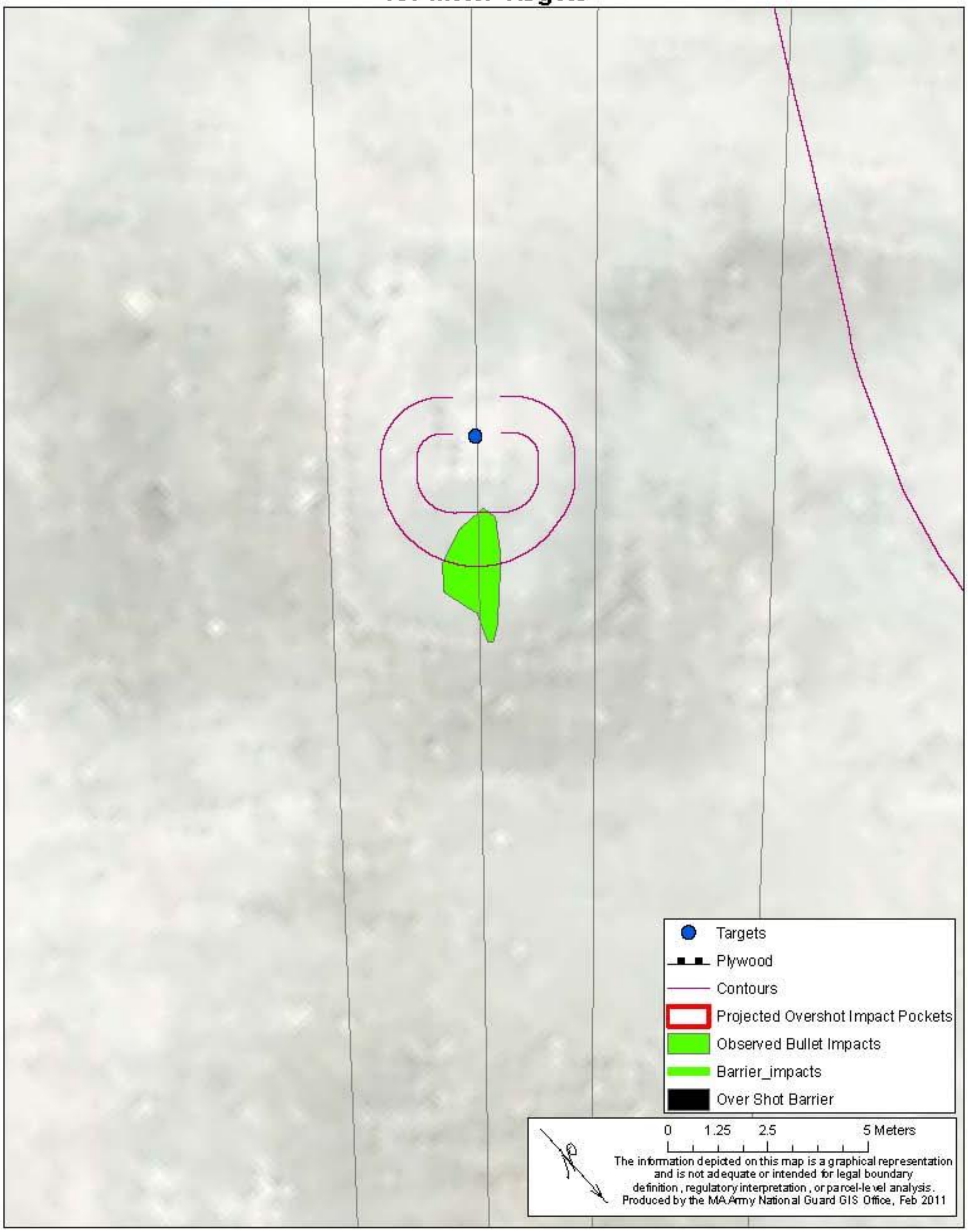
APPENDIX E


Projected Overshot Pockets
Observed Impact Pockets
300 Meter
250 Meter
200 Meter
150 Meter
100 Meter
50 Meter
Expanded 300 meter berm not present in Aerial
Overshot Barrier
Targets
Plywood
Overshot Barrier Impacts
Projected Overshot Impact Pockets
Observed Impact Pockets
Over Shot Barrier
fp
0 5 10 20 Meters
The information depicted on this map is a graphical representation and is not adequate or intended for legal boundary definition, regulatory interpretation, or parcel-level analysis.
Produced by the MA Army National Guard GIS Office, Feb 2011

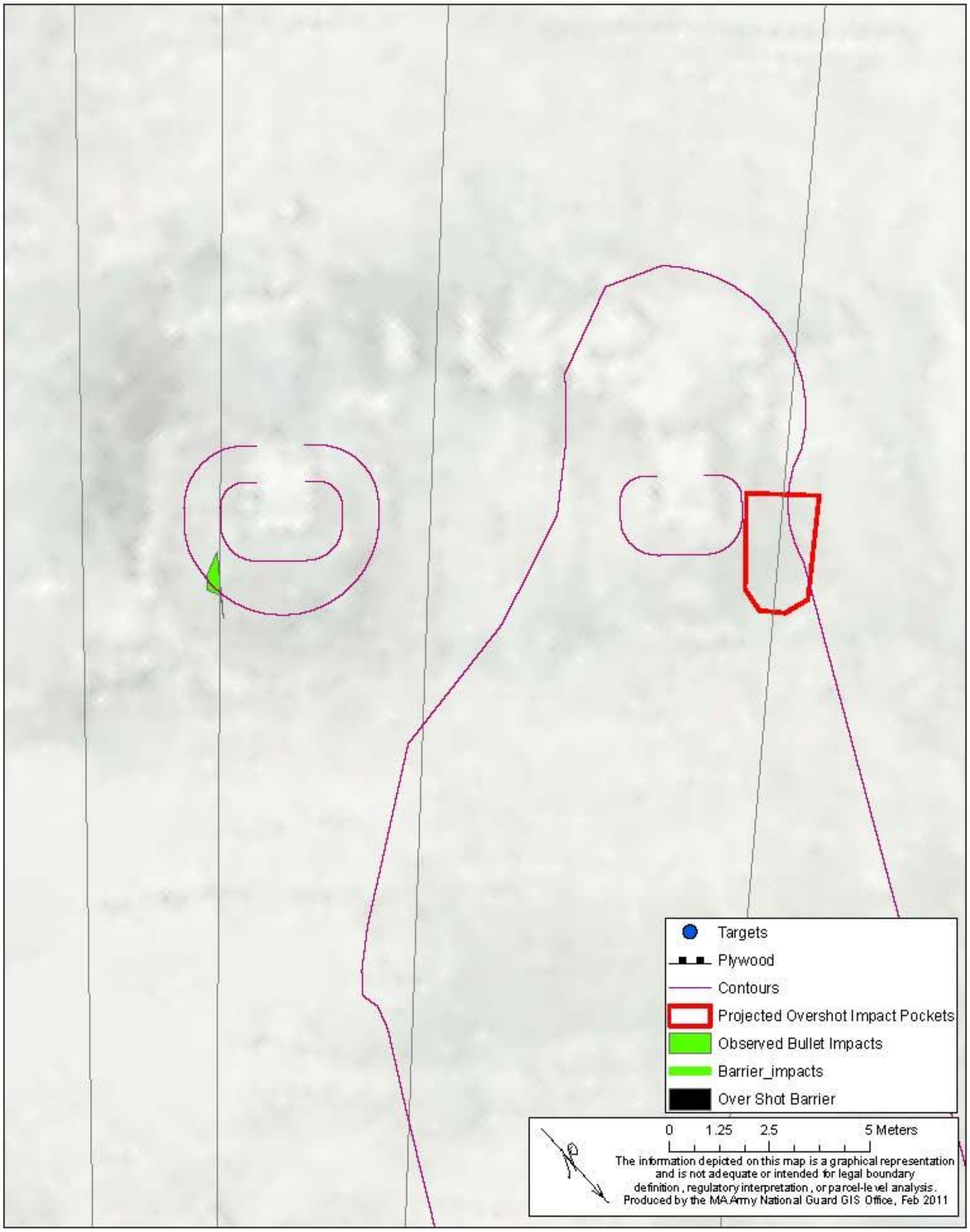

50 Meter Targets
Targets
Plywood
Contours
Projected Overshot Impact Pockets
Observed Bullet Impacts
Barrier_impacts
Over Shot Barrier
0
1.25
2.5
5 Meters
The information depicted on this map is a graphical representation
and is not adequate or intended for legal boundary
definition, regulatory interpretation, or parcel-level analysis.
Produced by the MA Army National Guard GIS Office, Feb 2011


100 Meter Targets
Targets
Plywood
Contours
Projected Overshot Impact Pockets
Observed Bullet Impacts
Barrier_impacts
Over Shot Barrier
0
1.25
2.5
5 Meters
The information depicted on this map is a graphical representation and is not adequate or intended for legal boundary definition, regulatory interpretation, or parcel-level analysis.
Produced by the MA Army National Guard GIS Office, Feb 2011

150 Meter Targets

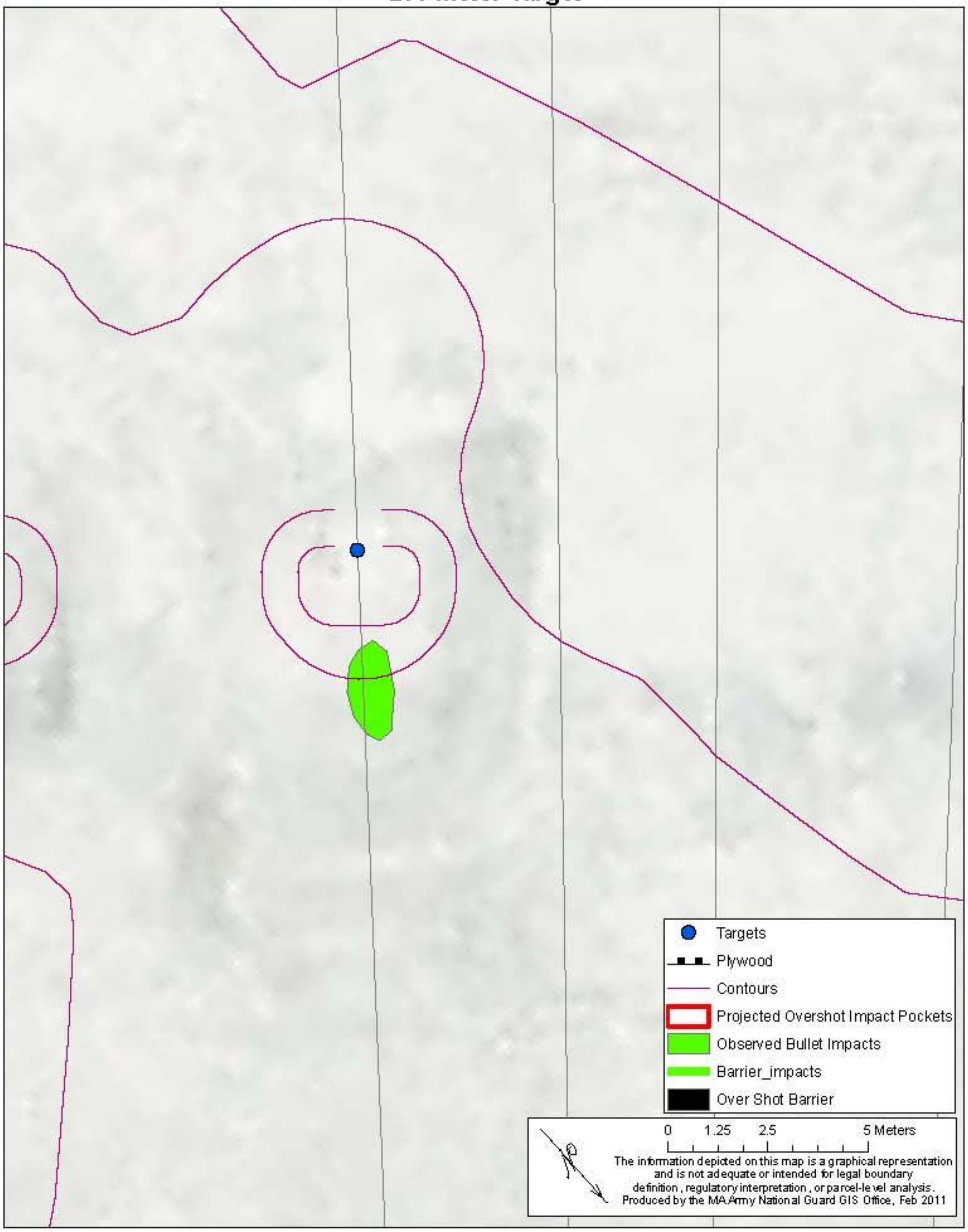


175 Meter

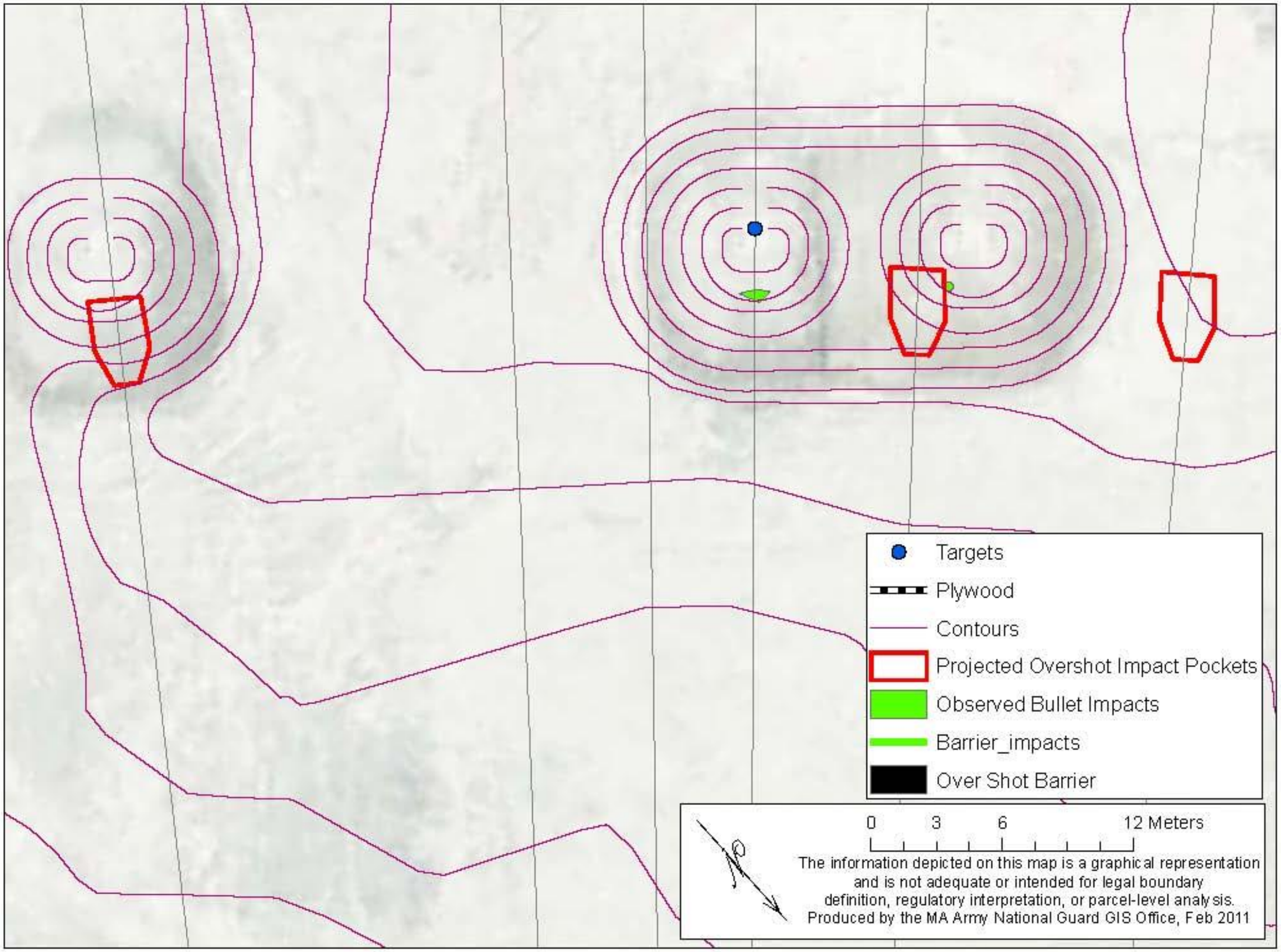


Targets
Plywood
Contours
Projected Overshot Impact Pockets
Observed Bullet Impacts
Barrier_impacts
Over Shot Barrier
0 1.25 2.5 5 Meters
The information depicted on this map is a graphical representation and is not adequate or intended for legal boundary definition, regulatory interpretation, or parcel-level analysis.
Produced by the MA Army National Guard GIS Office, Feb 2011

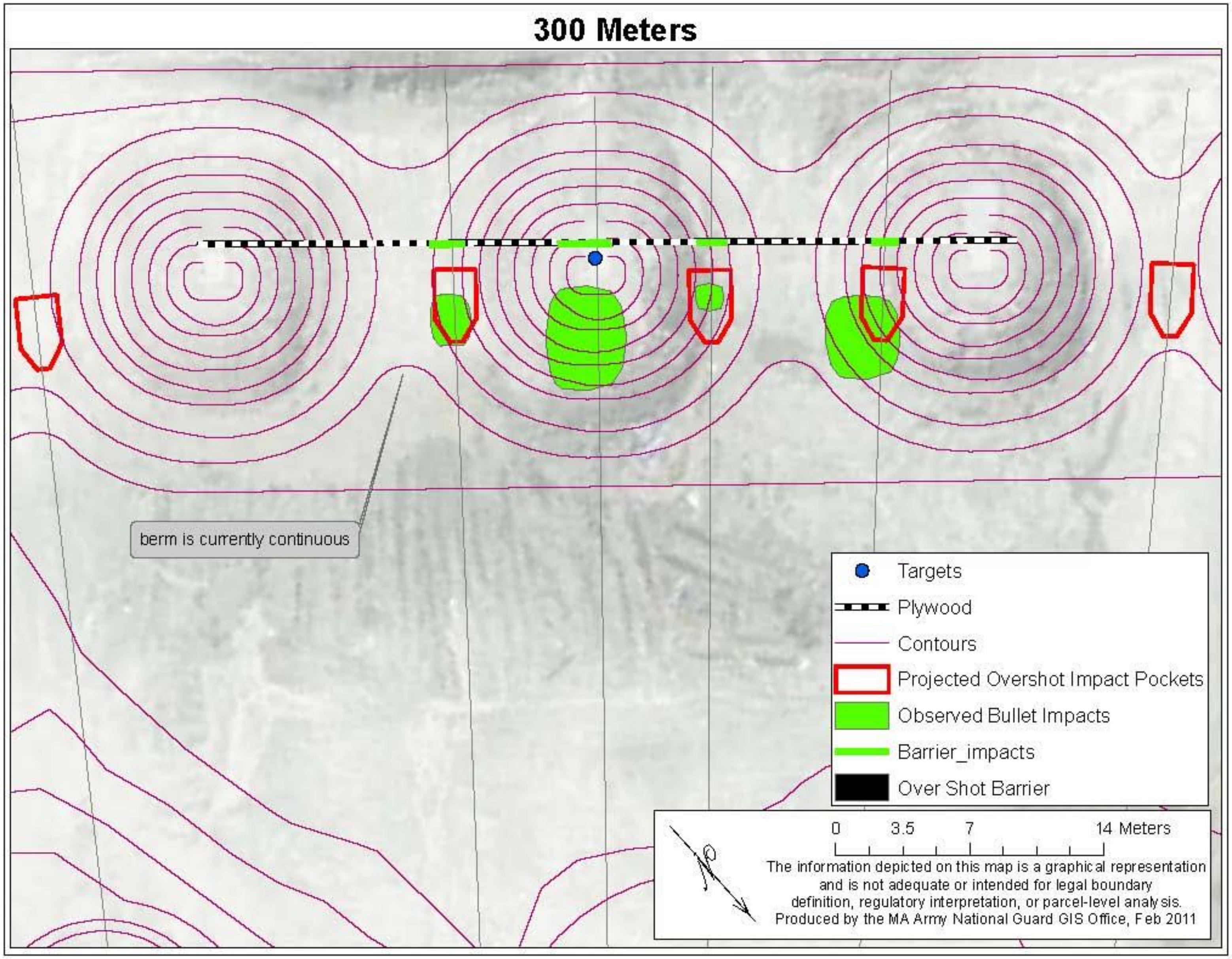
200 Meter Target



250 Meters



Targets
Plywood
Contours
Projected Overshot Impact Pockets
Observed Bullet Impacts
Barrier_impacts
Over Shot Barrier
0
3
6
12 Meters
The information depicted on this map is a graphical representation and is not adequate or intended for legal boundary definition, regulatory interpretation, or parcel-level analysis.
Produced by the MA Army National Guard GIS Office, Feb 2011


300 Meters
berm is currently continuous
Targets
Plywood
Contours
Projected Overshot Impact Pockets
Observed Bullet Impacts
Barrier_impacts
Over Shot Barrier
0
3.5
7
14 Meters
The information depicted on this map is a graphical representation
and is not adequate or intended for legal boundary
definition, regulatory interpretation, or parcel-level analysis.
Produced by the MA Army National Guard GIS Office, Feb 2011

Appendix 4

Compiled Sierra Range Data for Soil, Porewater and Groundwater

Sierra Range Soil Data 2012-2020

Range Location	Location ID	Date Sampled	Analyte	Result Value (mg/kg)	Qualifier	MDL	RL	LOQ	LOD	OMMP Action Levels (mg/kg)
Firing Line	SSSRNG001	09/12/12	Antimony	ND	U	0.11	1.3			
Firing Line	SSSRNG001	8/22/14	Antimony	0.5	J	0.19	1			300
Firing Line	SSSRNG001	9/27/16	Antimony	0.44	J	0.056	0.86			300
Firing Line	SSSRNG001	10/5/17	Antimony	0.39	J	0.33		5.00		300
Firing Line	SSSRNG001	10/26/18	Antimony	ND	UJ	1.2	4.8			300
Firing Line	SSSRNG001	10/1/19	Antimony	0.648		0.04		0.43	0.27	300
Firing Line	SSSRNG001	4/1/20	Antimony	0.93	J	0.46		1.8	1.4	300
Firing Line	SSSRNG001	09/12/12	Copper	21		0.049	0.56			
Firing Line	SSSRNG001	8/22/14	Copper	31.0		0.26	1.3			10,000
Firing Line	SSSRNG001	9/27/16	Copper	29.1		0.043	1.1			10,000
Firing Line	SSSRNG001	10/5/17	Copper	34.3		0.25		6.30		10,000
Firing Line	SSSRNG001	10/26/18	Copper	11	J	3.6	12			10,000
Firing Line	SSSRNG001	10/1/19	Copper	50.6		0.09		1.3	0.54	10,000
Firing Line	SSSRNG001	4/1/20	Copper	23.00		1.4		4.6	4.1	10,000
Firing Line	SSSRNG001	09/12/12	Lead	14.5		0.098	0.22			
Firing Line	SSSRNG001	8/22/14	Lead	16.4		0.15	0.5			3,000
Firing Line	SSSRNG001	9/27/16	Lead	13.1		0.043	0.86			3,000
Firing Line	SSSRNG001	10/5/17	Lead	17.6		0.25		5.00		3,000
Firing Line	SSSRNG001	10/26/18	Lead	27		1.2	4.8			3,000
Firing Line	SSSRNG001	10/1/19	Lead	17.8		0.05		0.27	0.21	3,000
Firing Line	SSSRNG001	4/1/20	Lead	16		0.46		1.8	1.4	3,000

Notes:

U = not detected

mg/kg = milligram(s) per kilogram

J = estimated value

Sierra Range Soil Data 2012-2021

Location ID	Date Sampled	Test Method	Analyte	Result Value (ppm)
050 m backstop, Lane 4	9/1/12	XRF	Copper	21
050 m backstop, Lane 4	10/1/13	XRF	Copper	178
050 m backstop, Lane 4	8/20/14	XRF	Copper	0
050 m backstop, Lane 4	9/27/16	XRF	Copper	186
050 m backstop, Lane 4	10/4/17	XRF	Copper	48
050 m backstop, Lane 4	10/24/18	XRF	Copper	167
050 m backstop, Lane 4	10/7/19	XRF	Copper	62
050 m backstop, Lane 4	4/8/20	XRF	Copper	62
050 m backstop, Lane 4	10/6/2021	XRF	Copper	129
100 m backstop, Lane 6	9/1/12	XRF	Copper	21
100 m backstop, Lane 6	10/1/13	XRF	Copper	135
100 m backstop, Lane 6	8/20/14	XRF	Copper	44
100 m backstop, Lane 6	9/27/16	XRF	Copper	69
100 m backstop, Lane 6	10/4/17	XRF	Copper	268.3
100 m backstop, Lane 6	10/24/18	XRF	Copper	131
100 m backstop, Lane 6	10/7/19	XRF	Copper	317.3
100 m backstop, Lane 6	4/8/20	XRF	Copper	317.3
100 m backstop, Lane 6	10/6/2021	XRF	Copper	251
320 m backstop, Lane 4	9/1/12	XRF	Copper	20
320 m backstop, Lane 4	10/1/13	XRF	Copper	38
320 m backstop, Lane 4	8/20/14	XRF	Copper	305
320 m backstop, Lane 4	9/27/16	XRF	Copper	27
320 m backstop, Lane 4	10/4/17	XRF	Copper	22.3
320 m backstop, Lane 4	10/24/18	XRF	Copper	31.3
320 m backstop, Lane 4	10/7/19	XRF	Copper	22.6
320 m backstop, Lane 4	4/8/20	XRF	Copper	22.6
320 m backstop, Lane 4	10/6/2021	XRF	Copper	78

Sierra Range Soil Sample Results Fall 2019

Field Sample ID	Analytical Method	Analyte	Lab Result	LOQ	LOD	DL	Units	OMMP Action Level (mg/kg)	Qualifier	Reason
SSSRNG001_OCT19	SW6010C	Antimony	0.648	0.43	0.27	0.038	mg/kg	300		
SSSRNG001_OCT19	SW6010C	Calcium	976	5.4	4.3	0.97	mg/kg			
SSSRNG001_OCT19	SW9056A	Chloride	23	20	10	0.993	mg/L			
SSSRNG001_OCT19	SW6010C	Copper	50.6	1.3	0.54	0.086	mg/kg	10,000		
SSSRNG001_OCT19	SW6010C	Lead	17.8	0.27	0.21	0.047	mg/kg	3,000		
SSSRNG001_OCT19	SW6010C	Magnesium	1,020	5.4	4.3	0.36	mg/kg			
SSSRNG001_OCT19	SW9045D	pH	6.1	0.1	--	0.1	pH units			
SSSRNG001_OCT19	E365.4	Phosphorus, total	290	15	7.5	3.9	mg/kg			
SSSRNG001_OCT19	SW6010C	Potassium	497	54	27	1.6	mg/kg			
SSSRNG001_OCT19	SW6010C	Sodium	27.6	54	27	0.8	mg/kg		J	TR
SSSRNG001_OCT19	SW9056A	Sulfate	8.2	10	5.0	0.637	mg/L		J	TR

Notes:

TR = trace result (<LOQ and >DL)   mg/kg = milligram(s) per kilogram

J = estimated value   mg/L = milligram(s) per liter

Sierra Range Soil Sample Results Spring 2020

Field Sample ID	Analytical Method	Analyte	Lab Result	MDL	LOD	LOQ	Units	OMMP Action Level (mg/kg)	Qualifier	Reason
SSSRNG001_APR20	SW6010C	Antimony	0.93	0.46	1.4	1.8	mg/kg	300	J	TR
SSSRNG001_APR20	SW6010C	Calcium	790.00	140	410	460	mg/kg			
SSSRNG001_APR20	SW9056A	Chloride	17	0.20	0.20	2.0	mg/kg			
SSSRNG001_APR20	SW6010C	Copper	23.00	1.4	4.1	4.6	mg/kg	10,000		
SSSRNG001_APR20	SW6010C	Iron	7,300	4.6	14	18	mg/kg			
SSSRNG001_APR20	SW6010C	Lead	16	0.46	1.4	1.8	mg/kg	3,000		
SSSRNG001_APR20	SW6010C	Magnesium	860	46	140	180	mg/kg			
SSSRNG001_APR20	SW9045D	pH	6.2	0.10	0.10	0.10	pH units			
SSSRNG001_APR20	E365.4	Phosphorus, total	380	11	20	20	mg/kg			
SSSRNG001_APR20	SW6010C	Potassium	310	270	820	920	mg/kg		J	TR
SSSRNG001_APR20	SW6010C	Sodium	140	46	140	180	mg/kg		U	ND
SSSRNG001_APR20	SW9056A	Sulfate	3.7	1.5	4.5	5	mg/kg		J	TR

Notes:

mg/kg = milligram(s) per kilogram

ND = not detectable

J = estimated value

TR = trace result (<LOQ and >MDL)

U = not detected

Sierra Range Soil Sample Results 2021

Sample Code	Method	Analyte	Result	Units	Qualifiers	Method Detction Limit	Reporting Detection Limit	Quantitation Limit	Detection Limit Units
SSSRNG001_SEP21-09152021	SW6010C	Antimony	1.9	mg/kg	U	0.91	1.9	2.5	mg/kg
SSSRNG001_SEP21-09152021	SW6010C	Calcium	1300	mg/kg		18	62	120	mg/kg
SSSRNG001_SEP21-09152021	SW9056	Chloride	15	mg/kg	JM	14	37	37	mg/kg
SSSRNG001_SEP21-09152021	SW6010C	Copper	23	mg/kg		0.27	1	6.2	mg/kg
SSSRNG001_SEP21-09152021	SW6010C	Iron	9700	mg/kg		10	25	100	mg/kg
SSSRNG001_SEP21-09152021	SW6010C	Lead	22	mg/kg	Q	0.39	1	1.1	mg/kg
SSSRNG001_SEP21-09152021	SW6010C	Magnesium	1300	mg/kg		9.9	25	37	mg/kg
SSSRNG001_SEP21-09152021	SW9045D	pH adj. to 25 deg C	5.8	pH units	HF	0.1	0.1	0.1	pH units
SSSRNG001_SEP21-09152021	SW6010C	Potassium	570	mg/kg		51	200	370	mg/kg
SSSRNG001_SEP21-09152021	SW6010C	Sodium	48	mg/kg	J	36	120	620	mg/kg
SSSRNG001_SEP21-09152021	SW9056	Sulfate	31	mg/kg	UM	11	31	62	mg/kg

Notes:

U = not detected

HF= Field parameter with a holding time of 15 minutes. Test performed by laboratory at client's request.

M = manual integrated compound

J = estimated value

J = estimated value

Q = One or more quality control criteria failed.

Sierra Range Porewater Data 2012-2020

Range Location	Location ID	Date Sampled	Analyte	Result Value (µg/L)	Qualifier	MDL	RL	LOQ	LOD	OMMP Action Levels (µg/L)
Background	LYSRBGD01	08/18/15	Antimony	0.92	J	0.26	2			6.0
Background	LYSRBGD01	09/14/16	Antimony	0.93	J	0.20	2.0			
Background	LYSBGD01	09/27/17	Antimony	0.7	J	0.20		2		
Background	LYSRBGD01	10/24/18	Antimony	ND	U	2.0	5.0			6
Background	LYSRNG001	10/01/19	Antimony	0.39	J	0.5		1.0	0.055	6
Background	LYSRNG001	04/01/20	Antimony	4.0		2		5.0	4.0	6
Background	LYSRBGD01	08/18/15	Copper	ND	U	2.1	5			1,300
Background	LYSRBGD01	09/14/16	Copper	7.5		0.20	2.0			
Background	LYSBGD01	09/27/17	Copper	3.0	B	0.20		2		
Background	LYSRBGD01	10/24/18	Copper	2.6	J	1.9	3.0			1,300
Background	LYSRNG001	10/01/19	Copper	1.8	J	2		3.0	0.19	1300
Background	LYSRNG001	04/01/20	Copper	2.5		1.9		3.0	2.5	1300
Background	LYSRBGD01	09/13/12	DRY - No Sample							
Background	LYSRNG001	08/18/15	Lead	ND	U	0.12	1			15
Background	LYSRNG001	09/14/16	Lead	4.2		0.20	2.0			
Background	LYSBGD01	09/27/17	Lead	0.8	J	0.20		2		
Background	LYSRNG001	10/24/18	Lead	ND	U	1.0	3.0			15
Background	LYSRNG001	10/01/19	Lead	0.21	J	0.5		1.0	0.075	15
Background	LYSRNG001	04/01/20	Lead	2.0		1		3.0	2.0	15
Berm	LYSRNG002	09/13/12	Antimony	1.3	J	0.073	20			
Berm	LYSRNG002	09/13/12	Antimony	1.3	J	0.073	20			
Berm	LYSRNG002	02/06/13	Antimony	0.41	J B	0.073	20			
Berm	LYSRNG002	02/06/13	Antimony	ND			5			
Berm	LYSRNG002	07/31/13	Antimony	0.27	J B	0.073	4			
Berm	LYSRNG002	08/20/14	Antimony	0.23	J	0.073	20			6.0
Berm	LYSRNG002	08/18/15	Antimony	ND	U	0.26	2			
Berm	LYSRNG002	09/14/16	Antimony	0.25	J	0.20	2.0			

Berm	LYSRNG002	09/27/17	Antimony	1.0	U	0.20		2		
Berm	LYSRNG002	10/24/18	Antimony	ND	U	2.0	5.0			6
Berm	LYSRNG002	10/01/19	Antimony	0.14	J	0.5		1.0	0.055	6
Berm	LYSRNG002	04/01/20	Antimony	0	U	2		5.0	4.0	6
Berm	LYSRNG002	09/13/12	Copper	3.5	J	0.23	20			
Berm	LYSRNG002	09/13/12	Copper	2.2	J	0.23	20			
Berm	LYSRNG002	07/31/13	Copper	1.9	J B	0.23	20			
Berm	LYSRNG002	08/20/14	Copper	2.5	J	0.23	20			1,300
Berm	LYSRNG002	08/18/15	Copper	ND	U	2.1	5			
Berm	LYSRNG002	09/14/16	Copper	3.1		0.20	2.0			
Berm	LYSRNG002	09/27/17	Copper	1.4	UB	0.20		2		
Berm	LYSRNG002	10/24/18	Copper	2.7	J	1.9	3.0			1,300
Berm	LYSRNG002	10/01/19	Copper	1.2	J	2		3.0	0.19	1300
Berm	LYSRNG002	04/01/20	Copper	3		1.9		3.0	2.5	1300
Berm	LYSRNG002	09/13/12	Lead	1.2	J	0.024	2			
Berm	LYSRNG002	09/13/12	Lead	0.55	J	0.024	2			
Berm	LYSRNG002	07/31/13	Lead	0.2	J	0.024	2			
Berm	LYSRNG002	08/20/14	Lead	0.88	J	0.024	2			15
Berm	LYSRNG002	08/18/15	Lead	ND	U	0.12	1			
Berm	LYSRNG002	09/14/16	Lead	1.1	J	0.20	2.0			
Berm	LYSRNG002	09/27/17	Lead	0.3	J	0.20		2		
Berm	LYSRNG002	10/24/18	Lead	ND	U	1.0	3.0			15
Berm	LYSRNG002	10/01/19	Lead	0.22	J	0.5		1.0	0.075	15
Berm	LYSRNG002	04/01/20	Lead	2	U	1		3.0	2.0	15
Firing Line	LYSRNG001	09/13/12	Antimony	1.9	J	0.073	20			
Firing Line	LYSRNG001	09/13/12	Antimony	2	J	0.073	20			
Firing Line	LYSRNG001	02/06/13	Antimony	0.62	J B	0.073	20			
Firing Line	LYSRNG001	02/06/13	Antimony	ND			5			
Firing Line	LYSRNG001	07/31/13	Antimony	0.36	J B	0.073	4			
Firing Line	LYSRNG001	08/20/14	Antimony	0.67	J	0.073	20			6.0
Firing Line	LYSRNG001	08/18/15	Antimony	0.65	J	0.26	2			
Firing Line	LYSRNG001	09/14/16	Antimony	0.77	J	0.20	2.0			
Firing Line	LYSRNG001	09/27/17	Antimony	1.3	J	0.20		2		
Firing Line	LYSRNG001	10/24/18	Antimony	ND	U	2.0	5.0			6
Firing Line	LYSRNG001	10/01/19	Antimony	1.3		0.5		1.0	0.055	6

Firing Line	LYSRNG001	04/01/20	Antimony	4.0	U	2		5.0	4.0	6
Firing Line	LYSRNG001	09/13/12	Copper	3.8	J	0.23	20			
Firing Line	LYSRNG001	09/13/12	Copper	2.9	J	0.23	20			
Firing Line	LYSRNG001	07/31/13	Copper	4.3	J B	0.23	20			
Firing Line	LYSRNG001	08/20/14	Copper	3.4	J	0.23	20			1,300
Firing Line	LYSRNG001	08/18/15	Copper	ND	U	2.1	5			
Firing Line	LYSRNG001	09/14/16	Copper	2.6		0.20	2.0			
Firing Line	LYSRNG001	09/27/17	Copper	4.9	B	0.20		2		
Firing Line	LYSRNG001	10/24/18	Copper	6.6		1.9	3.0			1,300
Firing Line	LYSRNG001	10/01/19	Copper	4.33		2		3.0	0.19	1300
Firing Line	LYSRNG001	04/01/20	Copper	4.2		1.9		3.0	2.5	1300
Firing Line	LYSRNG001	09/13/12	Lead	1.4	J	0.024	2			
Firing Line	LYSRNG001	09/13/12	Lead	0.43	J	0.024	2			
Firing Line	LYSRNG001	07/31/13	Lead	0.16	J	0.024	2			
Firing Line	LYSRNG001	08/20/14	Lead	0.34	J	0.024	2			15
Firing Line	LYSRNG001	08/18/15	Lead	ND	U	0.12	1			
Firing Line	LYSRNG001	09/14/16	Lead	0.34	J	0.20	2.0			
Firing Line	LYSRNG001	09/27/17	Lead	0.3	J	0.20		2		
Firing Line	LYSRNG001	10/24/18	Lead	ND	U	1.0	3.0			15
Firing Line	LYSRNG001	10/01/19	Lead	0.13	J	0.5		1.0	0.075	15
Firing Line	LYSRNG001	04/01/20	Lead	2.0	U	1		3.0	2.0	15

Notes:

µg/L = microgram(s) per liter

J = estimated value

U = not detected

B = Blank contamination: The analyte was detected above one-half the reportinglimit in an associated blank.

Sierra Range Porewater Sample Results Fall 2019

Field Sample ID	Analytical Method	Analyte	Lab Result	LOQ	LOD	DL	Units	OMMP Action Level (mg/L)	Qualifier	Reason
LYSBGD01_OCT19	SM2320B	Alkalinity, total	2.9	5.0	4.0	0.23	mg/L		J	TR
LYSBGD01_OCT19	SW6020A	Antimony	0.39	1.0	0.055	0.50	µg/L	6	J	TR
LYSBGD01_OCT19	SW6020A	Calcium	12400	100	21	80	µg/L			
LYSBGD01_OCT19	SW9056A	Chloride	59	10	5.0	0.50	mg/L			
LYSBGD01_OCT19	SW6020A	Copper	1.8	3.0	0.19	2.0	µg/L	1300	J	TR
LYSBGD01_OCT19	SW6020A	Lead	0.21	1.0	0.075	0.50	µg/L	15	J	TR
LYSBGD01_OCT19	SW6020A	Magnesium	3050	100	8	80	µg/L			
LYSBGD01_OCT19	SW6020A	Potassium	2,080	1,000	31	400	µg/L			
LYSBGD01_OCT19	SW6020A	Sodium	24,700	1,000	19	400	µg/L			
LYSBGD01_OCT19	SW9056A	Sulfate	12	1.0	0.50	0.064	mg/L			
LYSRNG001_OCT19	SM2320B	Alkalinity, total	71	5.0	4.0	0.23	mg/L			
LYSRNG001_OCT19	SW6020A	Antimony	1.29	1.0	0.055	0.5	µg/L	6		
LYSRNG001_OCT19	SW6020A	Calcium	27,400	100	21	80	µg/L			
LYSRNG001_OCT19	SW9056A	Chloride	5.4	2.0	1.0	0.0993	mg/L			
LYSRNG001_OCT19	SW6020A	Copper	4.33	3.0	0.19	2.0	µg/L	1300		
LYSRNG001_OCT19	SW6020A	Lead	0.13	1.0	0.075	0.50	µg/L	15	J	TR
LYSRNG001_OCT19	SW6020A	Magnesium	2480	100	8.0	80	µg/L			
LYSRNG001_OCT19	SW6020A	Potassium	861	1,000	31	400	µg/L		J	TR
LYSRNG001_OCT19	SW6020A	Sodium	5,800	1,000	19	400	µg/L			
LYSRNG001_OCT19	SW9056A	Sulfate	3.0	1.0	0.50	0.064	mg/L			
LYSRNG002_OCT19	SM2320B	Alkalinity, total	3.6	5.0	4.0	0.23	mg/L		J	TR
LYSRNG002_OCT19	SW6020A	Antimony	0.14	1.0	0.055	0.50	µg/L	6	J	TR
LYSRNG002_OCT19	SW6020A	Calcium	912	100	21	80	µg/L			
LYSRNG002_OCT19	SW9056A	Chloride	3.1	2.0	1.0	0.0993	mg/L			
LYSRNG002_OCT19	SW6020A	Copper	1.2	3.0	0.19	2.0	µg/L	1300	J	TR
LYSRNG002_OCT19	SW6020A	Lead	0.22	1.0	0.075	0.50	µg/L	15	J	TR
LYSRNG002_OCT19	SW6020A	Magnesium	228	100	8.0	80	µg/L			
LYSRNG002_OCT19	SW6020A	Potassium	2,480	1,000	31	400	µg/L			
LYSRNG002_OCT19	SW6020A	Sodium	1,560	1,000	19	400	µg/L			
LYSRNG002_OCT19	SW9056A	Sulfate	0.93	1.0	0.50	0.064	mg/L		J	TR

Notes:

µg/L = microgram(s) per liter

mg/L = milligram(s) per liter

J = estimated value

TR = trace result (<LOQ and >MDL)

Sierra Range Porewater Sample Results Spring 2020

Field Sample ID	Analytical Method	Analyte	Lab Result	MDL	LOD	LOQ	Units	OMMP Action Level (mg/L)	Qualifier	Reason
LYSBGD01_APR20	SM2320B	Alkalinity, total	5	5	5	5	mg/L		U	ND
LYSBGD01_APR20	SW6020A	Antimony	4.0	2.0	4.0	5.0	µg/L	6	U	ND
LYSBGD01_APR20	SW6020A	Calcium	9,200	96	180	200	µg/L		J	TR
LYSBGD01_APR20	SW9056A	Chloride	50	1.2	3.0	4.0	mg/L			
LYSBGD01_APR20	SW6020A	Copper	2.5	1.9	2.5	3.0	µg/L	1300	U	ND
LYSBGD01_APR20	SW6020A	Iron	40	20	40	50	µg/L		U	ND
LYSBGD01_APR20	SW6020A	Lead	2.0	1.0	2.0	3.0	µg/L	15	U	ND
LYSBGD01_APR20	SW6020A	Magnesium	2,300	20	40	50	µg/L			
LYSBGD01_APR20	E365.4	Phosphorus, total	0.045	0.041	0.057	0.10	mg/L		J	TR
LYSBGD01_APR20	SW6020A	Potassium	2,200	45	90	100	µg/L			
LYSBGD01_APR20	SW6020A	Sodium	21,000	50	90	100	µg/L			
LYSBGD01_APR20	SW6020A	Sodium	7,200	50	90	100	µg/L			
LYSBGD01_APR20	SW9056A	Sulfate	8.1	0.050	0.15	0.50	mg/L			
LYSBGD01_APR20	E415.1	Total Carbon	3.7	0.50	0.50	1.0	mg/L			
LYSRNG001_APR20	SM2320B	Alkalinity, total	60	5	5	5	mg/L			
LYSRNG001_APR20	SW6020A	Antimony	4.0	2.0	4.0	5.0	µg/L	6	U	ND
LYSRNG001_APR20	SW6020A	Calcium	25,000	96	180	200	µg/L			
LYSRNG001_APR20	SW9056A	Chloride	12	0.30	0.75	1.0	mg/L			
LYSRNG001_APR20	SW6020A	Copper	4.2	1.9	2.5	3.0	µg/L	1300		
LYSRNG001_APR20	SW6020A	Iron	230	20	40	50	µg/L			
LYSRNG001_APR20	SW6020A	Lead	2.0	1.0	2.0	3.0	µg/L	15	U	ND
LYSRNG001_APR20	SW6020A	Magnesium	2,300	20	40	50	µg/L			
LYSRNG001_APR20	E365.4	Phosphorus, total	0.057	0.041	0.057	0.10	mg/L		U	ND
LYSRNG001_APR20	SW6020A	Potassium	790	45	90	100	µg/L			
LYSRNG001_APR20	SW6020A	Sodium	4,500	50	90	100	µg/L			
LYSRNG001_APR20	SW9056A	Sulfate	4.0	0.050	0.15	0.50	mg/L			
LYSRNG001_APR20	E415.1	Total Carbon	6.6	0.50	0.50	1.0	mg/L			
LYSRNG002_APR20	SM2320B	Alkalinity, total	5	5	5	5	mg/L		U	ND
LYSRNG002_APR20	SW6020A	Antimony	4	2	4	5	µg/L	6	U	ND

LYSRNG002_APR20	SW6020A	Calcium	870	96	180	200	µg/L			
LYSRNG002_APR20	SW9056A	Chloride	7.1	0.12	0.30	0.40	mg/L			
LYSRNG002_APR20	SW6020A	Copper	3	1.9	2.5	3	µg/L	1300		
LYSRNG002_APR20	SW6020A	Iron	27	20	40	50	µg/L		J	TR
LYSRNG002_APR20	SW6020A	Lead	2	1	2	3	µg/L	15	U	ND
LYSRNG002_APR20	SW6020A	Magnesium	450	20	40	50	µg/L			
LYSRNG002_APR20	E365.4	Phosphorus, total	0.057	0.041	0.057	0.10	mg/L		U	ND
LYSRNG002_APR20	SW6020A	Potassium	4,000	45	90	100	µg/L			
LYSRNG002_APR20	SW6020A	Sodium	3,000	50	90	100	µg/L			
LYSRNG002_APR20	SW9056A	Sulfate	1.1	0.050	0.15	0.50	mg/L			
LYSRNG002_APR20	E415.1	Total Carbon	2.4	0.50	0.50	1.0	mg/L			

Notes:

ND = nondetectable

TR = trace result (<LOQ and >MDL)

U = not detected

J = estimated value

mg/L = milligram(s) per liter

µg/L = microgram(s) per liter

Sierra Range Porewater Sample Results Spring 2021

Sample Code	Method	Analyte	Result	Units	Qualifier	Method Detection Limit	Reporting Detection Limit	Quantitation Limit	Detection Limit Units
LYSRNG001_SEP21-09222021	SM2320B	Alkalinity	53	mg/l		3.1	6.4	10	mg/l
LYSRNG001_SEP21-09222021	SW6010C	Antimony	12	ug/l	U	5.2	12	20	ug/l
LYSRNG001_SEP21-09222021	SW6010C	Calcium	18000	ug/l		78	160	1000	ug/l
LYSRNG001_SEP21-09222021	SW9056	Chloride	5.1	mg/l	M	1	2.5	3	mg/l
LYSRNG001_SEP21-09222021	SW6010C	Copper	10	ug/l	U	4.2	10	15	ug/l
LYSRNG001_SEP21-09222021	SM5310B	Dissolved Organic Carbon	7	mg/l		0.35	0.8	1	mg/l
LYSRNG001_SEP21-09222021	SW6010C	Iron	85	ug/l	U	22	85	100	ug/l
LYSRNG001_SEP21-09222021	SW6010C	Lead	9	ug/l	U	2.7	9	15	ug/l
LYSRNG001_SEP21-09222021	SW6010C	Magnesium	1700	ug/l		26	60	500	ug/l
LYSRNG001_SEP21-09222021	E365.4	Phosphates, Total as P	0.057	mg/l	U	0.041	0.057	0.1	mg/l
LYSRNG001_SEP21-09222021	SW6010C	Potassium	940	ug/l	U	240	940	3000	ug/l
LYSRNG001_SEP21-09222021	SW6010C	Sodium	4300	ug/l	J	370	1000	5000	ug/l
LYSRNG001_SEP21-09222021	SW9056	Sulfate	2.8	mg/l	J	1	2.5	5	mg/l
LYSRNG002_SEP21-09222021	SM2320B	Alkalinity	6	mg/l	J	3.1	6.4	10	mg/l
LYSRNG002_SEP21-09222021	SW6010C	Antimony	12	ug/l	U	5.2	12	20	ug/l
LYSRNG002_SEP21-09222021	SW6010C	Calcium	880	ug/l	J	78	160	1000	ug/l
LYSRNG002_SEP21-09222021	SW9056	Chloride	5.1	mg/l		1	2.5	3	mg/l
LYSRNG002_SEP21-09222021	SW6010C	Copper	10	ug/l	U	4.2	10	15	ug/l
LYSRNG002_SEP21-09222021	SM5310B	Dissolved Organic Carbon	3.3	mg/l		0.35	0.8	1	mg/l
LYSRNG002_SEP21-09222021	SW6010C	Iron	30	ug/l	J	22	85	100	ug/l
LYSRNG002_SEP21-09222021	SW6010C	Lead	9	ug/l	U	2.7	9	15	ug/l
LYSRNG002_SEP21-09222021	SW6010C	Magnesium	220	ug/l	J	26	60	500	ug/l
LYSRNG002_SEP21-09222021	E365.4	Phosphates, Total as P	0.057	mg/l	U	0.041	0.057	0.1	mg/l
LYSRNG002_SEP21-09222021	SW6010C	Potassium	3800	ug/l		240	940	3000	ug/l
LYSRNG002_SEP21-09222021	SW6010C	Sodium	2900	ug/l	J	370	1000	5000	ug/l
LYSRNG002_SEP21-09222021	SW9056	Sulfate	1.5	mg/l	J	1	2.5	5	mg/l
LYSBGD01_SEP21-09232021	SM2320B	Alkalinity	6.6	mg/l	J	3.1	6.4	10	mg/l
LYSBGD01_SEP21-09232021	SW6010C	Antimony	12	ug/l	U	5.2	12	20	ug/l

LYSBGD01_SEP21-09232021	SW6010C	Calcium	3000	ug/l		78	160	1000	ug/l
LYSBGD01_SEP21-09232021	SW9056	Chloride	11	mg/l	M	1	2.5	3	mg/l
LYSBGD01_SEP21-09232021	SW6010C	Copper	10	ug/l	U	4.2	10	15	ug/l
LYSBGD01_SEP21-09232021	SM5310B	Dissolved Organic Carbon	4.5	mg/l		0.35	0.8	1	mg/l
LYSBGD01_SEP21-09232021	SW6010C	Iron	85	ug/l	U	22	85	100	ug/l
LYSBGD01_SEP21-09232021	SW6010C	Lead	9	ug/l	U	2.7	9	15	ug/l
LYSBGD01_SEP21-09232021	SW6010C	Magnesium	700	ug/l		26	60	500	ug/l
LYSBGD01_SEP21-09232021	E365.4	Phosphates, Total as P	0.057	mg/l	U	0.041	0.057	0.1	mg/l
LYSBGD01_SEP21-09232021	SW6010C	Potassium	1100	ug/l	J	240	940	3000	ug/l
LYSBGD01_SEP21-09232021	SW6010C	Sodium	9300	ug/l		370	1000	5000	ug/l
LYSBGD01_SEP21-09232021	SW9056	Sulfate	7.1	mg/l	M	1	2.5	5	mg/l

Notes:

ug/l = microgram(s) per liter | mg/l = milligram(s) per liter

U = not detected

M = manual integrated compound

J = estimated value

Sierra Range Groundwater Data 2012-2018

Location	Sample Date	Analyte	Result Value (µg/L)	Qualifier	MDL	RL	LOQ	LOD	OMMP Action Levels (µg/L)	Remarks
MW-465S	09/17/12	Antimony	ND	U	0.073	20				
MW-465S	8/1/13	Antimony	4	U	0.073	4				
MW-465S	8/20/14	Antimony	ND	U	0.073	20			3	
MW-465S	8/19/15	Antimony	ND	U	0.26	2			3	Grab Sample
MW-465S	9/19/16	Antimony	0.25	J	0.20	2.0				Low Flow
MW-465S	10/23/17	Antimony	1.0	U						
MW-465S	10/26/18	Antimony	4.4	J	2.0	5.0			3	Low Flow
MW-465S	09/17/12	Copper	0.42	J	0.23	20				
MW-465S	8/1/13	Copper	1.3	J B	0.23	20				
MW-465S	8/20/14	Copper	2.2	J	0.23	20			650	
MW-465S	8/19/15	Copper	12.7		2.1	5			650	Grab Sample
MW-465S	9/19/16	Copper	1.7	J	0.20	2.0				Low Flow
MW-465S	10/23/17	Copper	1.0	U	0.2		4			
MW-465S	10/26/18	Copper	10		2.0	5.0			650	Low Flow
MW-465S	09/17/12	Lead	ND	U	0.024	2				
MW-465S	8/1/13	Lead	0.099	J	0.024	2				
MW-465S	8/20/14	Lead	0.42	J	0.024	2			7.5	
MW-465S	8/19/15	Lead	4.2		0.12	1			7.5	Grab Sample
MW-465S	9/19/16	Lead	0.30	J	0.20	2.0				Low Flow
MW-465S	10/23/17	Lead	1.0	J	0.2		2			
MW-465S	10/26/18	Lead	ND	J	1.9	3.0			7.5	Low Flow
MW-466S	09/17/12	Antimony	ND	U	0.073	20				
MW-466S	09/17/12	Antimony	ND	U	0.073	20				
MW-466S	8/1/13	Antimony	0.46	J	0.073	4				
MW-466S	8/22/14	Antimony	0.074	J	0.073	20			3	GRAB Sample
MW-466S	8/19/15	Antimony	ND	U	0.26	2			3	Grab Sample

MW-466S	9/22/16	Antimony	0.27	J	0.20	2.0				Low Flow
MW-466S	10/23/17	Antimony	1.0	U	0.2		2			
MW-466S	10/26/18	Antimony	ND	U	2.0	5.0			3	Low Flow
MW-466S	09/17/12	Copper	0.32	J	0.23	20				
MW-466S	09/17/12	Copper	0.31	J	0.23	20				
MW-466S	8/1/13	Copper	7.1	J B	0.23	20				
MW-466S	8/22/14	Copper	2.6	J	0.23	20			650	GRAB Sample
MW-466S	8/19/15	Copper	9.7		2.1	5			650	Grab Sample
MW-466S	9/22/16	Copper	0.36	J	0.20	2.0				Low Flow
MW-466S	10/23/17	Copper	1.0	U	0.2		4			
MW-466S	10/26/18	Copper	ND	U	2.0	5.0			650	Low Flow
MW-466S	09/17/12	Lead	ND	U	0.024	2				
MW-466S	09/17/12	Lead	ND	U	0.024	2				
MW-466S	8/1/13	Lead	1.7	J	0.024	2				
MW-466S	8/22/14	Lead	0.85	J	0.024	2			7.5	GRAB Sample
MW-466S	8/19/15	Lead	2.4		0.12	1			7.5	Grab Sample
MW-466S	9/22/16	Lead	ND	U	0.20	2.0				Low Flow
MW-466S	10/23/17	Lead	1.0	U	0.2		2			
MW-466S	10/26/18	Lead	ND	U	1.9	3.0			7.5	Low Flow

Notes:

µg/L = microgram(s) per liter

J = estimated value

U = not detected

B = Blank contamination: The analyte was detected above one-half the reportinglimit in an associated blank.

Sierra Range Groundwater Sample Results Fall 2019

Field Sample ID	Analytical Method	Analyte	Lab Result	LOQ	LOD	DL	Units	OMMP Action Level (mg/L)	Qualifier	Reason
MW-465S_OCT19	SM2320B	Alkalinity, total	20	5.0	4.0	0.23	mg/L			
MW-465S_OCT19	SW6020A	Antimony	0.50	1.0	0.055	0.50	µg/L	3.00	U	ND
MW-465S_OCT19	SW6020A	Calcium	5150	100	21	80	µg/L			
MW-465S_OCT19	SW9056A	Chloride	6.1	2.0	1.0	0.0993	mg/L			
MW-465S_OCT19	SW6020A	Copper	0.60	3.0	0.19	2.0	µg/L	650	J	TR
MW-465S_OCT19	SW6020A	Lead	0.20	1.0	0.075	0.50	µg/L	7.50	J	TR
MW-465S_OCT19	SW6020A	Magnesium	2490	100	8	80	µg/L			
MW-465S_OCT19	SW6020A	Potassium	678	1,000	31	400	µg/L		J	TR
MW-465S_OCT19	SW6020A	Sodium	6,250	1,000	19	400	µg/L			
MW-465S_OCT19	SW9056A	Sulfate	6.6	1.0	0.50	0.064	mg/L		J	FD RPD
MW-465S_OCT19FD	SM2320B	Alkalinity, total	17	5.0	4.0	0.23	mg/L			
MW-465S_OCT19FD	SW6020A	Antimony	0.089	1.0	0.055	0.50	µg/L	3.00	J	TR
MW-465S_OCT19FD	SW6020A	Calcium	5,430	100	21	80	µg/L			
MW-465S_OCT19FD	SW9056A	Chloride	6.2	2.0	1.0	0.0993	mg/L			
MW-465S_OCT19FD	SW6020A	Copper	1.2	3.0	0.19	2.0	µg/L	650	J	TR
MW-465S_OCT19FD	SW6020A	Lead	0.47	1.0	0.075	0.50	µg/L	7.50	J	TR
MW-465S_OCT19FD	SW6020A	Magnesium	2620	100	8	80	µg/L			
MW-465S_OCT19FD	SW6020A	Potassium	719	1,000	31	400	µg/L		J	TR
MW-465S_OCT19FD	SW6020A	Sodium	6,550	1,000	19	400	µg/L			
MW-465S_OCT19FD	SW9056A	Sulfate	11	1.0	0.50	0.064	mg/L		J	FD RPD
MW-466S_OCT19	SM2320B	Alkalinity, total	23	5.0	4.0	0.23	mg/L			
MW-466S_OCT19	SW6020A	Antimony	0.50	1.0	0.055	0.50	µg/L	3.00	U	ND
MW-466S_OCT19	SW6020A	Calcium	5,610	100	21	80	µg/L			
MW-466S_OCT19	SW9056A	Chloride	7.4	2.0	1.0	0.0993	mg/L		J	MS%R
MW-466S_OCT19	SW6020A	Copper	1.4	3.0	0.19	2.0	µg/L	650	J	TR
MW-466S_OCT19	SW6020A	Lead	0.13	1.0	0.075	0.50	µg/L	7.50	J	TR
MW-466S_OCT19	SW6020A	Magnesium	2640	100	8	80	µg/L			

MW-466S_OCT19	SW6020A	Potassium	751	1,000	31	400	µg/L		J	TR
MW-466S_OCT19	SW6020A	Sodium	8,300	1,000	19	400	µg/L			
MW-466S_OCT19	SW9056A	Sulfate	6.3	1.0	0.50	0.064	mg/L			

Notes:
µg/L = microgram(s) per liter   MS%R = matrix spike % recovery
mg/L = milligram(s) per liter   ND = nondetectable
J = estimated value   TR = trace result (<LOQ and >DL)
U = not detected

Sierra Range Groundwater Sample Results Spring 2020

Field Sample ID	Analytical Method	Analyte	Lab Result	MDL	LOD	LOQ	Units	OMMP Action Level (mg/L)	Qualifier	Reason
MW-465S_APR20	SM2320B	Alkalinity, total	20	5.0	5.0	5.0	mg/L			
MW-465S_APR20	SW6020A	Antimony	4.0	2.0	4.0	5.0	µg/L	3	U	ND
MW-465S_APR20	SW6020A	Calcium	5,000	96	180	200	µg/L			
MW-465S_APR20	SW9056A	Chloride	6.0	0.12	0.30	0.40	mg/L			
MW-465S_APR20	SW6020A	Copper	2.5	1.9	2.5	3.0	µg/L	650	U	ND
MW-465S_APR20	SW6020A	Iron	24	20	40	50	µg/L		J	TR
MW-465S_APR20	SW6020A	Lead	2.0	1.0	2.0	3.0	µg/L	7.5	U	ND
MW-465S_APR20	SW6020A	Magnesium	2,500	20	40	50	µg/L			
MW-465S_APR20	E365.4	Phosphorus, total	2.6	0.82	1.1	2.0	mg/L			
MW-465S_APR20	SW6020A	Potassium	690	45	90	100	µg/L			
MW-465S_APR20	SW6020A	Sodium	6,500	50	90	100	µg/L			
MW-465S_APR20	SW9056A	Sulfate	6.3	0.10	0.30	1.0	mg/L			
MW-465S_APR20	E415.1	Total Carbon	0.50	0.50	0.50	1.0	mg/L		U	ND
MW-465S_APR20 FD	SM2320B	Alkalinity, total	21	5.0	5.0	5.0	mg/L			
MW-465S_APR20 FD	SW6020A	Antimony	4.0	2.0	4.0	5.0	µg/L	3	U	ND
MW-465S_APR20 FD	SW6020A	Calcium	4,900	96	180	200	µg/L			
MW-465S_APR20 FD	SW9056A	Chloride	6.0	0.12	0.30	0.40	mg/L			
MW-465S_APR20 FD	SW6020A	Copper	2.5	1.9	2.5	3.0	µg/L	650	U	ND
MW-465S_APR20 FD	SW6020A	Iron	40	20	40	50	µg/L		U	ND
MW-465S_APR20 FD	SW6020A	Lead	2.0	1.0	2.0	3.0	µg/L	7.5	U	ND
MW-465S_APR20 FD	SW6020A	Magnesium	2,400	20	40	50	µg/L			
MW-465S_APR20 FD	E365.4	Phosphorus, total	1.6	0.82	1.1	2.0	mg/L		J	TR
MW-465S_APR20 FD	SW6020A	Potassium	620	45	90	100	µg/L			
MW-465S_APR20 FD	SW6020A	Sodium	6,100	50	90	100	µg/L			
MW-465S_APR20 FD	SW9056A	Sulfate	6.3	0.10	0.30	1.0	mg/L			
MW-465S_APR20 FD	E415.1	Total Carbon	0.50	0.50	0.50	1.0	mg/L		U	ND
MW-466S_APR20	SM2320B	Alkalinity, total	28	5.0	5.0	5.0	mg/L			

MW-466S_APR20	SW6020A	Antimony	4.0	2.0	4.0	5.0	µg/L	3	U	ND
MW-466S_APR20	SW6020A	Calcium	6,300	96	180	200	µg/L			
MW-466S_APR20	SW9056A	Chloride	7.5	0.12	0.30	0.40	mg/L			
MW-466S_APR20	SW6020A	Copper	8.6	1.9	2.5	3.0	µg/L	650		
MW-466S_APR20	SW6020A	Iron	30	20	40	50	µg/L		J	TR
MW-466S_APR20	SW6020A	Lead	2.0	1.0	2.0	3.0	µg/L	7.5	U	ND
MW-466S_APR20	SW6020A	Magnesium	2,900	20	40	50	µg/L			
MW-466S_APR20	E365.4	Phosphorus, total	1.5	0.82	1.1	2.0	mg/L		J	TR
MW-466S_APR20	SW6020A	Potassium	740	45	90	100	µg/L			
MW-466S_APR20	SW6020A	Sodium	8,200	50	90	100	µg/L			
MW-466S_APR20	SW9056A	Sulfate	6.0	0.10	0.30	1.0	mg/L			
MW-466S_APR20	E415.1	Total Carbon	0.50	0.50	0.50	1.0	mg/L		U	ND

Notes:

µg/L = microgram(s) per liter

mg/L = milligram(s) per liter

ND = nondetectable

J = estimated value

TR = trace result (<LOQ and >DL)

U = not detected

Sierra Range Groundwater Sample Results Spring 2020

Sample Code	Method	Analyte	Result	Units	Qualifiers	Method Detection Limit	Reporting Limit	Quantitatoin Limit	Detection Limit Units
MW-465S_SEP21 FD-09202021	SM2320B	Alkalinity	23	mg/l		3.1	6.4	10	mg/l
MW-465S_SEP21 FD-09202021	SW6010C	Antimony	12	ug/l	U	5.2	12	20	ug/l
MW-465S_SEP21 FD-09202021	SW6010C	Calcium	4100	ug/l		78	160	1000	ug/l
MW-465S_SEP21 FD-09202021	SW9056	Chloride	5.6	mg/l		1	2.5	3	mg/l
MW-465S_SEP21 FD-09202021	SW6010C	Copper	7.1	ug/l	J	4.2	10	15	ug/l
MW-465S_SEP21 FD-09202021	SM5310B	Dissolved Organic Carbon	0.8	mg/l	U	0.35	0.8	1	mg/l
MW-465S_SEP21 FD-09202021	SW6010C	Iron	2800	ug/l		22	85	100	ug/l
MW-465S_SEP21 FD-09202021	SW6010C	Lead	9	ug/l	U	2.7	9	15	ug/l
MW-465S_SEP21 FD-09202021	SW6010C	Magnesium	2000	ug/l		26	60	500	ug/l
MW-465S_SEP21 FD-09202021	E365.4	Phosphates, Total as P	0.057	mg/l	U	0.041	0.057	0.1	mg/l
MW-465S_SEP21 FD-09202021	SW6010C	Potassium	570	ug/l	J	240	940	3000	ug/l
MW-465S_SEP21 FD-09202021	SW6010C	Sodium	5900	ug/l		370	1000	5000	ug/l
MW-465S_SEP21 FD-09202021	SW9056	Sulfate	5.3	mg/l		1	2.5	5	mg/l
MW-465S_SEP21-09202021	SM2320B	Alkalinity	22	mg/l		3.1	6.4	10	mg/l
MW-465S_SEP21-09202021	SW6010C	Antimony	12	ug/l	U	5.2	12	20	ug/l
MW-465S_SEP21-09202021	SW6010C	Calcium	4100	ug/l		78	160	1000	ug/l
MW-465S_SEP21-09202021	SW9056	Chloride	5.7	mg/l		1	2.5	3	mg/l
MW-465S_SEP21-09202021	SW6010C	Copper	10	ug/l	U	4.2	10	15	ug/l
MW-465S_SEP21-09202021	SM5310B	Dissolved Organic Carbon	0.8	mg/l	U	0.35	0.8	1	mg/l
MW-465S_SEP21-09202021	SW6010C	Iron	23	ug/l	J	22	85	100	ug/l
MW-465S_SEP21-09202021	SW6010C	Lead	9	ug/l	U	2.7	9	15	ug/l
MW-465S_SEP21-09202021	SW6010C	Magnesium	2000	ug/l		26	60	500	ug/l
MW-465S_SEP21-09202021	E365.4	Phosphates, Total as P	0.057	mg/l	U	0.041	0.057	0.1	mg/l
MW-465S_SEP21-09202021	SW6010C	Potassium	610	ug/l	J	240	940	3000	ug/l
MW-465S_SEP21-09202021	SW6010C	Sodium	5900	ug/l		370	1000	5000	ug/l
MW-465S_SEP21-09202021	SW9056	Sulfate	5.5	mg/l		1	2.5	5	mg/l
MW-466S_SEP21-09202021	SM2320B	Alkalinity	23	mg/l		3.1	6.4	10	mg/l

MW-466S_SEP21-09202021	SW6010C	Antimony	12	ug/l	U	5.2	12	20	ug/l
MW-466S_SEP21-09202021	SW6010C	Calcium	4400	ug/l		78	160	1000	ug/l
MW-466S_SEP21-09202021	SW9056	Chloride	5	mg/l	M	1	2.5	3	mg/l
MW-466S_SEP21-09202021	SW6010C	Copper	10	ug/l	U	4.2	10	15	ug/l
MW-466S_SEP21-09202021	SM5310B	Dissolved Organic Carbon	0.58	mg/l	J	0.35	0.8	1	mg/l
MW-466S_SEP21-09202021	SW6010C	Iron	100	ug/l		22	85	100	ug/l
MW-466S_SEP21-09202021	SW6010C	Lead	9	ug/l	U	2.7	9	15	ug/l
MW-466S_SEP21-09202021	SW6010C	Magnesium	1900	ug/l		26	60	500	ug/l
MW-466S_SEP21-09202021	E365.4	Phosphates, Total as P	0.057	mg/l	U	0.041	0.057	0.1	mg/l
MW-466S_SEP21-09202021	SW6010C	Potassium	650	ug/l	J	240	940	3000	ug/l
MW-466S_SEP21-09202021	SW6010C	Sodium	7300	ug/l		370	1000	5000	ug/l
MW-466S_SEP21-09202021	SW9056	Sulfate	6.8	mg/l		1	2.5	5	mg/l

Notes:

J = estimated value — ug/L = microgram(s) per liter

U = not detected — mg/L = milligram(s) per liter

Appendix 5

Scope of Work and Results for Tracer Test

AT4 TRAINING ROUND TRACER PROOF OF CONCEPT

INTRODUCTION

The Camp Edwards training area and the other training venues at Joint Base Cape Cod (JBCC) combine to make JBCC a focal point to train Soldiers (Figure 1). By maximizing training opportunities, the time away from home for the Soldier is reduced while at the same time the Soldier is receiving the required training needed to execute the National Guard's missions as defined by the State and Federal Government. The Massachusetts Army National Guard (MAARNG) emphatically recognizes that it must conduct training in a manner that is protective of groundwater and complies with environmental requirements, regulations, and law.

The MAAARNG at Camp Edwards has conducted a proof of concept to test the AT4 M287 9mm sub caliber tracer trainer to determine whether the device is considered compatible for use in training exercises at Camp Edwards / Upper Cape Water Supply Reserve. The test occured 16-18 November 2021. This device is used to simulate battlefield weapons, conditions, and effects during troop maneuvers and training. Use of this device is to prepare soldiers for live fire weapons use, battlefield tactics and the rigors of combat by simulating the stress and confusion (battlefield awareness) is an important aspect of military training.

Since 2002, the Massachusetts Army National Guard (MAARNG) has only used artillery, grenade, and smoke simulator devices on Camp Edwards that have been approved for use through Chapter 47 the Acts of 2002 and the associated Environmental Performance Standards (EPS).

Strontium peroxide and strontium nitrate are oxidizers used in the tracer component of the proposed simulator training systems. Strontium peroxide is an inorganic compound with the formula SrO_2 that exists in both anhydrous and octahydrate form, both of which are white solids. It is an oxidizing agent used for bleaching, in some pyrotechnic compositions as an oxidizer, a vivid red pyrotechnic colorant, an antiseptic, and in tracer munitions. As with strontium peroxide strontium nitrate is an inorganic compound composed of the elements strontium, nitrogen and oxygen with the formula $Sr(NO_3)_2$. This colorless solid is used as a red colorant and oxidizer in pyrotechnics and tracer munitions.

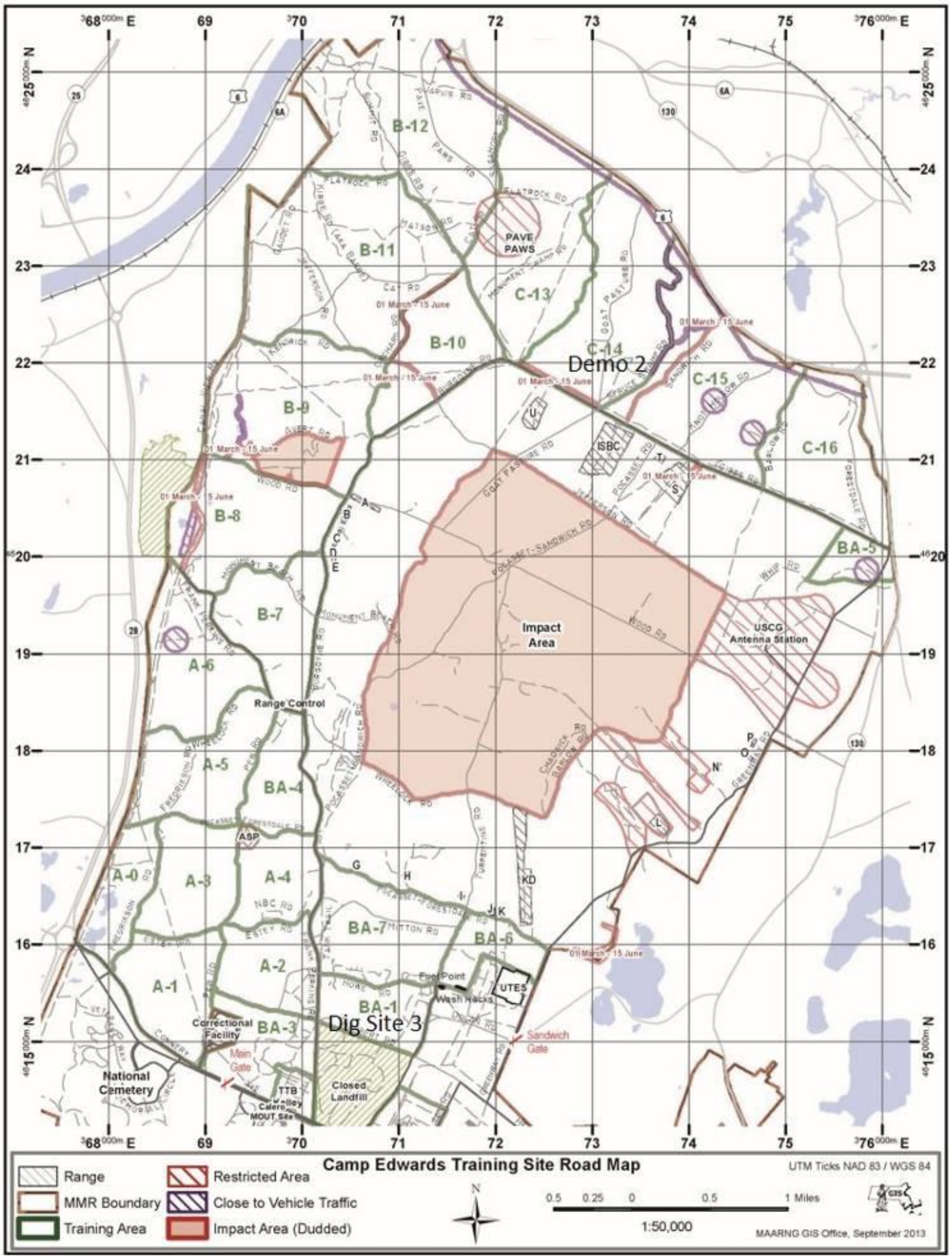


Figure 1. Camp Edwards Training Area, Massachusetts

As described in the EPS's of 6 April 2017 under Camp Edwards Training Area General Performance Standards, "Blank ammunition for small arms and simulated munitions may be used in areas outside of the small arms ranges, using only blank ammunition and simulated munitions identified on an approved list of munitions. Joint review and approval for the inclusion on the list shall be through the Environmental & Readiness Center (E &RC) and the EMC." The MAAARNG has tested the AT4 M287

9mm sub caliber tracer trainer for its compatibility for use at Camp Edwards / Upper Cape Water Supply Reserve for future training exercises.

The M136 AT4 uses the M287 sub caliber training launcher. This AT4 trainer uses the 9-mm M939 training practice-tracer (TP-T) cartridge (Figure 2 and 3). This trainer simulates the M136 AT4 in weight, balance, and operation. The velocity and trajectory of its ammunition match that of the M136 AT4's HEAT cartridge, but the M287 produces less noise and overpressure. The M287 tracer trainer is a specially constructed M136 AT4. It is designed to accept a special rifle barrel that fires a reduced-load 9-mm cartridge. The trainer has a 9-mm submachine gun barrel, a breech assembly, and a bolt. The M939 9-mm tracer cartridge has a lighter powder charge than a standard 9-mm bullet. The lighter charge enables the cartridge to closely duplicate the trajectory of the M136 AT4 tactical round at ranges out to 700 meters. The M939 cartridge also has a tracer element to enable the firer to compare the impact of the cartridge with the sight picture. The firer can see the tracer out to 550 meters. The cartridge's red tip and half-black base distinguishes it from standard 9-mm ammunition, which should never be fired from the M287 tracer trainer.

Figure 2, AT4, M287 Subcaliber Tracer Trainer

Figure 3, M939 9-mm Training Practice-Tracer

This test was conducted to determine if use of this training simulator is compatible military training that can be conducted in the Upper Cape Water Supply Reserve / Camp Edwards Training Area. The subcaliber device was tested to verify that it can be used without adverse impact to the environment. In coordination with the EMC EO the MAARNG developed this test to determine if the proposed training simulator (M939 9mm subcaliber) leaves strontium nitrate, or strontium peroxide residue (strontium) after use and if the residue poses a risk to soil or groundwater. A test is considered appropriate as a demonstration of the effectiveness of the training device in consuming the strontium nitrate, and strontium peroxide.

The following describes how the testing and analysis was condcucted to demonstrate that the training device requested can be used for effective and necessary Soldier training with no adverse impacts to the environment.

OBJECTIVE

The objective of the proposed training device testing included herein is to provide data regarding strontium nitrate, strontium peroxide residue (Strontium), in soil, and to determine whether the device is considered compatible for use at Camp Edwards / Upper Cape Water Supply Reserve.

TESTING PROCEDURES

The test was located at outside of the Upper Cape Waters Supply Reserve at Tactical Training Base (TTB) Kelley (Figure 6 and 7).

A firing lane was set up for the device to be tested. There was up to three sampling areas, the target area, range floor, and possible back blast area (Figure 7). Three to five rounds from the AT4 were fired into the target area. One 30ft x 30ft soil grid was set up for the target area and one 30x30 to 50x50ft (real time decision) soil grid was set up for the, range floor sampling area and possible back blast area. The test was conducted at TTB Kelley (Figures 6 and 7). Pretest Incremental Sampling Method (ISM) soil samples were taken from each grid at the target area, range floor, and possible back blast area. After three to five rounds were fired post firing soil samples were taken. Soil samples were collected as detailed below. Photos and video were taken of the testing conducted.

SOIL SAMPLING

All soil samples were 50 point ISM collected from the identified sampling areas (Figure 8). They were collected via the random systematic method of collecting. The samples will be composited soil increments with replicates (n=2) to be collected.

Pre-test fire soil grids were sampled via ISM to confirm there are no pre-existing contaminants of concern. Samples were collected and analyzed from a depth of 0-3". Samples were analyzed for Strontium. There are no EPA methods to determine the compounds of strontium nitrate and strontium peroxide directly as such the standard EPA Method 3050 can be used to determine strontium levels. Nitrates and peroxides will not be sampled for as the levels of nitrates would be far less than is in standard plant fertilizers and peroxide oxidizes rapidly and is not available for soil deposition.

After firing 3-5 rounds ISM with replicates were collected from each soil grid. The samples will be collected from a depth of 0-3". There are no EPA methods to determine the compounds of strontium nitrate and strontium peroxide directly as such the standard EPA Method 3050 can be used to determine strontium levels.

SAMPLE PREPARATION

Samples will be handled in accordance with the Impact Area Groundwater Study Program (IAGWSP) Quality Assurance Project Plan (QAPP). A 50 point ISM were collected from a depth of 0-3 inches from each sample area. All samples are to be collected using a systematic random sampling method. This requires dividing the sample area into exactly as many sub-areas as the number of increments required for the sample. One increment is collected from each sub-area. The same relative location should be used for each sub area. For example, if the center of the first sub-area is used to collect the first soil increment, the center of each following sub-area should also be used until the sample is complete. Samplers will use a plug extractor to systematically collect representative samples from each grid and will not concentrate samples in one portion of the sampling grid.

Two replicate samples, in addition to the primary sample, will also be collected for quality assurance purposes from the sample areas. Replicate samples should be collected in the same way as the primary sample, but from different locations within the sub-areas. Replicates can be collected at the same time if practical. Decontamination between replicates or between sub-areas is not necessary since all three samples are characterizing the same sample area. Decontamination is required before beginning to sample a different area.

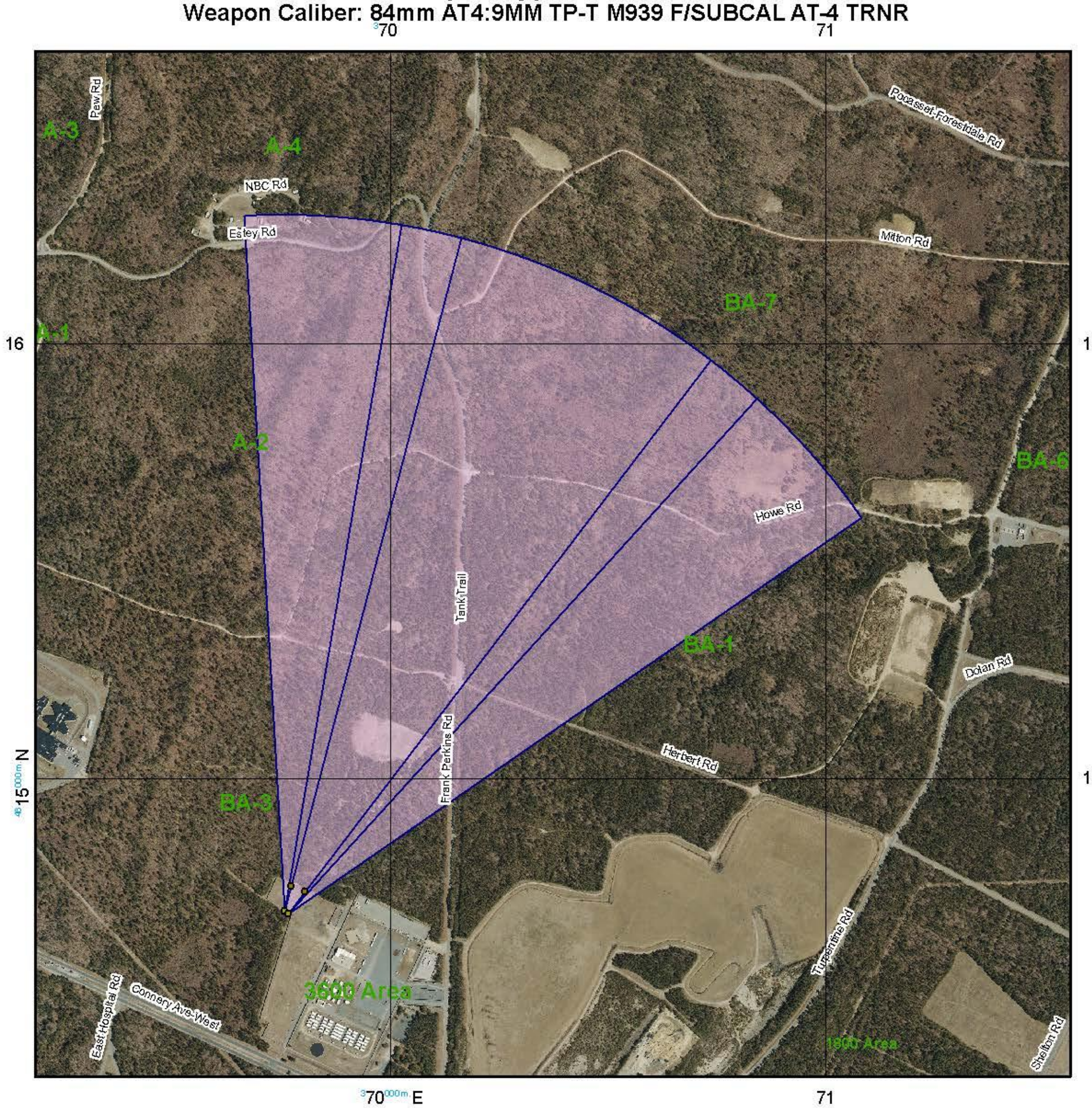
Map Scale: 1:12,500
Layout Date: 11/04/2021

FOUO

Weapon Type: ROCKETS

Weapon Caliber: 84mm AT4:9MM TP-T M939 F/SUBCAL AT-4 TRNR

RMTK Build: 10.6.1.0.6
RMTK Build Date: 05/18/2021



Range Manager Signature Authority:	Date:		
Approving Authority:	Date:		

SDZ Created By: JWalsh — Date: 11/04/2021 — Unit: GIS Manager — Phone: 339-202-9347 — Email: jeremiah.walsh2.nfg@mail.mil

SDZ Name: 84mm AT4_9MM TP-T M939 F/SUBCAL	Ground Target	Rt GTL Azi: 37.31 deg
Installation: None	Distance X: 1,600.00 m	FP: 19TCG6975514696
Range Name: None	Dispersion Angle: 5.00 deg	FP: 19TCG6976314690
Range Officer:	Ricochet Angle: 13.00 deg	TP: 19TCG6977014753
Min Target Dist: 59.00 m	Angle A: 25.00 deg	TP: 19TCG6980114739
Max Target Dist: 62.00 m	Area F Depth: 5.00 m	
Direct Fire	Lt GTL Azi: 14.69 deg	

FOUO

Figure 6. Firing Line, Target and Sampling Area, and Surface Danger Zone, AT4 9mm Training Round

TTB Kelley, Camp Edwards, Massachusetts

Figure 7. AT4 Trainer Firing Lane and Sampling Areas, Tactical Training Base Kelly
Camp Edwards, Massachusetts

Samples were prepared for analysis using standard methods for mixing and drying. The samples were ground to a fine powder prior to digestion. From these samples, 2 grams of homogenized soil were removed and digested according to method 3050B Nitric Acid Digestion for Soils. For the strontium constituents there are no EPA methods to determine the compounds of strontium nitrate and strontium peroxide directly. Strontium levels were analyzed for by EPA Method 3050. Nitrates and peroxides will not be sampled for as the levels of nitrates would be far less than is in standard plant fertilizers and peroxide oxidizes rapidly and is not available for soil deposition.

Standard reporting and minimum detection limits specified in the QAPP was achieved for all analyses or the results may be rejected during data validation.

The results are being used to determine if constituents (Strontium (strontium nitrate, and strontium peroxide)) are being deposited onto the soil from the AT4 trainer ammunition being tested. The data will be evaluated to determine if it is appropriate to use these simulators for training in the Upper Cape Water Supply Reserve / Camp Edwards Training Area, i.e., is it compatible military training.

CLEANUP

Ammunition dunnage will be collected and properly discarded. Any soil that may be required to be removed will be removed and disposed of in accordance with disposal requirements for the constituent of concern.

EVALUATION OF SAMPLE RESULTS

Testing was completed on the training device and the results were provided, evaluated, and discussed with the EMC (Figure 8). The results will be evaluated to determine if training with the tested device is acceptable in terms of environmental protection and compatible military training.

AT4 Trainer, Subcaliber Test Data and Area Image, Camp Edwards, Massachusetts, 2021

Area	Pre / Post Test	Sample Code	Analyte	Result mg/kg
A	Post Test	SSAT4RNG_POST_NOV21A-11182021	Perchlorate	0.23
A	Post Test	SSAT4TGT_POST_NOV21A-11182021	Perchlorate	0.086
A	Post Test	SSAT4RNG_POST_NOV21A-11182021	Strontium	28
A	Post Test	SSAT4TGT_POST_NOV21A-11182021	Strontium	25
A	Pre Test	SSAT4RNG_PRE_NOV21A-11172021	Perchlorate	0.085
A	Pre Test	SSAT4TGT_PRE_NOV21A-11172021	Perchlorate	0.095
A	Pre Test	SSAT4RNG_PRE_NOV21A-11172021	Strontium	29
A	Pre Test	SSAT4TGT_PRE_NOV21A-11172021	Strontium	30
Area	Pre / Post Test	Sample Code	Analyte	Result mg/kg
B	Post Test	SSAT4RNG_POST_NOV21B-11182021	Perchlorate	0.25
B	Post Test	SSAT4TGT_POST_NOV21B-11182021	Perchlorate	0.23
B	Post Test	SSAT4RNG_POST_NOV21B-11182021	Strontium	29
B	Post Test	SSAT4TGT_POST_NOV21B-11182021	Strontium	27
B	Pre Test	SSAT4RNG_PRE_NOV21B-11172021	Perchlorate	0.24
B	Pre Test	SSAT4TGT_PRE_NOV21B-11172021	Perchlorate	0.088
B	Pre Test	SSAT4RNG_PRE_NOV21B-11172021	Strontium	28
B	Pre Test	SSAT4TGT_PRE_NOV21B-11172021	Strontium	29
Area	Pre / Post Test	Sample Code	Analyte	Result mg/kg
C	Post Test	SSAT4RNG_POST_NOV21C-11182021	Perchlorate	0.24
C	Post Test	SSAT4TGT_POST_NOV21C-11182021	Perchlorate	0.11
C	Post Test	SSAT4RNG_POST_NOV21C-11182021	Strontium	31
C	Post Test	SSAT4TGT_POST_NOV21C-11182021	Strontium	26
C	Pre Test	SSAT4RNG_PRE_NOV21C-11172021	Perchlorate	0.24
C	Pre Test	SSAT4TGT_PRE_NOV21C-11172021	Perchlorate	0.25
C	Pre Test	SSAT4RNG_PRE_NOV21C-11172021	Strontium	25
C	Pre Test	SSAT4TGT_PRE_NOV21C-11172021	Strontium	32

Note: Weapons system tested did not have back blast sample area

Figure 8. AT4 Trainer Tracer Test, Perchlorate and Strontium Data, Camp Edwards, Massachusetts