Final Preliminary Assessment/Site Inspection Report

Additional and Uncharacterized Sites Operable Unit
Crab Orchard National Wildlife Refuge NPL Site
Marion, Illinois (Williamson County)

June 2003

This Final PA/SI Report is identical to the "Draft-Final" Report issued in September 2001.

VOLUME I

Executive Summary
and
Sections 1 and 2

EXECUTIVE SUMMARY

DESCRIPTION AND PURPOSE

The Additional and Uncharacterized Sites Operable Unit (AUS OU) was created by the U.S. Fish and Wildlife Service (USFWS) as the final operable unit of the Crab Orchard National Wildlife Refuge (Refuge) National Priority List (NPL) Site designated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA). It was intended to include all Refuge sites that may pose a potential threat to human health or the environment due to releases of hazardous substances, and that are not included in one of the six other operable units at the Refuge. With that objective, USFWS personnel at the Refuge developed a list of 83 AUS sites. The list was compiled from various sources during 1997 to 1999. These 83 sites are listed in Table ES-1.

The purpose of this Preliminary Assessment and Site Inspection (PA/SI) was to identify which of the original AUS OU sites should be recommended for no further action, for a remedial investigation (RI), or for a removal action if imminent threats are identified.

The PA phase included a review of historical information, and visits to each of the sites. The purpose was to identify which sites, if any, warranted further investigation in the SI phase.

The SI phase involved sampling locations identified in the PA phase as having potential for contamination. Chemical results were compared with screening levels established for the SI, to identify sites to recommend for an RI. The SI also included some physical site characterization.

The PA program and results are summarized below, followed by a similar discussion for the SI.

PA (HISTORIC SEARCH)

The original purpose of the historic search was to evaluate each of the original 83 sites to judge which of these sites may have had hazardous substance releases that could pose a threat to human health or the environment and, conversely, those which did not. The evaluations would be based on site visits, review of historical aerial photographs and Refuge records, CERCLA Section 104(e) responses and documents, and interviews with former employees of industrial tenants at the Refuge. Based on the results, the sites judged as non-threats would be eliminated from further study and the sites judged as potential threats would be retained for a SI field investigation.

Re-evaluation of Original Site List

As the site visits and review of existing information progressed, a different environmental setting began to emerge than that suggested by the 83 individual sites. The review gradually revealed a setting of major industrial activity on the Refuge, beginning with the 22,000-acre, 536-building Illinois Ordnance Plant (IOP), where ordnance was manufactured at seven separate load lines during World War II by Sherwin Williams Defense Corporation, under contract with the War Department. IOP employment during World War II peaked at over 5,000. On VJ Day, thousands of people left their jobs and went home, leaving behind an industrial facility and hundreds of thousands of ordnance products no longer needed by the military. During the next

several decades, many of the old IOP areas were occupied by tenants engaged in a widely varied list of potentially polluting industrial activities in a rural setting with little infrastructure, and in an age of few environmental restrictions. During the peak industrial years of the 1950s, 60s and 70s, industrial employment was in the thousands. Some buildings and complexes were occupied by a succession of different tenants, sometimes engaging in very different activities. However, ordnance and explosives manufacturing were the principal activities over time, with one predominant tenant conducting these activities in a number of industrial areas on the Refuge.

As the historic search progressed, it became obvious that the program needed modification. Many of the 83 AUS sites were found to be parts of larger industrial facilities, and could be evaluated coherently only in the context of the industrial operations that occurred at that facility as a whole. In other words, rather than 83 isolated sites, we found several former industrial facilities and disposal areas and a few isolated sites. In addition, a number of sites on the original list were identified as requiring no further action when the research showed no substantive evidence of a potential threat.

Evaluation Criteria

All 83 sites were evaluated initially and recommendations for changes were developed based on that research. Several indicators were used to determine whether a site would be recommended for further evaluation or eliminated. This was some of the information used to include a site for further evaluation:

- Existing analytical results above screening levels.
- Evidence of industrial activity at locations not adequately investigated previously (from existing documents, aerial photographs, and interviews and depositions).
- Evidence of potential contamination or hazardous substance release (from existing documents, aerial photographs, and interviews and depositions).
- Observations of potential contamination during site visits.
- On-site evidence of industrial waste disposal activities.

PA Recommendations

Table ES-1 shows the recommendations for each of the original 83 AUS OU sites and a summary of the basis for the recommendations. One of four recommendations was possible for each site:

1. No further action,
2. Perform an immediate removal action,
3. Perform a SI on the original site, or
4. Perform a SI after grouping the original site into an Area.

The recommended grouping for the AUS OU is by industrial area (Areas 1-14), or industrial activity within an area. Areas are briefly described on Table ES-2 and shown on Figure 1-2.

Twenty-four of the original AUS sites warrant no further action. No sites were found to warrant immediate removal actions. The remaining 59 of the original 83 sites were recommended for the

SI either as individual sites or as part of larger industrial areas. This redefinition resulted in 39 sites that moved forward into the SI.

SITE INSPECTION

Sites Investigated

The results of the PA were used to develop a field sampling plan for the SI. Table ES-2 is the revised list of 39 sites that were included in the SI. Most of the current AUS OU sites include one or more of the sites in the original AUS OU list. Two of these sites, however, are new. These are Area 7 (AUS-0A07), which was used by industrial tenants for storage and manufacturing; and AUS-106A, a drum disposal site.

The SI site list also includes the following six sites which were added after the field work began, based on additional review of aerial photographs:

- AUS-0A2R (railroad spur used by industrial tenants)
- AUS-0019 (railroad spur with historic stained soil area)
- AUS-0022 (probable IOP small arms training range)
- AUS-0064 (mounds/brick pits in area used for explosive detonation)
- AUS-0107 (possible former disposal site)
- AUS-0108 (possible former disposal area)
- AUS-0109 (possible former detonation area)

Screening Results

Analytical results were compared to human health screening values to identify chemicals of potential concern (COPCs) for human health; and compared to ecological screening values to identify chemicals of potential ecological concern (COPECs). For the human health evaluation, for each media sampled, each analyte analyzed was classified as either a COPC, not a COPC, or an uncertainty. For the ecological evaluation, for each media sampled, each analyte analyzed was classified as either a COPEC, not a COPEC, or an uncertainty. These screening results are tabulated for each site, and presented at the end of each site-specific section in this report, except for Site AUS-0063, discussed below.

SCIENTIFIC MANAGEMENT DECISION POINT

Recommendations for future action (or no action) are provided in this report, at the end of each site-specific section. No sites were found to have threats so imminent as to warrant immediate removal actions. Six sites are recommended for no further action. Site AUS-0063 was eliminated from further investigation because it had previously been determined to be a no-action site, as part of another operable unit.[1] The report recommends that Site AUS-0021, the

[1] This site, which is in the Crab Orchard Cemetery (COC) area, had been investigated previously as part of the Explosives/Munitions Operable Unit (EMMA OU), as Site COC-9. As part of the EMMA OU, Site COC-9 was determined to require no further action. See U.S. Environmental Protection Agency, Region V, 1997, Record of Decision for Crab Orchard National Wildlife Refuge Explosives/Munitions Operable Unit. The U.S. Army is the lead agency for the EMMA OU.

IOP Area 7 Fire Station, be incorporated into Site AUS-0A07. The remaining 31 sites are recommended for Remedial Investigations (RIs). This recommendation for RI is not intended to rule out the option of removal actions as responses for at least some of these sites. No-further action and RI recommendations are summarized below.

In addition to the sites recommended for RIs, Area 3 was identified as a site that warrants investigation because of past usage as part of the IOP and by later industrial tenants. Area 3 was not included in the PA/SI. This report recommends that a historic record search and preliminary investigation of this site be included in a Phase I RI for the AUS OU.

Sites Recommended for No Further Action

Six sites were judged to have sufficiently low risk such that no further investigation or action under CERCLA is warranted. The justification for each is detailed in this report. The sites recommended for no further action under CERCLA are as follows:

- AUS-0019—Former railroad spur north of Area 4 East
- AUS-0022—Probable IOP small arms training range
- AUS-0064—Former EMMA OU COC-13 area
- AUS-0107—Possible disposal area northwest of Area 8
- AUS-0108—Possible surface disposal area near COC-10
- AUS-0109—Possible Former UXO detonation area

Sites Recommended for Remedial Investigation (RI)

The remaining 31 AUS OU sites are recommended for an RI. These sites, shown in Figure ES-1, vary widely in geographic size and complexity of contaminant issues.

The two major site groups in the AUS OU, in terms of size and complexity, are the Area 2 sites and the Area 11/12 sites. The Area 2 sites (2B, 2D, 2F, and 2P) include about 550 acres of currently active, fenced industrial facilities that have been in operation, with brief breaks, since 1942. The six sites in Areas 11/12 (11A, 11H, 11N, 11P, 11S, and 12) include about 300 acres of former industrial facilities; the tenant leases covered over 600 acres, which included buffer zones. The Area 11/12 sites were used during World War II, and then by industrial tenants from 1956 to 1982. Decontamination for explosives only was done by industrial tenants in the 1970s and early 1980s, and the remaining buildings were razed by USFWS in the 1980s. All these sites have revealed significant contamination in almost all media sampled.

Intermediate in terms of size and complexity are other sites in numbered industrial areas which were part of the IOP facility and were used later by post-World War II industrial tenants. Parts of these areas which had high levels of industrial activity have already been remediated or are planned for remediation as parts of other operable units on the Refuge. Thus, parts of Area 4 East and Area 4 West were remediated as part of the Metals Areas OU; a large portion of Area 9 is part of the PCB OU remediation; and the northern portion of Area 8 is planned for remediation as part of the Miscellaneous Areas OU. The remedies for these OUs have addressed much of the

contamination in these areas. The remaining portions of Areas 4, 8, and 9 (those not included in other operable units) generally did not have as high a level of industrial activity as the sites in Areas 2 and 11/12. The other industrial areas discussed below (6, 7, 10, and 13), which were not included in other OU remedies, also have not had as great a level of industrial activity.

At the other end of the spectrum are small sites, with little industrial history, and contamination that appears to be at lower levels and limited in extent. Examples of these sites are AUS-0065, AUS-0066, AUS-0067, AUS-0018, and AUS-0043.

Each of these 31 sites is summarized below. Each summary briefly describes the site, the operational history and waste characteristics, major operators/lessees, and major contaminants found in the SI. The full lists of contaminants of concern recommended for investigation in the RI are included at the end of each section of the report. References for the summarized information can be found in the applicable sections of the report. The summarized information is tabulated on Table ES-3.

The various sections of this report discuss the 31 sites in numerical order by industrial area, followed by the small sites not in any industrial area. The summaries in this section, however, are grouped as follows:

- Area 2 sites. (2B, 2D, 2F, and 2P). Site AUS-0A2R is included because of proximity.
- Area 11/12 sites. (11A, 11H, 11N, 11P, 11S, and 12).
- Other sites in industrial areas. (4 East and West, 6, 7, 8 South, 9, 10, and 13).
- Sites in the COC Area. (AUS-0062, -0065, -0066, -0067, and -0069).
- Other small sites not in industrial areas. (AUS-0001, -0002, -0018, -0043, -0060, -0061, and –106A).

Area 2 Sites

Area 2 is located on the east side of Wolf Creek Road, north of Crab Orchard Lake. During the IOP era, this area was used for loading boosters, detonators, fuses, and primers for the ordnance produced at the IOP. Boosters, detonators, fuses and primers are parts of the explosive train in a device such as a bomb or mine. The material that makes up the actual bursting charge in a bomb or mine, which was primarily TNT at the IOP, is relatively insensitive and is set off by a series of decreasingly sensitive, but increasingly powerful charges. The sequence in the explosive train is fuse/primer/detonator/booster. These IOP uses are the basis for the sub-area designations still in use today (Areas 2B, 2D, 2F, and 2P).

Area 2 has been leased by industrial tenants continuously since 1952 and is a current industrial facility. Only two major tenants have occupied this area: Universal Match Corporation (UMC)

(later Crane/Unidynamics-Phoenix, now Crane Co.), and Olin/Primex/GDO&TS,[2] both manufacturers of munitions, propellants, and related products. Olin/Primex/GDO&TS has been the sole tenant in Area 2 since 1970.

Area 2 is currently fenced, and access is controlled by the tenant. Areas 2B, 2F, and 2D are connected by roadways and are serviced by a single main security entrance on Post Oak Road, at the north end of Area 2. Access to Area 2P is through a security entrance on Stringtown Road, at the south end of Area 2.

AUS-0A2B (Area 2B)

Site Description

Area 2B, the former IOP Booster Load Line, is on the west side of Area 2. The IOP Booster Load Line consisted of 17 buildings. All the building numbers were prefixed with "B-2." Later industrial tenants added and removed buildings. This fenced site covers about 125 acres.

Operational History and Waste Characteristics

Boosters produced at the IOP used tetryl (2,4,6-tetranitro-N-methyl aniline) for the explosive charge and they may also have contained some mercury fulminate. Tetryl was delivered from off site; processing on the booster load line included screening, blending, pressing, and loading.

Post-World War II industrial tenants used Area 2B for ordnance and pyrotechnic manufacturing. UMC began operating in Area 2B sometime after 1952. UMC used Area 2B for tetryl-pelleting operations, manufacturing gas generators and delayed fuses, and for loading large explosive devices. UMC also used this area for manufacturing and testing pyrotechnic devices including explosive switches, igniters, detonators, flares, and atomic bomb burst simulators. UMC left the Refuge in 1963.

After UMC left, several former UMC employees formed Central Technologies, Inc. (CTI), which manufactured and tested pyrotechnic devices in Areas 2B for a short period. Little is known of their operation

Olin/Primex/GDO&TS began leasing in Area 2B in 1963 and have been the only documented lessee in Area 2B since 1970. GDO&TS is the current tenant. Olin/Primex/GDO&TS has used Area 2B for manufacturing ammonium nitrate propellants, ammonium oxalate inhibitors, insulator mixes, and magnesium-teflon flares; for machining; testing gas generators; storing hazardous waste; and for quality assurance laboratory analysis. One building contained a trichlorethane vapor degreaser.

[2] Olin Corporation (formerly Olin Mathieson Chemical Corp.) spun off its ordnance manufacturing division to Primex Technologies, Inc. (Primex) at the end of 1996. In January 2001, General Dynamics Corporation acquired Primex. Primex became a wholly owned subsidiary of General Dynamics and changed its name to General Dynamics Ordnance and Tactical Systems, Inc. (hereafter referred to as GDO&TS). Primex took over the Olin leases at the end of 1996. GDO&TS assumed the leases in January 2001.

Statements by former employees of both UMC and Olin indicate that dumping of organic chemicals (solvents) onto the grounds around process buildings was common. It is likely that this type of activity was also prevalent during the IOP period. Solvents reportedly used and/or dumped by industrial tenants include methylene chloride, methyl ethyl ketone, acetone, trichloroethylene (TCE), and hexane. Documented Olin wastes include the following, among others: beryllium dust; salts of barium, cadmium, chromium, lead, mercury, selenium, and silver; trichloroethane; di-n-octyl phthalate; dimethyl phthalate; toluene di-isocyanate, spent halogenated solvents; and 2-nitrodiphenylamine.

During regular cleaning activities in some process buildings not containing sumps, water was used to hose down the building interiors. The wash water was then allowed to drain out the door onto the surrounding grounds and ditches.

Olin was known to have used the following chemicals at the Refuge, among others: boron, barium nitrate, chromic acid, mercury, copper sulfate, zinc oxide, chloroform, and several phthalates.

Both UMC and CTI reportedly maintained burn pads in Area 2B. Early industrial tenants at the Refuge used burning as a principal means of disposing of explosive and other industrial wastes.

Site Investigation

The SI included sampling of soil, groundwater, surface water and drums.

Notable Contamination Found

TCE was detected in the groundwater at a maximum concentration of 47 micrograms per liter (ug/L). The federal maximum contaminant level (MCL), one of the SI screening criterion, is 5 ug/L for TCE. Cis-1,2-dichloroethene a degradation product of TCE, was detected above the respective SI screening criteria for groundwater. TCE concentrations exceeded screening criteria in the soil. PCE also exceeded screening criteria in groundwater and soil.

Detections of 18 semivolatile organic compounds (SVOCs) in soils exceeded SI screening criteria. These included dibenzofuran and 12 polyaromatic hydrocarbons (PAHs), which are products of incomplete combustion; they are all common industrial contaminants. Other SVOCs detected above SI screening criteria included three phthalates, which are common plasticizers; methylnaphthalene, a component of diesel fuel; and carbazole. Carbazole has been found to be common at other propellant manufacturing sites. It is a possible breakdown product of the nitrodiphenylamines used as stabilizers in propellant.

Most inorganic constituents exceeded SI soil screening criteria, including, among others, barium, beryllium, boron, cadmium, copper, cyanide, lead, mercury, selenium, silver, and zinc. Maximum detections included antimony at 56 mg/kg *(background = 0.8 mg/kg)*, chromium at 104 *(background = 25 mg/kg)*, copper at 1,560 mg/kg *(background = 11 mg/kg)*, and lead at 2,000 mg/kg *(background = 23 mg/kg)*. Illinois surface water standards were exceeded for some metals.

AUS-0A2D (Area 2D)

Site Description

Area 2D, the IOP Detonator Loading Line, is located on the north side of Area 2. The original building complex consisted of 41 buildings. All the building numbers were prefixed with "D-1." Industrial tenants have removed some buildings and added many more. Building numbers now extend into the 90s. This fenced site covers about 150 acres.

Operational History and Waste Characteristics

Detonators produced at the IOP used lead azide, tetryl, and probably mercury fulminate as the explosive charge. Other materials used in production were antimony sulfide and potassium chlorate. Explosives were not manufactured at the IOP; they were shipped in and processed on the load lines.

Since World War II, ordnance and pyrotechnic manufacturers have used Area 2D for production. UMC leased Area 2D from 1953 to 1963. UMC reportedly began with research and development of primary and secondary explosives, pyrotechnic devices, and propellants in Area 2D. Originally UMC's production work at the Refuge consisted mainly of pyrotechnic devices, initiators (fuse trains), large explosive devices, smoke markers, and photoflash shells. UMC's pyrotechnic devices included explosive switches; igniters, detonators, flares and atomic bomb burst simulators. UMC reportedly used lead styphnate and lead azide in their operations.

Olin/Primex/GDO&TS have operated in Area 2D from 1964 to the present. Olin began the bulk of their solid propellant operations (SPO) in Area 2D in 1964. This included gas generators, jet starters (starter cartridges), tank pressurizers, missile guidance control products, and aircraft emergency evacuation slide inflation devices. Solid propellants are manufactured by mixing the propellant components together in a mixer either dry or with a solvent. Powdered lead stearate was reportedly used in the manufacture of gas generators in Area 2D, as was TCE.

Other Olin/Primex/GDO&TS Area 2D products include the Light Antitank Weapon (LAW) rocket, 20mm fuses, boosters, and ammunition ignition mixes. Olin/Primex also used several building in Area 2D for storage of explosive/hazardous waste and used some buildings as explosive scrap pick-up points.

Refer to the discussion under AUS-0A2B above for a description of the dumping of organic chemicals, industrial tenant cleaning activities, chemicals used, waste products, and waste burning.

Both UMC and Olin reportedly maintained burn pads in Area 2D.

Site Investigation

The SI included soil, groundwater, and surface water samples.

Notable Contamination Found

TCE was detected in the groundwater at a maximum concentration of 54,000 ug/L *(MCL = 5 ug/L)*. Detections of cis-1,2-dichloroethene and vinyl chloride, degradation products of TCE, also exceeded SI screening criteria for groundwater, as did several other chlorinated volatile organic compounds (VOCs), including 1,1,2-trichloroethane. RDX (Royal Demolition Explosive), was detected in soils at concentrations exceeding SI screening criteria. Detections of several VOCs in soil exceeded SI screening criteria.

Most of the SVOCs that exceeded SI soil screening at AUS-0A2B also exceeded the screening criteria at AUS-0A2D, including the PAHs, the phthalates, methylnaphthalene, dibenzofuran, and carbazole. At AUS-0A2D, concentrations of carbazole and most PAHs were well above screening criteria.

Detections of most inorganics in soils exceeded SI screening criteria, including the same chemicals listed under AUS-0A2B, except that cyanide and selenium did not exceed the criteria at AUS-0A2D. Maximum detections include arsenic at 120 mg/kg *(background = 13 mg/kg)*, chromium at 97 mg/*kg (background = 25)*, copper at 937 *(background = 11 kg)*, silver at 40 mg/kg *(background = 0.6 mg/kg)*, and zinc at 1,060 mg/kg *(background = 51 mg/kg)*.

AUS-0A2F (Area 2F)

Site Description

Area 2F, the IOP Fuse Loading Line, is located east of Area 2B and south of Area 2D. The original Area 2F building complex consisted of 14 buildings, all prefixed with "F-2." Industrial tenants have removed some buildings and added others. This fenced site covers about 125 acres.

Operational History and Waste Characteristics

The IOP Fuse Loading Line was used for manufacturing delays and fuses which included the preparation and loading of black powder, lead azide, antimony sulfide, potassium chlorate, and tetryl.

UMC leased Area 2F from 1959 to 1961. There is little information about UMC's activities in Area 2F.

Olin/Primex/GDO&TS have operated in Area 2F from 1970 to the present. Olin/Primex/GDO&TS manufactured artillery projectiles in Area 2F. Olin also had a metal fabrication operation in Area 2F that used cutting oils and degreasers, including TCE and/or methylene chloride. This area has also been used as a storage facility for components and finished products, as well as for fuels and oxidizers such as magnesium, boron, perchlorates, nitrates, and peroxides. The area has also reportedly been used for manufacturing propellant systems and gas generators.

Refer to the discussion under AUS-0A2B above for a description of the dumping of organic chemicals, industrial tenant cleaning activities, chemicals used, waste products, and waste burning.

A large area that has been used as a dumping ground was observed during the site reconnaissance, at the north end of Area 2F. The materials dumped in the area include soil, trees, construction debris and three boilers.

Site Investigation

The SI included soil, groundwater, and surface water samples.

Notable Contamination Found

TCE was detected in the groundwater at a maximum concentration of 2,400 ug/L *(MCL = 5 ug/L).* Detections of cis-1,2-dichloroethene and tetrachloroethylene (PCE) also exceeded SI screening criteria for groundwater. Detections of TCE and cis-1,2-dichloroethene in soil exceeded SI screening criteria.

Among the SVOCs, 9 PAHs exceeded soil screening criteria.

Maximum detections of most inorganic constituents in soils exceeded SI screening criteria, including antimony, boron, cadmium, copper, mercury, silver, and zinc.

AUS-0A2P (Area 2P)

Site Description

Area 2P, the IOP Artillery Primer Loading Line, is on the south side of Area 2, and originally consisted of 14 buildings, all designated with "P-1." Since the end of World War II, some buildings have been removed and others added by industrial tenants. This fenced site covers about 150 acres.

Operational History and Waste Characteristics

Primers that were loaded at the IOP Primer Loading Line were constructed of inert materials such as brass, onion skin paper, percussion cup and beeswax. They also contained ignitable components such as percussion compounds and black powder, which is made up of potassium nitrate, sulfur, and charcoal.

The only known industrial tenant in Area 2P is Olin/Primex/GDO&TS, which has leased the area from 1957 to the present. Olin's use of Area 2P began with research and development (R&D) of solid propellants, and some production of solid propellants. A small part of Olin's work in the P area was developing ball powder propellant that included materials such as nitroglycerin, dioctyl phthalate, and other plasticizers. Initially, a larger part of Olin's work in Area 2P involved gas generators that included the use of ammonium nitrate with a plastic/rubber base.

Olin's solid propellant R&D activities involved the small scale mixing of solid propellants and their subsequent testing. During the 1970s, Olin began R&D for their ammunition product lines in Area 2P.

Chemicals used in Area 2P include degreasers and solvents used in solid propellant production. Olin used some of the buildings in this area for storage of solvents, plasticizers, propellants, ammunition, incendiary mixes, and for PCB transformers. Olin also used some of the buildings for ballistic testing, black powder screening and pelleting, gas generator testing, and for machine shop activities such as welding, lathing, and degreasing.

Olin also generated the following explosive scrap which was stored at pick up points in Area 2P: J-66 type ammonium perchlorate, ammonium nitrate rubber, perchlorate propellant with iron oxide, composite double base propellant containing aluminum and ammonium perchlorate, and ethyl acetate with scrap propellant. Primex used some of the buildings as 90-day hazardous waste accumulation areas.

Site Investigation

The SI included soil, groundwater, and surface water samples.

Notable Contamination Found

TCE was detected in the groundwater at a maximum concentration of 120,000 ug/L *(MCL = 5 ug/L)*. Other VOCs in groundwater detected above SI screening criteria include trichloroethane, dichloroethane, dichloroethene, chloroform (an industrial solvent), tetrachloroethylene (PCE, used for vapor degreasing of metals), vinyl chloride, perchlorate (a propellant component), nitrate-nitrite and phosphorous. Detections of PCE and TCE in soil exceeded SI screening criteria.

The SVOCs that exceeded soil screening criteria were the same as those in AUS-0A2B, except that two additional PAHs exceeded SI screening criteria, and only two of the three phthalates exceeded the criteria.

Detections of most inorganic constituents in soils exceeded SI screening criteria, including antimony, boron, cadmium, chromium, copper, mercury, selenium, silver, and zinc.

AUS-0A2R (Area 2R)

Site Description

Area 2R is a railroad spur that was constructed as part of the IOP and has been used by later industrial tenants. The site, which covers about 30 acres, is located just northeast of the rest of Area 2 and was considered a part of Area 2 for the purposes of this report.

The site currently consists of two storage areas, a railroad spur and a loading dock. There were originally two rail spurs and one main line.

Operational History and Waste Characteristics

The USFWS operated the railroads on the Refuge from 1947 to 1976. It is assumed that any of the tenants in Area 2 may have used the rail lines and loading docks in Area 2R. The area is now used by GDO&TS, the current Area 2 tenant.

Open storage of materials, a excavation with probable liquid, and a probable horizontal tank were observed on the 1943 aerial photograph. A possible disposal area was noted on the 1980 aerial photograph.

Site Investigation

The SI included soil and trench water samples; no groundwater monitoring wells were installed.

Notable Contamination Found

Detections of methylnaphthalene and 13 PAHs, common contaminants at railyards, exceeded SI soil screening criteria. Several inorganic constituents in soil exceeded SI screening criteria, including antimony, barium, boron, cadmium, copper, lead, mercury, and zinc.

Areas 11/12 Sites

Areas 11 and 12, located south of Crab Orchard Lake, are addressed together because they were part of a single, large post-World War II industrial facility. At the north end of this now contiguous area is the site of the IOP Group II Load Line, which is in Area 11. At the south end is the site of the IOP Ammonium Nitrate Plant, which is in Area 12. The current Areas 11/12 include these two IOP features plus about 100 to 200 acres of Refuge land between them that was developed by post-Word War II industrial tenants.

The enlarged industrial complex, including buffer zones, was over 600 acres in size. Access was limited to tenant employees. Because of its size and the variety of past industrial activities, Area 11 was subdivided into five sites for the purposes of this report. The boundaries of these five sites are based on industrial use by Olin and Commercial Solvents Corporation (CSC), the major tenants, as follows:

- Area 11A—acid and ammonium nitrate manufacturing (Site AUS-A11A).
- Area 11H—high explosives manufacturing (Site AUS-A11H).
- Area 11N—nitroglycerin manufacturing (Site AUS-A11N).
- Area 11P—propellant manufacturing (Olin), explosive cap manufacturing (CSC) (Site AUS-A11P).
- Area 11S—support area for explosives manufacturing (Site AUS-A11S).

Beginning in 1956, Areas 11 and 12 were leased by Olin and used primarily for manufacturing industrial (non-military) explosives. Olin built an acid and ammonium nitrate plant using some of the IOP Load Line II structures. Olin also constructed and operated a nitroglycerin plant,

dynamite mix houses, a burn area, and ponds for storage of millions of pounds of explosives. These features were built in previously undeveloped parts of the Refuge between the original Group II Load Line and the Ammonium Nitrate Plant.

Olin sold its industrial explosives business to CSC in 1963 and CSC moved into Areas 11/12 in 1964. CSC and its successors leased this area from 1964 through 1982. Part of the sale to CSC included an RDX manufacturing operation and an explosive cap manufacturing operation, both of which were located at Olin facilities off the Refuge and moved by CSC to Areas 11/12. Olin also operated a pilot propellant plant in Area 11 which was not included in the sale. The propellant operation had been moved to Area 2 prior to the sale.

Trojan Powder Company, a CSC division, operated the Area 11/12 facility. Manufacturing was phased out beginning in 1968, and ended completely sometime before 1976. Trojan did some explosive decontamination in 1971 and 1972, but was still storing explosives at the site in 1977, when its successor, IMC Chemical Group (IMC), petitioned the Illinois Pollution Control Board for a variance from the regulations that prohibited open burning because such burning was necessary for further decontamination of the buildings in Areas 11 and 12. Three variances were granted during 1977 and 1978, for building decontamination and destruction of unusable explosives. After IMC removed the remaining usable explosives and completed the explosive decontamination, they left the site in 1982. Mallinckrodt, Inc, is the corporate successor to CSC/IMC. The purpose of the CSC/IMC decontamination was to eliminate explosive hazards at the site. The work did not address chemical contamination. The remaining buildings in the area were demolished by the USFWS in the late 1980s and early 1990s.

AUS-A11A (Area 11 Acid and Ammonium Nitrate Area)

Operational History and Waste Characteristics

AUS-A11A

Area 11A is the acid and ammonium nitrate manufacturing area and is located in the north-central portion of Area 11 between Areas 11P and 11S. This area was part of the IOP Group II Load Line and was used mostly for TNT and ammonium nitrate storage and screening.

Both Olin and CSC used this area as an acid and ammonium nitrate production facility. In 1957, Olin began production of acid and ammonium nitrate in this area. Nitric and possibly sulfuric acid were produced. Both acids were stored in this area. CSC used the buildings and other facilities as Olin did, with minor changes. CSC/IMC ended production in Area 11A in 1969.

Site Investigation

The SI included soil, sediment, groundwater, and surface water samples.

Notable Contamination Found

Phosphorus and nitrate-nitrite in groundwater exceeded SI screening criteria. N-nitrosodiphenylamine and 2,4-dinitrotoluene detections in sediments exceeded SI screening

criteria. Dinitrotoluene is used as a gelatinizing and waterproofing agent in explosives, and as an additive in propellant and smokeless powder. 2,4-dinitrotoluene is also used in the production of toluene di-isocyanate.

Detections of most inorganics, many PAHs, three phthalates, and carbazole exceeded screening criteria in soil and/or sediments.

Detections of some metals exceeded Illinois surface water quality standards.

AUS-A11H (Area 11 High Explosives Area)

Site Description

Site AUS-A11H, the High Explosives Area, is located in the western portion of Area 11 just south of Area 11P. It was used by industrial tenants for manufacturing high explosives from the 1950s to the 1970s. During World War II, the northern section of Site AUS-A11H was part of the IOP Group II Load Line.

Operational History and Waste Characteristics

Area 11H was used by the SWDC/War Department during IOP operations as a part of the Melt Loading Line and contained two change houses and a melt loading building.

Olin constructed the High Explosives Manufacturing Area, or Dynamite Area, on the property between the IOP Group II Load Line and the IOP Ammonium Nitrate Plant. Note that the term "dynamite" as used here is a generic term for industrial blasting explosives. It appears that Olin produced nitroglycerin dynamite in this area, as well as ammonium nitrate fuel oil explosives (ANFO), and water gel and slurry explosives which are the common explosives used in the mining industry.

The major constituents of nitroglycerin dynamite are nitroglycerin and dope, which is a general term for the porous combustible material that is combined with nitroglycerin to form dynamite. Some other raw materials used in production were ammonium nitrate, nitrocellulose, nitrocotton, ethyl centralite, and dimethyl sebacate (also known as dimethyl ester).

Water gels and slurry explosives consist of ammonium nitrate with or without other oxidizing agents, sensitizers, fuels, and gelatin forming compounds. Materials that are commonly used as additives in these explosives, and that Olin was known to have used in Area 11H, include TNT and smokeless powder. Other common additives that might have been used are pentolite, methylamine nitrate, potassium dichromate and PETN.

CSC and its successors operated the High Explosives Area from 1964 until they phased out production between 1968 and 1971. CSC most often used the same buildings as Olin; however, CSC used Building 22 for their Torpex operation. Torpex is composed of RDX, TNT, aluminum powder and wax.

Site Investigation

The SI included soil, sediment, groundwater, surface water, and trench water samples.

Notable Contamination Found

The following explosive compounds exceeded SI screening criteria in sediment: nitroglycerin, HMX (Her Majesty's Explosive), RDX, TNT, nitrobenzene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, 1,3,5-trinitrobenzene, and 1,3-dinitrobenzene. These compounds were detected at levels of concern for toxicity and/or cancer effects, but not at levels of concern for explosive effects.

TCE, PCE, and cis-1,2-dichloroethene exceeded SI screening criteria in soils.

Nitrate-nitrite and phosphorus detection in groundwater exceeded SI screening criteria.

Detections of most PAHs in soil and/or sediment exceeded screening criteria, plus two phthalates, carbazole, and n-nitrosodiphenylamine. Maximum detections of most inorganics in soil and/or sediment exceeded screening criteria, including soil concentrations of cadmium at 204 mg/kg, and chromium at 585 mg/kg.

AUS-A11N (Area 11 Nitroglycerin Area)

Site Description

Area 11N, the Nitroglycerin Area, is located in the eastern portion of Area 11, south of Area 11S and east of Area 11H. Post-World War II industrial tenants used this area for manufacturing nitroglycerin, from the 1950s to the 1970s. During World War II, a small portion of the northern section of Site AUS-A11N was within the IOP Group II Load Line and was used as a parking area, with no buildings.

Operational History and Waste Characteristics

The part of the former IOP Group II Load Line that is within Area 11N was used for loading shells with melted TNT, which sometimes had added ammonium nitrate.

Olin began manufacturing nitroglycerin in late 1957, at the same time it began acid and ammonium nitrate production in Area 11A. Olin produced nitroglycerin by the Biazzi process, which used concentrated nitric and sulfuric acid, pure glycerin or ethylene glycol, and soda ash. The wastewater from the nitroglycerin manufacturing was probably discharged to the East Holding Pond just north of the Nitroglycerin Area. This wastewater probably contained soluble materials like ammonium nitrate, sodium nitrate, acid, and traces of nitroglycerin.

After they acquired it from Olin, CSC probably continued to operate the nitroglycerin manufacturing facility the same way as Olin had.

There were eight possible burning trenches located in AUS-A11N that were identified in historical aerial photographs. The AUS OU site reconnaissance identified two buried railroad tank cars in Area 11N. Buried railroad tank cars are known to have been used at other industrial facilities for liquid waste or fuel storage.

Site Investigation

The SI included soil and surface water samples; no groundwater monitoring wells were installed.

Notable Contamination Found

Several SVOC and inorganic detections in soil exceeded SI screening criteria. Illinois surface water quality standards were exceeded for some metals. Lead was detected in the soil at 568 mg/kg.

AUS-A11P (Area 11 Pilot Propellant Plant/CAP Production Area)

Site Description

Site AUS-A11P, the former Area 11 Pilot Propellant Plant/CAP Production Area, is located in the northwestern portion of Area 11, west of Area 11A and north of Area 11H. From the 1950s to the 1970s, industrial tenants used this area for propellant/explosives manufacturing. During World War II, this site was part of the IOP Group II Load Line.

Operational History and Waste Characteristics

Several buildings within AUS-A11P were originally a part of the IOP Group II Load Line which SWDC/War Department operated during World War II. Shells, anti-tank mines and 500-pound (lb) bombs were loaded with TNT on this line.

Olin began occupying Area 11 in 1956. They initially used this area as a Pilot Propellant Plant for research and development of propellants, and may have later used this area for the manufacture of jet starter cartridges or jet engine starters. Solid propellant used at this plant was composed of ammonium nitrate, synthetic rubber, carbon black, and ammonium oxalate. The propellants contained ammonium perchlorate, magnesium, aluminum, and a plastic binder.

Some of the chemical constituents of gas generators produced by Olin were perchlorates, ammonium nitrate, hexane and various plasticizers. Olin also tested experimental explosive devices in a building in this area. Olin jet engine starters were made using nitroglycerin and ball powder. Ammonium nitrate, nitrocellulose and a plasticizer – dioctyl phthalate – were also used in the gas generators for the jet engine starters.

After Olin sold a portion of its business to CSC in 1964, CSC leased the former Olin facility and used it for the manufacture of Big Inch Caps, which were listed as "Blasting Caps" "for detonators" in the Olin/CSC agreement. The caps were ½-inch in diameter and 1-inch long. They were used with a cord fuse and contained a combination of lead azide and lead styphnate. According to CSC/IMC records, RDX, lead azide and lead styphnate were the explosive

contaminants of concern in the buildings used for Big Inch Cap production. CSC/IMC ended production sometime around 1971.

Site Investigation

The SI included soil, sediment, groundwater, and surface water samples.

Notable Contamination Found

TCE and PCE were detected in groundwater above SI screening criteria, but just below MCLs. Many SVOCs were detected in soils and sediments above SI screening criteria, including n-nitrosodiphenylamine and carbazole. 2,4-dinitrotoluene exceeded screening criteria in soils, as did most inorganics. Detections of some metals exceeded Illinois surface water quality standards.

AUS-A11S (Area 11 Support Area)

Site Description

Site AUS-A11S, the Support Area, is located in the northeastern portion of Area 11, east of Area 11A and north of Area 11N. During World War II, the area was part of the IOP Group II Load Line. Site AUS-A11S was used by industrial tenants from 1946 to the 1980s as a support area for the high explosives manufacturing.

Operational History and Waste Characteristics

SWDC/War Department operated the IOP Group II Load Line during World War II. The area occupied by Site AUS-A11S was on the front end of the load line, where shells were delivered, cleaned and painted.

Silas Mason Company, a War Department contractor who operated the IOP Ammonium Nitrate Plant in Area 12 from 1946 to 1950, also occupied two buildings in Area 11 as warehouses from 1946 to 1948.

Post-IOP industrial tenants included Hoosier Cardinal Corporation (Hoosier) who leased property in Area 11 from 1948 to 1956. Hoosier manufactured and finished decorative equipment and emblems for stoves, refrigerators and automobiles.

During Olin's tenure from 1956 to 1964, most of the buildings in the Support Area were former IOP buildings. Olin used the buildings in this area for a boiler house, laboratory, a component magazine, a carpenter and machine shop, a garage, a welding shop, and oil storage.

CSC/IMC apparently used most of the buildings in Site AUS-A11S for the same purposes as Olin.

Site Investigation

The SI included soil, sediment, groundwater, and surface water samples.

Notable Contamination Found

TCE was detected in the groundwater at 280,000 ug/L. Other contaminants that exceed SI screening criteria for groundwater are: cis-1,2-dichloroethene, naphthalene, TNT, phosphorus, and sulfate. Several chlorinated VOCs exceeded SI screening criteria in soils.

2,4-dinitrotoluene in soil exceeded screening criteria, as did many PAHs and three phthalates. Maximum detections of most inorganics exceeded SI screening criteria in soils and/or sediments.

Detections of several metals exceeded Illinois surface water quality standards.

AUS-0A12 (Area 12 Former Ammonium Nitrate Plant)

Site Description

Area 12 was the former IOP Ammonium Nitrate Plant. It is located south of Area 11, and is accessible by way of Area 11 roadways. It originally consisted of 12 buildings designated with the prefix "ANP-1.

The area has been unoccupied since 1982, and all buildings have been removed.

Operational History and Waste Characteristics

SWDC/War Department used Area 12 for ammonium nitrate production during World War II. The IOP was a "melt-pour" facility. Explosives that were produced elsewhere were melted and poured into various ordnance shells and bombs. TNT was the preferred explosive, but because of a TNT shortage, many ordnance plants, including the IOP, were designed and built to use amatol, a mixture of TNT and ammonium nitrate. Unlike TNT, ammonium nitrate was produced at the plant. When the TNT shortage ended in 1943, TNT alone was used for the main ordnance explosive, and ammonium nitrate production stopped.

The process of producing ammonium nitrate included passing ammonia gas through the nitric acid creating a solution that was then stirred to complete the evaporation process.

Silas Mason, under contract with the War Department, manufactured fertilizer-grade ammonium nitrate sometime between 1946 and 1950. In 1950, fertilizer production ended, and the Army transferred control and jurisdiction of the facility to the United States Department of Interior (USDOI).

Post-IOP industrial tenants included UMC, who tested photo flash signals in this area for approximately six months during 1955. Barium nitrate and potassium perchlorate were waste products from the manufacture of photo flash signals.

Olin leased this area from January 1956 through April 1964 for storage, burning, and explosives manufacturing. Olin originally manufactured ammonium nitrate in Area 12 until its ammonium nitrate facility in Area 11 was completed. It is likely that Olin also used Area 12 to manufacture Olinite 7, which was a form of dynamite made with ammonium nitrate and diesel fuel.

In 1960, Olin constructed and filled eight powder storage ponds in the area between the IOP Group II Load Line and the Ammonium Nitrate Plant. The ponds were excavated, lined with a black plastic, filled with powder and then filled with water. Olin stored flashless, non-hydroscopic powder (FNH) in these ponds.

Olin reported that open burning began in this area in 1956 and continued until 1964, and they estimated that 4,000,000 lbs of explosives, pyrotechnics and propellants were burned in these burning grounds from 1956 through 1964. They also estimated that approximately 40,000 lbs of primarily metal oxides remained at the burning grounds.

CSC occupied Area 12 from April 1964 through 1982. CSC (and its successors) used this area for storage and for RDX production. Additionally, burning grounds were still present on the western side of the property during CSC's tenure, and presumably were used by CSC.

Site Investigation

The SI included drum content, soil, sediment, groundwater, surface water, and trench water samples.

Notable Contamination Found

Arsenic, beryllium, chromium, lead, and nitrate-nitrate exceeded MCLs in groundwater.

Detections of carbon tetrachloride, choroform, dichloroethene, methylene chloride, PCE and TCE in soil exceeded SI screening criteria.

Maximum detections of most inorganics in soils exceeded SI screening criteria, including cadmium at 15 mg/kg, chromium at 4,010 mg/kg, copper at 846 mg/kg, lead at 7,270 mg/kg, and zinc at 1,970 mg/kg.

Illinois surface water quality standards were exceeded for some metals.

Other Sites in Designated Refuge Industrial Areas

Fourteen numbered industrial areas have been designated on the Refuge (Areas 1 through 14). These designations began with the various IOP building complexes but, as discussed above, some of the numbered areas have grown beyond the original IOP area boundaries.

In addition to Areas 2 and 11/12 discussed above, several of the other numbered industrial areas are AUS OU sites. These are Area 4 (divided into Area 4 East and Area 4 West), Area 6, Area 7, Area 8 South, Area 9, Area 10, and Area 13.

AUS-0A4E (Area 4 East)

Site Description

Area 4, the IOP Shop Area, is north of Crab Orchard Lake on both sides of Highway 148. For the purposes of this report, Area 4 has been divided into two separate areas: Area 4 East, which includes all of the Area 4 buildings on the east side of Highway 148, and Area 4 West, which includes all Area 4 buildings on the west side of Highway 148.

Area 4 East was originally built as an automotive shop to support IOP operations. Only two of the six original buildings remain. Since World War II, the area has been used by various tenants for purposes such as manufacturing and storage. The site covers about 60 acres.

Operational History and Waste Characteristics

During World War II, this area was used for maintenance of the IOP truck pool and heavy equipment. All automotive shop buildings begin with the designation "S-4"; they include a wash and grease house, a gas station, a garage, and buildings for the storage of oil and auto parts. Another building, S-3-4, was used to pump fuel to the West Shop Area.

Tenant uses of the buildings varied from manufacturing wrought iron items, latex rolls, and crates and cartons. Area 4 East was also used for refurbishing mining equipment and likely for vehicle maintenance, and as a service garage. The current tenant in this area is Ensign Bickford Industries.

Site Investigation

The SI included soil, groundwater, and surface water samples.

Notable Contamination Found

Exceedances of screening criteria at this site were mostly relatively small. Detections of ethylbenzene and xylenes in the soil near the former IOP gas station exceeded SI screening criteria. Among the SVOCs, methylnaphthalene, dibenzofuran, two phthalates and 12 PAHs in soils exceeded SI screening criteria. SI soil screening criteria was exceeded for most inorganics, although, except for copper which was detected at 816 mg/kg *(background = 11 mg/kg)* the exceedances were small.

AUS-0A4W (Area 4 West)

Site Description

Area 4 West, an approximately 80-acre site on the west side of Highway 148, originally housed buildings that supported IOP infrastructure and operation. All of the buildings started with the prefixes "S-1," "S-2" or "S-3, " and are arranged in three north-south oriented rows. Some buildings are no longer on site.

Operational History and Waste Characteristics

IOP buildings included a laundry, a locomotive repair building, a tool and gage shop, a laboratory, a machine shop, a piping and plumbing shop, a boiler house, and a light equipment repair building.

After the end of World War II, several of the buildings were leased by businesses including furniture, transformer, and coder cartridge manufacturers; printers; lumber suppliers; and publishers. There were also two plating operations. Under the direction of the Illinois Environmental Protection Agency, one of these tenants (Supreme Plating) cleaned and emptied an underground tank that contained liquid waste from its operation. Part of this area was also remediated under the Metals Areas Operable Unit.

GDO&TS is the major current tenant in Area 4 West.

Site Investigation

The SI included several soil samples of varying depths; no groundwater monitoring wells were installed.

Notable Contamination Found

SVOCs that exceeded SI soil screening criteria included methylnaphthalene, dibenzofuran, carbazole, two phthalates, and nine PAHs; exceedances were generally small.

Most inorganic constituents were detected at levels exceeding SI screening criteria, including arsenic at 60 mg/kg, cadmium at 4,520 mg/kg, chromium at 298 mg/kg, and zinc at 780 mg/kg.

AUS-0A06 (Area 6)

Site Description

Area 6 is the former IOP Ammonium Nitrate High Explosive and Smokeless Powder Storage Area. This approximately 550-acre site is located south of Old Highway 13, in the eastern part of the Refuge.

Area 6 consists of 79 explosive storage igloos in 7 rows. All of the igloos numbers are prefixed with "HE" (high explosives).

Operational History and Waste Characteristics

During the IOP era from 1942 through 1945, all of the igloos in this area were used for storage of high explosives. Tenants have since used the igloos mostly for storage of propellants and explosives. Some tenants have also stored pesticides, gun powder, fireworks, and fertilizers.

One of the current tenants, Dooley Brothers, Inc., indicated they buried explosive materials next to Igloos HE-7-11 and HE-7-12 on two occasions.

GDO&TS and Ensign Bickford Industries, Inc. are the two major current tenants in Area 6.

Site Investigation

The SI included several soil samples of varying depths; no groundwater monitoring wells were installed.

Notable Contamination Found

Detections of the explosive compound nitrobenzene exceeded SI soil screening criteria. It was not detected at levels at which explosion is a hazard; the issue is toxicity.

Detections of many SVOCs in soil exceeded screening criteria. N-nitroso-di-n-propylamine and n-nitrosodiphenylamine were detected at concentrations well above screening criteria. Diphenylamines are commonly used as stabilizers and antioxidants for propellants. 2-nitrodiphenylamine is a documented Olin waste product. Carbazole, a possible degradation production of diphenylamines, was also detected above SI soil screening criteria.

Four phthalates exceeded SI soil screening criteria, including di-n-octyl phthalate, a documented Olin waste product.

Fourteen PAHs exceeded screening criteria, many by a wide margin.

Pentachlorophenol, a wood preservative that has also been used as a herbicide and pesticide, was detected above SI soil screening criteria. Hexachlorobenzene, which is used in some military explosives and is a contaminant in some pesticides, was detected above SI soil screening criteria. Another pesticide ingredient, 2,4,6-trichlorophenol, was detected above SI soil screening criteria.

AUS-0A07 (Area 7)

Site Description

Area 7, the IOP Inert Storage Area, is located just south of the east end of Crab Orchard Lake. It was used for warehousing metal parts and other inert materials used in ordnance production. The site also incorporates the former Site AUS-0021, the Area 7 Fire Station.

The original building complex consisted of 6 rows of buildings (6 to 7 buildings per row) each of which were 51 feet (ft) wide by 200 ft long. All building numbers were prefixed with "IN" (for Inert Storage). The site covers about 100 acres.

Operational History and Waste Characteristics

During the IOP era, all but two of the buildings in Area 7 were used as warehouses for inert storage.

A succession of tenants have since leased the buildings, mostly for storage, but a few were used for manufacturing and maintenance work. Based on the information to date, the most significant

areas of concern appear to the related to Great Lakes Terminal and Transport Company's pesticide storage operation, Olin's short-lived metal fabrication operation, and the related operations of Helical Bit/R.A. Wilkie Machine and Plating Co.

Site Investigation

The SI included only shallow soil samples; no groundwater monitoring wells were installed.

Notable Contamination Found

TCE, a common metal degreaser, was found in the soil above the SI screening criteria at many sampling locations throughout the site. Methylene chloride was also detected above SI soil screening criteria.

Many pesticides concentrations exceeded SI screening criteria for soil in the vicinity of the former pesticide storage areas. Pesticides, with maximum soil concentrations detected include aldrin, 520 mg/kg *(SI screening criterion = 0.15 mg/kg)*, and dieldrin, 290 mg/kg *(SI screening criterion = 0.15 mg/kg)*. DDE, DDT, DDD, chlordane, heptachlor, and other pesticides were also detected above SI screening criteria. SVOCs, PCBs, and several metals were detected above SI soil screening criteria.

AUS-0A8S (Area 8 South)

Site Description

Site AUS-0A8S is south of Crab Orchard Lake and includes the southern part of the former IOP Group III Load Line. The load line originally included 29 buildings, which were prefixed with "III-1." The site includes about 150 acres.

The only remaining buildings from the Group III Load Line are those from the northern portion of the former load line. None of the buildings in the site designated as AUS-0A8S are still on site.

Operational History and Waste Characteristics

Load Line III was an IOP melt-pour operation for 500 pound bombs. TNT, which was sometimes blended with ammonium nitrate, was brought from off-site, melted, and poured into the bomb casings.

Products manufactured by post-World War II tenants included fiberglass canoes, propellants, pyrotechnics, and ground explosive powder. After a 1981 fire, the entire site was razed and buried. No industrial activity has taken place at Area 8 South since that time.

Olin occupied several of the former IOP buildings in Area 8 South from 1959 through the early 1960s for storage of ammonium nitrate fertilizer. Lease information indicates that Olin occupied the entire southern portion of Area 8 from 1960 through 1962.

Petrof Trading Company (Petrof) occupied two Area 8 buildings in the late 1960s. Petrof's operation in Area 8 involved grinding explosive powder. After Petrof left the site, black powder that he had left behind was buried by the USFWS and the burial area was fenced off and marked.

CTI leased the south end of Area 8 from June 1969 to November 1970. CTI produced pyrotechnic devices for the military and their major product was the Mark II ground burst simulator. They also produced cannon net traps and parts for rocket separators.

American Fiber-Glass, Incorporated (AFL), leased this area from 1973 to 1981, when fire destroyed the facility. AFL manufactured fiberglass products, primarily canoes. A former employee reported that AFL used organic solvents, such as toluene, for cleanup operations.

Site Investigation

The SI included drum content, soil, sediment, groundwater, and surface water samples.

Notable Contamination Found

Most of the contamination was limited to the far southern end of the site. Both 2,4-and 2,6-dinitrotoluene were detected in the soil above SI screening criteria. 2,4-dinitrotoluene was detected at 1,400 ug/kg, compared to a screening criterion of 0.04 ug/kg.

Maximum concentrations of several metals in sediments exceeded SI screening criteria, including arsenic at 63 mg/kg, copper at 3,300 mg/kg, lead at 665 mg/kg, and zinc at 1,800 mg/kg.

AUS-0A09 (Area 9)

Site Description

Area 9 was the IOP Group Load Line I and is located south of Crab Orchard Lake and east of Highway 148.

Load Line I originally consisted of the 38 buildings. All the building numbers are prefixed with "I-1."Later industrial tenants have added many buildings and building numbers now extend into the 100s.

In 1996 and 1997, a large area in and near Area 9 was remediated as a part of the PCB OU. Site AUS-0A09, includes that part of Area 9 located outside the excavation boundaries for the original PCB OU remediation, and outside the area currently planned for remediation for chlorinated VOC groundwater contamination under the PCB OU. Site AUS-0A09 includes about 100 acres.

Operational History and Waste Characteristics

During World War II, TNT was screened, melted, and loaded on this artillery and bomb loading line.

There were two major tenants and several minor ones in Area 9. Sangamo Electric Company, later Sangamo Weston, Inc. (Sangamo), now Schlumberger Industries, Inc., was the first major tenant, and contamination from its operations is the focus of the PCB OU remediation. Olin and its successors have been the other major tenant.

From 1946 to 1962, Sangamo leased the site and manufactured various kinds of capacitors as well as transducers and delay line equalizers. Sangamo used lead to coat small parts, such as electrical connections. Sangamo also used degreasers and other chemicals in their manufacturing processes, such as acids, acetone, ethylene glycol, epoxy resins, silver, ammonia, trichloroethylene, perchloroethylene (PCE), liquid Aroclor 1254 and 1242.

Olin/Primex/GDO&TS have leased buildings in Area 9 from 1967 to the present, for several different activities, including pyrotechnic operations, which included manufacturing magnesium flares and illumination flares; as well as medium caliber ammunition production.

See the discussion under the AUS-0A2B summary for known chemicals used and waste products generated by Olin and its successors.

Site Investigation

The SI included soil and groundwater samples.

Notable Contamination Found

Many PAHs, three phthalates, and several metals were detected in soil at concentrations above SI screening criteria. 2,4-dinitrotoluene was detected at 2,100 ug/kg in soil.

AUS-0A10 (Area 10)

Site Description

Area 10, the former IOP Fuse and Booster Storage Magazine (FBM) area, is located south of Crab Orchard Lake, on the north side of Ogden Road. Area 10 was a group of 16 storage magazines for components of ordnance produced on the load lines. The site covers about 40 acres.

The FBM area was in the shape of a polygon, and the storage magazines were arranged in four rows. All of the magazine numbers started with the prefix "FBM."

By 1965, all of the magazines had been removed.

Operational History and Waste Characteristics

During World War II, fuses and boosters stored in Area 10 were transported to the IOP Load Lines, where anti-tank mines, bombs and artillery were being produced.

In 1949, USFWS used three of the magazines for grain storage. Sangamo., the only documented tenant in Area 10, leased two magazines from 1949 to at least 1951.

Although it had no leases in Area 10, Olin constructed and used large pits in this area for the incineration of ignitable wastes from its production operations. John Miller, a former Olin manager and chemist, indicated that Olin moved from one burning ground to another as they outgrew the previous burn areas, and that all of Olin's manufacturing operations on the Refuge used a single burn area at the same time. Olin documents indicate that their burning grounds were moved from Area 12 to Area 2D in 1965, from Area 2D to Area 9 in 1967 and from Area 9 to Area 10 in 1968. The Area 10 burn area was not available to other industrial tenants. It was in operation until open burning was banned at the Refuge in 1970.

Scrap explosive wastes that Olin burned at Area 10 consisted of propellant, illumination scrap mix, igniter scrap, laboratory waste pyrotechnic materials, and other explosives and explosive contaminated materials. Oil was added to explosive material to cushion and dampen the material to prevent explosions prior to burning. Scrap was collected at workstations or scrap areas and taken to Area 10 where it was dumped into the burn pits and topped with small quantities of ignitable powders.

Olin has estimated that 120,000 pounds (lbs) of waste were burned in this area and that about 1,000 lbs of residue remained, consisting mainly of metal oxides. Olin reported that the soils in the vicinity of this burning ground possibly contained lead contamination, and also that fuel oil, acetone, lupersol (methyl ethyl ketone peroxide)and other chemicals would have been present in these pits.

In 1970, when open burning was banned, the pits were covered. Since that time the site has been used by local law enforcement personnel for small arms practice.

Site Investigation

The SI included soil and surface water samples; no groundwater monitoring wells were installed.

Notable Contamination Found

TCE was detected above SI screening criteria in soil. Maximum detections of several inorganics exceeded SI screening criteria, including barium at 14,100 mg/kg, and boron at 513 mg/kg.

AUS-0A13 (Area 13)

Site Description

Area 13, IOP Finished Ammunition Igloos (FAI) Area, is west of Areas 10 and 11, and south of Crab Orchard Lake. The site originally included 88 igloos, and covers about 500 acres.

Operational History and Waste Characteristics

These finished ammunition storage igloos were constructed and operated by SWDC/War Department as part of the IOP. The igloos have been used by various post-war tenants to store raw materials and products.

Olin began leasing igloos in the southern half of Area 13 in 1956. It continued to lease igloos in Area 13, including some in the northern half, until Primex and then GDO&TS took over the Olin leases.

Reportedly, Olin stored and detonated (tested) nitroglycerin in Area 13. Also, Olin reportedly burned dynamite on the road in Area 13, in front of the igloos, using straw and diesel fuel.

Early lease and corporate information is incomplete, but it appears that CSC took over some of Olin's igloos in the northern portion of Area 13 when it purchased a portion of the Olin business on the Refuge in 1963. CSC later changed its name to International Minerals and Chemical Corporation (IMC). IMC sold a portion of its explosives business to Trojan Corporation in 1982. Trojan was acquired by Ensign Bickford Industries in 1986. For a time, Trojan leased the igloos in the southern portion of Area 13 in its own name; Ensign Bickford later took over the leases.

GDO&TS and Ensign Bickford currently lease all the igloos in Area 13. These igloos, in the southern and northern half of the area, respectively, have been used historically for propellant and explosives storage.

Site Investigation

The SI included several soil samples of varying depths; no groundwater monitoring wells were installed.

Notable Contamination Found

The following explosives were detected in soils above SI screening criteria: 2,4-dinitrotoluene, 2,6-dinitrotoluene, and nitroglycerin. None of these were detected at potentially explosive levels. 2,4-dinitrotoluene was detected at 64,000 ug/kg in the soils.

N-nitrosodiphenylamine and carbazole were also detected above SI screening criteria in the soils, as were many other SVOCs and inorganics.

Chromium was detected at 155 mg/kg in the soil.

COC Area Sites

Five AUS OU sites are located in the area around the Crab Orchard Cemetery, the COC Area, south of Crab Orchard Lake. After the end of World War II, the War Department used parts of this area to destroy surplus land mines and other ordnance products. There have been no industrial tenants in the COC Area. Several EMMA OU sites were located in this area. One has been remediated for chemical contamination and others have been remediated for ordnance only.

AUS-0062

According to the USFWS, AUS-0062 is a former landfill that was closed by the Refuge in 1974. The site covers about 2 acres. No activity was observed on aerial photographs of this area until 1971, when the site appeared to be a roadside clearing and fill operation. By 1980, the site appeared to be inactive. The SI included soil, sediment, and surface water samples; no groundwater monitoring wells were installed. TCE and most inorganics in soil exceeded SI screening criteria.

AUS-0065

AUS-0065 is an approximately one half-acre site in the COC area with building foundations and debris. Concrete foundations, soil mounds, depressions, and a brick structure resembling a well are currently visible on site. There have been no known industrial lessees of this property. The SI included several soil samples of varying depths; no groundwater monitoring wells were installed. Many SVOCs and several inorganics exceeded SI soil screening criteria.

AUS-0066

AUS-0066 is a small wooded site in the COC area, covering about three quarters of an acre. AUS-0066 was originally described as "berm with red brick rubble" with a "Danger Contaminated Area" sign to the west. It was also COC-14 of the EMMA OU and was one of the COC sites investigated by the Army only for unexploded ordnance (UXO). In 1997, the Army conducted an ordnance and explosive waste (OEW) investigation at this site. A total of 20 magnetic anomalies were identified; all twenty were identified as ordnance scrap. The SI included soil, sediment, and surface water samples; no groundwater monitoring wells were installed. Many SVOCs and several inorganics exceeded SI soil screening criteria. Maximum concentrations detected included cadmium at 36 mg/kg and zinc at 447 mg/kg. Illinois surface water quality standards were exceeded for some metals.

AUS-0067

AUS-0067 is an approximately one fourth-acre site located west of Wolf Creek Road and north of the COC Area Road. It was included in the AUS OU primarily because of suspect fencing and signage. AUS-0067 was originally described as "fence with contaminated area (sign) northwest of COC-6." A collapsed foundation, a cistern, some construction debris and some soil mounds were observed during the site visit. The SI included soil samples and a water sample from a cistern; no groundwater monitoring wells were installed. The dinitrotoluene concentration in a water sample from a cistern exceeded SI screening criteria. Tetryl was also detected at this site, but below the SI screening criteria.

AUS-0069

AUS-0069 is adjacent to Crab Orchard Lake and partially coincides with EMMA OU Site COC-15, one of the COC sites for which no chemical analyses were performed as part of the EMMA OU RI. AUS-0069 was a dump site used during the IOP era. The site covers roughly 15 acres. The 1943 aerial photographs, taken during the IOP era, showed deposits of probable debris and

large numbers of crated materials in this area, along with a looping access road. By 1951, there was still some ground scarring and mounded debris present on site, however it appears that activity in this area had been terminated.

During the site visit, rusted drums and other debris were observed. Most of the debris is located in a stand of trees along the lakeshore and some of the debris is in Crab Orchard Lake.

The SI included soil, sediment and trench water samples; no groundwater monitoring wells were installed.

PCE was detected in soils above the SI screening criteria. Maximum detections of many SVOCs and inorganics exceeded soil and/or sediment SI screening criteria. Maximum soil inorganic detections include antimony at 173 mg/kg, barium at 4,940 mg/kg, cadmium at 28 mg/kg, chromium at 266 mg/kg, lead at 51,000 mg/kg, and zinc at 16,400 mg/kg. Low levels of explosives were detected, including TNT, 2-amino-4,6-dinitrotoluene, and 4-amino-2,6-dinitrotoluene.

Other Small Sites

AUS-0001 (Fire and Police Headquarters)

This site is located west of Wolf Creek Road and south of Old Highway 13. No buildings remain on this site, which covers about 1.5 acres. The facility was originally constructed and operated by SWDC/War Department as a part of the IOP. The main building was razed sometime between 1971 and 1980. The Crab Orchard Sportsmen's Association used this building as their club headquarters. The SI included soil and groundwater samples. Maximum detections of SVOCs and inorganics in soils exceeded SI screening criteria, including arsenic at 535 mg/kg and zinc at 1,410 mg/kg.

AUS-0002 (Wastewater Treatment Plant, WWTP)

This site, about 1.5 acres in size, is south of Old Highway 13 and west of Wolf Creek Road. This IOP WWTP was originally constructed and operated by SWDC/War Department. Based on IOP drawings, this WWTP may have supported not only Area 1 but also parts of Area 2.

The WWTP consisted of a blockhouse with four treatment pits and an assumed underground sewer line to the west emptying into two small lagoons. The blockhouse and the four treatment pits were razed sometime between 1980 and 1993. The lagoons are still on site. No industrial lessees were identified for this plant. According to the historical aerial photograph interpretations, this plant appears to have been abandoned sometime between 1943 and 1951. The SI included soil and surface water samples; no groundwater monitoring wells were installed. Maximum detections of many inorganics in soils exceeded SI screening criteria, including chromium at 737 mg/kg and silver at 99 mg/kg.

AUS-0018 (Railroad Classification Yard)

This site is located at the southeast corner of the intersection of Old Highway 13 and Route 148. It includes about 7 acres. Based on IOP drawings, there were numerous sets of railroad tracks and four buildings, all prefixed with "Y-1." All the tracks and buildings have been removed. This train-sorting facility was originally constructed and operated by SWDC/War Department as a part of the IOP and had a 200-car capacity. Larger post-World War II tenants in this area included Olin and Trojan/U.S. Powder/Commercial Solvents Corporation. The SI included several soil samples of varying depths; no groundwater monitoring wells were installed. Among the inorganics in soil that exceeded SI screening criteria are arsenic, barium, lead, and nickel.

AUS-0043 (Areas 11 and 12 Fire Station)

This site, which covers about one half acre, is located south of Crab Orchard Lake and northwest of Areas 11 and 12. There are no remaining buildings on site. This fire station was operated by SWDC/War Department as a part of the IOP, and serviced IOP facilities in its area. No industrial lessees were identified for this site. The SI included soil and surface water samples; no groundwater monitoring wells were installed. 2,6-dinitrotoluene in soil exceeded SI screening criteria. SVOCs and inorganics exceeded SI soil screening criteria. Lead was detected at 1,110 mg/kg in soil.

AUS-0060 (Fulminate Storage Igloos)

Site AUS-0060 is the location of the IOP Fulminate Storage Igloos, Area 14. The site is located north of Crab Orchard Lake and west of Area 2. It covers about 6 acres. Because of the relatively small size of the site and the fact that the original AUS OU designation as Site 60 included the entire area, the original designation was retained, rather than renaming it as Area 14. IOP used this site for storing lead azide and mercury fulminate, which are explosive components of detonators. There were five structures in this area: two azide storage vaults, two fulminate storage vaults and a guard house. After World War II, the storage igloos may have been used to store other compounds, including trinitrotoluene (TNT), tetryl, and nitrocellulose. Lease documents indicate UMC occupied this area from 1956 to 1964. Olin also used these igloos for general storage from 1970 through at least 1985. Wildlife Materials, Inc., leased Igloo FS-2-2 from at least 1970 to 1985 for storage of black powder, M6 propellant. and electric squibs. In 1997, the U.S. Army investigated this site to determine if ordnance or explosives remained in the bunkers. A small amount of propellant powder was removed and destroyed.

The SI included several soil samples of varying depths; no groundwater monitoring wells were installed. Arsenic, lead, and mercury exceeded SI soil screening criteria.

AUS-0061 (IOP Detonation and Disposal Area)

This site is west of Wolf Creek Road and South of Old Highway 13. "IOP Detonation and Disposal Area" is not an official IOP designation. The site name was developed during the PA/SI investigation as a description of the site, which was apparently used during the IOP era for testing explosives, and for disposal. There are three concrete structures on the "detonation"

portion of the site. According to Mr. Wayne Adams, a former Refuge manager, the concrete structures in the "Detonation Area" of the site were used to detonate explosives during World War II. The two westernmost structures are probable detonation pits and the easternmost structure is a probable firing pit. The detonation part of the site includes about ½ acre.

The disposal portion of the site was not investigated during the PA/SI because it was not discovered until the SI field investigation was already in progress. The disposal area is north of the detonation area, and was observed only in the 1943 historical aerial photographs. This area appeared to contain 13 to 15 trenches filled with unidentifiable materials. The overall area of the trenches covers about 20 acres.

The 1951 and 1960 aerial photographs showed evidence of surface dumping in the western part of the former trench area. This activity appeared to be unrelated to the IOP Disposal Area observed in the 1943 photograph. This surface dump was apparently the Job Corps Landfill, which was remediated as part of the PCB OU.

There were no known industrial lessees of this property.

The SI included several soil samples of varying depths in the Detonation Area only; no groundwater monitoring wells were installed. The SI included only the detonation pits and not the trenches observed in the photographs. SVOCs and most inorganics exceeded SI soil screening criteria at the detonation pits. In the soil samples, cadmium was detected at 91 mg/kg and mercury at 1.1 mg/kg.

AUS-106A (Drum Disposal Area East of Area 11)

This site is located due east of Site AUS-A11N on the north side of an abandoned roadway. The site covers approximately 3,000 square feet (ft) and consists of a mounded area of partially buried drums with some nearby debris. There are an estimated 50 to 100 drums.

The 1951 aerial photograph showed a possible disposal site in this location. There was no evidence of this disposal site in the 1943 aerial photographs. In 1951, portions of the site were vegetated, indicating that they may not have been used for some time. By 1960, this area was completely covered with vegetation and the former farm lane no longer appears on the photo, suggesting that this area had been inactive for some time. This also suggests that an operator/tenant who was at the site prior to 1951 may have been responsible for the drums. These operators/tenants include the SWDC/War Department (operator 1942-1945), Hoosier Cardinal (tenant, 1948 through 1954) or Silas Mason (operator, 1947 through 1950).

The SI included drum content samples and several soil samples of varying depths; no groundwater monitoring wells were installed. Benzene and TCE were detected in the drums. TCE was detected at a maximum concentration of 13,000 ug/kg in the soil, well above SI screening criteria. Soil results included cadmium at 150 mg/kg, chromium at 239 mg/kg, copper at 3,300 mg/kg, lead at 2,470 mg/kg, selenium at 22 mg/kg, and zinc at 3,160 mg/kg. Low levels of the explosive compounds tetryl and HMX were detected in soil.

The Next Steps in the Process

Assuming federal and state agency concurrence with the recommendations in this report, the next steps in the CERCLA process are development of a schedule, an RI scope of work, and an RI work plan.

TABLE ES-1
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU

AUS Site	Description	Recommendation	Comments
1	Fire and Police Headquarters	Site Inspection	See Table ES-2
2	Former Wastewater Treatment Plant for Area 1	Site Inspection	See Table ES-2
3	Fuse Line Loading/dumped organics	Include with Area 2F	Investigate Area 2F as Industrial Facility
4	Artillery Primer Line - 2P/dumped organics	Include with Area 2P	Investigate Area 2P as Industrial Facility
5	Detonator Loading Line - 2D	Include with Area 2D	Investigate Area 2D as Industrial Facility
6	Booster Loading Line - 2B/tested pyrotechnic devices	Include with Area 2B	Investigate Area 2B as Industrial Facility
7	Tested pyrotechnic devices in Areas 2D, 2B, 2F	Include with Area 2B, 2D, 2F, 2P	Investigate Area 2 as Industrial Facilities
8	Dumped organics in Areas 2D, 2B, 2F	Include with Area 2D, 2B, 2F	Investigate Area 2 as Industrial Facilities
9	Dump East of Area 2F	Include with Area 2F	Investigate Area 2F as Industrial Facility
10	Boiler House South of Area 2P	Site Inspection	This site was recommended for no further action in the draft Historic Search Report based on the fact that the USTs were reportedly removed during building demolition. It was later added back because historical aerial photographs identified areas of surficial discoloration next to the bldg.
11	Gas Station East of Highway 148 from Old Refuge Shop	Include with Area 4	Investigate Area 4 as Industrial Area
12	Waste Oil Tank at Old Refuge Shop	No further action	No evidence of waste oil tank; nothing on drawings; FWS personnel report there was a tank removed in 1988 or 1989
13	Laundry Facility	Include with Area 4	Investigate Area 4 as Industrial Area

TABLE ES-1
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU

AUS Site	Description	Recommendation	Comments
14	Dry Cleaner	Include with Area 4	Investigate Area 4 as Industrial Area
15	Boiler House	Include with Area 4	Investigate Area 4 as Industrial Area
16	Old Refuge Shop Concrete Pit of Supreme Plating	No further action.	This site was recommended for inclusion with the rest of Area 4 in the draft Historic Search Report, however documentation provided by the USFWS, reported that this tank was considered closed by the IEPA and no further action was necessary.
17	Degreasing Bldg	Include with Area 4	Investigate Area 4 as Industrial Area
18	Railroad Classification Yard	Site Inspection	See Table ES-2
19	Dump of concrete rubble/later renamed as Railroad Spur north of Area 4 East	Site Inspection	No concrete rubble; pile of RR ballast. Note: this site was recommended for no further action in the draft Historic Search Report, based on the observation from the site visit that the "concrete rubble" was RR ballast, and there were no other indications of contamination. It was later added back, based on aerial photography which indicated it was a railroad spur with possible historic surface spillage.
20	Railroad Loading Dock	Include with Area 6	Investigate Area 6 as Industrial Storage Facility
21	Fire Station near PCB OU LF	Site Inspection	See Table ES-2
22	Refuge Border by Prison landfill/later renamed probable small arms range	Site Inspection	Site was recommended for no further action in the draft Historic Search Report because the site could not be found. A site that appeared to be a small arms range was later identified on aerial photographs, and assumed to be this site.
23	Group III Load Line (LL III) Boiler House	Include with Area 8	Investigate Area 8 as Industrial facility

TABLE ES-1
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU

AUS Site	Description	Recommendation	Comments
24	LL III - Underground Storage Tanks (USTs)	Include with Area 8	Investigate Area 8 as Industrial facility
25	LL III - Cleaning & Painting Bldg	No further action.	Part of Site 14 (MISCA)
26	LL III - Evaporation Basin	Include with Area 8	Investigate Area 8 as Industrial facility
27	LL III - Change House Sewers	Include with Area 8	Investigate Area 8 as Industrial facility
28	LL III - Drainage Ditch Sediments	Include with Area 8	Investigate Area 8 as Industrial facility
29	LL III - Area Around Bldg.	Include with Area 8	Investigate Area 8 as Industrial facility
30	LL III - Change House	Include with Area 8	Investigate Area 8 as Industrial facility
31	South End of Area 8, Black Powder	Include with Area 8	Investigate Area 8 as Industrial facility
32	South End of Area 8, Fiberlite	Include with Area 8	Investigate Area 8 as Industrial facility
33	Soil Pile W of Industrial Bldg.	Remedial Investigation	Site was recommended for no further action in the draft Historic Search Report because it was originally assumed that this soil pile was a borrow pile used by the USFWS. After reviewing historical aerial photographs, it is likely that this soil pile was a berm that was built around a possible former explosives manufacturing facility, so it was decided to include this area in the RI.
34	LL I - Boiler House	Remedial Investigation	Site was recommended for no further action in the draft Historic Search Report because it was originally assumed that this area was remediated as a part of the PCB OU. However, it appears that the area immediately surrounding this former building may not have been remediated, so it will be investigated as a part of the RI.

TABLE ES-1
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU

AUS Site	Description	Recommendation	Comments
35	LL I - USTs	Remedial Investigation	Site was recommended for no further action in the draft Historic Search Report because it was originally assumed that this area was remediated as a part of the PCB OU. However, it is now assumed that the PCB-remediated soils were shallow in depth in this area and therefore if contamination remains in the soils related to the USTs, they would not have been remediated as a part of the PCB OU.
36	LL I - Cleaning and Painting Bldg	No further action.	It is assumed that the areas surrounding this building are being investigated along with the on-going TCE investigation, since monitoring wells were placed next to this building during this investigation. Note: there may be some question as to whether portions of this area were remediated as a part of the PCB OU.
37	LL I - Evaporation Basin	Include with Area 9	Investigate Area 9 as industrial facility
38	LL I - Change House	Include with Area 9	Investigate Area 9 as industrial facility
39	LL I - Drainage Ditch Sedim.	Include with Area 9	Investigate Area 9 as industrial facility
40	LL I - Area Around Bldg.	Include with Area 9	Investigate Area 9 as industrial facility
41	Area 10 - Firing Range	No further action.	This site was originally going to be investigated as a part of Area 10, however it is still in use so it was not included in the SI.
42	Area 10 - Burn Areas	Include with Area 10	Investigate Area 10 as industrial facility
43	Fire Station east of Area 10	Site Inspection	See Table ES-2
44	LL II - Boiler House	Include with Area 11/12	Investigate Area 11/12 as industrial facilities

TABLE ES-1
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU

AUS Site	Description	Recommendation	Comments
45	LL II - USTs	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
46	LL II - Cleaning and Painting Bldg	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
47	LL II - Evaporation Basin	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
48	LL II - Change House	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
49	LL II - Drainage Ditch Sedim.	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
50	LL II - Area Around Bldgs	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
51	Area 12 - Concrete Slab with boosters on it	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
52	Area 12 - Dump west of road (ditch w/ glass/metal)	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
53	Area 12 - COP-6	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
54	Area 12 - US Powder Dump (West Portion of COP-4)	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
55	Area 12 - Burned Solid Propellant	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
56	Dump w/Tanks Area 11/12	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
57	East of road from Area 11/12--metal object on ground	No further action.	This site appeared to be a piece of an old metal stack and there was no reason to suspect contamination in this area related to this metal stack.
58	Drum on east side of Area 12 road on east end	Include with Area 11/12	Investigate Area 11/12 as industrial facilities

TABLE ES-1
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU

AUS Site	Description	Recommendation	Comments
59	Railroad Loading Docks (one north, one south)	Include with Area 13	Investigate Area 13 as industrial storage facility
60	Lead Azide/fulminate igloos	Site Inspection	See Table ES-2
61	North of Area 14, Concrete Structures/later renamed IOP detonation/disposal area	Site Inspection	See Table ES-2
62	Mounds & Pits 100 yds W of COC1	Site Inspection	See Table ES-2
63	Fenced Areas W of Site 62 (COC12)	Site Inspection	See Table ES-2
64	Mounds/Brick Pit Near S-63 (COC13)	Site Inspection	This site was recommended for no further action in the draft Historic Search Report based on the fact that it couldn't be located and there was no other information suggesting it represented risk. It was later added back.
65	Foundations NE of COC-1	Site Inspection	See Table ES-2
66	Berm w/red brick Rubble COC-14	Site Inspection	See Table ES-2
67	Fence w/"cont. area" NW COC-6	Site Inspection	See Table ES-2
68	Pasture North of Hampton Cemetery	No further action.	No field evidence or available information indicating potential or actual releases.
69	Dump formerly COC-15	Site Inspection	See Table ES-2
70	Dump S of Site 69	No further action.	No evidence of dump in records or at site. FWS unable to locate.
71	Mounds of Unknown Material	No further action.	No evidence of contamination in records or at site.
72	Marion Pump Station	No further action.	No evidence of contamination in records or at site.

TABLE ES-1
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU

AUS Site	Description	Recommendation	Comments
73	West end of Crab Orchard Lake Dam, dump	No further action.	Probable household waste; recommend FWS remove and dispose at landfill. Recommend removal work be done with qualified supervision.
74	Lost 40 Acres - Homestead Dump	No further action.	Probable household waste; recommend removal and disposal at landfill. Recommend removal work be done with qualified supervision.
75	W Refuge Border S - Homestead Dmp	No further action.	Probable household waste; recommend FWS remove and dispose at landfill. Recommend removal work be done with qualified supervision.
76	Open Burn Site at Rte 13 Marina	No further action.	No detections above screening levels. No evidence of contamination.
77	NW of DK Lake - Homestead Dump	No further action.	Probable household waste; recommend FWS remove and dispose at landfill. Recommend removal work be done with qualified supervision.
78	Pasture Area E of DK Lake with treated wood posts	No further action.	No evidence of release of hazardous substances.
79	Boy Scout Camp Dump	No further action.	Unable to locate site (FWS also unable to locate). Camp caretaker reports no dumps on site.
80	Girl Scout Camp Dump by Beach	No further action.	Most of the debris has been removed by FWS. No evidence of release of hazardous substances.
81	Girl Scout Camp Dump by Camp Site	No further action.	Debris has been removed. No evidence of release of hazardous substances.
82	Area by Water Tower 3 between PCB and WT removal	No further action.	Site has been eliminated from AUS OU and included in Water Towers OU.
83	Area 2 - RR Spur used by Olin/Primex	Include with Area 2.	Investigate Area 2 as Industrial Facilities
AUS-106A	Drum Disposal	Site Inspection	See Table ES-2

TABLE ES-2
AUS OU SITES RECOMMENDED FOR SITE INSPECTIONS

CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site	Approximate Size, Acres	Description	Comments
AUS-0A2B (Area 2B)	100	Booster load line	Area of industrial activity since 1942. Used for booster loading (IOP); various uses by subsequent ordnance manufacturers, including propellant manufacturing and explosive waste incineration. Concentrations of several SVOCs were detected above EPA SSLs, and metal concentrations were detected above both EPA SSLs and Refuge background levels (EPA, 1998).
AUS-0A2D (Area 2D)	100	Detonator load line	Area of industrial activity since 1942. Used for detonator loading (IOP) and for R&D, pyrotechnic manufacturing, propellant mixing, machining, and milling by later industrial tenants. Reports of improper disposal of solvents and burning of explosive waste by previous employees. Several SVOC compounds detected above EPA SSLs. Mercury and zinc concentrations were detected above both EPA SSLs and Refuge background levels (EPA, 1998).
AUS-0A2F (Area 2F)	100	Fuse load line	Area of industrial activity since 1942. Used for fuze loading (IOP) and various uses by subsequent ordnance manufacturers, including milling, machining, and R&D. Improper disposal of TCE and cutting oil reported by former employees. Metal concentrations were detected above both EPA SSLs and Refuge background levels (EPA, 1998).
AUS-0A2P (Area 2P)	100	Primer loading line	Industrial area used for artillery primer production for IOP; and for gas generator development and production, propellant development and production, agricultural chemical storage, metal working/machining by later industrial tenants.
AUS-0A2R (Area 2R)	~20	Area 2 Railroad spur	Used as a railroad spur by industrial tenants in Area 2.
AUS-0A4E (Area 4 East)	25	Shop Area east of Route 148	Area of industrial activity from 1942 to 1980s. Area includes former gas station, wash and degreasing building, and other industrial activities. Also includes possible disposal site.
AUS-0A4W (Area 4 West)	35	Shop Area west of Route 148	Area of industrial activity from 1942 to 1980s. Area includes former dry cleaners, electric and communication building (with reported use of carbon tetrachloride), IOP laboratory, and other industrial activities. Also includes former plating operation. Ditches and sewers around plating operation were remediated with MAOU remediation; however, results from EPA sampling (1998) indicate that surficial soils in the area of the former plating operation still have some residual cadmium contamination above previous cleanup levels (this area was remediated as an add-on to the Old Refuge Shop, MAOU Site 22). Cadmium was detected at concentrations of 29 mg/kg and 21 mg/kg in the vicinity of the former plating operation (the MAOU cleanup level for cadmium was 10 mg/kg). Other known areas of cadmium contamination in excess of current screening level of 1.4 mg/kg.
AUS-0A06 (Area 6)	550	Explosive Storage	Storage of explosives by IOP and later industrial tenants. USEPA 1998 analytical results above site screening levels at RR loading docks.

TABLE ES-2
AUS OU SITES RECOMMENDED FOR SITE INSPECTIONS

CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site	Approximate Size, Acres	Description	Comments
AUS-0A07 (Area 7)	100	IOP Inert Storage	Area consists of 30 large buildings which had been leased to at least 30 different industrial tenants. Activities included plating, painting, metal forming, oil transfer, and warehousing.
AUS-0A8S (Area 8 South)	150	IOP Load Line III, south	Location of IOP TNT melt Load Line III. Subsequently used by industrial tenants for explosive/ordnance manufacturing and manufacturing of fiberglass boats.
AUS-0A9W (Area 9 West)	100	IOP Load Line I	Location of IOP TNT melt Load Line I. Subsequently used by industrial tenants for transformer/capacitor manufacturing and explosive/ordnance manufacturing. Significant remediation and investigation have been done, but not all areas of potential contamination have been investigated. (Note: Area remediated for PCBs is not included in total.)
AUS-0A10 (Area 10)	40	IOP Fuze & Booster storage	Location of fuse and booster storage (IOP). Site later used for firing range and burn pits. Exceedances of screening criteria.
AUS-A11A (Area 11--Acid/AN)	40	Former IOP Load Line II; later area of industrial acid and ammonium nitrate (AN) manufacturing	Part of IOP ammunition load line (Group II Load Line). From 1950s to 1980s, area was used for manufacture and storage of nitric acid, sulfuric acid, and ammonium nitrate for explosives. Includes disposal pond.
AUS-A11H (Area 11--High Explosives)	60	High explosives manufacturing.	Area used from 1950s to 1980s for manufacture of high explosives, including dynamite, ANOIL, and products containing PETN, TNT, and RDX. Includes waste disposal areas.
AUS-A11N (Area 11--NG)	30	Nitroglycerin manufacturing.	Area used from 1950s to 1980s for manufacture of nitroglycerin. Includes holding ponds for wash water.
AUS-A11P (Area 11--Cap/Propellant)	20	Former IOP Load Line II; later area of propellant research and blasting cap manufacturing.	Part of IOP ammunition load line (Group II Load Line). IOP area used for cleaning and painting shells. From 1950s to 1980s, area was used for propellant research (Olin) and cap manufacturing (Trojan).
AUS-A11S (Area 11--Support)	30	Former IOP Load Line II; later industrial support area	Part of IOP ammunition load line (Group II Load Line). From 1950s to 1980s, support area for explosives manufacturing plant. Included machine shop, scrap yard, boiler, tanks, storage areas.

TABLE ES-2
AUS OU SITES RECOMMENDED FOR SITE INSPECTIONS

CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site	Approximate Size, Acres	Description	Comments
AUS-0A12 (Area 12)	80	AN/RDX manufacturing. Burn pits for ignitable wastes.	Area used during IOP for AN manufacturing. RDX manufacturing from 1960s to 1980s. Includes ponds used for explosive storage. Burn pit used for explosive waste disposal from 1950s to 1980s. Includes dump sites.
AUS-0A13 (Area 13)	500	Explosives Storage Area	Area used during IOP and later by industrial tenants for explosives storage.
AUS-0062	unknown	Mounds & Pits 100 yds W of COC1	Detections of metals above soil screening levels (USEPA 1998).
AUS-0063	<1	Fenced Areas W of Site 62 (COC12)	Ordnance scrap noted. Detections above soil screening levels (USEPA 1998).
AUS-0064	<1	Mound/brick pit, COC-13	Exceedances of screening levels for beryllium and nickel (USEPA 1998).
AUS-0065	unknown	Foundations NE of COC-1	Several samples had exceedances of screening levels for SVOCs and metals (USEPA 1998).
AUS-0066	unknown	Berm w/red brick Rubble COC-14	Brick appears to be from change houses; danger sign posted nearby; creek water has reddish tinge suggesting TNT contamination.
AUS-0067	<1	Fence w/"cont. area" NW COC-6	"Danger: Contaminated Area" sign and rubble warrant investigation.
AUS-0069	unknown	Dump near south shore COL	55-gallon drums and brick with appearance of change house brick suggests industrial dumping.
AUS-0109	<1	Possible detonation area	Possible former explosives detonation area based on historic aerial photographs.
AUS-0001	< 1	Fire and Police Headquarters	Potential for two on-site petroleum underground storage tanks (USTs) based on site visit and site usage. On-site industrial demolition debris. EPA (1998) sample results exceeded site screening levels (SSLs) for semi-volatile compounds (SVOCs) and exceeded Refuge background and screening levels for some metals.
AUS-0002	<1	Former WWTP .	Based on IOP sewer diagrams, WWTP appears to have served part of the industrial area (part of Area 2) in addition to the Administrative Area. Because of this, there is a likelihood of metals, explosives compounds, and other industrial contaminants in the lagoon.
AUS-0018	30	RR classification yard	Concentrations of cadmium, mercury, lead, and zinc exceeded EPA SSLs and Refuge background.
AUS-0019	<1	RR spur	Possible disposal area and area of surficial discoloration as noted on historic aerial photographs.

TABLE ES-2
AUS OU SITES RECOMMENDED FOR SITE INSPECTIONS

CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site	Approximate Size, Acres	Description	Comments
AUS-0021	<1	Fire station Area 7	Ordnance/explosive waste identified on site.
AUS-0022	<1	Probable small arms firing range	Identified in 1943 aerial photograph as probable small arms firing range.
AUS-0043	<1	Fire Station east of Area 10	Possible burning area noted. Two sumps noted in former building area. Some metals exceeded Refuge background and screening criteria.
AUS-0060	30	Area 14 fulminate storage	Original use as storage for mercury fulminate (IOP). Later used for lead azide storage. Former employee believed spill of lead azide had occurred during unpacking of materials. Lead concentration well in excess of background and site screening levels (USEPA 1998). Abandoned drums on site.
AUS-0061	<1	IOP detonation/disposal area.	Concrete structures used for testing explosives. Nearby site identified in aerial photographs as possible IOP trench disposal area. (Trench area was identified in 2000; previous site name assigned earlier was replaced by current site name--see also Table ES-1.)
AUS-106A	1	Drum Disposal	Disposal area with about 50 to 100 rusted drums of unknown material.
AUS-0107	<1	Possible Disposal Area NW of Area 8	Possible disposal area based on historic aerial photographs.
AUS-0108	<1	Possible Disposal Area SE of COC-10	Possible disposal area based on historic aerial photographs.

TABLE ES-3
AUS OU SITES RECOMMENDED FOR REMEDIAL INVESTIGATION

CRAB ORCHARD NATIONAL WILDLIFE REFUGE
MARION, ILLINOIS

Site	Past/Present Usage	Notable Contamination
Area 2 Sites		
AUS-0A2B (Area 2B)	Booster Loading Line during Illinois Ordnance Plant (IOP) era (1942-1945); Various uses by subsequent ordnance manufacturers including propellant manufacturing and explosive waste incineration. Major tenants: UMC (1952± to 1963) and Olin/Primex/GDO&TS (1963 –present).	TCE in groundwater at 47 ug/L *(MCL = 5 ug/L)*. PCE and dichloroethene also in groundwater. TCE and PCE in soils. 18 SVOCs in soils. Most inorganics in soils: antimony at 56 mg/kg *(background = 0.8 mg/kg)*, chromium at 104 *(background = 25 mg/kg)*, mg/kg, copper at 1,560 mg/kg *(background = 11 mg/kg)*, lead at 2,000 mg/kg. *(background=23 mg/kg)*. Several inorganics exceeded standards in a drum sample. Illinois surface water standards exceeded for some metals.
AUS-0A2D (Area 2D)	Detonator Loading Line during IOP era; used for R&D, pyrotechnic manufacturing, propellant mixing, machining and milling by post-WWII industrial tenants. Surface disposal of solvents and burning of explosive waste reported. Major tenants: UMC (1953-1963) and Olin/Primex/GDO&TS (1964-present).	TCE in groundwater at 54,000 ug/L *(MCL = 5 ug/L)*. Other VOCs in groundwater: trichloroethane, dichloroethene, chloroform, PCE, vinyl chloride. VOCs and SVOCs in soils. RDX in soil. Most inorganics in soils. Arsenic at 120 mg/kg *(background = 13 mg/kg)*; chromium at 97 mg/kg, copper at 937 mg/kg; silver at 40 mg/kg *(background = 0.6 mg/kg)*; zinc at 1,060 mg/kg *(background = 51 mg/kg)*.
AUS-0A2F (Area 2F)	Fuse Loading Line during IOP era; various uses by subsequent ordnance manufacturer tenants, including milling, machining and R&D. Surface disposal of TCE and cutting oils reported. Major tenants: UMC (1959-1961) and Olin/Primex/GDO&TS (1970-present).	TCE in groundwater at 2,400 ug/L *(MCL=5 ug/L)*. Other groundwater exceedances of screening criteria: dichloroethene and PCE. VOCs and SVOCs in soils; most metals in soils.
AUS-0A2P (Area 2P)	Artillery Primer Line during IOP era; gas generator/propellant development and production, metal working/ machining by later industrial tenants. Major tenants: Olin/Primex/GDO&TS (1957-present).	TCE in groundwater at 120,000 ug/L *(MCL = 5 ug/L)*. Other groundwater exceedances: trichloroethane, dichloroethene, dichloroethane, PCE, vinyl chloride, perchlorates, phosphorous and nitrogen. VOCs and SVOCs in soils. Most metals in soils, including silver as high as 237 mg/kg.
AUS-0A2R (Area 2R)	Railroad spur/loading dock used by IOP and Area 2 tenants.	PAHs and most metals in soils.

TABLE ES-3
AUS OU SITES RECOMMENDED FOR REMEDIAL INVESTIGATION

CRAB ORCHARD NATIONAL WILDLIFE REFUGE
MARION, ILLINOIS

Site	Past/Present Usage	Notable Contamination
Areas 11/12 Sites		
AUS-A11A (Area 11-Acid/AN)	Part of Group II Load Line during IOP era. Post World-War II tenants manufactured nitric acid and ammonium nitrate for nitroglycerin production. Area includes disposal pond. Major tenants: Olin (1956-1963) and CSC/IMC (1964-1982; production ended in 1969).	Phosphorus and nitrate-nitrite in groundwater. SVOCs in soil and sediment. 2,4-dinitrotoluene and n-nitrosodiphenylamine in sediments. Most inorganics in soil and sediment. Illinois surface water quality standards exceeded for some metals.
AUS-A11H (Area 11-High Explosives)	Part of Group II Load Line during IOP era. Tenant use for manufacturing high explosives, including dynamite, ANOIL, and products containing PETN, TNT, and RDX. Major tenants: Olin (1956-1963) and CSC/IMC (1964-1982; production ended about 1969).	Dichloroethene, TCE, and PCE in soil. Most SVOCs in soil and sediment, including n-nitrosodiphenylamine, carbazole, and pentachlorophenol. Explosives in soil: HMX, nitrobenzene, nitroglycerin, 1,3-dinitrobenzene, 2,4- and 4,6-dinitrotoluene. Most inorganics in soil and sediment. Soil: cadmium at 204 mg/kg and chromium at 585 mg/kg. Nitrate-nitrite and phosphorus in groundwater.
AUS-A11N (Area 11-Nitroglycerin)	Part of Group II Load Line during IOP era. Area used from 1950s to late 1960s for manufacture of nitroglycerin. Includes holding pond for wash water. Major tenants: Olin (1956-1963) and CSC/IMC (1964-1982; production ended around 1969).	SVOCs and metals in soil. Illinois surface water quality standard exceeded for some metals. Lead in soil at 568 mg/kg.
AUS-A11P (Area 11-CAP/Propellant)	Part of Group II Load Line, used for cleaning and painting shells (IOP). Post World War II tenant use: propellant research and cap manufacturing. Major tenants: Olin (1956-1963) and CSC/IMC (1964-1982; production ended in early 1970s).	TCE and PCE in groundwater above SI screening criteria, but just below MCLs. SVOC in soil and sediment. 2,4-dinitrotoluene and n-nitrosodiphenylamine in soil. Most metals in soil and sediment. Some metals exceeded Illinois surface water quality standards.
AUS-A11S (Area 11-Support)	Part of Group II Load Line during IOP era. Post-war tenant use as support facility for explosives manufacturing plant. Included machine shop, scrap yard, boiler, tanks, storage areas. Major tenants: Olin (1956-1963) and CSC/IMC (1964-1982; production ended in early 1970s).	TCE in groundwater at 280,000 ug/L. Other contaminants that exceed SI screening criteria for groundwater are: cis-1,2-dichloroethene, naphthalene, TNT, phosphorus, and sulfate. Several chlorinated VOCs exceeded SI screening criteria in soils. 2,4-dinitrotoluene in soil exceeded screening criteria, as did many PAHs and three phthalates. Maximum detections of most inorganics exceeded SI screening criteria in soils and/or sediments. Several metals exceeded Illinois surface water quality standards.

TABLE ES-3
AUS OU SITES RECOMMENDED FOR REMEDIAL INVESTIGATION

CRAB ORCHARD NATIONAL WILDLIFE REFUGE
MARION, ILLINOIS

Site	Past/Present Usage	Notable Contamination
AUS-0A12 (Area 12)	Ammonium Nitrate (AN) Plant during IOP era. RDX manufacturing from 1960s to 1970s. Includes ponds used for explosive storage, burn pits used for explosive waste disposal from 1950s to 1980s. Also includes dump sites. This area was used for burning of all Olin waste from 1956-1964.	Arsenic, beryllium, chromium and lead in groundwater. Carbon tetrachloride, chloroform, dichloroethene, methylene chloride, PCE and TCE in soil. SVOCs in soil and sediment. 2,4- and 2,6-dinitrotoluene and n-nitrosodiphenylamine in soil and/or sediment. PCBs in soil. Most metals in soil, some in sediment. Metals in soil, including cadmium at 15mg/kg, chromium at 4,010 mg/kg, copper at 846 mg/kg, lead at 7,270 mg/kg, zinc at 1,970 mg/kg. Illinois surface water quality standards exceeded for some metals.
Other Sites in Designated Refuge Industrial Areas		
AUS-0A4E (Area 4 East)	Industrial shop area during IOP era, included gas station, wash and degreasing building. Numerous tenants.	Copper in soil at 816 mg/kg.
AUS-0A4W (Area 4 West)	Industrial shop area during IOP era included machine shop, electric and communication building, IOP laboratory. Post-WWII activities included industrial tenant plating operation. Numerous tenants.	SVOCs and most metals in soils, including: arsenic at 60 mg/kg, cadmium at 4,520 mg/kg, chromium at 298 mg/kg, zinc at 780 mg/kg.
AUS-0A06 (Area 6)	Explosive storage area during IOP era; storage of explosives, pesticides and other materials by post-WWII industrial tenants. Numerous tenants. GDO&TS and Ensign Bickford are current tenants.	SVOCs, metals and nitrobenzene in soil. N-nitroso-di-n-propylamine (carcinogen) at 41 ug/kg *(SI screening criteria = 0.002 ug/kg)* N-nitrosodiphenylamine and pentachlorophenol (carcinogens) also exceeded screening. Pesticide storage area not investigated.
AUS-0A07 (Area 7)	Inert Storage Area during IOP era. Area consists of 30 large buildings which have been leased to a number of industrial tenants. Activities included pesticide storage, metal forming, oil transfer, and warehousing.	TCE in soil at most sampling locations; groundwater concentrations unknown (no groundwater wells were installed). Pesticides: aldrin, 520 mg/kg *(SI soil screening criteria = 0.15 mg/kg)*, dieldrin, 290 mg/kg *(SI soil screening criteria = 0.15 mg/kg)*. Also, DDE, DDT, DDD, chlordane, heptachlor, and other pesticides.
AUS-0A8S (Area 8 South)	TNT melt Load Line III during IOP era. Used by later industrial tenants for explosive/propellant manufacturing and manufacturing of fiberglass boats.	Most contamination limited to far south end of site. 2,4-dinitrotoluene in soil at 1,400 ug/kg *(SI soil screening criteria = 0.04 ug/kg)*. 2,6-dinitrotoluene at 100 ug/kg in soil. Sediment: arsenic at 63 mg/kg, copper at 3,330 mg/kg; lead at 665 mg/kg, zinc at 1,800 mg/kg.

TABLE ES-3
AUS OU SITES RECOMMENDED FOR REMEDIAL INVESTIGATION

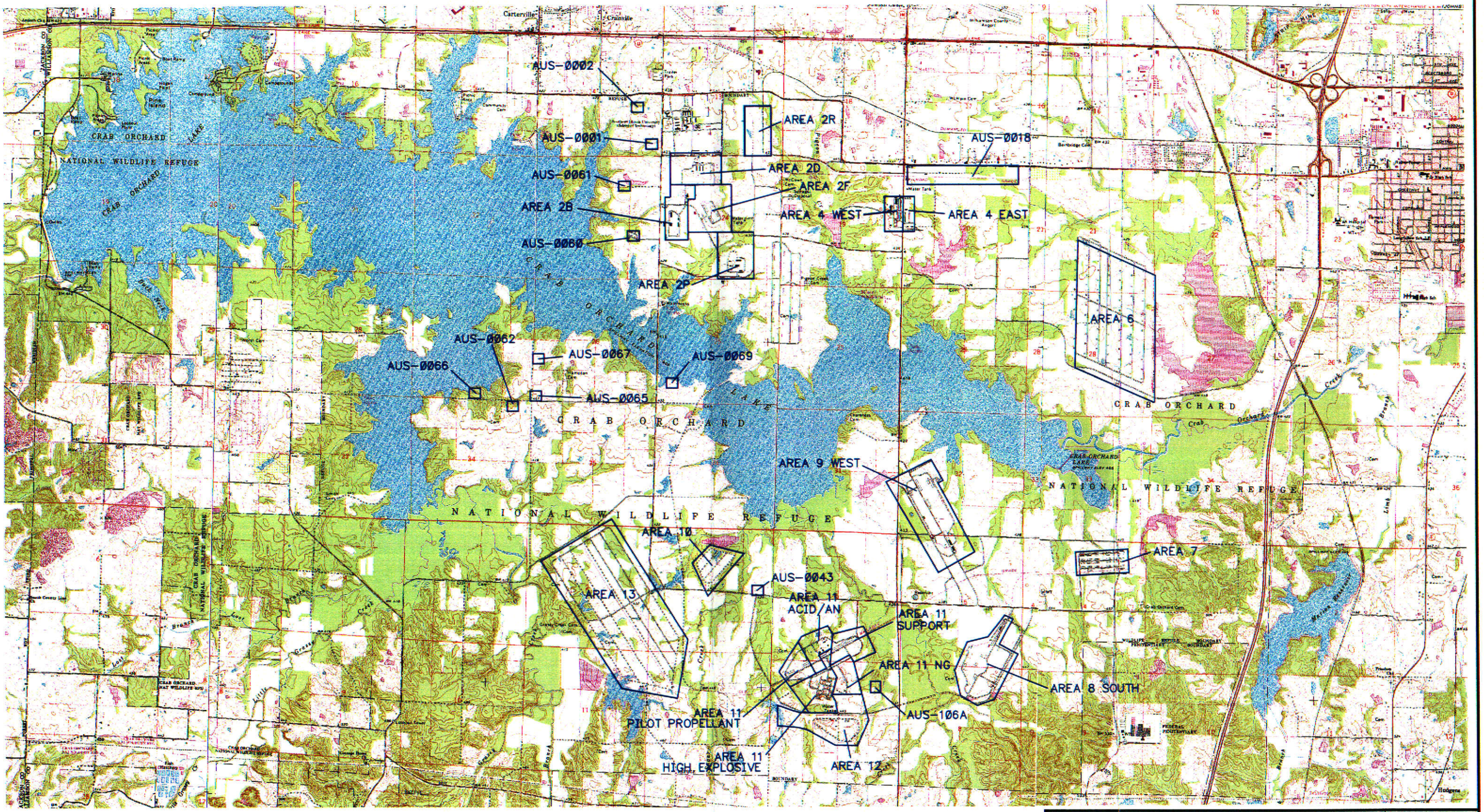
CRAB ORCHARD NATIONAL WILDLIFE REFUGE
MARION, ILLINOIS

Site	Past/Present Usage	Notable Contamination
AUS-0A09 (Area 9)	TNT melt Load Line I during IOP era. Subsequently used by industrial tenants for transformer/capacitor and explosive/ordnance manufacturing. Significant remediation has been done but not all areas of potential contamination have been investigated. Major tenants: Sangamo (1946-1962) and Olin/Primex/GDO&TS (1967-present).	SVOCs, most metals, 2,4-dinitrotoluene at 2,100 ug/kg in soil.
AUS-0A10 (Area 10)	Fuse and Booster Storage Magazine area during IOP era. Area used later for burn pits and firing range. Olin used this area for incineration of all its production wastes from 1967-1970.	TCE in soil; no groundwater wells were installed during site inspection. Soil: barium at 14,100 mg/kg *(background=195 mg/kg)*, boron at 513 mg/kg *(background=5 mg/kg)*.
AUS-0A13 (Area 13)	Finished Ammunition Igloos during IOP era; used by later tenants for explosives storage.	SVOCs and most metals in soil. 2,4-dinitrotoluene (64,000 ug/kg), 2,6-dinitrotoluene, n-nitrosodiphenylamine and nitoglycerin in soil. Chromium at 155 mg/kg in soil.
COC Area Sites		
AUS-0062	Mounds and pits 100 yards west of COC-1; probable former landfill site.	TCE in soil. (No groundwater wells were installed during site inspection). Most ino found in sediment, some in soil.
AUS-0065	Foundations northeast of COC-1; possible detonation/disposal area used by Army after World War II.	SVOCs and inorganics in soil.
AUS-0066	Berm with red brick rubble near COC-14; possible detonation/disposal area used by Army after World War II.	SVOCs and metals in soils and sediment. Cadmium at 36 mg/kg in sediment *(background=1.6 mg/kg)*, zinc at 447 mg/kg *(background=57 mg/kg)*. Some exceedances of Illinois water quality standards for metals.
AUS-0067	Fence with "contaminated area" sign northwest of COC-6; possible detonation/disposal area used by Army after World War II.	2,6-dinitrotoluene was detected in a sample of cistern water. The explosive tetryl was detected at low levels.
AUS-0069	Dump near south shore of Crab Orchard Lake used during IOP era.	PCE in soil. SVOCs, most metals in soil and sediment. Soil: antimony at 173 mg/kg; barium at 4,940 mg/kg; cadmium at 28 mg/kg; chromium at 266 mg/kg; lead at 51,000 mg/kg; zinc at 16,400 mg/kg.

TABLE ES-3
AUS OU SITES RECOMMENDED FOR REMEDIAL INVESTIGATION

CRAB ORCHARD NATIONAL WILDLIFE REFUGE
MARION, ILLINOIS

Site	Past/Present Usage	Notable Contamination
Other Small Sites		
AUS-0001	IOP Fire and Police Headquarters.	SVOCs and metals in soils. Soil: arsenic at 535 mg/kg; zinc at 1410 mg/kg.
AUS-0002	IOP wastewater treatment plant that served the administration area and probably also part of Area 2.	Metals in soil. Soil: chromium at 737 mg/kg, silver at 99 mg/kg.
AUS-0018	IOP railroad classification yard.	Metals in soil: arsenic, barium, lead, and nickel.
AUS-0043	IOP fire station east of Area 10.	SVOCs, 2,6-dinitrotoluene, and several metals in soil. Lead at 1,110 mg/kg in soil.
AUS-0060	Original use as storage area for mercury fulminate and lead azide during IOP era; later used for other explosive storage.	Metals in soil: arsenic, lead, mercury. Lead concentration well in excess of background and site screening levels (USEPA 1998).
AUS-0061	Concrete structures probably used during IOP era for testing explosives. Nearby 20-acre site identified as probable IOP trench disposal area based on aerial photographs.	SVOCs and most metals in soils at detonation area. Cadmium at 91 mg/kg, mercury at 1.1 mg/kg in soil. Disposal area not investigated.
AUS-106A	Disposal area with about 50 to 100 rusted drums containing unidentified material.	Benzene and TCE in drums. TCE (13,000 ug/kg) and dichloroethene in soil. (no wells at site). Most inorganics in drums and soil. Maximum soil results, e.g., cadmium at 150 mg/kg, chromium at 239 mg/kg, copper at 3,300 mg/kg, lead at 2,470 mg/kg, selenium at 22 mg/kg, zinc at 3,160 mg/kg. The explosives tetryl and HMX were detected in soil, but below SI screening criteria.



PA/SI REPORT–AUS OU
CRAB ORCHARD NWR
MARION, ILLINOIS

PROJECT NO.
2320000026.00

URS

DRN. BY: djd 9/7/99
DSGN. BY:cmw
CHKD. BY:cmw

AUS OU Sites Recommended for Remedial Investigation

FIG. NO.
ES–1

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ACRONYM LIST
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ACRONYM	DEFINITION
$3S_b$	Mean plus three standard deviations
A.N.	Ammonium Nitrate
ARAR	Applicable, Relevant and Appropriate Requirements
AOC	Area of Concern
AST	Aboveground Storage Tank
ASTER	Assessment Tools for the Management of Risk (USEPA database)
AUS OU	Additional Uncharacterized Sites Operable Unit
BGS	Below Ground Surface
BNA	Base-Neutral Acids
BOD	Biological Oxygen Demand
BOR	U.S. Bureau of Reclamation
BRA	Baseline Risk Assessment
BTAG	Biological Technical Assistance Group
BTOC	Below Top of Casing
BWT	Below Water Table
CCME	Canadian Council of Ministers of the Environment
CERCLA	Comprehensive Environmental Response Compensation and Liability Act of 1980 (a.k.a. Superfund)
CIA	Central Intelligence Agency
CIPS	Central Illinois Public Service
CLP	Contract Laboratory Program
CM/SEC	Centimeters per Second
COC	Chain-of-Custody
COC	Chemical of Concern
COC	Crab Orchard Cemetery
COI	Chemical of Interest
COL	Crab Orchard Lake
CONWR	Crab Orchard National Wildlife Refuge
COP	Crab Orchard Pond
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSC	Commercial Solvents Corporation
CSEQGs	Canadian Sediment Quality Guidelines
CSOQGs	Canadian Soil Quality Guidelines
CTI	Central Technologies Incorporated
CVOC	Chlorinated Volatile Organic Compounds
CWQG	Canadian Water Quality Guidelines
DAF	Dilution Attenuation Factor
DEHP	bis(2-ethylhexyl)phthalate
DERP	Defense Environmental Restoration Program
DGOLs	New Dutchlist Groundwater Optimum Levels
DNT	Dinitrotoluene
DOD	Department of Defense
DOI	U.S. Department of the Interior

ACRONYM LIST
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ACRONYM	DEFINITION
DQCR	Daily Quality Control Reports
DQO	Data Quality Objective
DRO	Diesel Range Organics
DSOLs	New Dutchlist Soil Optimum Levels
DTW	Depth to water
DU	Depleted Uranium
EMMA OU	Explosives and Munitions Manufacturing Area Operable Unit
EPA	U.S. Environmental Protection Agency
EqP	Equilibrium Partitioning
ERL	Effects-Range Low
ERM	Effects-Range Medium
ESV	Ecological Screening Value
FDAP	Field Director of Ammunition Plants
FFA	Federal Facility Agreement
FID	Flame Ionization Detector
FOIA	Freedom of Information Act
FNH	Flashless Non-hydroscopic Powder
FS	Feasibility Study
FSP	Field Sampling Plan
FT	feet or foot
FWS	U.S. Fish and Wildlife Service
GPS	Global Positioning System
GRO	Gasoline Range Organics
GSA	General Services Administration
GW	Ground Water
HBX	High Blast Explosives
HE	High Explosives
HEDP	High Explosive Detonation Product
HEI	High Explosives Igniter
HMX	Her Majesty's Explosive (Cyclotetramethylenetetranitramine)
HQ	Hazard Quotient
HSA	Hollow Stem Auger
HSP	Health and Safety Plan
IAC	Illinois Administrative Code
IDW	Investigation Derived Waste
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
IOP	Illinois Ordnance Plant
K_{ow}	Octanol-to-Water Partitioning Coefficient
LAW	Light Antitank Weapon
LOEC	Lowest Observed Effects Concentration
MAOU	Metals Area Operable Unit
MATC	Maximum Acceptable Toxicant Concentration

ACRONYM LIST
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ACRONYM	DEFINITION
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MG/KG	milligrams per kilogram
MG/L	milligrams per liter
MHSPE	Ministry of Housing, Spatial Planning, and the Environment
MISCA OU	Miscellaneous Areas Operable Unit
MM	millimeter
MOCA	4,4' - Methylenebis (2-chloroaniline)
MSDS	Material Safety Data Sheets
MSL	Mean Sea Level
MW	Monitoring Well
NA	Not analyzed
NA	Not applicable
NAPL	Non-aqueous Phase Liquid
NEC	No Effect Concentration
NCP	National Contingency Plan
ND	Not detected
NG	Nitroglycerin
NG/KG	Nanograms per kilogram
NOAA	National Oceanic and Atmospheric Administration
NaOH	Caustic Soda
NOEC	No-observed-effect concentration
NPL	National Priorities List
OD	Outside Diameter
OE	Ordnance and Explosives
OEW	Ordnance and Explosive Waste
OFDAP	Ordnance Field Director of Ammunition Plants
OU	Operable Unit
PA	Preliminary Assessment
PAH	Polynuclear Aromatic Hydrocarbons
PA/SI	Preliminary Assessment/Site Investigation
PBX	Plastic Bonded Explosives
PCB	Poly-chlorinated Biphenyl
PCB OU	PCB Operable Unit
PCE	Tetrachloroethylene
PEC	Probable Effect Concentration
PEL	Probable Effect Level
PETN	Pentaerythritol Tetranitrate
PID	Photo Ionization Detector
PLC	Preliminary Levels of Concern
PM	Project Manager
PPB	Parts Per Billion
PPE	Personnel Protection Equipment

ACRONYM LIST
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ACRONYM	DEFINITION
PPM	Parts Per Million
PRG	Preliminary Remediation Goals
PRP	Potentially Responsible Party
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QCSR	Quality Control Summary Report
R&D	Research & Development
RAGS	Risk Assessment Guidance for Superfund (USEPA document)
RCRA	Resource Conservation and Recovery Act
RDX	Royal Demolition Explosive (Cyclonite)
RI	Remedial Investigation
RI/FS	Remedial Investigation / Feasibility Study
RL	Reporting Limit
ROD	Record of Decision
RR	Railroad
RRTC	Railroad Tank Car
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act (1986)
SI	Site Investigation
SIU	Southern Illinois University
SMCL	Secondary Maximum Contaminant Level
SMDP	Scientific Management Decision Point
SOP	Standard Operating Procedure
SPO	Solid Propellant Operations
SSLs	Soil Screening Levels (USEPA)
SVOC	Semi-volatile Organic Compound
SWDC	Sherwin Williams Defense Corporation
TACO	Tiered Approach to Corrective Action Objectives
TAL	Target Analyte List
TBD	To Be Determined
TCDD	Tetrachlorodibenzo-p-Dioxin
TCE	Trichloroethylene
TCL	Target Compound List
TDS	Total Dissolved Solids
TEC	Threshold Effect Concentration
TEL	Threshold Effect Level
TEQ	Toxicity Equivalent for Dioxins/Furans
TNT	Trinitrotoluene
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TRPH	Total Recoverable Petroleum Hydrocarbons
TRV	Toxicity Reference Value

ACRONYM LIST
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ACRONYM	DEFINITION
TSS	Total Suspended Solids
UET	Upper Effect Threshold
UG/KG	micrograms per kilogram
UG/L	micrograms per liter
UMC	Universal Match Corporation
USACE	U.S. Army Corp of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
ECOTOX	Ecological Toxicity Database
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
UXO	Unexploded Ordnance
VJ Day	Victory over Japan day (August 15, 1945)
VOCs	Volatile Organic Compounds
WAA	War Assets Administration
WSA	West Shop Area
WWII	World War II
WWTP	Wastewater Treatment Plant

This is the Preliminary Assessment/Site Inspection (PA/SI) Report for the Additional and Uncharacterized Sites Operable Unit (AUS OU) of the Crab Orchard National Wildlife Refuge (Refuge) National Priority List (NPL) Site in Marion, Illinois.[1] The Refuge is administered by the United States Department of Interior (USDOI), Fish and Wildlife Service (USFWS). The PA/SI work was done under URS' contract with the USDOI Bureau of Reclamation (BOR)[2]. The activities were conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Additionally, the United States Environmental Protection Agency (USEPA) *Guidance for Performing Preliminary Assessments under CERCLA,* and *Guidance for Performing Site Inspections under CERCLA, 'Interim Final'* were used, except that the sites were not scored.

1.1 GENERAL REFUGE HISTORY

The Refuge is located about 5 miles west of the City of Marion in Williamson, Jackson, and Union Counties in southern Illinois (Figure 1-1). It includes 43,500 acres of forests, grassland areas, cropland, wetlands, and industrial areas.

A portion of the area now occupied by the Refuge was the Illinois Ordnance Plant (IOP) during World War II. The IOP was managed by the War Department, a predecessor to the current Department of Defense (DOD). From 1942 to 1945, The Sherwin Williams Defense Corporation operated the IOP under contract with the War Department (SWDC/War Department) for the manufacture of military ordnance. The IOP occupied some 22,000 acres and contained some 534 buildings and various utilities, including steam generating, water, sewage and wastewater treatment facilities and a railroad line. IOP operations consisted of seven load lines: three were 2,4,6-trinitrotoluene (TNT) melt-pour operations for shells, bombs and mines; the other four were for boosters, detonators, primers and fuses for the shells, bombs and mines.

There were 14 separate areas of IOP activity which were identified by the functions performed in them during World War II. Later the various IOP areas were given numbers (Areas 1-14). These area numbers (and many of the old IOP building numbers) have survived and are still in use today. The 14 industrial areas, their IOP names and the building prefixes in the various areas are presented in Table 1-1

On VJ Day, September 2, 1945, operations ceased and the IOP was transferred to the War Assets Administration (WAA) for disposition. In 1947 an Act of Congress transferred the old IOP area, together with an additional 21,500 acres, to the Department of the Interior, thereby creating the Crab Orchard National Wildlife Refuge. The enabling legislation assigned USDOI the responsibility of managing the area as a wildlife refuge, with the additional missions of supporting recreation, agriculture and industrial use.[3]

[1] The Crab Orchard National Wildlife Refuge was placed on the U.S. Environmental Protection Agency's National Priorities List (NPL) in 1987. 52 Fed. Reg. 27620, 27265 (July 22, 1987). Since then seven operable units have been created at the NPL Site, which is referred to as the "Site." Areas within the various operable units are referred to as "sites."
[2] Contract No. 1425-97-CA-81-20003, dated November 15, 1996. Delivery Order No. 178.
[3] Act of August 5, 1947, Public Law No. 80-361, 16 USC§§ 666f-666g.

Over the years, some 200 tenants have operated manufacturing and/or storage facilities under lease to the DOI USFWS at the Refuge. Many of these have been small businesses or short-term tenants. Larger and/or longer term tenants have included manufacturers of ordnance and explosives, electrical components, inks and printing materials, machined and plated metal parts, various painted products and boats. Over time, the principal tenant has been the Olin Corporation (formerly Olin Mathieson Chemical Corporation) and its successors, Primex Technologies, Inc. (Primex), now General Dynamics Ordnance and Technical Systems, Inc. (GDO&TS),[4,5] a subsidiary of General Dynamics Corporation, which has operated ordnance/explosives manufacturing and storage facilities in several industrial areas on the Refuge since 1956. Table 1-2 summarizes the 14 industrial areas according to IOP usage and subsequent industrial tenant use.

Table 1-3 is a current Refuge tenant roster as of March 2001. In addition to the specific buildings listed in Table 1-3, some of the current tenant leases include acreage within fenced areas to which only the tenant has access. Historically, such arrangements were usually designed to ensure secure access and buffer zones for the explosives or ordnance manufacturing operation within the area.

1.2 HISTORY RELATED TO CERCLA

In the 1970s, the State of Illinois identified poly-chlorinated biphenyl (PCB) and cadmium contamination during a watershed-wide study at the Refuge[6]. A 1982 USFWS study identified PCB and lead contamination in Area 9. On the basis of the Area 9 contamination, the Refuge was placed on the National Priority List (NPL) on July 22, 1987.

O'Brien and Gere conducted a Remedial Investigation (RI) in 1988 and a Feasibility Study (FS) in 1989.[7,8] The major focus of the Remedial Investigation/Feasibility Study (RI/FS) was the "Sangamo Dump" (Sites 32/33) and other sites contaminated with PCBs. The O'Brien and Gere RI also addressed other sites and was originally thought to be a "Refuge-wide" RI. However, little historic research was done prior to the investigation. There was little understanding of the past industrial usage, and sites were apparently identified based primarily on oral information from USFWS employees at the Refuge. Consequently, large areas of past industrial usage and potential contamination were not identified.

The O'Brien and Gere RI/FS identified seven sites that posed unacceptable risks to human health and the environment, and proposed remediation for those sites. Three of those sites were contaminated primarily with metals and the other four sites were contaminated primarily with PCBs.

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[4] General Dynamics Ordnance and Tactical Systems, Letter to Crab Orchard National Wildlife Refuge regarding Building and Igloo Lease Contract No. 14-16-0003-96-579, changing Primex's name to General Dynamics Ordnance and Tactical Systems, Inc., dated January 29, 2001.

[5] Amendment No. 13 to Building and Igloo Lease Contract No. 14-16-0003-96-579, Primex Technologies, Inc., effective January 29, 2001; and, Crab Orchard National Wildlife Refuge, Letter to General Dynamics Ordnance and Tactical Systems, Inc. enclosing Amendment No. 13 regarding the Primex name change, dated March 13, 2001.

[6] Illinois Environmental Protection Agency, 1977. *Biological Investigation of the Crab Orchard Creek Basin, Summer 1975*, by Robert L. Hite and Marvin King.

[7] O'Brien & Gere, 1988. *Remedial Investigation Report, Crab Orchard National Wildlife Refuge*, August, 1988.

[8] O'Brien & Gere, 1989. *Feasibility Study, Crab Orchard National Wildlife Refuge*, August, 1989.

As a result of the 1988-89 RI/FS, the Metals Areas Operable Unit (MAOU) and the PCB Operable Unit (PCB OU) were formed. These OUs were defined loosely by contaminants, and sites within them are not necessarily contiguous or even in the same industrial area. Records of Decision (RODs) for both the PCB and Metals OUs were signed in 1990.[9,10]

USDOI, the Department of the Army, the USEPA, and the Illinois Environmental Protection Agency (IEPA) are actively involved in the site remediation process under Section 120 of the Comprehensive Environmental Response Compensation and Liability Act/Superfund Amendments and Reauthorization Act (CERCLA/SARA) and the Defense Environmental Restoration Program (DERP). These agencies entered into a Federal Facilities Agreement (FFA) in 1991,[11] which defined roles and responsibilities for the CERCLA investigations and remediation.

In addition to the PCB OU and the MAOU, the Miscellaneous Areas Operable Unit (MISCA OU) was formed to investigate sites identified by O'Brien and Gere as requiring additional investigation and/or monitoring or maintenance. The FFA assigns the USDOI the role of lead agency for the MISCA OU. The RI for the MISCA OU was completed in 1996. The RI Addendum for Site 14 of the MISCA OU was completed in 1999.[12] Two sites in the MISCA OU, Site 14 and Site 36, were later identified as requiring remediation. Draft final RODs have been prepared for these sites.

The Explosives/Munitions Manufacturing Areas Operable Unit (EMMA OU) was created to include sites contaminated with chemicals from World War II explosives and heavy metals associated with munitions manufacturing, for which the DOD has responsibility. The ROD for the EMMA OU was signed in 1997[13] and remediation is nearly complete. A removal action was conducted at some sites for unexploded ordnance (UXO) only.

USDOI has created three other OUs: Lake Monitoring, Water Towers, and the AUS.

USDOI formed the AUS OU from 1997 to 1999 to address potential releases of hazardous substances not included in existing OUs at the Refuge. The intention was that the AUS OU would be the last OU for this NPL site. Table 1-4 lists the 83 sites originally designated by the USFWS for the AUS OU.

Some sites in other OUs are in the vicinity of current AUS OU sites. Results from previous investigations at these other sites, which may impact the AUS OU, are discussed in the relevant sections of this report.

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[9] U.S. Environmental Protection Agency, 1990b. *Declaration for the Record of Decision, Crab Orchard National Wildlife Refuge, PCB Areas Operable Unit*, August 1, 1990.

[10] USEPA, Region V, *Declaration for the Record of Decision, Crab Orchard National Wildlife Refuge, Metals Areas Operable Unit*, March 30, 1990.

[11] U.S. Environmental Protection Agency, Region V, and the Illinois Environmental Protection Agency, and the United States Department of the Interior, and the United States Department of the Army, 1991. Federal Facilities Agreement Under CERLCA Section 120, in the Matter of the U.S. Department of the Interior's Crab Orchard National Wildlife Refuge. September 1991.

[12] DPRA Document No. 00003705. U.S. Department of the Interior, U.S. Fish & Wildlife Service, Draft Final RI Addendum Report, Sites 14 and 36 Investigation, Miscellaneous Areas Operable Unit, Crab Orchard National Wildlife Refuge Superfund Site, Marion, Illinois (Williamson County), September 1999.

[13] U.S. Environmental Protection Agency, Region V, 1997. Record of Decision for Crab Orchard National Wildlife Refuge Explosives/Munitions Operable Unit.

All OUs and their current status are summarized in Table 1-5.

1.3 PURPOSE OF THE PA/SI

The purpose of this investigation was to gather sufficient information to determine whether releases of hazardous substances to various environmental media (i.e., soils, sediment, surface water, and groundwater) have occurred, and if they have, whether they pose a potential threat to human health or the environment.

One of several decisions could result from review of this report:

- Conclude that a threat is unlikely, and recommend no further action.
- Conclude there is a potential threat and recommend a remedial investigation.
- Conclude there is an imminent threat and recommend a removal action.

1.3.1 PA (Historic Search)

The PA historic search involved evaluating available information on the history and nature of industrial activity on the Refuge as well as historic waste disposal and other practices that may have contributed to or resulted in potential releases of hazardous substances.

Sites judged to have significant potential for releases of hazardous substances, based on past usage, were retained for further evaluation in the SI.

The historic search material contained in this report supersedes the material presented in the Draft Historic Search Report for the AUS OU (September 1999).

Data from a USEPA 1998 investigation of AUS OU sites[14] were compared to the PA screening criteria described in Section 2.5 of this report. Sites with contaminant levels exceeding the screening criteria were retained for further evaluation in the SI.

As stated above, the original purpose of the PA was to evaluate the original list of 83 sites developed by USFWS to determine which sites warranted further action and which did not. Information from the historic search and site visits soon revealed that there were uninvestigated areas of potential releases on the Refuge that were not included in the original list of 83 sites or in other operable units on the Refuge.

The end result of the process was a revised list of AUS OU sites recommended for the SI, the second phase of screening. The locations of the revised sites that were included in the SI are shown in Figure 1-2. While some of the original 83 sites were determined to require no further action based on the PA, the areal extent of the revised sites is considerably greater than that of the original 83 sites, which were mostly very small in area. The revised sites include large parts of former or current industrial areas which had never been previously investigated and that were not on the original list of 83 sites.

[14] In 1998 the USEPA conducted limited sampling at a number of the original AUS OU sites. No report was prepared, but the unreviewed laboratory analytical data, plus survey locations for most points were provided.

1.3.2 Site Investigation

The SI included development of new screening criteria, a field investigation, and development of additional background data. The screening criteria developed for the SI are presented in Section 2.6.

1.4 METHODOLOGY FOR THE PA (HISTORIC RECORDS SEARCH)

The methods used to evaluate the original AUS OU sites designated by USFWS in 1997-1999, and to identify the final list, are summarized below.

1.4.1 Site Visits

Site visits were done at each of the original AUS OU sites. The site visits consisted of a thorough reconnaissance and documentation (by field notes, photographs, and site sketches) of all relevant site features observed at the time of the visit. This included topography, drainage features, vegetation, evidence of past releases, and documentation of any potentially relevant anthropogenic features. Standard forms were developed and used for the site visits. The site visit reports were included as Appendix A of the draft Historic Search Report (September 1999) (four volumes), and are not included as part of this document.

The original intent of the historic records search was to complete a review of existing data and then complete the site visits. However, because of scheduling and technical issues, the site visits were done first[15].

1.4.2 Records Search

Hundreds of documents were reviewed and are referenced in this report. Documents included technical investigation reports, potentially responsible parties (PRP) search reports, information and documents obtained from CERCLA Section 104(e) requests, interviews and CERCLA administrative depositions, Army documents, correspondence, newspaper articles, contracts, Refuge annual reports, and tenant leases. Many of the documents are referenced by their "Bates number", a unique number stamped on the document for legal purposes. This information was used to determine sampling locations for the Field Sampling Plan (FSP) for the AUS OU SI.

1.4.3 Interviews and Depositions

Several interviews of former employees at the Refuge were conducted in the course of early PRP search investigations (see, e.g., TechLaw, Inc., 1992, *Final Draft Report, Site Operations/Ownership History, Crab Orchard National Wildlife Refuge*) and are referenced in this report. In addition, a number of interviews of former industrial tenant employees were conducted in the 1997-1999 time period. Some candidates were identified by responses to a newspaper advertisement or from names found in the record review, or by referral from other interviews. Other candidates were identified in preliminary interviews by civil investigators.

[15] The notice to proceed for the work was issued in early March of 1999. Many of the sites are in remote, heavily vegetated areas. Therefore, to effectively conduct the site visit, most the work had to be completed by mid-April 1999, before the vegetative cover would obscure site features. This required that site visits be done first.

CERCLA administrative depositions were taken of several of these individuals. Table 1-6 is a list of the people who were interviewed in the 1997-1999 time period, as part of the PA. Notes from interviews listed in Table 1-6 are contained in Appendix D.

1.4.4 Historical Aerial Photography

Entech, Inc. did aerial photography interpretation of most of the AUS OU, using a series of historic aerial photographs from various government archives that dated from 1943 to 1993. As noted above, the photographs were used to identify and bracket in time such features as potential solid and liquid waste disposal sites and areas of industrial activity. This information was used in the development of the FSP for the SI to supplement and confirm information from other sources.

1.4.5 Documentation

Site summary forms and site evaluation forms for the PA were prepared and approved by the BOR and USFWS in the early planning stages of the project. The intention was that relevant data obtained from the site visit, the records search, and the interviews would be summarized and referenced on the site summary forms (one per AUS site).

Site Summary Forms

The site summary forms briefly outlined the following information for each of the original 83 AUS OU sites, plus a site that was added during the site visits:

- Site name
- Location
- Directions to site
- Site description
- Results of previous sampling
- Results of other previous investigations at the site (if any)
- Leasing history
- Operations history
- Storage/disposal features
- Material/waste characteristics and practices
- Information from interviews/depositions

The completed site summary forms are included in Appendix E.

Site Evaluation Forms

The evaluation forms summarized only the data relevant to making a decision as to whether no further action was required, or an SI was recommended along with a brief rationale (one per AUS site).

The site evaluation forms summarized the following information for each of the original 83 sites, plus one site added during the site visits:

- Contaminants detected above screening levels in previous studies

- Other contaminants detected/not detected, relevant to site evaluation
- Documented/reported releases of hazardous substances
- Industrial activities with potential for release of hazardous substances
- Other activities with potential for release of hazardous substances
- On-site evidence of potential hazardous substances
- Other features observed during site visits related to potential or actual releases
- Water bodies/wetlands/streams that may have been impacted
- Recommendation (one of three boxes is checked: no further action warranted; a SI should be done; a removal action should be done)
- Statement of rationale for recommendation.

The completed site evaluation forms are included in Appendix F.

1.5 RESULTS OF PRELIMINARY ASSESSMENT

1.5.1 Redefinition of Areas 11 and 12

Site visits were completed at each of the original 83 AUS sites before the records search had begun. A gradual redefinition of the sites began with the Area 11/12 sites, as described below.

The original AUS Sites AUS-44 through AUS-58 were in Areas 11 and 12. During the site visits, many more features of interest were gradually revealed that had not been included in the original AUS sites. The site visits resulted in the identification of 24 potential new sites, which were tentatively designated as AUS-84A through AUS-0106A. Site visit reports were prepared for each of these new sites, and were included in Appendix A of the draft Historic Search Report (September 1999). These site designations were made based only on field observations, before any of the record review had begun. As the record review was done, it became apparent that the original site designations (AUS-44 through AUS-58, and AUS-84A through AUS-105A) bore little or no relationship to previous industrial activities in that area. For example, AUS-51 was originally designated as "Concrete slab with boosters on it." In fact, the concrete slab was part of the remains of an industrial facility, and other debris was also present in the area that was not included in the original description. On this basis, the original designations were dropped and Area 11/12, which had been used primarily as a post-World War II explosives manufacturing facility, was then addressed in terms of the industrial activity performed in the following sub-areas:

- Area 11 Support Area (Area 11S)
- Area 11 High Explosives Area (Area 11H)
- Area 11 Acid and Ammonium Nitrate Production Area (Area 11A)
- Area 11 Pilot Propellant Plant/Cap Area (Area 11P)
- Area 11 Nitroglycerin Area (Area 11N)
- Area 12 - Former Ammonium Nitrate Plant
- Site AUS-106A – Drum Disposal Area

1.5.2 Redefinition of Other Areas

Similar site grouping issues arose in other areas and with other sites, but to a lesser extent. In most areas, the original AUS site designations did not include all the relevant features of the area

and its past usage. Rather than add more small AUS OU sites, it was decided to address sites in terms of the Refuge industrial areas 1 to 14. Industrial activity is most easily described, understood, and evaluated in terms of these areas. Accordingly, all the AUS OU located in an industrial area were regrouped into an area-wide site.

1.5.3 Recommendations for Site Inspection

Table 1-7 lists the original AUS OU sites. As discussed above, information reviewed during the records search revealed that many of the sites were actually fragments of industrial facilities that could be evaluated better when viewed together as one area. Table 1-7 also shows the recommended regrouping of many of the original AUS OU sites. Note that these newly designated areas include many site features of potential interest for the SI but which were not identified in the original site list. Table 1-7 also shows sites recommended for no further action and those recommended for a Site Inspection, and a summary of the basis for these recommendations.

Table 1-8 is the recommended revised list of AUS sites for the SI, based on the results of the PA. This table gives a brief description of each site and the rationale for including it in the revised list. Some new sites were added that were not included in the original AUS list, for example, Area 7. The sites included in the SI are shown in Figure 1-2.

The work for the SI was done in accordance with the Quality Assurance Project Plan (QAPP) and FSP (March 2000) with exceptions as noted in this report.

After the SI was completed, an additional area of concern was identified that was not part of the PA/SI. That area is Area 3, shown in Figure 1-2. Area 3 was the IOP Finished Ammunition – Group I Area (FAM) and the buildings have since been leased to industrial tenants. A preliminary investigation of Area 3 should be included in the RI for the AUS OU.

1.6 REPORT ORGANIZATION

This report consists of 14 volumes, a Book of Large Figures, plus the separate Quality Control Summary Report (QCSR), a companion document to this report which contains the laboratory analytic results from the Site Investigation. Volume I of this report includes the Executive Summary, Section 1 and Section 2. This section, Section 1, presents general information on the Refuge and the AUS OU. It also summarizes the results of the PA. Section 2 presents the results of those parts of the SI investigation that are not specific to any of the AUS sites, such as the bedrock well data and the soil, surface water and sediment background results. Section 2 also discusses the screening criteria for both the PA and the SI as well as a discussion of exposure pathways and receptors.

Sections 3 through 41 address each of 39 AUS OU sites that were ultimately investigated in the SI. These 39 sites are the result of the PA, and are different from the original list shown in Table 1-4. These 39 sites are shown in Figure 1-2.

These sites are presented in the report in the same order as they were in the FSP, as follows:

- Sections 3 through 7—Area 2 sites (Area 2B, 2D, 2F, 2P, and 2R). *Volume II.*

- Sections 8 and 9—Area 4 East and Area 4 West. *Volume III.*
- Section 10—Area 6. *Volume IV.*
- Section 11—Area 7. *Volume V.*
- Section 12—Area 8 South. *Volume VI.*
- Section 13—Area 9. *Volume VI.*
- Section 14—Area 10. *Volume VII.*
- Sections 15 through 19—Area 11 sites (Area 11A, 11H, 11N, 11P, and 11S). *Volume VIII.*
- Section 20—Area 12. *Volume VIII.*
- Section 21—Area 13. *Volume IX.*
- Sections 22 through 29—COC[16] Area Sites: AUS-62,- 63, -64, -65, -66, -67, -69, and –109. *Volume X.*
- Sections 30 through 41—miscellaneous small sites: AUS-01, -02, -18, -19, -21, -22, -43, -60, -61, -106A, -107, and –108. *Volume XI.*

Each section is structured the same, as follows:

- Section __.1 Historic Search Information
- Section __.1.1 Site Description
- Section __.1.2 Operational History and Waste Characteristics
- Section __.1.2.1 Products and Constituents (not always used)
- Section __.1.2.2 Processes and Operations (not always used))
- Section __1.2.3 Miscellaneous Information (not always used)
- Section __.1.3 Previous Sampling Results
- Section __.1.4 Observations During Site Visit
- Section __.1.5 Recommendations Based on Preliminary Assessment
- Section __.2 Site Investigation Information
- Section __ 2.1 Field Investigation
- Section __.2.2 Field Results
- Section __.2.2.1 Site Conditions
- Section __.2.2.1.1 Geologic Conditions
- Section __.2.2.1.2 Hydrogeologic Conditions
- Section __.2.2.1.3 Hydrologic Conditions
- Section __.2.2.2 Chemical Results
- Section __.3 Screening Risk Assessment
- Section __.3.1 Human Health Risk
- Section __.3.1.1 Soil/Sediment/Drum (when applicable)
- Section __.3.1.2 Groundwater/Trench Water/Cistern Water (when applicable)
- Section __.3.1.3 Surface Water (when applicable)
- Section __.3.2 Ecological Risk
- Section __.3.2.1 Soil/Drum (when applicable)
- Section __.3.2.2 Sediment (when applicable)
- Section __.3.2.3 Surface Water (when applicable)
- Section __.4 Scientific Management Decision Point

[16] COC refers to sites in the Crab Orchard Cemetery area. Several EMMA OU sites are located in the COC area.

Sections 42 and 43 are included in Volume XI. Section 42 of the report discusses potential sites that were eliminated based on an aerial photography investigation.[17] Section 43 discusses additions that were made to the investigation after the FSP was issued.

Report appendices are organized as follows:

Volume XII:

- Appendix A. Boring Logs.
- Appendix B. Monitoring Well Construction Diagrams.
- Appendix C. Slug Test Data.

Volume XIII:

- Appendix D. Interview Notes.
- Appendix E. Site Summary Forms from the PA.
- Appendix F. Site Evaluation Forms from the PA.

Volume XIV:

- Screening Risk Assessment Work Plan.

The *Book of Large Figures* contains all the large figures for the report that would otherwise be folded and inserted in pockets. Because there are so many, it was judged to be more convenient for the report users to have the large figures compiled in a book.

[17] The aerial photography investigation involved reviewing a series of photographs from the Site from the period 1943 to 1993. The aerial photography was used to identify and bracket in time areas of industrial activity and such features as potential solid and liquid waste disposal sites.

TABLE 1-1

AREA NUMBERS, BUILDING PREFIXES, AND IOP AREA NAMES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Area Numbers [1]	Building Prefixes	IOP Area Names
Area 1	A	Administration Area
Area 2B	B	Booster Loading Line
Area 2D	D	Detonator Loading Line
Area 2F	F	Fuze Loading Line
Area 2P	P	Artillery Primer Line
Area 3	FAM	Finished Ammunition Group I
Area 4	S	Shop Area
Area 5	Y	Classification Yard
Area 6	HE	Ammonium Nitrate High Explosive and Smokeless Powder Storage Area
Area 7	IN	Inert Storage Area
Area 8	III	Group III Loading Line
Area 9	I	Group I Loading Line
Area 10	FBM	Fuze and Booster Storage Magazine
Area 11	III	Group II Loading Line
Area 12	ANP	Ammonium Nitrate Plant
Area 13	FAI	Finished Ammunition Igloos
Area 14	FS	Fulminate Storage Area

[1] These area numbers were not assigned as part of IOP, but came into use by USFWS in the early days of industrial use at the Refuge.

TABLE 1-2

SUMMARY OF INDUSTRIAL OPERATORS/LESSEES BY AREA
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Area	Major Industrial Operator/Lessee	Industrial Category	Years
1	Sherwin-Williams Defense Corporation (SWDC)/War Department	Offices and Living Quarters	1942-1945
1	Southern Illinois University (SIU), DOE	Research and Development, Coal Research, Training	1946-Present
2	SWDC/War Department	Ordnance and Explosives Manufacture	1942-1945
2	Universal Match Corporation (UMC), Olin/Primex/GDO&TS, Central Technologies, Inc. (CTI)	Ordnance and Explosives Manufacture	1952-Present
3	SWDC/War Department	Finished Ammunition Storage	1942-1945
3	Monsanto, Olin/Primex/General Dynamics, Schilli Transportation	Storage	1946-Present
4	SWDC/War Department	Industrial Shops	1942-1945
4	Norge, Supreme Transformer, East Side Lumber, Wilkie, Olin/Primex/General Dynamics, Elmac	Manufacturing, Storage, Shipping and Receiving, Plating, Equipment Servicing	1947-Present
5	SWDC/War Department	Railroad Operations	1942-1945
6	SWDC/War Department	High Explosives Storage	1942-1945
6	U.S. Powder, Olin/Primex/GDO&TS, Austin Powder, Dooley Brothers, and Others	Explosives Storage Facilities	1946-Present
7	SWDC/War Department	Inert Storage	1942-1945
7	Norge, Wilkie, Olin/Primex/GDO&TS, Shell, Dura-Plex, Midwest Woodworking, National Tape, Pennziol, Radionic Products	Manufacturing and Storage (Washing Machines, Oil, Fiberglass Products, Store Fixtures, Tape Products, Radio Components), metal finishing	1946-Present
8	SWDC/War Department	Bomb Loading Line	1942-1945
8	Diagraph, CTI, American Fiberlite, Olin/Primex/General Dynamics	Various Manufacturing (Inks, Pyrotechnics, Fiberglass Products)	1946-Present
9	SWDC/War Department	Artillery Loading Line	1942-1945
9	Sangamo, Olin/Primex/General Dynamics	Various Manufacturing (Electrical Capacitors, Pyrotechnics, Ammunition)	1946-Present
10	SWDC/War Department	Ordnance Storage	1942-1945
10	None	Firing Range, Open Burning of Ignitable Wastes	1967-Present
11	SWDC/War Department	Artillery and Tank Mine Loading	1942-1945
11	Olin, U.S. Powder	Dynamite Manufacturing, Nitroglycerin Production	1957-1984
12	SWDC/War Department	Ammonium Nitrate Manufacturing	1942-1948
13	SWDC/War Department	Ordnance and Explosives Storage	1942-1946
13	UMC, Olin/Primex/GDO&TS, U.S. Powder, Others	Ordnance and Explosives Storage	1946-Present
14	SWDC/War Department	Explosives Storage	1942-1945
14	UMC, Jobcorp, Olin/Primex/GOD&TS and Others	Explosives Storage, Landfill	1946-1990s

TABLE 1-3

INDUSTRIAL TENANT ROSTER - MARCH 2001
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Area Designation	Tenant	Building Designation					
Area 2B	General Dynamics Ordnance and Technical Systems, Inc. (GDO&TS)	B-2-1	B-2-9	B-2-13	B-2-16	B-2-19	B-2-22
		B-2-2	B-2-10	B-2-14	B-2-17	B-2-20	B-2-23
		B-2-3	B-2-12	B-2-15	B-2-18	B-2-21	B-2-27
Area 2D	GDO&TS	D-1-2	D-1-14	D-1-36	D-1-52	D-1-68	D-1-90A
		D-1-3	D-1-15	D-1-37	D-1-53	D-1-69	D-1-91
		D-1-4	D-1-16	D-1-42	D-1-54	D-1-71	D-1-92
		D-1-5	D-1-17	D-1-43	D-1-55	D-1-72	D-1-93
		D-1-6	D-1-25	D-1-44	D-1-56	D-1-74	
		D-1-7	D-1-25 AN#1	D-1-45	D-1-57	D-1-75	
		D-1-8	D-1-26	D-1-46	D-1-58	D-1-76	
		D-1-9	D-1-27	D-1-47	D-1-60	D-1-82	
		D-1-10	D-1-29	D-1-48	D-1-62	D-1-83	
		D-1-11	D-1-33	D-1-49	D-1-63	D-1-84	
		D-1-12	D-1-34	D-1-50	D-1-64	D-1-87	
		D-1-13	D-1-35	D-1-51	D-1-65	D-1-90	
Area 2F	GDO&TS[1]	F-2-1	F-2-2B	F-2-5	F-2-10	F-2-15	F-645
		F-2-2	F-2-3	F-2-8	F-2-11	F-2-20	
		F-2-2A	F-2-4	F-2-9	F-2-12	F-2-36	
Area 2P	GDO&TS	P-1-1	P-1-12	P-1-52	P-1-62	P-1-69	P-1-76
		P-1-3	P-1-15	P-1-53	P-1-63	P-1-70	P-1-83
		P-1-7	P-1-42	P-1-54	P-1-64	P-1-71	P-1-85
		P-1-8	P-1-43	P-1-55	P-1-65	P-1-72	
		P-1-9	P-1-49	P-1-59	P-1-66	P-1-73	
		P-1-10	P-1-50	P-1-60	P-1-67	P-1-74	
		P-1-11	P-1-51	P-1-61	P-1-68	P-1-75	
Area 3	GDO&TS[2]	FAM-1-1	FAM-1-4	FAM-1-7	FAM-2-5	FAM-3-2	FAM-4-3
		FAM-1-2	FAM-1-5	FAM-2-1	FAM-2-6	FAM-4-1	
		FAM-1-3 Pad	FAM-1-6	FAM-2-4	FAM-2-7	FAM-4-2	

TABLE 1-3

INDUSTRIAL TENANT ROSTER - MARCH 2001
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Area Designation	Tenant	Building Designation					
Area 4[3]	Illinois Department of Natural Resources	S-1-2					
	Williamson County Emergency Management Agency	S-1-3					
	Williamson County Emergency Management Agency	S-2-5					
	Illinois Department of Natural Resources	S-3-5					
	Ensign Bickford Industries, Inc. (Ensign Bickford)	S-4-4					
	GDO&TS[4]	S-1-1	S-3-1	S-3-2	S-3-3		
Area 6	GDO&TS	HE-1-2	HE-1-10	HE-3-3	HE-4-4	HE-6-3	HE-7-7
		HE-1-4	HE-1-11	HE-3-4	HE-4-5	HE-6-4	HE-7-8
		HE-1-5	HE-2-2	HE-3-5	HE-4-6	HE-6-5	HE-7-9
		HE-1-6	HE-2-3	HE-3-6	HE-4-8	HE-6-6	
		HE-1-7	HE-2-4	HE-3-8	HE-4-10	HE-6-7	
		HE-1-8	HE-2-6	HE-3-9	HE-4-11	HE-7-1	
		HE-1-9	HE-2-11	HE-4-3	HE-5-4	HE-7-6	
	Ensign Bickford	HE-1-12	HE-2-9	HE-3-11	HE-5-9	HE-6-8	
		HE-2-7	HE-2-10	HE-5-7	HE-5-10	HE-6-9	
		HE-2-8	HE-3-7	HE-5-8	HE-5-11	HE-10	
	Winn-Star	HE-1-1	HE-3-2				
	Silverado Fireworks	HE-2-5					
	Williamson County Emergency Management Agency	HE-3-1	HE-5-1	HE-5-3	HE-5-12		
	Propellex Corporation	HE-3-12	HE-7-2	HE-7-3			
	DYNO NOBEL Midwest, Inc.	HE-4-2	HE-6-1	HE-6-2	HE-6-11		
	Illinois State Police	HE-4-7					
	Hanley Industries, Inc.	HE-3-10	HE-4-9				
	U.S. Treasury Department, BATF	HE-4-12					
	Dooley Brothers	HE-5-2	HE-5-6	HE-7-10	HE-7-11	HE-7-12	
	Federal Bureau of Investigation	HE-5-5					

TABLE 1-3

INDUSTRIAL TENANT ROSTER - MARCH 2001
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Area Designation	Tenant	Building Designation					
Area 7[5]	John L. Rosenberger/Rod Starkweather[6]	IN-1-1					
	MDM (The Party Shop)	IN-1-2	IN-1-6				
	Maytag Appliances	IN-1-3[7]					
	Hospital & Physician Publishing, Inc.	IN-2-1[8]					
	Olin Corporation (East Alton)	IN-4-1	IN-4-6				
	GDO&TS	IN-4-5	IN-6-5				
	U.S. Department of Justice, Federal Bureau of Prisons	IN-5-1	IN-6-1				
	Local 318, International Union of Operating Engineers	IN-5-6[9]					
Area 8	Diagraph[10]	III-1-1	II-1-2	III-1-3	III-1-5		
Area 9	GDO&TS[11]	I-1-1	I-1-21	I-1-44	I-1-56	I-1-84	I-1-103
		I-1-2	I-1-22	I-1-45	I-1-57	I-1-86	I-1-104
		I-1-3	I-1-33	I-1-46	I-1-62	I-1-88	I-1-105
		I-1-3A	I-1-34	I-1-47	I-1-73	I-1-89	I-1-106
		I-1-11	I-1-34 An #1	I-1-48	I-1-74	I-1-91	I-1-107
		I-1-12	I-1-35A	I-1-49	I-1-75	I-1-92	I-1-108
		I-1-12A An #1	I-1-35B	I-1-52	I-1-76	I-1-93	
		I-1-15	I-1-41	I-1-53	I-1-77	I-1-101	
		I-1-19	I-1-42	I-1-54	I-1-78	I-1-101 An #1	
		I-1-20	I-1-43	I-1-55	I-1-79	I-1-102	
Area 10	*No Tenants*						
Area 11	*No Tenants*						
Area 12	*No Tenants*						

TABLE 1-3

INDUSTRIAL TENANT ROSTER - MARCH 2001
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Area Designation	Tenant	Building Designation					
Area 13	Ensign Bickford	FAI 1-1	FAI 2-3	FAI 3-5	FAI 4-5	FAI 5-6	FAI 7-1
		FAI 1-2	FAI 2-5	FAI 3-6	FAI 4-6	FAI 5-7	FAI 7-2
		FAI 1-3	FAI 2-6	FAI 3-7	FIA 4-7	FAI 5-8	FAI 7-3
		FAI 1-4	FAI 2-7	FAI 3-8	FAI 5-1	FAI 6-2	FAI 7-4
		FAI 1-5	FAI 3-1	FAI 4-1	FAI 5-2	FAI 6-3	FAI 7-5
		FAI 1-7	FAI 3-2	FAI 4-2	FAI 5-3	FAI 6-5	FAI 7-8
		FAI 2-1	FAI 3-3	FAI 4-3	FAI 5-4	FAI 6-6	
		FAI 2-2	FAI 3-4	FAI 4-4	FAI 5-5	FAI 6-7	
	GDO&TS	FAI-1-11	FAI-2-11	FAI-3-13	FAI-4-12	FAI-5-14	FAI-6-14
		FAI-1-12	FAI-2-12	FAI-3-14	FAI-4-13	FAI-5-15	FAI-7-9
		FAI-1-13	FAI-2-13	FAI-3-15	FAI-4-14	FAI-6-8	FAI-7-12
		FAI-1-14	FAI-2-14	FAI-4-8	FAI-4-15	FAI-6-9	
		FAI-2-8	FAI-3-9	FAI-4-9	FAI-4-16	FAI-6-10	
		FAI-2-9	FAI-3-10	FAI-4-10	FAI-5-12	FAI-6-12	
		FAI-2-10	FAI-3-11	FAI-4-11	FAI-5-13	FAI-6-13	

[1] Includes ramps 3, 5, 6, 7, 8, 9, and a ramp associated with F-2-36.

[2] GDO&TS is the only current tenant in this area.

[3] USFWS Fisheries operations are also in this area.

[4] GDO&TS is now the tenant in the old shop complex. Also includes the S Boiler Room and buildings designed #430, #543 Block, and the #544 Pole.

[5] Buildings in Area 7 are used for warehouse storage only. The structures have not utilities or heat.

[6] Concessionaire.

[7] Storage of excess parts.

[8] Quonset.

[9] Classroom storage.

[10] Diagraph is currently the only tenant in this area; also occupying annexes and associated boiler rooms.

[11] GDO&TS is the only current tenant in this area.

TABLE 1-4

ORIGINAL AUS OU LIST
(US FISH AND WILDLIFE SERVICE, JANUARY 1999)

CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site No.	Area	Past Use
1	Area 1	Fire Training
2	Area 1	Former Wastewater Treatment Plant for Area 1
3	Area 2	Fuse Line Loading/dumped organics
4	Area 2	Artillery Primer Line - 2P/dumped organics
5	Area 2	Detonator Loadng Line - 2D
6	Area 2	Booster Loading Line - 2B/tested pyrotechnic devices
7	Area 2	Tested pyrotechnic devices in Areas 2D, 2B, 2F
8	Area 2	Dumped organics in Areas 2D, 2B, 2F
9	Area 2	Dump East of Area 2F
10	Area 2	Boiler House South of Area 2P
11	Area 4	Gas Station East of Highway 148 from Old Refuge Shop
12	Area 4	Waste Oil Tank at Old Refuge Shop
13	Area 4	Laundry Facility
14	Area 4	Dry Cleaner
15	Area 4	Boiler House
16	Area 4	Old Refuge Shop Concrete Pit of Supreme Plating
17	Area 4	Degreasing Bldg
18	Area 5	Railraod Classification Yard
19	Area 5	Dump of concrete rubble
20	Area 5	Railroad Loading Dock
21	Area 7	Fire Station near PCB OU LF
22	Area 7	Refuge Border by Prison landfill
23	Area 8	Group III Load Line (LL III) Boiler House
24	Area 8	LL III - Underground Storage Tanks (USTs)
25	Area 8	LL III - Cleaning & Painting Bldg
26	Area 8	LL III - Evaporation Basin
27	Area 8	LL III - Change House Sewers
28	Area 8	LL III - Drainage Ditch Sediments
29	Area 8	LL III - Area Around Bldg.
30	Area 8	LL III - Change House
31	Area 8	South End of Area 8, Black Powder
32	Area 8	South End of Area 8, Fiberlite
33	Area 8	Soil Pile W of Industrial Bldg.
34	Area 9	LL I - Boiler House
35	Area 9	LL I - USTs
36	Area 9	LL I - Cleaning and Painting Bldg
37	Area 9	LL I - Evaporation Basin
38	Area 9	LL I - Change House
39	Area 9	LL I - Drainage Ditch Sedim.
40	Area 9	LL I - Area Around Bldg.
41	Area 10	Area 10 - Firing Range
42	Area 10	Area 10 - Burn Areas

TABLE 1-4

ORIGINAL AUS OU LIST
(US FISH AND WILDLIFE SERVICE, JANUARY 1999)

CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site No.	Area	Past Use
43	Area 10	Fire Station east of Area 10
44	Area 11/12	LL II - Boiler House
45	Area 11/12	LL II - USTs
46	Area 11/12	LL II - Cleaning and Painting Bldg
47	Area 11/12	LL II - Evaporation Basin
48	Area 11/12	LL II - Change House
49	Area 11/12	LL II - Drainage Ditch Sedim.
50	Area 11/12	LL II - Area Around Bldgs
51	Area 11/12	Area 12 - Concrete Slab with boosters on it
52	Area 11/12	Area 12 - Dump west of road on west end (ditch full of glass/metal debris)
53	Area 11/12	Area 12 - COP-6
54	Area 11/12	Area 12 - US Powder Dump (West Portion of COP-4)
55	Area 11/12	Area 12 - Burned Solid Propellent
56	Area 11/12	Dump w/Tanks Area 11/12
57	Area 11/12	East of road from Area 11/12--metal object on ground
58	Area 11/12	Drum on east side of Area 12 road on east end
59	Area 13	Railroad Loading Docks (one north, one south)
60	Area 14	Lead Azide/fulminate igloos
61	Area 14	North of Area 14, Concrete Structures
62	COC	Mounds & Pits 100 yds W of COC1
63	COC	Fenced Areas W of Site 62 (COC12)
64	COC	Mounds/Brick Pit Near S-63 COC13
65	COC	Foundations NE of COC-1
66	COC	Berm w/red brick Rubble COC-14
67	COC	Fence w/"cont. area" NW COC-6
68	COC	Pasture North of Hampton Cemetery
69	Bass Pond Area	Dump formerly COC-15
70	Bass Pond Area	Dump S of Site 69
71	Route 148 Causeway	Mounds of Unk. Material
72	Route 148 Causeway	Marion Pump Station
73	NW Portion of Refuge	West end of Crab Orchard Lake Dam, dump
74	NW Portion of Refuge	Lost 40 Acres - Homestead Dump
75	NW Portion of Refuge	W Refuge Border S - Homestead Dmp
76	NW Portion of Refuge	Open Burn Site at Rte 13 Marina
77	Devils Kitchen Lake Area	NW of DK Lake - Homestead Dump
78	Devils Kitchen Lake Area	Pasture Area E of DK Lake with treated wood posts
79	Little Grassy Lake Area	Boy Scout Camp Dump
80	Little Grassy Lake Area	Girl Scout Camp Dump by Beach
81	Little Grassy Lake Area	Girl Scout Camp Dump by Camp Site
82	Additional Sites	Area by Water Tower 3 between PCB and WT removal
83	Additional Sites	Area 2 - RR Spur used by Olin/Primex

TABLE 1-5

REFUGE OPERABLE UNITS

Operable Unit	Description	Major Contaminants	Status
PCB	Sites 32/33 (Area 9), Sangamo Dump and Industrial Area; Site 17, Job Corps Landfill; Site 28, Water Tower Landfill	Sites 17, 28: PCBs cadmium, lead. Sites 32/33: PCB, cadmium, lead, chlorinated solvents, esp. TCE.	Remediation of PCBs completed in 1997. TCE groundwater contamination discovered at Sites 32/33, currently in pre-design stage. (Investigation report 2001, design 2001). ESD for groundwater remediation was signed June 2000.
Metals Areas	Site 15, Plating Pond (Area 7); Site 22, Old Refuge Shop Channel (Area 4 west); and Site 29, Fire Station Landfill (Area 4 east).	Site 15, chromium. Site 22, cadmium, chromium, lead, and cyanide (from plating). Site 29, lead.	Remediation completed in 1996.
Explosives and Munitions Areas (EMMA)	Sites with DOD responsibility. Sites COC-3 and COP-4 identified for remediation and included in ROD. Removal action for Sites COC-1, -4, -5, -6, and –15.	Explosives, lead, and unexploded ordnance.	Remediation of COP-4 and COC-3 complete except for UST issues. Removal action complete including reforestation of 88 acres.
Miscellaneous Areas (MISCA)	Several sites with various contaminants investigated. Three identified for remediation: Site 22A, Post Treating Facility (Area 4); Site 14, Diagraph Facility (Area 8); and Site 36, Refuge Wastewater Treatment Plant.	Site 22A: pentachlorophenol, dioxin. Site 14: ethylbenzene, toluene, xylene, methylene chloride, and heavy metals. Site 36: cadmium, PCBs, chromium, other metals, dioxins, pesticides.	Site 22A remediated as removal action in 1996. RODs for Site 14 and 36 expected to be signed in 2001.
Water Towers	Five water tower sites and the Visitors' Center.	Lead from paint.	Removal action in 1992-1993. Draft final closure report submitted 2001.
Lake Monitoring	Crab Orchard Lake.	Suspected: PCB, mercury, cadmium, pesticides	Draft Final Preliminary Screening report submitted April 2001.
Additional and Uncharacterized Sites (AUS)	Intended to be a comprehensive listing of all remaining potentially contaminated areas on the Refuge.	VOCs, especially TCE, SVOCs, pesticides, explosives, metals.	PA/SI stage.

TABLE 1-6
INTERVIEWS CONDUCTED FOR HISTORICAL SEARCH REPORT

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Name	Interview Date	Employer	Period of Employment	Job Description	Brief Summary of Interview/Deposition
Adams, Wayne	03/23/2000	USFWS	1973 to 1986	CONWR Project Manager	Knowledge of activities refuge-wide.
Altekruse, Richard	07/14/1999	Olin-Alton	1956	Chemical Engineer	Knowledge of research and development of solid propellant and gas generators. Knowledge of the Olin testing range in Energy, Illinois.
		Olin-Marion	1957 to 1982	Process Development Engineer and Project Manager	
Arnett, Maynard	06/29/1999	Olin-Marion	1957 to 1973 or 1974	QC Foreman/Facility Engineer	Some knowledge of the I Area, the P Area and Area 11.
Dupont Employees[1]	08/24/1999	DuPont Chemical Co.	Varies	Varies	Knowledge of lead azide and lead styphnate production.
Kerley, Barbara	06/30/1999	American Fiberlite	1977 to 1978	"Brusher"	Some knowledge of American Fiberlite operations.
Moore, Paul	07/14/1999	Olin-Marion	1959 to 1998	Calibration and Inspection	Knowledge of operations in Areas 2B, 2D, 2F, 2P, 7 and 9.
Okolski, Rudy	06/30/1999	Olin-Marion	1960 or 1964 to 1999	Calibration and Inspection	General knowledge of Areas 2P, 2D, 2F, 4, 6, 7, 9, 13 and the Fire Station Landfill.
Pitt, Harvey	07/14/1999 (follow-up to deposition)	Universal Match	1953 to 1962	Research and Development	Extensive knowldege of Universal Match operations in Area 2D and Olin metal fabrication operations in Areas 2F and 7. General knowledge of other Olin operations.
		Olin-Marion	1962 to 1972	Production and Inventory Control Manager	
Throgmorton, Thomas J.	11/9/1999	SWDC/War Dep't	1941 to 1943	Driver	General knowledge of SWDC/War Dep't, UMC, CTI, and Winn-Star operations. Some knowledge of UMC's use of buildings in Area 2 and CTI's operation in Area 8. Some general knowledge of Olin's operation at the Refuge.
		Universal Match	1957 to 1963	Research Engineer	
		CTI	1963-1965, 1968-1970	Vice President	
		Winn-Star	1970 to Present	Owner	
Watson, Sam	06/30/1999	Sangamo	1947 to 1959	Designed Capacitors/Accountant	General knowledge of Sangamo operations.
		Universal Match	1959 to 1962 or 1963	Estimating/Part Tracking	General knowledge of Universal Match operations.
Wilkie, Robert Andrew	07/28/1999	R.A. Wilkie Machine Co./ Supreme Plating	From ?? to Present	Owner/Operator/Machinist	Knowledge of R.A. Wilkie Machine company and their operations in Areas 4 and 7.
			On occasion		
Wilkie, Frank	07/28/1999	R.A. Wilkie Machine Co./ Supreme Plating	1962 to 1974	Plating/Operator	Detailed knowledge of plating operations at Supreme Plating in Area 4 and of R.A. Wilkie operations in Area 7.
			On occasion		
Woodcock, Arthur	11/9/1999	R.A. Wilke Machine Co.	1968 to ??	Machinist/Tool Maker	General knowledge of R.A. Wilkie operations in Area 7 and Supreme Plating's operations in Area 4.

[1] Dupont employees: Charlie Kershaw, Ralph Sloat, and Mark Vetter.

TABLE 1-7
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

AUS Site	Description	Recommendation	Comments
1	Fire and Police Headquarters	Site Inspection	See Table 1-8
2	Former Wastewater Treatment Plant for Area 1	Site Inspection	See Table 1-8
3	Fuse Line Loading/dumped organics	Include with Area 2F	Investigate Area 2F as Industrial Facility
4	Artillery Primer Line - 2P/dumped organics	Include with Area 2P	Investigate Area 2P as Industrial Facility
5	Detonator Loadng Line - 2D	Include with Area 2D	Investigate Area 2D as Industrial Facility
6	Booster Loading Line - 2B/tested pyrotechnic devices	Include with Area 2B	Investigate Area 2B as Industrial Facility
7	Tested pyrotechnic devices in Areas 2D, 2B, 2F	Include with Area 2B, 2D, 2F, 2P	Investigate Area 2 as Industrial Facilities
8	Dumped organics in Areas 2D, 2B, 2F	Include with Area 2D, 2B, 2F	Investigate Area 2 as Industrial Facilities
9	Dump East of Area 2F	Include with Area 2F	Investigate Area 2F as Industrial Facility
10	Boiler House South of Area 2P	No further action.	Building demolished by FWS, USTs removed, no spillage or contamination noted
11	Gas Station East of Highway 148 from Old Refuge Shop	Include with Area 4	Investigate Area 4 as Industrial Area
12	Waste Oil Tank at Old Refuge Shop	No further action	No evidence of waste oil tank; nothing on drawings; FWS personnel report there was a tank removed in 1988 or 1989
13	Laundry Facility	Include with Area 4	Investigate Area 4 as Industrial Area
14	Dry Cleaner	Include with Area 4	Investigate Area 4 as Industrial Area
15	Boiler House	Include with Area 4	Investigate Area 4 as Industrial Area

TABLE 1-7
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

AUS Site	Description	Recommendation	Comments
16	Old Refuge Shop Concrete Pit of Supreme Plating	Include with Area 4	Investigate Area 4 as Industrial Area
17	Degreasing Bldg	Include with Area 4	Investigate Area 4 as Industrial Area
18	Railroad Classification Yard	Site Inspection	See Table 1-8
19	Dump of concrete rubble	Based on PA, site was determined to require no further action. During SI, site was re-added basedon aerial photograph intrepretation.	Site was initially eliminated; however was readded during SI based on ground staining noted in aerial photograph intrepretation.
20	Railroad Loading Dock	Include with Area 6	Investigate Area 6 as Industrial Storage Facility
21	Fire Station near PCB OU LF	Site Inspection	See Table 1-8
22	Refuge Border by Prison landfill	Based on PA, site was determined to require no further action. During SI, site was re-added basedon aerial photograph intrepretation.	Site was initially eliminated; however was readded during SI based aerial photograph intrepretation of a small arms training facility noted.
23	Group III Load Line (LL III) Boiler House	Include with Area 8	Investigate Area 8 as Industrial facility
24	LL III - Underground Storage Tanks (USTs)	Include with Area 8	Investigate Area 8 as Industrial facility
25	LL III - Cleaning & Painting Bldg	No further action.	Part of Site 14 (MISCA)
26	LL III - Evaporation Basin	Include with Area 8	Investigate Area 8 as Industrial facility
27	LL III - Change House Sewers	Include with Area 8	Investigate Area 8 as Industrial facility
28	LL III - Drainage Ditch Sediments	Include with Area 8	Investigate Area 8 as Industrial facility

TABLE 1-7
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

AUS Site	Description	Recommendation	Comments
29	LL III - Area Around Bldg.	Include with Area 8	Investigate Area 8 as Industrial facility
30	LL III - Change House	Include with Area 8	Investigate Area 8 as Industrial facility
31	South End of Area 8, Black Powder	Include with Area 8	Investigate Area 8 as Industrial facility
32	South End of Area 8, Fiberlite	Include with Area 8	Investigate Area 8 as Industrial facility
33	Soil Pile W of Industrial Bldg.	No further action.	No visible signs of contamination; based on records, it was probably used by FWS for borrow.
34	LL I - Boiler House	No further action.	Remediated as part of PCB OU.
35	LL I - USTs	No further action.	Remediated as part of PCB OU.
36	LL I - Cleaning and Painting Bldg	No further action.	Remediated as part of PCB OU. Note: there may be some question as to whether this area was remediated: this will be addressed when final drawings of remediated areas are provided.
37	LL I - Evaporation Basin	Include with Area 9 west	Investigate Area 9 as industrial facility
38	LL I - Change House	Include with Area 9 west	Investigate Area 9 as industrial facility
39	LL I - Drainage Ditch Sedim.	Include with Area 9 west	Investigate Area 9 as industrial facility
40	LL I - Area Around Bldg.	Include with Area 9 west	Investigate Area 9 as industrial facility
41	Area 10 - Firing Range	Include with Area 10	Investigate Area 10 as industrial facility
42	Area 10 - Burn Areas	Include with Area 10	Investigate Area 10 as industrial facility

TABLE 1-7
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

AUS Site	Description	Recommendation	Comments
43	Fire Station east of Area 10	Site Inspection	See Table 1-8
44	LL II - Boiler House	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
45	LL II - USTs	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
46	LL II - Cleaning and Painting Bldg	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
47	LL II - Evaporation Basin	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
48	LL II - Change House	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
49	LL II - Drainage Ditch Sedim.	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
50	LL II - Area Around Bldgs	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
51	Area 12 - Concrete Slab with boosters on it	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
52	Area 12 - Dump west of road (ditch w/ glass/metal)	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
53	Area 12 - COP-6	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
54	Area 12 - US Powder Dump (West Portion of COP-4)	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
55	Area 12 - Burned Solid Propellent	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
56	Dump w/Tanks Area 11/12	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
57	East of road from Area 11/12--metal object on ground	Include with Site AUS-106A	AUS-057 is a small disposal site that could be included with the large drum disposal site AUS-106A

TABLE 1-7
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

AUS Site	Description	Recommendation	Comments
58	Drum on east side of Area 12 road on east end	Include with Area 11/12	Investigate Area 11/12 as industrial facilities
59	Railroad Loading Docks (one north, one south)	Include with Area 13	Investigate Area 13 as industrial storage facility
60	Lead Azide/fulminate igloos	Site Inspection	See Table 1-8
61	North of Area 14, Concrete Structures	Site Inspection	See Table 1-8
62	Mounds & Pits 100 yds W of COC1	Site Inspection	See Table 1-8
63	Fenced Areas W of Site 62 (COC12)	Site Inspection	See Table 1-8
64	Mounds/Brick Pit Near S-63 COC13	No further action.	Unable to locate site
65	Foundations NE of COC-1	Site Inspection	See Table 1-8
66	Berm w/red brick Rubble COC-14	Site Inspection	See Table 1-8
67	Fence w/"cont. area" NW COC-6	Site Inspection	See Table 1-8
68	Pasture North of Hampton Cemetery	No further action.	No field evidence or available information indicating potential or actual releases.
69	Dump formerly COC-15	Site Inspection	See Table 1-8
70	Dump S of Site 69	No further action.	No evidence of dump in records or at site. Unable to locate
71	Mounds of Unk. Material	No further action.	No evidence of contamination in records or at site.
72	Marion Pump Station	No further action.	No evidence of contamination in records or at site.

TABLE 1-7
RECOMMENDATIONS FOR SITE GROUPING, SITE INSPECTIONS, AND NO FURTHER ACTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

AUS Site	Description	Recommendation	Comments
73	West end of Crab Orchard Lake Dam, dump	No further action.	Probable household waste; recommend FWS remove and dispose at landfill. Recommend removal work be done with qualified supervision.
74	Lost 40 Acres - Homestead Dump	No further action.	Probable household waste; recommend removal and disposal at landfill. Recommend removal work be done with qualified supervision.
75	W Refuge Border S - Homestead Dmp	No further action.	Probable household waste; recommend FWS remove and dispose at landfill. Recommend removal work be done with qualified supervision.
76	Open Burn Site at Rte 13 Marina	No further action.	No detections above screening levels. No evidence of contamination.
77	NW of DK Lake - Homestead Dump	No further action.	Probable household waste; recommend FWS remove and dispose at landfill. Recommend removal work be done with qualified supervision.
78	Pasture Area E of DK Lake with treated wood posts	No further action.	No evidence of release of hazardous substances.
79	Boy Scout Camp Dump	No further action.	Unable to locate site. Camp caretaker reports no dumps on site.
80	Girl Scout Camp Dump by Beach	No further action.	Most of the debris has been removed by FWS. No evidence of release of hazardous substances.
81	Girl Scout Camp Dump by Camp Site	No further action.	Debris has been removed. No evidence of release of hazardous substances.
82	Area by Water Tower 3 between PCB and WT removal	No further action.	Site has been eliminated from AUS OU and included in Water Towers OU.
83	Area 2 - RR Spur used by Olin/Primex	Include with Area 2.	Investigate Area 2 as Industrial Facilities
AUS-106A	Drum Disposal	Site Inspection	See Table 1-8

TABLE 1-8
RECOMMENDED REVISED LIST OF AUS SITES FOR SITE INSPECTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site	Approx. Size (Acres)	Description	Comments
AUS-0A2B	125	Area 2 Booster Load Line	Area of industrial activity since 1942. Used for booster loading (IOP); various uses by subsequent ordnance manufacturers, including propellant manufacturing and explosive waste incineration. Concentrations of several SVOCs were detected above EPA SSLs and Refuge background levels.
AUS-0A2D	150	Area 2 Detonator Load Line	Area of industrial activity since 1942. Used for detonator loading (IOP) and for R&D, pyrotechnic manufacturing, propellant mixing, machining, and milling by later industrial tenants. Reports of dumping of solvents and burning of explosive waste by previous employees. Several SVOC compounds detected above EPA SSLs. Mercury and zinc concentrations were detected above both EPA SSLs and Refuge background levels.
AUS-0A2F	125	Area 2 Fuse Load Line	Area of industrial activity since 1942. Used for fuze loading (IOP) and various uses by subsequent ordnance manufacturers, including milling, machining, and R&D. Dumping of TCE and cutting oil reported by former employees.
AUS-0A2P	150	Area 2 Primer Load Load	Industrial area used for artillery primer production for IOP; and for gas generator development and production, propellant development and production, metal working/machining by later industrial tenants.
AUS-0A2R	30	Area 2 Railroad Spur	Site was added during SI based on aerial photograph review.
AUS-0A4E	60	Area 4 East Shop Area	Area of industrial activity from 1942 to 1980s. Area includes former gas station, dry cleaners, electric and communication building (with reported use of carbon tetrachloride), wash and degreasing building, IOP laboratory, and other industrial activities
AUS-0A4W	80	Area 4 West Shop Area	
AUS-0A06	550	Area 6 Explosive Storage Igloos	Storage of explosives by IOP and later industrial tenants. USEPA 1998 analytical results above site screening levels at RR loading docks .
AUS-0A07	100	Area 7 Inert Storage	Area consists of a number large buildings which had been leased to many different industrial tenants. Activities included pesticide storage, painting, metal forming, oil transfer, and warehousing.
AUS-0A8S	150	Southern Portion of Area 8, IOP Load Line III	Location of IOP TNT melt Load Line III. Subsequently used by industrial tenants for explosive/ordnance manufacturing and manufacturing of fiberglass boats.
AUS-0A09	100	Western portion of Area 9 IOP Load Line I	Location of IOP TNT melt Load Line I. Subsequently used by industrial tenants for transformer/capacitor manufacturing and explosive/ordnance manufacturing. Significant remediation and investigation have been done, but not all areas of potential contamination have been investigated.
AUS-0A10	40	Area 10 Fuze & Booster Storage Magazines	Location of fuse and booster storage (IOP). Site later used for firing range and burn pits. Exceedances of screening criteria.

TABLE 1-8
RECOMMENDED REVISED LIST OF AUS SITES FOR SITE INSPECTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site	Approx. Size (Acres)	Description	Comments
AUS-A11A	50	Area 11 - IOP Load Line II; later area of Industrial Acid and Ammonium Nitrate Manufacturing	Part of IOP ammunition load line (Group II Load Line). From 1950s to 1980s, area was used for manufacture and storage of nitric acid, sulfuric acid, and ammonium nitrate for explosives. Includes disposal pond.
AUS-A11H	70	Area 11 - IOP Load Line II-High Explosives Manufacturing	Area used from 1950s to 1980s for manufacture of high explosives, including dynamite, ANOIL, and products containing PETN, TNT, and RDX. Includes waste disposal areas.
AUS-A11N	30	Area 11 - IOP Load Line II-Nitroglycerin Manufacturing	Area used from 1950s to 1980s for manufacture of nitroglycerin. Includes holding ponds for wash water.
AUS-A11P	30	Area 11 - IOP Load Line II; later area of Propellant Research and Blasting Cap Manufacturing.	Part of IOP ammunition load line (Group II Load Line). From 1950s to 1970s, area was used for propellant research (Olin) and cap manufacturing (Trojan).
AUS-A11S	50	Area 11 - IOP Load Line II; later Industrial Support Area	Part of IOP ammunition load line (Group II Load Line). From 1950s to 1980s, support area for explosives manufacturing plant. Included machine shop, scrap yard, boiler, tanks, storage areas.
AUS-0A12	100	Area 12 Ammonium Nitrate/RDX Manufacturing; Burn Pits for Ignitable Wastes	Area used during IOP for AN manufacturing. RDX manufacturing from 1960s to 1980s. Includes ponds used for explosive storage. Burn pit used for explosive waste disposal from 1950s to 1980s. Includes dump sites.
AUS-0A13	500	Explosives Storage Area (Finished Ammunition Igloos)	Area used during IOP and later by industrial tenants for explosives storage.
AUS-0062	2	Mounds & Pits 100 yds W of COC-1	Detections of metals above soil screening levels (USEPA 1998).
AUS-0063	<1	Fenced Areas W of Site 62 (COC-12)	Ordnance scrap noted. Detections above soil screening levels (USEPA 1998).
AUS-0064	<1	Mounds & Brick Pit near AUS-0063 (COC-13)	Because this site was not located during the initial site reconnaissance, it was designated to require no further action. However, it was located during the field investigation for the AUS OU SI and was added to the SI at that time. Detections above soil screening levels (USEPA 1998).
AUS-0065	1/2	Foundations NE of COC-1	Several samples had exceedances of screening levels for SVOCs and metals (USEPA 1998).
AUS-0066	1/2 to 1	Berm w/red brick Rubble COC-14	Brick appears to be from change houses; danger sign posted nearby; creek water has reddish tint suggesting TNT contamination.

TABLE 1-8
RECOMMENDED REVISED LIST OF AUS SITES FOR SITE INSPECTION

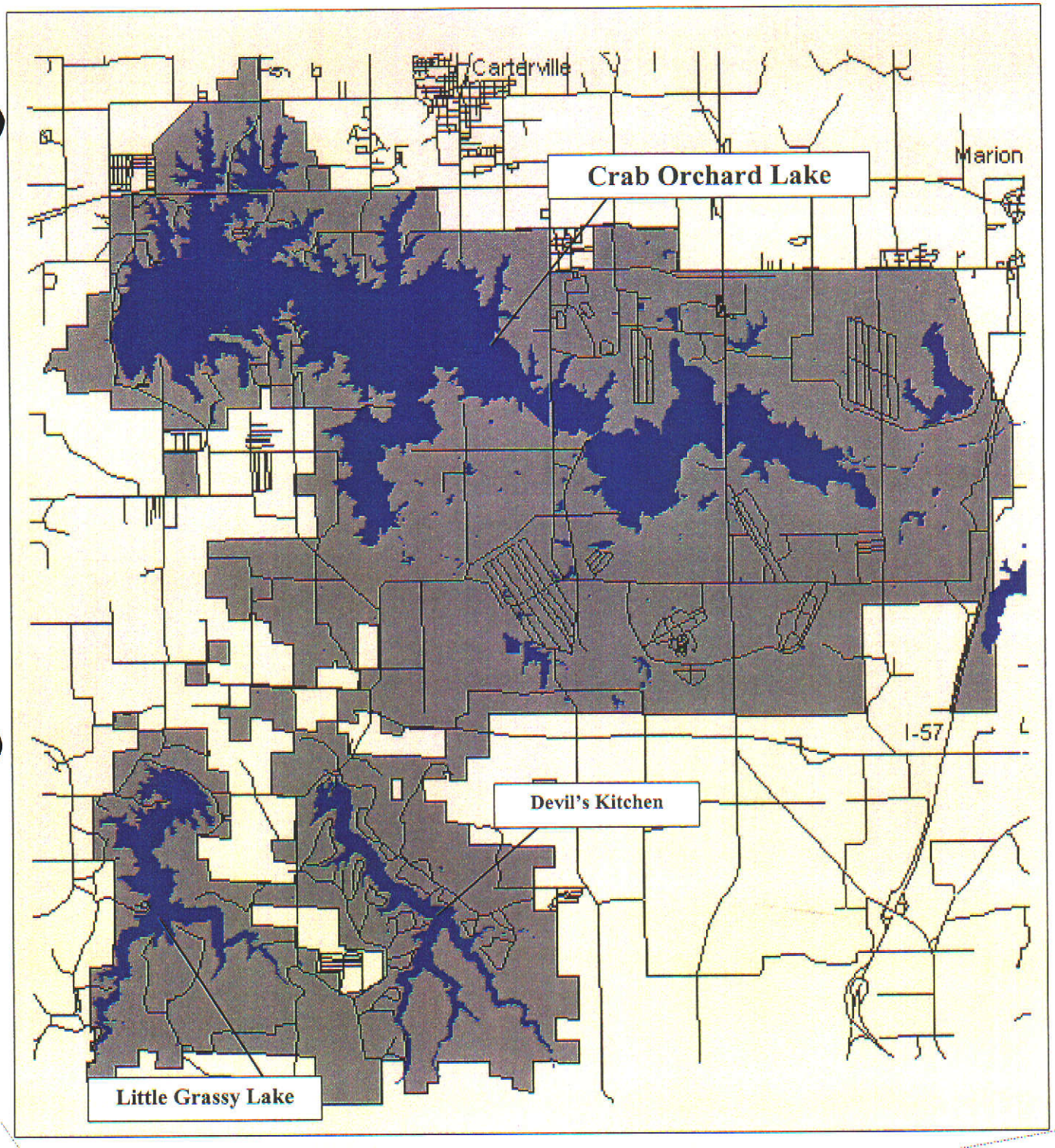
ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site	Approx. Size (Acres)	Description	Comments
AUS-0067	1/4	Fence w/"cont. area" NW COC-6	"Danger: Contaminated Area" sign and rubble warrant investigation.
AUS-0069	15±	Dump near south shore COL	55-gallon drums and brick with appearance of change house brick suggests industrial dumping.
AUS-0109	<1	Possible Former Explosives Detonation Area located south of AUS-0062	Possible explosives detonation area identified during aerial photograph review.
AUS-0001	1.5	Fire and Police Headquarters	Potential for two on-site petroleum underground storage tanks (USTs) based on site visit and site usage. On-site industrial demolition debris. EPA (1998) sample results exceeded site screening levels (SSLs) for semi-volatile compounds (SVOCs), and exceeded Refuge background and screening levels for some metals.
AUS-0002	1.5	Former WWTP	Based on IOP sewer diagrams, WWTP appears to have served part of the industrial area (part of Area 2) in addition to the Administrative Area. Because of this, there is a likelihood of metals, explosives compounds, and other industrial contaminants in the lagoons.
AUS-0018	7	RR classification yard	Concentrations of metals and PAHs exceeded PA screening criteria.
AUS-0019	<1	Dump of Concrete Rubble at a former Railroad Spur located north of Area 4.	Site was initially eliminated in PA but was re-added during SI based on ground staining noted in aerial photorgraphs.
AUS-0021	<1	Fire station Area 7	Ordnance/explosive waste identified on site.
AUS-0022	1/4	Small Arms Training Facility	Site was not located during the initial site reconnaissance and was therefore designated to require no further action. However, it was located during an aerial photograph search and was determined to be a small arms training facility.
AUS-0043	1/2	Fire Station east of Area 10	Possible burning area noted. Two sumps noted in former building area. Some metals exceeded Refuge background and screening criteria.
AUS-0060	6	Area 14 fulminate storage	Original use as storage for mercury fulminate (IOP). Later used for lead azide storage. Former employee believed spill of lead azide had occurred during unpacking of materials. Lead concentration well in excess of background and site screening levels
AUS-0061	1/2	Explosive testing structures N of Area 14	Concrete structures used for testing explosives. Large number of exceedances of screening criteria for SVOCs and metals (USEPA 1998).

TABLE 1-8
RECOMMENDED REVISED LIST OF AUS SITES FOR SITE INSPECTION

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Site	Approx. Size (Acres)	Description	Comments
AUS-106A	0.1	Drum Disposal	Disposal area with about 50 to 100 rusted drums of unknown material
AUS-0107	<1	Possible Former Explosive Detonation Area	Possible explosives detonation area identified during aerial photograph review.
AUS-0108	<1	Possible Former Explosive Detonation Area	Possible explosives detonation area identified during aerial photograph review.



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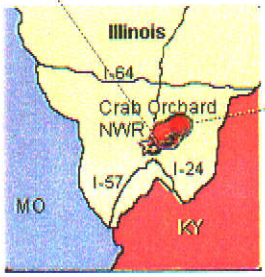
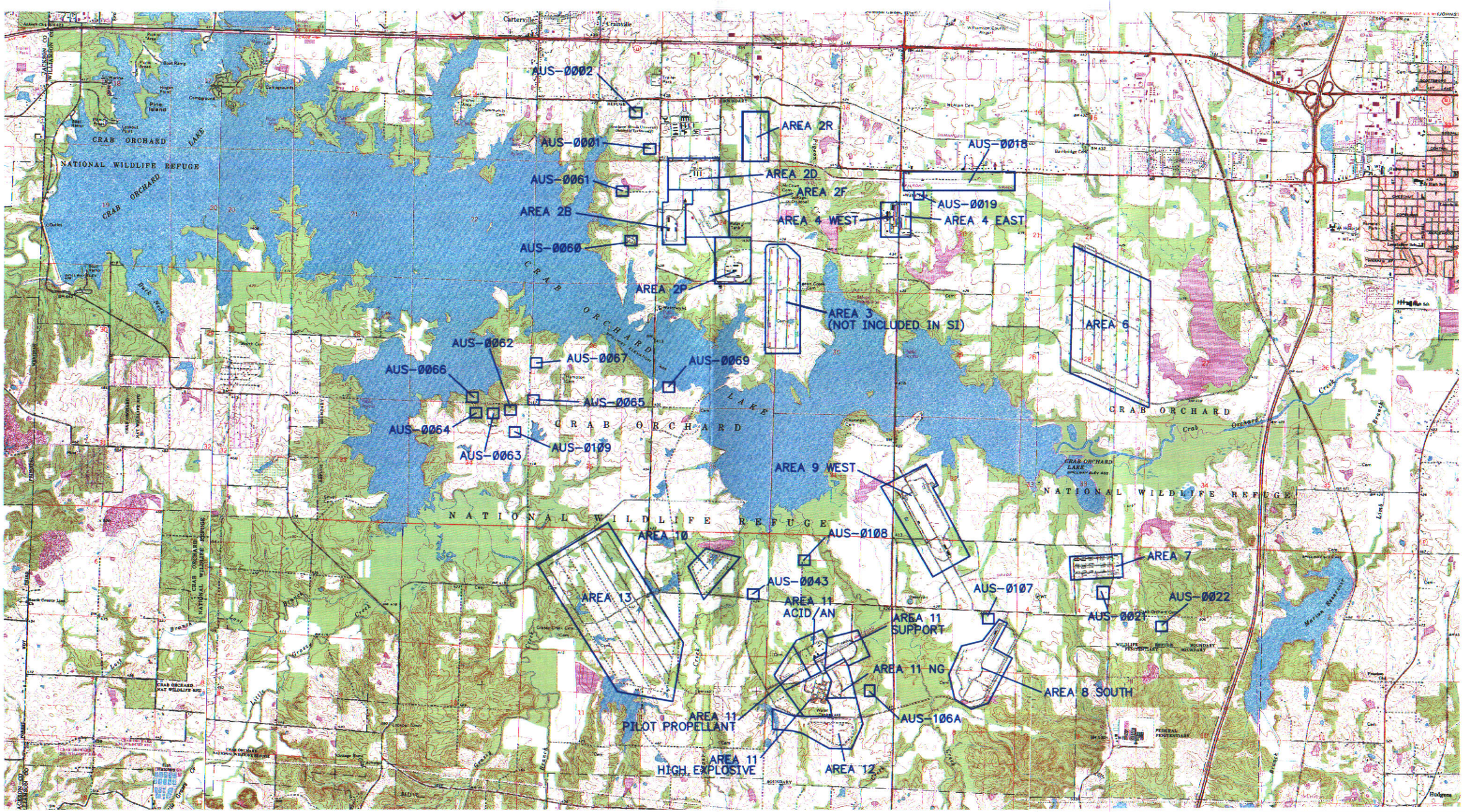


Source: U.S. Fish & Wildlife Service Web Site, *Crab Orchard National Wildlife Refuge Area Map*, http://www.fws.gov/r3pao/cr_orch/map.htm

PA / SI REPORT AUS OU CRAB ORCHARD NWR MARION, ILLINOIS		PROJECT NO. 2320000026.00
URS		
DRN. BY: CMW DSGN. BY CMW CHD. BY: MCH	CRAB ORCHARD NATIONAL WILDLIFE REFUGE	FIG NO. 1 - 1



PA/SI REPORT–AUS OU CRAB ORCHARD NWR MARION, ILLINOIS	PROJECT NO. 2320000026.00
URS	
DRN. BY: djd 9/7/99 DSGN. BY:mch CHKD. BY:cmw	AUS OU Sites Investigated in SI — FIG. NO. 1–2

File: E:\45FOM9602N\CRABAUS OU SITE LOCATION MAP.DWG Last edited: 08/07/01 @ 3:53 p.m. @ WCC-ST.LOUIS

This section presents results of those parts of the Site Investigation (SI) investigation that are not specific to any of the Additional and Uncharacterized Sites Operable Unit (AUS OU) sites, and includes bedrock well data and soil, surface water and sediment background results.

2.1 PHYSICAL DESCRIPTION OF REFUGE

2.1.1 Drainage and Surface Water Features

The major surface water feature of the Refuge is the 6,965-acre Crab Orchard Lake. It was created in the 1930s by damming the east-flowing Crab Orchard Creek. Other perennial streams that flow into the lake in the eastern part of the Refuge are Pigeon Creek, Wolf Creek, Sugar Creek, Little Grassy Creek, and Grassy Creek.

Most of the industrial part of the Refuge has low relief and includes many flat marshy areas.

2.1.2 Geologic Setting

This section discusses the overall geologic setting of the Refuge. Site-specific geologic conditions are discussed by site.

Quaternary Geology

Crab Orchard Lake is located near the southernmost boundary of continental glaciation in the Northern Hemisphere. The general Quaternary (glacial-age to recent times) geology of the area is shown in Figure 2-1. The unglaciated area just south of the Refuge is shown in white on the figure.

Glacial Till

The pink areas in Figure 2-1 are Illinois Age till of the Vandalia Member of the Glasford Formation, which for this area has been described as a hard silty till[1] (till is deposited when a glacier melts and the material it carried is dropped. Because it is not moved much by water, it is unsorted and unstratified[2].) From previous investigations at the Refuge, the till is known to have lenses or layers of water-bearing sandy material.

Glacial Lake Deposits

The purple areas shown on Figure 2-1 are glacial lake deposits of the Equality Formation. Crab Orchard Creek was once a tributary arm of the glacial lake in the Big Muddy River valley, located north of the Refuge (shown as the larger purple area to the north of Crab Orchard Lake in Figure 2-1). These lake deposits were laid down in the quiet lake water and are dominated by well-bedded silt and some clay.[3]

[1] Jerry Lineback, *Quaternary Deposits of Illinois*, (Map) Illinois State Geological Survey, 1979.
[2] Frankie, W.T., et al, *Guide to the Geology of the Carbondale Area Jackson, Union, and Williamson Counties, Illinois*, Illinois State Geological Survey Field Trip Guidebook 1995D, October 28, 1995.
[3] Jerry Lineback, *Quaternary Deposits of Illinois*, (Map) Illinois State Geological Survey, 1979.

Thickness of Glacial Deposits

Generalized information from the Illinois Geological Survey indicates that, south of Crab Orchard Lake and in the area north of the lake that includes Area 2 and Area 4, glacial deposits extend to depths of 20 feet (ft) or less, and overlie bedrock. Other areas north of the lake are shown as having glacial deposits extending to depths between 20 and 50 ft,[4] also directly overlying bedrock. In other words, based on these maps, throughout most of the AUS OU, glacial deposits extend to depths of 20 ft or less and directly overlie bedrock. This appears to be generally correct for most areas, based on borings done at the Refuge, although some boring logs show localized areas of greater till thickness. The borings also show that in some areas the glacial till overlies residual material developed on bedrock.

Other generalized information from the Illinois State Geological Survey shows glacial deposits up to 50 ft thick on the Refuge[5].

Recent Alluvium

The yellow areas shown on Figure 2-1 are recent alluvial deposits (Cahokia alluvium) consisting of sand, silt, and clay. As shown in the figure, there are very few of these deposits in the area around Crab Orchard Lake.

Loess Deposits

The red contour lines on Figure 2-1 indicate the approximate thickness of loess, a silty-clay windblown material. These loess deposits do not typically have horizontal stratification, but they do have vertical fractures, which are probably the main pathway for water flow through the loess. Note that the Refuge lies between the 5-ft and the 10-ft contour, and that there are no loess deposits in the areas of the glacial lake deposits (the lakes existed at the same time the windblown loess deposits were laid down). Specific information for Williamson County[6] indicates that loess deposits are present in almost all of the AUS OU area, and for most of the area, the loess deposits range from 5.5 to 12.5 ft in thickness. In Area 6, the loess thickness is shown as less than 5 ft[7]. Unfortunately, on boring logs from the Refuge, the distinction between the loess and the underlying till is often not made. Both soils are primarily low-plastic silty clay, but they may vary significantly in structure and hydraulic properties.

Bedrock

The bedrock at the Refuge is Pennsylvanian-Age, mostly sandstone with some shale. It also has beds of limestone and coal. We do not know of any rock outcrops within the AUS OU area. Rock, primarily sandstone, is exposed in many locations in the unglaciated area south of the

[4] Berg, R.C., and J.P. Kempton, *Stack Unit Mapping of Geologic Material in Illinois to a Depth of 15 Meters*, Illinois State Geological Survey, Publication C542, 1987.
[5] Piskin, K, *Thickness of Glacial Drift in Illinois*, (Map), Illinois State Geological Survey, 1975.
[6] Fehrenbacher, J.B., and R.T. Odell, *Williamson County Soils*, Soil Report 79, University of Illinois Agricultural Experiment Station, 1959.
[7] Ibid.

Refuge. The Pennsylvanian Age rocks are about 600 to 800 ft thick at the Refuge[8]. Bedrock dips generally toward the north, in the direction of the Illinois Basin, a regional geologic structural feature with its greatest depth in about the middle of the state.

The Refuge lies just south of the southern edge of minable coal found in the Herrin No. 6 coal seam. The Herrin No. 6 is a continuous coal layer that underlies thousands of square miles of southern Illinois. Figure 2-2 shows a part of the location of the Herrin No. 6 in the vicinity of the Refuge. The very southern edge of mining, just north of the Refuge, was done by surface mining, as shown in the figure. Just to the north, underground mines underlie the area. Note that the map is dated 1975, and areas indicated as reserves may have been removed.

2.1.3 Groundwater

This section discusses the general groundwater conditions for the Refuge. The groundwater information obtained from bedrock wells installed as part of the SI is discussed in Section 2. Site-specific groundwater conditions are discussed with each site.

Groundwater in the upper till aquifer is generally shallow, ranging from near the ground surface to about 20 ft below ground surface (bgs), depending on season and location. There are currently no water supply wells on the Refuge. At least three of the other operable units on the Refuge are underlain by aquifers in the glacial till which are classified in accordance with 35 IAC 620[9] as Class I (potable) Groundwater, based on measured hydraulic conductivity.

Results for sites where monitoring wells were installed are discussed in the site-specific sections.

Although the hydraulic conductivity of the till aquifer is often sufficiently high for it to be Class I, yields are usually low. Monitoring wells in this upper aquifer can generally be bailed dry and are slow to recover. The aquifer appears to consist of thin, discontinuous sand lenses in the glacial till. The Illinois Geological Survey reported the following for Williamson County in 1956.[10]

The glacial deposits are thin and are not water-yielding. The thickest valley-fill material is in the Big Muddy Valley, where thin sand and gravel deposits are locally present within thick sections of silt and clay.

Sandstone aquifers in the Pennsylvanian system are water-yielding throughout most of the county. Domestic water supplies are obtained with little difficulty at depths ranging from 50 to 800 ft.

Figure 2-3 shows locations of water wells on record with the Illinois State Geological Survey. The records do not indicate whether the wells are currently in use. Well depths in feet are shown on the figure. These wells are apparently in the lower aquifer that is in the sandstone bedrock. Most of the wells are reportedly for single family residential use. The Marion Federal

[8] Williams, H.B., et al, *Handbook of Illinois Stratigraphy*, Illinois State Geological Survey, Bulletin 95, 1975.
[9] Illinois Administrative Code, Title 35, Section 620
[10] Wayne A. Pryor, *Groundwater Geology in Southern Illinois, A Preliminary Geologic Report*, Illinois State Geological Survey Circular 212, 1956; pp. 24-25.

Penitentiary, located near the southeast corner of the Refuge, has seven water supply wells ranging in depth from 588 to 702 ft deep. The Illinois State Geological Survey reports the following for the area near the Refuge.[11]

The bedrock is of Pennsylvanian age and consists of shale with relatively thick, fairly continuous, sandstone beds and scattered limestone beds. Small sandstone layers may be found within a few hundred feet of the surface. Well log data indicate the presence of thick, water-bearing sandstones at depths of between 400 and 500 ft. Other sandstones may be encountered between 600 and 700 ft and perhaps as deep as 860 ft. Below this depth, any water encountered may not be usable due to the tendency of the ground water to be increasingly mineralized at greater depths. These sandstones, when encountered, may provide a small to moderate ground-water supply. A well in the SE1/4 NW1/4 SW1/4 Section 18, T9S, R3E produced 46.5 gallons per minute (gpm) from deep sandstones.

In summary, the prospect of developing more than the smallest water supply from the drift is extremely poor. However, a well penetrating bedrock down to depths of 860 ft should provide a good chance for a moderate water supply, with some question as to ground water quality.

No specific information could be found regarding the hydraulic relationship between the upper aquifer in the glacial till, and the bedrock aquifer.

2.2 BEDROCK WELLS

2.2.1 Well Installation

In accordance with the Field Sampling Plan (FSP) for the SI, eleven bedrock monitoring wells were installed throughout the Refuge. Three of these wells were located in the area surrounding Area 2, four were located in the area of the former major load lines (Areas 8, 9, and 11/12), and the remaining four wells were scattered across the Refuge near the Refuge boundaries. Bedrock well locations are shown in Figure 2-4. In addition to the planned wells, two intermediate depth wells, Wells 5I and 9I were installed at locations 5 and 9, as shown in Figure 2-4. Bedrock Wells BDRK-5 and BDRK-9 were then designated 5D and 9D.

The purpose of the wells was to develop some information about bedrock stratigraphy, hydraulic conductivity, and groundwater flow directions and gradients, which has not been done at the Refuge. The intent of the program was to install the wells in the sandstone bedrock, which is an aquifer in this area.

The wells were installed between May 18 and June 22, 2000 using a Schramm air rotary drilling rig with a 8 ¾-inch diameter tricone bit. The borings were logged based on drill cuttings. Two-inch diameter by 10-ft long well screens were installed, in accordance with the Standard Operating Procedure (SOP) in the FSP. The bedrock wells ranged in depth from 93 (BDRK-1) to 241 ft (BDRK-5D).

[11] Geologic Report on the Ground-Water Conditions for a Domestic Supply in Section 7, T9S, R3E, Williamson County, Illinois, by Robert Vaiden, Research Assistant, Hydrogeology and Physics Section, October 14, 1980

As mentioned above, at locations BDRK-5 and BDRK-9, intermediate depth wells were drilled. In the first attempts to install bedrock wells at these locations, a gravelly material was encountered. Because of the lack of cohesion in the gravelly material, the borings would not stay open and they were abandoned. Additional equipment was brought on site so that casing could be driven into the borings to keep them open, and the bedrock wells were installed as planned. It was decided that it would also be useful to install wells in the gravelly material. Based on the drill cuttings, the gravelly zone was expected to have a relatively high hydraulic conductivity, and that type of material apparently is not often encountered in the subsurface at the Refuge. Note that material descriptions may not be accurate, though, since only the drill cuttings were available for observation, not intact samples. To differentiate the wells installed at these two locations, the deep wells were designated as BDRK-5D and BDRK-9D, and the "intermediate" depth wells (deeper than the shallow monitoring wells drilled at the AUS sites) were designated as BDRK-5I and BDRK-9I. The "BDRK" is a misnomer for 5I and 9I because these wells are not screened in the bedrock, but rather in glacial material. The "BDRK" designator was retained because these two wells were installed as part of the bedrock series of wells.

Following development of the wells, slug testing was done to estimate the hydraulic conductivity of the zone in which the well screen was installed. The hydraulic conductivity values for each well, as calculated from the slug test data, are shown in Table 2-1. Water levels were measured in July, September, and October 2000 (Table 2-2). Survey coordinates for the wells are shown in Table 2-2A.

2.2.2 Subsurface Conditions at Well Locations

2.2.2.1 General Conditions

Depths to bedrock ranged from 23 ft at borings BDRK-1 (elevation 390 ft mean sea level (msl)) and BDRK-10 (elevation 440 ft msl) to 48 ft (elevation 374 ft msl) at BDRK-5D.

Material overlying the bedrock consisted of loess to depths of 6 to 12 ft, then glacial till. The glacial material usually extended to the top of bedrock. In some cases there was a few ft of residual soil material overlying the bedrock. The glacial till usually consisted of low plastic clay with some sand and gravel. At locations 5 and 9, zones of very sandy/gravelly material were encountered in the glacial till.

Bedrock is Pennsylvanian Age and is highly heterogeneous. It consisted primarily of interbedded shale and sandstone. There were a few coal seams and a little limestone. There was no discernable continuity of bedding between borings, except for some coal seams. Based on discussions with field personnel, the coal seams appeared to be the only significant water bearing zones encountered. The hydraulic conductivity of the coal seams was not determined—no well screens were installed in coal seams. The sandstone did not seem to contain much water, to the depths encountered. The sandstone is a known aquifer, and apparently wells must be installed deeper than these were to achieve significant yields.

Except for BDRK-5I and 9I, all wells were screened in the sandstone. As shown in Table 2-1, measured hydraulic conductivity values were variable, ranging from about 4×10^{-3} centimeters

per second (cm/sec) in BDRK-7 to 9 x 10^{-7} in BDRK-1. BDRK-4 may have been even lower; slug testing was not done because the water had not risen high enough in the well to do the test (by June 2000 when the slug testing of the bedrock wells was done). The measured values were within the range reported for sandstone by Freeze and Cherry,[12] except for BDRK-7, which had a higher measured conductivity. The screened interval for BDRK-7 was in sandstone described as fractured.

2.2.2.2 Wells Near Area 2

At the three wells installed near Area 2, BDRK-1, -2, and –4, depths to bedrock ranged from 23 to 34 ft. The surface elevation of the bedrock ranged from about 390 to 400 ft msl. The material overlying the bedrock consisted of clayey silt loess to depths of 6 to 8 ft, overlying glacial till which consisted of low plastic clay with some sand and gravel. There was some surficial soil fill at all three locations.

In all three locations, the uppermost bedrock layer was shale, ranging from 14 to 23 ft in thickness. Beneath this uppermost shale layer, in all three borings a 2- to 3-ft coal seam was encountered. This uppermost coal seam was found at about elevation 370 ft in BDRK-1 and BDRK –2, and around elevation 385 ft in BDRK-4. A second coal seam, about a ft thick, was found at about elevation 365 ft in BDRK-4. A second 2-ft-thick coal seam was encountered in BDRK-1, at around elevation 335 ft. It is not known whether any of these coal seams are connected. It would not be unusual if they were—in this area of southern Illinois, individual coal seams can have large areal extent. In all three borings, beneath the coal layers, the bedrock consisted primarily of interbedded shale and sandstone, with sandstone slightly more common than shale. There was no discernable continuity of bedding layers between the borings, except for the coal seam that was encountered at elevations between about 365 and 370 ft msl in all three borings.

The geologic cross section based on these wells is shown in Figure 2-5.

The hydraulic conductivity values calculated from the slug testing were 9 x 10^{-7} for BDRK-1 and 1 x 10^{-6} for BDRK-2. BDRK-4 was not slug tested, as discussed above, because of the slow recovery in the well.

Measured water levels, with dates, are shown in Figure 2-5.

2.2.2.3 Wells Near Former Load Lines (Areas 8, 9, and 11/12)

At the four wells in this area that were installed to bedrock, BDRK-7, -8, and –9D, and –11, depths to bedrock ranged from 23 to 44 ft. At BDRK-9I, the boring ended at the top of bedrock, at 53 ft. The surface elevation of the bedrock ranged from about 400 to about 430 ft msl. The material overlying the bedrock consisted of clayey silt loess to depths of 6 to 12 ft, overlying glacial till which consisted of low plastic clay with some sand and gravel. There was some surficial soil fill at some locations. In boring BDRK-9I, clay with gravel and sand was encountered between 25 ft and the bottom of the boring, at 53 ft. As discussed above, this

[12] Freeze, R.A., and J.A. Cherry, 1979. *Groundwater*. Published by Prentice-Hall, Inc.

material was not cohesive and was expected to have a higher hydraulic conductivity. In BDRK-7 and –9D, the uppermost bedrock material was shale, and in BDRK-8 and –11, the uppermost bedrock material was sandstone. In BDRK-7 the uppermost shale was 15 ft thick and underlain by a 5-ft thick coal seam. The remainder of the boring was primarily in sandstone, to the bottom at 123 ft. The sandstone was described as fractured from 114 ft depth to the bottom of the boring. The boring log indicates that the boring was producing water at a depth of 114 ft, at the top of the fractured sandstone zone. The well screen was installed in the fractured sandstone. The bedrock in BDRK-8 was almost entirely sandstone, with a little shale and some traces of coal. BDRK-8 was 113 ft deep. In BDRK-9D, the uppermost 60 ft of bedrock was shale, except for a 1-ft thick coal seam at elevation 355 ft msl. The remainder of the boring was interbedded shale and sandstone, to the full depth of 151 ft. In BDRK-11, the bedrock consisted of, from top to bottom, 23 ft of sandstone, 39 ft of shale, and 19 ft of sandstone. The boring ended at 104 ft.

The geologic cross section is shown in Figure 2-6. Measured water levels, with dates, are shown in the figure.

The hydraulic conductivity values for bedrock calculated from the slug testing ranged from 4 x 10^{-3} for BDRK-7 to 3 x 10^{-5} for BDRK-11. As noted above, BDRK-7 was in fractured sandstone.

The well screen in BDRK-9I was installed in the sandy, gravelly clay layer described above. The calculated hydraulic conductivity was 5 x 10^{-5}, within the range of values found for the sandstone. The material was less conductive than expected. However, as noted, the material descriptions were based on drill cuttings and not intact samples.

2.2.2.4 Other Bedrock Wells—North and East of Crab Orchard Lake

Bedrock wells BDRK-3, 5D, 6, and 10 were placed at locations designed to provide overall coverage of the AUS OU, in combination with the wells already discussed.

BDRK-3 and –5D are located on the north side of the Lake, in the eastern part of the area, as shown in Figure 2-4. BDRK-5I was installed near BDRK-5D, in a gravelly layer found in the glacial deposits.

Bedrock was encountered at a depth of 40 ft (elevation 380 ft msl) in BDRK-3 and 48 ft (elevation 374 ft) in BDRK-5D. At BDRK-5I, the boring ended at 51 ft, above the top of bedrock. The material overlying the bedrock consisted of clayey silt loess to depths of 6 to 8 ft, overlying glacial till which consisted of low plastic clay with some sand and gravel. In boring BDRK-5I, a sandy, gravelly material was encountered between 40 and 45 ft. As discussed above, this material was not cohesive and was expected to have a higher hydraulic conductivity. The well was screened in this sandy, gravelly material. The bottom 6 ft of the boring, from 45 to 51 ft, encountered silt, which may be a glacial lake deposit of the Equality Formation (see Figure 2-7).

In both BDRK-3 and BDRK-5D, the uppermost bedrock layer was shale. In BDRK-3, this shale, described as hard and black, was 35 ft thick, then underlain by layers of sandstone and more

shale. In BDRK-5D, the uppermost shale layer was 79 ft thick, with some interbedded clay and a little coal at elevation 356 ft. The remainder of the boring was interbedded shale and sandstone. The boring was extended to 240 ft in an attempt to find a distinct water-bearing zone. None was encountered, and the screen was installed in sandstone at the bottom of the boring.

The geologic cross section is shown in Figure 2-7. Measured water levels, with dates, are shown in the figure.

The calculated hydraulic conductivity for BDRK-3 was 3×10^{-5} and for BDRK-5D, 1×10^{-6}.

The well screen in BDRK-5I was installed in the sandy, gravelly layer described above. The calculated hydraulic conductivity was 7×10^{-5}, very similar to BDRK-9I, and within the range of values found for the sandstone. The material was less conductive than expected. However, as noted, the material descriptions were based on drill cuttings and not intact samples.

2.2.2.5 Other Bedrock Wells—South of Crab Orchard Lake

Bedrock wells BDRK-3, 5D, 6, and 10 were placed at locations designed to provide overall coverage of the AUS OU, in combination with the wells already discussed.

BDRK-6 and –10 are located on the south side of the Lake, in the western part of the AUS OU area, as shown in Figure 2-4.

Bedrock was encountered at a depth of 34 ft (elevation 374 ft msl) in BDRK-6 and 23 ft (elevation 440 ft) in BDRK-10. The material overlying the bedrock consisted of clayey silt loess to depths of 6 and 10 ft, overlying glacial till which consisted of low plastic clay with some sand and gravel.

In both BDRK-6 and BDRK-10, the uppermost bedrock layer was sandstone. The full depth of bedrock in BDRK-6 was described as gray sandstone, with a 4-ft-thick coal seam at about elevation 340 ft msl, and a 1-ft thick coal seam at about elevation 310 ft msl. The bottom of the boring was at 132 ft. Most of the bedrock in BDRK-10 was also sandstone, with the top part red and the lower parts gray. There was some shale and clay in BDRK-10. The bottom of the BDRK-10 boring was at 163 ft in depth.

The geologic cross section is shown in Figure 2-8. Measured water levels, with dates, are shown in the figure.

The calculated hydraulic conductivity for BDRK-6 was 1×10^{-5} and for BDRK-5D, 9×10^{-5}.

2.2.3 Results of Chemical Analysis of Bedrock Groundwater Samples

Groundwater samples from each well except BDRK-4 were analyzed for TCL organics, TAL inorganics, explosives, and standard water quality parameters. Results are shown in Table 2-3. When the groundwater sampling was done, the water level in BDRK-4 had not recovered sufficiently to obtain a sample. Soil samples from some of the wells were analyzed for total organic carbon (TOC). These results are shown in Table 2-4.

Table 2-5 further summarizes the results of the both the groundwater and soil analyses.

Trichloroethylene (TCE) and cis-1,2-dichloroethene were detected at low levels, below maximum contaminant levels (MCLs)/Class I standards, in the groundwater from BDRK-6. TCE was reported at an estimated concentration of 0.9 micrograms per Liter (µg/L), just below the reporting limit of 1 µg/L, and cis-1,2-dichloroethene was detected at 2 µg/L. These constituents were not detected in a groundwater sample taken from this well in September 2000.

Two SVOC compounds were detected in the groundwater samples, at estimated levels, below the reporting limit of 10 µg/L. Bis(2-ethylhexyl)phthalate was detected in the groundwater from BDRK-3 and BDRK-7, at estimated concentrations of 1.9 and 1.8 µg/L, respectively. Di-n-butyl phthalate was detected in the groundwater from BDRK-5D at an estimated concentration of 1.1 µg/L.

No explosive compounds were detected in the groundwater.

All inorganic constituents analyzed in the groundwater were detected in at least one of the twelve samples analyzed except cobalt, copper, mercury, silver, and thallium, which were not detected in any samples. The following constituents exceeded MCLs and/or Illinois Environmental Protection Agency (IEPA) Class I Groundwater Standards (note that Class I standards would not apply to all wells; this information is presented for comparison purposes).

Constituent	MCL and/or Class I Groundwater Standard	Number of Exceedances	Detection	Well
Iron	5,000 µg/L	4	12,500	BDRK-2
			6,810	BDRK-5D
			6,100	BDRK-9D
			12,100	BDRK-11
Manganese	150 µg/L	4	348	BDRK-2
			273	BDRK-5I
			394	BDRK-9I
			210	BDRK-11
Sulfate	400,000 µg/L	2	430,000 J	BDRK-5I
			690,000 J	BDRK-9I
Total Dissolved Solids (TDS)	1,200 mg/L	3	1,900	BDRK-5I
			2,300	BDRK-5D
			1,420	BDRK-9I

J = Estimated
µg/L = micrograms per Liter
mg/L = milligrams per Liter

These concentrations appear to be naturally occurring. Iron and manganese are typically found at high levels in the wells in the till at the Refuge. Note that two of the four manganese exceedances were in the intermediate depth wells. Both sulfate exceedances were in the intermediate depth wells, as were two of the exceedances of TDS.

2.3 BACKGROUND VALUES

Background soil samples were collected from the AUS OU, as part of the Preliminary Assessment/Site Investigation (PA/SI) analysis for the AUS OU. Background sediment and surface water samples were also collected. The sediment and surface water data were gathered from Little Grassy Lake, as part of the preliminary screening analysis for the Lake Monitoring OU. Background comparison values were developed for soil, sediments, and surface water to provide the ability to compare detected concentrations in these media from the AUS OU with those in the reference area. Soil samples were collected in March 2000. The majority of the sediment samples were collected in November and December of 1999; some samples were collected in January, March, and April of 2000.

2.3.1 Selection of Background Sampling Locations

Surface water and sediment samples were obtained from a nearby lake on the Refuge with no known contaminant sources. The selection of the locations for background soil samples is described below. The approach is consistent with the United States Environmental Protection Agency (USEPA) guidance for background sampling.[13]

Four criteria were established for the background soil locations for the AUS OU. They are as follows:

1. The locations must have no known or suspected sources of contamination.

2. The locations should have similar geology and soil chemistry.

3. The locations should be grass-covered rather than forested. Most AUS OU locations are primarily grass-covered. Soil chemistry is more likely to be similar at other grass-covered areas

4. The locations should be on the Refuge. Refuge personnel have more information about past usage, and have more control over usage, compared with sites around the Refuge. Also, sampling on the Refuge avoids the necessity of making arrangements with other property owners. (Property owners are often unwilling to allow sampling because of the liability it represents).

To meet criterion No. 1, the industrial part of the Refuge was eliminated. The industrial areas of the Refuge generally coincide with the AUS OU sites. Also, locations that drain the developed areas to the north and east of the Refuge (including all of Route 13 and the communities nearby) were eliminated due to the potential for contamination. Former strip mines and areas that drain the strip mines, mostly located north of Crab Orchard Lake, were also eliminated.

Criterion No. 2: Figure 2-9 shows soil types on the Refuge. Soil types differ by geologic origin and soil chemistry. As shown in the figure, the predominant soil types for the AUS OU sites are

[13] USEPA, December 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites, EPA/540/5-96/500, OSWER Engineering Forum Issue.

165A (Wier silt loam with 0 to 1.5% slopes) and 164B (Stoy silt loam with 1.5 to 4% slopes). Both these soil types are developed on 5.5 to 12.5 ft of loess[14]. (Virtually all the soil types shown in Figure 2-9 that are within the AUS OU are developed on loess, except for 108 and 382, which are developed on sediment deposits).

Criterion No. 3: for the northern part of the Refuge, grass covered areas are shown in white in Figure 2-9, and forested areas are shown in green. Most candidate areas that meet Criterion No. 2 are grass-covered.

Criterion No. 4: the Refuge boundary is shown in Figure 1-1. Most candidate areas that meet Criterion No. 2 are not on the Refuge. Only a few areas on the Refuge meet all three above criteria.

Five areas were found that meet the criteria listed above. These are shown on Figure 2-9. A total of 30 soil samples were taken from the depth interval 0- to 6-inches, at locations distributed through these areas. These samples were analyzed for metals and TOC. Specific sample locations were based on field conditions, visual observation, and accessibility. Samples were not obtained from any area with visible signs of debris or potential contamination sources. Further, the approach was modified to include previous soil background data.

2.3.2 Previous Soil Background Data

Background values for the Refuge were previously determined, and approved, as discussed and presented in Section 1. These values are listed in Table 2-6 of this report. These background values were presented in a report submitted in 1995.[15] The data used to calculate the 1995 background values are presented in Table 2-7. At that time, background data were needed, and no data had been collected specifically for background. Therefore, the existing body of data from soil sampling at the Refuge was used and reviewed to eliminate samples taken from contaminated sites.[16] The USEPA and the IEPA requested that these previous results be included with the results from the current investigation, to form the data set to use for calculating soil background.

2.3.3 Results

The results of the analyses for the background soil, sediment, and surface water samples are presented in Tables 2-8, 2-9, and 2-10, respectively.

2.3.4 Evaluation of Background Data

The statistical parameter calculated with inorganic background soil, sediment, and surface water data was the upper tolerance limit presented in USEPA *Statistical Analysis of Groundwater*

[14] Fehrenbacher, J.B., and R.T. Odell, *Williamson County Soils*, Soil Report 79, University of Illinois Agricultural Experiment Station, 1959.
[15] Woodward-Clyde, 1995, for USFWS. Summary of Background Metals, Crab Orchard National Wildlife Refuge.
[16] USEPA, December 1995. Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites, EPA/540/5-96/500, OSWER Engineering Forum Issue.

Monitoring Data at RCRA Facilities - Interim Final Guidance.[17] An upper tolerance limit was calculated for each chemical in soil, sediment, and surface water. The upper tolerance limit represents the concentration value (for a given chemical) containing a specified portion of the population with a specified confidence. The portion of the sample population expected to fall below the upper tolerance limit is denoted as the coverage. The 95% coverage level and 95% confidence level, typically recommended by USEPA[18], were used to calculate upper tolerance limits for this investigation. The following equation was used to determine the upper tolerance limits: mean + standard deviation * K, where: K = tolerance factor.

The equation to determine tolerance factors was obtained from USEPA.[19] Since an upper tolerance limit was calculated, rather than a tolerance interval; one-sided tolerance factors were applied. The tolerance factor equation is as follows: $K = t_{n-1,1-\beta}\sqrt{1+\frac{1}{n}}$

where the t-value represents the percentile of the t-distribution at the desired alpha level (95%) with n-1 degrees of freedom.

An assumption underlying the calculation of tolerance limits is that the data are normally or approximately normally distributed. The Shapiro-Wilk test of normality was used to classify the data. When data were not normally distributed, log-transformed values were used in the Shapiro-Wilk test. A non-normal distribution refers to data sets that were neither normally- nor log-normally distributed.

Tables 2-11 through 2-13 present the data distribution, p-values computed in the Shapiro-Wilk test of normality, the t-value and K-value, the mean and standard deviation, and upper tolerance level (UTL) of each data set for soil, sediment, and surface water, respectively. In the Shapiro-Wilk test of normality, a p-value is calculated. The p-value is the probability of correctly accepting or rejecting the null hypothesis (H_0: data are normally distributed). An alpha-level (significance level) of 0.05 was pre-selected for the normality test. If the calculated p-value is smaller than the alpha-level, the null hypothesis is rejected (i.e. the data are not normally distributed). If the raw data fail the Shapiro-Wilk test, the log-transformed data are used to calculate another value. If this p-value is greater than 0.05, the data are assumed to be log-normally distributed. If neither the raw nor log-transformed data pass the Shapiro-Wilk test (p-value<0.05), the data are assumed to be non-normally distributed. The equation for the Shapiro-Wilk calculated value is: $W = \frac{1}{d}\left[\sum_{i=1}^{k} a_i (x_{[n-i+1]} - x_{[i]})\right]^2$

where $d = \sum_{i=1}^{n}(x_i - \bar{x})^2 = \sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum x_i\right)^2$

[17] United States Environmental Protection Agency, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim Final Guidance*, Office of Solid Waste Permit and State Programs, 1992.
[18] Ibid.
[19] Ibid.

a_i = coefficients a_1, a_2 .....a_k, from Table A-6 in Gilbert (1987)

if n is even then : $k = \frac{n}{2}$

if n is odd then: $k = \frac{n-1}{2}$

Parametric procedures were not appropriate for some of the data due to a non-normal distribution. When background data for a particular constituent were neither normally- nor log-normally distributed, the non-parametric tolerance limit method[20] was used to determine a comparison value representative of the data set. In this method, the UTL is defined to be the maximum background value. Non-normal distributions within background data sets were most often attributable to no detections or only one detection of a constituent. When a data set did not have any detected values, the highest reporting limit served as the upper limit. Otherwise, the highest detected value was used as the upper limit for a non-normally distributed data set.

The non-parametric method requires a larger number of background data points to meet the same confidence level. The expected coverage (i.e., confidence level) for the UTL is given by n/(n+1), in which "n" equals the sample size. Therefore, the non-parametric tolerance limit method would require 19 background samples to obtain a confidence level of 95%. The confidence level represents the percentage of confidence that a given number of future observations would fall below the established UTL, assuming that the observations were drawn from the same population as the background data.

The non-normally distributed soil data sets contained enough samples to achieve UTLs with 95% confidence levels, despite the use of the non-parametric tolerance limit method. However, the sediment and surface water data sets did not contain sufficient numbers of samples (i.e., 19) to have a 95% confidence level. The UTLs established for sediment and surface water data, analyzed via the non-parametric method, have confidence levels of approximately 90% and 87%, respectively. Table 2-14 identifies the background data sets for which the non-parametric tolerance limit method was used to establish UTLs.

The USEPA Interim Final Guidance recommends methods for handling various proportions of non-detects within the data sets. However, the United States Geological Survey (USGS) probability plotting method was used because it provides a more accurate representation of data with non-detect values[21,22,23]. In the probability plotting method, data points within a data set are

[20] Ibid

[21] Helsel, D.R. and T.A. Cohn, *Estimation of Descriptive Statistics for Multiply Censored Water Quality Data. Water Resource Research 24(12): 1997-2004*, 1988.

[22] Travis, C.C. and M.L. Land, *Estimating the Mean of Data Sets with Nondetectable Values. Environmental Science and Technology* 24(7): 961-962, 1990.

[23] Helsel, D.R., *Statistical Treatment of Data Below the Detection Limit. Environmental Science and Technology 24(12): 1766-1774*, 1990.

ranked and plotting positions are calculated for each point. Regression analysis is then used to characterize the data set and values are estimated for each censored (non-detect) data point. A mean and standard deviation may then be calculated for the data set and an upper tolerance limit deduced[24].

An outlier's test was also applied to the data. This test identified four potential outliers. Silver (1.3 milligrams per kilogram (mg/kg)) was identified as a potential outlier in soil sample AUS-BKGD-002-SS-0X. Detectable concentrations of silver in other background soil samples ranged from 0.34 mg/kg to 0.43 mg/kg. The average concentration (1.85 mg/kg) of selenium from sediment samples LG99SD005 and LG99SD055 was identified as a potential outlier.[25] The average of the selenium concentrations (1.35 mg/kg) from sample LG99SD001 and duplicate sample LG99SD051 was also identified as a potential outlier. A fourth potential outlier was identified in the surface water data analysis. Total organic carbon was detected at a concentration of 71 milligrams per Liter (mg/L) in sample LG99SW006. This concentration was well above that of all other TOC sample detections. It is assumed that these outlier samples may be impacted by some potential source. Therefore, the results may not be representative of background conditions. Excluding these values results in lower, more protective limits. These potential outliers were removed from the data sets and were not included in the calculation of UTLs.

The background comparison values for inorganic compounds in soil, sediment, and surface water are presented on Table 2-14. The sediment and surface water values are also presented in the April 2001 draft final of the Preliminary Screening Assessment Report for the Lake Monitoring OU. The 95% UTL numbers represent those that were calculated using the above-described upper tolerance limit method. The background values based on the highest reporting limit or highest detected value are denoted on the table. Table 2-14 also presents additional values derived for the background soil, sediment, and surface water data. These were calculated by adding three standard deviations to the mean value. This approach is based on guidance in *Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites.*[26] These "Mean + 3SD" values provide a reasonable maximum value for the reference area data sets in addition to the 95% UTL numbers.

2.4 GENERAL EXPOSURE PATHWAYS AND RECEPTORS

The site conceptual exposure model is a representation relating the contaminant source areas, chemical release mechanisms, environmental transport media, potential human and ecological intake routes, and potential human/ecological receptors to identify exposure pathways that are complete or incomplete. The model provides a framework for problem definition, identifying exposure pathways that may result in health risks, identifying potential data needs to evaluate those pathways, and identifying potential measures that could be used to reduce exposure and risk. An exposure pathway includes four necessary elements:

[24] Ibid.

[25] For locations with duplicates, the value that was used in the analysis was the average concentration of the two samples.

[26] United States Environmental Protection Agency, *Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites*, EPA/540/S-96/500, 1995.

- A source of chemicals and mechanism of chemical release
- An environmental transport medium (air, surface water, etc.) and/or a mechanism of contaminant transfer from one medium to another
- An exposure point
- An intake route (e.g., ingestion, dermal contact, inhalation)

Each of these elements must be present for an exposure pathway to be complete. An incomplete pathway means that no exposure can occur. Only potentially complete pathways are addressed in subsequent risk assessments. Exposure pathways are considered to be potentially complete if there are potential chemical release and transport mechanisms and identified receptors for that exposure pathway.

The primary sources of chemical release at the Refuge are hazardous substances that have been released to the soils and drainage ditches from various industrial facilities and activities. Soil is the primary environmental medium to which receptors may be exposed. Once mixed with soils, the chemicals may be released to surface water by storm water transport, to groundwater by infiltration and percolation, to the atmosphere by volatilization or wind erosion of dust, and to receptors by direct contact. Contaminants discharged at the surface water drainage may remain in surface water, adsorb to sediments, be taken up by aquatic biota, or be released to the atmosphere via volatilization.

2.4.1 Groundwater

Groundwater has been identified as an incomplete exposure pathway to current receptors in previous risk assessments at the Refuge.[27,28] It may represent an exposure pathway to future receptors. There are currently no water wells on the Refuge that are used as potable water sources. Monitoring wells can often be bailed dry and are generally slow to recharge. However, the groundwater beneath the Refuge is typically shallow; therefore, hypothetical construction workers may be exposed to groundwater in excavations via direct contact and inhalation.

Previous risk assessments had not considered the potential for contaminants in the shallow groundwater to migrate to the bedrock aquifer, which is a drinking water source. This may be evaluated as part of future risk assessments.

Discharge of contaminated groundwater to surface water is a potential concern, since many of the AUS sites are close to Crab Orchard Lake and other water bodies. Therefore, aquatic organisms and higher order predators, and recreational users are potential receptors via exposure to contaminated surface water and sediment (as described below).

2.4.2 Surface Water and Sediment

Surface water can become contaminated from runoff and direct discharge from industrial activity, including dumping and burning which the historic records review indicated were the

[27] Woodward-Clyde, *Miscellaneous Areas Operable Unit Remedial Investigation*, 1996.
[28] Environmental Science & Engineering, *Final Revised Feasibility Study Report, EMMA OU, September 26, 1995.*

principal means of disposal of solvents and explosive/ordnance waste. Potential receptors are plankton, aquatic invertebrates, fish, and terrestrial predators that feed on aquatic organisms, including insectivores (e.g., bat and swallow), piscivores (e.g., heron, mink and bald eagle), and herbivores (e.g., Canada goose). Recreational users and construction workers are also potential human receptors. Potential human pathways include dermal contact and incidental ingestion from both surface water and sediments and inhalation of volatile emissions from surface water for both receptors. In addition, ingestion of contaminated fish is considered a potentially complete pathway for recreational users.

2.4.3 Soils and Air

Soil contamination can result from residual contamination from disposal, runoff, and from burn areas. Exposure to contaminants in surface soils is considered to be relevant at the Refuge because nearly all of the area is unpaved. Therefore, direct contact with soil, surface water runoff, or volatilization and dust production are potentially significant pathways for receptors. Potential receptors include terrestrial species that feed on plants and soil invertebrates such as earthworms and grubs and/or otherwise incidentally ingest soils; and burrowing animals. Construction or site workers are also potential receptors, primarily from inhalation, but also from ingestion and dermal contact. Trespassers and recreational users such as hunters are also potential receptors

Air containing contaminants volatilized from soil or airborne particulate matter represents a potentially complete inhalation pathway to recreational users, site workers or hypothetical future construction workers involved in excavation of contaminated soils. Direct contact with contaminated soils by hypothetical construction workers represents a potentially complete ingestion and dermal contact pathway.

2.5 SCREENING CRITERIA FOR PA

As part of the PA, published screening levels were used to evaluate existing analytical data. If existing data showed exceedances of the screening levels for an AUS site, the site was retained for further evaluation in the Site Inspection (SI).

Note that the screening levels used for the PA were not the same as those used for the SI. The PA involved preliminary screening of sites based on available data and information. The SI screening (discussed in Section 1.11) was developed as part of this project, after the PA was finished. The Screening Risk Assessment Work Plan for the AUS OU, which is included as Appendix G of this report (Volume XIV) presents the rationale and criteria for screening used for the SI. The SI screening is the basis for the final recommendations in this report. The screening used in the PA is summarized below.

Screening levels used in the PA for evaluating available soil and sediment data (before the SI part of the project) are shown in Table 2-15; surface water and groundwater screening data are shown in Table 2-16 (References are included in the table). The following list summarizes the application of screening levels to the various media:

- For surface water and sediment, both the Ecotox Thresholds and the USEPA Region IV screening values are shown. Canadian Sediment Quality Guidelines (CSQGs) were also used for sediment. In cases where each has a value for a particular constituent, the lowest value was used.
- Judgement was exercised in deciding whether to apply the soil or sediment criteria. For example, some samples were initially designated as sediment because they were collected from a drainageway, such as a ditch or depression. In many instances, however, the drainageway was a grass-covered area that might transport surface water during a storm event, but never contains standing water, and may support earthworms but would never support aquatic benthic macroinvertebrates. In this example, the media sampled from the drainageway would appropriately be considered a soil. This is important because, for ecological receptors, it is inappropriate to apply sediment screening concentrations to soils, and *vice versa*. In order to evaluate this more closely, a site visit and review of each of the AUS sites was conducted in November 2000 by USFWS and URS. Characteristics taken into consideration in assessing whether a sample was soil or sediment were: presence of depositional material (e.g., silt, sand, or gravel); vegetation; water coverage; presence, or indication of the potential presence of aquatic benthic macroinvertebrates
- MCLs were generally used for screening for groundwater results (the Canadian Water Quality Guidelines and New Dutchlist Groundwater Optimum Levels are shown for reference). Federal MCLs are generally the same as State of Illinois Class I groundwater standards.
- For metal concentrations in soil, existing data were also compared to background levels for the Refuge (Table 2-6). Metal results were considered elevated only in cases where the results exceeded both background and the USEPA Soil Screening Levels (SSLs).

Note that State of Illinois criteria such as TACO[29] and Illinois Water Quality Standards were not included in screening. These criteria were included in the SI. Using the State of Illinois criteria would not have changed the outcome. All 24 of the original AUS OU sites that were recommended for no further action were in one of the following categories:

- Previous analytical results were non-detect (only Site AUS-10 is in this category).
- The site was part of a different existing OU (sites AUS-25, -34, -35, and –36).
- There were no previous sampling results available (the remaining 19 sites were in this category).

2.6 OVERVIEW OF DEVELOPMENT OF SCREENING CRITERIA FOR SI

2.6.1 Human Health Risk

The overall guidance for the human health evaluation followed the structure presented in *Risk Assessment Guidance for Superfund* (RAGS) (USEPA 1989). For the screening evaluation, there were three media of interest: groundwater, surface water, and soils/sediments. For human

[29] TACO = Tiered Approach to Corrective Action Objectives, 35 IAC 742, the Illinois voluntary cleanup program.

exposure purposes, soils and sediments were included together and were evaluated using soil-screening criteria. Drum samples were also screened using soil-screening criteria.

For groundwater, Federal drinking water MCLs, State of Illinois Class I groundwater standards and USEPA Region IX tap water preliminary remediation goals (PRGs) were used.

For surface water, screening concentrations for human health were based on the State of Illinois General Use Surface Water Quality Criteria (Title 35 of the Illinois Administrative Code (35 IAC) Part 302, Subpart B).

There are no published values available for evaluating sediments or drum contents. Soil screening concentrations were used to evaluate sediments and drum contents. This is believed to be a conservative approach, since exposures to sediments and drum contents will generally be less or similar to exposure for soils. Soil screening values were obtained from both the Illinois TACO Program and USEPA Region IX. The specific soil screening values referenced from the Illinois TACO Program were the IEPA Industrial/Commercial Soil Ingestion Pathway, the IEPA Construction Worker Soil Ingestion Pathway, and the IEPA Class I Soil Component of Groundwater Criteria. The referenced USEPA Region IX values were Industrial Soil PRGs for Carcinogens, Industrial Soil PRGs for Toxins, and the Migration to Groundwater Pathway (Dilution Attenuation Factor (DAF)=1).

For dioxins/furans, the toxic equivalent (TEQ) for 2,3,7,8-tetrachlorodibenzo-p-Dioxin (TCDD) was calculated. A screening value of 1 micrograms per kilogram (µg/kg) TCDD TEQ was used, based on USEPA policy. OSWER Directive 9200.4-26, dated 13 April 1998, states that until USEPA develops guidance based on comprehensive on-going studies of dioxins/furans, USEPA will generally use 1 part per billion (ppb) (1 µg/kg) for residential soil cleanup levels. Using this value for these sites is a conservative application of that policy.

2.6.1.1 Selection of Chemicals of Potential Concern for Human Health

Chemicals of potential concern (COPCs) were selected as described below. Screening concentrations derived from the sources noted above were compared to the maximum concentration of a contaminant of interest (COI) detected in applicable media at each AUS OU site except Site AUS-0063. The following criteria were used in selecting COPCs for each AUS OU site:

- If a chemical was not detected, and there was no screening concentration, then the chemical was not selected as a COPC.
- If the maximum concentration of a chemical exceeded the screening concentration, then the chemical was classified as a COPC.
- If the maximum concentration of a chemical was less than the screening concentration, then the chemical was not classified as a COPC.
- If a chemical was detected, and there was no screening concentration, then the chemical was identified as an uncertainty.

- If a chemical was not detected, but the reporting limit exceeded the screening concentration, then the chemical was identified as an uncertainty.

2.6.2 Ecological Risk

The *Ecological Risk Assessment Guidance for Superfund* (ERAGS) (USEPA 1997) was used as the primary guidance for the ecological risk evaluation. ERAGS presents an eight-step process for evaluating the potential for ecological risk. Step 1 of the process involves screening-level problem formulation and ecological effects evaluation. Step 2 deals with screening-level exposure estimates and preliminary risk calculation. Steps 1 and 2 comprise the processes outlined in this report as detailed in the AUS OU Screening Risk Assessment Work Plan, which is included as Appendix G of this report. A brief description of the overall approach is presented in this section.

Problem formulation is a systematic planning process that establishes the goals, focus, and scope of the assessment. A conceptual model is developed during the screening-level problem formulation that addresses five issues (USEPA 1997), as follows:

1. Environmental setting and contaminants known or suspected to exist at the site;
2. Contaminant fate and transport mechanisms;
3. Mechanisms of ecotoxicity associated with contaminants and likely categories of receptors that could be effected;
4. Complete exposure pathways; and,
5. Selection of endpoints to screen for ecological risk.

The primary outcome of the screening-level problem formulation process is the selection of a series of assessment endpoints. ERAGS states that for the screening-level ecological risk assessment, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats and sensitive environments. During problem formulation, nineteen assessment endpoints were identified for evaluation of the AUS OU sites. These were divided into aquatic systems (containing surface water and sediments), and terrestrial systems (containing soils), and are summarized below.

<u>Aquatic Communities – Surface Water and Sediments</u>

Assessment Endpoint #1: Viability and Function of the Benthic Macroinvertebrate Community

Assessment Endpoint #2: Viability and Function of the Periphyton Community

Assessment Endpoint #3: Viability and Function of the Amphibian Community

Assessment Endpoint #4: Viability and Function of the Fish Community

Assessment Endpoint #5: Survival, Growth, and Reproduction of Omnivorous Birds

Assessment Endpoint #6: Survival, Growth, and Reproduction of Omnivorous Mammals

Assessment Endpoint #7: Survival, Growth, and Reproduction of Herbivorous Mammals

Assessment Endpoint #8: Survival, Growth, and Reproduction of Insectivorous Mammals

Assessment Endpoint #9: Survival, Growth, and Reproduction of Insectivorous Birds

Assessment Endpoint # 10: Survival, Growth, and Reproduction of Piscivorous Birds

Assessment Endpoint #11: Survival, Growth, and Reproduction of Piscivorous Mammals

Terrestrial Communities - Soils

Assessment Endpoint #12: Viability and Function of the Soil Community

Assessment Endpoint #13: Viability and Function of the Vascular Plant Community

Assessment Endpoint #14: Survival, Growth, and Reproduction of Herbivorous Birds

Assessment Endpoint #15: Survival, Growth, and Reproduction of Herbivorous Mammals

Assessment Endpoint #16: Survival, Growth, and Reproduction of Insectivorous Birds

Assessment Endpoint #17: Survival, Growth, and Reproduction of Insectivorous Mammals

Assessment Endpoint #18: Survival, Growth, and Reproduction of Carnivorous Birds

Assessment Endpoint #19: Survival, Growth, and Reproduction of Carnivorous Mammals

In the ecological effects evaluation, two exposure pathways were considered: direct exposures and ingestion pathway exposures. Direct exposures are associated with direct contact of a medium with the skin. From an ecological perspective, direct exposures are associated with organisms that live in water, sediment or soil. Ingestion pathway exposures are exposures that occur through the accumulation of constituents into biological material that is eaten.

Assessment Endpoints 1, 2, 3, 4, 12 and 13 relate primarily to direct exposures to surface water, sediment or soils. To develop chemical-specific screening concentrations, it is necessary to understand the level at which a chemical may affect ecological receptors. For the purposes of developing screening concentrations, effects are based on identification of relevant toxicity reference values (TRVs). TRVs selected were generally no-observed effect concentrations (NOECs): the concentration of a chemical that does not adversely impact biota. A single ecological screening value (ESV) was then selected from among multiple TRVs. The ratio of the maximum concentration to the screening concentration is expressed as a screening hazard quotient (HQ). If the screening HQ exceeds 1, that is, if the maximum concentration of the chemical measured at a specific AUS OU site exceeds the screening concentration, then the constituent is characterized as a chemical of potential ecological concern (COPEC), and

additional evaluation of the AUS OU site may be warranted. ESVs were developed in discussions with the Ecological Work Group[30] for the site. The Work Plan (Appendix G) discusses the prioritization, logic, and assumptions used in the selection of ESVs.

The remaining assessment endpoints are associated with ingestion pathway exposures. The screening approach for evaluating ingestion pathway exposures is based on the potential for a chemical to bioaccumulate. The approach for selecting potentially bioaccumulative organic chemicals is based on the chemical-specific octanol-to-water partitioning coefficient (K_{ow}). The K_{ow} provides an indication of the lipophilicity of an organic chemical, and its potential for sequestration in biological tissue. The document *Assessment and Control of Bioconcentratable Contaminants in Surface Waters* (USEPA 1991)[31] suggests a log K_{ow} of 3.5 as a target threshold value indicative of bioaccumulation to target organic chemicals of greatest concern. Using this as a guideline, organic chemicals with a log K_{ow} greater than 3.5 are considered potentially bioaccumulative chemicals in the AUS OU screening evaluation. Among inorganics, mercury and selenium were selected as potentially bioaccumulative chemicals, since there is evidence indicating they biomagnify in food chains (USACE 1995)[32]. Any potentially bioaccumulative chemical detected is retained as a chemical of potential ecological concern (COPEC).

2.6.2.1 Selection of Chemicals of Potential Ecological Concern

The goal of the screening process is to identify COPECs. The following criteria were used in the ecological screening process for selecting COPECs at each of the AUS OU sites except AUS-0063:

- If a chemical was not detected, and there was no screening concentration, then the chemical was not selected as a COPEC.
- If the maximum concentration of a chemical exceeded the screening concentration, then the chemical was classified as a COPEC.
- If the maximum concentration of a chemical was less than the screening concentration, then the chemical was not classified as a COPEC.
- If a chemical was not detected, but the reporting limit exceeded the screening concentration, then the chemical was carried forward as an uncertainty to the Scientific Management Decision Point (SMDP).
- If an organic chemical was detected and had a log K_{ow} greater than 3.5, then it was classified as a COPEC.
- If mercury or selenium were detected, they were classified as a COPEC.

[30] The Ecological Work Group is made up of ecological risk practitioners from the USFWS, USEPA and IEPA; plus the USFWS, USEPA and IEPA CERCLA project managers.
[31] USEPA 1991. Assessment and Control of Bioconcentratable Contaminants in Surface Waters (Draft). US Environmental Protection Agency, Office of Research and Development, Washington, D.C.
[32] USACE. 1995. Trophic transfer and biomagnification potential of contaminants in aquatic ecosystems. Environmental Effects of Dredging: Technical Notes. EEDP-01-33. US Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

- If a chemical was detected, and there was no screening concentration, then the chemical was characterized as an uncertainty for evaluation in the Scientific Management Decision Point.

If no COPECs are identified, it is concluded that there are no chemicals of potential ecological concern and no further investigation for ecological concerns would be warranted. If identified, COPECs are examined by risk assessors and risk managers in the SMDP where a recommendation is made for further evaluation, or elimination of the chemical from further evaluation.

TABLE 2-1

SLUG TEST RESULTS
BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Well ID Number	Hydralic Conductivity (cm/sec)
BDRK-1	9.11E-07
BDRK-2	1.38E-06
BDRK-3	3.35E-05
BDRK-4	not measured
BDRK-5I	6.71E-05
BDRK-5D	1.35E-06
BDRK-6	1.18E-05
BDRK-7	3.91E-03
BDRK-8	1.70E-04
BDRK-9I	4.77E-05
BDRK-9D	9.25E-05
BDRK-10	9.09E-05
BDRK-11	2.97E-05

TABLE 2-2
BEDROCK WELLS - WATER LEVEL DATA

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Monitoring Well	Ground Surface Elevation (feet MSL)	TOC Elevation (feet MSL)	July-00		September-00		October-00	
			DTW (feet BTOC)	Water Elev. (feet MSL)	DTW (feet BTOC)	Water Elev. (feet MSL)	DTW (feet BTOC)	Water Elev. (feet MSL)
BDRK-001	413.49	416.82	10.70	406.12	11.11	405.71	11.25	405.57
BDRK-002	431.26	434.07	26.71	407.36	24.51	409.56	24.37	409.70
BDRK-003	420.18	422.44	2.01	420.43	2.26	420.18	2.68	419.76
BDRK-004	427.06	429.29	**90.02**	339.27	32.95	396.34	28.15	401.14
BDRK-05I (5A)	416.92	419.27	31.57	387.70	16.03	403.24	16.75	402.52
BDRK-05D (5B)	415.89	418.68	14.70	403.98	14.50	404.18	14.24	404.44
BDRK-006	408.09	410.62	0.01	410.61	0.00	410.62	0.00	410.62
BDRK-007	437.17	439.65	24.42	415.23	24.77	414.88	25.08	414.57
BDRK-008	428.99	432.06	12.14	419.92	15.35	416.71	16.18	415.88
BDRK-09I (9A)	451.25	454.17	12.51	441.66	19.47	434.70	20.49	433.68
BDRK-09D (9B)	451.22	454.02	27.15	426.87	27.42	426.60	27.64	426.38
BDRK-010	463.28	464.91	39.76	425.15	NA	NA	41.00	423.91
BDRK-011	452.27	455.03	24.84	430.19	27.70	427.33	27.25	427.78

MSL = Mean Sea Level
BTOC = Below Top of Casing
DTW = Depth to Water

TABLE 2-2A
SURVEY COORDINATES FOR BEDROCK MONITORING WELL LOCATIONS

CRAB ORCHARD NATIONAL WILDLIFE REFUGE
MARION, ILLINOIS

Sample Location	Northing	Easting	Ground Surface Elevation	Top of Casing Elevation	Comments
BDRK-001	390776.0	772667.2	413.49	416.82	New monitoring well
BDRK-002	388300.8	777282.7	431.26	434.07	New monitoring well
BDRK-003	387689.2	794757.7	420.18	422.44	New monitoring well
BDRK-004	384550.8	774359.1	427.06	429.29	New monitoring well
BDRK-05I (5A)	380104.0	785005.8	416.92	419.27	New monitoring well
BDRK-05D (5B)	380093.4	785004.1	415.89	418.68	New monitoring well
BDRK-006	377509.0	761413.9	408.09	410.62	New monitoring well
BDRK-007	368552.2	787103.4	437.17	439.65	New monitoring well
BDRK-008	367596.5	778738.0	428.99	432.06	New monitoring well
BDRK-09I (9A)	365170.5	789462.7	451.25	454.17	New monitoring well
BDRK-09D (9B)	365165.0	789469.0	451.22	454.02	New monitoring well
BDRK-010	365647.0	760840.8	463.28	464.91	New monitoring well
BDRK-011	361924.9	785071.3	452.27	455.03	New monitoring well

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-001-GW-00			AUS-BDRK-002-GW-00			AUS-BDRK-003-GW-00			AUS-BDRK-006-GW-00			AUS-BDRK-007-GW-00		
DATE COLLECTED			June 27, 2000			June 29, 2000			June 27, 2000			June 28, 2000			June 27, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANIC COMPOUNDS (µg/L)																	
1,1,1-Trichloroethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
1,1,2,2-Tetrachloroethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
1,1,2-Trichloroethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
1,1-Dichloroethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
1,1-Dichloroethene	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
1,2-Dichloroethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
1,2-Dichloropropane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
2-Hexanone	ND	0 / 12	<	5	U	<	5	U	<	5	U	<	5	U	<	5	U
Acetone	ND	0 / 12	<	5	U	<	5	U	<	5	U	<	5	U	<	5	U
Benzene	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Bromodichloromethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Bromoform	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Bromomethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Carbon Disulfide	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Carbon Tetrachloride	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Chlorobenzene	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Chloroethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Chloroform	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Chloromethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Cis-1,2-dichloroethene	2	1 / 12	<	1	U	<	1	U	<	1	U	2	1		<	1	U
Cis-1,3-dichloropropene	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Dibromochloromethane	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Ethylbenzene	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Methyl Ethyl Ketone (2-butanone)	ND	0 / 12	<	5	U	<	5	U	<	5	U	<	5	U	<	5	U
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	ND	0 / 12	<	5	U	<	5	U	<	5	U	<	5	U	<	5	U
Methylene Chloride	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Trans-1,2-dichloroethene	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Trans-1,3-dichloropropene	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
Trichloroethylene (TCE)	0.9 J	1 / 12	<	1	U	<	1	U	<	1	U	0.9	1	J	<	1	U
Vinyl Chloride	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-001-GW-00			AUS-BDRK-002-GW-00			AUS-BDRK-003-GW-00			AUS-BDRK-006-GW-00			AUS-BDRK-007-GW-00		
DATE COLLECTED			June 27, 2000			June 29, 2000			June 27, 2000			June 28, 2000			June 27, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Xylenes, Total	ND	0 / 12	<	1	U	<	1	U	<	1	U	<	1	U	<	1	U
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)																	
1,2,4-Trichlorobenzene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
1,2-Dichlorobenzene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
1,3-Dichlorobenzene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
1,4-Dichlorobenzene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2,4,5-Trichlorophenol	ND	0 / 12	<	53	U	<	53	U	<	50	U	<	50	U	<	51	U
2,4,6-Trichlorophenol	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2,4-Dichlorophenol	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2,4-Dimethylphenol	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2,4-Dinitrophenol	ND	0 / 12	<	53	U	<	53	U	<	50	U	<	50	U	<	51	U
2,4-Dinitrotoluene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2,6-Dinitrotoluene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2-Chloronaphthalene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2-Chlorophenol	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2-Methylnaphthalene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2-Methylphenol (o-cresol)	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
2-Nitroaniline	ND	0 / 12	<	53	U	<	53	U	<	50	U	<	50	U	<	51	U
2-Nitrophenol	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
3,3'-Dichlorobenzidine	ND	0 / 12	<	21	U	<	21	U	<	20	U	<	20	U	<	20	U
3-Nitroaniline	ND	0 / 12	<	53	U	<	53	U	<	50	U	<	50	U	<	51	U
4,6-Dinitro-2-methylphenol	ND	0 / 12	<	53	U	<	53	U	<	50	U	<	50	U	<	51	U
4-Bromophenyl Phenyl Ether	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
4-Chloro-3-methylphenol	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
4-Chloroaniline	ND	0 / 12	<	21	U	<	21	U	<	20	U	<	20	U	<	20	U
4-Chlorophenyl Phenyl Ether	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
4-Methylphenol (p-cresol)	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
4-Nitroaniline	ND	0 / 12	<	53	U	<	53	U	<	50	U	<	50	U	<	51	U
4-Nitrophenol	ND	0 / 12	<	53	U	<	53	U	<	50	U	<	50	U	<	51	U
Acenaphthene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Acenaphthylene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-001-GW-00			AUS-BDRK-002-GW-00			AUS-BDRK-003-GW-00			AUS-BDRK-006-GW-00			AUS-BDRK-007-GW-00		
DATE COLLECTED			June 27, 2000			June 29, 2000			June 27, 2000			June 28, 2000			June 27, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Anthracene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Benzo(a)anthracene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Benzo(a)pyrene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Benzo(b)fluoranthene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Benzo(g,h,i)perylene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Benzo(k)fluoranthene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Benzyl Butyl Phthalate	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Bis(2-chloroethoxy) Methane	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Bis(2-chloroethyl) Ether	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Bis(2-chloroisopropyl) Ether	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Bis(2-ethylhexyl) Phthalate	1.9 J	2 / 12	<	11	U	<	21	U	1.9	10	J	<	10	U	1.8	10	J
Carbazole	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Chrysene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Di-n-butyl Phthalate	1.1 J	1 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Di-n-octylphthalate	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Dibenz(a,h)anthracene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Dibenzofuran	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Diethyl Phthalate	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Dimethyl Phthalate	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Fluoranthene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Fluorene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Hexachlorobenzene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Hexachlorobutadiene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Hexachlorocyclopentadiene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Hexachloroethane	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Indeno(1,2,3-c,d)pyrene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Isophorone	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
N-nitrosodi-n-propylamine	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
N-nitrosodiphenylamine	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Naphthalene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Nitrobenzene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-001-GW-00			AUS-BDRK-002-GW-00			AUS-BDRK-003-GW-00			AUS-BDRK-006-GW-00			AUS-BDRK-007-GW-00		
DATE COLLECTED			June 27, 2000			June 29, 2000			June 27, 2000			June 28, 2000			June 27, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Pentachlorophenol	ND	0 / 12	<	53	U	<	53	U	<	50	U	<	50	U	<	51	U
Phenanthrene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Phenol	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
Pyrene	ND	0 / 12	<	11	U	<	11	U	<	10	U	<	10	U	<	10	U
EXPLOSIVES (µg/L)																	
1,3,5-Trinitrobenzene	ND	0 / 12	<	0.25	U	<	0.25	U	<	0.25	U	<	0.25	U	<	0.25	U
1,3-Dinitrobenzene	ND	0 / 12	<	0.25	U	<	0.25	U	<	0.25	U	<	0.25	U	<	0.25	U
2,4,6-Trinitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
2,4-Dinitrotoluene	ND	0 / 12	<	0.25	U	<	0.25	U	<	0.25	U	<	0.25	U	<	0.25	U
2,6-Dinitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
2-Amino-4,6-dinitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
2-Nitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
3-Nitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
4-Amino-2,6-dinitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
4-Nitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
hmx	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
Nitrobenzene	ND	0 / 12	<	0.25	U	<	0.25	U	<	0.25	U	<	0.25	U	<	0.25	U
rdx	ND	0 / 12	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U	<	0.5	U
Tetryl	ND	0 / 12	<	0.75	U	<	0.75	U	<	0.75	U	<	0.75	U	<	0.75	U
METALS (µg/L)																	
Aluminum	9840	10 / 12	1330	200		9840	200		904	200		622	200		<	399	U
Antimony	2.2 J	1 / 12	2.2	6	J	<	6	U	<	6	U	<	6	U	<	6	U
Arsenic	9.7	5 / 12	5	10	J	<	10	U	2.7	10	J	<	10	U	5	10	J
Barium	215	12 / 12	47.3	200	J	139	200	J	25.5	200	J	111	200	J	57.6	200	J
Beryllium	0.6 J	1 / 12	<	5	U	<	5	U	<	5	U	<	5	U	<	5	U
Boron	609	8 / 12	447	100		477	100		609	100		72.6	100	J	71.5	100	J
Cadmium	0.27 J	2 / 12	0.27	5	J	<	5	U	<	5	U	<	5	U	<	5	U
Calcium	223000	12 / 12	4830	1000		6680	1000		14800	1000		42300	1000		38700	1000	
Chromium	12.3	8 / 12	4.1	10	J	12.3	10		<	10	U	2.5	10	J	<	10	U
Cobalt	ND	0 / 12	<	50	U	<	50	U	<	50	U	<	50	U	<	50	U
Copper	ND	0 / 12	<	10	U	<	10	U	<	10	U	<	10	U	<	10	U

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-001-GW-00			AUS-BDRK-002-GW-00			AUS-BDRK-003-GW-00			AUS-BDRK-006-GW-00			AUS-BDRK-007-GW-00		
DATE COLLECTED			June 27, 2000			June 29, 2000			June 27, 2000			June 28, 2000			June 27, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Iron	12500	12 / 12	1570	100		12500	100		140	100		792	100		500	100	
Lead	3	2 / 12	<	3	U	<	8.7	U	<	3	U	<	3	U	<	3	U
Magnesium	115000	12 / 12	2000	1000		2220	1000		348	1000	J	19900	1000		17400	1000	
Manganese	394	10 / 12	<	15	U	348	15		<	15	U	47.5	15		90.4	15	
Mercury	ND	0 / 12	<	0.2	U	<	0.2	U	<	0.2	U	<	0.2	U	<	0.2	U
Nickel	13.7 J	5 / 12	3.9	10	J	13.1	40	J	<	10	U	<	40	U	<	10	U
Potassium	17700 J	12 / 12	2540	1000		4970	1000		3220	1000		12200	1000		5550	1000	
Selenium	1.9 J	1 / 12	<	5	U	<	5	U	<	5	U	<	5	U	1.9	5	J
Silver	ND	0 / 12	<	10	U	<	10	U	<	10	U	<	10	U	<	10	U
Sodium	861000	12 / 12	286000	10000		454000	10000		231000	10000		78100	1000		49800	1000	
Thallium	ND	0 / 12	<	10	U	<	10	U	<	10	U	<	10	U	<	10	U
Vanadium	13.2 J	2 / 12	<	50	U	13.2	50	J	<	50	U	<	50	U	<	50	U
Zinc	50.1	6 / 12	<	20	U	50.1	20		<	20	U	18.6	20	J	<	20	U
OTHER PARAMETERS (mg/L)																	
Alkalinity, Total (as $CaCO_3$)	837	12 / 12	837	4		795	4		474	4		355	4		297	4	
Nitrogen, Ammonia (as N)	4.9	12 / 12	0.3	0.1		0.45	0.1		0.51	0.1	J	0.4	0.1		0.49	0.1	
Nitrogen, Nitrate-nitrite	0.27	1 / 12	0.27	0.05		<	0.05	U	<	0.05	U	<	0.05	U	<	0.05	U
Phosphorus, Total (as P)	0.82	12 / 12	0.26	0.05		0.17	0.05		0.32	0.05	J	0.42	0.05		0.17	0.05	
Sulfate (as SO_4), (µg/L)	690000 J	11 / 12			R	6300	100	J			R	2400	100	J			R
Suspended Solids (residue, Non-filterable)	1540	12 / 12	209	2.5		1540	5		43	2.5		32.5	2.5		23.5	2.5	
Total Dissolved Solids (residue, Filterable)	2300	12 / 12	757	5		1190	10		568	5		382	5		320	5	

Qual = Qualifier
DIL = Dilution
E = Value exceeds linear range. Use diluted sample result if available.
J = Estimated
ND = Not Detected
R = Rejected
U = Nondetect
UJ = Estimated Nondetect
RL = Reporting Limit
mg/L = milligram per liter
µg/L = microgram per liter

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-008-GW-00			AUS-BDRK-010-GW-00			AUS-BDRK-010-GW-00 DIL			AUS-BDRK-011-GW-00			AUS-BDRK-05D-GW-00		
DATE COLLECTED			June 28, 2000			June 28, 2000			June 28, 2000			June 29, 2000			July 6, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANIC COMPOUNDS (µg/L)																	
1,1,1-Trichloroethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
1,1,2,2-Tetrachloroethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
1,1,2-Trichloroethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
1,1-Dichloroethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
1,1-Dichloroethene	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
1,2-Dichloroethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
1,2-Dichloropropane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
2-Hexanone	ND	0 / 12	<	5	U	<	5	U				<	5	U	<	2	U
Acetone	ND	0 / 12	<	5	U	<	5	U				<	5	U	<	4	U
Benzene	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Bromodichloromethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Bromoform	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Bromomethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Carbon Disulfide	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Carbon Tetrachloride	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Chlorobenzene	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Chloroethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Chloroform	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Chloromethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Cis-1,2-dichloroethene	2	1 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Cis-1,3-dichloropropene	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Dibromochloromethane	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Ethylbenzene	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Methyl Ethyl Ketone (2-butanone)	ND	0 / 12	<	5	U	<	5	U				<	5	U	<	2	U
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	ND	0 / 12	<	5	U	<	5	U				<	5	U	<	2	U
Methylene Chloride	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Trans-1,2-dichloroethene	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Trans-1,3-dichloropropene	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Trichloroethylene (TCE)	0.9 J	1 / 12	<	1	U	<	1	U				<	1	U	<	1	U
Vinyl Chloride	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-008-GW-00			AUS-BDRK-010-GW-00			AUS-BDRK-010-GW-00 DIL			AUS-BDRK-011-GW-00			AUS-BDRK-05D-GW-00		
DATE COLLECTED			June 28, 2000			June 28, 2000			June 28, 2000			June 29, 2000			July 6, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Xylenes, Total	ND	0 / 12	<	1	U	<	1	U				<	1	U	<	1	U
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)																	
1,2,4-Trichlorobenzene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
1,2-Dichlorobenzene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
1,3-Dichlorobenzene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
1,4-Dichlorobenzene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2,4,5-Trichlorophenol	ND	0 / 12	<	52	U	<	51	U				<	52	U	<	50	U
2,4,6-Trichlorophenol	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2,4-Dichlorophenol	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2,4-Dimethylphenol	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2,4-Dinitrophenol	ND	0 / 12	<	52	U	<	51	U				<	52	U	<	50	U
2,4-Dinitrotoluene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2,6-Dinitrotoluene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2-Chloronaphthalene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2-Chlorophenol	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2-Methylnaphthalene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2-Methylphenol (o-cresol)	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
2-Nitroaniline	ND	0 / 12	<	52	U	<	51	U				<	52	U	<	50	U
2-Nitrophenol	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
3,3'-Dichlorobenzidine	ND	0 / 12	<	21	U	<	21	U				<	21	U	<	20	U
3-Nitroaniline	ND	0 / 12	<	52	U	<	51	U				<	52	U	<	50	U
4,6-Dinitro-2-methylphenol	ND	0 / 12	<	52	U	<	51	U				<	52	U	<	50	U
4-Bromophenyl Phenyl Ether	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
4-Chloro-3-methylphenol	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
4-Chloroaniline	ND	0 / 12	<	21	U	<	21	U				<	21	U	<	20	U
4-Chlorophenyl Phenyl Ether	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
4-Methylphenol (p-cresol)	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
4-Nitroaniline	ND	0 / 12	<	52	U	<	51	U				<	52	U	<	50	U
4-Nitrophenol	ND	0 / 12	<	52	U	<	51	U				<	52	U	<	50	U
Acenaphthene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Acenaphthylene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-008-GW-00			AUS-BDRK-010-GW-00			AUS-BDRK-010-GW-00 DIL			AUS-BDRK-011-GW-00			AUS-BDRK-05D-GW-00		
DATE COLLECTED			June 28, 2000			June 28, 2000			June 28, 2000			June 29, 2000			July 6, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Anthracene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Benzo(a)anthracene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Benzo(a)pyrene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Benzo(b)fluoranthene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Benzo(g,h,i)perylene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Benzo(k)fluoranthene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Benzyl Butyl Phthalate	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Bis(2-chloroethoxy) Methane	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Bis(2-chloroethyl) Ether	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Bis(2-chloroisopropyl) Ether	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Bis(2-ethylhexyl) Phthalate	1.9 J	2 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Carbazole	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Chrysene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Di-n-butyl Phthalate	1.1 J	1 / 12	<	10	U	<	10	U				<	10	U	1.1	10	J
Di-n-octylphthalate	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Dibenz(a,h)anthracene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Dibenzofuran	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Diethyl Phthalate	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Dimethyl Phthalate	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Fluoranthene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Fluorene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Hexachlorobenzene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Hexachlorobutadiene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Hexachlorocyclopentadiene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Hexachloroethane	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Indeno(1,2,3-c,d)pyrene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Isophorone	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
N-nitrosodi-n-propylamine	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
N-nitrosodiphenylamine	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Naphthalene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Nitrobenzene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-008-GW-00			AUS-BDRK-010-GW-00			AUS-BDRK-010-GW-00 DIL			AUS-BDRK-011-GW-00			AUS-BDRK-05D-GW-00		
DATE COLLECTED			June 28, 2000			June 28, 2000			June 28, 2000			June 29, 2000			July 6, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Pentachlorophenol	ND	0 / 12	<	52	U	<	51	U				<	52	U	<	50	U
Phenanthrene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Phenol	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Pyrene	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
EXPLOSIVES (µg/L)																	
1,3,5-Trinitrobenzene	ND	0 / 12	<	0.25	U	<	0.25	U				<	0.25	U	<	0.25	U
1,3-Dinitrobenzene	ND	0 / 12	<	0.25	U	<	0.25	U				<	0.25	U	<	0.25	U
2,4,6-Trinitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
2,4-Dinitrotoluene	ND	0 / 12	<	0.25	U	<	0.25	U				<	0.25	U	<	0.25	U
2,6-Dinitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
2-Amino-4,6-dinitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
2-Nitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
3-Nitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
4-Amino-2,6-dinitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
4-Nitrotoluene	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
hmx	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
Nitrobenzene	ND	0 / 12	<	0.25	U	<	0.25	U				<	0.25	U	<	0.25	U
rdx	ND	0 / 12	<	0.5	U	<	0.5	U				<	0.5	U	<	0.5	U
Tetryl	ND	0 / 12	<	0.75	U	<	0.75	U				<	0.75	U	<	0.75	U
METALS (µg/L)																	
Aluminum	9840	10 / 12	665	200		<	320	U				7310	200		2250	200	J
Antimony	2.2 J	1 / 12	<	6	U	<	6	U				<	6	U	<	6	U
Arsenic	9.7	5 / 12	<	10	U	<	10	U				<	10	U	5.2	10	J
Barium	215	12 / 12	84.1	200	J	19.3	200	J				110	200	J	108	200	
Beryllium	0.6 J	1 / 12	<	5	U	<	5	U				0.6	5	J	<	5	U
Boron	609	8 / 12	<	100	U	<	100	U				<	100	U	239	100	
Cadmium	0.27 J	2 / 12	<	5	U	<	5	U				<	5	U	0.25	5	J
Calcium	223000	12 / 12	60100	1000		53000	1000					41700	1000		6530	1000	
Chromium	12.3	8 / 12	<	10	U	<	10	U				9	10	J	11.1	10	
Cobalt	ND	0 / 12	<	50	U	<	50	U				<	50	U	<	50	U
Copper	ND	0 / 12	<	10	U	<	10	U				<	11	U	<	10	U

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-008-GW-00			AUS-BDRK-010-GW-00			AUS-BDRK-010-GW-00 DIL			AUS-BDRK-011-GW-00			AUS-BDRK-05D-GW-00		
DATE COLLECTED			June 28, 2000			June 28, 2000			June 28, 2000			June 29, 2000			July 6, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Iron	12500	12 / 12	1190	100		1100	100					12100	100		6810	100	
Lead	3	2 / 12	<	3	U	<	3	U				<	7	U	2.5	3	J
Magnesium	115000	12 / 12	21200	1000		21200	1000					27800	1000		2610	1000	
Manganese	394	10 / 12	129	15		136	15					210	15		61.8	15	
Mercury	ND	0 / 12	<	0.2	U	<	0.2	U				<	0.2	U	<	0.2	U
Nickel	13.7 J	5 / 12	<	40	U	<	40	U				13.7	40	J	10.1	40	J
Potassium	17700 J	12 / 12	4190	1000		1610	1000					10400	1000		17700	1000	J
Selenium	1.9 J	1 / 12	<	5	U	<	5	U				<	5	U	<	5	U
Silver	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	U
Sodium	861000	12 / 12	8380	1000		8590	1000					23800	1000		861000	1000	
Thallium	ND	0 / 12	<	10	U	<	10	U				<	10	U	<	10	UJ
Vanadium	13.2 J	2 / 12	<	50	U	<	50	U				9.5	50	J	<	50	U
Zinc	50.1	6 / 12	<	20	U	<	20	U				37.3	20		29.6	20	J
OTHER PARAMETERS (mg/L)																	
Alkalinity, Total (as $CaCO_3$)	837	12 / 12	262	4		219	4					269	4		584	1	
Nitrogen, Ammonia (as N)	4.9	12 / 12	0.4	0.1		0.29	0.1					0.31	0.1		0.54	0.1	
Nitrogen, Nitrate-nitrite	0.27	1 / 12	<	0.05	U	<	0.05	U				<	0.05	U	<	0.05	U
Phosphorus, Total (as P)	0.82	12 / 12	0.18	0.05		0.35	0.05					0.27	0.05		0.82	0.05	
Sulfate (as SO_4), (µg/L)	690000 J	11 / 12	14000	100	J	35000	100	J	37000	200	J	17000	100	J	17000	100	J
Suspended Solids (residue, Non-filterable)	1540	12 / 12	28	2.5		8	2.5					128	2.5		135	2.5	
Total Dissolved Solids (residue, Filterable)	2300	12 / 12	271	5		256	5					322	5		2300	5	

Qual = Qualifier
DIL = Dilution
E = Value exceeds linear range. Use diluted sample result if available.
J = Estimated
ND = Not Detected
R = Rejected
U = Nondetect
UJ = Estimated Nondetect
RL = Reporting Limit
mg/L = milligram per liter
µg/L = microgram per liter

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-05I-GW-00			AUS-BDRK-05I-GW-00 DIL			AUS-BDRK-09D-GW-00			AUS-BDRK-09I-GW-00			AUS-BDRK-09I-GW-00 DIL		
DATE COLLECTED			June 29, 2000			June 29, 2000			July 6, 2000			June 29, 2000			June 29, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
VOLATILE ORGANIC COMPOUNDS (µg/L)																	
1,1,1-Trichloroethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
1,1,2,2-Tetrachloroethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
1,1,2-Trichloroethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
1,1-Dichloroethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
1,1-Dichloroethene	ND	0 / 12	<	1	U				<	1	U	<	1	U			
1,2-Dichloroethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
1,2-Dichloropropane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
2-Hexanone	ND	0 / 12	<	5	U				<	2	U	<	5	U			
Acetone	ND	0 / 12	<	5	U				<	2	U	<	5	U			
Benzene	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Bromodichloromethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Bromoform	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Bromomethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Carbon Disulfide	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Carbon Tetrachloride	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Chlorobenzene	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Chloroethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Chloroform	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Chloromethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Cis-1,2-dichloroethene	2	1 / 12	<	1	U				<	1	U	<	1	U			
Cis-1,3-dichloropropene	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Dibromochloromethane	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Ethylbenzene	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Methyl Ethyl Ketone (2-butanone)	ND	0 / 12	<	5	U				<	2	U	<	5	U			
Methyl Isobutyl Ketone (4-methyl-2-pentanone)	ND	0 / 12	<	5	U				<	2	U	<	5	U			
Methylene Chloride	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Trans-1,2-dichloroethene	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Trans-1,3-dichloropropene	ND	0 / 12	<	1	U				<	1	U	<	1	U			
Trichloroethylene (TCE)	0.9 J	1 / 12	<	1	U				<	1	U	<	1	U			
Vinyl Chloride	ND	0 / 12	<	1	U				<	1	U	<	1	U			

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-05I-GW-00			AUS-BDRK-05I-GW-00 DIL			AUS-BDRK-09D-GW-00			AUS-BDRK-09I-GW-00			AUS-BDRK-09I-GW-00 DIL		
DATE COLLECTED			June 29, 2000			June 29, 2000			July 6, 2000			June 29, 2000			June 29, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Xylenes, Total	ND	0 / 12	<	1	U				<	1	U	<	1	U			
SEMIVOLATILE ORGANIC COMPOUNDS (µg/L)																	
1,2,4-Trichlorobenzene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
1,2-Dichlorobenzene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
1,3-Dichlorobenzene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
1,4-Dichlorobenzene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2,4,5-Trichlorophenol	ND	0 / 12	<	52	U				<	52	U	<	52	U			
2,4,6-Trichlorophenol	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2,4-Dichlorophenol	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2,4-Dimethylphenol	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2,4-Dinitrophenol	ND	0 / 12	<	52	U				<	52	U	<	52	U			
2,4-Dinitrotoluene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2,6-Dinitrotoluene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2-Chloronaphthalene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2-Chlorophenol	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2-Methylnaphthalene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2-Methylphenol (o-cresol)	ND	0 / 12	<	10	U				<	10	U	<	10	U			
2-Nitroaniline	ND	0 / 12	<	52	U				<	52	U	<	52	U			
2-Nitrophenol	ND	0 / 12	<	10	U				<	10	U	<	10	U			
3,3'-Dichlorobenzidine	ND	0 / 12	<	21	U				<	21	U	<	21	U			
3-Nitroaniline	ND	0 / 12	<	52	U				<	52	U	<	52	U			
4,6-Dinitro-2-methylphenol	ND	0 / 12	<	52	U				<	52	U	<	52	U			
4-Bromophenyl Phenyl Ether	ND	0 / 12	<	10	U				<	10	U	<	10	U			
4-Chloro-3-methylphenol	ND	0 / 12	<	10	U				<	10	U	<	10	U			
4-Chloroaniline	ND	0 / 12	<	21	U				<	21	U	<	21	U			
4-Chlorophenyl Phenyl Ether	ND	0 / 12	<	10	U				<	10	U	<	10	U			
4-Methylphenol (p-cresol)	ND	0 / 12	<	10	U				<	10	U	<	10	U			
4-Nitroaniline	ND	0 / 12	<	52	U				<	52	U	<	52	U			
4-Nitrophenol	ND	0 / 12	<	52	U				<	52	U	<	52	U			
Acenaphthene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Acenaphthylene	ND	0 / 12	<	10	U				<	10	U	<	10	U			

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-05I-GW-00			AUS-BDRK-05I-GW-00 DIL			AUS-BDRK-09D-GW-00			AUS-BDRK-09I-GW-00			AUS-BDRK-09I-GW-00 DIL		
DATE COLLECTED			June 29, 2000			June 29, 2000			July 6, 2000			June 29, 2000			June 29, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Anthracene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Benzo(a)anthracene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Benzo(a)pyrene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Benzo(b)fluoranthene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Benzo(g,h,i)perylene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Benzo(k)fluoranthene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Benzyl Butyl Phthalate	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Bis(2-chloroethoxy) Methane	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Bis(2-chloroethyl) Ether	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Bis(2-chloroisopropyl) Ether	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Bis(2-ethylhexyl) Phthalate	1.9 J	2 / 12	<	10	U				<	10	U	<	110	U			
Carbazole	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Chrysene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Di-n-butyl Phthalate	1.1 J	1 / 12	<	10	U				<	10	U	<	10	U			
Di-n-octylphthalate	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Dibenz(a,h)anthracene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Dibenzofuran	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Diethyl Phthalate	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Dimethyl Phthalate	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Fluoranthene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Fluorene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Hexachlorobenzene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Hexachlorobutadiene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Hexachlorocyclopentadiene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Hexachloroethane	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Indeno(1,2,3-c,d)pyrene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Isophorone	ND	0 / 12	<	10	U				<	10	U	<	10	U			
N-nitrosodi-n-propylamine	ND	0 / 12	<	10	U				<	10	U	<	10	U			
N-nitrosodiphenylamine	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Naphthalene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Nitrobenzene	ND	0 / 12	<	10	U				<	10	U	<	10	U			

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-05I-GW-00			AUS-BDRK-05I-GW-00 DIL			AUS-BDRK-09D-GW-00			AUS-BDRK-09I-GW-00			AUS-BDRK-09I-GW-00 DIL		
DATE COLLECTED			June 29, 2000			June 29, 2000			July 6, 2000			June 29, 2000			June 29, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Pentachlorophenol	ND	0 / 12	<	52	U				<	52	U	<	52	U			
Phenanthrene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Phenol	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Pyrene	ND	0 / 12	<	10	U				<	10	U	<	10	U			
EXPLOSIVES (µg/L)																	
1,3,5-Trinitrobenzene	ND	0 / 12	<	0.25	U				<	0.25	U	<	0.25	U			
1,3-Dinitrobenzene	ND	0 / 12	<	0.25	U				<	0.25	U	<	0.25	U			
2,4,6-Trinitrotoluene	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
2,4-Dinitrotoluene	ND	0 / 12	<	0.25	U				<	0.25	U	<	0.25	U			
2,6-Dinitrotoluene	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
2-Amino-4,6-dinitrotoluene	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
2-Nitrotoluene	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
3-Nitrotoluene	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
4-Amino-2,6-dinitrotoluene	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
4-Nitrotoluene	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
hmx	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
Nitrobenzene	ND	0 / 12	<	0.25	U				<	0.25	U	<	0.25	U			
rdx	ND	0 / 12	<	0.5	U				<	0.5	U	<	0.5	U			
Tetryl	ND	0 / 12	<	0.75	U				<	0.75	U	<	0.75	U			
METALS (µg/L)																	
Aluminum	9840	10 / 12	1080	200					3080	200		1520	200				
Antimony	2.2 J	1 / 12	<	6	U				<	6	U	<	6	U			
Arsenic	9.7	5 / 12	<	10	U				9.7	10	J	<	10	U			
Barium	215	12 / 12	155	200	J				215	200		20.1	200	J			
Beryllium	0.6 J	1 / 12	<	5	U				<	5	U	<	5	U			
Boron	609	8 / 12	108	100					110	100		<	100	U			
Cadmium	0.27 J	2 / 12	<	5	U				<	5	U	<	5	U			
Calcium	223000	12 / 12	223000	1000					58400	1000		134000	1000				
Chromium	12.3	8 / 12	1.4	10	J				4.7	10	J	2.2	10	J			
Cobalt	ND	0 / 12	<	50	U				<	50	U	<	50	U			
Copper	ND	0 / 12	<	10	U				<	10	U	<	10	U			

TABLE 2-3
SUMMARY OF ANALYTICAL DATA FOR GROUNDWATER COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-05I-GW-00			AUS-BDRK-05I-GW-00 DIL			AUS-BDRK-09D-GW-00			AUS-BDRK-09I-GW-00			AUS-BDRK-09I-GW-00 DIL		
DATE COLLECTED			June 29, 2000			June 29, 2000			July 6, 2000			June 29, 2000			June 29, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
Iron	12500	12 / 12	1310	100					6100	100		2590	100				
Lead	3	2 / 12	<	3	U				3	3		<	3	U			
Magnesium	115000	12 / 12	115000	1000					31200	1000		84300	1000				
Manganese	394	10 / 12	273	15					120	15		394	15				
Mercury	ND	0 / 12	<	0.2	UJ				<	0.2	U	<	0.2	U			
Nickel	13.7 J	5 / 12	<	40	U				6.2	40	J	<	40	U			
Potassium	17700 J	12 / 12	5140	1000					5360	1000		3330	1000				
Selenium	1.9 J	1 / 12	<	5	U				<	5	U	<	5	U			
Silver	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Sodium	861000	12 / 12	204000	10000					46500	1000		122000	1000				
Thallium	ND	0 / 12	<	10	U				<	10	U	<	10	U			
Vanadium	13.2 J	2 / 12	<	50	U				<	50	U	<	50	U			
Zinc	50.1	6 / 12	14.4	20	J				<	20	U	16.7	20	J			
OTHER PARAMETERS (mg/L)																	
Alkalinity, Total (as $CaCO_3$)	837	12 / 12	487	4					413	1		368	4				
Nitrogen, Ammonia (as N)	4.9	12 / 12	1.5	0.1					4.9	0.1		0.65	0.1				
Nitrogen, Nitrate-nitrite	0.27	1 / 12	<	0.05	U				<	0.05	U	<	0.05	U			
Phosphorus, Total (as P)	0.82	12 / 12	0.033	0.05	J				0.58	0.05		0.13	0.05				
Sulfate (as SO_4), (µg/L)	690000 J	11 / 12	200000	100	J	430000	2000	J	<	1200	UJ	270000	100	J	690000	2000	J
Suspended Solids (residue, Non-filterable)	1540	12 / 12	230	2.5					140	2.5		43.5	2.5				
Total Dissolved Solids (residue, Filterable)	2300	12 / 12	1900	5					423	5		1420	5				

Qual = Qualifier
DIL = Dilution
E = Value exceeds linear range. Use diluted sample result if available.
J = Estimated
ND = Not Detected
R = Rejected
U = Nondetect
UJ = Estimated Nondetect
RL = Reporting Limit
mg/L = milligram per liter
µg/L = microgram per liter

TABLE 2-4
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BDRK-002-SS-04			AUS-BDRK-002-SS-08			AUS-BDRK-006-SS-04			AUS-BDRK-006-SS-08			AUS-BDRK-007-SS-04			AUS-BDRK-007-SS-16		
DATE COLLECTED			May 23, 2000			May 23, 2000			May 23, 2000			May 23, 2000			May 15, 2000			May 15, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
OTHER PARAMETERS (mg/kg)																				
Total Organic Carbon	54900	3 / 6	13500	5450		<	4900	U	11200	4310		<	4620	U	54900	4080		<	6390	U

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-5
SOIL AND GROUNDWATER SAMPLE ANALYTICAL RESULTS SUMMARY FROM BEDROCK WELLS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Constituent	Number of Detections	Range of Detections
SOIL		
Other Parameters		
Total Organic Carbon	3/6	11,200 mg/kg to 54,900 mg/kg
GROUNDWATER		
Volatile Organic Compounds		
Cis-1,2-dichloroethene	1/12	2 ug/L
Trichloroethylene (TCE)	1/12	0.9J ug/L
Semivolatile Organic Compounds		
Bis (2-ethylhexyl) Phthalate	2/12	1.8J ug/L to 1.9J ug/L
Di-n-butyl Phthalate	1/12	1.1J ug/L
Metals		
Aluminum	10/12	622 ug/L to 9840 ug/L
Antimony	1/12	2.2 ug/L
Arsenic	5/12	2.7 ug/L to 9.7 ug/L
Barium	12/12	19.3 ug/L to 215 ug/L
Beryllium	1/12	0.6 ug/L
Boron	8/12	71.5 ug/L to 609 ug/L
Cadmium	2/12	0.25 ug/L to 0.27 ug/L
Calcium	12/12	4830 ug/L to 223,000 ug/L
Chromium	8/12	1.4 ug/L to 12.3 ug/L
Iron	12/12	140 ug/L to 12,500 ug/L
Lead	2/12	2.5 ug/L to 3 ug/L
Magnesium	12/12	348 ug/L to 115,000 ug/L
Manganese	10/12	47.5 ug/L to 394 ug/L
Nickel	5/12	3.9 ug/L to 13.7 ug/L
Potassium	12/12	1610 ug/L to 17,700 ug/L
Selenium	1/12	1.9 ug/L
Sodium	12/12	8590 ug/L to 861,000 ug/L
Vanadium	2/12	9.5 ug/L to 13.2 ug/L
Zinc	6/12	14.4 ug/L to 50.1 ug/L
Other Parameters		
Alkalinity, Total (as $CaCO_3$)	12/12	219 mg/L to 837 mg/L
Nitrogen, Ammonia (as N)	12/12	0.29 mg/L to 4.9 mg/L
Nitrogen, Nitrate-nitrite	1/12	0.27 mg/L
Phosphorus, Total (as P)	12/12	0.033 mg/L to 0.82 mg/L
Sulfate (as SO_4)	11/12	2400 ug/L to 690,000 ug/L
Suspended Solids (residue, Non-filterable)	12/12	8 mg/L to 1540 mg/L
Total Dissolved Solids (residue, Filterable)	12/12	256 mg/L to 2300 mg/L

Qual = Qualifier
DIL = Dilution
E = Value exceeds linear range. Use diluted sample result if available.
J = Estimated
ND = Not Detected
R = Rejected
U = Nondetect
UJ = Estimated Nondetect
RL = Reporting Limit
mg/L = milligram per liter
µg/L = microgram per liter

TABLE 2-6

UPPER TOLERANCE LIMITS (UTLs) OF BACKGROUND SOIL METALS AT CRAB ORCHARD NATIONAL WILDLIFE REFUGE (1995)

Chemical	Distribution[a]	UTL[b] (mg/kg)	Basis of UTL
Aluminum	Normal	30,071	(90% UCL of 95th percentile)
Antimony		ND	(all nondetect)
Arsenic	Normal	19.4	(90% UCL of 95th percentile)
Barium	Normal	163	(90% UCL of 95th percentile)
Beryllium	Lognormal	1.02	(90% UCL of 95th percentile)
Cadmium	Other	1.4	(highest detection)
Chromium	Normal	35.1	(90% UCL of 95th percentile)
Cobalt	Normal	16.3	(90% UCL of 95th percentile)
Copper	Other	16.0	(highest detection)
Lead	Normal	17.6	(90% UCL of 95th percentile)
Manganese	Lognormal	5,884	(90% UCL of 95th percentile)
Mercury		ND	(highest detection)
Nickel	Normal	22.0	(90% UCL of 95th percentile)
Selenium	Other	0.6	(highest detection)
Silver	Other	0.27	(highest detection)
Thallium	Other	0.36	(highest detection)
Vanadium	Lognormal	79.4	(90% UCL of 95th percentile)
Zinc	Lognormal	79.1	(90% UCL of 95th percentile)

(a) Distribution based on Chi-square, Coefficient of Variance, Skewness and Kurtosis. Data sets that were not shown to be normally distributed, but that had fewer than 50% nondetects, were assumed to be lognormal in accordance with EPA (1992).

(b) UTL for normal distributions from: UTL = mean + SD * K. UTL for lognormal distribution calculated from log-transformed data $UTL' = \exp(\overline{X'} + SD' * K)$.

RL = Reporting Limit

SD = Standard Deviation

UCL = Upper Confidence Limit

K = Tabulated statistical parameter used to estimate a UTL on the specified percentile of a normal distribution (Gilbert 1987).

Note: For those metals which were greater than 50% nondetect, the UTL is either the highest detection or the highest RL.

Source: Woodward-Clyde, 1995, Crab Orchard National Wildlife Refuge, Summary of Background Metals

TABLE 2-7
BACKGROUND METALS CONCENTRATIONS IN SOILS (1995) (mg/kg)

CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Sample Number	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc
TPCOC5-2-4-6	15000	0.645	2.86	124	0.65	0.25	18.8	7.58	9.08	10.5	350	0.04195	16.2	0.105	0.27	0.2	34.4	33.4
COSO07A01	6000	2.45*	3.2	51	0.3	0.3	8.1	3.4	5.2	7.6	410	0.04	3.6	0.75	0.3	0.36	16	21
COSO07A03	6100	2.4*	2.9	130	0.3	0.3	7.5	0.5	5.7	7.2	1200	0.02	5.8	0.7	0.3	0.5	18	20
LF-2F-SA-001	11700	3.5	0.3	132	0.73	1.1	15.9	14.9	13.9	13.5	652	0.06	15.3	0.06	0.06	0.06	33.7	44.2
D2-001-MW-001	16400	NA	5	67.9	0.52	0.24	18.6	5.7	NA	8.2	389	0.02	10.7	0.33	0.24	0.49	29.3	38.1
D2-001-MW-011	15800	NA	7.2	68.6	0.65	0.24	18.1	11.4	NA	14.8	992	0.02	11.2	0.53	0.24	0.12	33.9	32.7
D2-002-MW-001	18800	NA	10.5	83	0.38	0.24	23.2	6.6	NA	8.1	289	0.02	12.6	0.47	0.24	0.26	40.1	38.5
D2-002-MW-021	16900	NA	10.9	93.7	0.4	0.25	21.4	9.2	NA	6.9	486	0.02	11.7	0.48	0.25	0.3	38.9	33.5
D2-003-MW-001	21600	NA	10.8	134	0.52	0.24	25.4	0.24	NA	8.5	374	0.02	15.6	0.36	0.24	0.25	44.3	54.9
B1-001-SA-001	28800	NA	18.3	136	0.77	0.36	28	12.2	NA	13.7	565	0.03	21.1	0.24	0.24	0.48	61.7	70.7
B1-002-SA-001	23300	NA	11.5	124	0.73	0.37	29	7.5	NA	11.9	254	0.03	15.8	0.25	0.25	0.46	53.5	48.9
B1-003-SA-001	22600	NA	10.9	89.7	0.64	0.37	30.3	7.1	NA	8.9	197	0.09	14.5	0.25	0.25	0.29	52.2	41.1
B1-004-SA-001	11100	NA	9.5	84.7	0.48	0.38	12.9	9.3	NA	11.6	291	0.03	11.9	0.26	0.26	0.13	25.1	34.3
B1-005-SA-001	11000	NA	10.6	108	0.42	0.37	14.5	8	NA	12.1	354	0.03	11.4	0.25	0.25	0.12	26.7	38.1
B1-005-SA-021	12500	NA	11.9	102	0.5	0.19	15.2	8.3	NA	12.2	371	0.015	12.7	0.125	0.125	0.065	28.4	42.8
LF-6D-SA-005	14700	3.5	0.3	101	0.56	1.4	21.1	4.5	16	16.6	262	0.06	10.9	0.6	0.6	0.6	39.6	47.2
Count(N)	16	3	16	16	16	16	16	16	5	16	16	16	16	16	16	16	16	16
Minimum	6000		0.3	51	0.3	0.19	7.5	0.24	5.2	6.9	197		3.6	0.06	0.06	0.06	16	20
Maximum	28800		18.3	136	0.77	1.4	30.3	14.9	16	16.6	1200		21.1	0.75	0.6	0.6	61.7	70.7
Average	15769		8	101.9	0.5344	0.4125	19.25	7.28	9.98	10.77	464.8		12.56	0.360	0.2572	0.293	35.99	39.96
Standard Deviation	6221		5.014	26.62	0.1506	0.337	6.880	3.92	4.837	2.970	274.9		4.113	0.209	0.1094	0.173	12.60	12.29
k Statistic[1]	2.299		2.299	2.299	2.299		2.299	2.299		2.299	2.299		2.299				2.299	2.299
Distribution	Normal		Normal	Normal	Lognormal	Other	Normal	Normal	Other	Normal	Lognormal		Normal	Other	Other	Other	Lognormal	Lognormal
95% UTL	30071	ND	19.4	163	1.02	1.4	35.1	16.3	16.0	17.6	5884	ND	22.0	0.6	0.27	0.36	79.4	79.1
Outlier Test																		
Outlier Statistic	2.0948		2.0711	1.2829	1.5651	2.9301	1.6061	1.9469	1.2454	1.9637	2.6745		2.0756	1.8698	3.1347	1.7783	2.0411	2.5018
Critical Value	2.747		2.747	2.747	2.747	2.747	2.747	2.747	1.749	2.747	2.747		2.747	2.747	2.747	2.747	2.747	2.747
Outlier?	NO		NO	NO	NO	YES	NO	NO	NO	NO	NO		NO	NO	YES	NO	NO	NO

Shaded values denote actual detections

Non-shaded values are one-half reporting limits for nondetect sample

* Values were reported as biased low by laboratory review

[1] Source: Gilbert 1987

[2] Source: EPA 1989

Average and 95% UTLs are calculated using one-half reporting limits for nondetect

Source: Woodward-Clyde, 1995, Crab Orchard National Wildlife Refuge, Summary of Background Metals

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-001-SS-0X			AUS-BKGD-002-SS-0X			AUS-BKGD-003-SS-0X		
DATE COLLECTED			March 3, 2000			March 3, 2000			March 3, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	5370	28		3700	26		2830	26	
Antimony	ND	0 / 30	<	0.84	U	<	0.78	UJ	<	0.78	U
Arsenic	16.9	30 / 30	4.1	1.4	J	16.9	1.3		4.8	1.3	
Barium	197 J	30 / 30	84.6	28	J	197	26	J	56	26	
Beryllium	0.81	18 / 30	0.39	0.7	J	0.64	0.65	J	0.28	0.65	J
Boron	5.4 J	22 / 30	<	14	U	4.2	13	J	<	13	U
Cadmium	ND	0 / 30	<	0.7	U	<	0.65	U	<	0.65	U
Calcium	2640	30 / 30	1550	140		922	130		639	130	
Chromium	11.6	30 / 30	6.6	1.4	J	8.6	1.3		4.3	1.3	
Cobalt	21.7	17 / 30	<	7	U	5	6.5	J	<	6.5	U
Copper	8.6	23 / 30	7.7	1.4		6.6	1.3		<	2	U
Iron	20500 J	30 / 30	8870	14	J	20500	13	J	6600	13	
Lead	28.5	30 / 30	11.5	0.42		16.1	0.39	J	18.2	0.39	
Magnesium	1760	30 / 30	1060	140		485	130		356	130	
Manganese	5650	30 / 30	5650	2		5590	2	J	703	1.9	
Mercury	0.06 J	5 / 30	<	0.64	U	<	0.66	U	<	0.62	U
Nickel	12.2	24 / 30	5.4	5.6	J	5.4	5.2		2.1	5.2	J
Potassium	706	30 / 30	476	140		409	130		194	130	
Selenium	2.5	19 / 30	0.69	0.7	J	2.5	0.65		1.3	0.65	
Silver	1.3	6 / 30	<	1.4	U	1.3	1.3		0.34	1.3	J
Sodium	ND	0 / 30	<	140	U	<	130	U	<	130	U
Thallium	0.26 J	14 / 30	0.25	1.4	J	<	1.3	U	0.25	1.3	J
Vanadium	32.5 J	30 / 30	13.8	7	J	32.5	6.5	J	14.7	6.5	
Zinc	46.7 J	30 / 30	26	2.8		22	2.6		11.9	2.6	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.29	U	<	0.26	U	<	0.26	U
Total Organic Carbon	34100	30 / 30	33900	7700	J	11800	6600	J	15000	5600	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-004-SS-0X			AUS-BKGD-005-SS-0X			AUS-BKGD-006-SS-0X		
DATE COLLECTED			March 3, 2000			March 3, 2000			March 3, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	4960	26		5320	28		3760	27	
Antimony	ND	0 / 30	<	0.79	U	<	0.83	U	<	0.8	U
Arsenic	16.9	30 / 30	8.8	1.3		5.1	1.4		4.6	1.3	
Barium	197 J	30 / 30	73.8	26		66.8	28		44.9	27	
Beryllium	0.81	18 / 30	0.4	0.66	J	0.45	0.69	J	0.28	0.67	J
Boron	5.4 J	22 / 30	1.9	13	J	<	14	U	<	13	U
Cadmium	ND	0 / 30	<	0.66	U	<	0.69	U	<	0.67	U
Calcium	2640	30 / 30	707	130		922	140		597	130	
Chromium	11.6	30 / 30	6.7	1.3		6.5	1.4		4.6	1.3	
Cobalt	21.7	17 / 30	4.3	6.6	J	<	6.9	U	<	6.7	U
Copper	8.6	23 / 30	4.8	1.3		6.3	1.4		<	2.7	U
Iron	20500 J	30 / 30	12000	13		9620	14		7450	13	
Lead	28.5	30 / 30	17.2	0.4		13.8	0.41		12.9	0.4	
Magnesium	1760	30 / 30	749	130		851	140		567	130	
Manganese	5650	30 / 30	782	2		652	2		629	2	
Mercury	0.06 J	5 / 30	<	0.67	U	<	0.63	U	<	0.59	U
Nickel	12.2	24 / 30	3.7	5.3	J	4.5	5.5	J	2.2	5.3	J
Potassium	706	30 / 30	324	130		354	140		235	130	
Selenium	2.5	19 / 30	1	0.66		1.2	0.69		0.9	0.67	
Silver	1.3	6 / 30	0.41	1.3	J	<	1.4	U	0.43	1.3	J
Sodium	ND	0 / 30	<	140	U	<	160	U	<	170	U
Thallium	0.26 J	14 / 30	0.19	1.3	J	<	1.4	U	0.22	1.3	J
Vanadium	32.5 J	30 / 30	23.2	6.6		16.2	6.9		14.6	6.7	
Zinc	46.7 J	30 / 30	18.4	2.6		22.3	2.8		14	2.7	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	0.51	0.27		<	0.28	U	<	0.27	U
Total Organic Carbon	34100	30 / 30	15000	4400		15800	6900		9080	5400	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-007-SS-0X			AUS-BKGD-008-SS-0X			AUS-BKGD-009-SS-0X		
DATE COLLECTED			March 3, 2000			March 3, 2000			March 3, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	3720	24		4140	26		5840	26	
Antimony	ND	0 / 30	<	0.73	U	<	0.79	U	<	0.77	U
Arsenic	16.9	30 / 30	3.6	1.2		3.9	1.3		6.1	1.3	
Barium	197 J	30 / 30	41.7	24		64.7	26		73.3	26	
Beryllium	0.81	18 / 30	0.39	0.6	J	0.33	0.66	J	0.4	0.64	J
Boron	5.4 J	22 / 30	<	12	U	<	13	U	<	13	U
Cadmium	ND	0 / 30	<	0.6	U	<	0.66	U	<	0.64	U
Calcium	2640	30 / 30	721	120		890	130		741	130	
Chromium	11.6	30 / 30	6	1.2		4.8	1.3		7.7	1.3	
Cobalt	21.7	17 / 30	5	6	J	8.4	6.6		7.7	6.4	
Copper	8.6	23 / 30	<	4.4	U	4.1	1.3		4.9	1.3	
Iron	20500 J	30 / 30	10500	12		8430	13		12400	13	
Lead	28.5	30 / 30	14	0.36		14.8	0.4		15.6	0.39	
Magnesium	1760	30 / 30	665	120		849	130		1250	130	
Manganese	5650	30 / 30	439	1.8		779	2		658	1.9	
Mercury	0.06 J	5 / 30	<	0.53	U	<	0.63	U	<	0.61	U
Nickel	12.2	24 / 30	5.6	4.8		5.6	5.3		6.5	5.2	
Potassium	706	30 / 30	308	120		606	130		543	130	
Selenium	2.5	19 / 30	0.8	0.6		0.74	0.66		0.77	0.64	
Silver	1.3	6 / 30	0.38	1.2	J	<	1.3	U	<	1.3	U
Sodium	ND	0 / 30	<	120	U	<	130	U	<	130	U
Thallium	0.26 J	14 / 30	<	1.2	U	<	1.3	U	0.2	1.3	J
Vanadium	32.5 J	30 / 30	9.4	6		11.5	6.6		15.9	6.4	
Zinc	46.7 J	30 / 30	20	2.4		22.1	2.6		28.3	2.6	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.23	U	<	0.27	U	<	0.25	U
Total Organic Carbon	34100	30 / 30	11700	3500		24200	6600		16000	3700	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-010-SS-0X			AUS-BKGD-011-SS-0X			AUS-BKGD-012-SS-0X		
DATE COLLECTED			March 3, 2000			March 3, 2000			March 3, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	8290	25		7860	25		6650	25	
Antimony	ND	0 / 30			R	<	0.75	U	<	0.74	U
Arsenic	16.9	30 / 30	6.6	1.2		5.2	1.3		4.4	1.2	
Barium	197 J	30 / 30	42.8	25		36.6	25		35.1	25	
Beryllium	0.81	18 / 30	<	0.62	U	<	0.63	U	<	0.62	U
Boron	5.4 J	22 / 30	2.5	12	J	2.2	13	J	<	12	U
Cadmium	ND	0 / 30	<	0.62	U	<	0.63	U	<	0.62	U
Calcium	2640	30 / 30	479	120		101	130	J	600	120	
Chromium	11.6	30 / 30	10.3	1.2		11.6	1.3		11.5	1.2	
Cobalt	21.7	17 / 30	<	6.2	U	<	6.3	U	<	6.2	U
Copper	8.6	23 / 30	6.8	1.2		7.7	1.3		4.9	1.2	
Iron	20500 J	30 / 30	15700	12		14700	13		13000	12	
Lead	28.5	30 / 30	13.3	0.37		12.3	0.38		13.2	0.37	
Magnesium	1760	30 / 30	1220	120		1320	130		1170	120	
Manganese	5650	30 / 30	357	1.8		253	1.9		215	1.9	
Mercury	0.06 J	5 / 30	0.06	0.57	J	<	0.63	U	<	0.57	U
Nickel	12.2	24 / 30	<	6.8	U	<	6.1	U	<	5	U
Potassium	706	30 / 30	497	120		448	130		301	120	
Selenium	2.5	19 / 30	0.97	0.62		0.54	0.63	J	0.39	0.62	J
Silver	1.3	6 / 30	<	1.2	U	<	1.3	U	<	1.2	U
Sodium	ND	0 / 30	<	120	U	<	130	U	<	120	U
Thallium	0.26 J	14 / 30	0.18	1.2	J	<	1.3	U	<	1.3	U
Vanadium	32.5 J	30 / 30	21.3	6.2		21.8	6.3		21.9	6.2	
Zinc	46.7 J	30 / 30	27.3	2.5		26.1	2.5		21.5	2.5	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.25	U	<	0.26	U	<	0.26	U
Total Organic Carbon	34100	30 / 30	28200	6200		22900	5800		34100	5400	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-013-SS-0X			AUS-BKGD-014-SS-0X			AUS-BKGD-015-SS-0X		
DATE COLLECTED			March 3, 2000			March 3, 2000			March 3, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	7600	26		8670	26		5360	25	
Antimony	ND	0 / 30	<	0.77	U	<	0.77	U	<	0.76	U
Arsenic	16.9	30 / 30	8.6	1.3		8.8	1.3		11.7	1.3	
Barium	197 J	30 / 30	113	26		89.7	26		140	25	
Beryllium	0.81	18 / 30	<	0.64	U	<	0.64	U	<	0.64	U
Boron	5.4 J	22 / 30	3	13	J	2.6	13	J	4.7	13	J
Cadmium	ND	0 / 30	<	0.64	U	<	0.64	U	<	0.64	U
Calcium	2640	30 / 30	1640	130		1970	130		2210	130	
Chromium	11.6	30 / 30	11.5	1.3		11.6	1.3		10.8	1.3	
Cobalt	21.7	17 / 30	10.1	6.4		<	6.4	U	11.2	6.4	
Copper	8.6	23 / 30	4.9	1.3		8.6	1.3		<	3.8	U
Iron	20500 J	30 / 30	16100	13		17200	13		17700	13	
Lead	28.5	30 / 30	19.9	0.39		18.1	0.38		22.4	0.38	
Magnesium	1760	30 / 30	1180	130		1760	130		785	130	
Manganese	5650	30 / 30	2060	1.9		553	1.9		2940	1.9	
Mercury	0.06 J	5 / 30	0.06	0.58	J	<	0.59	U	<	0.62	U
Nickel	12.2	24 / 30	<	7.7	U	9.1	5.1		<	5.9	U
Potassium	706	30 / 30	399	130		556	130		327	130	
Selenium	2.5	19 / 30	1.8	0.64		0.42	0.64	J	2.5	0.64	
Silver	1.3	6 / 30	<	1.3	U	<	1.3	U	<	1.3	U
Sodium	ND	0 / 30	<	130	U	<	130	U	<	130	U
Thallium	0.26 J	14 / 30	0.21	1.3	J	0.19	1.3	J	<	1.3	U
Vanadium	32.5 J	30 / 30	23.7	6.4		21.6	6.4		30.3	6.4	
Zinc	46.7 J	30 / 30	23.5	2.6		31.8	2.6		19.1	2.5	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.27	U	<	0.27	U	0.47	0.26	
Total Organic Carbon	34100	30 / 30	24500	3700		27900	7900		20500	7900	

RL = Reporting Limit
mg kg = milligram per kilogram
µg kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-016-SS-0X			AUS-BKGD-017-SS-0X			AUS-BKGD-018-SS-0X		
DATE COLLECTED			March 25, 2000			March 25, 2000			March 25, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	6500	25		8280	25		5670	26	
Antimony	ND	0 / 30	<	0.75	U	<	0.75	U	<	0.78	U
Arsenic	16.9	30 / 30	3.4	1.2		7.8	1.2		6	1.3	
Barium	197 J	30 / 30	65.5	25		42.1	25		76.5	26	
Beryllium	0.81	18 / 30	0.54	0.62	J	<	0.62	U	<	0.65	U
Boron	5.4 J	22 / 30	2.3	12	J	3.4	12	J	3.6	13	J
Cadmium	ND	0 / 30	<	0.62	U	<	0.62	U	<	0.65	U
Calcium	2640	30 / 30	2640	120		2590	120		1490	130	
Chromium	11.6	30 / 30	9.2	1.2		10.7	1.2		8.2	1.3	
Cobalt	21.7	17 / 30	<	6.2	U	5	6.2	J	10.2	6.5	
Copper	8.6	23 / 30	7.3	1.2	J	5.8	1.2	J	<	2.3	U
Iron	20500 J	30 / 30	9800	12		15500	12		11800	13	
Lead	28.5	30 / 30	13.8	0.36		16.4	0.37		18.4	0.37	
Magnesium	1760	30 / 30	1170	120		1610	120		707	130	
Manganese	5650	30 / 30	167	1.9		390	1.9		1340	1.9	
Mercury	0.06 J	5 / 30	<	0.57	U	0.05	0.52	J	<	0.57	U
Nickel	12.2	24 / 30	7.4	5		7.6	5		5.7	5.2	
Potassium	706	30 / 30	334	120		619	120		331	130	
Selenium	2.5	19 / 30	<	0.67	U	<	0.65	U	<	1.3	U
Silver	1.3	6 / 30	<	1.2	U	<	1.2	U	<	1.3	U
Sodium	ND	0 / 30	<	130	U	<	140	U	<	130	U
Thallium	0.26 J	14 / 30	0.15	1.2	J	<	1.2	U	<	1.3	U
Vanadium	32.5 J	30 / 30	19.9	6.2		23.4	6.2		21.1	6.5	
Zinc	46.7 J	30 / 30	23.9	2.5		31.7	2.5		20.2	2.6	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.25	U	<	0.26	U	<	0.26	U
Total Organic Carbon	34100	30 / 30	17900	6200		13400	7500		14400	3900	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-019-SS-0X			AUS-BKGD-020-SS-0X			AUS-BKGD-021-SS-0X		
DATE COLLECTED			March 25, 2000			March 25, 2000			March 25, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	5400	26		6330	27		6650	26	
Antimony	ND	0 / 30	<	0.79	U	<	0.8	U	<	0.78	U
Arsenic	16.9	30 / 30	5	1.3		5.5	1.3		8	1.3	
Barium	197 J	30 / 30	133	26		138	27		158	26	
Beryllium	0.81	18 / 30	0.59	0.66	J	0.73	0.67		0.81	0.65	
Boron	5.4 J	22 / 30	3.2	13	J	3.2	13	J	4.7	13	J
Cadmium	ND	0 / 30	<	0.66	U	<	0.67	U	<	0.65	U
Calcium	2640	30 / 30	2030	130		2100	130		1950	130	
Chromium	11.6	30 / 30	6.2	1.3		8.5	1.3		10.3	1.3	
Cobalt	21.7	17 / 30	11.8	6.6		8.8	6.7		13.1	6.5	
Copper	8.6	23 / 30	5.8	1.3	J	5.8	1.3	J	6.1	1.3	J
Iron	20500 J	30 / 30	9970	13		11200	13		13900	13	
Lead	28.5	30 / 30	20.1	0.39		18.1	0.37		22.8	0.39	
Magnesium	1760	30 / 30	806	130		807	130		810	130	
Manganese	5650	30 / 30	1890	2		1910	2		2710	2	
Mercury	0.06 J	5 / 30	<	0.6	U	<	0.63	U	0.05	0.52	J
Nickel	12.2	24 / 30	9.9	5.2		10.8	5.3		12.2	5.2	
Potassium	706	30 / 30	553	130		455	130		706	130	
Selenium	2.5	19 / 30	<	1.3	U	<	1.5	U	1.8	0.65	
Silver	1.3	6 / 30	<	1.3	U	<	1.3	U	<	1.3	U
Sodium	ND	0 / 30	<	130	U	<	140	U	<	140	U
Thallium	0.26 J	14 / 30	<	1.3	U	0.19	1.3	J	0.2	1.3	J
Vanadium	32.5 J	30 / 30	15.3	6.6		17.8	6.7		22.4	6.5	
Zinc	46.7 J	30 / 30	26.8	2.6		27.2	2.7		28.8	2.6	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.27	U	<	0.28	U	<	0.27	U
Total Organic Carbon	34100	30 / 30	27100	6600		26900	8000		24700	7100	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-022-SS-0X			AUS-BKGD-023-SS-0X			AUS-BKGD-024-SS-0X		
DATE COLLECTED			March 25, 2000			March 25, 2000			March 25, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	5670	26		5780	27		6170	25	
Antimony	ND	0 / 30	<	0.79	U	<	0.8	U	<	0.76	U
Arsenic	16.9	30 / 30	5.1	1.3		4.5	1.3		7	1.3	
Barium	197 J	30 / 30	137	26		68.8	27		113	25	
Beryllium	0.81	18 / 30	0.61	0.66	J	<	0.67	U	0.52	0.63	J
Boron	5.4 J	22 / 30	3.4	13	J	2.2	13	J	3.6	13	J
Cadmium	ND	0 / 30	<	0.66	U	<	0.67	U	<	0.63	U
Calcium	2640	30 / 30	2110	130		1170	130		2020	130	
Chromium	11.6	30 / 30	8.9	1.3		7.7	1.3		8.9	1.3	
Cobalt	21.7	17 / 30	11.6	6.6		9.7	6.7		15.3	6.3	
Copper	8.6	23 / 30	5.4	1.3	J	4.2	1.3	J	4.2	1.3	J
Iron	20500 J	30 / 30	10500	13		10700	13		13800	13	
Lead	28.5	30 / 30	19.2	0.37		16.6	0.37		20.9	0.38	
Magnesium	1760	30 / 30	780	130		820	130		837	130	
Manganese	5650	30 / 30	1990	2	J	737	2		2130	1.9	
Mercury	0.06 J	5 / 30	0.05	0.53	J	<	0.63	U	<	0.56	U
Nickel	12.2	24 / 30	9.9	5.2		7.3	5.3		7.9	5.1	
Potassium	706	30 / 30	488	130		351	130		392	130	
Selenium	2.5	19 / 30	<	1.4	U	<	1.1	U	1.5	0.66	
Silver	1.3	6 / 30	<	1.3	U	<	1.3	U	<	1.3	U
Sodium	ND	0 / 30	<	130	U	<	150	U	<	140	U
Thallium	0.26 J	14 / 30	<	1.3	U	<	1.3	U	0.16	1.3	J
Vanadium	32.5 J	30 / 30	16.6	6.6		16.6	6.7		22.3	6.3	
Zinc	46.7 J	30 / 30	24.5	2.6		24.2	2.7		24.1	2.5	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.27	U	<	0.28	U	0.56	0.25	
Total Organic Carbon	34100	30 / 30	20800	7200	J	20600	6200		12500	5900	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-025-SS-0X			AUS-BKGD-026-SS-0X			AUS-BKGD-027-SS-0X		
DATE COLLECTED			March 26, 2000			March 26, 2000			March 26, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	3750	26		4790	25		4320	25	
Antimony	ND	0 / 30	<	0.77	U	<	0.74	U	<	0.75	U
Arsenic	16.9	30 / 30	6.1	1.3		5.6	1.2		8.3	1.2	
Barium	197 J	30 / 30	59.6	26		87.2	25		57.1	25	
Beryllium	0.81	18 / 30	<	0.64	U	0.57	0.61	J	<	0.62	U
Boron	5.4 J	22 / 30	2.5	13	J	2.6	12	J	1.9	12	J
Cadmium	ND	0 / 30	<	0.64	U	<	0.61	U	<	0.62	U
Calcium	2640	30 / 30	976	130		1370	120		1490	120	
Chromium	11.6	30 / 30	6.3	1.3		7.8	1.2		6.8	1.2	
Cobalt	21.7	17 / 30	<	6.4	U	<	6.1	U	<	6.2	U
Copper	8.6	23 / 30	<	2.2	U	<	3	U	4.2	1.2	J
Iron	20500 J	30 / 30	9880	13		9630	12		12600	12	
Lead	28.5	30 / 30	19	0.37		17	0.37		16.7	0.37	
Magnesium	1760	30 / 30	634	130		638	120		754	120	
Manganese	5650	30 / 30	1080	1.9		1580	1.8		568	1.9	
Mercury	0.06 J	5 / 30	<	0.52	U	<	0.52	U	<	0.57	U
Nickel	12.2	24 / 30	4.1	5.1	J	<	6.3	U	5.4	4	
Potassium	706	30 / 30	448	130		326	120		383	120	
Selenium	2.5	19 / 30	<	1.2	U	<	0.89	U	<	1	U
Silver	1.3	6 / 30	<	1.3	U	<	1.2	U	<	1.2	U
Sodium	ND	0 / 30	<	130	U	<	130	U	<	130	U
Thallium	0.26 J	14 / 30	<	1.3	U	<	1.2	U	<	1.2	U
Vanadium	32.5 J	30 / 30	20.5	6.4		20.8	6.1		27.4	6.2	
Zinc	46.7 J	30 / 30	16	2.6		21.2	2.5		21.5	2.5	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.26	U	0.29	0.24		<	0.24	U
Total Organic Carbon	34100	30 / 30	12400	5200		15200	5300		12200	5300	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-8
SUMMARY OF ANALYTICAL DATA FOR SOILS COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			AUS-BKGD-028-SS-0X			AUS-BKGD-029-SS-0X			AUS-BKGD-030-SS-0X		
DATE COLLECTED			March 26, 2000			March 26, 2000			March 26, 2000		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)											
Aluminum	8670	30 / 30	5630	25		7000	25		6210	25	
Antimony	ND	0 / 30			R	<	0.74	U	<	0.75	U
Arsenic	16.9	30 / 30	6.8	1.3		7.4	1.2		6.7	1.3	
Barium	197 J	30 / 30	58.4	25		180	25		148	25	
Beryllium	0.81	18 / 30	<	0.63	U	0.68	0.62		0.63	0.63	
Boron	5.4 J	22 / 30	1.9	13	J	5.4	12	J	3.9	13	J
Cadmium	ND	0 / 30	<	0.63	U	<	0.62	U	<	0.63	U
Calcium	2640	30 / 30	1310	130		1570	120		1510	130	
Chromium	11.6	30 / 30	9.4	1.3		11.5	1.2		8.5	1.3	
Cobalt	21.7	17 / 30	<	6.8	U	21.7	6.2		17.6	6.3	
Copper	8.6	23 / 30	4.3	1.3	J	4.3	1.2	J	4.3	1.3	J
Iron	20500 J	30 / 30	11500	13	J	14500	12		13100	13	
Lead	28.5	30 / 30	14.5	0.36		28.5	0.37		22.9	0.38	
Magnesium	1760	30 / 30	1020	130		823	120		854	130	
Manganese	5650	30 / 30	656	1.9		3690	1.9		2670	1.9	
Mercury	0.06 J	5 / 30	<	0.61	U	<	0.52	U	<	0.58	U
Nickel	12.2	24 / 30	6.1	5.1		10.7	5		9.8	5	
Potassium	706	30 / 30	525	130		435	120		443	130	
Selenium	2.5	19 / 30	<	0.77	U	2.2	0.62		1.8	0.63	
Silver	1.3	6 / 30	<	1.3	U	0.41	1.2	J	<	1.3	U
Sodium	ND	0 / 30	<	130	U	<	130	U	<	130	U
Thallium	0.26 J	14 / 30	<	1.3	U	0.26	1.2	J	0.23	1.3	J
Vanadium	32.5 J	30 / 30	19.8	6.3		25.4	6.2		22.2	6.3	
Zinc	46.7 J	30 / 30	46.7	2.5	J	26	2.5		25.3	2.5	
OTHER PARAMETERS (mg/kg)											
Cyanide	0.56	4 / 30	<	0.26	U	<	0.25	U	<	0.26	U
Total Organic Carbon	34100	30 / 30	17600	5500		14300	6200		25500	5800	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-9
SUMMARY OF ANALYTICAL DATA FOR SEDIMENT COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SD001			LG99SD002		
DATE COLLECTED			December 7, 1999			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)								
Aluminum	12600	10 / 10	8180	51		3860	37	
Antimony	ND	0 / 10	<	1.5	U	<	1.1	U
Arsenic	11.9	10 / 10	6.2	2.5		3.2	1.8	
Barium	208	10 / 10	126	51		70.9	37	
Beryllium	ND	0 / 10	<	1.3	U	<	0.92	U
Cadmium	ND	0 / 10	<	1.3	U	<	0.92	U
Calcium	1480	10 / 10	1150	250		677	180	
Chromium	18.9	10 / 10	13.2	2.5		7.5	1.8	
Cobalt	10.4 J	10 / 10	6.4	13	J	3.6	9.2	J
Copper	18.6	10 / 10	12.5	2.5		7.4	1.8	
Iron	24500	10 / 10	11700	250		8880	180	
Lead	28.5	10 / 10	16.2	0.76		10.6	0.55	
Magnesium	2010	10 / 10	1600	250		845	180	
Manganese	1190	10 / 10	749	3.8		516	2.7	
Mercury	0.16 J	8 / 10	0.14	0.26	J	0.11	0.19	J
Nickel	19.1	10 / 10	11.8	10		7.7	7.3	
Potassium	1530	10 / 10	645	250		303	180	
Selenium	1.6	2 / 10	1.5	1.3		<	0.92	U
Silver	ND	0 / 10	<	2.5	U	<	1.8	U
Sodium	1450	1 / 10	<	250	U	<	180	U
Thallium	0.26 J	3 / 10	<	2.5	U	0.2	1.8	J
Vanadium	30.3	10 / 10	20.4	13		11.1	9.2	
Zinc	58.7	10 / 10	39.8	5.1		20.9	3.7	
OTHER PARAMETERS (mg/kg)								
Nitrogen, Ammonia (as N)	144	10 / 10	103	3.1		32.8	0.46	
Nitrogen, Nitrate-nitrite	ND	0 / 10	<	1.2	U	<	0.92	U
Phosphorus, Total (as P)	512	10 / 10	374	25		160	8.6	
Phosphorus, Total Orthophosphate (as P)	4.4 J	6 / 10	<	1.3	U	1.5	0.92	
Total Organic Carbon	55800 J	10 / 10	55800	14000	J	16100	7900	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-9
SUMMARY OF ANALYTICAL DATA FOR SEDIMENT COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SD003			LG99SD004		
DATE COLLECTED			December 7, 1999			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)								
Aluminum	12600	10 / 10	4090	33		2970	30	
Antimony	ND	0 / 10	<	0.98	U	<	0.9	U
Arsenic	11.9	10 / 10	3.4	1.6		3.4	1.5	
Barium	208	10 / 10	66	33		54.1	30	
Beryllium	ND	0 / 10	<	0.82	U	<	0.75	U
Cadmium	ND	0 / 10	<	0.82	U	<	0.75	U
Calcium	1480	10 / 10	515	160		436	150	
Chromium	18.9	10 / 10	7.7	1.6		7.7	1.5	
Cobalt	10.4 J	10 / 10	3.9	8.2	J	5	7.5	J
Copper	18.6	10 / 10	6.9	1.6		4.8	1.5	
Iron	24500	10 / 10	15300	160		6910	150	
Lead	28.5	10 / 10	9.5	0.49		8.9	0.45	
Magnesium	2010	10 / 10	878	160		503	150	
Manganese	1190	10 / 10	431	2.5		506	2.3	
Mercury	0.16 J	8 / 10	<	0.16	U	<	0.14	U
Nickel	19.1	10 / 10	7.4	6.5		6.6	6	
Potassium	1530	10 / 10	339	160		232	150	
Selenium	1.6	2 / 10	<	0.82	U	<	0.75	U
Silver	ND	0 / 10	<	1.6	U	<	1.5	U
Sodium	1450	1 / 10	<	160	U	<	150	U
Thallium	0.26 J	3 / 10	<	1.6	U	0.15	1.5	J
Vanadium	30.3	10 / 10	11.2	8.2		10.5	7.5	
Zinc	58.7	10 / 10	19.8	3.3		17.1	3	
OTHER PARAMETERS (mg/kg)								
Nitrogen, Ammonia (as N)	144	10 / 10	29.9	0.41		16.1	0.37	
Nitrogen, Nitrate-nitrite	ND	0 / 10	<	0.83	U	<	0.76	U
Phosphorus, Total (as P)	512	10 / 10	143	7.7		129	6.6	
Phosphorus, Total Orthophosphate (as P)	4.4 J	6 / 10	2	0.83		<	0.76	U
Total Organic Carbon	55800 J	10 / 10	11900	7100		9950	6500	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-9
SUMMARY OF ANALYTICAL DATA FOR SEDIMENT COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SD005			LG99SD006		
DATE COLLECTED			December 7, 1999			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)								
Aluminum	12600	10 / 10	12600	62		5570	48	
Antimony	ND	0 / 10	<	1.9	U	<	1.4	U
Arsenic	11.9	10 / 10	11.9	3.1		5.4	2.4	
Barium	208	10 / 10	208	62		93.4	48	
Beryllium	ND	0 / 10	<	1.6	U	<	1.2	U
Cadmium	ND	0 / 10	<	1.6	U	<	1.2	U
Calcium	1480	10 / 10	1480	310		1180	240	
Chromium	18.9	10 / 10	18.9	3.1		10.1	2.4	
Cobalt	10.4 J	10 / 10	10.4	16	J	4.9	12	J
Copper	18.6	10 / 10	18.6	3.1		11.2	2.4	
Iron	24500	10 / 10	24500	31		15800	240	
Lead	28.5	10 / 10	28.5	0.93		11.6	0.72	
Magnesium	2010	10 / 10	2010	310		1150	240	
Manganese	1190	10 / 10	1190	4.7		705	3.6	
Mercury	0.16 J	8 / 10	0.16	0.33	J	0.12	0.23	J
Nickel	19.1	10 / 10	19.1	12		10.1	9.7	
Potassium	1530	10 / 10	921	310		481	240	
Selenium	1.6	2 / 10	1.6	1.6		<	1.2	U
Silver	ND	0 / 10	<	3.1	U	<	2.4	U
Sodium	1450	1 / 10	<	310	U	<	240	U
Thallium	0.26 J	3 / 10	<	3.1	U	0.26	2.4	J
Vanadium	30.3	10 / 10	30.3	16		14	12	
Zinc	58.7	10 / 10	58.7	6.2		37.5	4.8	
OTHER PARAMETERS (mg/kg)								
Nitrogen, Ammonia (as N)	144	10 / 10	123	3.8		58.6	0.58	
Nitrogen, Nitrate-nitrite	ND	0 / 10	<	1.6	U	<	1.2	U
Phosphorus, Total (as P)	512	10 / 10	512	26		425	61	
Phosphorus, Total Orthophosphate (as P)	4.4 J	6 / 10	4.4	1.6	J	1.6	1.2	
Total Organic Carbon	55800 J	10 / 10	49000	11800		39200	11300	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-9
SUMMARY OF ANALYTICAL DATA FOR SEDIMENT COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SD007			LG99SD008		
DATE COLLECTED			December 7, 1999			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)								
Aluminum	12600	10 / 10	3280	34		3720	36	
Antimony	ND	0 / 10	<	1	UJ	<	1.1	U
Arsenic	11.9	10 / 10	4.3	1.7		4.5	1.8	
Barium	208	10 / 10	52.4	34		52.2	36	
Beryllium	ND	0 / 10	<	0.85	U	<	0.9	U
Cadmium	ND	0 / 10	<	0.85	U	<	0.9	U
Calcium	1480	10 / 10	598	170		734	180	
Chromium	18.9	10 / 10	6.5	1.7		6.5	1.8	
Cobalt	10.4 J	10 / 10	5.3	8.5	J	3.6	9	J
Copper	18.6	10 / 10	6.9	1.7		6.3	1.8	
Iron	24500	10 / 10	7500	170		12600	180	
Lead	28.5	10 / 10	11	0.51		7.4	0.54	
Magnesium	2010	10 / 10	841	170		697	180	
Manganese	1190	10 / 10	367	2.5	J	591	2.7	
Mercury	0.16 J	8 / 10	0.09	0.14	J	0.09	0.17	J
Nickel	19.1	10 / 10	7.3	6.8		6.4	7.2	J
Potassium	1530	10 / 10	293	170		350	180	
Selenium	1.6	2 / 10	<	0.85	U	<	0.9	U
Silver	ND	0 / 10	<	1.7	U	<	1.8	U
Sodium	1450	1 / 10	<	170	U	<	180	U
Thallium	0.26 J	3 / 10	<	1.7	U	<	1.8	U
Vanadium	30.3	10 / 10	10.7	8.5		8.4	9	J
Zinc	58.7	10 / 10	18.5	3.4		18.4	3.6	
OTHER PARAMETERS (mg/kg)								
Nitrogen, Ammonia (as N)	144	10 / 10	24.7	0.41		30.1	0.44	
Nitrogen, Nitrate-nitrite	ND	0 / 10	<	0.84	U	<	0.89	U
Phosphorus, Total (as P)	512	10 / 10	178	17		163	9.1	
Phosphorus, Total Orthophosphate (as P)	4.4 J	6 / 10	<	0.84	U	<	0.89	U
Total Organic Carbon	55800 J	10 / 10	18200	6800		14400	9900	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-9
SUMMARY OF ANALYTICAL DATA FOR SEDIMENT COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SD009			LG99SD010		
DATE COLLECTED			December 7, 1999			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual
METALS (mg/kg)								
Aluminum	12600	10 / 10	3080	28		5940	44	
Antimony	ND	0 / 10	<	0.84	U	<	1.3	U
Arsenic	11.9	10 / 10	3.6	1.4		6.3	2.2	
Barium	208	10 / 10	39.5	28		107	44	
Beryllium	ND	0 / 10	<	0.7	U	<	1.1	U
Cadmium	ND	0 / 10	<	0.7	U	<	1.1	U
Calcium	1480	10 / 10	376	140		727	220	
Chromium	18.9	10 / 10	8.9	1.4		10.6	2.2	
Cobalt	10.4 J	10 / 10	2.8	7	J	4.8	11	J
Copper	18.6	10 / 10	5.3	1.4		10.2	2.2	
Iron	24500	10 / 10	7580	140		13500	22	
Lead	28.5	10 / 10	7.9	0.42		13	0.66	
Magnesium	2010	10 / 10	975	140		1150	220	
Manganese	1190	10 / 10	316	2.1		570	3.3	
Mercury	0.16 J	8 / 10	0.07	0.12	J	0.12	0.21	J
Nickel	19.1	10 / 10	5.4	5.6	J	9.9	8.8	
Potassium	1530	10 / 10	1530	140		467	220	
Selenium	1.6	2 / 10	<	0.7	U	<	1.1	U
Silver	ND	0 / 10	<	1.4	U	<	2.2	U
Sodium	1450	1 / 10	1450	140		<	220	U
Thallium	0.26 J	3 / 10	<	1.4	U	<	2.2	U
Vanadium	30.3	10 / 10	11.5	7		17	11	
Zinc	58.7	10 / 10	15.2	2.8		29.3	4.4	
OTHER PARAMETERS (mg/kg)								
Nitrogen, Ammonia (as N)	144	10 / 10	31.2	0.35		144	2.7	
Nitrogen, Nitrate-nitrite	ND	0 / 10	<	0.7	U	<	1	U
Phosphorus, Total (as P)	512	10 / 10	188	14		344	53	
Phosphorus, Total Orthophosphate (as P)	4.4 J	6 / 10	1.2	0.7		1.5	1.1	
Total Organic Carbon	55800 J	10 / 10	12500	6000		27300	7800	

RL = Reporting Limit
mg/kg = milligram per kilogram
µg/kg = microgram per kilogram
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-10
SUMMARY OF ANALYTICAL DATA FOR SURFACE WATER COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SW001			LG99SW002		
DATE COLLECTED			December 7, 1999			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual
METALS (µg/L)								
Aluminum	ND	0 / 7	<	200	U	<	200	U
Antimony	ND	0 / 7	<	6	U	<	6	U
Arsenic	ND	0 / 7	<	10	U	<	10	U
Barium	20.9 J	6 / 7	18.3	200	J	20.9	200	J
Beryllium	ND	0 / 7	<	5	U	<	5	U
Cadmium	ND	0 / 7	<	5	U	<	5	U
Calcium	7170	7 / 7	7080	1000		6970	1000	
Chromium	ND	0 / 7	<	10	U	<	10	U
Cobalt	ND	0 / 7	<	50	U	<	50	U
Copper	ND	0 / 7	<	10	U	<	10	U
Iron	ND	0 / 7	<	100	U	<	100	U
Lead	1.8 J	4 / 7	1.2	3	J	<	3	U
Magnesium	2520	7 / 7	2520	1000		2480	1000	
Manganese	571	7 / 7	563	20		571	20	
Mercury	0.16 J	3 / 7	0.16	0.2	J	<	0.2	U
Nickel	ND	0 / 7	<	10	U	<	10	U
Potassium	1560	7 / 7	1530	1000		1520	1000	
Selenium	2.6 J	2 / 7	<	5	U	2.5	5	J
Silver	ND	0 / 7	<	10	U	<	10	U
Sodium	3090	7 / 7	2920	1000		2790	1000	
Thallium	ND	0 / 7	<	10	U	<	10	U
Vanadium	ND	0 / 7	<	50	U	<	50	U
Zinc	ND	0 / 7	<	20	U	<	20	U
OTHER PARAMETERS (mg/L)								
Alkalinity, Total (as CaCO3)	30.7	4 / 4	30.7	1		23.4	1	
Nitrogen, Ammonia (as N)	0.2	4 / 7	0.13	0.1		<	0.1	U
Nitrogen, Nitrate-nitrite	ND	0 / 7	<	0.05	U	<	0.05	U
Phosphorus, Total (as P)	ND	0 / 7	<	0.05	U	<	0.05	U
Phosphorus, Total Orthophosphate (as P)	0.22	2 / 7	<	0.05	U	<	0.05	U
Suspended Solids (residue, Non-filterable)	8	6 / 7	5	5		5	5	
Total Dissolved Solids (residue, Filterable)	65.5	6 / 6	57.5	10		65.5	10	
Total Organic Carbon	71	7 / 7	7.5	1		4.1	1	

RL = Reporting Limit
mg/L = milligram per liter
µg/L = microgram per liter
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-10
SUMMARY OF ANALYTICAL DATA FOR SURFACE WATER COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SW003			LG99SW004		
DATE COLLECTED			December 7, 1999			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual
METALS (µg/L)								
Aluminum	ND	0 / 7	<	200	U	<	200	U
Antimony	ND	0 / 7	<	6	U	<	6	U
Arsenic	ND	0 / 7	<	10	U	<	10	U
Barium	20.9 J	6 / 7	17.7	200	J	17.9	200	J
Beryllium	ND	0 / 7	<	5	U	<	5	U
Cadmium	ND	0 / 7	<	5	U	<	5	U
Calcium	7170	7 / 7	7170	1000		7040	1000	
Chromium	ND	0 / 7	<	10	U	<	10	U
Cobalt	ND	0 / 7	<	50	U	<	50	U
Copper	ND	0 / 7	<	10	U	<	10	U
Iron	ND	0 / 7	<	100	U	<	100	U
Lead	1.8 J	4 / 7	<	3	U	1.3	3	J
Magnesium	2520	7 / 7	2510	1000		2510	1000	
Manganese	571	7 / 7	561	20		542	20	
Mercury	0.16 J	3 / 7	<	0.2	U	<	0.2	U
Nickel	ND	0 / 7	<	10	U	<	10	U
Potassium	1560	7 / 7	1480	1000		1560	1000	
Selenium	2.6 J	2 / 7	<	5	U	<	5	U
Silver	ND	0 / 7	<	10	U	<	10	U
Sodium	3090	7 / 7	3090	1000		3070	1000	
Thallium	ND	0 / 7	<	10	U	<	10	U
Vanadium	ND	0 / 7	<	50	U	<	50	U
Zinc	ND	0 / 7	<	20	U	<	20	U
OTHER PARAMETERS (mg/L)								
Alkalinity, Total (as CaCO3)	30.7	4 / 4						
Nitrogen, Ammonia (as N)	0.2	4 / 7	0.16	0.1		<	0.1	U
Nitrogen, Nitrate-nitrite	ND	0 / 7	<	0.05	U	<	0.05	U
Phosphorus, Total (as P)	ND	0 / 7	<	0.05	U	<	0.05	U
Phosphorus, Total Orthophosphate (as P)	0.22	2 / 7	0.074	0.05		0.22	0.05	
Suspended Solids (residue, Non-filterable)	8	6 / 7	7.5	5		<	7	U
Total Dissolved Solids (residue, Filterable)	65.5	6 / 6	43.5	10		42	10	
Total Organic Carbon	71	7 / 7	4.2	1		4.1	1	

RL = Reporting Limit
mg/L = milligram per liter
µg/L = microgram per liter
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-10
SUMMARY OF ANALYTICAL DATA FOR SURFACE WATER COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SW005			LG99SW006		
DATE COLLECTED			December 7, 1999			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual	Result	RL	Qual
METALS (µg/L)								
Aluminum	ND	0 / 7	<	200	U	<	200	U
Antimony	ND	0 / 7	<	6	U	<	6	U
Arsenic	ND	0 / 7	<	10	U	<	10	U
Barium	20.9 J	6 / 7	13.9	200	J	19.6	200	J
Beryllium	ND	0 / 7	<	5	U	<	5	U
Cadmium	ND	0 / 7	<	5	U	<	5	U
Calcium	7170	7 / 7	6960	1000		6970	1000	
Chromium	ND	0 / 7	<	10	U	<	10	U
Cobalt	ND	0 / 7	<	50	U	<	50	U
Copper	ND	0 / 7	<	10	U	<	10	U
Iron	ND	0 / 7	<	100	U	<	100	U
Lead	1.8 J	4 / 7	<	3	U	1.8	3	J
Magnesium	2520	7 / 7	2490	1000		2470	1000	
Manganese	571	7 / 7	562	20		555	20	
Mercury	0.16 J	3 / 7	0.13	0.2	J	0.1	0.2	J
Nickel	ND	0 / 7	<	10	U	<	10	U
Potassium	1560	7 / 7	1530	1000		1460	1000	
Selenium	2.6 J	2 / 7	2.6	5	J	<	5	U
Silver	ND	0 / 7	<	10	U	<	10	U
Sodium	3090	7 / 7	2840	1000		2850	1000	
Thallium	ND	0 / 7	<	10	U	<	10	U
Vanadium	ND	0 / 7	<	50	U	<	50	U
Zinc	ND	0 / 7	<	20	U	<	20	U
OTHER PARAMETERS (mg/L)								
Alkalinity, Total (as CaCO3)	30.7	4 / 4				26.6	1	
Nitrogen, Ammonia (as N)	0.2	4 / 7	0.2	0.1		<	0.1	U
Nitrogen, Nitrate-nitrite	ND	0 / 7	<	0.05	U	<	0.05	U
Phosphorus, Total (as P)	ND	0 / 7	<	0.05	U	<	0.05	U
Phosphorus, Total Orthophosphate (as P)	0.22	2 / 7	<	0.05	U	<	0.05	U
Suspended Solids (residue, Non-filterable)	8	6 / 7	7	5		8	5	
Total Dissolved Solids (residue, Filterable)	65.5	6 / 6				48.5	10	
Total Organic Carbon	71	7 / 7	4.1	1		71	1	

RL = Reporting Limit
mg/L = milligram per liter
µg/L = microgram per liter
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-10
SUMMARY OF ANALYTICAL DATA FOR SURFACE WATER COLLECTED AT SITE BACKGROUND

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

FIELD ID			LG99SW007		
DATE COLLECTED			December 7, 1999		
	Maximum	Frequency	Result	RL	Qual
METALS (µg/L)					
Aluminum	ND	0 / 7	<	200	U
Antimony	ND	0 / 7	<	6	U
Arsenic	ND	0 / 7	<	10	U
Barium	20.9 J	6 / 7	<	200	U
Beryllium	ND	0 / 7	<	5	U
Cadmium	ND	0 / 7	<	5	U
Calcium	7170	7 / 7	6980	1000	
Chromium	ND	0 / 7	<	10	U
Cobalt	ND	0 / 7	<	50	U
Copper	ND	0 / 7	<	10	U
Iron	ND	0 / 7	<	100	U
Lead	1.8 J	4 / 7	1.5	3	J
Magnesium	2520	7 / 7	2490	1000	
Manganese	571	7 / 7	543	20	
Mercury	0.16 J	3 / 7	<	0.2	U
Nickel	ND	0 / 7	<	10	U
Potassium	1560	7 / 7	1560	1000	
Selenium	2.6 J	2 / 7	<	5	U
Silver	ND	0 / 7	<	10	U
Sodium	3090	7 / 7	2880	1000	
Thallium	ND	0 / 7	<	10	U
Vanadium	ND	0 / 7	<	50	U
Zinc	ND	0 / 7	<	20	U
OTHER PARAMETERS (mg/L)					
Alkalinity, Total (as CaCO3)	30.7	4 / 4	25.6	1	
Nitrogen, Ammonia (as N)	0.2	4 / 7	0.2	0.1	
Nitrogen, Nitrate-nitrite	ND	0 / 7	<	0.05	U
Phosphorus, Total (as P)	ND	0 / 7	<	0.05	U
Phosphorus, Total Orthophosphate (as P)	0.22	2 / 7	<	0.05	U
Suspended Solids (residue, Non-filterable)	8	6 / 7	5.5	5	
Total Dissolved Solids (residue, Filterable)	65.5	6 / 6	58.5	10	
Total Organic Carbon	71	7 / 7	4.2	1	J

RL = Reporting Limit
mg/L = milligram per liter
µg/L = microgram per liter
E = Value exceeds linear range. Use diluted sample result.
ND = Not Detected
UJ = Estimated Nondetect
Qual = Qualifier
U = Nondetect
J = Estimated
R = Rejected
REA = Reanalysis
DIL = Dilution

TABLE 2-11
NORMALITY AND UPPER TOLERANCE LIMIT CALCULATIONS FOR BACKGROUND SOIL DATA

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WIDLIFE REFUGE

	SHAPIRO-WILK NORMALITY TEST		TOLERANCE FACTOR			95% UTL			
mg/kg	Distribution	p-value	n	t-value	K	Mean	Std. Dev.	log-transformed 95% UTL	95%UTL
Total Organic Carbon	log-normal	0.0653	30	1.699	1.727	9.798	0.322	10.35	31393
Cyanide	log-normal	0.3364	30	1.699	1.727	-2.12	0.711	-0.89	0.41
Aluminum	non-normal	0.0131	46						28800
Antimony	ALL NON-DETECT		30						0.83
Arsenic	normal	0.0555	46	1.679	1.697	7.207	3.6906	NA	13.5
Barium	log-normal	0.3305	46	1.679	1.697	4.475	0.471	5.275	195
Beryllium	log-normal	0.5699	46	1.679	1.697	-0.7	0.256	-0.27	0.76
Boron	log-normal	0.3988	30	1.699	1.727	1.129	0.311	1.667	5.3
Cadmium	ALL NON-DETECT with the exception of the outliers (which were excluded)								0.19
Calcium	normal	0.4406	30	1.699	1.727	1356.8	660.07	NA	2497
Chromium, Total	log-normal	0.0919	46	1.679	1.697	2.374	0.502	3.226	25.2
Cobalt	non-normal	0.0001	46						21.7
Copper	log-normal	0.5469	35	1.6912	1.715	1.625	0.467	2.426	11.3
Iron	log-normal	0.9595	30	1.699	1.727	9.411	0.265	9.868	19306
Lead	normal	0.5579	46	1.679	1.697	15.265	4.785	NA	23.4
Magnesium	log-normal	0.4810	30	1.699	1.727	6.759	0.341	7.348	1552
Manganese	log-normal	0.0607	46	1.679	1.697	6.612	0.935	8.2	3640
Mercury	log-normal	0.6412	46	1.679	1.697	-3.43	0.397	-2.76	0.06
Nickel	log-normal	0.1799	46	1.679	1.697	2.03	0.535	2.938	18.9
Potassium	normal	0.7223	30	1.699	1.727	425.12	115.8	NA	625
Selenium	log-normal	0.1363	46	1.679	1.697	-0.61	0.859	0.849	2.34
Silver	log-normal	0.2305	46	1.679	1.697	-1.63	0.644	-0.54	0.58
Sodium	ALL NON-DETECT		30						170
Thallium	log-normal	0.4135	46	1.679	1.697	-1.52	0.37	-0.89	0.41
Vanadium	log-normal	0.7948	46	1.679	1.697	3.177	0.398	3.853	47.2
Zinc	log-normal	0.8802	46	1.679	1.697	3.324	0.363	3.94	51.4

NOTE: The Shapiro-Wilk p-values shown for log and non-normally distributed data sets were calculated with log-transformed data.
When data are log-normally distributed, the log of the mean and standard deviation are presented.

TABLE 2-12
NORMALITY AND UPPER TOLERANCE LIMIT CALCULATIONS FOR BACKGROUND SEDIMENT DATA

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WIDLIFE REFUGE

	SHAPIRO-WILK NORMALITY TEST		TOLERANCE FACTOR			95% UTL			
mg/kg	Distribution	p-value	n	t-value	K	Mean	Std. Dev.	log-transformed 95% UTL	95%UTL
Nitrogen, Ammonia	log-normal	0.1087	10	1.833	1.922	3.848	0.797	5.380	217
Nitrogen, Nitrate-Nitrite	ALL NON-DETECT		10						1.5
Total Phosphorous	log-normal	0.1074	10	1.833	1.922	5.457	0.516	6.449	632
Total Orthophosphate	log-normal	0.2323	10	1.833	1.922	0.17	0.488	1.108	3.03
Total Organic Carbon	log-normal	0.1977	10	1.833	1.922	9.929	0.582	11.05	62778
Aluminum	log-normal	0.1488	10	1.833	1.922	8.454	0.454	9.326	11241
Antimony	ALL NON-DETECT		10						1.9
Arsenic	log-normal	0.1488	10	1.833	1.922	1.565	0.401	2.336	10.3
Barium	log-normal	0.5883	10	1.833	1.922	4.331	0.492	5.277	196
Beryllium	ALL NON-DETECT		10						1.6
Cadmium	ALL NON-DETECT		10						1.6
Calcium	normal	0.2748	10	1.833	1.922	777.2	348.8	NA	1448
Chromium, Total	log-normal	0.2054	10	1.833	1.922	2.213	0.329	2.845	17.2
Cobalt	log-normal	0.4240	10	1.833	1.922	1.545	0.346	2.210	9.1
Copper	normal	0.0759	10	1.833	1.922	8.9	4.107	NA	16.8
Iron	normal	0.3855	10	1.833	1.922	12247	4423	NA	20750
Lead	log-normal	0.1298	10	1.833	1.922	2.433	0.393	3.188	24.2
Magnesium	normal	0.2123	10	1.833	1.922	1061	441.4	NA	1909
Manganese	normal	0.1257	10	1.833	1.922	590.7	235.5	NA	1043
Mercury	normal	0.7642	10	1.833	1.922	0.1077	0.0207	NA	0.15
Nickel	log-normal	0.3061	10	1.833	1.922	2.135	0.359	2.825	16.9
Potassium	log-normal	0.3031	10	1.833	1.922	6.140	0.582	7.259	1421
Selenium	ALL NON-DETECT with the exception of the outliers (which were excluded)								0.64
Silver	ALL NON-DETECT		10						3.0
Sodium	ONLY ONE DETECTED VALUE		10						1450
Thallium	normal	0.0958	10	1.833	1.922	0.2345	0.041	NA	0.31
Vanadium	log-normal	0.1476	10	1.833	1.922	2.592	0.378	3.319	27.6
Zinc	log-normal	0.1449	10	1.833	1.922	3.206	0.436	4.044	57.1

NOTE: The Shapiro-Wilk p-values shown for log and non-normally distributed data sets were calculated with log-transformed data.
When data are log-normally distributed, the log of the mean and standard deviation are presented.

TABLE 2-13
NORMALITY AND UPPER TOLERANCE LIMIT CALCULATIONS FOR BACKGROUND SURFACE WATER DATA

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WIDLIFE REFUGE

	SHAPIRO-WILK NORMALITY TEST		TOLERANCE FACTOR			95% UTL			
ug/L	Distribution	p-value	n	t-value	K	Mean	Std. Dev.	log-transformed 95% UTL	95%UTL
Alkalinity	NOT ENOUGH DATA POINTS		4			26380	2684	NA	30700
Nitrogen, Ammonia	log-normal	0.8792	7	1.943	2.077	-2.11	0.361	-1.36	260
Nitrogen, Nitrate-Nitrite	ALL NON-DETECT		7						50
Total Phosphorous	ALL NON-DETECT		7						50
Total Orthophosphate	log-normal	0.9177	7	1.943	2.077	-3.67	1.403	-0.75	470
Total Organic Carbon	non-normal	0.0009	6	2.015	2.176				7500
Suspended Solids	non-normal	0.0491	7	1.943	2.077				8000
Total Dissolved Solids	normal	0.7249	6	2.015	2.176	52042	9028	NA	71700
Aluminum	ALL NON-DETECT		7						200
Antimony	ALL NON-DETECT		7						6
Arsenic	ALL NON-DETECT		7						10
Barium	normal	0.3737	7	1.943	2.077	18.15	2.175	NA	22.7
Beryllium	ALL NON-DETECT		7						5
Cadmium	ALL NON-DETECT		7						5
Calcium	normal	0.4533	7	1.943	2.077	7015	87.51	NA	7197
Chromium, Total	ALL NON-DETECT		7						10
Cobalt	ALL NON-DETECT		7						50
Copper	ALL NON-DETECT		7						10
Iron	ALL NON-DETECT		7						100
Lead	log-normal	0.6732	7	1.943	2.077	0.342	0.162	0.678	2.0
Magnesium	normal	0.3999	7	1.943	2.077	2494	19.02	NA	2534
Manganese	normal	0.4261	7	1.943	2.077	555.6	12.59	NA	582
Mercury	log-normal	0.6056	7	1.943	2.077	-2.09	0.224	-1.63	0.20
Nickel	ALL NON-DETECT		7						10
Potassium	normal	0.8421	7	1.943	2.077	1524	43.08	NA	1613
Selenium	log-normal	0.9859	7	1.943	2.077	0.931	0.029	0.991	2.7
Silver	ALL NON-DETECT		7						10
Sodium	normal	0.4314	7	1.943	2.077	2929	115.2	NA	3169
Thallium	ALL NON-DETECT		7						10
Vanadium	ALL NON-DETECT		7						50
Zinc	ALL NON-DETECT		7						20

NOTE: The Shapiro-Wilk p-values shown for log and non-normally distributed data sets were calculated with log-transformed data.
When data are log-normally distributed, the log of the mean and standard deviation are presented.

TABLE 2-14
SOIL, SEDIMENT, AND SURFACE WATER BACKGROUND CONTAMINANT LEVELS
AUS OU AND LITTLE GRASSY LAKE

CRAB ORCHARD NATIONAL WILDLIFE REFUGE

Analyte	Soil (mg/kg)		Sediment (mg/kg)		Surface Water (µg/L)	
	95% UTL	Mean + 3SD	95% UTL	Mean + 3SD	95% UTL	Mean + 3SD
Alkalinity	----	----	----	----	*30700a*	----
Nitrogen, Ammonia	----	----	217	513	*260*	360
Nitrogen, Nitrate-Nitrite	----	----	1.5a	----	50a	----
Total Phosphorous	----	----	632	1101	50a	----
Total Orthophosphate	----	----	*3.0*	5.12	*470*	1710
Total Organic Carbon	31393	47287	62778	117527	*7500a*	----
Suspended Solids	----	----	----	----	*8000a*	----
Total Dissolved Solids	----	----	----	----	71700	79100
Cyanide	*0.41*	1.01	----	----	----	----
Aluminum	28800a	----	11241	18336	200a	----
Antimony	*0.83a*	----	1.9a	----	6a	----
Arsenic	*13.5*	18.3	10.3	15.9	10a	----
Barium	*195.0*	360.7	196	333	*22.70*	24.7
Beryllium	*0.8*	1.07	1.6a	----	5a	----
Boron	*5.3*	7.9	----	----	----	----
Cadmium	*0.19a*	----	1.6a	----	5a	----
Calcium	2497	3337	1448	1824	7197	7278
Chromium, Total	25.2	48.4	17.2	24.5	10a	----
Cobalt	*21.7a*	----	9.1	13.2	50a	----
Copper	*11.3*	20.6	16.8	21.2	10a	----
Iron	19306	27065	20750	25516	100a	----
Lead	23.4	29.6	24	37	*2.00*	2.3
Magnesium	1552	2397	1909	2385	2534	2551
Manganese	3640	12296	1043	1297	582	593
Mercury	*0.1*	0.11	*0.2*	0.17	*0.20*	0.24
Nickel	*18.9*	37.9	16.9	24.9	10a	----
Potassium	625	773	1421	2662	1613	1653
Selenium	*2.3*	7.15	*0.64a*	----	*2.70*	2.8
Silver	*0.6*	1.35	3.0a	----	10a	----
Sodium	170a	----	1450a	----	3169	3275
Thallium	*0.4*	0.66	*0.3*	0.36	10a	----
Vanadium	*47.2*	79.1	28	42	50a	----
Zinc	51.4	82.5	57.1	91.4	20a	----

a = Non-parametric method (confidence levels: soil = 96%, sediment = 90%, surface water = 87%)
Italics indicates that probability plotting method used for non-detects

Soil UTLs were calculated with data collected in both 1995 and 2000. The 1995 data were obtained from Attachment A Laboratory Results of the DRAFT "Summary Metals Background in Soil and Groundwater, prepared by Woodward Clyde for U.S. Fish and Wildlife Service, March 1995". The laboratory results did not contain data for sample location TPCOC5-2-2-4-6. Data for this location were obtained from Table 2-2 of the 1995 report.

TABLE 2-15
SCREENING LEVELS FOR SOILS AND SEDIMENTS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

	SOIL			SEDIMENT		
	USEPA Generic Soil Screening Levels (1) (mg/kg)	Canadian Soil Quality Guidelines (2) (mg/kg)	New Dutchlist Soil Optimum Levels (3) (mg/kg)	USEPA ECOTOX Thresholds (4) (mg/kg)	USEPA Region IV Screening Values (5) (mg/kg)	Canadian Sediment Quality Guidelines (6) (mg/kg)
Volatile Organic Compounds						
Acetone	0.8 a					
Benzene	0.002 b	0.50 w	0.05	0.057		
Bromochloromethane						
Bromodichloromethane	0.03					
Bromoform	0.04					
Bromomethane (Methyl Bromide)	0.01 a,b					
2-Butanone						
Carbon Disulfide	2.0 a					
Carbon Tetrachloride	0.003 b	5.0				
Chlorobenzene	0.07	1.0		0.82		
Chloroethane						
Chloroform	0.03	5.0				
Chloromethane						
Dibromochloromethane	0.02					
1,2-Dibromo-3-Chloropropane						
1,2-Dibromoethane						
1,1-Dichloroethane	1.0 a	5.0				
1,2-Dichloroethane	0.001 b	5.0	4			
1,1-Dichloroethene	0.003 b	5.0				
cis-1,2-Dichloroethene	0.02					
trans-1,2-Dichloroethene	0.03					
1,2-Dichloroethene (total)		5.0				
1,2-Dichloropropane	0.001 b	5.0				
cis-1,3-Dichloropropene	0.0002 c (for total not just cis)	5.0				
trans-1,3-Dichloropropene	0.0002 c (for total not just trans)	5.0				
Ethylbenzene	0.70	1.2 x	0.05	3.6		
2-Hexanone						
Methylene Chloride	0.001 b,c	5.0	20			

TABLE 2-15
SCREENING LEVELS FOR SOILS AND SEDIMENTS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

	SOIL			SEDIMENT		
	USEPA Generic Soil Screening Levels (1) (mg/kg)	Canadian Soil Quality Guidelines (2) (mg/kg)	New Dutchlist Soil Optimum Levels (3) (mg/kg)	USEPA ECOTOX Thresholds (4) (mg/kg)	USEPA Region IV Screening Values (5) (mg/kg)	Canadian Sediment Quality Guidelines (6) (mg/kg)
4-Methyl-2-Pentanone						
Styrene	0.20	5.0	0.10			
1,1,2,2-Tetrachloroethane	0.0002 b,c		0.01	0.94		
Tetrachloroethene	0.003 b	0.20 y		0.53		
Toluene	0.60	0.80 y	0.05	0.67		
1,1,1-Trichloroethane	0.10	5.0		0.17		
1,1,2-Trichloroethane	0.0009 b	5.0				
Trichloroethene	0.003 b	3.0 x	0.001	1.6		
Vinyl Chloride	0.0007 b		0.1			
Xylenes (Total)	9 (o-xylene only)	1.0 y	0.05	0.025 (m-xylene only)		
Semi-Volatile Organic Compounds						
Acenaphthene	29.0 a			0.016	0.00671 g	0.00671 af
Acenaphthylene					0.00587 g	0.00587 af
Anthracene	590 a				0.0469 g	0.0469 af
Benzo(a)anthracene	0.08 b,c	1.0			0.0748 g	0.0317
Benzo(a)pyrene	0.09 b,c	0.70 y		0.43	0.0888 g	0.0319
Benzo(b)fluoranthene	0.20 b,c	1.0				
Benzo(g,h,i)perylene						
Benzo(k)fluoranthene	2.0 c	1.0				
bis(2-Chloroethoxy)methane						
bis(2-Chloroethyl)ether	0.00002 b,c					
bis(2-ethylhexyl)phthalate	46.0 c				0.182 g	
4-Bromophenyl-phenyl ether				1.3		
Butylbenzylphthalate	810 a			11.0		
Carbazole	0.03 b,c					
4-Chloroaniline	0.03 a,b					
4-Chloro-3-methylphenol						
2-Chloronaphthalene			10			
2-Chlorophenol	0.20 a,b,d	0.50	10			

TABLE 2-15
SCREENING LEVELS FOR SOILS AND SEDIMENTS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

	SOIL			SEDIMENT		
	USEPA Generic Soil Screening Levels (1) (mg/kg)	Canadian Soil Quality Guidelines (2) (mg/kg)	New Dutchlist Soil Optimum Levels (3) (mg/kg)	USEPA ECOTOX Thresholds (4) (mg/kg)	USEPA Region IV Screening Values (5) (mg/kg)	Canadian Sediment Quality Guidelines (6) (mg/kg)
4-Chlorophenyl-phenyl ether						
Chrysene	8.0 c				0.108 g	0.0571
Dibenz(a,h)anthracene	0.08 b,c	1.0			0.00622 g	0.00622 af
Dibenzofuran				2.0		
1,2-Dichlorobenzene	0.90	1.0		0.34		
1,3-Dichlorobenzene		1.0		1.7		
1,4-Dichlorobenzene	0.10 b	1.0		0.35		
3,3'-Dichlorobenzidine	0.0003 b,c					
2,4-Dichlorphenol	0.05 a,b,d	0.50				
Diethylphthalate	23.0 a			0.63		
2,4-Dimethylphenol	0.40 a	1.0				
Dimethylphthalate						
Di-n-butylphthalate				11.0		
4,6-Dinitro-2-methylphenol		1.0				
2,4-Dinitrophenol	0.01 a,b,d	1.0				
2,4-Dinitrotoluene	0.00004 b,c					
2,6-Dinitrotoluene	0.00003 b,c					
Di-n-octylphthalate	1,600 a					
Fluoranthene	210 a			0.60	0.113 g	0.111
Fluorene	28.0 a			0.54	0.0212 g	0.0212 af
Hexachlorobenzene	0.10 b	2.0	0.0025			
Hexachlorobutadiene	0.10 b					
Hexachlorocyclopentadiene	10.0 a					
Hexachloroethane	0.02 b,c			1.0		
Indeno(1,2,3-cd)pyrene	0.70 c	1.0				
Isophorone	0.03 b,c					
2-Methylnaphthalene					0.0202 g	0.0202 af
2-Methylphenol	0.80 a	1.0				
4-Methylphenol		1.0				

TABLE 2-15
SCREENING LEVELS FOR SOILS AND SEDIMENTS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

	SOIL			SEDIMENT		
	USEPA Generic Soil Screening Levels (1) (mg/kg)	Canadian Soil Quality Guidelines (2) (mg/kg)	New Dutchlist Soil Optimum Levels (3) (mg/kg)	USEPA ECOTOX Thresholds (4) (mg/kg)	USEPA Region IV Screening Values (5) (mg/kg)	Canadian Sediment Quality Guidelines (6) (mg/kg)
Naphthalene	4.0 a	0.60 x		0.16	0.0346 g	0.0346 af
2-Nitroaniline						
3-Nitroaniline						
4-Nitroaniline						
Nitrobenzene	0.007 a,b					
2-Nitrophenol		1.0				
4-Nitrophenol		1.0				
N-Nitroso-di-n-propylamine	0.06 b,c					
N-Nitrosodiphenylamine	0.007 a,b					
2,2'-oxybis(1-Chloropropane)						
PAHS (total)			1	4.0	1.684 g	
Pentachlorophenol	0.001 b,d	7.6 z	0.002			
Phenanthrene		5.0		0.24	0.0867 g	0.0419
Phenol	5.0 a	3.8 z	0.05			
Pyrene	210 a	10.0		0.66	0.153 g	0.053
1,2,4-Trichlorobenzene	0.30 b	2.0		9.2		
2,4,5-Trichlorophenol	14.0 a,d	0.50	0.001			
2,4,6-Trichlorophenol	0.008 b,c,d	0.50	0.001			
Pesticides/PCBs						
Aroclor-1061	1.0 e (total PCBs)	0.30 aa (total PCBs)	0.02 (total PCBs)	0.023 (total PCBs)	0.0216 g (total PCBs)	0.0341 (total PCBs)
Aroclor-1221	1.0 e (total PCBs)	0.30 aa (total PCBs)	0.02 (total PCBs)	0.023 (total PCBs)	0.0216 g (total PCBs)	0.0341 (total PCBs)
Aroclor-1232	1.0 e (total PCBs)	0.30 aa (total PCBs)	0.02 (total PCBs)	0.023 (total PCBs)	0.0216 g (total PCBs)	0.0341 (total PCBs)
Aroclor-1242	1.0 e (total PCBs)	0.30 aa (total PCBs)	0.02 (total PCBs)	0.023 (total PCBs)	0.0216 g (total PCBs)	0.0341 (total PCBs)
Aroclor-1248	1.0 e (total PCBs)	0.30 aa (total PCBs)	0.02 (total PCBs)	0.023 (total PCBs)	0.0216 g (total PCBs)	0.0341 (total PCBs)
Aroclor-1254	1.0 e (total PCBs)	0.30 aa (total PCBs)	0.02 (total PCBs)	0.023 (total PCBs)	0.0216 g (total PCBs)	0.0341 (total PCBs)
Aroclor-1260	1.0 e (total PCBs)	0.30 aa (total PCBs)	0.02 (total PCBs)	0.023 (total PCBs)	0.0216 g (total PCBs)	0.0341 (total PCBs)
TAL Metals + Cyanide						
Aluminum						

TABLE 2-15
SCREENING LEVELS FOR SOILS AND SEDIMENTS

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

	SOIL			SEDIMENT		
	USEPA Generic Soil Screening Levels (1) (mg/kg)	Canadian Soil Quality Guidelines (2) (mg/kg)	New Dutchlist Soil Optimum Levels (3) (mg/kg)	USEPA ECOTOX Thresholds (4) (mg/kg)	USEPA Region IV Screening Values (5) (mg/kg)	Canadian Sediment Quality Guidelines (6) (mg/kg)
Antimony	0.30	20.0		8.2	2.0 h	5.9
Arsenic	0.40 c	12.0 z	29.0		7.24 g	
Barium	82.0 d	500 ab	200			
Beryllium	0.10 c	4.0				
Cadmium	0.40 d	10.0 ac	0.80	1.2	0.676 g	0.60
Calcium						
Chromium	78,000 a/2.0 d (Cr III/VI)	64.0 z/0.40 x (Cr total/VI)	100	81.0	52.3 g	37.3
Cobalt		50.0	20.0			
Copper		63.0 z	36.0	34.0	18.7 g	35.7
Iron						
Lead	400 f	140 z	85.0	47.0	30.2 g	35.0
Magnesium						
Manganese						
Mercury	0.10 d	6.6 z	0.30	0.15	0.13 g	0.17
Nickel	7.0 d	50.0 aa	35.0	21.0	15.9 i	
Potassium						
Selenium	0.30 d	3.0				
Silver	2.0 a,d	20.0			0.733 g	
Sodium						
Thallium	0.04 d	1.0 ad				
Vanadium	300 a	130 aa				
Zinc	620 a,d	200 aa	140	150	124 g	123
Nitrate						
Sulfate						
Cyanide	2.0 (amenable)	0.90 z (free)	1.0/5.0 (free/complex)			

FOOTNOTES FOR TABLE 2-15

(1) Generic soil screening levels obtained from Appendix A of USEPA's "Soil Screening Guidance: Technical Background Document", EPA/540/R95/128, May 1996. The lowest SSL value was chosen from the inhalation, ingestion and migration to groundwater pathways.

(2) "Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health - Residential/Parkland Land Use" from the Canadian Environmental Quality Guidelines from the Guidelines and Standards Division, Environmental Quality Branch of the Environmental Conservaton Service, last updated September, 1998.

(3) Optimum Soil Levels from the New Dutchlist.

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a Calculated values correspond to a noncancer hazard quotient of 1.

b Level is at or below Contract Laboratory Program required quantitation limit for Regular Analytical Services (RAS).

c Calculated values correspond to a cancer risk level of 1 in 1,000,000.

d SSL for pH of 6.8

e A preliminary remediation goal of 1 mg/kg has been set for PCBs based on *Guidance on Remedial Actions for Superfund Sites with PCB Contamination* (USEPA, 1990) and on EPA efforts to manage PCB contamination.

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j Value as calculated in Suter and Mabrey, 1994.

k Value calculated for this project.

m Final chronic value derived for EPA Sediment Quality Criteria Documents *(EPA, 1993a, b, c, d, e)*

n pH-dependent ambient water quality criterion (7.8 pH used).

o Value with EPA Support Documents.

p Hardness-dependent ambient water quality criterion (100 mg/L as CaCo3 used).

q Criteria

r Based on the marketability of fish. The use of other values which may have greater ecological significance may be considered.

s 1994 Proposed Rule for Disinfectants and Disinfection By-products: Total for all THMs combined cannot exceed the 0.08 level.

t USEPA Secondary Maximum Contaminant Levels which are unenforceable federal guidelines regarding taste, color, odor and certain other non-aesthetic effects of drinking water.

u At tap. Copper action level is 1.3 mg/l and lead action level is 0.015 mg/l.

v Being remanded.

w Data are sufficient and adequate to calculate only a provisional soil quality guideline for environmental health (SQGe). It is greater than the corresponding interim soil quality criterion (CCME, 1991). Therefore, in consideration of receptors and/or pathways not examined, the interim soil quality criterion is retained as the soil quality guideline for this land use.

x Data are sufficient and adequate to calculate only a provisional SQGe, which is less than the existiong interim soil quality criterion (CCME 1991). Therefore, the soil quality guideline supersedes the interim soil quality guideline.

y Data are sufficient and adequate to calculate a soil quality guideline for human health (SQGhh) and a provisional SQGe. Both are less than corresponding interim soil quality criterion (CCME 1991). Therefore the soil quality guideline supersedes the interim soil quality criterion for this land use.

z Data are sufficient and adequate to calcuate an SQGhh and an SQGe. Therefore the soil quality guideline is the lower of the two and represents a fully

FOOTNOTES FOR TABLE 2-15

integrated de novo guideline for this land use, derived in accordance with the soil protocol (CCME 1996). The corresponding interim soil quality criterion (CCME 1991) is superseded by the soil quality guideline.

aa Data are sufficient and adequate to calculate only and SQGe, which is less than the interim soil quality criterion (CCME 1991) for this land use. Therefore the SQGe becomes the soil quality guideline, which supersedes the interim soil quality criterion for this land use.

ab Data are insufficient/inadequate to calculate and SQGh, a provisional SQGhh, an SQGe or a provisional SQGe. Therefore the interim soil quality criterion (CCME 1991) is retained as the soil quality guideline for this land use.

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ad Data are sufficient and adequate to calculate a provisional SQGhh and an SQGe. The provisional SQGhh is less than the SQGe and thus becomes the soil quality guideline for this land use.

af Provisional; adoption of marine interim sediment quality guidelines (ISQGs).

ag Substance has been re-evaluated since CCREM 1987+appendices, either a new guideline has beeen derived or insufficient data existed to drive a new guideline.

ah Interim guideline.

ai Substance has been re-evaluated since CCREM 1987+appendices, due to re-evaluation of the significant figures.

aj Aluminum Guideline: Assuming pH > or = 6.5, $CaCO_3$ >4mg/L and DOC > or = 2.0 mg/L; Al guideline = 100 ug/L.

ak Cadmium guideline: Assuming $CaCO_3$ = 100 mg/L, Cd guideline = 0.033 ug/L.

al Copper guideline: Assuming $CaCO_3$ = 100 mg/L, Cu guideline = 2 ug/L.

am Lead guideline: Assuming $CaCO_3$ = 100 mg/L, Pb guideline = 2 ug/L.

an Nickel guideline: Assuming $CaCO_3$ = 100 mg/L, Ni guideline = 65 ug/L.

TABLE 2-16
SCREENING LEVELS FOR SURFACE WATER AND GROUNDWATER

ADDITIONAL AND UNCHARACTERIZED SITES OU
CRAB ORCHARD NATIONAL WILDLIFE REFUGE

	SURFACE WATER		GROUNDWATER		
	USEPA ECOTOX Thresholds (7) (ug/L)	USEPA Region IV Screening Values (8) (ug/L)	USEPA Drinking Water MCLs (9) (ug/L)	Canadian Water Quality Guidelines (10) (ug/L)	New Dutchlist Groundwater Optimum Levels (11) (ug/L)
Volatile Organic Compounds					
Acetone					
Benzene	46.0 j	53.0	5	370 ag	0.20
Bromochloromethane					
Bromodichloromethane			80s		
Bromoform		293	80s		
Bromomethane (Methyl Bromide)		110			
2-Butanone					
Carbon Disulfide					
Carbon Tetrachloride		352	5		
Chlorobenzene	130 j	195			
Chloroethane					
Chloroform		289	80.0 s	1.8 ah,ai	
Chloromethane		5500			
Dibromochloromethane			80.0 s		
1,2-Dibromo-3-Chloropropane			0.20		
1,2-Dibromoethane					
1,1-Dichloroethane	47.0 j				
1,2-Dichloroethane		2000	5.0	100 ah,ai	0.01
1,1-Dichloroethene		303	7.0		
cis-1,2-Dichloroethene			70.0		
trans-1,2-Dichloroethene		1350	100		
1,2-Dichloroethene (total)					
1,2-Dichloropropane		525	5.0		
cis-1,3-Dichloropropene		24.4 (total)			
trans-1,3-Dichloropropene		24.4 (total)			

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Ethylbenzene	290 j	453	700.00	90.0 ah	0.20
2-Hexanone					
Methylene Chloride		1930	5.0	98.1 ah,ai	0.01
4-Methyl-2-Pentanone					
Styrene			100	72.0 ah	0.50
1,1,2,2-Tetrachloroethane	420 j	240			0.01
Tetrachloroethene	120 j	84.0	5.0	111ah,ai	
Toluene	130 j	175	1000	2.0 ag,ah	0.20
1,1,1-Trichloroethane	62.0 j	528	200		
1,1,2-Trichloroethane		940	5.0		0.01
Trichloroethene	350 j		5.0	21.0 ah,ai	0.7
Vinyl Chloride			2.0		0.20
Xylenes (Total)	1.8 k (m-xylene only)		10000		
Semi-Volatile Organic Compounds					
Acenaphthene	23.0 m	17.0		5.8 ah	
Acenaphthylene					
Anthracene				0.012 ah	0.02
Benzo(a)anthracene				0.018 ah	
Benzo(a)pyrene	0.014 j		0.2	0.015 ah	0.001
Benzo(b)fluoranthene					0.003
Benzo(g,h,i)perylene					0.0002
Benzo(k)fluoranthene					0.001
bis(2-Chloroethoxy)methane					
bis(2-Chloroethyl)ether		2380			
bis(2-ethylhexyl)phthalate	32.0 j	<0.30		16.0 ah	
4-Bromophenyl-phenyl ether	1.5 k				

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Butylbenzylphthalate	19.0 k	22.0			
Carbazole					
4-Chloroaniline					
4-Chloro-3-methylphenol	0.30				
2-Chloronaphthalene					6
2-Chlorophenol		43.8			
4-Chlorophenyl-phenyl ether					
Chrysene					0.002
Dibenz(a,h)anthracene					
Dibenzofuran	20.0 j				
1,2-Dichlorobenzene	14.0 k	15.8	600	0.70 ag,ah	
1,3-Dichlorobenzene	71.0 k	50.2		150 ag,ah	
1,4-Dichlorobenzene	15.0 k	11.2	75.0	26.0 ag,ah	
3,3'-Dichlorobenzidine					
2,4-Dichlorphenol		36.5		0.20	0.08
Diethylphthalate	220 j	521			
2,4-Dimethylphenol		21.2			
Dimethylphthalate		330			
Di-n-butylphthalate	33.0 j	9.4		19.0 ah	
4,6-Dinitro-2-methylphenol		2.3			
2,4-Dinitrophenol		6.2			
2,4-Dinitrotoluene		310			
2,6-Dinitrotoluene					
Di-n-octylphthalate					
Fluoranthene	8.1 m	39.8		0.04 ah	0.005
Fluorene	3.9 k			3.0 ah	

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Hexachlorobenzene			1.0		0.01
Hexachlorobutadiene		0.93		1.3 ag,ah	
Hexachlorocyclopentadiene		0.07	50.0		
Hexachloroethane	12 k	9.8			
Indeno(1,2,3-cd)pyrene					0.0004
Isophorone		1170			
2-Methylnaphthalene					
2-Methylphenol					
4-Methylphenol					
Naphthalene	24.0 j	62.0		1.1 ah	0.10
2-Nitroaniline					
3-Nitroaniline					
4-Nitroaniline					
Nitrobenzene		270			
2-Nitrophenol		3500			
4-Nitrophenol		82.8			
N-Nitroso-di-n-propylamine					
N-Nitrosodiphenylamine		58.5			
2,2'-oxybis(1-Chloropropane)					
PAHS (total)					
Pentachlorophenol	13.0 n	13.0 q	1.0	0.50	0.02
Phenanthrene	6.3 m			0.40 ah	0.03
Phenol		256			0.20
Pyrene				0.025 ah	
1,2,4-Trichlorobenzene	110 k	44.9	70.0	24.0 ag,ah	
2,4,5-Trichlorophenol				18.0	0.025

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2,4,6-Trichlorophenol		3.2		18.0	0.025
Pesticides/PCBs					
Aroclor-1061	0.019 j (total PCBs)	0.014 q	0.50 (total PCBs)		0.01 (total PCBs)
Aroclor-1221	0.019 j (total PCBs)	0.014 q	0.50 (total PCBs)		0.01 (total PCBs)
Aroclor-1232	0.019 j (total PCBs)	0.014 q	0.50 (total PCBs)		0.01 (total PCBs)
Aroclor-1242	0.019 j (total PCBs)	0.014 q	0.50 (total PCBs)		0.01 (total PCBs)
Aroclor-1248	0.019 j (total PCBs)	0.014 q	0.50 (total PCBs)		0.01 (total PCBs)
Aroclor-1254	0.019 j (total PCBs)	0.014 q	0.50 (total PCBs)		0.01 (total PCBs)
Aroclor-1260	0.019 j (total PCBs)	0.014 q	0.50 (total PCBs)		0.01 (total PCBs)
TAL Metals + Cyanide					
Aluminum		87.0 q	50.0 t	100 aj	
Antimony		160	6.0		
Arsenic	190/8.1 j (As III/V)	90.0 q (As III)	50.0	5.0 ag	10.0
Barium	3.9 j		2000		50.0
Beryllium	5.1 j	0.53	4.0		
Cadmium	1.0 p	0.66 q	5.0	0.033 ak	0.40
Calcium					
Chromium	180 H/10.0 (Cr III/VI)	117.32 q/11.0 q (Cr III/VI)	100	8.9 ag,ah/1.0 ag (Cr III/IV)	1.0
Cobalt	3.0 j				20.0
Copper	11.0 p	6.54 q	1300 u	2.0 al	15.0
Iron	1000	1000 q	300 t	300	
Lead	2.5 p	1.32 q	15.0 u	2.0 am	15.0
Magnesium					
Manganese	80 j		50.0 t		
Mercury	1.3	0.012 q,r	2.0	0.10	0.05
Nickel	160 p	87.71 q	100 v	65.0 an	15.0

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Potassium					
Selenium	5.0	5.0 q	50.0	1.0	
Silver		0.012	100 t	0.10	
Sodium					
Thallium		4.0	2.0	0.80	
Vanadium	19.0 j				
Zinc	100 p	58.9 l	5000	30.0	65.0
Nitrate			10000		
Sulfate			500,000 (250,000 u)		
Cyanide	5.2	5.2 q	200	5.0 (free)	5.0/10.0 (free/complex)

FOOTNOTES FOR TABLE 2-16

(1) Generic soil screening levels obtained from Appendix A of USEPA's "Soil Screening Guidance: Technical Background Document", EPA/540/R95/128, May 1996. The lowest SSL value was chosen from the inhalation, ingestion and migration to groundwater pathways.

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z Data are sufficient and adequate to calcuate an SQGhh and an SQGe. Therefore the soil quality guideline is the lower of the two and represents a fully integrated de novo guideline for this land use, derived in accordance with the soil protocol (CCME 1996). The corresponding interim soil quality criterion

FOOTNOTES FOR TABLE 2-16

(CCME 1991) is superseded by the soil quality guideline.

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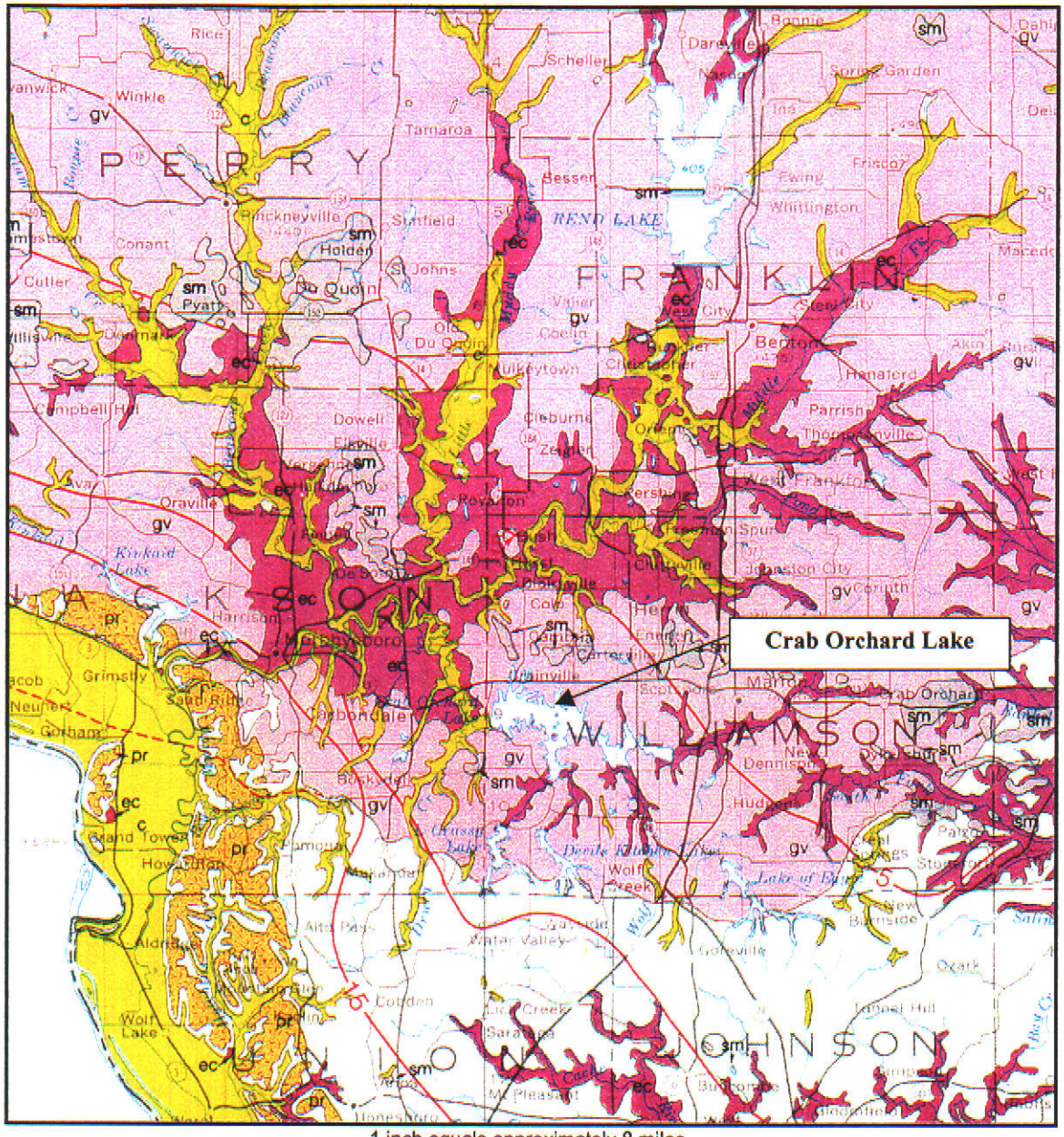


1 inch equals approximately 8 miles

LEGEND

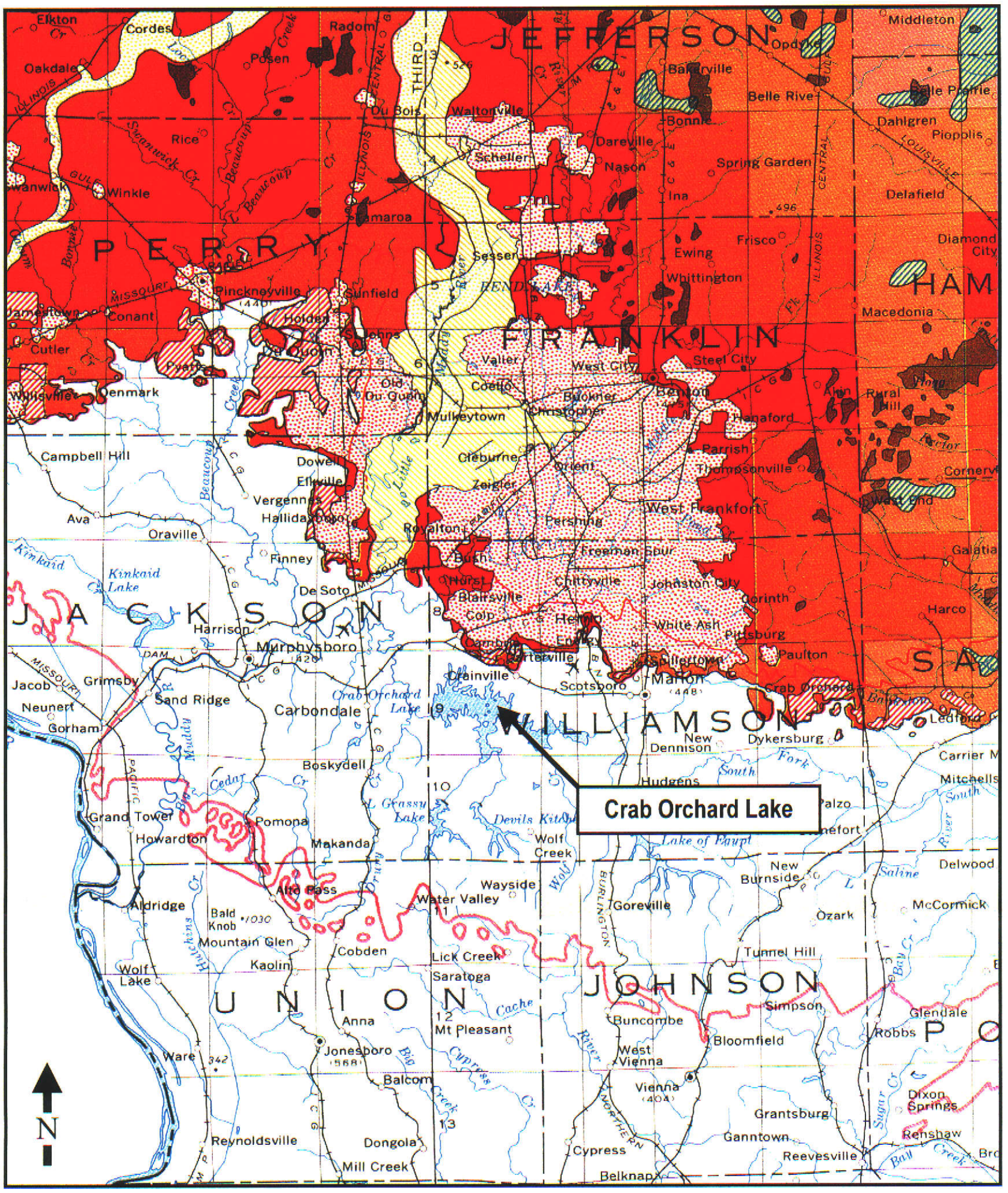
- gv = GLACIAL TILL (GLASFORD FORMATION)
- ec = GLACIAL LAKE DEPOSITS (EQUALITY FORMATION)
- c = RECENT ALLUMIUM (CAHOKIA FORMATION)
- sm = SURFACE MINES

5 — LOESS THICKNESS (5 FT. CONTOURS)

WHITE AREAS ARE UNGLACIATED

Source: Lineback, Jerry. *Quaternary Deposits of Illinois*, (Map), Institute of Natural Resources, State of Illinois, Illinois State Geological Survey, 1979.

PA/SI REPORT – AUS OU CRAB ORCHARD NWR, MARION, ILLINOIS	PROJECT NO. 2320000026.00
URS	
DRN. BY: CMW DSGN BY: MCH CHCK. BY: MCH	**Local Quarternary Deposits** — FIG. NO. **2-1**



THIN COAL, LIMITING FEATURES, AND DEPLETED AREAS

- Coal less than 42″ thick
- Thin coal (av. less than 28″ thick)
- Heavily drilled for oil and gas
- Insufficient data for estimates of reserves
- Coal split or thin
- Coal missing because of sandstone channels
- Mined-out area — strip
- Mined-out area — underground

(Mined-out areas: boundaries drawn to July 1, 1973)

- Coal eroded
- Limit of Coal Seam
- 150 Foot Depth Line
- Boundary of Pennsylvanian System

RESERVES OF HERRIN (NO. 6) COAL
(more than 42 inches thick)

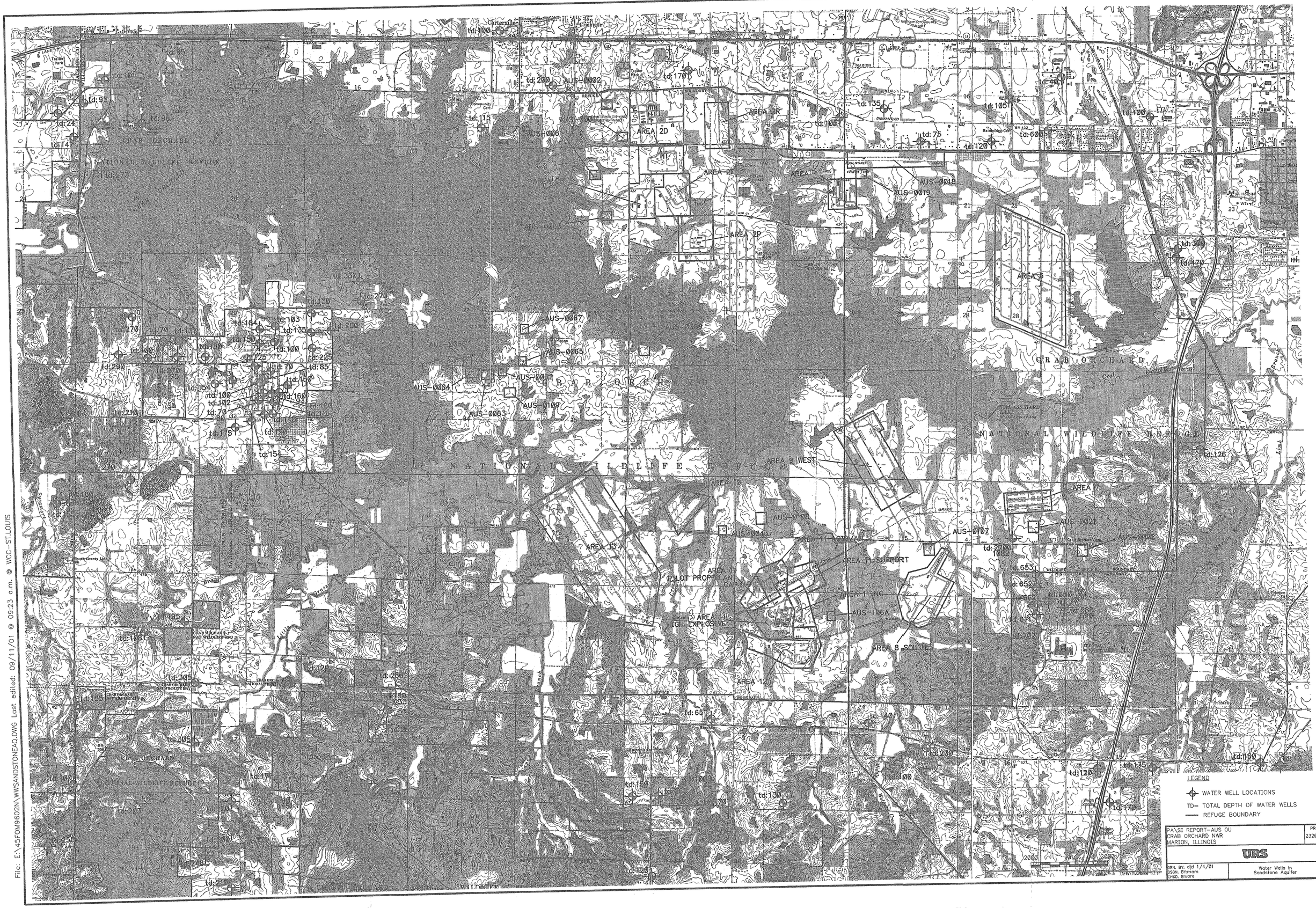
AVERAGE TONS OF COAL PER SQUARE MILE
(in millions of tons)

- > 9
- 8-9
- 7-8
- 6-7
- 5-6
- 4-5

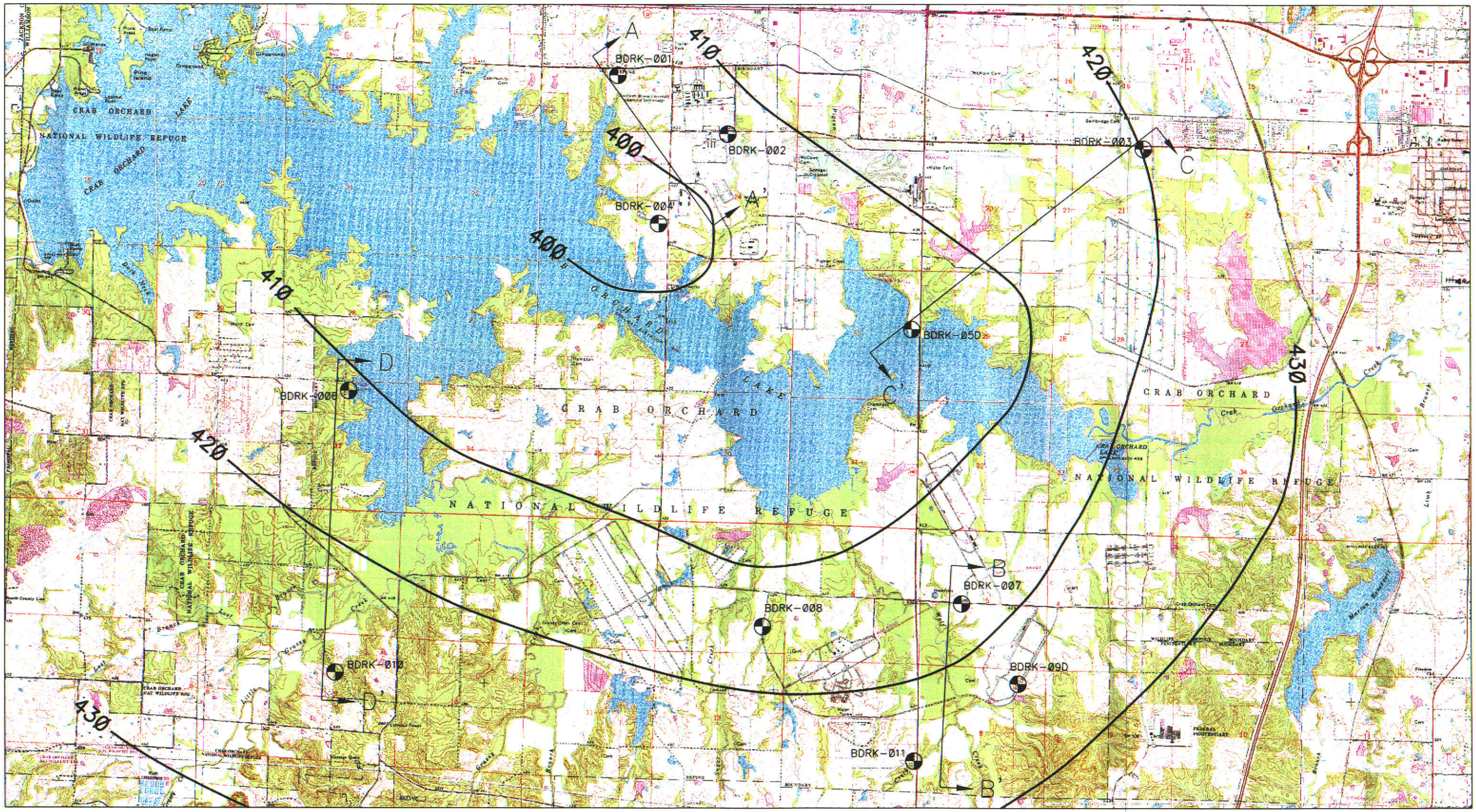
1" = Approximately 13.5 Miles

Source: Smith, William H. and Bengal, Lawrence E., *Coal Reserves of Illinois, Herrin (No. 6) Coal, Cooperative Report 4*, Plate 1, State of Illinois, Department of Registration and Education, Illinois State Geological Survey, January 1975.

PA/SI REPORT – AUS OU CRAB ORCHARD NWR, MARION, ILLINOIS		PROJECT NO. 2320000026.00
URS		
DRN. BY: MCH DSGN BY: MCH CHCK. BY: CMW	**Herrin No. 6 Coal Seam**	FIG. NO. **2-2**



File: E:\45FOM9602N\WWSANDSTONEAQ.DWG Last edited: 09/11/01 @ 09:23 a.m. @ WCC-ST.LOUIS



LEGEND

- BORING LOCATION
- 400 — GROUNDWATER ELEVATION
- A A' GEOLOGIC CROSS-SECTION LOCATION

0 4000
SCALE FEET

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CRAB ORCHARD NWR
MARION, ILLINOIS

PROJECT NO. 2320000026.00

URS

DRN. BY:djd 9-26-00
DSGN. BY: jmr
CHKD. BY:mch/cmw

Groundwater Elevations for Bedrock Monitoring Wells September, 2000

FIG. NO. 2-4

File: E:\SFDMS6026\AUS OU SITE BDRK.DWG Last edited SEP. 11, 01 @ 08:47 a.m. URS Corp.

(NORTHWEST)
A

(SOUTHEAST)
A'

ELEVATION (FT.)

430
410
390
370
350
330
310
290
270

BDRK-001

SEPT. 2000

LOESS

TILL

BEDROCK

SHALE W/ COAL

SHALE W/ HIGH PLASTICITY CLAY

SHALE W/ SANDSTONE

SHALE W/ SANDSTONE

BDRK-002
(OFFSET 2,800'NE)

SEPT. 2000

LOESS

TILL

SILTY CLAY
W/ SHALE

BEDROCK

SHALE W/ HIGH
PLASTICITY CLAY

SHALE W/ COAL

SANDSTONE W/ HIGH
PLASTICITY CLAY

SHALE W/ SANDSTONE

SHALE W/ COAL

SANDSTONE W/ SHALE

BDRK-004
(OFFSET 2,800'SW)

OCT. 2000

SEPT. 2000

LOESS

SANDSTONE
W/ SHALE

SHALE W/ HIGH
PLASTICITY CLAY

JULY 2000

SANDSTONE W/ HIGH
PLASTICITY CLAY

LEGEND

- GROUNDWATER ELEVATION
- FILL
- SILT
- LOW PLASTIC CLAY
- HIGH PLASTIC CLAY
- SANDSTONE
- LIMESTONE
- SHALE
- COAL
- SILTY CLAY
- SILTY CLAY W/ GRAVEL AND SAND
- SILTY CLAY W/ GRAVEL

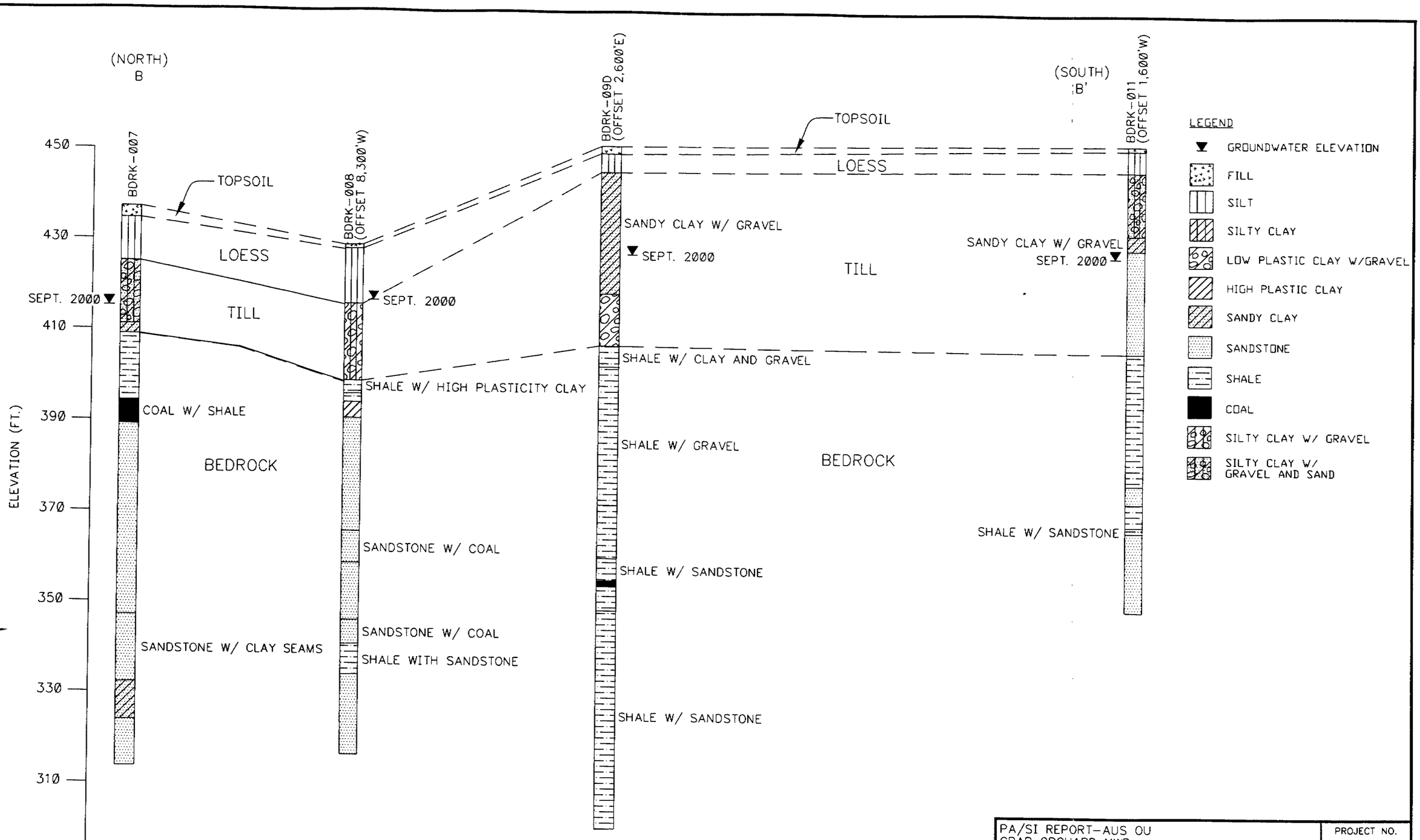
HORIZONTAL SCALE 1"=600'
VERTICAL SCALE 1"=20'

PA/SI REPORT-AUS OU CRAB ORCHARD NWR MARION, ILLINOIS	PROJECT NO. 2320000026.00

URS

DRN. BY: chs 1/5/01 DSGN. BY: jmr 1/5/01 CHKD. BY: are/sea	Geologic Cross-Section A-A' for Bedrock Wells near Area 2	FIG. NO. 2-5

File: E:\2320000026.00\PA-SI REPORT-AUS OU\FIG2-2.DWG Last edited: 09/11/01 @ 08:50 a.m. WC-ST.LOUIS, MO



HORIZONTAL SCALE 1"=600'
VERTICAL SCALE 1"=20'

File: E:\2320000026.00\PA-SI REPORT-AUS OU\FIG2-3.DWG Last edited: WED. 09, 01 @ 08:55 a.m. URS Corp.

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URS	
DRN. BY: chs 1/5/01 DSGN. BY: jmr 1/5/01 CHKD. BY: are	Geologic Cross-Section B-B' for Bedrock Wells near Former Major Load Lines
	FIG. NO. 2-6

(NORTHEAST) C

(SOUTHWEST) C'

BDRK-003

BDRK-05D

SEPT. 2000

SEPT. 2000

LOESS

HIGH PLASTICITY CLAY W/ SAND & GRAVEL

TILL

SILT

BEDROCK

SANDSTONE W/ SHALE

SHALE W/ GRAVEL

SHALE W/ SANDSTONE

SHALE W/ CLAY

SHALE W/ COAL

SHALE W/ SANDSTONE

SHALE W/ SAND

ELEVATION (FT.)

425
410
380
350
320
290
260
230
200
170

LEGEND

- GROUNDWATER ELEVATION
- SILTY CLAY
- SILTY CLAY W/ GRAVEL AND SAND
- FILL
- SILT
- CLAYEY SILT W/ GRAVEL
- LOW PLASTIC CLAY W/GRAVEL
- LOW PLASTIC CLAY
- HIGH PLASTIC CLAY
- SANDY CLAY
- SANDSTONE
- SHALE
- COAL

HORIZONTAL SCALE 1"=1000'
VERTICAL SCALE 1"=30'

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CRAB ORCHARD NWR
MARION, ILLINOIS

PROJECT NO. 2320000026.00

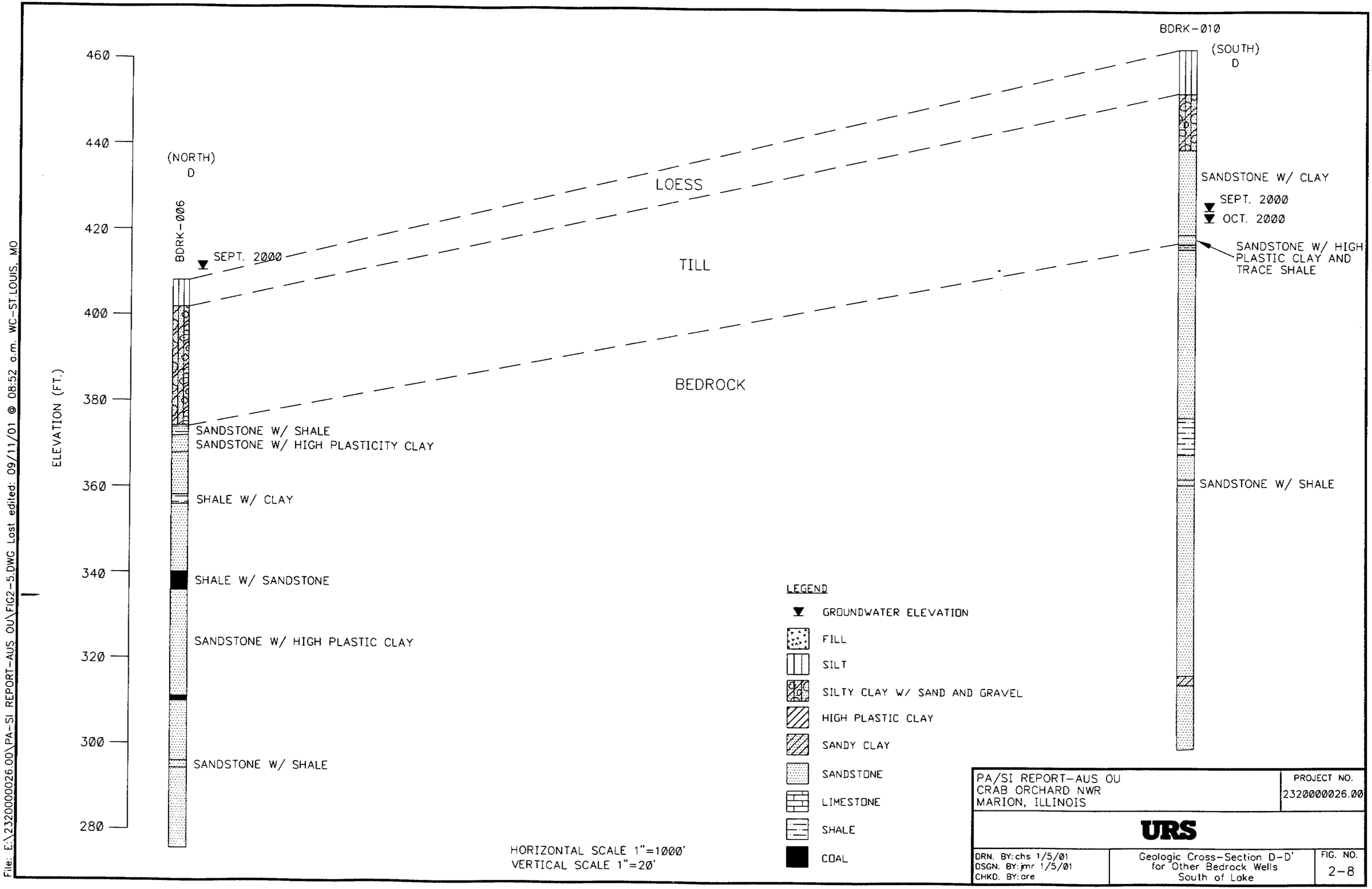
URS

DRN. BY: chs 1/5/01
DSGN. BY: jmr 1/5/01
CHKD. BY: are

Geologic Cross-Section C-C' for Other Bedrock Wells North and East of Lake

FIG. NO. 2-7

File: E:\2320000026.00\PA-SI REPORT-AUS OU\FIG2-4.DWG Last edited: SEP. 11, 01 @ 08:52 a.m. URS Corp.



File: E:\2320000026.00\PA-SI REPORT-AUS OU\FIG2-5.DWG Last edited: 09/11/01 @ 08:52 a.m. WC-ST.LOUIS, MO

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URS	
DRN. BY: chs 1/5/01 DSGN. BY: jmr 1/5/01 CHKD. BY: are	Geologic Cross-Section D-D' for Other Bedrock Wells South of Lake
	FIG. NO. 2-8

SOIL TYPES

2	CISNE SILT LOAM	70	BEAUCOUP SILTY CLAY LOAM, BOTTOM	167	LUKIN SILT LOAM
3	HOYLETON SILT LOAM	71	DARWIN CLAY, BOTTOM	176	MARISSA SILT LOAM
4	RICHVIEW SILT LOAM	72	SHARON SILT LOAM, BOTTOM	214	HOSMER SILT LOAM
5	BLAIR SILT LOAM	84	OKAW SILT LOAM	287	CHAUNCEY SILT LOAM
8	HICKORY LOAM	85	JACOB CLAY, BOTTOM	288	PETROLIA SILTY CLAY LOAM
8-14	HICKORY LOAM - AVA SILT LOAM, COMPLEX	108	BONNIE SILT LOAM, BOTTOM	301	GRANTSBURG SILT LOAM
8-214	HICKORY LOAM - HOSMER SILT LOAM, COMPLEX	109	RACOON SILT LOAM	335	ROBBS SILT LOAM
9	STEEP ROCKY LAND, SANDSTONE MATERIAL	122	COLP SILT LOAM	337	CREAL SILT LOAM
11	LOY SILT LOAM	132	STARKS SILT LOAM	338	HURST SILT LOAM
12	WYNOOSE SILT LOAM	134	CAMDEN SILT LOAM	339	WELLSTON SILT LOAM
13	BLUFORD SILT LOAM	164	STOY SILT LOAM	340	MANITOU SILT LOAM
14	AVA SILT LOAM	165	WEIR SILT LOAM	382	BELKNAP SILT LOAM, BOTTOM

SLOPE SYMBOLS

A : 0 TO 1.5% SLOPE

B : 1.5 TO 4% SLOPE

C : 4 TO 7% SLOPE

D : 7 TO 12% SLOPE

E : 12 TO 18% SLOPE

F : 18 TO 30% SLOPE

G : OVER 30% SLOPE

EROSION SYMBOLS

SLOPE SYMBOL FOLLOWED BY + SIGN (FOR EXAMPLE, A+) DENOTES LIGHT-COLORED SILTY SEDIMENT 8 TO 15 INCHES THICK ON A NORMAL SURFACE SOIL. ALSO, IN THE VICINITY OF HERRIN, + ON SMALL BOTTOMLANDS INDICATES MINE-WASH MATERIAL HAS COVERED THE AREA.

SLOPE SYMBOL ALONE (FOR EXAMPLE, C) DENOTES NONE TO SLIGHTLY ERODED (OVER 7 INCHES OF SURFACE AND SUBSURFACE SOIL REMAINING)

SLOPE SYMBOL OVERSCORED (FOR EXAMPLE, $\bar{C}$) DENOTES MODERATELY ERODED (3 TO 7 INCHES OF SURFACE AND SUBSURFACE REMAINING)

SLOPE SYMBOL UNDERSCORED (FOR EXAMPLE, $\underline{C}$) DENOTES SEVERELY ERODED (LESS THAN 3 INCHES OF SURFACE AND SUBSURFACE SOIL REMAINING)

★ STAR FOLLOWING SLOPE SYMBOL DENOTES PRESENCE OF NUMEROUS MINE SINKS IN AREA

CONVENTIONAL SYMBOLS

- PAVED ROAD
- BLACKTOP OR 1-LANE PAVED ROAD
- GRAVEL OR MINE-WASTE ROAD
- IMPROVED DIRT ROAD
- PRIVATE LANE
- RAILROAD
- RAILROAD (2 OR MORE TRACKS)
- ABANDONED RAILROAD
- LEVEE (TICKS PROTECTED SIDE)
- SANDSTONE OUTCROP
- COUNTY BOUNDARY
- TOWNSHIP BOUNDARY

- LARGE RIVER
- SMALL FLOWING STREAM
- NONCROSSABLE DRAINAGE
- CROSSABLE DRAINAGE
- POND OR LAKE
- SWAMPY AREA
- DAM
- MD MINE DUMP
- BP BORROW PIT
- SM SURFACE MINE

- TOWN
- TOWN
- HOUSE
- SCHOOL
- CHURCH
- BUSINESS ESTABLISHMENT
- LARGE BUILDING
- SHAFT MINE
- CEMETERY

SCALE

0 1/4 1/2 1 2 MILES

A. E. LINE, SOIL CORRELATOR
UNITED STATES DEPARTMENT OF AGRICULTURE

R. T. ODELL, IN CHARGE OF SOIL SURVEY
UNIVERSITY OF ILLINOIS AGRICULTURAL EXP. STATION

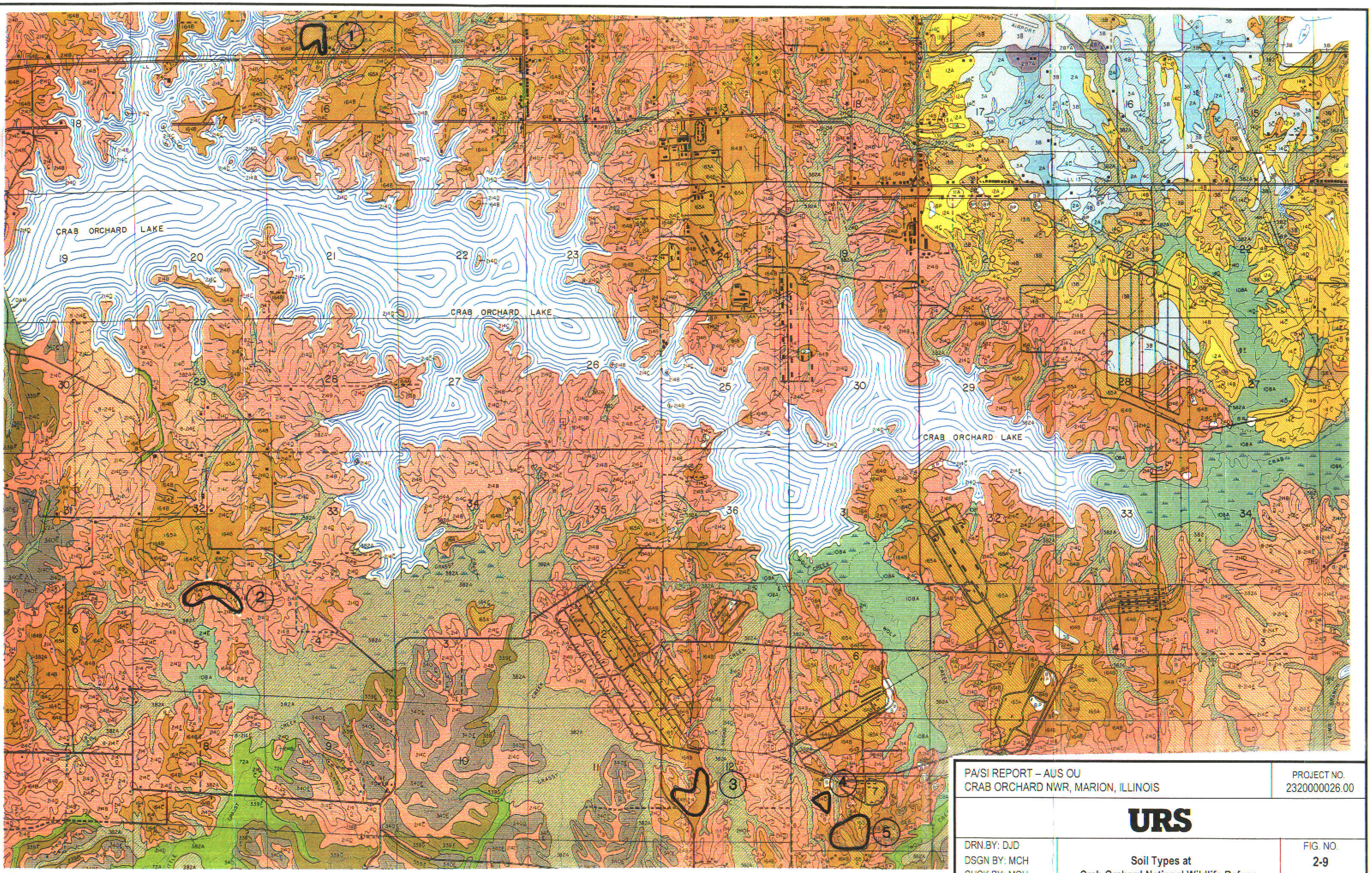
SOIL SURVEYED BY J. R. FEHRENBACHER, IN CHARGE, J. D. ALEXANDER, R. A. HOHANNON, W. G. HOLMES, AND H. H. RUST
UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION, AND H. P. McCULLOCH, SOIL CONSERVATION SERVICE, USDA

SOIL SURVEY MAP OF WILLIAMSON COUNTY, ILLINOIS

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION
IN COOPERATION WITH
UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE

① BACKGROUND SOIL SAMPLE LOCATIONS

KEY TO FIGURE 2-9



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URS

DRN.BY: DJD DSGN BY: MCH CHCK.BY: MCH	Soil Types at Crab Orchard National Wildlife Refuge	FIG. NO. 2-9