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CURRENT CONDITIONS REPORT FOR THE FORMER DUPONT BARKSDALE WORKS, BARKSDALE WISCONSIN

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EXECUTIVE SUMMARY

This Current Conditions Report (CCR) presents the current environmental status of the former E.I. du Pont de Nemours and Company (DuPont) Barksdale Works facility located in Barksdale, Wisconsin (Figure 1). The purpose of this CCR is to provide the Wisconsin Department of Natural Resources (WDNR) with the information and rationale that were used to prioritize on-going investigations.

The current environmental condition of at the former Barksdale Works can be summarized as follows:

- The current land use of the property formerly comprising the Barksdale Works is either recreational (i.e., used for hunting and game management) or residential. Residential use is limited to the former site property that is east of Highway 13. Use of the former DuPont property west of Highway 13 is primarily recreational. Access to the site is strictly controlled by the current landowner (Bretting) and unauthorized use is further restricted by the security fencing surrounding the site (Figure 2) and other administrative controls. There are no other current land uses identified or anticipated.

- The former Barksdale Works has been separated into 60 former Use Areas (Figure 3), which encompass approximately 1,698 acres. Groundwater below the site is treated as a 61st area. Of the total acreage, DuPont has investigated, to varying extents, approximately 1,148 acres. The areas are segregated according to former use, and are categorized as production, waste, support, or historically undeveloped areas. The former production and support areas (i.e., where either chemical/product storage or maintenance activities occurred) comprise the majority of the former site, encompassing approximately 372 and 996 acres, respectively.

- The primary constituents of interest (COIs, constituents that are likely present and related to past activities) detected in environmental media at the facility are nitramine and nitroaromatic organic compounds (NNOCs) and arsenic and lead. Arsenic and lead are believed to most likely be associated with prior use of lead-arsenate pesticides.

- Residual solid product (i.e., solid 2,4,6-trinitrtoluene (TNT), 2,4- and 2,6-dinitrotolene (DNT), and trinitroxylene (TNX)) and elevated concentrations of NNOCs are present at and below ground surface within several former manufacturing and manufacturing support areas. The vast majority of the solid residual product observed is confined within approximately 234 acres that comprise a portion of the former production areas of the site. The few exceptions where solid residual product is present outside of the former production areas are in relatively small, isolated former waste disposal areas.

- The vast majority of the historically undeveloped areas investigated (approximately 640 acres) are acceptable for continued recreational use by the landowner. This includes the majority of the area of the site that is south of Boyd

Creek (approximately 400 acres) and approximately 240 acres in the northern portion of the site.

- No unacceptable off-site releases to surface water or sediment have been detected to date.
- Low levels of manufacturing-related constituents were detected within the drainage features in a residential property east of Highway 13 that is currently owned by Bretting. The average concentrations of these constituents are within the acceptable range for residential use of the property.
- Two plumes of site-related compounds are present in groundwater. One plume is located in the northeastern portion of the site and the other is located in the east central portion of the site. As of April 2005, groundwater downgradient of the site was no longer used as a drinking water supply or for any other purposes. Drinking water wells at residences that had a potential to be affected by site-related constituents have been replaced by a municipal supply system operated by Washburn, Wisconsin. Furthermore, all drinking water wells were plugged and abandoned per Wisconsin guidelines at each residence to ensure that the potential for residential exposure to groundwater affected by site-related constituents has been eliminated.

In order to prioritize future investigation decisions, DuPont utilized a risk-based prioritization system to "rank" the site Use Areas according to their level of concern (i.e., potential for adverse impact to human health and the environment) against one another. The area prioritization process used existing environmental information to evaluate the potential for adverse effects from potential physical and chemical hazards and specific migration/exposure pathways.

Each of the Use Areas was grouped into one of four priority categories based on the potential to affect human health and the environment. These are: (1) recommend immediate interim measures (IRM), (2) high priority for further investigation, (3) low priority for further investigation, and (4) no further investigations are required.

Based on this evaluation, no areas were determined to require new interim remedial measures. Of the 61 site Use Areas,

- Thirty–three of the Use Areas (primarily the former production and waste areas) were determined to be a high priority for further investigation. These areas have either residual solid product present, elevated concentrations of site-related constituents, are located outside of the site security fence, or have yet to be investigated and are a priority based on the nature of previous activities.
- Twenty–one Use Areas were determined to be a low priority for further investigations, i.e., these sections of the site do not pose an imminent or unacceptable risk but additional investigation may be required to confirm these observations and to help optimize remedial decisions, if necessary.
- The other seven Use Areas, which include the former product test area (PAG, approximately 1.25 acres), the Triangle Buffer (UAA) and the five full Use Areas comprising the southern portion of the site (approximately 443 acres south of

Boyd Creek) were found not to require additional investigation. A request to classify the areas south of Boyd Creek as administratively complete will be made to the WDNR.

The prioritization process led to the following recommendations for future investigative efforts:

- The primary investigation focus in 2007 and 2008 should continue to be the Use Areas identified as high priority for further investigation. This focus should include characterization of historically undeveloped areas that may be accessed by unauthorized users (i.e., areas outside of the current fence), potentially used for recreational purposes by the landowner, or areas that are currently used for non-industrial purposes.
- Periodically characterize the surface water and sediment at the drainages located along the boundary of the property east of Highway 13 and continue to verify that unacceptable off-site releases of site-related constituents are not occurring. In addition, continue to monitor and maintain the effectiveness of the interim measure (i.e., stream diversion) undertaken at the former Burning Grounds.
- Work with WDNR to develop a framework to classify as administratively complete the six Use Areas comprising the southern portion of the site (i.e., area south of Boyd Creek).
- Continue to implement site administrative controls in order to reduce the potential for human exposure to site-related compounds.

1.0 INTRODUCTION

The former DuPont Barksdale Works consists of 1,698-acres located along State Highway 13 in Bayfield County, Wisconsin (3-miles south of Washburn and 6-miles north and west of Ashland). The property was sold to C. G. Bretting Manufacturing Corporation, Inc. (Bretting) in 1986 and subsequently transferred to Bretting Development Corporation, Inc. (BDC). Bretting and BDC have used the site primarily for recreational activities, which include hunting and vehicle and equipment storage.

To support characterization of the former Barksdale Works, DuPont separated the property into 61 former Use Areas (Figure 3), which encompass approximately 1,698 acres. Of the total acreage, DuPont has investigated, to varying extents, approximately 1,148 acres. The areas are segregated according to former use, and are categorized as follows:

1. Production Areas: Designated “PA”. Production areas are defined as areas of the site where chemical production occurred. There are 21 production areas, which encompass approximately 372 acres.
2. Waste Areas: Designated “WA”. Waste areas are defined as areas where buried waste or decommissioning debris were disposed. There are 9 waste areas, which encompass approximately 14.5 acres.
3. Support Areas: Designated “SA”. Support areas are defined as areas where either storage or maintenance activities occurred. There are 14 support areas, which encompass approximately 315 acres.
4. Historically undeveloped areas: Designated “UA”. Undeveloped areas are defined as areas that have been generally unused over the operation life of the former Barksdale Works. There are 16 of these areas, which encompass approximately 996 acres.
5. Groundwater: Groundwater was evaluated as a separate Use Area so that issues regarding any potential physical and chemical hazards, and specific migration/exposure pathways beneath and within the vicinity of the former Barksdale Works could be addressed as a whole.

This Current Conditions Report (CCR) presents the current environmental status of the former DuPont Barksdale Works. The information contained in this report is a compilation of relevant and available environmental data generated as a result of past investigations conducted at the property. This information will be used to prioritize future investigative efforts.

1.1 Project Background

Investigation activities were initiated in 1997 when a groundwater sample collected from an adjacent residential drinking water well by WDNR indicated the presence of 2,4-dinitrotoluene (DNT) and 2,6-DNT. In response, DuPont worked closely with the WDNR to identify affected private wells, and where warranted, installed and maintained carbon treatment systems at affected homes, so that residential drinking water met appropriate Wisconsin regulatory criteria. At the same time, DuPont undertook several hydrogeological and engineering feasibility studies to determine the most appropriate long-term solution to address the affected drinking water supplies in the vicinity of the former Barksdale Works.

In 2003, it was concluded that a municipal water supply pipeline from Washburn, Wisconsin was the most appropriate long-term solution to supply drinking water to residents downgradient of the former site. Construction of the pipeline began in 2004 and completed in the spring of 2005. In total, over nine miles of water pipeline mains and laterals were installed as part of the project. All residences that had the potential to be affected by site-related constituents were connected to the Washburn system and each residential drinking water well was subsequently plugged and abandoned (i.e., pump removed and well casing filled).

Concurrent with the priority of addressing the affected residential drinking water supplies, site investigation activities have been conducted in each year since 1998. These investigations have been extensive and have included:

- Soil sampling and analyses. To date, over 1,400 soil samples have been collected from the former Barksdale Works and analyzed to characterize the condition of soil at the ground surface and at depth.
- Historical data reviews and research to determine past manufacturing operations and activities. Over 2,000 drawings, files, photographs, and other documents relating to past operations have been reviewed by DuPont. Additionally, numerous interviews with former employees and other people knowledgeable about historical operations at the facility have been conducted.
- Groundwater characterization. Characterization of groundwater has included well installation and sampling, and sampling of residential drinking water wells in the vicinity of the former Barksdale Works. One hundred twenty wells have been installed (both on and off of the site boundaries) to characterize the condition of groundwater. Approximately 1,300 groundwater characterization samples have been collected, analyzed, and evaluated.
- Surface water and sediment sampling. Over 40 sediment and 60 surface water samples have been collected from all drainage features in the vicinity of the former Barksdale Works. Additionally, at each of the 12 drainage features that exit the property, periodic sampling has been conducted to monitor the condition of surface water and sediment that may be leaving property.
- Excavation around former manufacturing and support buildings, as well as at process ditches. Two hundred eighty-six (286) trenches have been excavated and sampled to determine whether residual site-related constituents are present in the vicinity of former manufacturing buildings.

The data collected in these investigations through the 2006 field season serves as the basis for the evaluation completed in this CCR. Summaries of previous investigations conducted at the site are provided in Appendix A.

1.2 Objectives

The objective of this CCR is to document the current conditions and use that information as a basis for prioritizing future investigation activities at the former Barksdale Works. To meet this objective, a risk-based prioritization process was used to rank the site's Use Areas based on the potential for adverse impact to human health and the environment. This process used existing environmental data to evaluate the potential for adverse effects via specific migration/exposure pathways. The findings of the prioritization effort were then used to identify the Use Areas with the highest potential for physical and chemical hazards, and thus should become the focus of future investigative efforts. As additional data are acquired the prioritization process will be revisited and results refined. Areas were placed into one of the following priority groups:

- Interim Remedial Measure – If the Use Area poses a readily apparent risk to human health or the environment, then immediate interim measures (IRMs) are recommended.
- High Priority – If the Use Area exhibits a likely potential for risks to human health or the environment, then it is categorized as a high priority for further investigation.
- Low Priority – If the Use Area exhibits a low potential for risks to human health or the environment, then it is categorized as a low priority for further investigation. If more information is needed to confirm a low priority for certain pathways, additional assessment is recommended.
- No Further Investigation or Action – Likewise, if sufficient information is available to conclude that conditions in a Use Area indicate no potential for unacceptable exposures, then a recommendation for no further investigation or action is made.

This prioritization process is discussed in detail in Section 4.

1.3 Report Organization

This document is organized into six sections. Section 1 presents a summary of background information and the objective of this report and describes the general evaluation approach. Section 2 provides the plant history and project background. Section 3 describes the physical and environmental setting of the facility, including land use, geology and hydrogeology, and ecological setting for the site. Section 4 presents the prioritization approach that was conducted for each area. Section 5 details the prioritization results for each Use Area, including a description of each unit, a qualitative discussion of analytical data, the potential for human exposures, and the overall priority ranking. Although a qualitative data discussion is presented in Section 5, detailed results are provided in the Tables and Appendixes. Section 6 presents the conclusions of the Use Area prioritization conclusions and the priorities for future investigations. Section 7 lists the references cited in the report.

2.0 PLANT HISTORY AND BACKGROUND

DuPont operated the former Barksdale Works facility from 1904 to 1971. The facility primarily produced dynamite, nitroglycerin (NG) and TNT for the U.S. Military and the mining industry. Other products associated with the explosives industry were produced at the Barksdale Works in smaller quantities including Trinitroxylene, Trivelene, Lydol, Nitramon, soda amatol, and Nitramex. Intermediate and supplemental materials produced included sulfuric acid (oil of vitriol), nitric acid, and sellite.

Production of explosives officially ceased at Barksdale in 1971. From 1971 through 1973, cladding and industrial diamond operations (conducted in the Chequamegon-Nicolet National Forest) continued utilizing stockpiled explosives. Upon termination of these operations, DuPont performed dismantling, demolition and clean-up activities during construction seasons through 1983. Following shutdown, the grounds became overgrown by prairie and forest vegetation. Smaller scale demolition activities occurred as late as 1985. The property owner’s residence and several other residences are located on former Barksdale Works non-manufacturing area property, east of the former main manufacturing area, between State Highway 13 and the Lake Superior shoreline (see Figure 2).

2.1 Production Summary

The following sections describe the current understanding of the processes, materials, and major waste streams involved with the various products made by the former Barksdale Works. To date, only one manual (a 1940 discussion of TNT production) has been found that describes the actual production processes that existed on the former Barksdale Works. As such, the descriptions provided herein are based on available historic documentation (i.e., building construction drawings) and *The Barksdale Works the First 50 Years,* which is a lay history produced by DuPont in 1954 in celebration of site operations from 1904 through 1954. General process information has also been obtained from the references titled *Military Explosives* (November 1967 U.S. Department of the Army Technical Manual TM9-1300-214) and the *Encyclopedia Of Explosives And Related Items* (U.S. Army Research And Development Command, Tacom, Ardec, Warheads, Energetics And Combat Support Center, Picatinny Arsenal, New Jersey, USA) that DuPont has reviewed and found to be generally consistent with historical site information. DuPont reserves the right to revise and/or update the dates, processes, and all other information contained within this section should new information become available.

2.1.1 Trinitrotoluene and Trinitroxylene (includes refining)

Trinitrotoluene (TNT)

TNT is comprised of toluene to which three nitro functional groups (-NO_2) have been added in a process called nitration. Based on historical site building plans, DuPont is believed to have begun production of TNT at the Barksdale Works around 1912. The first large-scale production of TNT occurred in Germany in 1901; therefore, production of TNT was a relatively new process at the time it was undertaken at the Barksdale Works. Industrial synthesis of TNT in the early years of production (approximately 1912-1937) was accomplished by the “sequential nitration process”. Over time, the process was improved, and the “direct nitration process” became the preferred production method just before World War II (WWII), at which time plant buildings were rebuilt to include the improved processes. Historical plans for former TNT production buildings at the site indicate that each of these nitration processes was likely used during corresponding time periods.

Synthesis of TNT is initiated by placing toluene in contact with nitric acid (NA) to form mononitrotoluene (MNT). The second nitration (binitration) results in dinitrotoluene (DNT) and the third nitration step produces TNT. The attachment of nitro groups is accelerated by the addition of strong sulfuric acid (SA) to the toluene/nitric acid mixture, which acts to protonate the hydroxy group of the nitric acid. The mixture of nitric and strong sulfuric acids is called mixed acid (MA).

TNT produced at Barksdale was either crude (obtained from the initial neutralization and graining following nitration) or refined (subjected to additional processing including solvent extractions and repeated neutralization and graining steps).

Crude TNT

Synthesis of TNT occurred in three buildings as follows:

- Mononitration House (Mono House)
- Binitration and Trinitration House (Bi/Tri House)
- Neutralizing House

The TNT was packaged in two additional buildings:

- Graining House
- Box Packing House (Box House)

The operation also required support buildings to handle raw materials, acids and wastes:

- Toluene Storage Tanks (Toluol Basin)
- Acid Storage Tanks (NA Store and SA Store)
- Acid Fortifying House (Fortifier)
- Absorption Tower House (Absorber)
- Waste Acid Store House (WA Store)

Schematics for the mono-nitration buildings (Mono House) indicate that fortified spent acid (acid recovered from a higher nitration level step and strengthened by the addition of fresh nitric acid in the Fortifying House) was added to toluene. This mixture would have been heated and reacted for a specific duration after which the heavy fraction containing the nitrated toluene (i.e., MNT) was drained off. The remaining spent or waste acid (WA) was sent to the Waste Acid House. The MNT batch was then piped (via gravity) to the next process building, called the Bi/Tri House. Batches that generated excess heat during nitration (called burned charges) were directed to a wooden tank filled with water ("dumped") to prevent explosions. Mono House plans typically indicate that material from the drowning tank (i.e., a water filled tank used to cool uncontrolled process batches) over flowed to a sump tank from which it was pumped to a catch tank where the burned charge (i.e., a batch of product that exceeded thermal control limits) was gravity separated from the water. The burned charge was carried to the plant burning ground for disposal and the water drained to the site ditches. After 1964 the TNT operations purchased MNT from DuPont Chambers Works and mononitration was no longer conducted on-site.

Bi/Tri building plans indicate that fortified spent acid was reacted with the MNT to produce DNT. Spent acid drawn from the binitration step was sent to the Fortifying House. Fresh MA was then added to the vessel containing the DNT and heated to form TNT. The spent acid from this step was sent to the Fortifying House, and Oil of Vitriol (OV) was added to the vessel containing the TNT. Addition of the OV vaporized residual NA and dissolved any TNT crystals that had begun to solidify. From the Bi/Tri House, the OV/TNT solution flowed to the Neutralizing House. Bi/Tri House plans indicate that burned charges in these processes were also drowned. The dilution of the acidic solution by the drowning tank water caused the DNT or TNT to precipitate as a solid which was periodically removed from the drowning tank and taken to the burning ground while the water drained via a wood flume to the Neutralizing House catch box.

Neutralizing House plans indicate that the OV/TNT solution was mixed with bicarbonate (soda ash) solution to neutralize the acid and precipitate solid TNT. The vessel bottom discharged to a hopper with a screened conveyor that separated the solids to a draining bin, while the remaining liquid was routed to a catch box (i.e., settling basin). This procedure, called the "soda ash process", produced pellets of crude TNT and an aqueous waste stream. The aqueous waste stream and spilled products discharged to floor drains, while the crude TNT pellets were scooped from the draining bin and shipped to the Graining House via rail buggy. Red water, which contained neutralized acid and various NNOC residues, passed from the floor drains through a baffled catch box to remove suspended TNT solids. The plans indicate that settled red water typically over flowed from the catch boxes into wooden flumes that carried it to site ditches. Former employees interviewed about operations indicated that settled solids were periodically shoveled from the catch box and taken to the burning ground (reportedly once per month from 1966 to1970).

Graining House plans indicate that crude TNT was melted in a steam jacketed vessel then poured onto a brine cooled metal surface to crystallize it into sand-sized (#14 sieve) granules. The grains discharged through a bottom chute into hand carts for transfer to rail buggies. This process was occasionally upset resulting in release of molten TNT to the Graining House floor. The grained TNT was transferred via rail buggies to the Box House. Staff interviews indicated that spilled solids were periodically swept or shoveled from the floors and taken to the burning ground.

Box House plans depict equipment for weighing and packaging the grained TNT in boxes. Rail lines shown on the plans indicate that the finished boxes were distributed to magazines or to refining operations. The Boxing operation produced a solid TNT waste stream consisting of floor sweepings collected in floor pits and dust collected at building exhaust fans.

Plans indicate that, throughout the TNT production process, fumes from nitration vessels were collected and piped to the Absorption Tower House where they were condensed and accumulated as weak NA. The acid recovered from the fumes as well as the WA accumulated in the WA Store House were loaded to rail cars and returned to the Acid Recovery Plant for reprocessing.

Refined TNT

The crude TNT produced by the ‘soda ash process’ includes various TNT isomers other than the alpha-TNT (i.e, 2,4,6-TNT) desired for use as an explosive. Removing these other isomers as well as the residual DNT and other undesirable compounds present in the crude mixture is known as Refining. TNT produced by the sellite process does not include as many impurities and did not require additional refining.

Prior to World War I (WWI), refining at Barksdale was accomplished by the ‘crystallization process’ which consisted of successive applications of the soda ash process. However, since the soda ash solution tended to degrade the alpha-fraction of the TNT as well as extract the impurities, alternate methods were sought.

One alternative, Chloride Refining, extracted impurities from crude TNT with recycled carbon tetrachloride. At Barksdale, plans indicate that Chloride Refining took place at an area called the Finishing Plant. Finishing Plant extraction houses, called Wash & Press Houses, received crude TNT delivered by rail which was lifted to dissolving kettles charged with carbon tetrachloride. The kettles were stirred for a predefined time, then gravity drained to pressure filters. Spent solvent containing TNT impurities (called Mother Liquor) from the press bottom was pumped to a recovery house where it was distilled and recycled. TNT filter cake was carried by rail to finishing houses. Vacuum-fitted kettles in the finishing houses were used to draw off residual solvent from the cake which was condensed and returned to the solvent recovery houses. The evacuated cake TNT was then melted and recrystallized in open-top heated graining kettles. Solid TNT within the finishing houses was moved in hand barrows which allowed the potential for spills to floors and soil at rail car loading spots. Kettles and floors in the finishing houses were rinsed to catch boxes from which wash water overflowed to ditches. In the Solvent Recovery House, distillation column sludge was periodically collected and taken to the burning ground. Sludge tank wash and under flow from the solvent distillation process were discharged to drains that opened to ditches. Spills of solvent also were possible in and around the solvent recovery and storage buildings.

In approximately 1917, DuPont began using sellite (a solution of sodium sulfite and sodium hydrogen sulfite produced by injection of soda ash solution into the absorption tower rather than water) to refine crude TNT. The sodium sulfite removed other TNT isomers while the sodium hydrogen sulfite neutralized free acid. Staff interviews indicated that in application, the process, known as the sellite process, still required a small amount of bicarbonate to fully address residual MA, but the primary refining solution was now warm water rather than acid and the warm TNT produced by sellite washing allowed graining within the wash house rather than requiring a separate Graining House structure. Sellite washing produced an aqueous waste stream, called “red water”.

Trinitroxylene (TNX)

Plans indicate that Trinitroxylene was produced at Barksdale between approximately 1918 and 1919 due a toluene shortage. In this process, xylene, a major component of petroleum, was used as a substrate rather than the more scarce toluene fraction. Per U.S. Army documents, the resulting explosive is slightly less desirable, since it tends to degrade more easily and has some hard to manage properties (high viscosity) in the neutralization process. TNX and its precursors (nitroxylene [MNX] and dinitroxylene [DNX]) were manufactured using the same materials and operational units as TNT. Analysis of TNX and its production precursors is problematic since analytical standards for these seldom used compounds are not typically available. DuPont has contracted specialty laboratory services to have such standards developed, produced and statistically evaluated so that analysis of samples collected from TNX production areas that are currently in laboratory storage can be completed in 2007.

2.1.2 Lydol and Trivelene

Lydol and Trivelene were brand name products manufactured by DuPont at Barksdale. Plans indicate that the Lydol and Trivelene units operated from approximately 1915 through WWI. Lydol was used as an additive in dynamite and Trivelene was used as a gun barrel "lubricant" (used to heat the gun barrels walls to reduce potential for the projectile to "stick").

Lydol

Lydol is binitrated solvent naphtha (the heavy aromatic petroleum fraction from C9 to C19). Plans indicate that Lydol was produced using sequential nitration in a single recirculated reaction vessel located in the Lydol Nitrating House. Once reacted, the product was gravity separated within the Nitrating House then blown (batch discharge through overhead pipes under pressure induced by compressed air) to the Lydol House for refining. Like the TNT process, acid from previous binitration steps was fortified and reused in the mononitration step at an Acid Fortifying House and fumes were recovered and reclaimed from all nitration steps in an Absorption Tower House. WA from the nitrating process was blown to an area WA Store House for accumulation. Red water was discharged to a catch box and onto the site drainage system. In the Lydol House solvent naphtha was neutralized using the soda ash process and settled to decant the neutralization water through internal catch boxes then, to the site drainage. The resulting viscous mixture of nitrated hydrocarbons was drummed and transported by rail car to magazines or the Dynamite line.

Trivelene

Trivelene is refined DNT. Like Lydol, plans indicate it was produced by sequential nitration in a single recirculated reaction vessel using the acid handling procedures common to Lydol and TNT. Crude Trivelene was blown from the Nitration House to a sellite process Wash House for neutralization, then blown to a refining house where it was heated (known as sweating) to drive off water and acid as fumes and separate the otrtho (o)- and meta (m)-DNT fractions (which have freezing points of –13 and 60 F, respectively) from the desired para (p)-DNT fraction. From the Sweating House the crude Trivelene was grained and the p-DNT (solid to 120 F) was packaged for sale at the area

Box House. The waste o- and m-DNT and other liquids produced were blown to storage skids for use in TNT manufacture.

2.1.3 Nitrogylcerin, Dynamite, and Nitrocotton

Nitrogylcerin (NG)

Nitrogylcerin was produced at Barksdale from approximately 1904 through 1961. Plans indicate NG was produced by single stage reaction of MA with glycerin in the NG Nitration House. Due to the tendency of NG to freeze below 55 F, glycol was used to replace some or all of the glycerin during winter months. The result of nitration is a supernatant mixture of NG and residual acids floating on spent WA. The WA was decanted to a WA House where it was frozen to physically separate the NG from the MA which was returned to Acid Recovery. The crude NG/acid supernatant layer from the Nitration House flowed through heated elevated lead gutters to the Half-way House where it was agitated and hot water washed, then settled. Wash and supernatant waters were discharged to the Slum House where they were filtered and NG recovered was returned to the neutralizer while filtered water was treated with sodium sulfite to destroy any residual NG before discharge to Boyd Creek. The settled NG flowed via gutters to the Neutralizing House, was neutralized with soda ash, washed again, settled, and drained then heated to drive off entrained water. The final product was wheeled in barrows from the Neutralizing House to the mix houses in the adjacent powder lines.

Nitrocotton (NC)

Nitrocellulose, in the form of Nitrocotton, was used at Barksdale in the Gelatin Dynamite Line between approximately 1937 and 1946. It was brought in by rail from DuPont Parlin in drums that contained water for safety during shipping. The drums were opened in batches in a drying house then stored near the head of the powder line to provide a backlog of material ready for use. Dry NC was mixed with NG (and in cold weather with gelatinizing agents, such as acetone or alcohol) to form the base powder for gelatin dynamite.

Dynamite

Dynamite is a physical mixture of NG, dope (inert filler materials), accelerants (ammonium nitrate, DNT, or TNT) and moisture proofing agents (nitrocellulose). The Barksdale dynamite plant or Powder Line, which operated from approximately 1904 to 1961, contained multiple process units that were included or excluded from production of a given batch depending on the intended final use of the dynamite.

Supporting operations feeding the powder lines included: the Dope House, the NC Screen House, and a set of Melt Houses. Products from these operations were brought to the Mix Houses in rail buggies.

Dope preparation is a dry mixing operation where various fillers (wood pulp, sawdust, soda, chalk, flour, sulfur, magnesia, guar, salt, and ammonium nitrate) were mixed. The purpose of dope was to absorb the NG in order to pack it into paper shell casings and to make it less sensitive to shock during packing and shipping operations. Potential waste streams from this building include floor sweepings containing the various dope components. This material was accumulated and periodically disposed at the burning ground.

Melt Houses for Lydol and DNT warmed barrels of these products brought down through the Dope House from storage skids to the north. The molten DNT could potentially be spilled in or near the Melt and Mix Houses or along the railways between them.

At the NC Screening House, nitrocotton was gelatinized by the addition of acetone and/or DNT. Gelatinizing of nitrocellulose produces a residual paste that was periodically dissolved from the equipment using acetone then sent to the burning ground.

Blending NG, dope and additives, to produce a mixture known as powder, was conducted at the Mix Houses. In the Mix House, large wooden bowls fitted with wooden blades were filled from the top and tilted to dump out to buggies for delivery to packing houses. Waste streams from this operation included spills to floors and mixing basin wash.

Packing Houses, named for the packing machines they housed (Kimber Pack, Hall Pack, Hand Pack, and Gel Cartridge Pack), were interconnected so that any one of the Mix Houses could serve any Packing House. Packing machines produced dust, which was collected by exhaust fans that discharged indoor air outside the Packing Houses through a water spray to settle the dust. The packing houses also produced floor sweepings which were collected after shifts.

Once packed, the dynamite cartridges were sent by rail buggy to the Box Houses where they were coated with paraffin and packed in crates.

The sweepings and exhaust residue from the various powder line buildings were periodically collected and sent to the burning ground.

2.1.4 Nitric and Sulfuric Acid

The various nitration processes at the Barksdale Works utilized large quantities of Nitric and Sulfuric Acid. These were produced at Barksdale from bulk minerals and ores brought in by rail.

Nitric Acid (NA)

Between approximately 1904 and 1927, nitric acid was produced at Barksdale by the Soda Process, which involves heating of soda nitre (i.e., Soda), a caliche containing sodium nitrate. A letter from Hamilton Barksdale (former DuPont General Manager) to a Chilean business associate regarding staffing in the Chilean operation indicates that DuPont may have used Chilean ores as a Soda supply. Chilean Soda ores are known to contain perchlorate.

Soda was delivered in bags and stored in large warehouses called Soda Stores. Soda is hygroscopic and needed to be dried prior to use; therefore, the Soda process chain was: rail platform to Soda Store to Soda Dry House to Soda Elevator from which the ore entered the upper floor of the NA House.

In the NA House, Soda was heated in retorts to drive off nitric oxide fumes. The fumes were drawn through an Absorption Tower House where countercurrent water spray was used to scrub the nitric oxide from the retort exhaust. The solid ore residue left in the retort was periodically washed down to a basin called the Salt Cake Ditch were it settled and the wash water ran off to a secondary settling area, the Salt Cake Pond, and then into the plant drainage system. The Salt Cake was periodically removed from the ditch and used as daily cover at the burning ground. The weak NA in the spray down was sent through a ‘decolorization’ process to remove dissolved nitrate compounds then cooled in a brine chiller and accumulated in tanks adjacent to the NA House. This weak NA, and naturally occurring ammonia generated in the Soda process, was drawn off and sent to the Ammonia Neutralizing House.

Weak NA was concentrated to strong NA by distillation in the presence of strong sulfuric acid at the Nitric Concentrating Plant. Weak acid from the NA House was mixed with strong sulfuric acid in large open pans. The sulfuric acid dehydrates the weak NA, generating strong nitric fumes. These fumes were collected and condensed to recover the strong NA.

After 1928, the nitric oxide required to produce weak NA was produced by oxidizing ammonia in the presence of platinum and the waste streams associated with the Soda process were removed.

Sulfuric Acid (SA)

Sulfuric Acid was originally (between approximately 1904-1916) produced at Barksdale by the Pyrite Process, which involves heating of iron pyrite (an iron ore containing sulfur).

Pyrite was delivered by rail and stored in a large warehouse called the Pyrite Trestle. It was heated with coal in the Burner House to produce fumes containing sulfur dioxide. The fumes passed through a Dust Catcher and then were cooled in a long length of flue en-route to a Scrubber House. In the Scrubber House, counter-current water spray followed by filtration in the Suction Filters extracted the inert ore and coal residue leaving sulfur dioxide vapors. The vapors were drawn through a Blower House and blown into a Converter House were they were heated and further oxidized to sulfur trioxide. In the subsequent Absorber House, sulfur trioxide vapors were cooled and passed through a series of tanks containing liquid SA, which absorbed the vapor and strengthened the liquid acid. If the liquid SA in the absorber house is replaced by strong SA (SA stronger than 98%) the resulting supersaturated mixture of sulfur trioxide in sulfuric acid solution is called Oleum or Oil of Vitriol (OV).

In 1916, the Pyrite process was replaced by the Elemental Sulfur process in which solid sulfur was burned directly, eliminating the need to remove coal residues and ore dust from the sulfur dioxide fumes. This process was used at the Barksdale Works until plant closure in 1971.

Acid Recovery

Plans indicate that both NA and SA were recycled for reuse at the plant. Each production area typically contained one or more storage houses for the accumulation of spent or waste acids (WA). The accumulated WA was delivered by rail to the Acid Recovery Plant for reprocessing. WA was staged in elevated tanks (Waste Acid Towers) at the Acid Recovery Plant. From the towers the WA first entered the NA Recovery Houses where OV was added to drive off NA as vapors. The recovered NA vapors were absorbed, condensed, cooled and returned to the Acid Stores area for production use. The remaining OV/WA solution was then accumulated in the Denitrified OV Storage Houses prior to pumping to the SA Recovery Houses. In the SA Recovery House denitrified OV was boiled in a series of open lead pans reducing the water content and converting any residual TNT to trinitrobenzene. The OV was then further evaporated in open iron pans. Vapors were collected and passed through a series of drying towers where acid mist was recovered and returned to the process. The concentrated OV was then run through a lead contact apparatus known as the acid worm and finally through a coke box filtration unit to remove hydrocarbons before being returned to the Acid Store House for reuse.

2.1.5 Ammonium Nitrate (AN) Soda Amatol, Nitramon and Nitramex

Ammonium Nitrate (AN) was originally produced at Barksdale for use in dynamite. Between approximately 1951 and 1971, AN was combined with TNT to form Amatol, and combined with DNT to form Nitramon and with both DNT and TNT to form Nitramex. The Nitramon /Nitramex plant was destroyed by an explosion in 1952 and did not reopen until 1953.

AN is a salt produced by the neutralization of an aqueous solution of ammonia with nitric acid. The process consists of the neutralizing step followed by settling, evaporation and graining. Ingredients included weak nitric acid (from the NA House and NA Recovery Houses), ammonia (from the Ammonia Gas Plant where Calium Cyanamide was autoclaved with steam 1904-1928, or purchased from DuPont Belle, West Virginia 1928-1971.) and Milk of Lime (calcium hydroxide [CaOH] suspension used as a buffer).

2.1.6 Cladding and Industrial Diamonds

After WWII additional uses for the explosives produced by DuPont’s facilities were sought. One process developed was the bonding of materials under explosive pressures. Two applications of this process were explosive bonding of dissimilar metals (i.e., cladding) and production of industrial diamonds.

The Barksdale Works was awarded a large contract from the U. S. Mint around 1965 to produce silver-copper and nickel-copper plates for coin stock. The process of creating explosively bonded metal required assembly of frameworks for rigidly holding highly cleaned metal plates in specific alignment and packing a carefully controlled amount of explosive around them. The metal plates were cleaned in the Clad House (now the Bretting Barn) using perclene and ultrex solvents. The frames, called clads, were assembled in the Clad House then hauled off-site to the Chequamegon National Forest to be packed with Amatol and table salt then detonated.

Industrial diamonds were similarly created except they utilized a carbon rod as the substrate and did not require solvent cleaning.

2.1.7 Smokeless Powder, Dumorite and Pyrotol

Between approximately 1922 and 1928, DuPont obtained a contract from the U.S. Army to reprocess excess military smokeless powder (NC alone or mixed with NG or nitroguanidine) into commercial explosives. This operation involved grinding wetted smokeless powder propellant charges (Grinding House), screening the pieces to specific sizes (Screening House) and repackaging the ground material for agricultural uses such as clearing land of stumps and rocks (Dry and Store Houses). The materials formed were various combinations of the ground smokeless grains with ammonium nitrate labeled Sodatol, Agritol, Dumorite and Pyrotol distinguished primarily by the containers used for repackaging.

2.2 Manufacturing Changes and Post Site Closure Activities

The following sections describe major process closure, decommissioning and decontamination actions taken at the former Barksdale Works.

2.2.1 Post WWI Manufacturing Changes

In the period following WWI, reductions in product demand and changes in manufacturing processes eliminated the need for many of the buildings present at the site. Lydol and Trivelene operations were closed, but dynamite production was continued. TNT operations were centralized in the vicinity of TNT02 and TNT04 lines (PAB on Figure 3).

TNTand TNX production lines that were closed include:

- Lines TNT03, TNT05, TNT06-TNT10, TNX01-TNX05,
- The Refined Triton Plant and the Triton Refinery.

Additionally, several excess support facilities also were closed, including the majority of the Acid Recovery and OV plants (Areas SAF, PAS, PAF and most of PAT on Figure 3).

Since the closed production buildings contained residues of explosives, the plant reclaimed usable scrap metal and building materials then burned the remaining wooden structures. Many support buildings were left in place as empty shells.

Reclaimed materials are visible in the remnants of the Smokeless Powder Reprocessing line that was built during this time frame. Debris from the WW-I era is also found along many ravine banks including WAB and WAC where large recalcitrant items, like bricks, tile, and concrete, that survived the fires were used as rip-rap adjacent to roads and rail grades.

2.2.2 Post WWII Manufacturing Changes

In 1946 a major flood occurred which moved the channel of Boyd Creek 400-ft in one night (DuPont, 1954). The flood destroyed the rail crossing of Boyd Creek below TNT02 creating the WAE debris area. It also destroyed the lower smokeless powder buildings, the NC buildings, the NG Halfway house and the NG Slum House. The NG buildings were replaced on higher ground, but the remains of the other structures were salvaged and burned.

In 1951, the remnants of the WWI expansion were burned, including the old NA recovery area and the remaining TNT support buildings. All dynamite lines were closed and equipment was salvaged in 1961. The Biazzi nitrator operation was sold in its entirety and transported off the property. In 1963, the dynamite and NG buildings were burned. TNT production line TNT02 was the only remaining production line at the site after 1963.

2.2.3 Post Plant Closure Decommissioning

From 1971 through 1975 the plant maintained a small staff to support the cladding and diamond operations. During this period, most of the useful equipment and materials from the other operations were salvaged and shipped for use at other DuPont facilities. Active production buildings on the property were burned during this period and the ash was reportedly buried at the Burning Ground. Investigation of previously used areas of the site which included clean-up of identified waste deposits was conducted between 1976 and 1985, after all manufacturing operations ceased. The following decommissioning activities were reported by plant staff between 1976 and 1985 (DuPont, 1997):

- 1976 – The magazines in SAA were burned and the barricades leveled.
- 1977 – Approximately 200 building foundations were staked out and cored with an auger. TNT on the ground surface was collected and burned at the decontamination burning ground (PAA).
- 1978 – Catch boxes from the last operating lines (PAB) were located, excavated and their contents burned. Soil around these catch boxes was soaked with oil and subsequently burned. NG ditches and drains were detonated with water gel (PAO). An area called the "WWI TNT ravine" was examined, and material was collected and burned (this ravine is probably the drainage that forms the western border of PAA).
- 1979 – WWI TNT ravine was examined further, and material from suspicious areas was excavated and burned. One catch box from the WWI plant was excavated (believed to be at the Triton Refinery [PAD]).
- 1980 – Contractor barricades and other construction debris were removed.
- 1981 – Drums in the "empty barrel dump" (western portion of WAB) were recovered and cleaned, crushed, and subsequently buried on the site east of the barrel dump (eastern WAB). Soil at the acid area culvert and ditch (PAT near sulfur barn) was neutralized with sodium carbonate and seeded with grass. The NA production area (PAR near the current decontamination area) was neutralized with sodium carbonate and seeded with grass. The "Old TNT area" (PAB at TNT04) was examined and additional catch box material was removed.
- 1982 – Three soil samples were collected in the TNX area (PAI) and analyzed for TNT. No detectable concentrations of TNT were found. Metal caps were placed onto the casing of the main gate and powerhouse wells. Catch box removal continued. Barrel dump cleanup continued. The Old TNT manufacturing area (TNT04) was stripped to virgin soil along the ditch. A large catch box was excavated, and the material was removed and burned at the Decommissioning Burning Ground (the large shaded area in PAA on Figure 6.1). Soil removed

from this area was spread out in several 6-inch layers, and catch box waste was manually removed from the soil and burned. Approximately 400 cubic yards of soil were managed in this way at the Decommissioning Burning Ground (Figure 6.1). A 1-foot thick clay cover was placed on top of these layers. A second catch box was located but not excavated. The surface of the old acid area (PAS) was examined for bare spots and these areas were excavated and burned (resin coated pellets of ammonium nitrate had been dumped in this area and had not dissolved). Asbestos left after burning area buildings was bagged and taken to a local landfill. Two buildings in the TNX area (Use Area PAI) were excavated to audit cleanliness. TNX area was examined and TNX-triton drainage collection system was excavated.

- 1983 – WWI TNT area (PAH) excavation was completed. Catch boxes were unearthed and interior material was burned, but not all drains or foundations were addressed. Chloride Refine, Lydol, and Trivelene areas were excavated. Excavated dirt was spread in 6-inch layers at the Decommissioning Burning Ground to examine and remove residual product. A clay cover was placed over the entire examination area. The "Old OV dump" areas were reexamined for cleanliness. Many surface drainage ditches in the TNX and TNT areas were regraded to avoid stagnant water pools. Five small transformers were disposed off-site.

2.2.4 Post Property Sale Alterations

Since the sale of the property in 1986, the following new site features have been constructed (Figure 4):

- Shop/Barn: a wood frame structure built on the former Cladding Building foundation. This structure is used by BDC to store recreational vehicles and for wood working and vehicle maintenance.
- Club House: a brick addition to the former Shell House. The Club House is a residential room utilized by site day visitors. The former Shell House is currently utilized by BDC as a garage and game processing area.
- Cow Shed (Decon Facility): a wood shed built in the vicinity of the former Ammonia Neutralizing House and used to shelter cattle and feed between 1986 and 1998. DuPont began using the structure for an investigation support area and equipment decontamination area in 2003.
- Hay Barn: a sheet metal barn constructed on the former Sulfur Barn foundations used by BDC to store hay and farm equipment.
- DuPont Office: a modular office structure located near the front entry of the site. The trailer was brought onto the site by DuPont for use as an office in 2002. A septic holding tank was installed adjacent to the trailer in 2003.
- Duck Ponds: two surface water impoundments were by created by BDC to attract water fowl and deer to the site. The southern of the two adjacent ponds was

created by damming the former Central Drainage using barricade soils from the adjacent TNT07 Box House.

- Bretting Burn Pile: A debris dump and waste burning area utilized by BDC to dispose of containers and miscellaneous household debris.

Conditions at these features are not necessarily related to former manufacturing operations at the Barksdale Works.

2.3 Previous Investigations

As discussed in Section 1.1, characterization of various media since 1998 have included extensive soil sampling and analyses, historical data reviews, groundwater characterization, surface water and sediment sampling, and excavation and trenching. Details of past investigations are included in the reports listed in Appendix A. Section 5 includes summaries the findings of past investigations as they pertain to the evaluation of each Use Area.

3.0 SUMMARY OF SITE SETTING

The Barksdale Works lies between Nolander Road, Ondassagon Road, East Ondassagon Road and Chequamegon Bay of Lake Superior (Figure 1). State Highway 13 runs northeast across the eastern portion of the former Barksdale Works at about 1,000 feet from the Lake Superior shoreline. The property is bordered by township roads along its north and west sides. The security fence surrounding the former Barksdale Works (i.e., site) marks the southern boundary.

The majority of the fenced portion of the plant grounds is zoned as Forestry-1 (forest programs and compatible recreational development) with Agricultural-1 (general agricultural and minor non-farm residences, with no commercial and industrial enterprises) zoning in small areas near the southern boundary. The property between State Highway 13 and the shore of Chequamegon Bay is zoned Residential-1 (permanent residential development).

Use of approximately 196 acres of the former Barksdale Works was restricted at the time of sale via a deed restriction. The originally restricted area roughly corresponds to the WWI era acid production area and the former TNT manufacturing area (Use Areas PAA, PAB, PAD-PAH, PAT, PAU, SAH, WAB, UAH and UAM). Since the time of sale, it was recognized that the originally restricted area needed to be expanded and administrative controls were put in place to restrict landowner access to certain areas where an unacceptable exposure may occur if recreational activities were to occur. The current areas restricted from recreational use are discussed in Section 4.3.

The following subsections summarize pertinent aspects of the site setting. Details of the issues discussed can be found in the June 20, 2002 report of the 2001 Site Investigation.

3.1 Hydrology and Drainage

3.1.1 Climate

Bayfield County averages 27-inches of rainfall per year and 53-inches of snowfall per year. Average temperatures range from 39° to 45°F in spring, 65° to 71°F in summer, 42° to 47°F in fall, and 18° to 23°F in winter. Typically the ground is frozen from November through March. In general, wind direction in the area is from the southwest during the spring and fall, from the northeast in the winter, and variable during the summer.

3.1.2 Topography

The surface elevation on-site varies from 793 feet MSL in the northwestern corner of the property to 602 feet MSL at the Lake Superior shoreline. In general, the site surface is relatively smooth with contours paralleling the current lakeshore. Where stream channels cut the site surface, steep banks up to 50 feet high are present. Steep, 20- to 30-feet, bluffs are also present at the lakeshore in the northern part of the site.

3.1.3 Surface Water Bodies

The streams with well-defined channels on or adjacent to the site are: Bono Creek; the Northern Drainage; the Central Drainage; Boyd Creek; and Mission Springs Creek. These streams flow west-northwest to southeast terminating in Chequamegon Bay, with only the eastern 500 feet of Bono and Boyd Creeks maintaining flow year round.

About 2 miles of Boyd Creek's 5.8-mile length is located within the current site boundaries within a steeply cut valley, with banks ranging from 30- to 60-feet high. The streambed within the valley drops a total of 133-feet and is relatively uniform with a gradient of about 40-feet/mile over 82 percent of the on-site channel length. The remaining 18 percent of the stream on-site consists of half a dozen isolated, 200- to 600-feet long, reaches of streambed with gradients of between 100- and 180-feet/mile and two small rapids with drops of about 4 to 6 feet.

One intermittent tributary of Bono Creek, which has the ditch line of Nolander Road as its headwaters, receives over flow from the northwest part of the site (UAH, UAI, and UAP) during heavy rains and periods of snow melt. The 1964 USGS map erroneously shows the tributary being fed from within the site near the WWI acid area.

3.1.4 Drainage

The site drains primarily from northwest to southeast along eight stream basins ranging from 36- to 679-acres. The largest basin feeds Boyd Creek and contains two ponds (sloughs within areas WAE and PAP). Two other substantial basins, over 250-acres each, feed the Central Drainage (containing 2 ponds in PAH and one in UAG) and Mission Springs Creek (with no ponds). The other six basins range from 70- to 36-acres each and feed drainages with minimally defined stream channels (often only grassed swales or roadside ditches) containing up to a dozen small intermittent ponds all together.

Numerous pocket wetlands (less than an acre each) and three areas of emergent wetland vegetation (1 to 4 acres) have been mapped on the site by the State of Wisconsin. The pocket wetlands are located primarily in the northwest corner of the property (UAP & UAI), which is relatively flat and poorly drained. The mapped emergent areas are along the site boundaries near the wells PZ-13 (PAH), PZ-03 (UAP), and PZ-08 (UAC).

3.2 Ecological Setting

The site is about 65 percent scrub forest and 35 percent meadow. Most of the site interior was strip logged in the late 1800s and many areas were selectively logged in the 1970s. Therefore, the forest present is typically in re-growth. SAL and SAN contain some old growth pine stands, but the remaining land outside the security fence is also scrub forest.

Tree species present include aspen, birch, alder, oak, red maple and white pine. A plantation of red pine was planted in PAH in the late 1970s. Maple and alder are typically more prevalent in the sandstone outcrop areas between elevations 680 and 600 at the lakeshore.

Animal species observed on-site include deer, beaver, rabbits, porcupine, bobcats, fishers, martens, mink, coyote, raccoon, fox, wolf, bear, owls, eagles, hawks, songbirds, woodpeckers, waterfowl, and grouse. The eagles, owls, wolves and some of the song birds are protected species.

Boyd Creek and the ponds on the Central Drainage have been observed to support populations of frogs, salamanders, turtles and crayfish, as well as numerous insects and other invertebrates. The year round reaches of Boyd Creek also support game fish.

3.3 Geologic Setting

The site has three main geological units of interest: surface deposits, glacial sediments and underlying sandstone.

Surface deposits

Surface deposits include man-made features (barricades in the old magazine/production areas and the road/rail grades), erosional deposits (sandbars, collapsed banks, stream deltas, stream terraces or silted-in ponds), topsoil (organic clays, vegetation derived surface materials such as forest leaf mold or detritus, prairie root zone materials, and hydric soils) and proglacial lake clays (red to red-brown silty clay layers averaging 7 ft in thickness and ranging from 33-ft thick in the western portions of the site to less than 2-ft thick east of a line running from PZ-05 to PZ-34). The clay has relatively low permeability and typically acts as the bottom for water moving through the other surface layers when it is present.

Glacial deposits

Glacial deposits on-site are comprised of Pleistocene-age tills and interbedded outwash deposits. The tills typically retard groundwater movement while the outwash within and between the till units collect infiltrating water and can act as preferential pathways where drainage is allowed.

Glacial deposits are absent east of a line running from PZ-05 to PZ-34.

From this line to a line from PZ-21 (PAI) to the east edge of PAP, the tills present belong to the Miller Creek Formation, which has three parts: an upper till about 10-ft thick, an outwash layer about 20-ft thick and a lower till that averages 15-ft thick with boulders found at the base. Glacial outwash below the lower Miller Creek ranges from 1 to 130-ft thick.

West of the PAI-PAP line, a second glacial deposit the Copper Falls Formation is present below the Miller Creek. This formation includes very dense till with thin (0.1 to 3-ft) layers of poorly graded sand or layered silt. This formation can be as thick as 200 ft.

Sandstone

Two zones of Precambrian sandstone bedrock have been observed on-site. The upper zone is characterized as thickly bedded to massive, uniformly orange to medium-brown colored, medium to fine-grained sandstone which is typically mildly to moderately weathered with numerous large (over 0.5-in.) fractures or voids. The lower zone is thinly to thickly bedded, red-violet to red-brown colored fine-grained sandstone with numerous light bands and spots present. The lower unit contains frequent siltstone inclusions, many of which are expressed as zones of contorted laminations with abrupt, closely spaced color changes. The lower zone is typically less weathered and considerably less fractured than the upper zone, even though it contains approximately 10 to 20 times as many visible indications of bedding as the upper zone.

3.4 Site Hydrogeology

Regionally, groundwater discharges from all geologic units to Lake Superior. At the site, groundwater flow in the sandstone is toward Chequamegon Bay from the west-northwest toward the east-southeast estimated at approximately 20-ft per day, or approximately 150 gallons per day per square foot of aquifer thickness (Krohelski, 1997).

Investigation data indicate that the site is underlain by three distinct groundwater zones: a shallow zone (in the surface and glacial materials), an intermediate zone (in the upper sandstone unit), and a deep zone (in the lower sandstone unit). Information supporting this conclusion includes: 1) depth intervals of recognizable stratigraphic units observed during well installations and subsequent BIPS logging efforts, 2) elevations of groundwater potentiometric surfaces in non-residential wells, 3) groundwater cation and anion data collected in October 2001, and 4) groundwater heat-pulse data collected in wells installed between 2001 and 2003.

Shallow Zone

This is the uppermost groundwater system in the portion of the site where glacial material is present. Vertical gradients in this zone are strongly downward in the northern part of the site to neutral or slightly upward in the central and far southern parts of the site. The wells drawing water from the shallow groundwater zone are typically indicated as PZ-##O. The shallow zone is believed to be unconfined and locally recharged directly from precipitation received on-site. Groundwater flow direction in this zone is southeastward toward the Lake, generally perpendicular to the shoreline. Surface water drainage features such as Boyd Creek and Bono Creek (Figure 2) influence the shallow groundwater zone bending flow toward their channels in the eastern reaches.

Intermediate Aquifer

Wells in the intermediate zone draw water from the base of the glacial materials, from within the upper bedrock or within fractured zones at the top of the lower bedrock. Typical vertical hydraulic gradients in the intermediate wells are downward at 0.05 feet per foot or more from above and neutral or upward from below. Eight of the intermediate wells have converging gradients from above and below. Wells drawing water from the intermediate groundwater zone are designated as PZ-##S and PZ-##D with some eastern PZ-##O wells drawing from this zone as well. The intermediate groundwater zone is believed to be unconfined and locally recharged directly from the overlying shallow zone. The intermediate zone is not believed to be in direct hydraulic communication with any on-site surface waters where glacial materials are present, and flow direction in this zone is southeastward toward the Lake generally perpendicular to the shoreline. In areas east of a line running from PZ-05 to PZ-34 (UAA, UAC, UAD, UAE, UAR, SAC, SAD, SAL, SAN and PAN) the shallow nature of the intermediate zone may receive a limited amount of recharge directly from precipitation at the ground surface or from infiltration of surface water from the streambed of nearby Boyd Creek.

Deep Aquifer

Wells in the deep zone draw water from within the lower sandstone bedrock unit. Water in this zone is partially confined, as evidenced by vertical gradients, which are upward from 0.01 to 0.41 feet per foot. These gradients typically are more strongly upward in the northeastern portion of the site. Wells drawing water from this aquifer typically are designated as PZ-##X. The deep groundwater zone is not believed to receive any appreciable amount of on-site recharge from the overlying intermediate or shallow zones. As reported (Young and Skinner, 1974), the regional recharge area for the deep zone underlying the site is believed to be located to the west of the site in the central portion of the Bayfield Peninsula. The TDS and cation/anion data collected from the on-site wells in October 2001 also suggest that the deep groundwater zone is associated with a different recharge source than are the shallow and intermediate zones. The lack of significant hydraulic communication between the deep groundwater zone and the overlying zones may be due more to the limited amount of secondary porosity (voids, joint sets, and fractures) present in the lower sandstone unit than due to the presence of a physically-unique barrier or confining bed typical of a traditional confined aquifer system. For this reason, the deep zone is considered to be more representative of a leaky or fractured bedrock system than a traditional confined system that requires such a confining bed. Like the intermediate zone, the lake represents the most likely discharge area for the deep zone.

Groundwater Flow Direction

The groundwater elevation contours on Figures 5A and 5B are based on static water levels in on-site wells and on direct field observations. These measurements and observations indicate that Boyd Creek is a losing stream in the central and western portions of the site and a gaining stream in its eastern reach as it approaches State Highway 13. This gaining condition is due to the intersection of the bottom of the incised stream channel with the top of the shallow zone water table and reflects a direct hydraulic communication between groundwater and surface water in this area.

4.0 AREA PRIORITIZATION APPROACH

This section presents the prioritization process applied to the Use Areas at the site. The prioritization process uses a risk-based approach to evaluate the potential for exposure to contaminants in environmental media in order to identify those units, areas, or releases that may pose the greatest potential for adverse effects on human health and the environment.

The prioritization process was based, in part, on the established National Corrective Action Prioritization System and incorporates three general steps. Step one compares existing data to risk-based screening values, where appropriate. Step two is a qualitative evaluation of mitigating factors that can offset or support the results of the first evaluation step. The first two steps evaluate the individual areas without regard to each other. Step three is less structured and consists of a comparative review of all identified concerns resulting from the first two steps in relation to each other.

The prioritization process also is supported by the Advanced Notice of Proposed Rulemaking for Corrective Action for Releases from Solid Waste Management Units at Hazardous Waste Management Facilities (ANPRM) (USEPA, 1996). The ANPRM promotes the use of risk management concepts and decision-making to prioritize efforts in order to more efficiently achieve the objective of protecting human health and the environment.

The findings of the prioritization effort were used to identify the areas that will be the focus of the next phase of the investigation. The prioritization process resulted in each Use Area being placed into one of the following categories:

- Interim Measure - Interim Measure areas are those that pose a readily apparent risk to human health or the environment, as to warrant corrective measures.
- High Priority - High Priority areas are those that exhibit likely potential for risks to human health or the environment, and as such are high priority for further investigation.
- Low Priority - Low Priority Areas are those that exhibit a low potential for risks to human health or the environment, and as such are a low priority for further investigation. In some areas, more information may be needed to confirm that the area is low priority, or to establish that no further investigation or action is warranted.
- No Further Investigation - No Further Investigation Areas are those where analysis of the sampling results indicate that residual concentrations are below land use specific screening levels; or, an area where an area-specific risk assessment was performed and the risks are below target levels, or if conditions indicate no potential for exposure.

The prioritization process is ongoing and iterative. As more information about a Use Area is obtained through subsequent investigation, the priority assigned may be re-evaluated and changed, as appropriate.

Sections 4.1 through 4.3 describe the prioritization criteria and steps in more detail. Section 5 presents priority justification for exposure pathways at each of the 61 Areas located at the site. Section 6 summarizes the priority rationale and rankings for each Use Area.

4.1 Area Description and Current Data

To provide an overview of each Use Area, a description of the area and the investigation results to date are presented in summary form. Information included for each area consists of a summary of:

- The general setting, boundaries, historical use, topography, notable features, vegetation, and surface drainage pathways.
- The analytical results for samples collected to date, where such data exist.
- The field observations made during investigations of the area.

This information is intended to support the evaluation of prioritization effort used to rank each area.

4.2 Prioritization Criteria

Based on the investigation results, each Use Area was evaluated using the following criteria:

- Potential for Fire and Explosion Hazards
- Potential for Human Exposure
- Potential Releases to Surface Water
- Potential Releases to Groundwater

The results from each evaluation step were used to determine the overall priority for the area. Each of the evaluation criteria are discussed below.

4.2.1 Potential for Fire and Explosion Hazards

Evaluation of each of the Areas with regard to fire and explosion potential was performed as part of the prioritization process. The potential for these hazards to be present was evaluated by examining the types and concentrations of constituents detected in soil, and their physical properties.

Physical characteristics including flash point and auto-ignition temperature were used to evaluate the flammability characteristics of detected constituents. The flash point is the temperature at which there is enough vapor above a liquid to ignite in the presence of a spark, and the auto-ignition temperature is the temperature which a material (liquid or solid) will ignite spontaneously without an ignition source. Generally, the lower a substance’s flash point and auto-ignition temperature, the greater the flammability hazard. Under RCRA, a characteristically hazardous ignitable waste includes those substances having a flash point of 140 degrees Fahrenheit (°F) or less. For example, the commonly accepted auto-ignition temperature of paper is approximately 451 °F, while typical gasoline blends have a flash point of -50 °F and an auto-ignition temperature of 536 °F.

In general there are two suites of constituents for which this hazard is a concern at Barksdale: volatile and nitramine/nitroaromatic organics.

For volatile organic constituents (VOCs) detected in soil, evaluation of the potential for fire hazard was performed by summing the concentrations of each volatile constituent detected in soil at each Use Area to determine if the total concentration was in excess of 1 percent of the total sample volume. This threshold was established as the limit at which a potential for fire or explosion may exist.

For the nitramine and nitroaromatic constituents, the typical flash points for the most prevalent compounds detected (2,4- and 2,6-DNT, and TNT) range from (404 °F for DNT mixtures to 450 °F for TNT). Thus, while these compounds are flammable, their potential to ignite due to heating is low when compared to VOCs. A typical grass fire (451 °F) could ignite DNT and dry TNT but would likely not ignite TNT with any amount of moisture present. Some sort of more intense heat source like a burning VOC or electrical arc would be required to initiate burning of moist TNT. Application of kinetic energy can also ignite TNT. If the TNT is confined, this ignition will result in explosion. Sensitivity studies by Safety Management Specialists conducted on Barksdale TNT samples indicate ignition will occur when the applied kinetic energy exceeds the following levels:

Material	Friction (lbs. @ m.p.h.)	Shock (lbs/ft)
TNT – weathered, dry	25 @ 2.7	414
TNT – fresh, dry	240 @ 5.4	2720
TNT – any, wet	800 @ 5.4	5200

Based on this information it is apparent that the likelihood of fire or explosion is dependent on the weather as well as the condition and concentration of the NNOCs present. The risk of initiating such an event is typically only significant during extended periods of very dry weather or during prohibited activities such as welding, open burning, or use of ungrounded electrical equipment. There have been no documented uncontrolled fires (i.e., fires not associated with waste disposal) on the facility since Barksdale Works was closed in 1971, which would indicate that although there is the potential for a fire due to the nature of the constituents in these areas, the likelihood is somewhat low.

4.2.2 Potential for Human Exposure

To evaluate the potential for human exposure in an Use Area, concentrations of detected constituents were evaluated by either quantitatively comparing the values to background concentrations or to health risk-based screening levels; or, by conducting a qualitative evaluation of analytical results in the context of the current or anticipated future use of an Use Area.

The quantitative evaluation of data provides a sample-specific result. Comparisons of analytical data to site-specific risk-based screening levels were performed at Use Areas where:

1. Recreational use of a Use Area is currently occurring or where this scenario is anticipated to be the most likely potential near-term future use.
2. Non-Industrial (i.e., residential) use of a Use Area is currently occurring or where this scenario is anticipated to be the most likely potential near-term future use.

The site-specific recreational risk-based screening levels (SSLs) were developed in accordance with procedures listed in Wisconsin Administrative Code NR 720.19 and in other relevent guidance. The non-industrial SSLs, which are based on a residential exposure scenario, were developed using the default inputs. In addition to the default exposure pathways, exposure to constituents in soil through dermal contact and absorption may also be a potential route of exposure for NNOCs, and therefore was included for both the recreational and non-industrial exposure scenarios. The process that was used to develop the SSLs is presented in Appendix B.

Analytical results for samples collected in portions of the Barksdale site that are currently used for recreational purposes were compared to the recreational SSLs for each area. Samples that were collected in areas outside the site boundary were compared to non-industrial SSLs.

Because inorganic constituents are naturally present in the environment, detected concentrations of inorganic constituents in soil were evaluated to determine if they are representative of background concentrations or the result of previous site activities. Inorganic constituent analytical results for each sample were compared to the background concentrations, and if they were below background concentrations they were not compared to risk-based screening levels. The process that was used to determine background concentrations is presented in Appendix C.

Qualitative evaluations of data and field observations were conducted for the remaining Areas of the site. Data collected in these areas were not compared to SSLs because these Areas, such as the majority of the former production areas, are not currently being used for recreational purposes. These areas are not currently being used for recreational purposes because:

- A potential fire or explosion hazard and/or the potential for human exposure via direct contact may exist due to the presence of solid residual product or elevated concentrations of site-related constituents exist in soil.
- A potential exists that former site activities have impacted the area and the area has not been completely investigated. This applies to areas where additional samples are needed to fully characterize the area, or where there are no data available for an Area.

Administrative controls have been implemented to ensure that these areas are not inadvertently used for recreational purposes and that potential hazards are communicated to stakeholders.

4.3 Evaluation of Mitigating Factors

For some areas, little existing data may be available for evaluation during the first step of the process (i.e., no data exits or historical use is unknown). In other cases, the screening process may yield an incomplete picture that over- or underestimates a unit's or area's potential to represent a risk to human health or the environment. The evaluation of mitigating factors incorporates logical and scientifically defensible reasoning, based on the site conceptual model, to predict more accurately the potential effects of evaluated releases. This evaluation considers the physical conditions that exist at an area and focuses on potential exposure pathways and receptors. Factors included in the evaluation of mitigating factors were:

- Area setting (location, accessibility, surface cover or cap, other physical characteristics),
- Activity patterns at or near the area,
- Presence of current administrative controls and health and safety protocols governing intrusive activities,
- Depth of soil contamination (soil deeper than 12 feet below ground surface (bgs) was not considered an exposure medium for humans),
- Estimated extent of impacts,
- Groundwater use, and
- Waste management history or background levels that can help distinguish site-related constituents.

Current administrative controls present at the site include:

- **Security Fencing**: A perimeter security fence surrounds 55 of the 61 Use Areas (Figure 2) and access is controlled via locked gates. None of the Use Areas located outside of the fence were used by DuPont for manufacturing or storage. Inspection (and repair, as necessary) is periodically conducted to insure fence integrity. The fence is also posted with signs at 500 foot intervals, which warn of potential hazards and state the manufacture of explosives was once conducted on the property.
- **Interior Access Controls:** Currently 23 of the 61 Use Areas are not currently used for recreational purposes by the landowner (Figure 3). All site roads entering these Use Areas have been chained and posted to limit entry to authorized personnel. With the exception of overhead power lines in Use Areas UAH, UAI, and PAH there are no utilities potentially requiring repair and access is limited to DuPont and their contractors. Any authorized activities in these Use Areas area are undertaken in a manner that is consistent with the site-specific

health and safety plan (HASP) developed by DuPont and consistent with OSHA regulations.

- **Hazard Communication**: The potential hazards on the facility are frequently reviewed with the landowner. At a minimum, communication of hazards takes place at the beginning and end of each phase of field work or as new information becomes available. Areas that are acceptable for recreational use are reviewed, identified, and clearly communicated to the landowner, as necessary.

4.4 Priority Ranking

The priority ranking step integrates the results of the previous four steps and categorizes each area. Areas that exhibit the potential to pose a readily apparent risk to human health or the environment were identified for interim measures. Areas were categorized as high priority if there was a likely potential for health or environmental risks; and, these areas are targeted for additional assessment or risk management actions. Areas were categorized as low priority if there was low potential for human health or environmental risks. If the low potential for risks needed to be confirmed, a recommendation to that effect was added. Further action at low priority areas is generally deferred until areas with higher priority are addressed. If no potential for exposure could be identified or if the constituent concentrations are below risk-based criteria, a priority ranking of no further investigation was assigned. The prioritization evaluation for each unit and the justification for each priority assignment are discussed in Section 5.

5.0 AREA CHARACTERIZATION AND PRIORITIZATION

The objective of this section is to prioritize the 61 Areas at the former DuPont Barksdale Works based on information obtained from previous investigations and historical data. The prioritization process uses the criteria presented in Section 4 to identify those areas that should be given priority for further investigation efforts. Discussions regarding individual Use Areas at the site have been combined where either physical proximity and/or similarity of past operations make these groupings appropriate.

The rationale for including each of these Use Areas in their respective priority groups are provided in the following sections. Table 1 summarizes the results of the prioritization for each individual area. Tables 2 through 7 contain the data used in evaluating each Use Area. Table 2 presents surface soil analytical detections. Table 3 presents subsurface soil analytical detections. Table 4 summarizes detections within site drainages (for both soil and sediment samples). Due to the size of the data sets, Tables 2 through 4 are subdivided with section numbers corresponding to the following subsection of this text (1 through 18); for example Table 2.06 presents surface soil detections for the Test Grounds discussed in section 5.6. Table 5 presents surface water data collected to date grouped by Use Area and position relative to the site boundary. Table 6 presents groundwater data since the last report in 2002 grouped by Use Area and groundwater flow regime (shallow, intermediate and deep). Table 7 presents a compound by compound statistical summary of the analytical results within each Use Area by media sampled.

5.1 TNT 2,3,4, and 5 Lines and Surrounding Areas (Areas PAA, PAB, WAB, WAE, and WAH)

Areas PAA, PAB, WAB, WAE, and WAH are located in the west central portion of the site (inset Figure 6.1). These Use Areas have been grouped together for discussion due to their proximity to one another and the similarity of historical manufacturing activities. PAA (left of center on Figure 6.1) contains TNT production lines TNT03 and TNT05, and the Reed Field. The Reed Field is a former ridge and furrow system that was planted with reeds to treat red-water prior to discharge to Boyd Creek. PAB (right of center on Figure 6.1) contains former TNT Production lines TNT02 and TNT04, and a decommissioning debris area (WAH in northern PAB). TNT02 line was the longest operated TNT production line at the former Barksdale Works. The West Area Rail Fill (WAB - low center on Figure 6.1) and the Slab Crossing Debris Field (WAE - at lower left on Figure 6.1).

5.1.1 Area Description

Currently Areas PAA, PAB, WAB, WAE, and WAH are generally open grass meadows (or in the north central portion of these areas, dense trees and brush) with concrete building foundations at the sites of previous production buildings. Small areas, covering between 3 and 1,100-square feet each, where vegetation is stressed or absent (i.e., bare areas) are observed interspersed throughout these Use Areas, although these bare spots are predominately located in the vicinity of foundations and former process ditches in Use Areas PAA and PAB. Surface water in PAA drains to Boyd Creek through the Reed Field Ditch (central PAA) and the WWI Ravine (the southwest border of PAA). Surface water from PAB (including WAH) drains east to Boyd Creek through the TNT02 Fortifier Ditch (northeast PAB) and TNT04 Graining House Drainage (southeast PAB). Surface water from both WAB and WAE flows directly to Boyd Creek.

Production of TNT in Use Areas PAA and PAB occurred between 1915 to plant closure in 1971. Production lines TNT02, TNT03 and TNT05 were decommissioned around 1920 and TNT04 (central PAB) remained in service until approximately 1939, when it was renamed the #1 Line. In approximately 1940, TNT02 (western PAB) was rebuilt to use the sellite process and direct nitration and renamed Line #2. Around 1945, TNT04 was dismantled and only TNT02 remained in operation. TNT02 remained in service until 1971 although it was shut down from 1945 to 1951 due to lack of product demand.

The only visible remnants of the former production operations in PAA and PAB are building foundations. To date, foundations of 46 buildings consisting of the following types have been identified in Use Areas PAA and PAB: Acid Store Houses (four NA, four MA and two WA), five Acid Fortifying Houses, five Absorption Tower Houses, five Mononitration Houses, five Bi/Trinitration Houses, four Neutralization Houses, four Graining Houses, two Box Houses, Acid Tanks (one each OV and MA), two Blow Cases, one Wash House, and a Nailing House. Descriptions of the processes previously conducted within these buildings are presented in section 2. Building types are depicted by color coding on Figure 6.1 through 6.17 as listed in the figure legend).

In addition to the building foundations listed above, PAA contains the Reed Field (depicted as a large neutralizing area in south central PAA), which was built in the late 1950s in an attempt to improve the quality of effluent discharged into Boyd Creek. Between 1971 and 1980, building debris (such as timbers, shingles, etc.) was burned at this location, which was identified in records from that period as the “decommissioning burning ground” (PAA). Residual ash was reportedly buried at the former Burning Ground (WAA) and the decommissioning burning ground was subsequently covered with one to two feet of clay. During the early 1980s, TNT recovered from demolition activities was brought to this location and burned in open burn piles. Residue from the burning was capped with another one to two feet of clay.

The West Rail Fill area (WAB) is the site of a former railroad bridge over Boyd Creek. This area consists of construction debris such as bricks and tile used to bring the rail bed within the valley to a grade level with the adjacent site uplands. Also within WAB is a used container (i.e., drums, product cans, lab ware, lab jars, and miscellaneous metal debris) disposal area known as the “drum dump” (near WAB001). Debris was believed to be periodically placed in the drum dump to stabilize the stream bank upstream of the rail crossing due to damage caused by flooding. In approximately 1980, the majority of the drums in the “drum dump” were excavated, visually inspected for the presence of product, crushed and reburied at the “crushed drum dump” (near sample WAB003). The Slab Crossing Debris Field (WAE) consists if material from WAB that was washed downstream. Waste area WAH consists of a deposit of pipes and metallic residuals from decommissioning activities that occurred between approximately 1971 and 1980.

5.1.2 Investigation Activities

Visual results from trench investigations, colorimetric screening with Expray® test kits, and soil analyses are the primary data sets used in the prioritization of Use Areas PAA, PAB, WAB, WAE, and WAH. Groundwater and sediment data were also collected as part of characterization of these Use Areas, but to a much more limited extent. Sampling was generally biased at locations where site-related residual compounds would be expected to be found. Samples were not submitted if visible solid products were present or if screening indicated elevated concentrations of TNT which could exceed DOT shipping thresholds.

The portion of PAA north of the neutralizing houses has yet to be investigated. Occasional visits to this area have indicated one or more foundations adjacent to the ravine at the western edge of the area that are not indicated on available plans. Aerial photographs from 1980 show a significant amount of excavation near one of these and additional investigation may be advisable. The wooded portion of PAA has not been reconnoitered to date. Investigation activities in WAB consisted of a geophysical survey (EM-61), surface soil sampling, and trenching. The geophysical survey (Appendix D) was performed at the "drum dump", the rail fill, and the "crushed drum dump". Screening at the locations of debris on the ground in WAE and WAH did not detect TNT or DNT; therefore, no surface soil samples were collected.

Sample locations and the results of field observations (trench and residual product recovery locations) are depicted in Figure 6.1. Available data for this Use Area group are summarized in Table-2.01 (surface soil), Table-3.01 (subsurface soil), Table-4.01 (drainage feature soil and sediment), and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7. Surface water is typically only present during storm events and therefore has not been collected in this group to date.

5.1.3 Summary of Investigation Findings

The investigation findings for this Use Area group are summarized as follows:

- Reconnaissance of historically documented manufacturing sites is complete, while inspection of the general grounds in these areas is estimated to be approximately 70% complete. Approximately 30% of PAA and 80% of WAE remain to be physically inspected.
- Characterization has been conducted at documented production buildings, mapped ditches, documented disposal areas, and soil bare areas (in excess of 50 square feet). Documented support and undocumented building foundations have not been characterized.
- Solid TNT is present at nine foundations at the surface and up to six feet below ground surface in layers that are between 0.25 and 18 inches in thickness. Solid TNT was identified in all catch boxes and drainage flumes uncovered adjacent to these buildings. Solid TNT was also located within two feet of the surface at all bare areas sampled. Investigations in PAA and PAB resulted in the removal of

approximately 125 pounds of TNT and off-site incineration. No solid TNT has been found in other areas sampled within this Use Area group to date.

- Solid DNT was found at the WAB rail fill at depth within the debris layer and five pounds were removed for off-site incineration. No other solid DNT was found in this Use Area grouping.
- Concentrations of NNOCs in surface soil were detected from highest to lowest at: the PAB bare spots, the PAA bare spot, the WAB rail fill, the PAA ditches, the reed field, and the PAB ditches. NNOCs were not detected at Boyd Creek in WAE. Expray® field screening did not identify any TNT or DNT in WAE.
- Concentrations of NNOCs in subsurface soil were detected from highest to lowest at: PAB foundations, PAA foundations, the reed field, the WAB rail fill, the WAB crushed drum dump, the WAB drum dump, and the WAH debris deposit.
- Samples at depth indicated that concentrations of NNOCs detected below the Reed Field drop by an order of magnitude between the surface samples and three and six feet below ground surface. Results drop below the laboratory detection limits before depths of 28 feet below ground surface. Samples collected at depth in PAB showed a 50% average decrease in concentration of detected compounds between three and five feet below ground surface.
- Horizontal delineation of production related compounds has not been conducted.
- The presence of DNT in the wells downgradient of these Use Areas indicates that there is a potential that a release to groundwater from Use Areas PAB and/or WAB has occurred. Results from the monitoring well installed through the downgradient edge of the former Reed Field (PZ43) indicate that releases to groundwater have not occurred in area PAA.
- Drainage samples were collected in the WWI Ravine (sample PAA013, R2, and R1) and the Reed Field ditch. TNT and the DNT isomers were the highest NNOCs detected in these samples and were generally more elevated in Reed Field ditch. Other NNOCs detected in the drainage samples include two amino-DNTs and nitroglycerin.

5.1.4 Potential for Fire or Explosion Hazards

The presence of TNT at ground surface in solid form and percentage-level concentrations of TNT and DNT in soil indicates there is a potential for fire or explosion hazards within areas PAA and PAB, but only under the specific conditions discussed in Section 4. WAB contains product at depth which may present an explosion hazard for intrusive activities. There are no known deposits of product at the surface that would present a fire hazard in WAB. WAE and WAH do not contain any known areas where production-related compounds may present a fire or explosion hazard. As a result of the solid TNT and DNT in PAA and PAB, the potential for fire or explosion in PAC is ranked as high.

5.1.5 Potential for Human Exposure

These Use Areas contain solid product and elevated concentrations of NNOCs at and near the ground surface; therefore, human exposure to site-related compounds is possible. However, these Use Areas are subject to the administrative controls detailed in Section 4.3, are within the site security fence and interior fencing, and are distant from public thoroughfares, which makes them unlikely to be attractive to trespassers. Therefore, under current conditions, the probability for human exposure in PAA, PAB, WAB, WAE, and WAH is ranked low.

5.1.6 Potential for Release to Groundwater and Surface Water

During plant operations process water discharged to Boyd Creek, the surface water body draining this area. While the amount of process water discharged was significant, the constituents likely to be present in water are known to have very short half-lives in surface water (on the order of hours) and are not anticipated to remain, since the discharge ceased over 35 years ago. This is confirmed by sediment samples that only indicate elevated NNOCs within the former Reed Field ditch (flowing east to west across central PAA).

Areas PAA, and PAB are heavily vegetated and have relatively flat topography such that little to no erosion is currently occurring in these areas. As a result, the potential for releases of impacted soil from these units to surface water is very limited.

Fill material in area WAB is visibly eroding to Boyd Creek. Area WAE contains debris formerly located in WAB that has since eroded to the creek valley. Since solid product and elevated NNOC compound residuals have been found in the waste buried at WAB the eroded material may potentially contain site-related constituents. Results from the monitoring well installed through the downgradient edge of the former Reed Field (PZ-43) indicate that releases to groundwater have not occurred in area PAA. Wells at cluster PZ-04 (side gradient of area PAB) contain DNT, indicating that a release from the area to groundwater has occurred

5.1.7 Priority Ranking

PAA, PAB, WAB, WAH, and WAE, have been assigned a high priority ranking for future investigation because:

- These Use Areas contain solid TNT and DNT and/or have not been completely characterized.
- Elevated NNOC concentrations are found in surface and sub-surface soils.
- Data indicate that there have been releases to groundwater and surface water.
- The presence of solid product indicates that there is the potential for fire or explosive hazards.

5.2 Lydol and Trivelene Lines (Area PAC)

The Lydol and Trivelene lines (PAC) are located north of Boyd Creek in the west central part of the facility, due east of PAB (location inset Figure 6.2). The area contains one Lydol and three Trivelene production lines, which were operated between approximately 1913 and 1920. PAC is approximately 16 acres and is divided by the West Gate Road, which crosses from east to west.

5.2.1 Area Description

The wooded portions of PAC and the drainages leading from Triv01 Sweating/Graining House (the large building in southern PAC) have been heavily reconnoitered near production buildings. The open southern part of PAC has been reviewed primarily from adjacent road ways. The unidentified structures along the Main Drive have only received cursory review.

The southern part of PAC (about 5 acres) is currently open meadow with several large debris piles. North of the West Gate Road the area is heavily wooded. The main drainage in PAC flows from west to east within the woods about 220-ft north of the West Gate Road. North to south ditches feed into this drainage from process buildings throughout the wooded area. Drainage enters the area through culverts under the Main Drive from PAE and PAU. Drainage leaves the area crossing the West Gate Road to the southeast into PAO and PAR. Sediment accumulations and wash-outs around culverts leaving the area indicate that some erosion is occurring in the main ditch crossing PAC.

The Lydol and three Trivelene production lines are known to have contained 28 buildings. The Lydol production line, which operated between 1916 and1920 consisted of a Lydol Nitrating House, WA Storage, and the Lydol House. Three support buildings identified in the Lydol line include the Absorption Tower House, MA Storage, and Solvent Naphtha Store. Only the foundation of the Nitrating House remains in the Lydol area. Other buildings in this operation apparently were built on wooden piers; however, few of these piers have been identified in the area. The Lydol area has a general chemical odor and contains bare spots near the former Lydol House and PZ-40o (the latter received process water from the Lydol Nitrating House drain).

The Trivelene lines (Triv01 – 1913 to 1920; Triv02 / Triv03 – 1916 to 1920) consisted of 16 process and six support buildings. These buildings included the two Nitrating Houses, two Acid Fortifying Houses, two Wash Houses, three Sweating/Graining Houses, two Absorption Tower Houses, three Waste Oil Skids, a Box Packing House, and two WA Store Houses. The six support buildings identified in PAC include the Toluol skid, two NA Store Houses, and two MA Store Houses. Each Trivelene line had its own Sweating and Graining Houses and waste oil skids. Production lines Triv02 and Triv03 shared buildings from acid handling through the wash step. All lines shared the toluol store and boxing operations. Foundations remain from each Trivelene production building but the store houses and Toluol skids have not been located and may have been removed during renovation of plant roadways. Bare spots are present at the Triv01 Waste Oil Skids and at each of the rail car spots adjacent to the WA Houses.

Two buildings adjacent to the Main Drive west of Triv03 are believed to have been office and change houses, based on foundation configurations, although no documentation of their use has been discovered.

5.2.2 Investigation Activities

Investigation activities in PAC were focused on initial characterization and as a result, samples were collected in areas expected to contain elevated concentrations of NNOCs. Visual results from trench investigations, colorimetric screening with Expray® test kits, and soil analyses are the primary data sets used in the prioritization. Samples were generally biased at building foundations (Lydol House; Lydol Nitrating House; and Triv01, Triv02 and Triv03 Sweating/Graining Houses), bare areas (Lydol House and PZ-40o area), and the main ditch that runs through the Use Area. Sample locations are depicted in Figure 6.2. Available data for this Use Area group are summarized in Table-2.02 (surface soil), Table-3.02 (subsurface soil), Table-4.02 (drainage feature soil and sediment), and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7. Investigation of former catch boxes in the wash houses and the foundations of the acid buildings, and Box House have not been conducted to date.

A single groundwater monitoring well (PZ-40o) was installed at a large bare spot near the intersection of the West Gate Road and the TNT Loop Road. Because this bare area is downgradient of three of the process lines in PAC, it was selected as a representative monitoring point for groundwater. Soil samples were also collected from the well boring to evaluate any potential releases from the bare spot.

Surface water is only present in PAC during heavy rains and spring floods, thus surface water samples have not been collected in PAC. Sediment samples were collected from the main ditch between the Lydol Plant and Triv02 between the various feeder ditches to determine which, if any, of the drainages contained process waste residues.

5.2.3 Summary of Investigation Findings

The investigation findings for this Use Area group are summarized as follows:

- Solid DNT was found at the ground surface, but was limited to two small pieces under one-inch in diameter and dispersed crystals within the soil pore spaces at one bare spot.
- Liquid DNT (Waste Oil) was found in voids within the foundation of the adjacent Triv01 Sweating/Graining House but, the amount of oil was limited to a thin layer on water accumulated in the foundation backfill.
- A small amount of TNT (less than 0.1 pounds) was found on the ground surface adjacent to the TNT Loop Road at the east side of PAC near the Triv01 drainage.
- Site-related compounds were detected in all of the surface soil samples collected from the bare areas in PAC. TNT and DNT were the most frequently detected NNOCs.

- The results of subsurface soil sampling indicate that DNT isomers are present at the Lydol House, Lydol Nitrating House, Triv01 Graining House Catch Box, and the bare area at PZ-40.
- Groundwater sampled from PZ-40o contained NNOCs. Wells upgradient of this Use Area contained significantly more TNT and less DNT, while downgradient wells typically contained lower concentrations of each compound. The difference in DNT concentrations in the upgradient and downgradient wells indicates that a release of NNOCs may have occurred from PAC to groundwater.
- The most frequently detected compounds in drainages in PAC were TNT and DNT. The TNT06 ditch, which received drainage from the Finishing Plant located in PAE to the north, also contained measurable concentrations of carbon tetrachloride.

5.2.4 Potential for Fire or Explosion Hazards

Solid TNT and DNT have been found in PAC. Elevated concentrations of DNT have also been detected. The presence of the elevated DNT concentrations indicates that a potential for fire exists in PAC. However, under typical area use and weather conditions the potential for the DNT to ignite is low. As a result, the potential for fire or explosion in PAC is ranked as low.

5.2.5 Potential for Human Exposure

PAC contains solid product and elevated concentrations of NNOCs at and near the ground surface; therefore, human exposure to site-related compounds is possible. However, this Use Area is subject to the administrative controls detailed in Section 4.3, is within the site security fence and interior fencing, and is distant from public thoroughfares, which makes the area unlikely to be attractive to trespassers. Therefore, under current conditions, the probability for human exposure in PAC is ranked low.

5.2.6 Potential for Release to Groundwater and Surface Water

The potential for release to groundwater and surface water for PAC is ranked as high. Samples from monitoring well PZ-40o contained NNOCs including TNT and DNT. Samples collected from the upgradient well PZ-45o, contained many of the same compounds, but lower concentrations of DNT, which indicates that a release to groundwater may have occurred within PAC.

Sediment accumulating in the area indicates that erosion is occurring within PAC. Elevated concentrations of site-related compounds in the main drainage of PAC indicate that there is potential for this sediment to contain production residuals.

5.2.7 Priority Ranking

PAC has been assigned a high priority ranking for future investigation because:

- Areas containing solid TNT and DNT are present and the Use Area has not been completely characterized.

- Elevated NNOC concentrations are found in surface and sub-surface soils.
- Data indicate that there have been releases to groundwater and surface water.
- The presence of solid product indicates that there is the potential for fire or explosive hazards.

5.3 TNT 6 and Triton Refine Lines (Area PAD)

PAD is located in the western portion of the Barksdale Works along the fence north of the West Gate Road (inset Figure 6.3). The area contained two production lines, which were operated between approximately 1916 and 1920.

5.3.1 Area Description

PAD is heavily wooded with thick trees and brush covering 93% of the approximately 22-acre area. The area contained 18 buildings used by the Triton Refinery and TNT06 operations. Based on the intact building barricades in the area, it appears little decommissioning occurred at these lines.

A former rail grade north of PAA parallels the south border of PAD. This rail grade (part of the current West Gate Road) connects the Refinery Neutralizing and Graining Houses within PAD to the Main Drive and production lines located in Use Areas PAA, PAB and PAU (collectively the TNT01 through TNT05 lines). Another rail grade roughly parallels the north border of PAD connecting the Triton Refinery and TNT06.

The Triton Refinery (1917–1920), although depicted by nine buildings on the 1918 site map, was not labeled on any of the historical site plans. The use of this area for TNT purification by OV crystallization, unique among the Barksdale operational areas, was identified based on the configuration of foundations located in the area. The following building foundations have been identified in the area: Wash House, the OV and Dilute Acid Storage Houses, Neutralizing and Graining Houses (three of each), two Final Dilution Tank Houses and a Catch Tank House. Foundations for the Catch Tank House and the Dilution Tank Houses have not yet been located. Because these were wooden above ground structures, the foundations may no longer remain. Configuration of the dual discharge lines from the Catch Tank House aligns with the dual process ditches located downstream of the Neutralization and Graining Houses. Former building plans indicate that process flow to the missing structures issued at the same point as tile lines that have been identified flowing to these ditches making it likely the missing buildings were also near these ditches. Bare areas are present near the process ditches and at the building barricade entrances.

The Triton Line TNT06 (1916-1920) is configured similarly to the TNT02, TNT03, TNT04, and TNT05 lines, but its process flow was south to north rather than north to south. Unlike the prior Triton Lines which obtained toluene from shared basins east of PAD, TNT06 contained its own Toluol Store, which was located west of the TNT06 Graining House. TNT06 consisted of the following 11 buildings: three Acid Stores, a Toluol Store, Acid Fortifying House, Absorption House, Mononitration House, Bi/Trinitration House, Neutralization House, Graining House , and a Box House. The area between the Mono House and SAH and the area between the TNT06 and Refinery buildings (including the Toluol Store) have not been reconnoitered.

Drainage from the four ditches draining the Refinery (two perimeter storm ditches and two process ditches) exits PAD via a culvert under the West Gate Road toward PAA. Sediment accumulation upstream of the culvert indicates that erosion had been occurring. A silt fence and hay bails were placed in 2004 and they were effective in eliminating erosion. Drainage from the TNT06 Graining house flows to a pond then into the TNT06 Neutralizing House ditch, which flows to PAC forming the boundary between PAD and PAU. Drainage from the TNT06 acid handling buildings follows a swale to the TNT Loop Road where it enters PAA. These drainages are overgrown with vegetation and show no evidence of erosion.

5.3.2 Investigation Activities

Characterization samples in PAD were biased in areas expected to contain site-related compounds. Samples were generally biased at building foundations, bare areas and drainages. Sample locations are depicted in Figure 6.3. Available data for this Use Area group are summarized in Table-2.03 (surface soil), Table-3.03 (subsurface soil), Table-4.03 (drainage feature soil and sediment), and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

Investigation activities included significant reconnaissance, trenching/excavation, and soil and sediment sampling. Reconnaissance was focused at the Refinery Graining Houses and the TNT06 Neutralizing, Graining, and Box Houses. This effort included surveying of sampling points and foundation features. TNT06 acid handling buildings and the Refinery building sites along the West Gate Road have been reviewed primarily from adjacent road ways and mapped based on historical plans.

Trenching was conducted at each of the Refinery Graining Houses and the TNT06 Neutralizing, Bi-Trinitrating and Box Houses. The trenches were dug to evaluate drains and catch boxes. Trenches were also dug at each proposed well location and the geoprobe transect location to clear the work sites of potential buried explosives before drilling.

Soil was collected from trenches listed above and from borings (at the TNT06 WA Store and Fortifying House; the SE and SW Triton Refinery Graining Houses; and the Refinery ditches). The analyses were directed toward roughly evaluating the depth and horizontal dispersion of site-related compounds around these features. For safety reasons samples could only shipped for analysis where solid residual product was not observed.

Well(s) PZ-47o through PZ50o were installed around the Triton Refinery Graining Houses and sampled to evaluate potential for releases to groundwater.

Surface water is only present in PAD during heavy rains and spring floods, and therefore has not been sampled to date in PAD. However, sediment samples have been collected from the Refinery ditches to determine the distribution of product residuals. Sediment from the Graining House Pond was also sampled to determine if site-related compounds were present. It is not clear if the samples recovered from the pond represent the full depth of the former pond, due to heavy vegetation and organic material. The following section summarizes the investigation findings for the media characterized in PAD.

5.3.3 Summary of Investigation Findings

The investigation findings for PAD are summarized as follows:

- Reconnaissance of historically documented manufacturing sites is approximately 70% complete while approximately 50% of the remaining area has been reconnoitered.
- Characterization has been conducted at documented TNT production buildings, mapped ditches, and bare areas (greater than 50 square feet). Two production building foundations and most of the support building foundations have not been investigated.
- Solid residual TNT is present in PAD at the surface and below ground. Solid DNT was not found in PAD. Solid residual product was identified at the TNT06 Box House, at the TNT06 Neutralizing House, and at each Refinery Graining House and in several related drainages from these buildings. TNT was observed either at ground surface within the drainages or at depth adjacent to building foundations.
- Elevated concentrations of NNOCs were detected in six of the seven surface soil samples collected from these areas, with TNT and DNT being the most frequently detected compounds in these samples. Surface concentrations of NNOCs in soil were detected from highest to lowest at: the Refinery Graining Houses, the Refinery Process ditches, the TNT06 acid buildings and the bare spots in the Refinery.
- Subsurface soil samples were collected to characterize soil in and around former production structures and drainages in PAD where production-related compounds were expected to be present. The subsurface sampling found TNT present at all the Refinery Graining buildings and the TNT06 Neutralizing and Box Houses. Low concentrations of TNT were detected at the TNT06 Graining House.
    - Subsurface concentrations of NNOCs in soil were detected (from highest to lowest) at: the Refinery Graining Houses, the TNT06 Box House, the TNT06 Neutralizing House and the Refinery Process ditches.
    - Samples at depth indicated that concentrations of TNT detected beneath the process ditches and bare spots decrease by greater than 90% between one to three feet bgs to below laboratory detection limits at a depth of seven feet. DNT also decreased, by 50%, from one to three feet and to below laboratory detection limits at seven feet.
- Surface soil and sediment were also sampled to characterize concentrations within the Refinery ditches and the TNT06 pond.
    - Detected NNOCs were limited to the seven samples in the Refinery drainages, where solid residual product was also observed. The most

frequently detected compounds in these samples were TNT, DNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT (A-DNT).

  - TNT and DNT were detected in soil beneath the Refinery process ditches. TNT detections ranged from solid product at the ditch base to 120 mg/kg at one foot bgs to 6.9 mg/kg three feet bgs. DNT was only detected below the West Refinery Process Ditch at three feet bgs. TNT and DNT were not detected at bare spots or storm ditches sampled in the Refinery area.

- Horizontal delineation of production-related compounds conducted at the West Refinery Process Ditch indicated lateral decreases in TNT concentrations by two orders of magnitude over a distance of 20 ft. DNT concentrations decreased about 10-fold over the same distance.
- Analytical results for three of the four wells indicate low concentrations of TNT (0.038 µg/L in PZ-47o to 3.8 µg/L in PZ-49o) and amino-DNT (a TNT degradation product). No other NNOCs were detected in these wells. The absence of these detected compounds in samples collected hydraulically upgradient at PZ-03s indicates a potential release from PAD to groundwater.

5.3.4 Potential for Fire or Explosion Hazards

The presence of TNT at ground surface in solid form and percentage-level concentrations in soil indicates there is a potential for fire or explosion hazards within PAD. PAD also contains solid TNT at depth which may present an explosion hazard in the context of intrusive activities. Therefore, the potential for fire or explosion in PAD is ranked as high.

5.3.5 Potential for Human Exposure

PAD contains solid product and elevated concentrations of NNOCs at and near the ground surface; therefore, human exposure to site-related compounds is possible. However, this Use Areas is subject to the administrative controls detailed in Section 4.3, is within the site security fence and interior fencing, and is distant from public thoroughfares, which makes the area unlikely to be attractive to trespassers. Therefore, under current conditions, the probability for human exposure in PAD is ranked low.

5.3.6 Potential for Release to Groundwater and Surface Water

The presence of solid TNT in drainage ditches in PAD indicates that releases to surface water are likely to occur. Accumulation of sediment at the discharge point from the Refinery area indicates that erosion is occurring. As a result, the potential for releases of product from PAD to surface water is high.

Results from the monitoring wells installed within and upgradient of the Refinery area indicate that releases to groundwater have occurred in area PAD.

5.3.7 Priority Ranking

PAD has been assigned a high priority ranking for future investigation because:

- Areas containing solid TNT have been identified and have not been completely characterized.
- NNOCs are present in surface and sub-surface soils, groundwater, surface water, and sediment. These media need to be further characterized.
- Data indicate that there have been releases to groundwater and the potential for releases to surface water exists.
- The presence of solid product indicates that there is the potential for fire or explosive hazards.

5.4 Triton Finishing Plant and West Tank Farm (Areas PAE, SAG and SAH)

Areas PAE, SAG, and SAH are located in the north central portion of the site between PAD and PAS (Figure 6.4). These Use Areas have been grouped together for discussion due to their proximity to one another . Use Area PAE originally contained the Chloride Refining or Finishing Plant, which operated between approximately 1915 and 1920. The operation was changed after WWI to the Slab Casting Plant which operated from 1920 through 1945. SAG contained the original Triton warehouses operated from 1912 to 1917. SAH contained toluene storage basins operated from 1912 through 1971.

5.4.1 Area Description

Former rail grades mark the eastern and northern boundaries of these Use Areas (Figure 6.4). The Main Drive forms the southern boundary while the western boundaries with PAD and PAU are marked by drainage channels. The Acid Loop road cuts through the area from south to northeast dividing SAG from PAE.

Approximately 29 of the 35 acres in PAE, SAG, and SAH are forested. The remaining six acres consist of generally tall grass or brush, although there is approximately ¾ of an acre near the center of PAE that contains wetland reeds and sedges. Surface water along the northern edge of SAG and PAE, as well as most of SAH, drains northward to the headwaters of the Central Drainage in UAI. The remaining areas are drained by ditches that flow beneath the Main Drive to the south into PAC. No significant areas of erosion have been noted in the Triton and West Tank Farm Use Areas. Bare spots are present southeast of the two former finishing houses and near the rail grade that serviced the former solvent storage houses in PAE.

Plant maps from 1915 identified PAE as the “Triton Finishing” or “Chloride Refine Plant”. The 1915 configuration of PAE consisted of 13 buildings including the: Solvent Recovery Tank House, Solvent Recovery House, Solvent Recovery Neutralization House, Chloride Store, two Wash & Press Houses, two Condenser Houses, two Finishing Houses, two Box Houses (one in the SE corner of PAE was shared with TNT01), and a Rail Car Shed. After WWI, the Finishing Plant operation ceased and by 1938 it had been replaced by the Slab Casting plant where TNT was melted and cast in molds. Many of the former buildings were retained for miscellaneous storage to support the TNT plants operating in PAB. The Slab Casting Plant configuration consisted of eight buildings: Slab Casting Pouring House, Slab Casting Packing House, Motor House, Solvent Stores, three Miscellaneous Warehouses, and a Warming House.

The Triton Store Houses (SAG) operated during the early years of TNT production (1912-1916). The area east of PAE contained two warehouses and a change house for the Finishing plant. Use of these buildings was discontinued when the adjacent SA Recovery Plant #3 was expanded in 1917. This area has only been lightly reconnoitered.

The Toluol Stores (SAH) operated from 1912 through 1971. The Toluol Stores were two sets of soil berms containing bulk storage tanks for toluene used in various TNT lines. Aboveground pipelines connected the tanks with the production lines. The tanks were filled by pumping from rail sidings at least 300 ft from these tanks. This area has not been fully reconnoitered.

5.4.2 Investigation Activities

Investigation activities in PAE have occurred between 2003 and 2006 and were focused on characterization biased toward areas expected to contain site-related compounds. Samples were biased at nine building foundations and four bare areas. Sample locations are depicted in Figure 6.4. Investigation activities included significant reconnaissance, trenching/excavation, and soil sampling. Surface water is only present in this Use Area group during heavy rains and spring floods and therefore has not been sampled to date. No samples have been collected from drainage areas in this Use Area group. Available data for this Use Area group are summarized in Table-2.04 (surface soil), Table-3.04 (subsurface soil), and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

Reconnaissance was focused at all known production buildings. The locations of the 1915 Rail Shed and TNT01 Box House sites were not identified in the field. SAH and SAG have been reviewed primarily from adjacent roadways, and structures within them have only received cursory review. Additionally, investigation of the two toluol basins, rail shed, TNT01 Box House, Triton Store warehouse, change house and office have not been conducted to date.

Soil was collected from the surface at bare areas adjacent to the Solvent Recovery Tank House, Solvent Recovery House, Chloride Store, Wash & Press House No. 2, and Finishing House No. 2; from trenches at both Finishing Houses and both Wash & Press Houses; and borings at the Solvent Recovery Tank House; the Chloride Store; and bare spots adjacent to Wash and Press House No. 2 and Finishing House No. 2. Laboratory analyses were quantification of soil for VOCs and NNOCs.

Groundwater monitoring well PZ-45O was installed at Wash & Press House No. 2. This location was selected to evaluate potential releases at the adjacent building, ditch and bare spot.

5.4.3 Summary of Investigation Findings

The investigation findings for this Use Area group are summarized as follows:

- Solid TNT was found at the Slab Casting Box House, both Finishing Houses and the bare spots adjacent to the Solvent Recovery and Chloride Store houses. This material is typically found below the ground surface at the buildings and at the ground surface in areas that are bare. No solid DNT was found in this Use Area group.
- Surface samples contained TNT ranging from 1.9% at the Solvent Recovery House to 53 mg/kg at the Chloride Store. 2,4-DNT was present in these same locations at concentrations of 9,400 and 2.8 mg/kg, respectively. 2,6-DNT was only detected at Finishing House #2 at low concentrations (0.10 mg/kg). Carbon tetrachloride was detected at bare areas adjacent to the solvent handling buildings and Finishing House #2.
- Subsurface samples also contained TNT, 2,4-DNT, and carbon tetrachloride. TNT was present in the subsurface at concentrations that were approximately 10% of the concentrations observed in surface soil, while DNT and carbon tetrachloride concentrations were on the same order of magnitude at depth as at observed in surface soil.
- Detected NNOCs in groundwater were limited to TNT (9.3 µg/L) and 2,4-DNT (0.1 µg/L). Other organic compounds detected include low concentrations of carbon tetrachloride (110 µg/L), chloroform (1,000 µg/L), benzene (280 µg/L) and methylene chloride (310 µg/L).

5.4.4 Potential for Fire or Explosion Hazards

The presence of TNT on the ground surface in solid form and percentage-level concentrations of TNT in soil indicates that there is a potential for fire or explosion hazards within area PAE. Additionally, PAE contains residual product at depth, which may present an explosion hazard for intrusive activities. SAG and SAH do not contain any known areas where production-related compounds may present a fire or explosion hazard. The potential for fire or explosion in this Use Area group is ranked as high due to the conditions in PAE.

5.4.5 Potential for Human Exposure

Of these Use Area group, only PAE contains solid product and elevated concentrations of NNOCs at and near the ground surface; therefore, human exposure to site-related compounds is possible. However, these Use Areas are subject to the administrative controls detailed in Section 4.3, are within the site security fence, and interior fencing, are distant from public thoroughfares, which makes them unlikely to be attractive to trespassers. Therefore, under current conditions, the probability for human exposure in PAE, SAG and SAH is ranked low.

5.4.6 Potential for Release to Groundwater and Surface Water

There is no documentation of past releases to surface water from these Use Areas. Sediment samples in downstream area PAC do contain carbon tetrachloride which was only documented to have been used in PAE. No evidence of erosion has been observed in these areas to date, the areas are well vegetated making erosion unlikely. Furthermore, the topography in these Use Areas is relatively flat and the resulting surface water flow velocities are typically low. As a result, the potential for releases of impacted soil from these units to surface water is low.

Results from the monitoring well installed in PAE indicate that NNOCs and chlorinated compounds are present in groundwater. There are no known operations upgradient of these Use Areas. Wells at PAC (downgradient of area PAE) contain similar chlorinated compounds. These data indicate that releases from these Use Areas to groundwater may have occurred.

5.4.7 Priority Ranking

PAE, SAG, and SAH have been assigned a high priority ranking for future investigation because:

- Areas containing solid residual product have been identified and have not been completely characterized.
- TNT, DNT, and carbon tetrachloride are present in surface and sub-surface soils, and in groundwater; therefore, further characterization is needed.
- Data indicate that there have been releases to groundwater.
- The presence of solid product indicates that there is the potential for fire or explosive hazards.
- No issues have been identified for SAG or SAH; however, these areas have not been completely investigated.

5.5 Nitric Acid Production Areas (Areas PAF, PAK, PAR, PAS, and SAF)

There have been four nitric acid (NA) production lines operated at the former Barksdale Works. These lines (one in PAK, one in PAR and two in PAS) were located in the central part of the site adjacent to the Main Drive (location inset Figure 6.5). NA and SA were recycled within the Acid Recovery plant (PAF) to the north of the NA production lines. Acid was stored in warehouses located in SAF to the east of the NA production lines near the North Gate Road. These Use Areas have been grouped together for discussion due to their proximity to one another and the similarity of the materials used in the areas.

5.5.1 Area Description

Nitric acid operations at the Barksdale works consisted of acid production/manufacture and acid recovery. Both operations are described below.

Nitric Acid Production

The original NA Plant (1904-1909) was called NA Plant #1, and was located in the southeast part of PAK (Figure 6.5). The former building foundations were paved over to form the Main Drive. This plant utilized the Soda Process and discharged nitre cake to the Salt Cake Pond, a settling basin in the low area located north of the Main Drive at the eastern edge of PAK. NA Plant #1 structures included: a Nitric Acid House, an Absorption Tower House, a Mixed Acid Store, and a Soda Store.

The second soda process NA plant (1910-1920), also located in PAK, was built west of the 1904 plant near the current intersection of the Main Drive and the West Gate Road. It discharged nitre cake to the original plant settling pond. The 1910 configuration included: a Nitric Acid House, an Absorber House and a set of Circulating Tanks, an OV Store and MA tanks, a Soda Store, a Soda Dry House, and a Soda Elevator.

A third soda process NA plant (called Nitric Acid Plant #2 on historical site drawings) was constructed in PAS northwest of the 1910 plant in 1915. It also discharged to the original Salt Cake Pond. Its structures were: one Nitric Acid House, one Absorber House and a set of Circulating Tanks, one OV Store and MA tanks, a Soda Store, a Soda Dry House, and a Soda Elevator.

The 1915 plant was expanded twice and operated until 1928 when it was replaced by the Ammonia Oxidation Process Nitric Acid plant (1928-1971). The 1928 plant included: an Ammonia Oxidation Plant, a Converter House, a NA Condenser Building, and a Mixed Acid Store.

Soda houses for the early plants were located along the rail grades in the northwest part of PAK and the southeast part of PAS. Large foundations for the store houses are still present in these areas.

Acid Recovery

Acid was recovered from spent acid (WA) and reused throughout the history of the Barksdale Works. Originally both NA and SA were recovered in a single operational area called the Acid Recovery Plant (1904-1915) located west of the Power House in southern PAR. The components of the original Acid Recovery Plant included: an Acid Recovery House, an Absorption Tower House, a Weak Acid Tank House, a Denitrified OV Storage House, a SA Recovery House, a drying tower converter, an Absorber House, and an Acid Worm & Coke Box.

The 1904 Acid Recovery plant was replaced with a new configuration in 1915 when the new NA Plant was built. The 1915 NA Recovery Plant was located in PAF north of the SA recovery plants (north of the 1915 NA House). WA was returned to NA Recovery via rail cars. Structures in the NA Recovery Plants (1915-1920) included: two WA Towers, four NA Recovery Houses, four Absorption Houses, two Condenser Houses, six Cooling Tanks and Pump Houses, four SA Recovery Houses, and a Special SA Recovery House.

After WWI all but one of the four NA Recovery Plants were closed. The last plant from that era continued operating (1920-1928) until the new AOP NA process was initiated.

After 1928, NA recovery was again conducted in the vicinity of the original Acid Recovery Plant in southern PAR. The NA related components of the 1928 Acid Recovery Plant were: a WA Tower, a WA Settling & Mixing House, a Mixed Acid House, a NA Condenser House, two Weak NA Tanks, a Converter House, an Absorber House, and two SA Store Tanks. This configuration remained active until plant closure.

The Acid Stores area (SAF) has not yet been investigated. It contains two very large acid storage warehouses and an office as well as 13 buildings of unknown use. A spray pond is also present in the area which was sampled by BDC in 1988 (sample labeled Concrete Pond). The pond was reportedly used for ‘product and acid resistance testing’ during post WWI plant operations. It is likely that the spray pond and four or five of the unidentified structures may be related to the WWI Acid Recovery operations. These structures, the grounds of the NA production areas away from the building foundations, and the SA Recovery foundations have received only cursory inspection.

About 29 of the 46 acres comprising this Use Area group consist of birch woods with trees two to four feet apart. The ground in these woods is sparsely vegetated and in some areas bare. Numerous foundations occupy the spaces between the trees. The remaining 17 acres are covered by grass meadows or sedge wetlands. Large bare areas covered with cinders are also present along rail grades through northern PAK and central PAS.

Drainage in PAS flows along the central rail grade southeast through SAF into UAG via a culvert under the North Gate Road near the Main Drive. Drainage from PAF follows similar rail side ditches through SAF then flows south along the North Gate Road to the same culvert. Drainage from PAK flows south through culverts under the Main Drive to two tributaries of Boyd Creek located along the edges of UAK. Drainage from PAR flows along roadside ditches at the area’s edge to a culvert west of the decontamination facility that discharges into the same tributaries as PAK.

5.5.2 Investigation Activities

Sampling related to NA operations has been conducted at the WA Tower locations, near the NA Plant buildings, and at five points along drainages within the areas. Available data are primarily from soil samples collected at 0-2 ft bgs. Soil samples collected at the WA Towers were analyzed for VOCs and NNOCs. Soil in the vicinity of the NA buildings was analyzed for perchlorate and NNOCs. One groundwater monitoring well was installed at the eastern WA Tower and five wells have been installed around the 1904 through 1915 NA Houses. Samples from the wells were analyzed for VOCs, NNOCs, and perchlorate. Additionally, five samples from drainages were analyzed for NNOCs and metals. Available data for this Use Area group are summarized in Table-2.05 (surface soil), Table-3.05 (subsurface soil), Table-4.05 (drainage feature soil and sediment), and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

5.5.3 Summary of Investigation Findings

The investigation findings for this Use Area group are summarized as follows:

- The nitric acid production areas contain no identified deposits of solid residual product.
- Low concentrations of TNT and DNT were detected in soil borings and surface samples at the two WA Tower bare spots. Concentrations of TNT detected ranged between 3.1 and 7.8 mg/kg and concentrations of DNT ranged between

0.45 and 48 mg/kg. No VOCs other than probable laboratory artifacts (acetone and methylene chloride at very low concentrations) were detected.

- Detected constituents in soil in the vicinity of the NA Plant Buildings include: TNT, four DNT detections, three MNT isomers, 1,3-DNB, and perchlorate (0.002 to 2.20 mg/kg). Samples from the NA#1 and NA#2 areas were more elevated than those from NA#3 where the concentrations of combined 2,4- and 2,6-DNT results ranged from 1.8 to 2.3 mg/kg..
- Analytical results for the groundwater samples collected from monitoring well PZ-44o, which is located at the WA towers, indicate that perchlorate (0.055 µg/L), 1,3,5-TNB (0.22 µg/L), and four DNT isomers (ranging from 0.22 to 0.58 µg/L) were detected. Groundwater samples collected from wells in the NA Plant building areas contain similar NNOCs. Maximum concentrations were typically found downgradient of the area at PZ-53o except for perchlorate, which was more elevated at PZ-51o. Results for samples from upgradient well PZ-55o were typically non-detect, except for TNT and perchlorate.
- Surface soil samples results indicate that perchlorate was detected in the creek beds draining Soda Process plants (SWI003 and SWI004) but not the AOP Plant (SWI005).
- Concentrations of NNOCs in drainages were most elevated at samples collected from the discharge of PAR (SWI005) and the collective discharge for the Use Area group at location SWI003. The combined DNT concentration at SWI005 was approximately 0.8%. The sample collected from the discharge of PAK (SWI004) contained the next highest NNOC concentrations followed by PAS (SWF030). The sample from the Acid Store area ditch contained no NNOCs.

5.5.4 Potential for Fire or Explosion Hazards

The nitric acid production areas contain no identified deposits of solid residual product or areas with percentage concentrations of flammable constituents. The potential for fire or explosion in PAE is ranked as low.

5.5.5 Potential for Human Exposure

No solid product was identified in this Use Area group. Of this Use Area group, only PAK is not subject to the administrative controls discussed in Section 4.3. In addition, PAF and PAS are relatively distant from major site roads. Utilities that may require entry by repair personnel are only present in PAK and in SAJ adjacent to PAR. There are no utilities in the other parts of this Use Area group. Except for PAS and PAR, there are no structures or other features that would make these areas attractive to trespassers. PAK and PAR are adjacent to the Main Drive and the DuPont decontamination structures, and PAS contains the plant water tower; therefore, there is a potential to attract trespassers to these areas. Therefore, under current conditions, the potential for human exposure in these Use Areas is ranked low.

5.5.6 Potential for Release to Groundwater and Surface Water

A comparison of upgradient and downgradient groundwater data indicate a release to groundwater is likely to have occurred from PAF.

Sediment accumulating downstream in SAF indicates that erosion may be occurring within PAF. Elevated concentrations of site-related compounds in the main drainage of PAF indicate that there is potential for this sediment to contain production residuals. Recently deposited sediment is also present in the ditch between PAR and the Decontamination Facility. This ditch contains elevated concentrations of site-related compounds and may also present an erosion hazard. Other areas in this group do not appear to have significant erosion issues.

5.5.7 Priority Ranking

PAF, PAK, PAR and SAF have been assigned a high priority ranking for future investigation because:

- PAF, PAK and PAR have elevated concentrations of NNOCs, show evidence of soil erosion, and appear to have impacted groundwater.
- SAF has not been completely characterized.

PAS has been assigned a low priority ranking for future investigation because NNOCs are present at low concentrations, the Area does not appear to have significant erosion potential, and it is free of fire hazards. Although additional delineation of some DNT detections may eventually be required prior to final case closure, this area has low priority for near term investigations.

5.6 Test Grounds (Area PAG)

The test grounds area (Use Area PAG) is located in the north-central portion of the site between UAH and SAF (Figure 6.6). PAG is the smallest of the 61 Use Areas, comprising approximately 1.25 acres. This area was used from 1963 into the late-1960s to test the blast velocity of the soda amatol used in DuPont's cladding operations in the Chequamegon-Nicolet National Forest. The area is visible in 1966 aerial photography, which indicates that barricades (i.e., soil mounds) located in the area were leveled in the late 1960s. Use of PAG prior to the soda amatol testing was primarily for access to the adjacent acid warehouses.

5.6.1 Area Description

The central portion of PAG contains a mix of small dogwood trees, moss, and saw grass, while the southern edge of this area is comprised of sandy meadow. A peat bog is present in the north. Drainage from PAG enters a plant storm water ditch along a former rail grade serving the former Acid Stores Area Warehouses (SAF). A foundation of one of the warehouses is located at the southern boundary of PAG. Sandy soil present at the ground surface differs from clays in adjacent Use Areas, which may indicate that the actual testing surface may have been buried by the regraded barricade fill.

5.6.2 Investigation Activities

A total of ten shallow soil samples (i.e., between 1 - 3 ft bgs) were collected for analysis for NNOCs from PAG (Figure 6.6). Because suspected re-grading of this area appears to have left little surficial evidence of previous activities, direct-push sampling at random points along a grid system was used to collect samples for laboratory analysis. Available data for this Use Area group are summarized in Table-2.06 (surface soil). No subsurface soil, sediment, surface water or groundwater samples have been collected in this area. Statistical summaries of the results within this Use Area are presented in Table 7.

5.6.3 Summary of Investigation Findings

The investigation findings for this Use Area are summarized as follows:

- No visible solid product was observed in surface soil in PAG. Additionally, no visible bare areas have been observed in PAG.
- Low concentrations of NNOCs were detected in eight of the ten samples collected from this area.
- The most frequently detected compounds were 2,4-DNT (detected in nine of the ten samples) and 2,6-DNT (detected in six of ten samples).
- All constituent concentrations were less than their respective recreational SSLs. The majority of the detected compounds were reported in samples PAG008, PAG009, and PAG010, which are located in the northeastern section of PAG.

5.6.4 Potential for Fire or Explosion Hazards

Due to the low concentrations of detected NNOCs present in surface soils and the absence of any visible solid residual product or bare areas at the ground surface, the potential for fire or explosion in PAG is ranked as low.

5.6.5 Potential for Human Exposure

PAG has been adequately characterized and found only to contain low concentrations of NNOCs. Additionally, this Use Area is subject to the administrative controls detailed in Section 4.3, is within the site security fence and interior fencing, and is distant from public thoroughfares, which makes the area unlikely to be attractive to trespassers. Therefore, under current conditions, the probability for human exposure in PAG is ranked low.

5.6.6 Potential for Release to Groundwater and Surface Water

There are no available groundwater wells within PAG to directly evaluate the potential for releases to groundwater. However, the low concentrations of detected compounds in surface soil coupled with known past area use makes the likelihood that releases to groundwater have occurred from this area low. The presence of vegetated cover and the generally flat topography of PAG would preclude significant surface water runoff from the area.

5.6.7 Priority Ranking

PAG has been assigned a no further action priority ranking because:

- The area is adequately characterized and all detected concentrations are less than recreational land use SSLs.
- There is no potential for fire or explosion.
- There is a low potential for release to groundwater, and surface water.

5.7 TNX 1-5, TNT 7-10, and Refined Triton Plant (Areas PAH, PAI, and PAJ)

PAH (TNT lines 7 through 10), PAI (TNX lines 1 through 5) and PAJ (Refined Triton Plant) are three production areas that are located adjacent to the north fence east of the North Gate Road (Figure 6.7). These lines operated prior to 1920 and large areas have since grown over with forest. About 57 of 118 acres are covered by aspen forest. Another 23 acres along the fence near the gate were planted with pines in the mid-1960s. The remaining 38 acres are grassy meadows, some of which had been cut for hay by BDC through 2001. Soil barricades remain at eight of the former structures in the areas; otherwise, the topography is relatively flat. These Use Areas have been grouped together for discussion due to their proximity to one another and the similarity of historical manufacturing activities.

The Central Drainage passes from northwest to southeast through PAH then forms the southwest border of PAJ. The TNX Ditch from the northeast corner of PAI to the southern tip of PAJ forms the eastern border for this Use Area group. A natural drainage course has been straightened in several sections (the East Nolander Drainage) and runs across the northern 300 ft of the Use Area group from west to east. Eight process and storm water ditches (named for the production lines at their headwater) drain from north to south through the areas. Two year-round ponds are present on the Central Drainage in PAH and areas that intermittently pond water are located at five locations on the East Nolander Drainage and the one location on the Central Refined Graining ditch.

5.7.1 Area Descriptions

TNT lines 7 through 10 (PAH) operated from 1917 through the end of WWI. They were located in open fields in a northeastern portion of the plant that was apparently unused after the 1920s. Decommissioning period excavations were reported in memos from the 1980s. These activities apparently focused primarily on catch boxes within neutralizing/pelleting and graining houses. Structures associated with other portions of the process (bi/tri, waste acid, and finishing houses) do not appear to have received as much attention based on the size of trees and conditions of barricades present in those areas. The lines contained 38 buildings housing: eight Acid Stores, two Toluol Stores, two Absorption Houses, four Acid Fortifying Houses, four Mononitration Houses, four Bi/Trinitration Houses, four Neutralization Houses, four Graining Houses, two Box Houses, a Weak Acid Store House, a Switch House, and two Change Houses. Two rail spurs with 22 sidings and switch lines served these buildings. Nineteen process ditches and drains (flumes, tile drains or open ditches) connected the buildings to the Central Drainage which received all PAH process flows. No bare areas or disposal sites have been identified in PAH.

TNX lines #1 through #5 (PAI) reportedly only operated during pre-production testing phases. These lines are present on drawings from the 1918 to 1919 period. Plans for construction are dated April 1918. They appear to have been decommissioned similarly to the adjacent TNT #7 through #10 lines. The 37 buildings present included: ten Acid Stores, two Xylol Stores, five Acid Fortifying Houses, five Mononitration Houses, five Bi/Trinitration Houses, five Neutralization Houses, three Graining Houses, and two Box Houses. Three rail spurs with 34 sidings and crosses served these buildings. Twenty process ditches and drains (flumes, tile drains or open ditches) connected the buildings to the TNX Ditch which received all PAI process flows. One bare area is present near an exposed pipe drain south of the TNX02 Neutralizing House. No disposal sites have been identified in PAI.

The Refined Triton Plant (PAJ) operated contemporaneously with TNT#7 through #10. However, it was not decommissioned in the 1980s like those adjacent lines. It contained a Wash House, two Graining Houses and a Screening House which refined the crude TNT using a sellite wash process. Tall barricades and a drainage ditch system remained including some areas with chemical odors and absent vegetation. Buildings present included: a Wash House, two Neutralizing & Graining Houses, two Dilution Tank Houses, and Screening House. Two rail spurs with seven sidings and crosses served these buildings. Two processes ditches and drains (tile drains and open ditches) connected the two western buildings to the Central Drainage and five connected the other structures to the TNX Ditch. One bare area is present where drainage from the area central catch box accumulated due to blockage after a tree fell in its ditch. No disposal sites have been identified in PAI.

5.7.2 Investigation Activities

Visual results from trench investigations, colorimetric screening with Expray® test kits, and soil analyses are the primary data sets used in the prioritization of these Use Areas. Soil samples were collected adjacent to 29 of the 38 buildings in PAH (all but the Acid Store Houses and the Switch House), 29 of the 37 buildings in PAI (all but the Acid Store Houses) and 5 of the 6 buildings identified in PAJ. Samples were typically collected as surface composites along the foundation perimeters and at depth at each building's primary catch box, sump or floor drain outfall, depending on building type. Additionally, samples were collected from rail grades in each area at 500 foot intervals. Soil and sediment samples to characterize drainage features were collected at 86 locations within this Use Area group (28 samples in PAH, 38 samples in PAI, and 20 samples in PAJ). The samples were collected in surface drainages and areas where surface water typically ponds. Samples were collected from the upper two feet at the current drainage elevation and at depths of up to four feet bgs, which corresponds to the estimated original elevations of the drainages. Groundwater and sediment data were also collected as part of characterization of these Use Areas, but to a much more limited extent. Sampling was generally biased at locations where site-related residual compounds would be expected to be found. There are six well clusters in this Use Area group: three in northern PAH, two in northern PAI, and one in central PAI (Figure 6.7). There are no wells located within PAJ. Available data for this Use Area group are summarized in Table-2.07 (surface soil), Table-3.07 (subsurface soil), Table-4.07 (drainage feature soil and sediment), Table 5 (surface water) and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

5.7.3 Summary of Investigation Findings

The investigation findings for PAH, PAI, and PAJ are summarized as follows:

- Residual solid product was not found at the ground surface in PAH. However, solid TNT was found below the ground surface in PAH at the TNT07 Neutralizing and Graining Houses; the TNT08 Neutralizing House; the TNT09 Neutralizing, Graining and Box Houses, and the TNT10 Neutralizing and Graining Houses. Solid TNT was also found in PAH buried within process drains and ditches adjacent to TNT07, TNT08, and TNT09. Solid TNX was found at the surface in PAI at the TNX04 Neutralizing House and below the ground surface at the TNT04 Neutralizing House, the bare spot south of TNX02 Neutralizing and the two TNX Box Houses. In PAJ, solid TNT was found at the surface at the Wash House and the impoundment on the Refined Triton Drainage. Solid TNT was also identified below ground in PAJ at the catch box feeding the Refined Triton Drainage.
- Detected VOCs in soil include acetone, toluene, methyl-ethyl-ketone, and carbon disulfide. Concentrations of VOCs were generally near the laboratory detection limit.
- The highest concentrations of NNOCs in surface soil within this Use Area group were generally detected adjacent to the former process buildings.
    - In PAH, the highest concentrations of TNT and the DNT isomers detected in surface soil were observed at the TNT08 Waste Acid building, where 5.4% of TNT, 3,000 mg/kg of 2,4-DNT, and 130 mg/kg of 2,6-DNT were detected.
    - In area PAI, soil samples may not fully reflect the NNOCs potentially present since the nitrated xylene constituents have yet to be quantified by the analytical laboratory. The highest NNOCs detected in surface soil in PAI were observed at the TNX04 Mono/Bi Building. At this location TNT was detected at 15 mg/kg, while reported concentrations of 2,4-DNT and 2,6-DNT were 2.4 mg/kg and 1.1 mg/kg, respectively.
    - The highest concentrations of NNOCs in Use Area PAJ were generally detected adjacent to the former Eastern Store House (PAJ019), where TNT was detected at a concentration of 6.1%. The highest concentration of 2,4-DNT was also detected at this location (35 mg/kg in PAJ019).
- At the rail grades, concentrations of detected NNOCs in soil were generally much lower than those observed in soil adjacent to the former process buildings.

NNOCs in soil at the rail grades were more frequently detected and elevated in PAH than in PAI and PAJ.

- NNOCs were detected in most of the drainage features in these Use Areas. Overall, concentrations within the upper two feet of these drainages were typically much higher than concentrations observed at depth. Generally, the highest concentrations of NNOCs in this Use Area group were observed within the drainage features within PAJ and in the TNT07 and TNT08 Neutralizing ditches, where solid product was also observed. In PAI, TNT was present at a maximum concentration of 22% in the near surface drainage samples and 6.1% in the deeper soil samples obtained from these drainages.
- Of the three shallow wells in PAH (PZ-02o, PZ-13o and PZ-43o), organic constituents were only detected in the upgradient well PZ-02. Samples obtained from wells in PAI (PZ-11s, PZ-21o and PZ-22o) contained seven NNOCs. The highest NNOCs detected were in PZ-11s, where concentrations of 2,4- and 2,6-DNT of up to 0.57 µg/L and 2.4 µg/L, respectively were reported.
- The impoundment on the Refined Triton Drainage was the only location where NNOCs were detected in surface water. Surface water samples from the ponds in PAH (within the Central Drainage) did not contain production related compounds. Furthermore, NNOCs were not detected in surface water samples collected at the fence line in PAI. This fence line location receives and conveys surface water from the northern portions of PAH and PAI to ditches located off-site and along Nolander Road.

5.7.4 Potential for Fire or Explosion Hazards

The presence of TNT and/or TNX on the ground surface or at depth in solid form and percentage-level concentrations in soil indicates that there is a potential for fire or explosion hazards within area PAH, PAI and PAJ. The potential for fire and explosion in this Use Area group is ranked as high due to these conditions.

5.7.5 Potential for Human Exposure

Solid product and percentage concentrations of NNOCs exist in PAH and PAJ. Concentrations of TNX have not been determined in PAI (See Section 2.1.1) as of this report, but because solid TNX was identified it is likely that elevated concentrations of TNX are present in soil within this area. Therefore, a potential for human exposure exists in all three areas. However, these Use Areas are subject to the administrative controls detailed in Section 4.3, are within the site security fence and interior fencing, making them difficult for trespassers to access. Furthermore, the only utilities in these areas are power lines that are located outside of primary manufacturing areas, where NNOCs were detected. Therefore, under current conditions, the probability for human exposure in PAH, PAI, and PAJ is ranked low.

5.7.6 Potential for Release to Groundwater and Surface Water

NNOC compounds were not detected in groundwater along the northern edge of PAH; however, 2,4- and 2,6-DNT and other NNOCs were detected in groundwater downgradient of PAH in Use Area PAI. Thus, a release to groundwater from either PAH or PAI is indicated.

Surface water in PAJ contains elevated TNT and DNT concentrations indicating that releases have occurred. Elevated NNOC concentrations in drainages in PAH and PAI indicate that release could potentially occur in these areas as well.

5.7.7 Priority Ranking

PAH, PAI and PAJ have been assigned a high priority ranking for future investigation because:

- Areas containing solid TNT and DNX have been identified and have not been completely characterized.
- NNOCs are present in surface and sub-surface soils, groundwater, surface water, and sediment and these media and have not been completely characterized.
- The presence of solid product indicates that there is the potential for fire or explosive hazards.
- Data indicate that there have been releases to groundwater and there may be releases to surface water.

5.8 Upper Dynamite, Ammonium Nitrate, and Plant Office (Areas PAL, PAQ, and SAE)

This Use Area group is located near the center of the Barksdale Works grounds east of the intersection of the Main Drive and the North Gate Road and contains the current BDC Clubhouse and Shop (Figure 6.8). The Main Drive crosses the group from east to west. The Main Magazine Drive forms the eastern boundary of the group. The north rim of the Boyd Creek forms the southern boundary of the group. The rail grade paralleling the Main Drive along its north side forms the northern boundary. These Use Areas have been grouped together for discussion due to their proximity to one another and the similarity of historical activities in the area.

5.8.1 Area Description

PAL (the Upper Dynamite Support and Clad Preparation Area) consists of 7.3 acres southeast of the intersection of the Main Drive and the North Gate Road. Currently the structures in PAL (Clubhouse/Garage, Barn/Shop, and two pheasant pens) are used by BDC. The grounds within 300 ft of these structures are kept mowed by BDC staff. Tall weeds and dense brush that obstructs foot traffic cover the remaining portions of PAL. Roads accessing the Bretting structures from the north are paved but the trails adjacent to the buildings to the west and south are bare earth. A former rail grade, west of the buildings leading toward the intersection of the Main Drive and the North Gate Road called the Shell House siding, is covered in cinders with no vegetation present. The former Salt Cake Pond Drainage crosses PAL from west to east. This ditch previously entered PAL from SAK, but since plant closure, the culvert that carried the flow under the structure that now houses the Bretting Garage has collapsed and the flow from SAK now turns to the southwest and enters PAO instead of PAL. The remainder of the drainage now only receives storm water from the south side of the Bretting building site and areas east of PAL. Storm water from the north side of the current structures drains through a swale in the center of the building turning circle and rejoins the Salt Cake Pond Drainage in SAE.

Most plant buildings in PAL were located near the current structures. These included the Shell House (now used as the BDC garage), the Clad House (its foundation was reused for the BDC Shop and Barn), the paper warehouse, the pay booth, a change house, heated ammonia storage and a paraffin shed. A lumber shed and a feature labeled the Skid Storage Area are located in the western part of the narrow arm of PAL that extends along a former rail grade toward the intersection of the Main Drive and the North Gate Road. Little historical information has been found regarding this area, which contains a bare spot with solid DNT and a strong odor. The spot is visible in photos as far back as 1938. No disposal sites have been identified in PAL. Another rail grade crossed PAL east to west under the pavement that now abuts the north side of the BDC buildings.

PAQ (the Ammonium Nitrate Plant) comprises 18 acres southwest of the intersection of the Main Drive and the Main Magazine Road, which forms its east border. The Main Drive Rail Main forms the northern border of PAQ. The former Salt Cake Pond Drainage from PAL forms the western border of PAQ. The central portion of PAQ is grass meadow that had been used as pasture by BDC. The southern third is covered by aspen woods with short grass and brush ground cover. Thick willows line the Salt Cake Pond Drainage and building sites north of the Main Drive. PAQ south of the Main Drive drains via interior swales southeast to road-side ditches. The ground north of the Main Drive drains into the adjacent Salt Cake Pond Drainage. Structures in PAQ included: the AN Plant Empty Barrel Store and RR Platform in the north; the Ammonia Crystallizing House, Ammonium Nitrate Store, Evaporating Shed, Loading Platform, Settling Tank Shed and a change house in the center; and a water system booster pump house in the south near the Boyd Creek ravine. The Main Drive Rail Main, the Substation Main and four rail sidings served these structures. A small bare area caused by pawing deer is present adjacent to the Empty Barrel Store. There are no known disposal sites in PAQ.

SAE (the Shop and Office Area) is 8.6 acres located adjacent to the Main Drive at the intersection of the Main Drive and the North Gate Road. SAE is bordered by the Main Drive Rail Main to the north, the PAL Dynamite Skid rail grade in the west, PAL to the south and the Salt Cake Pond Drainage to the east. The northern portion of SAE is covered by cinders and pavement near former building foundations. Northeastern SAE is covered by thick brush. The southeastern part of SAE is a red pine plantation and the southwestern part of SAE is covered in tall weeds and brush. Storm water in SAE drains to the east through a swale in the PAL turning circle and the north ditch of the Main Drive. Both features discharge to the Salt Cake Pond Drainage. Buildings in the Shop and Office area included: the Plant Shop, Boiler Shop, Carpenter Shop, Electrical Parts Storage, two general garages, the Main Office, Main Office Garage, Oil Distributor

Building, Plant Store, Supply House, Tool Shed, a rail platform, and Warehouse #438. The area was served by two yard sidings along the Main Drive Rail Main and by the Substation Main, which ended adjacent to the Plant Shop. In 1980 a former employee reported that transformer oil had been dumped by a transport company during removal of outdated equipment stored near the electrical parts store house in the 1970s. WDNR investigated and sampled the area the employee indicated in 1980, but the employee later said that the area had been filled with cinders since the dumping. DuPont resampled the indicated area, which lies primarily in Use Area SAK, in 2003. The findings are discussed in section 5.10. Other than the cinder areas along the PAL border and the Main Rail grade there are no known bare areas in SAE. There are no known disposal sites in SAE.

5.8.2 Investigation Activities

Surface soil samples were collected on a 4-acre grid across PAQ and SAE and on a 1-acre grid across PAL to evaluate average use conditions in these areas. Three rail grade surface samples and two drainage feature soil samples were collected in SAE.

At PAL surface soil samples were collected around the BDC buildings (PAL008-PAL026), three drainages (SWI002, SWF031, SWF032), two rail grades (PAL019, PAL025), the bare spot at the skids (PAL001-PAL007), and two wells (PZ-41o and Club House-Inflow). Samples were also collected on a one-acre grid for NNOCs and metals (PAL020-PAL024) and for VOCs (PAL027-PAL032).

At PAQ, soil samples were collected at three buildings (PAQ001-PAQ003), four rail grades (PAQ004-PAQ006, PAQ013), the bare spot at the empty barrel store (WWI-AREA2) , two wells (PZ-06s and PZ-06d) and the former water main closure pit near the booster pump house (CA1).

Groundwater samples were collected from two wells (PZ-41o and Club House-Inflow) in PAL.

Available data for this Use Area group are summarized in Table-2.08 (surface soil), Table-3.08 (subsurface soil), Table-4.08 (drainage feature soil and sediment), and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

5.8.3 Summary of Investigation Findings

The investigation findings for PAL, PAQ, and SAE are summarized as follows:

- Results for biased samples collected in PAL indicate results were below detection or background levels, except for TNT and DNT at the skid location, where concentrations of up to 4.9% of DNT were reported. Arsenic and lead at rail site (PAL025) and adjacent drainage sample (SWI002) were also elevated above background.
- In PAQ, no NNOCs were detected in soil at the pipe closure (CA1) or the bare spot (WWI-Area2). All NNOCs detected along the building and rail sites were

below the recreational SSLs, except for the combined 2,4- and 2,6-DNT concentration at five feet below the Crystallizing House, which was 9.7 mg/kg.

- Along the rail grades, all sample results were below SSLs, except for soil sampled from the Main Drive Rail Main (adjacent to the Boiler Shop). At this location, arsenic and lead exceeded recreational SSLs.
- Surface soil samples collected from the grids across PAQ, SAE, and PAL found only arsenic and lead in excess of calculated screening levels.
- Groundwater in PAL was sampled from PZ-41o and the Bretting Chlubhouse well. The DNT isomers were the only NNOCs detected in the PZ-41o, while the Bretting Clubhouse has been historically unaffected. Groundwater from both wells in PAQ (PZ-06s and PZ-06d) contained 2,4- and 2,6-DNT, chloroform, and amino-DNT.

5.8.4 Potential for Fire or Explosion Hazards

The percentage level DNT concentrations at the skid area of PAL represent a potential fire hazard. There is no product known to be present in other parts of PAL or in PAQ or PAE, which would present a potential for fire or explosion. Therefore, the potential for fire or explosion in PAL is ranked as low.

5.8.5 Potential for Human Exposure

This Use Area group contains the landowner clubhouse and barn and is subject to recreational use. However, recreational use is limited to the developed, paved, and unaffected portions of this group. The skid area in PAL, where percentage level concentrations of DNT in surface soil were detected is covered with rubber to prevent direct contact and is not used by the landowner. Other restricted use locations include the AN Plant Crystallizing House (in Use Area PAQ) even though the depth of detected NNOCs makes contact unlikely under current use. Arsenic and lead were detected above recreational SSLs at four locations within this Use Area group, while the remaining inorganic detections were typically consistent with background concentrations. Therefore, under current conditions, the probability for human exposure in PAL, PAQ, and SAE is ranked low.

5.8.6 Potential for Release to Groundwater and Surface Water

Groundwater contains NNOCs at low concentrations. These may represent migration from upgradient locations or infiltration from the adjacent skid area bare spot soil.

No surface water samples are available; however, concentrations of NNOCs and metals in ditches indicate some releases have occurred to surface water.

5.8.7 Priority Ranking

PAL and all of SAE and PAQ has been assigned a low priority ranking for future investigation because:

- PAL is adequately characterized, with the exception of the Shell House siding and skid area. The Shell House rail siding and adjacent skid area in the northern portion of PAL has percentage concentrations of DNT and presents potential for fire or explosion hazards and for releases to surface water and groundwater.
- SAE and PAQ contain no identified fire or explosion hazards, limited direct contact hazards in one area, and no potential for releases to surface water or groundwater.
- PAQ, which contains no identified fire or explosion hazards, no direct contact hazards, and no potential for releases to surface water or groundwater.

5.9 Nitramon/Nitramex, Rail Receiving, and Nitramon Container Dump (Areas PAN, SAC, and WAF)

The PAN, SAC, and WAF Use Areas are located on the northern rim of Boyd Creek between the Main Magazine Road and the east site fence (Figure 6.9). It contains the Nitramon/Nitramex Plant (PAN), Rail Receiving (SAC), and Nitramon Container Dumps (WAF). These Use Areas have been grouped together for discussion due to their proximity to one another and the related of historical manufacturing activities.

5.9.1 Area Descriptions

PAN (the Nitramon/Nitramex Plant) is comprised of 18 acres located adjacent to the Main Magazine Road northeast of the Boyd Creek bridge. PAN is relatively flat but is bordered by steep bluffs dropping to the Boyd Creek valley to the west and south. Northern PAN drains through swales to the northeast into SAC at a culvert under the Nitramon Loop Road. The rest of the area drains via overland sheet flow to the Boyd Valley. The area is wooded with open undergrowth, except along existing roads where small meadows are often present near former building sites. The nitramon plant contained 9 buildings: the Mix Tower Fan House, Mix Tower, Dope House & TNT Screening, Dope House, DNT Storage Tank, Nitramex/Nitramon House, Primer House, Paraffin Melt, and the DNT Pump. Three of the building sites in PAN are located on the crest and face of the southern bluff. One rail spur and one siding served these buildings. There are no known bare areas or disposal sites in PAN.

SAC (Rail Receiving) occupies 17.6 acres adjacent to the site fence at the northern edge of the Boyd Creek valley. SAC is wooded with open undergrowth except along existing roads where small strips of grass are present. SAC contained four buildings: BDC storage (the former Nitramon Change House), the Box Factory Saw Dust Bin, Magazine 13/Shook Store, and the Main Electrical Substation. These were served by two rail mains (the Substation Main and the Box Factory Main) and a crossing that connected them. The interior of the area drains to the southeast via ditches and swales comprising the Nitramon Drainage, which discharges to the east through a culvert under Highway 13. Surface water also flows along the northern edge of the area through the Substation drainage, which drains a small portion of SAC near the Substation structure.

WAF (the Nitramon Disposal Area) is located on the bluff face between the Nitramon Plant and Boyd Creek. This Use Area also contains the Box Factory which was adjacent to the east end of the disposal sites. Most of WAF is steep bluff below the Nitramon Loop Road. It is wooded with a leaf-covered ground surface. Empty containers, tires, building debris and other refuse are visible in three areas along the bluff face and toe. The Box Factory site is a level gravel area covered by aspen trees in the south and cleared for well construction in the north. The Box Factory contained five buildings: the Box Factory, two Shook Stores, a Box Store, a Change House and a rail loading platform. Debris similar to that on the bluff is visible along the southeast edge of the gravel area. Ditches drain the west side of the Box Factory area north to the Nitramon Drainage. Other portions of WAF drain by sheet flow into the adjacent Boyd Creek valley or the main Nitramon Drainage channel. There are no identified bare areas in WAF.

5.9.2 Investigation Activities

Soil samples were collected in PAN and SAC at each identified building site both as surface composites around the building perimeter and at depth either at the building center or at the locations of identified sumps. Surface soil was collected at branch points within drainages and on grids in both these areas (4-acre in SAC and 1-acre in PAN). Soil was also collected at 500-ft intervals along rail grades in SAC. Soil was collected in WAF at the surface on a random grid across the four identified waste areas and at depth near the center of each waste deposit. Groundwater has been collected at MW-01/PZ-19 in PAN, PZ-18 in WAF, and at MW-02/PZ-27 in SAC. Surface water samples have been collected at the Substation and Nitramon Drainages (SWG001 and SWH001 respectively on Figure 6.9) in SAC.

Available data for this Use Area group are summarized in Table-2.09 (surface soil), Table-3.09 (subsurface soil), Table-4.09 (drainage feature soil and sediment), and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

5.9.3 Summary of Investigation Findings

The investigation findings for PAN, SAC, and WAF are summarized as follows:

- No residual product was observed at the surface or at depth in PAN. Maximum NNOC concentrations detected in PAN were: TNT 360 mg/kg; 2,4-DNT 26 mg/kg; 2,6-DNT 0.92 mg/kg; and a maximum combined DNT concentration of 1.06 mg/kg.
- No residual product was observed at the surface or at depth in SAC. Maximum NNOC concentrations detected in SAC were: TNT 360 mg/kg; 2,4-DNT 26 mg/kg; 2,6-DNT 0.92 mg/kg; Combined DNT 0.34 mg/kg. Benzo(a)pyrene and arsenic were also detected and the arsenic concentrations ranged from 7.1 to 28.1 mg/kg at three locations along the western part of the Substation Rail Main and adjacent ditch.
- Residual product was observed at depth in WAF in the Nitramon Change House disposal site. Maximum NNOC concentrations detected in WAF were: TNT 4,500 mg/kg; 2,4-DNT 26 mg/kg; 2,6-DNT 0.92 mg/kg; Combined DNT 0.78 mg/kg.

5.9.4 Potential for Fire or Explosion Hazards

No residual product was present at the surface or subsurface in PAN or SAC. In addition, no compounds were detected at the surface in PAN or SAC at percentage concentrations. The residual TNT at WAF represents a potential fire hazard and therefore, the potential for fire or explosion in WAF is ranked as high.

5.9.5 Potential for Human Exposure

A comparison of detected compounds to SSLs, indicates the vast majority of this Use Area group is acceptable for recreational use. Exceptions exist where residual solid product was identified at the surface in WAF and where NNOCs above SSLs were detected in surface soil in WAF and PAN. Therefore, a potential for human exposure exists at these locations.

These Use Areas are open and accessible to recreational users and potential trespassers via the paved plant roads and along the ATV trail at the site fence along Highway 13. The presence of visible structures (the Nitramon Change House and in adjacent areas the Substation, Mix Tower, and Bridge) has attracted trespassers to this area in the past. Therefore, under current conditions, the potential for human exposure in PAN and SAC, is ranked low, while exposure potential in WAF is ranked as high.

5.9.6 Potential for Release to Groundwater and Surface Water

Water from wells in SAC (PZ-27o and MW-02) contains elevated NNOC concentrations; however, the values are low and likely represent lateral migration from upgradient areas rather than releases within these Use Areas.

Arsenic was detected in drainages in these areas; however, the concentrations are typically low and there is no noticeable movement of sediment in these areas.

5.9.7 Priority Ranking

WAF has been assigned a high priority ranking for future investigation because:

- Residual product is present and the area is not completely characterized.
- The presence of residual product indicates that there may be the potential for fire or explosive hazards.

PAN and SAC have been assigned a low priority ranking for future investigation because these areas:

- Contain no residual product in surface or subsurface soil, and the areas have been adequately characterized.
- Present no fire or explosion hazard.
- Present no surface water or groundwater discharge potential.
- Present low potential for human exposure with the following exceptions which need further characterization:

- - Low arsenic detections along the Substation Rail Main in SAC.

- Detections of DNT at the former DNT Tank site in PAN.

5.10 Powder Line and Adjacent Support Areas (Areas PAM, PAO, PAP, SAI, SAJ, SAK, UAK, UAL, and WAD)

This Use Area group is located in the center of the Barksdale Works between Boyd Creek and the Main Drive (Figure 6.10). These Use Areas have been grouped together for discussion due to their proximity to one another and the similarity of the materials used in the areas. The primary production areas in the group (PAM, PAO, and PAP) are located mostly within the Boyd Creek valley and are related to dynamite production. These areas were collectively known as the Powder Line. The undeveloped areas (UAK and UAL) are buffer areas above the creek valley between the nitroglycerin plant (PAO) and the support areas: SAK (store houses), SAJ (Power Plant) SAI (Triton Support) and WAD (power house demolition debris site); located at the northern edge of the group.

5.10.1 Area Descriptions

PAO (the NG plant) is located between the West Gate Drive (PAC) and Boyd Creek at PAP. The 27 buildings in this line with potential for explosion (the nitrating houses and down process neutralizing, talley mix and waste handling structures) were located in the creek valley. The 20 buildings on the upland consisted of raw material storage and preparation units (the glycerin stores, glycol stores, heater houses and change houses). Two rail grades served the glycerin area and a network of 15 elevated walkways called "angel walks" connected the lower NG buildings and lead out of the area to the Mix Houses in PAM. Surface water enters PAO from PAC via the TNT06 Ditch and the headwaters of the Glycerin Drainage at Triv01. These join and drain to the east into the NA01 Drainage, which forms the northern border of PAO. This system, the NG01 Drainage in the west and the Talley Mix 1 Drainage in the east, all drain the interior of POA southward into Boyd Creek, which forms the southern border of PAO. The valley bottom within PAO is covered by alder swamps which contain thick brush, cattails and reeds. A pond formed by a beaver dam is located in the center of the floodplain. The upland portions are covered by forest which are typically open and free of under growth other than ferns and sparse grass. There is one identified bare area in PAO, a 75-foot long stretch of the Glycerin Area Drainage at a former rail crossing where TNT pieces are present on the banks and vegetation is absent.

PAM (the Dynamite Plant) is located between Boyd Creek at the Magazine Road Bridge (UAR) and the northern valley wall at the Bretting Club House (PAL). Forty-seven of the 59 buildings in PAM are located on the valley floor with the remaining 12 structures (three packing houses and a box house with associated support buildings) built along a trail half way up the south valley bank. In general, dynamite processing has limited potential for releases except in the initial steps (near the two Dynamite Mix Houses and two Lydol/DNT Melt Houses). Later process steps generally utilize powder or gel mixtures that are amenable to dry clean up and produce limited aqueous wastes (typically only a water mist used to settle powder dust at building ventilators). The Powder Line was served by two main rail spurs and nine short sidings or cross-over sections. One "angel walk" connected the two mix houses. Surface water enters PAM from PAO via Boyd Creek and through a drainage of the southern upland that flows through the Box House #3 site into the Boyd Valley. Storm water within PAM either accumulates in two sedimentation ponds east of the Mix Houses (eventually over flowing to Boyd Creek) or in a wide swampy area on the valley floor adjacent to a swale that drains from the Kimber Pack House south to Boyd Creek. All of PAM with the exception of the swamp and ponds is forested with mature pines and thick under brush. The ponds are filled with cattails and the swamp contains thick saw grass and reeds making erosion limited from the PAM interior. The primary erosion sites for this area are along Boyd Creek, which is severely eroding its banks throughout PAM. There is one identified bare area in PAM, a pawed spot west of the area change house, which is apparently attractive to deer.

PAP (the Smokeless Powder/ Nitro-Cotton Plant) is located on the south side of Boyd Creek opposite PAO. The western part of this area was used for reprocessing of surplus military smokeless powder charges into agricultural explosive products from 1922 through 1928. Reprocessing operations were conducted in four buildings (Dry House, Grinding House, Store House, and Screening House). The Grinding house was on the valley bluff and the others were on the floodplain. A rail siding in UAN served the upper grinding house. No roads access the Smokeless Powder area. The eastern part of PAP housed the Nitro-Cotton Plant, which included six structures (Nitro-Cotton Blower House, Dry House, Store & Screening House, Salt House, and two small unlabelled structures) all of which were located on the floodplain. The NC plant was served by one rail siding and is not accessible from any roads. A slough is located in the NC Plant area along the base of the valley wall. This drains to Boyd Creek during wet periods. No bare areas have been found in PAP.

SAI (Triton Support) is located at the western edge of the group between UAK and PAB. The narrow Use Area contains a privy and four structures along two parallel rail spurs. These structures were reportedly warehouses and office buildings. The area drains to the TNT02 Fortifier Drainage that crosses SAI from west to east near its center. Western SAI is grass covered and aspen woods line the east side of the area. One small bare spot is located near the north building in SAI. A burn pile operated by BDC is located in the southern part of SAI.

SAK (the Store House Area) is located along the Main Drive north of UAL. This area contains the Guard Headquarters, Powder Line Store House, Shop Area Storage, Active Magazine, Shop Area Change House, Electrical Shop, Machine Shop, Over-the-road Truck Garage, Pulp Dry House, Pulp Store, and Main Store House. These structures are all located near the center of SAK adjacent to the Main drive, the Main Drive Rail Main and the east portions of two rail sidings forming the NA Yard. SAK is flat and drains either through the NA03 Drainage and Soda Stores Ditch east to the Central Drainage or via the Salt Cake Pond Drainage south to Boyd Creek. Most of SAK is covered by tall grass except for an area of dense reeds near the Main Drive at the east edge of the area and a stand of spruce in the southwest portion of the area. A transformer oil dump was reported in SAK near the Electric Shop and the Main Drive.

SAJ (the Power Plant) contains 21 buildings: Ammonium Nitrate Tank House #1, Ammonia Neutralizing Pump House, three Ammonia Neutralizing House Tanks, Coal Hopper, Decontamination Area Storage Trailer, Decontamination Area Water Treatment

Shed, Nitrate Ammonia House, Power House Reservoir, Ammonia Neutralizing House 1, Laundry, Boiler House, Coal Crusher Water Pump House, Main Power House, Pump House, Ammonia Condenser House, Brine Tank, Coal Bunker, Coal Crusher, Coal Crusher Water Tank, Fan House, Garage, and Spray Pond. Surface water enters SAJ at a swale from the north ditch of the Decon Facility, although most of the flow in this ditch typically crosses SAJ via a 40” terra cotta tile that crosses below the entire area from west to east. The NA01 Drainage forms the east border of SAJ and the Glycerin Area Drainage forms the south border. Water from the area interior drains via culverts from the Power House area into one or the other of these drainages. All of SAJ is covered in grass. No bare areas are present, although a borrow site used to cover debris at WAD is sparsely vegetated.

WAD (the power house demolition debris site) is located at the west edge of SAJ adjacent to PAO. This area contains the former Power House reservoir and cooling pond, both of which were filled with demolition debris after plant closure. Surface water flows through these features from, and back into, the adjacent Glycerin Area Drainage. WAD is covered in tall weeds and brush.

5.10.2 Investigation Activities

Due to investigation efforts in other Use Areas, sampling in this group to date has been limited. Production sites in PAO and PAM have yet to be investigated for NG. A thorough reconnaissance of drainages and structures has not been conducted in PAO, PAM or the support areas of this group. No samples have been collected from WAD.

Available data for this Use Area group are summarized in Table-2.10 (surface soil), Table-4.10 (drainage feature soil and sediment), and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

5.10.3 Summary of Investigation Findings

- The only residual product identified in this Use Area group was a few scattered pieces of TNT less than 0.25” in diameter adjacent to the Glycerin Area Drainage channel in PAO.
- Surface soil in SAJ was sampled at the confluence of the 40” drain tile and the NA01 Drainage where 11 mg/kg combined 2,4- and 2,6-DNT and concentrations of lead and zinc were detected.
- Surface soil in SAK was sampled at the reported transformer dumping site where PCB-1260 was detected in two of 13 samples (at 0.021 and 0.008 mg/kg).
- Soil at the single bare spot in SAI, was found to contain 8,700 mg/Kg combined DNT with traces of other NNOCs and naturally occurring metals.
- PAO was sampled at the Glycerin Area Drainage bare spot and TNT was present at a concentration of 48 mg/kg while 2,4-DNT was present at a concentration of 190 mg/kg.

- PAM was sampled at the Dynamite Mix House Ponds and the combined DNT concentration in soil was 0.38 mg/kg, while the arsenic concentration was 86.6 mg/kg at Box House #3.
- A groundwater sample was collected at SAJ at an abandoned potable well called the cow shed well and PZ-54o, where 0.03 µg/L TNT and 0.18 µg/L of combined 2,4 and 2,6-DNT were detected.
- PAO was sampled at Boyd Creek sediment locations B4 (0.24 mg/kg TNT and 0.14 mg/Kg combined DNT) and B5 (DNT and TNT were not detected).

5.10.4 Potential for Fire or Explosion Hazards

The isolated bare spots in PAO and SAI contain product or percentage concentrations of TNT and DNT and represent a potential fire or explosion hazard. Therefore, the potential for fire or explosion in PAO and SAI is ranked as high.

5.10.5 Potential for Human Exposure

The presence of product and/or percentage concentrations of NNOCs in PAO and SAI combined with the lack of characterization information for other areas indicates that there is the potential for human exposure in this Use Area group. However, these Use Areas are subject to the administrative controls detailed in Section 4.3, are within the site security fence and interior fencing, and are distant from public thoroughfares, which makes them unlikely to be attractive to trespassers. Therefore, under current conditions, the probability for human exposure in PAM, PAO, PAP, SAI, SAJ, SAK, UAK, UAL, and WAD is ranked low.

5.10.6 Potential for Release to Groundwater and Surface Water

The bare spot in PAO has potential to release TNT to surface water. No evidence of releases to groundwater from this group of Use Areas has been identified.

5.10.7 Priority Ranking

These Use Areas have been assigned a high priority ranking for future investigation because:

- Many of these areas, which include former production areas, have not been completely characterized.

5.11 Northern Grid Areas (UAA, UAC, UAD, UAE, UAG, and UAR)

The northern grid area consists of a group of undeveloped areas north of the Boyd Creek valley in the east half of the former Barksdale Works grounds (Figure 6.11). It is believed that these areas were not impacted by Barksdale Works activities. Therefore, the area was divided into grids and samples were collected to confirm that the area is suitable for continued recreational use by the current site owners. The northern grid area includes undeveloped areas UAA, UAC, UAD, UAE, UAG, and UAR. Each of these areas is used for recreational purposes by the current landowner.

5.11.1 Area Descriptions

UAA is a former buffer zone located outside the site security fence adjacent to the intersection of Highway 13 and Nolander Road. It was not developed and remained forested throughout the site history.

UAC is a buffer zone inside the east fence north of the Main Drive. This area was also undeveloped throughout the site history, although timber in UAC was harvested in the 1970s resulting in several logging trails within its boundaries. Drainage from the TNX plant may have entered the central portion of this area from the northwest during spring floods draining to the Northern Drainage, which flows eastward from the area's center.

UAD is a buffer zone along the east fence between the Main Drive and the Central Drainage. The north half of UAD has been maintained as a hay field and the southern half is forested. A small area with six empty barrels was identified in UAD near the fence just south of the Main Gate. Screening of the barrels did not identify any residual explosive compounds and the barrels are believed to have contained trash from the Gate House.

UAE is a wooded area adjacent to the Main Drive between the Central Drainage and the Main Magazine Road. A rail line and sidings form the southern border of UAE and the Burning Ground Access road forms the eastern boundary. Run-off from the Ammonium Nitrate Plant enters the area via the ditches along the southern rail sidings and run-off from the Burning Ground enters UAE via a swale leading out of that area. Both flows exit via the Substation Drainage to the southeast.

UAG is located north of the rail grade parallel to the Main Drive between the Central Drainage and the North Gate Road. It consists of a rolling hayfield surrounded by alder swamps along the area's borders. A small parking area formerly used by the security force is located in the southwestern corner of the area. Otherwise, it has always been undeveloped. Drainage from the acid plants enters the area along the rail grade at its southern border and flows eastward along the rail grade to the Central Drainage.

UAR is located within the Boyd Creek valley. It contains undeveloped wetlands and old growth cedar forests. The area receives run-off from ditches in the Nitramon Plant (PAN), the Powder Line Box House #3 (PAM) and the Southern Area Rail Station (SAA). It also receives groundwater seepage from below area SAC and floodwater from Boyd Creek. Twenty-five empty drums deposited by floodwaters have been recovered from UAR. The drums have been screened for explosives using Expray test equipment (results were non-detect) and removed for off-site disposal. Miscellaneous debris from WAF is scattered along the north edge of the area.

5.11.2 Investigation Activities

Areas UAA, UAC, UAD UAE, UAG and UAR are typically undeveloped and free from suspected sources and therefore, a grid system was used to evaluate each area. Two grid spacing intervals were used: an 8-acre grid in UAA and a 4-acre grid in the remaining areas. Biased samples were also collected within the gridded areas at locations where surface water bodies or transportation corridors (described in section 5.11.1) may exhibit concentrations not representative of the general area.

Available data for biased samples within this Use Area group are summarized in Table-2.11 (surface soil), Table-3.11 (subsurface soil), Table-4.11 (drainage feature soil and sediment), Table 5 (surface water) and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

5.11.3 Summary of Investigation Findings

The investigation findings for this Use Area group are summarized as follows:

- Organic compounds were infrequently detected in the resulting 79 grid samples and the biased samples collected from these areas. The few detections included low concentrations of: acetone, methyl-ethyl-ketone, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, 2-amino-4,6-DNT, 4-amino-2,6-DNT, 2-MNT, fluoranthrene, and pyrene at low concentrations. Additionally, 16 naturally occurring inorganic compounds were detected.
- Constituent concentrations in surface soil and sediment from the biased and grid sample results were compared to background concentrations and recreational SSLs. Only arsenic and lead in surface soil exceeded the SSLs.
    - The arsenic recreational SSL was exceeded at two locations in unit UAG and five locations in unit UAE. Of these locations, only one arsenic concentration was elevated compared to other sample concentrations. This concentration was 57.4 mg/kg, and was found in unit UAG at sample location UAG010.
    - The lead recreational SSL was only exceeded at one location in UAE, and the concentration was only slightly above the recreational land use SSL.

5.11.4 Potential for Fire or Explosion Hazards

Due to the absence of any visible solid residual product at the ground surface and the generally very low concentrations of detected flammable constituents, there does not appear to be any potential for fire or explosion in these Use Areas. Therefore, the potential for fire or explosion in these Use Areas is ranked as low.

5.11.5 Potential for Human Exposure

These Use Areas are located within the security fence and are currently used for recreational purposes and will continue to be used for that purpose in the future. There are a few sample locations where the concentrations are above recreational SSLs. With a few exceptions (i.e., arsenic and lead) all of constituent concentrations are less than the recreational SSLs. Overall, these data indicate that these Use Areas are acceptable for recreational use.

5.11.6 Potential for Release to Groundwater and Surface Water

The potential for release to groundwater and surface water for the Northern Grid Areas is assigned a low priority ranking. Concentrations of compounds detected in groundwater, surface water, and sediment in these areas are most likely present as a result of migration or transport from upgradient source areas. This conclusion is supported by the lack of historical use of these areas and the low concentrations of site-related constituents detected in these media.

5.11.7 Priority Ranking

Five of the Use Areas comprising the Northern Grid Areas (UAC, UAD, UAE, UAG, and UAR) are assigned a low priority for future investigation because:

- These areas are generally undeveloped and unaffected by former Barksdale Works activities.
- These areas have been adequately characterized through a comprehensive grid-sampling program and the resulting data confirm that these Use Areas are suitable for recreational purposes.
- There is low potential for fire or explosion.

Use Area UAA is assigned a NFA priority ranking because:

- This area is historically undeveloped and unaffected by former Barksdale Works activities.
- The area has been adequately characterized through a comprehensive grid-sampling program and the resulting data confirm that the Use Area is suitable for recreational purposes.
- There is low potential for fire or explosion.

5.12 Oil of Vitriol Plant (Area PAT)

The WWI era Oil of Vitriol Plant (PAT) is approximately 20 acres in size and is located adjacent to the security fence in the north central part of the Barksdale Works (Figure 6.12). It is accessed by the Acid Loop Road, which crosses from east to west at about the center of PAT. The area contains two rail spurs (the OV Plant Absorber House and OV Plant Burner House Spurs) and two other rail grades (the NS Main and Acid Recovery TNT Spur) form the west and south borders of PAT.

5.12.1 Area Description

This area is primarily wooded with birch groves covering approximately 13 acres. Ground cover within these groves is typically short grass, which is often sparse to absent. Exceptions to this type of ground cover are a small meadow (2.5 acres) along the northeast edge of the area and five large bare areas (ranging from 0.1 to 3.5 acres) in the southwestern part of PAT. These more open areas typically contain cinders and pieces of elemental sulfur up to six inches in diameter. Blocks of 4- to 8-inch diameter quartz (previously used as inert packing materials for air stripping towers) and pieces of coal (used to heat the converter houses) are also scattered in this area.

Surface water enters PAT from UAI via the Central Drainage. The Central Drainage crosses PAT from west to east just north of the Acid Loop Road then turns northeast to form part of the border between PAT and UAH. A second drainage, the OV05 Burner House Ditch forms the northern border of PAT and joins the Central Drainage just before it discharges into UAH. Surface water in the northwestern part of PAT ponds in an area called the Sulfur Pile Impoundment before overflowing into UAI and exiting through the plant fence. Storm water south of the Acid Loop Road is collected by a minor drainage, the OV03 swale, which drains to the Central Drainage. Some sediment (typically cinders and ore residue) is present within the Central Drainage channel in the vicinity of bare areas (production line OV04), but thick vegetation and peat bogs along the eastern border of PAT prevent this material from migrating into UAH. There is significant sediment in the OV03 swale, but this is prevented from migrating to the Central Drainage by the raised grade of the Acid Loop Road.

Former uses of PAT began in 1915 when the prior pyrite roasting OV Plant (OV01) in PAS was replaced with an elemental sulfur plant (OV02). The new OV plant was rapidly expanded with four new lines, OV03 through OV06, constructed within two years. Each line contained an Absorber House, two Absorber House Store Tanks, Blower House, Burner & Purification House, four Coke Filters, Gas Cooler, Preheater & Converter House, 16 Pressure Filters, and two Spray Catchers. These buildings, the Sulfur Barn, Coal Store, Regenerating House and a rail loading shed comprised the 149 buildings identified within PAT to date. After WWI all but the sulfur barn and the OV03 line buildings were shut down and demolished. The OV03 line and the sulfur barn remained in service until plant closure. The foundation for the Sulfur Barn was used as the foundation for the metal building constructed by BDC for hay and farm equipment storage.

5.12.2 Investigation Activities

Horizontal and vertical delineation of production related compounds has not been conducted in PAT. Surface soil was analyzed to characterize concentrations at the bare areas within PAT. These samples overlapped three building sites (OV02 Burner & Purification House, OV03 Pressure Filters, OV04 Preheater & Converter House), the OV Plant Burner House Rail Spur, the OV05 Drainage and the Sulfur Piles Impoundment. Characterization has been conducted at bare areas and the Sulfur Piles Impoundment. Building foundations and other drainages have not been characterized. There are no monitoring wells located within the boundaries of PAT.

Available data for this Use Area are summarized in Table-2.12 (surface soil), Table-4.12 (drainage feature soil and sediment), and Table 5 (surface water). Statistical summaries of the results within the Use Area are presented in Table 7. The following paragraphs summarize findings related to the various media sampled.

5.12.3 Summary of Investigation Findings

The investigation findings for PAT are summarized as follows:

- Reconnaissance of historically documented manufacturing sites: 10% complete (3 large buildings out of 149 sampled). Reconnaissance of general grounds: 50% (Wooded areas north of OV04 and east of the Converter houses, as well as bare areas in the northwest corner of the PAT remain to be evaluated).
- No disposal sites or solid residual product has been found in PAT.
- NNOCs were detected in surface soil (from highest to lowest) at: OV04 Bare Area, OV02&03 Bare Area, PAT Buildings, OV05 Bare Area, and PAT Drainages. Site-related compounds were detected in 11 of the 24 soil samples collected from these areas. TNT and 2,4-DNT were the most frequently detected NNOCs detected in these samples. Maximum detected concentrations of TNT and DNT were TNT 0.170 mg/kg, 2,4-DNT 4.70 mg/kg, 2,6-DNT 4.0 mg/kg, and a combined DNT value of 4.8 mg/kg (sample ACD2-04).
- Elevated concentrations of inorganic compounds (arsenic, lead, and mercury) were detected throughout the area. These elevated inorganic detections are likely associated with the cinders from the former powerhouse that were distributed as road base in this area.
- Low concentrations of NNOCs were detected in groundwater analyzed from downgradient wells (PZ-02o, PZ-20, and PZ-44). Given the nature of operations reported in PAT, these are likely not due to OV Plant releases.
- No NNOCs were detected in the single surface water sample collected from the Sulfur Piles Impoundment (ACDI-POND1).

5.12.4 Potential for Fire/ Explosion Hazards

Since there is no product on the ground surface in PAT, the potential for fire or explosion hazards is ranked as low. .

5.12.5 Potential for Human Exposure

Surface concentrations of NNOCs are elevated at one location in PAT for combined DNT. Additionally, several inorganic compounds (arsenic, mercury and lead) are present at elevated concentrations in the bare areas within PAT. Therefore, a potential for human exposure exists in this area.

The majority of this Use Area is subject to the administrative controls detailed in Section 4.3 and the area is within the site security fence and interior fencing. However, the sulfur barn, which was rebuilt and now used for hay storage is entered by the landowner. Access to this barn is obtained via the Acid Loop Road and recreational use is limited to the roadway and hay barn. Because the elevated concentrations in surface soil were detected approximately 600 feet northeast of the hay barn, the potential for direct contact is limited. As a result, the potential for human exposure is ranked low.

5.12.6 Potential for Release to Groundwater and Surface Water

There are no groundwater monitoring wells located within PAT; however, available downgradient data do not suggest releases have occurred from PAT.

5.12.7 Priority Ranking

PAT has been assigned a low high priority ranking for future investigation because:

- No disposal sites have been found in PAT and solid TNT, DNT or TNX were not observed in PAT.
- PAT is adequately characterized and the most detected NNOC compound concentrations are less than the recreational SSLs. One exception near the OV04 Preheater & Converter House requires additional characterization.
- The potential for fire or explosion is low.

5.13 TNT No. 1 Line (Area PAU)

PAU is located west of the plant water tower between the Lydol and TNT No. 6 areas (Figure 6.13). This area contains the former TNT01 production line, the oldest of the TNT production lines at the site, which operated between approximately 1912 and 1917.

5.13.1 Area Description

PAU is bounded to the southeast by the Main Drive. The TNT06 Ditch drains the southern half of PAU and forms its southwestern and southern borders. Swales feeding the Solvent Recovery Ditch drain the northern half of PAU and form this border. The northwestern border of PAU generally follows high ground west of the former TNT01 buildings.

Most of PAU is heavily vegetated; the eastern portion (i.e., within 150 ft of the Main Drive) is typically covered with grass and occasional dense thickets. The western portion of the area is typically wooded with a dense under story of dogwood and honeysuckle.

The Solvent Recovery Ditch enters from PAE near the center of the northern edge of PAU. It drains south to the TNT06 Ditch, which exits the area to the east into PAC. The ground surface is typically well vegetated and visible erosion is limited to points where former rail grades crossed the area drainages.

Foundations visible at the area indicate that little subsurface decommissioning work was done at the acid and nitration buildings. However soil barricades around the neutralizing and graining houses have been removed and one interviewee did report excavating around the TNT01Graining House in the late 1970s.

5.13.2 Investigation Activities

Investigation activities in PAU were limited to trenching conducted at Neutralizer and Graining Houses, and GeoProbe sampling at the Neutralizing building in 2006. Two soil samples were collected from each trench (one from near surface and one at the base of the trench). The GeoProbe boring (PAU002) was placed at the catch box in the Neutralizing house. Samples from this boring were collected to a depth of eight feet bgs.

Available analytical data are summarized in Table-3.13 (subsurface soil). Statistical summaries of the results are presented in Table 7.

5.13.3 Summary of Investigation Findings

The investigation findings for PAU are summarized as follows:

- Solid TNT was visually identified either at the ground surface or at depth (typically within six ft of the surface) at the Neutralizing and Graining buildings (Figure 6.13). Additionally, a small (15 square foot) bare soil area with solid TNT present is located near the southern edge of PAU where a former rail grade crossed the storm ditch
- Of the detected compounds, the highest concentrations reported were for 2,4-DNT, 2,4,6-TNT, and 2-amino-4,6-dinitrotoluene, which were detected in percentage concentrations. Other detected NNOC compounds are generally consistent with detections observed in other production areas of the site.

5.13.4 Potential for Fire or Explosion Hazards

The presence of TNT at ground surface in solid form and percentage-level concentrations of NNOC compounds in soil indicates there is a potential for fire or explosion hazards within area PAU. PAU also contains product at depth, which may present an explosion hazard for intrusive activities. Therefore, the potential for fire or explosion in PAU is ranked as high.

5.13.5 Potential for Human Exposure

PAU contains solid product and elevated concentrations of NNOCs at and near the ground surface; therefore, human exposure to site-related compounds is possible. However, this Use Area is subject to the administrative controls detailed in Section 4.3, is within the site security fence and interior fencing, and is distant from public thoroughfares, which makes the area unlikely to be attractive to trespassers. Therefore, under current conditions, the probability for human exposure in PAU is ranked low.

5.13.6 Potential for Release to Groundwater and Surface Water

Monitoring well PZ-41 is the single monitoring point for groundwater in the area and is located downgradient of PAU. Analytical results indicate the presence of NNOC compounds in PZ-41; however, whether these detected compounds are attributable to releases to groundwater from PAU is not known at this time. No surface water or sediment data are available for the drainages within PAU; however, the presence of solid product at the ground surface indicates a potential for release to surface water from this area. Additional information is needed to determine the potential for releases to groundwater and surface water from PAU.

5.13.7 Priority Ranking

PAU is assigned a high priority ranking for further investigation because:

- The Use Area has not been completely characterized.
- Residual product is present and the area has not been completely characterized.
- The presence of residual product indicates that there may be the potential for fire or explosive hazard.

5.14 Property East of Highway 13 (Areas SAD, SAL, SAN, and UAQ)

The property formerly owned by DuPont east of Highway 13 (Figure 6.14) is divided into four areas: SAD (Plant Pump House), SAL (MCK's Beach House), SAN (Plant Housing), and UAQ (the "Lakeshore Buffer"). These Use Areas have been grouped together for discussion due to their proximity to one another and because these areas were not used during the operational life of the Barksdale Works for any active manufacturing. SAD however, did contain the plant pump house that supplied water for manufacturing, fire suppression, and other non-potable purposes. Portions of SAD, SAL, and SAN contain residential housing.

5.14.1 Area Description

The southern boundary of SAD is located 500 feet south of the driveway of fire Call No. 72040 on Highway 13 and is bounded to the north by the driveway of the Barksdale Boy Scout Camp (Figure 6.14). This Use Area contains the former plant water system pump house (now the Bretting's guest house at the lakeshore), the Bretting residence, and Bretting's garage and sheds. The Use Area also contains the foundations of former bunk houses that were used by DuPont from approximately 1904 to 1920. Surface water flows through SAD via three drainages: the Substation Drainage, the Central Drainage Diversion, and the Former Central Drainage. The original Central Drainage channel was rerouted to accommodate plant expansion prior to WWI and most of the flow was diverted to Boyd Creek via the "Central Drainage Diversion". A dike was constructed at the intersection of the diversion channel and the original channel to divert flow. The original channel feeding the Bretting Pond is typically stagnant except during heavy rainfall events, when the dike has been observed to periodically be topped. Spring floods also allow surface water to enter from the Substation Drainage through the swale that flows under the turning circle in front of the Bretting residence. The majority of SAD is covered by brush or small grassy meadows with the exception of the Bretting's yard, which is mostly covered in turf grass.

SAL is located between the Highway and the lake north of the Northern Drainage. It is overgrown by forest but contains remnants of the former plant recreation hall (MCK's Beach House) and a shed. Surface water from SAL is drained via the unnamed natural drainage in the center of the Use Area. Surface water from the portion of Highway 13 that is adjacent to SAL drains to the northern drainage, which receives surface water from UAC. Small amounts of household refuse (i.e., beer cans, food cans, and food tins, etc.) have been observed along the northern bank of the central drainage in this area.

SAN is located between Highway 13 and the lake from the drive of the Barksdale Boy Scout Camp to the Northern Drainage. It contains seven existing residences and twelve associated out-buildings; the boy scout bunk house and out house; two former DuPont owned residences that have been removed; the foundations of a group of 11 former bunk houses, the former Plant YMCA, the former Gate House and the former Plant Rail Station. It receives surface water from the Main Gate Drainage via a culvert under the Highway. Except where cleared around the current residences SAN is covered by dense forest.

UAQ is a forested piece of land located between Highway 13 and the lake from the drive of Fire Call No. 72040 on Highway 13 and the southern fence line of the Plant. It receives surface water via floods from the channel of Boyd Creek, which passes through the area, and the Nitramon and Truck Gate Drainages, which enter via culverts under the Highway. Two empty drums deposited by floodwaters have been recovered from UAQ. The drums were screened for explosives using Expsray testing (results were non-detect) and removed for off-site disposal.

5.14.2 Investigation Activities

Samples have been collected for characterization from each of these Use Areas, with the exception of SAN where no characterization sampling has been performed to date. Available data for this Use Area group are summarized in Table-2.14 (surface soil), Table-3.14 (subsurface soil), Table-4.14 (drainage feature soil and sediment), Table 5 (surface water) and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

The majority of the sampling efforts have been focused on characterization of sediment in areas UAQ and SAD, which receive most of the surface water runoff from the former Barksdale Works. However, surface water and sediment samples also have been collected and analyzed from locations upstream of SAL, SAN, and UAQ at the site perimeter (along the site fence in Figure 6.14). The majority of samples collected in these Use Areas were analyzed for nitroaromatic and nitramine organic compounds and metals; however, laboratory analyses for VOCs were performed on select samples. Other investigation activities conducted in these areas have included groundwater sampling, use of canines trained to detect explosives to potentially locate residuals in soil within SAD, and recovery and subsequent off-site disposal of two empty drums from UAQ.

Groundwater samples were collected at the existing residences in SAN on routine basis between 2000 and 2005. The residential data were communicated to the WDNR after each sampling event. Because each of these residential wells have been abandoned and replaced by a municipal water supply pipeline, these previous data are not presented within this report. Analytical results for the monitoring wells located within these Use Areas are presented in Table-6, and groundwater sampling data from 1998 to 2001 are summarized in Appendix-E.

5.14.3 Summary of Investigation Findings

The investigation findings for SAD, SAL, SAN, and UAQ are summarized as follows:

- Soil has been sampled at depth along the former water supply pipeline that parallels the northern edge of the Bretting Drive. NNOCs were detected infrequently and at low concentrations in these samples.
- Soil screening in the Boyd Creek delta and canine investigation of the full area did not find any detectable NNOC compounds.
- Concentrations of compounds detected in soil in SAD were compared to non-industrial SSLs and none of the concentrations were greater than the non-industrial SSLs.
- Site-related constituents have been detected in each of the monitoring wells in these Use Areas. The highest concentrations of NNOCs in groundwater were generally observed in wells PZ-12, which is located in SAD. However, based on the known previous activities within these Use Areas, detected constituents in groundwater are not believed to be the result of releases from SAD, SAL, SAN, or UAQ, but rather the result of migration from the former manufacturing areas to the west of Highway 13. Groundwater in these Use Areas is not used for any purpose.
- Results of the sediment samples collected within UAQ and SAD indicate that detected organic constituents are generally limited to nitroaromatic and nitramine organic compounds. Very low concentrations of acetone and methylene chloride were detected in the sample from the Bretting Pond (BRE-POND1-B); however, these compounds are believed to be laboratory artifacts.
- The highest concentrations of detected constituents in sediment generally occur at locations where sediment accumulates in these drainage features. For example, the sample collected at the dike separating the Central Drainage Diversion from the Former Central Drainage (sample SWF004) and the sample collected at the base of the dike at the Bretting Pond (sample BRE-POND1-B) generally have the highest detection of site-related constituents.
- Concentrations of compounds detected in sediment in SAD were compared to non-industrial SSLs and only a single arsenic detection in the sample collected from the bottom of the Bretting Pond exceeded the non-industrial SSLs.
- Surface water samples collected upstream of UAQ and west of Highway 13 the Nitramon and Truck Gate Drainages did not contain site-related compounds at concentrations of concern. Surface water samples in the drainages entering SAN have been tested at the site fence and found to below screening values.

5.14.4 Potential for Fire or Explosion Hazards

Due to the low concentrations of detected compounds present in soil and sediment in these areas, the absence of any visible solid residual product at the ground surface, and the absence of any previous manufacturing or storage activities, the potential for fire or explosion in areas SAD, SAL, SAN, and UAQ is ranked as low.

5.14.5 Potential for Human Exposure

Detected concentrations of compounds detected in sediment and soil in SAD were compared to non-industrial SSLs. The results of the comparison indicate that only the single arsenic detection in the sample collected from the bottom of the Bretting Pond exceeds non-industrial SSLs. As a result, the potential for human exposure to site-related compounds in these Use Areas is ranked as low.

5.14.6 Potential for Release to Groundwater and Surface Water

Concentrations of compounds detected in soil, sediment, groundwater and surface water in SAD, SAL, SAN, and UAQ are most likely present as a result of transport through the drainage features that originate on the former manufacturing portion the site to the west of Highway 13. As such, the potential for release to groundwater and surface water from these areas is ranked as low.

5.14.7 Priority Ranking

Although these areas are generally unaffected by previous Barksdale manufacturing or storage activities and available analytical data support a priority ranking of low for fire or explosion hazards, potential human exposure, and potential release to groundwater and surface water, the property east of Highway 13 is assigned a high priority ranking for further investigation because:

- The property is located outside of the perimeter security fence,
- The property is used for non-industrial purposes.

5.15 Western Support and Undeveloped Areas (UAH, UAI, UAM, UAP, UAS, and SAM)

This Use Area group consists of five undeveloped areas and a minimally developed support area located north and west of the primary manufacturing areas (Figure 6.15). The Western Undeveloped areas are UAH, UAI, UAM, UAP, and UAS. For discussion purposes, they have been grouped with Support Area SAM, a small support area adjacent to them. Use Area UAP is located west of the security fence while the remaining areas are inside the security fence perimeter. Field reconnaissance of these areas has not identified any solid residual product or any previous manufacturing structures.

5.15.1 Area Description

UAH is a 14.2-acre area located inside the site fence adjacent to the North Gate (at the upper right of Figure 6.15). It is bisected by the Central Drainage, which crosses from west to east. The northern half of UAH is a heavily vegetated meadow that contains scattered Aspen and Maple trees, from which surface water drains to the north then to the east along Nolander Road. The southern portion of UAH is swampy and contains saw grass and peat bogs that drain to the Central Drainage. Plant roads accessing UAH include the perimeter security road that ran inside the site fence, a raised rail grade that separates UAH from PAT, the Acid Loop Road that forms UAH's southern border and the North Gate road that forms the eastern border of the Use Area. Other than these roads, there are no known structures in UAH.

UAI is approximately 71 acres in size and is located inside the northwestern corner of the fenced grounds. The perimeter security road and the fence form the northern and western borders of UAI. Rail grades along the northwestern sides of PAD, SAH, PAE, and PAT form the other borders. The northern three-quarters of UAI is relatively flat swampy woodlands with dense underbrush. Surface water in this area only flows during floods at which time it drains to the north then east. Small areas along the southern edge of UAI receive storm water from PAE, SAG and SAH. This water enters the Central Drainage which flows from west to east within 200 ft of the south edge of UAI. Other than the perimeter road and fence, there has been no known development within UAH.

UAM is approximately 14.5 acres in size and is located inside the center of the western fence adjacent to the north of Boyd Creek. The area is covered by dense woods, and the steep slopes in this area direct surface water to Boyd Creek and its tributary, the WWI Ravine. No surface water enters UAM and like UAI, the only development has been the perimeter security fence and adjacent road.

UAP is the largest Use Area in this grouping (approximately 155 acres) located outside the fence along Ondassagon Road. Most of the area is forested in spruce and aspen stands. The north quarter of the area drains north across UAI to Nolander Road. The center drains south to Boyd Creek and the southern third drains east to Mission Springs Creek in UAO. One historic plan indicates a hay shed was present in the central portion of UAI, but no sign of this structure has been identified. Overhead power transmission lines are located in a clear cut that extends west 70 ft along the full length of the site fence.

UAS encompasses approximately 22 acres and lies within the Boyd Creek valley inside the western security fence. It contains brush and grassy flood plains often flooded by beaver dams. There has been no known development within UAS.

SAM is approximately 4.5 acres in size and is known to have contained two structures near the center of its northern edge, the uses of which have yet to be identified. Rail grades connected these structures to PAD. The area drains southeast via the WWI Ravine and the Refinery Ditch.

5.15.2 Investigation Activities

Available data for this Use Area Grouping include analytical results for five soil samples (SSI05-SB394 through SSI05-SB398), groundwater samples obtained from monitoring wells PZ-03s and PZ-03d, and three sediment and three surface water samples. The soil samples collected in UAP were collected as part of inorganic background sampling efforts; therefore, the analytical results are limited to inorganic data only. PZ-03s and PZ-03d were installed within UAP to evaluate upgradient groundwater quality. Two of the surface water and sediment sample locations are along the north fence in UAI (SD1 and 1SD1), while the remaining sediment and surface water sampling location, SWF029, is located in the Central Drainage at its exit from UAH (just south of the North Gate on Figure 6.15). Surface water samples were collected between 1998 and 2005. No sampling has been conducted in the other Use Areas in this grouping. Available data for this Use Area group are summarized in Table-2.15 (surface soil), Table-4.15 (drainage feature soil and sediment), Table 5 (surface water) and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

5.15.3 Summary of Investigation Findings

The investigation findings for Western Support and Undeveloped Areas are summarized as follows:

- Soil sampling results indicate that concentrations of detected arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, and zinc are typical of soils in the northern Midwest. Concentrations ranges for these inorganic results are discussed further in Appendix C.
- Monitoring well PZ-03d was the only location where site-related NNOC compounds were detected. NNOCs detected include: TNT (0.1 µg/L), 2,4-DNT (0.3 µg/L), and 2,6-DNT (0.1 µg/L) . Each of these compounds were detected only once in the nine sampling events conducted since the well was installed.
- The results of the surface water sampling indicated no NNOC compounds were detected in any of the samples.

5.15.4 Potential for Fire or Explosion Hazards

Due to the absence of any visible solid residual product at the ground surface and the absence of any previous manufacturing or storage activities, the potential for fire or explosion in areas UAH, UAI, UAM, UAP, UAS, and SAM is ranked as low.

5.15.5 Potential for Human Exposure

All but one of these Use Areas are located inside of the perimeter security fence, thus access to these areas is controlled. Concentrations of detected inorganic compounds in UAP are within regional background ranges. Additionally, the absence of solid residual product in these areas and the fact that they were not used for previous manufacturing or storage purposes makes the potential for human exposure to any potential site-related constituents minimal, based on current site knowledge. Therefore, the potential for human exposure within these Use Areas is ranked as low.

5.15.6 Potential for Release to Groundwater and Surface Water

The low concentrations of detected naturally occurring inorganic compounds do not indicate a potential for release to groundwater or surface water. No site-related compounds were detected in the surface water samples collected from this Use Area grouping. Detected NNOCs in groundwater were observed during the early sampling efforts at the site and have not been repeated. Because these areas are historically undeveloped, it is unlikely that they are the source for detected NNOCs. As a result, the potential for releases to surface water and groundwater from the Western Support and Undeveloped Areas is ranked as low.

5.15.7 Priority Ranking

Use areas UAH, UAI, UAM, UAS, and SAM area assigned a low priority ranking because these areas:

- Were historically undeveloped during previous site activities,
- There is a low potential for fire and/or explosion, potential human exposure, and potential releases to groundwater.

Use Area UAP has been assigned a high priority for further investigation. Although historical site knowledge and available analytical data and support a priority ranking of low for fire or explosion hazards, potential human exposure, and potential release to groundwater and surface water, the high priority ranking for further investigation is assigned because:

- This area is located outside of the perimeter security fence and desirable for recreational use.

5.16 Former Burning Grounds and Associated Areas (Areas WAA, WAC, and WAI)

These Use Areas are located along the Central Drainage channel from the Main Drive to the east site fence (Figure 6.16) and encompass approximately 3.8 acres. The Burning Ground Access Road is the primary entry to WAC and WAA from the west. The Substation Loop trail accesses the eastern end of WAI. These Use Areas have been grouped together for discussion due to their proximity to one another and because they were used for similar purposes.

5.16.1 Area Description

WAA was the site of off-spec nitroglycerin incineration (via open burning) and other debris disposal between 1903 and 1976 and has been primarily unused since. No manufacturing activities are known to have occurred in this area. WAC was the entry to the Burning Ground and received miscellaneous containers and debris that would not burn.

In 2002 it was noted that the Central Drainage was eroding the northern face of the Burning Ground. WAI received the wash out from WAA and contains small amounts of light debris like plastic and ceramics that were carried into the area. Heavy metallic debris accumulated at the base of the cut bank. DuPont eliminated the any further erosion in 2003 by moving the channel 75-ft away from the waste face and armoring the new banks with fabric and Reno-mattresses.

WAC and WAI are forested with mature trees. WAI, which has a relatively open canopy due to aging of the birch and aspens present, has dense ground cover of ferns and grass, while WAC, where maple and beech trees are more prevalent has little to no ground cover. WAA was cleared during the erosion control activities and is currently open grass meadow.

Drainage is primarily toward and along the Central Drainage. A small area on the southern edge of WAA drains to a swale that flows south into UAE.

5.16.2 Investigation Activities

Available data for this Use Area group are summarized in Table-2.16 (surface soil), Table-3.16 (subsurface soil), Table-4.16 (drainage feature soil and sediment), Table 5 (surface water) and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

Soil samples were collected from 0- to 2-ft below the surface of the Burning Ground (BG), Central Drainage, BG Swale and BG Approach areas.

5.16.3 Summary of Investigation Findings

The investigation findings for WAA, WAC, and WAI are summarized as follows:

- The results of the soil sampling indicated that numerous NNOCs, VOCs, and metals were detected in the area.
- A comparison of the surface soil results to background concentrations and recreational SSLs indicated that arsenic and lead were the primary COPCs at the ground surface. The exception to this was the southeastern BG surface near the East BG Swale. In that area, where the cover added during erosion control activities was thinnest, combined 2,4- and 2,6-DNT concentration met or exceeded the recreational SSL at three locations.
- The arsenic recreational SSL was exceeded at a total of 13 locations: four locations in unit WAA and nine locations in unit WAC. Of these 13 locations four had arsenic concentrations that were elevated compared to other nine. The four elevated arsenic concentrations were 161 mg/kg, 102 mg/kg, 77.9 mg/kg, and 62 mg/kg, located at sample locations WAC010, WAC012, WAC003, and WAA 006, respectively.
- The lead recreational SSL was exceeded at four locations in unit WAA and one location in unit WAC. At all of these locations the lead concentration was only slightly above the recreational SSL.
- Higher concentrations of NNOCs are observed in groundwater beneath and downgradient of the Burning Ground than are observed in the upgradient wells. As such a release to groundwater from this location is indicated. WAC and WAI are not likely to have contributed as significantly as the Burning Ground to the results observed in groundwater.

5.16.4 Potential for Fire or Explosion Hazards

There have been no solid or percent level concentrations of residual products found on or near the surface in WAA, WAC or WAI. Therefore, the potential for fire or explosion hazard in these Use Areas is ranked as low.

5.16.5 Potential for Human Exposure

Waste materials are present below ground in these areas. However, there are only a few sample locations where the surface concentrations are above recreational land use SSLs. These data indicate that this area is typically acceptable for recreational use.

5.16.6 Potential for Release to Groundwater and Surface Water

There is evidence that a release to groundwater has occurred from the Burning Ground (WAA). Erosion is occurring in the BG Approach (WAC) and the BG Wash Off (WAI) areas. Actions taken by DuPont have eliminated the potential for further erosion at the BG itself (WAA). Sampling at the outfall from the area did not detect significant concentrations in sediment or groundwater leaving the area.

5.16.7 Priority Ranking

WAA, WAC and WAI have been assigned a low priority ranking for further investigation because:

- In general, these areas have been adequately characterized.
- There is no evidence of fire or explosion hazards.
- Channel reconfiguration at the Burning Ground has reduced the potential for erosion and mobilization of remaining residuals to surface water.
- The potential for human exposure via direct contact with surface soil exists in WAA and WAC, but is acceptable under the current recreational site use scenario.
- Releases to groundwater have occurred, but all downgradient receptors for groundwater have been removed.

5.17 Area South of Boyd Creek (Areas PAP, SAA, SAB, UAO, UAN and WAG)

The Area South of Boyd Creek encompasses approximately 433 acres located between the south rim of the Boyd Creek valley and the southern perimeter fence (Figure 6.17). All or portions of seven Use Areas are identified within this grouping: PAM, PAP, SAA, SAB, UAO, UAN, and WAG. The majority of this area consists of historically undeveloped sections of land (i.e., Use Areas UAN and UAO), which are mostly heavily forested with the exception of plant roads. This Use Area group also includes two small former production areas: PAM (the Powder Line) and PAP (the Smokeless Powder Reprocessing Plant); two support areas: SAA (the Magazine area) and SAB (the Truck Parking area); and one waste area (WAG), which is identified as the 1970s Berm. All of these Use Areas are currently used for recreational purposes and will continue to be used for that purpose in the future.

5.17.1 Area Description and Setting

Small portions of Use Areas PAM and PAP are located in the area south of Boyd Creek and these are the only two locations where production operations were known to have occurred. The portion of PAM (2.5 acres) included in this Use Area group contained Box House #3 and adjacent rail sidings. Box House No.3 operated from approximately 1906 through 1961 and was used for packing of finished dynamite sticks in crates. The 1.8 acres of PAP that is located south of Boyd creek contained a rail platform for unloading surplus military smokeless powder and the associated rail spur. Operations are believed to have occurred in PAP between approximately 1920 and 1930.

The Magazine Area (SAA) contained 20 finished product storage magazines, a scale house, a storm shelter, an office, a rail station and associated rail sidings. An area where off-specification product bags were accumulated and subsequently repackaged was located in the vicinity of Magazine No. 8. All of the magazines were constructed around the beginning of plant operations in 1904 and were used to varying degrees. Nine of the magazines (labeled Mag01 through Mag09) are believed to have been operated until plant closure in 1971. Magazines MagA1 and MagA2 operated until approximately 1918 and the remaining nine magazines (MagB1 through MagB3 and MagC1 through MagC6) operated until approximately 1945.

The Truck Parking area (SAB) was used for storage of empty over-the-road trailers between 1950 and 1971. It also contained a rail car storage shed from 1906 through 1961.

The 1970s Berm (WAG) was a product storage area built after plant closure for storage of surplus product in transit and burning of construction debris during building demolition. The area contains buried residues of the burning operations including sheet metal, charred poles, cables, pieces of drums and other building materials.

Surface water enters UAO via Mission Springs Creek at the southwestern fence corner. Surface water in UAO and SAA drains to the southeast through swales and ditches to join Mission Springs Creek. One group of these swales joins the creek south of Mag04, another group joins the creek just before it exits the plant. Several of these drainages are eroding banks within the Magazine area and UAO. Storm water in UAN north of the Main Magazine Road drains to the northeast into the Boyd Creek valley. These drainages are typically vegetated and show minimal signs of erosion. A smaller drainage south of SAB exits eastern UAN to Highway 13 ditches adjacent to the Truck Gate.

5.17.2 Investigation Activities

Surface water, sediment, soil, and groundwater samples collected between 2002 and 2006 were used to characterize the area south of Boyd Creek. Over 600 soil samples were collected on a grid system and at biased locations between 2004 and 2006. Surface water, sediment and groundwater samples were also collected as part of the characterization of these Use Areas, but to a much more limited extent.

A 4-acre grid was used in undeveloped areas (UAO) and a 1-acre grid was sampled in the support (SAA and SAB) and production areas (PAM and PAP) in order to characterize surface soil. Samples were also collected on a 1-acre grid in UAN due to the proximity of this area to the support and production Use Areas south of Boyd Creek. Biased surface soil samples were also collected at buildings, drainages, rail sites, and from three locations within the nine test pits excavated within the 1970s Berm (WAG). Additional soil sampling was conducted to delineate areas that indicated initially elevated concentrations of COPCs. These additional samples were collected in a biased manner, focusing on areas likely to have the highest constituent concentrations.

Surface water was sampled at two outfalls (the Truck Gate and Mission Springs Creek outfalls) along the eastern fence over three sampling events. Sediment was sampled at 24 locations in the areas south of Boyd Creek; one at the Truck Gate Drainage outfall (lower right of Figure 6.17), eight at ditches in the Magazine area (within eastern SAA below and to the right of center on Figure 6.17) and 15 others within the Mission Springs Creek system (at the bottom of Figure 6.17).

Groundwater was sampled at five nested groundwater well locations (PZ-04, PZ-05, PZ-29, PZ-35, and PZ-36) in these Use Areas. These wells are generally located at the perimeter of the area south of Boyd Creek (Figure PZ04, PZ05, and PZ29 along the north edge and PZ35 and PZ36 along the south edge on Figure 6.17). Available data for this Use Area group are summarized in Table-2.17 (surface soil), Table-3.17 (subsurface soil), Table-4.17 (drainage feature soil and sediment), Table 5 (surface water) and Table-6 (groundwater). Statistical summaries of the results within each Use Area are presented in Table 7.

5.17.3 Summary of Investigation Findings

The investigation findings for this Use Area group are summarized as follows:

- Three soil samples were collected from within the excavations in the 1970s Berm and the maximum TNT, DNT, and A-DNT results were less than recreational SSLs. These samples were collected at an average depth of 1 to 3- feet below ground surface.
- A comparison of constituent concentrations in surface soil from the biased and grid sample results to background concentrations and recreational SSLs indicated that arsenic and lead were the only COPCs. Virtually all of the samples that had arsenic or lead concentrations greater than the screening value were located along former railroad tracks, roads, and parking lots (Figure B-1).
- The presence of arsenic at these locations could be due to several factors, including natural background concentrations, the use of pesticides containing arsenic that were applied for fire control, and/or the use of arsenic-containing cinders from the power plant that were used for road base.
- Results of the sediment sampling indicate that low concentrations of three NNOC compounds and several inorganic compounds were detected at the Truck Gate and within the Mission Springs Creek drainage area. The 2,4-DNT, 2,6-DNT, and zinc detections at the Truck Gate Drainage were reported from samples collected during the 2002 spring thaw and these results have not been reproduced. The presence of arsenic and mercury in sediment at the Truck Gate Drainage has been observed during several sampling events.

- Surface water was sampled at the Truck Gate and Mission Springs Creek outfalls along the eastern fence. VOC or NNOC compounds were not detected. Detected inorganic constituents included arsenic, barium, copper, lead, nickel, and zinc. Of these inorganic detections, only barium exceeded surface water screening levels (see DuPont 2005).
- Groundwater sampling results indicate that detected NNOC compounds were limited to a single well (PZ-04s). PZ-04s is located downgradient of the former TNT02 production line red water discharge location; therefore, it is likely that the low levels of NNOC compounds observed in this well are attributable to this production line. The only other organic compound detected in groundwater was chloroform, which was observed in PZ-29x, which is adjacent to Boyd Creek. This detection was never replicated and may have been an artifact of well construction.
- Groundwater monitoring wells that are installed within local bedrock (PZ-29 through PZ36) contain elevated naturally occurring concentrations of aluminum, iron and manganese. Iron and manganese are known to be regionally elevated. No other evidence of affected groundwater has been observed in the area South of Boyd Creek.

5.17.4 Potential for Fire or Explosion Hazards

Due to the absence of any visible solid residual product at the ground surface and the generally very low concentrations of detected flammable constituents, there does not appear to be any potential for fire or explosion in each of the Use Areas south of Boyd Creek. Therefore, the potential for fire or explosion in these Use Areas is ranked as low.

5.17.5 Potential for Human Exposure

The results of the comprehensive surface soil, sediment, and surface water sampling and subsequent risk assessment indicate that the Use Areas in the area south of Boyd Creek are acceptable for recreational use. The depth of buried demolition debris present in the 1970s Berm, the only waste area south of Boyd Creek, makes it unlikely that direct content under the current recreational use scenario would occur.

The locations with arsenic and lead concentrations above the recreational SSLs are within areas used as a transportation corridor for people using the property for recreational purposes. These sample locations included in the transportation corridor are shown in Figure B-1. A risk assessment was conducted in order to evaluate the transportation corridor as a whole. The risk assessment is presented in Appendix B.

The site-specific recreational user exposure scenario was evaluated in the risk assessment and the exposure factors are the same as those used to calculate recreational SSLs. The 95 percent Upper Confidence Limit (95% UCL) on the mean was used for the exposure point concentrations (EPC) in the evaluation.

The cancer risk for the Southern Transportation Corridor was 5.9E-06, which is below the cumulative incremental cancer risk benchmark of 1.0E-05. Theoretical arsenic exposure was responsible for 96% of the risk. The noncancer hazard index for the

Southern Area Transportation Corridor was 0.2 and arsenic (45%) and lead (47%) were responsible for the majority of the hazard index. This HI is well below the noncancer risk benchmark of 1.

Furthermore, groundwater beneath and downgradient of these Use Areas is not used for any purpose. Therefore, potential human exposure to the low concentrations of organic and inorganic compounds detected in monitoring wells is not expected. As a result, the potential for human exposure in this Use Area group is ranked as low.

5.17.6 Potential for Release to Groundwater and Surface Water

The potential for release to groundwater and surface water for the area South of Boyd Creek is assigned a low priority. Concentrations of compounds detected in groundwater monitoring wells that are located within and downgradient of the area South of Boyd Creek do not indicate the presence of any site-related organic compounds that are attributable to the seven Use Areas in this grouping. In surface water no organic compounds have been detected in samples collected at the two main drainages from these Use Areas.

5.17.7 Priority Ranking

The area South of Boyd Creek comprised of PAP, SAA, SAB, UAO, UAN and WAG Use Areas has been designated as an area for no further investigation because:

- Comprehensive characterization of soil, sediment, and groundwater indicates that the area is acceptable for recreational use.
- The results of the site-specific risk assessment indicate that the property is suitable for recreational land use.

5.18 Site-Wide Groundwater

Site-wide groundwater is defined as groundwater within the shallow, intermediate and deep flow zones discussed in Section 3.4. Characterization of groundwater at the former Barksdale Works has been accomplished by installation of 112 monitoring wells (Figures 5A and 5B) and sampling of 128 adjacent residential wells since 1998. In 2005, the pumps for most of the adjacent residential wells were removed and the wells sealed with bentonite.

5.18.1 Investigation Activities and Findings

A comprehensive groundwater investigation was completed in 2001, the findings of which were reported to the WDNR in 2002 (DuPont, 2002). The findings presented in the 2002 investigation report are as follows:

- Two plumes are indicated in groundwater, with detected COPCs crossing the site perimeter generally located in the eastern central and the northeastern quarter of the site.

- NNOCs were the most frequently detected compounds that exceeded the health-based enforcement standards in groundwater, followed by VOCs, and a few inorganic compounds.
- Inorganic compounds in groundwater beneath the former Barksdale Works are not indicative of former site activities. These elevated inorganic results are associated with regionally elevated concentrations.
- The deep flow zone appears to be a unaffected by site-related activities.

Since 2002, groundwater characterization efforts were primarily focused on characterization of groundwater on-site, although some off-site characterization and study was also conducted. A total of 21 new monitoring wells were installed since 2002. These wells were installed in an effort to:

- Identify whether releases to groundwater are occurring from potential source areas within the interior of the Barksdale Works,
- Determine the viability of the deep aquifer as an alternative domestic water supply at the time that this option was being considered, and
- Determine whether perchlorate is present in groundwater beneath the facility.

In addition to the installation and sampling of the new monitoring wells, periodic monitoring of selected interior and perimeter groundwater monitoring wells was also conducted. Furthermore, ongoing monitoring of the residential wells surrounding the site was performed. The results from the residential well sampling are not presented herein because a) these data have been previously reported to WDNR and b) all downgradient residential drinking water wells were abandoned as part of the municipal water supply project (see Section 2).

The 21 on-site groundwater monitoring wells installed between 2002 and 2005 are PZ-37 through PZ-54. Each of these following wells was installed for the following specific investigation purposes and are discussed in earlier sections, above:

- PZ-37r and PZ-16r were installed for evaluation of condition of the deep aquifer.
- PZ-38o, PZ-38d, and PZ-39d: PZ-38o and PZ-38d provide data upgradient of the former Burning Grounds (WAA), while PZ-39d was installed to characterize groundwater beneath the former Burning Grounds.
- PZ-40o through PZ-46o were installed to evaluate the following potential on-site source areas: Pz-40o (the Lydol Area bare spot), PZ-41o (the Upper Dynamite Area Skid bare area), PZ-42o (the TNT08 Waste Acid car spot), PZ-43o (the Reed Fields), PZ-44o (the Acid Recovery Plant Waste Acid Towers), PZ-45o (the Finishing Plant Wash Houses), and PZ-46o (the Refined Triton Drainage impoundment).
- PZ-47o through PZ-50o were installed to evaluate groundwater upgradient and beneath the Triton Refinery (Use Area PAD), and
- PZ-51o through PZ-54o were installed to evaluate groundwater upgradient and beneath the Nitric Acid Plant areas (Use Areas PAK, PAR, and PAS).

Analytical results from the 2002 site investigation report for on-site monitoring wells are presented in electronic format in Appendix G. Analytical data for groundwater samples from monitoring wells installed and/or sampled between 2002 and 2005 are presented in Tables Tables 6-S, 6-I and 6-D.

Results of the interior and perimeter groundwater monitoring well sampling conducted between 2002 and 2005 confirm the findings presented in the 2002 investigation report. The results of the sampling between 2002 and 2005 are summarized below:

- NNOCs continue to be the primary COPCs present in groundwater. VOCS and metals were detected less frequently and at generally lower concentrations than detected NNOCs. The shallow and intermediate flow zones are the only affected groundwater flow zones beneath the site. The deep flow zone remains unaffected by previous manufacturing activities at the Barksdale Works.
- Concentrations of detected COPCs in groundwater have remained generally constant between 2002 and 2005 and are consistent with earlier analytical results. The highest concentrations of site-related COPCs in the east central portion plume are generally found in the vicinity of the Former Burning Grounds (WAA) at wells PZ-39d and PZ-01d. Results from monitoring well PZ-38d indicate much lower concentrations of COPCs immediately upgradient of the former Burning Grounds than are observed downgradient of this Use Area in wells PZ-39d and PZ-01d. Elevated concentrations in the northeast plume are generally observed at PZ-34d, which is immediately downgradient of the manufacturing areas.
- The area-specific groundwater investigations (wells PZ-40 through PZ-54) have not identified a primary source area for the northeastern plume. Results from monitoring well PZ-38d indicate much lower concentrations of COPCs immediately upgradient of the former Burning Grounds than are observed downgradient of this Use Area in wells PZ-39d and PZ-01d.
- Perchlorate has been identified as a COPC in groundwater. Perchlorate was detected in 16 of the 18 shallow zone wells sampled, and 21 of the 28 intermediate zone wells sampled (Tables 6-S and 6-I). The highest concentrations detected in the shallow zone were detected immediately downgradient of the Nitric Acid production area (Use Area PAK), where a concentration of 1,200 µg/L was detected. The highest perchlorate concentrations detected in the intermediate zone were observed at PZ-39d (150µg/L) and PZ-01d (200µg/L), which are located downgradient of the former Burning Grounds (WAA). Additionally, perchlorate was detected in PZ-12d and PZ-12r (located east of Highway 13 in Use Area SAD) at concentrations of 0.028 µg/L and 250 µg/L, respectively.
- Groundwater beneath the area south of Boyd Creek is relatively unaffected by previous site activities. Low concentrations of DNT isomers (combined 2,4- and 2,6-DNT value of 0.08 µg/L) are observed in the interior of this area near the point where the former Reed Fields discharged to Boyd Creek at PZ-04. No organic compounds were detected in the monitoring well clusters located at the perimeter of the southern area (PZ-29, PZ-35, and PZ-36).

5.18.2 Potential for Fire or Explosion Hazards

There is no potential for fire or explosion within site-wide groundwater.

5.18.3 Potential for Human Exposure

There is no potable use of groundwater off-site. All residential drinking water wells downgradient of the facility have been plugged and abandoned to prevent future use. The only potable use of groundwater is on the Barksdale Works site where two groundwater wells provide drinking water at the DuPont site office and the Bretting Clubhouse. Water obtained from both of these wells is filtered with granular activated carbon (GAC) prior to use. Additionally, the effectiveness of these GAC filters are monitored for performance and changed at regular intervals. Therefore, the potential for human exposure to site-wide groundwater is assigned a low priority ranking.

5.18.4 Potential for Release to Groundwater and Surface Water

Releases to surface water from groundwater appear to be a potential from the shallow groundwater zone in the eastern reaches of the site in the vicinity of Boyd Creek, where surface water influences on groundwater have been historically observed. Additionally, this potential exists for the intermediate flow zone to serve as a source of release as it discharges to Chequamegon Bay.

According to the Agency for Toxic Substances and Disease Registry (ATSDR), photolysis has been documented to be one of the most important removal processes for DNT in water. ASTDR identifies the half-lives for 2,4- and 2,6-DNT in sunlit natural waters are between three to ten hours, whereas the photolysis half-life of these compounds in distilled water is approximately 43 hours. Furthermore, ASTDR reports that the expected bioaccumulation of DNT in animal tissues is negligible because of its low octanol-water partition coefficient. As a result, releases to surface water from groundwater are assigned a low priority ranking.

5.18.5 Priority Ranking

Site-wide groundwater is assigned a low priority for future investigation because:

- There is no potential for fire or explosion.
- Groundwater downgradient of the site is not used for any purposes.
- Site-related constituents that could be released from groundwater to surface water have very short half-lives and are not expected to bioaccumulate.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The purpose of this CCR was to provide DuPont and WDNR with the foundation to make risk-based investigation and remediation decisions at the Barksdale Works. Each of the Use Areas was grouped into one of four priority categories based on potential to affect human health and the environment. These are: (1) recommend immediate interim measures (IRM), (2) high priority for further investigation, (3) low priority for further investigation, and (4) no further investigations are required. This section presents a summary of the prioritized rankings for all Use Areas at the Barksdale Works and recommendations for future investigations.

6.1 Use Area Prioritization Summary

As previously discussed, unit rankings were segregated into four priority divisions (interim measures, high priority, low priority and no further investigation). In addition, a priority of no further action was assigned if no potential for exposure could be identified.

6.1.1 Interim Measure Use Areas

None of the Use Areas at the former Barksdale Works were determined to require new interim measures. The interim measure currently in place at the Former Burning Grounds (Use Area WAA) is described in Section 5. Monitoring of the effectiveness of this interim measure will be continued.

6.1.2 High Priority Use Areas

A high priority designation was assigned to those Use Areas at which further investigation or reducing the potential for exposure (by evaluating or implementing institutional controls) is warranted based on current conditions, or where additional information is needed to assign a priority ranking for an area. The following 33 Use Areas were assigned a high priority for further investigation:

- TNT 2,3,4, and 5 Lines and Surrounding Areas (Use Areas PAA, PAB, WAB, WAE, and WAH),
- Lydol and Trivelene Line (Use Area PAC),
- TNT 6 and Triton Refine Lines (Use Area PAD),
- Triton Finishing and West Tank Farm (Use Areas PAE, SAG, and SAH),
- Four of the Nitric Acid Production Areas (Use Areas PAF, PAK, PAR, and SAF),
- TNT 1-5, 7-10, and refined Triton Plant (Areas PAH, PAI, and PAJ),
- Use Area WAF in the Nitramon/Nitramex, Rail Receiving, and Nitramon Container Dump Areas,
- The Powder Line and Adjacent Support Areas (Use Areas PAM, PAO, PAP, SAI, SAJ, SAK, UAK, UAL, and WAD),

- TNT No. 1 Line (Area PAU),
- Property East of Highway 13 (Areas SAD, SAL, SAN, and UAQ), and
- Use Area UAP of the Western Support and Undeveloped Areas.

6.1.3 Low Priority Use Areas

The prioritized ranking process indicates that a ranking of low priority for further investigation is warranted for many of the Use Areas on the Barksdale Works. The following 21 Use Areas are designated as a low priority for future investigation:

- Nitric Acid Production Area PAS,
- Upper Dynamite, Ammonium Nitrate, and Plant Office (Areas PAL, PAQ, and SAE),
- Use Areas PAN and SAC in the Nitramon/Nitramex, Rail Receiving, and Nitramon Container Dump group,
- The Northern Grid Areas UAC, UAD, UAE, UAG, and UAR,
- Oil of Vitriol Plant (Area PAT),
- Use Areas UAH, UAI, UAM, UAS, and SAM of the Western Support and Undeveloped Areas,
- Former Burning Grounds and Associated Areas (Areas WAA, WAC, and WAI),
- Site-wide Groundwater

6.1.4 No Further Action Use Areas

The following areas were assigned a “no further action at this time” priority ranking based on the lack of significant releases and limited or no potential for human exposure:

- The former Test Grounds (Use Area PAG)
- The Triangle Buffer (Use Area UAA)
- Area South of Boyd Creek (Use Areas SAA, SAB, UAO, UAN and WAG)

6.2 Recommendations

Based on the Use Area Prioritization, the following recommendations for future investigation are made:

- The primary investigation focus in 2007 and 2008 should continue to be the Use Areas identified as high priority for further investigation. This focus should include characterization of historically undeveloped areas that may be accessed by unauthorized users (i.e., areas outside of the current fence), potentially used for recreational purposes by the landowner, or areas that are currently used for non-industrial purposes.

- Periodically characterize the surface water and sediment at the drainages located along the boundary of the property east of Highway 13 and continue to verify that unacceptable off-site releases of site-related constituents are not occurring. In addition, continue to monitor and maintain the effectiveness of the interim measure (i.e., stream diversion) undertaken at the former Burning Grounds.
- Work with WDNR to develop a framework to classify as administratively complete the six Use Areas comprising the southern portion of the site (i.e., area south of Boyd Creek).
- Continue to implement site administrative controls in order to reduce the potential for human exposure to site-related compounds.

7.0 REFERENCES

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TABLES

FIGURES

APPENDICES