FINAL REPORT

VOLUME I

ARCHEOLOGICAL DATA RECOVERY UPPER AND LOWER COPPERAS FACTORIES AND INTERCOPPERAS AREAS AND MONITORING MITIGATION FOR A NON-TIME-CRITICAL REMOVAL ACTION (NTCRA) ELIZABETH MINE SITE (VT-OR-28)

South Strafford and Thetford, Vermont

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EXECUTIVE SUMMARY

An archaeological data recovery program and archaeological monitoring efforts were conducted at the Elizabeth Mine Site (VT-OR-28) in South Strafford, Orange County, Vermont. These investigations were conducted in support of the Non-Time-Critical Removal Action (NTCRA) at Tailings Pile 3 (TP 3) at the Elizabeth Mine being performed by the United States Army Corps of Engineers-New England District (USACE) for Region 1 of the Environmental Protection Agency (EPA) through Interagency Agreement. The archaeological data recovery and monitoring investigations were conducted in the Cleanup Action's Area of Potential Effect (APE) in accordance with Stipulations III and V of the Memorandum of Agreement (MOA) for the cleanup of the Elizabeth Mine, signed and dated March 2010.

The EPA NTCRA Cleanup Action activities were determined to result in irreversible impacts to the Copperas Factories Subsite (Upper and Lower Copperas Factories, Inter-Copperas Factory area) within TP 3 within the Elizabeth Mine Site. The archaeological data recovery and construction monitoring were conducted for these portions of TP 3 to mitigate the adverse effects of the cleanup impacts to these site elements. The data recovery plan was developed in conjunction with the cleanup design to minimize the adverse effects of the remediation on the significant Copperas Factories Subsite. Cleanup activities necessitated additional data recovery investigations in 2009 and 2010 in the area of the North Berm and Copperas Brook within the Copperas Factories Subsite, and the Pine Grove area situated both within and in proximity to the Subsite. The research design/questions for the original data recovery program and additional work areas expanded on the themes presented in the 2003 PAL technical report, *Historic/Archaeological Mapping and Testing, Elizabeth Mine Site, Stratford and Thetford, Vermont*. The research questions included the general process of copperas manufacture, particularly within the factories where the boiling, cooling, crystallizing and packing took place. The data recovery methodology was designed to address the research questions. The methodology consisted of field investigations, additional documentary research, and laboratory processing and analysis of recovered data.

The 2009 and 2010 data recovery and construction (mine waste removal) monitoring at the Elizabeth Mine copperas factories uncovered extensive, and in some cases, unanticipated industrial archaeological features associated with copperas manufacturing. The 2009 field season work at the visible foundation at the Upper Factory uncovered tiered remains of copperas boiling, cooling and crystallizing process structures and vessels. The 2009 field season work at the visible foundation at the Lower Factory uncovered an unusually intact assemblage of workspace features and artifacts, as well as the remains of copperas processing equipment both comparable to and different from that found at the Upper Factory. Work in 2009 in the North Berm and South Berm areas and the 2010 work in the Copperas Brook Corridor revealed additional copperas processing features and factory structural remains, and revealed that the Upper Factory site as originally understood was more complex and much larger than anticipated and may have contained the remains of more than one of the reported factories at that location. Subsequent mine waste removal monitoring in several of these areas revealed additional information that contributed to the understanding of the site.

The 2009 and 2010 archaeological data recovery campaigns provided sufficient data to address the research questions for the Copperas Factories Subsite posed in the 2003 PAL survey report and data recovery research design. The data recovery investigations contributed to the understanding of the copperas manufacturing process and plant construction and layout at the Elizabeth Mine site. The excavations confirmed and documented locations, relationships and construction of vessel structures associated with the successive steps of copperas production. In the case of the Upper Factory the data recovered corresponded elegantly with the tiered boiler-cooler-crystallizer sequence on the landscape as described in the historical record. The different layout of the Lower Factory indicated an alternate

arrangement of the manufacturing process, and the artifacts indicated an additional multi-use workshop function. The presence of additional boiler features in the North Berm and South Berm suggested the remains of another factory or factories, or steps in copperas manufacturing undocumented in the written historical record.

The data recovery investigations were also successful in documenting deep and/or expansive heavy masonry and timber substructures and brick and stone construction of copperas boilers, coolers and crystallizers that add to the understanding of nineteenth-century rural industrial site construction methods. The excavations demonstrated the site's three-dimensional, spatial and structural complexity and four-dimensional (temporal) complexity in remains that appear to reflect different factories operating in successive phases or in ways not described in historical record. The site analysis demonstrated the importance of the use of archival research materials and careful examination and creative use of the written historical record, which is not always accurate, for site interpretation. The site analysis also underscored the importance of consulting knowledgeable experts in the areas of applicable disciplines including mining engineering, chemistry, economic and structural geology, and even maple sugar pan construction and operation to inform an accurate understanding of industrial and natural processes and constraints affecting the manufacturing and post-manufacturing behavior of and impacts to the site and associated materials.

The 2009 and 2010 data recovery investigations also suggested that interpretation of archaeological data at similar types of industrial sites may be complicated by the action of mining and post-mining period natural and human-aggravated phenomena including steep topography, wet soils, waste material disturbance/movement/re-deposition, erosion, unusual rock and soil chemistry, rock alteration, and timber preservation and decay. The appearance and behavior of these phenomena can challenge the traditional understanding of soil stratigraphy, artifact and structure preservation, etc. The universal physics of natural processes obviously apply everywhere, but topographic or chemical anomalies can accelerate those processes, and mining activity disturbance can violate the basic principle of stratigraphic superposition. What applies in an undisturbed, or residential, or agricultural, etc. setting may not always apply in an industrial or mining setting.

Despite the extensive data recovery efforts in 2009 and 2010, the surviving unexcavated portions of the copperas factories still have the potential to provide information about copperas manufacturing at the Elizabeth Mine. EPA cleanup design elements for the copperas factories and small parts of TP 3 were changed during archaeological data recovery to balance the removal of mine waste with protection of significant archaeological resources. The South Berm, where a copperas liquor boiler was discovered, was set aside for preservation in exchange for the data recovery and monitoring of removal of the boiler feature at the adjacent North Berm in consultation and agreement with the VT State Archaeologist. At the Upper Factory and Lower Factory, instead of removing the mine waste after the data recovery, the archaeological sites were retained, including all structural remains, and covered with a geotextile fabric marker layer and capped with distinctive round tan granite river cobbles, the boundary of which corresponds with the larger, lead-contaminated soil area and contrasts with the gray, irregular crushed rock of the sedimentation basin lining. The capped sites also include the reburied objects (in situ and out of place) discussed in the report narrative and illustrated in Appendix B.2 of this report. The capping and marking method delineates the extent of cleanup archaeological investigations, protects the factory archaeological sites from looting, and preserves them for potential additional future archaeological investigations.

All project information (i.e., excavation records, maps, photographs, artifacts removed from the site) is currently on file at PAL, 26 Main Street, Pawtucket, Rhode Island, until such time as the USACE and/or EPA designates a permanent repository in accordance with the State of Vermont laws and the private

landowners. Appendix A contains the comprehensive inventory of all artifacts removed from the site during the 2009 and 2010 data recovery excavations, including the objects illustrated in Appendix B.1.

Should ongoing mine water or other environmental testing lead to a decision that the copperas factories or the South Berm are continuing to contribute to water quality issues, additional data recovery would add to the information collected during the 2009 and 2010 seasons. Data recovery within the unexcavated portions of the Upper Factory has the potential to reveal additional copperas manufacturing vessels, and most significantly, to expose the remaining underlying timbers and bedrock, potentially confirming interpretation of the sloping timber structure explored and documented in 2009 and 2010. Data recovery at the South Berm would confirm the function of the boiler feature located there; the apparent integrity of that feature suggests that careful bisection would add significantly to the understanding of its construction and operation. PAL does not recommend any additional data recovery at the Lower Factory; the 2009 data recovery uncovered the majority of the factory working floor and subsequent removal of mine waste at the north foot of the factory wall precludes work in that area. PAL's conclusion that the Inter-Copperas Area was associated with temporary copperas storage suggests that additional work in that area would not make a major contribution to the understanding of the manufacturing process and would not benefit from additional data recovery.

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CHAPTER ONE

INTRODUCTION

This technical report presents the results of the archaeological data recovery program and archaeological monitoring efforts at the Elizabeth Mine Site (VT-OR-28) in South Strafford, Orange County, Vermont (Figure 1-1). These investigations were conducted in support of the Non-Time-Critical Removal Action (NTCRA) at Tailings Pile 3 (TP 3) at the Elizabeth Mine being performed by the United States Army Corps of Engineers-New England District (USACE) for Region 1 of the Environmental Protection Agency (EPA) through Interagency Agreement. The archaeological data recovery and monitoring investigations were conducted in the Cleanup Action's Area of Potential Effect (APE) in accordance with Stipulations III and V of the Memorandum of Agreement (MOA) for the cleanup of the Elizabeth Mine, signed and dated March 2010. PAL conducted the archaeological investigations as a subconsultant under a Master Services Agreement with Woods Hole Group (WHG) for their Environmental Planning and Consulting Services for the United States Army Corp of Engineers-New England District (USACE), and as a subconsultant under a separate environmental contract with Weston Solutions, Inc. for the USACE (Table 1-1).

Table 1-1. Archaeological Investigations Conducted for the Elizabeth Mine Cleanup From 2009-2010 in accordance with the Final Memorandum of Agreement, signed and dated March 2010.

Archaeological Investigation	Responsible Party – PAL Work Order	MOA – Stipulation	When Conducted
Existing Conditions Field Documentation	Army Corps of Engineers W912WJ-08-R-0002 (WHG)	V. (A) NTCRA and other Cleanup Action Activities – Pre-Construction Landscape Assessment	May 2009
Data Recovery Program – Upper and Lower Copperas Factories	Army Corps of Engineers W912WJ-08-R-0002 (WHG)	III. (A) Copperas Factories Data Recovery	June – August 2009
Data Recovery Program – North Berm Area	Army Corps of Engineers W912WJ-08-R-0002 (WHG)	III. (A) Copperas Factories Data Recovery	July 2009
Data Recovery Program – Copperas Brook Area	Weston Solutions Inc. for Army Corps/EPA	III. (A) Copperas Factories Data Recovery	June – August 2010
Data Recovery Program – Pine Grove Area	Weston Solutions Inc. for Army Corps/EPA	III. (A) Copperas Factories Data Recovery	June – August 2010
Monitoring – TP 3 Cleanup	Weston Solutions Inc. for Army Corps/EPA	V. (B) Construction Monitoring	December 2009 – May 2010

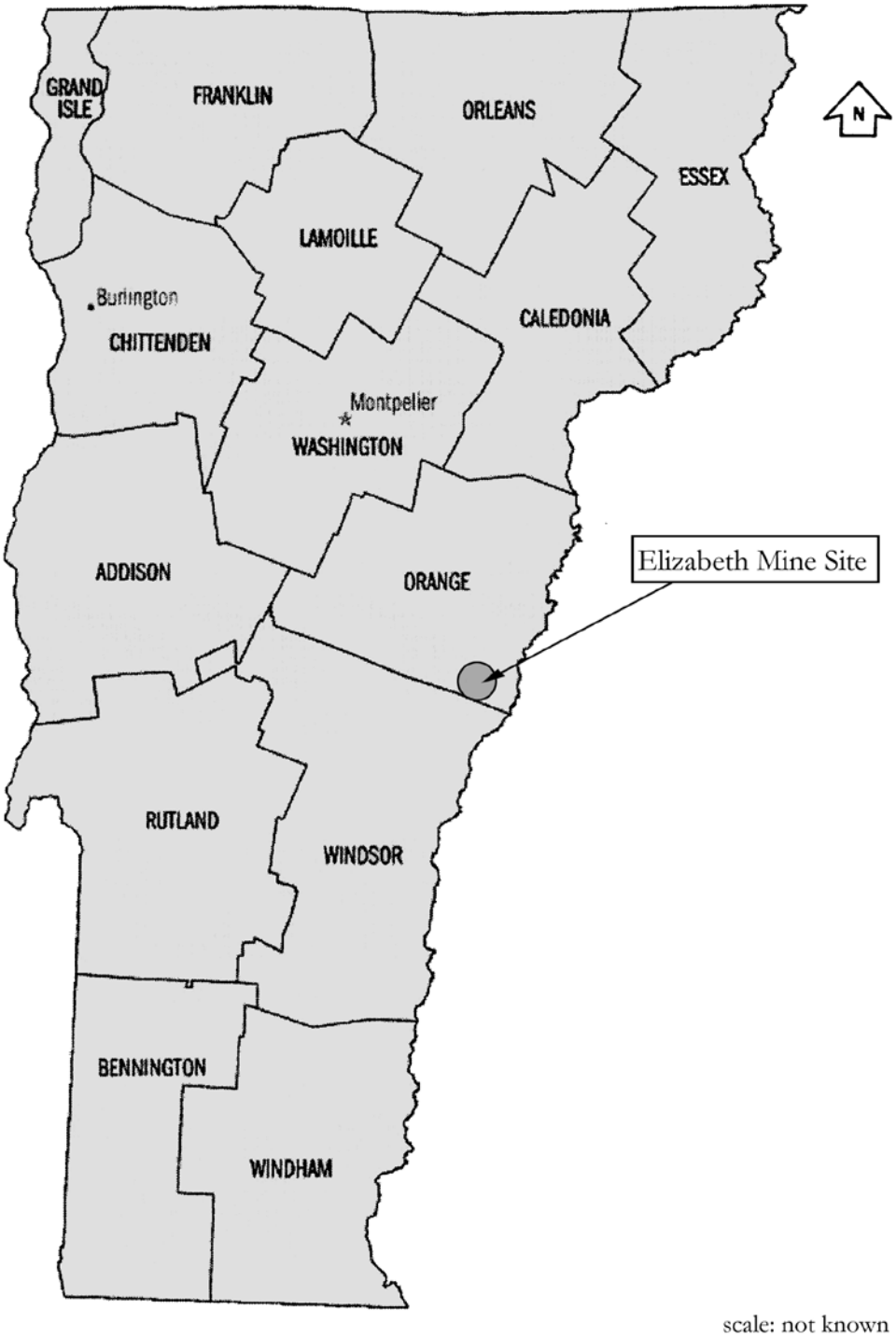

Figure 1-1. Map of Vermont with the location of the Elizabeth Mine Site in Orange County.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Project Scope

The EPA NTCRA Cleanup Action activities were determined to result in irreversible impacts to the Copperas Factories Subsite (Upper and Lower Copperas Factories, Inter-Copperas Factory area) within TP 3 within the Elizabeth Mine Site. The cleanup activities at TP 3 included the remediation of the health risk associated with the high lead content at the Upper and Lower Copperas Factories. The archaeological data recovery and construction monitoring were conducted for these portions of TP 3 to mitigate the adverse effects of the cleanup impacts to these site elements. The data recovery plan was developed in conjunction with the cleanup design to minimize the adverse effects of the remediation on the significant Copperas Factories Subsite. Cleanup activities necessitated additional data recovery investigations in 2009 and 2010 in the area of the North Berm and Copperas Brook within the Copperas Factories Subsite, and the Pine Grove area situated both within and in proximity to the Subsite.

The research design/questions for the original data recovery program and additional work areas expanded on the themes presented in the 2003 PAL technical report, *Historic/Archaeological Mapping and Testing, Elizabeth Mine Site, Stratford and Thetford, Vermont*. The research questions included the general process of copperas manufacture, particularly within the factories where the boiling, cooling, crystallizing and packing took place. The proposed data recovery methodology was designed to address the research questions. The methodology consisted of field investigations, additional documentary research, and laboratory processing and analysis of recovered data.

Project Authority

The archaeological data recovery program and construction monitoring in the Cleanup Action's APE were conducted in accordance with the Project's MOA and to assist the USACE and EPA in their compliance with Section 106 of the National Historic Preservation Act, which requires federal agencies to take historic properties into account prior to any federal undertaking. All tasks associated with the archaeological investigations were also undertaken in accordance with the standards outlined in the Secretary of the Interior's *Standards and Guidelines for Archaeology and Historic Preservation* (48 FR 44716, 1983).

Site Description

The Elizabeth Mine Site (VT-OR-28) encompasses approximately 800 acres of land within the Ompompanoosuc River drainage, a major tributary of the Connecticut River. The majority of the mine site is located in South Strafford in the southern part of the town of Strafford, with an eastern portion in Thetford and small portions at its southern extremity in Sharon and Norwich, which are located in Windsor County (Figure 1-2). The site is focused on the core area of historic mining activity, although the total land area historically associated with the mine reached 8,000 acres where the mining company(s) had mining rights. The Elizabeth Mine is a designated National Priorities List (Superfund) site, and as such, the Environmental Protection Agency (EPA) is coordinating the hazardous material cleanup of the site to protect human health and the environment. Tailings Pile 3 or simply "TP 3" is a name arbitrarily assigned by EPA to identify the area of historic mining activity and mine waste extending from the North Open Cut at the west to the Mine Road vicinity to the east (Figure 1-3). This area includes, but is not limited to, the open, barren hillside formerly containing exposed, un-vegetated mine waste. TP 3, where the copperas mining and manufacturing process was located, is one of the major cultural and technological landscapes included within the boundaries of the Elizabeth Mine Site.

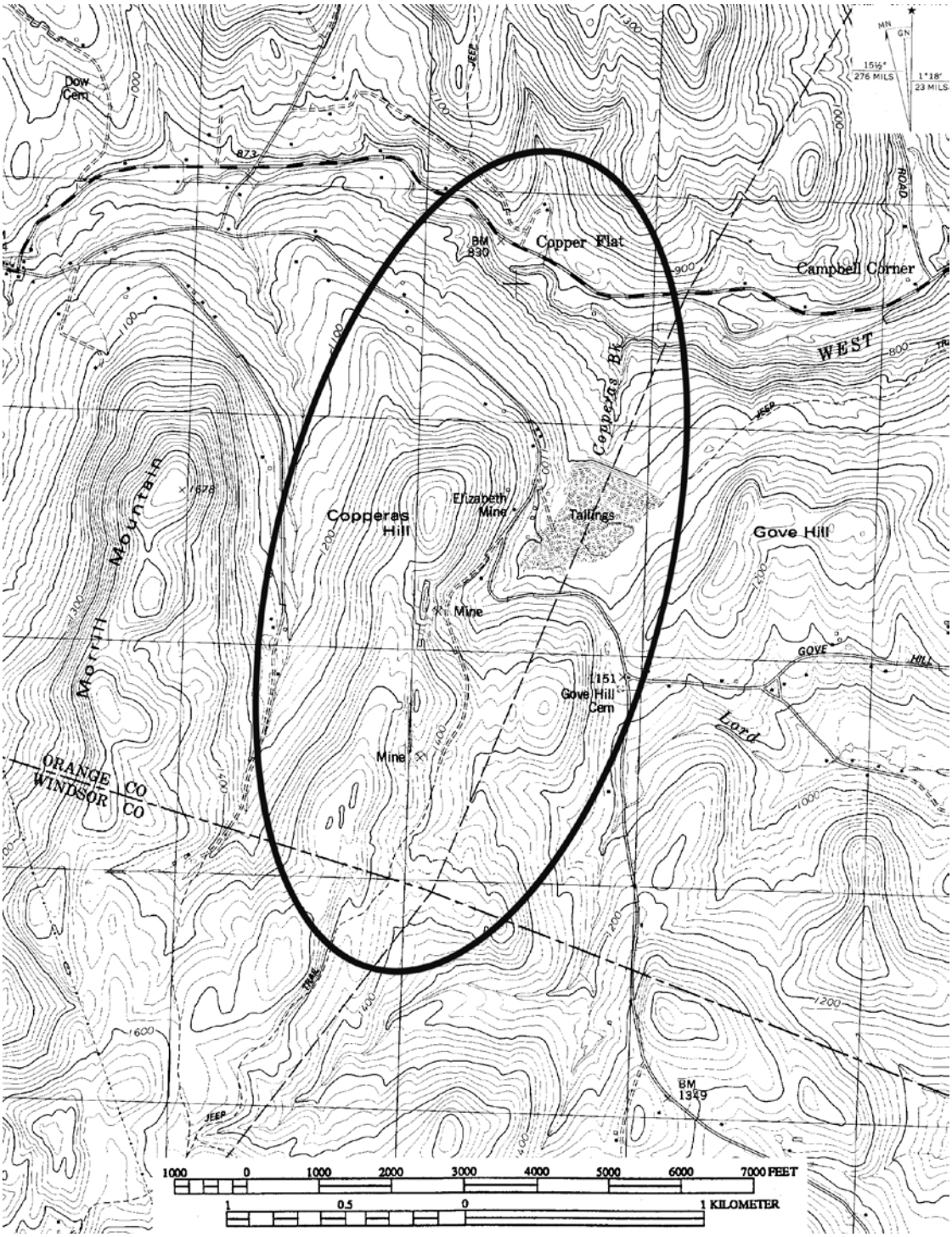

Figure 1-2. Location of the Elizabeth Mine Site on the USGS South Strafford, Vermont topographic quadrangle, 7.5 minute series.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

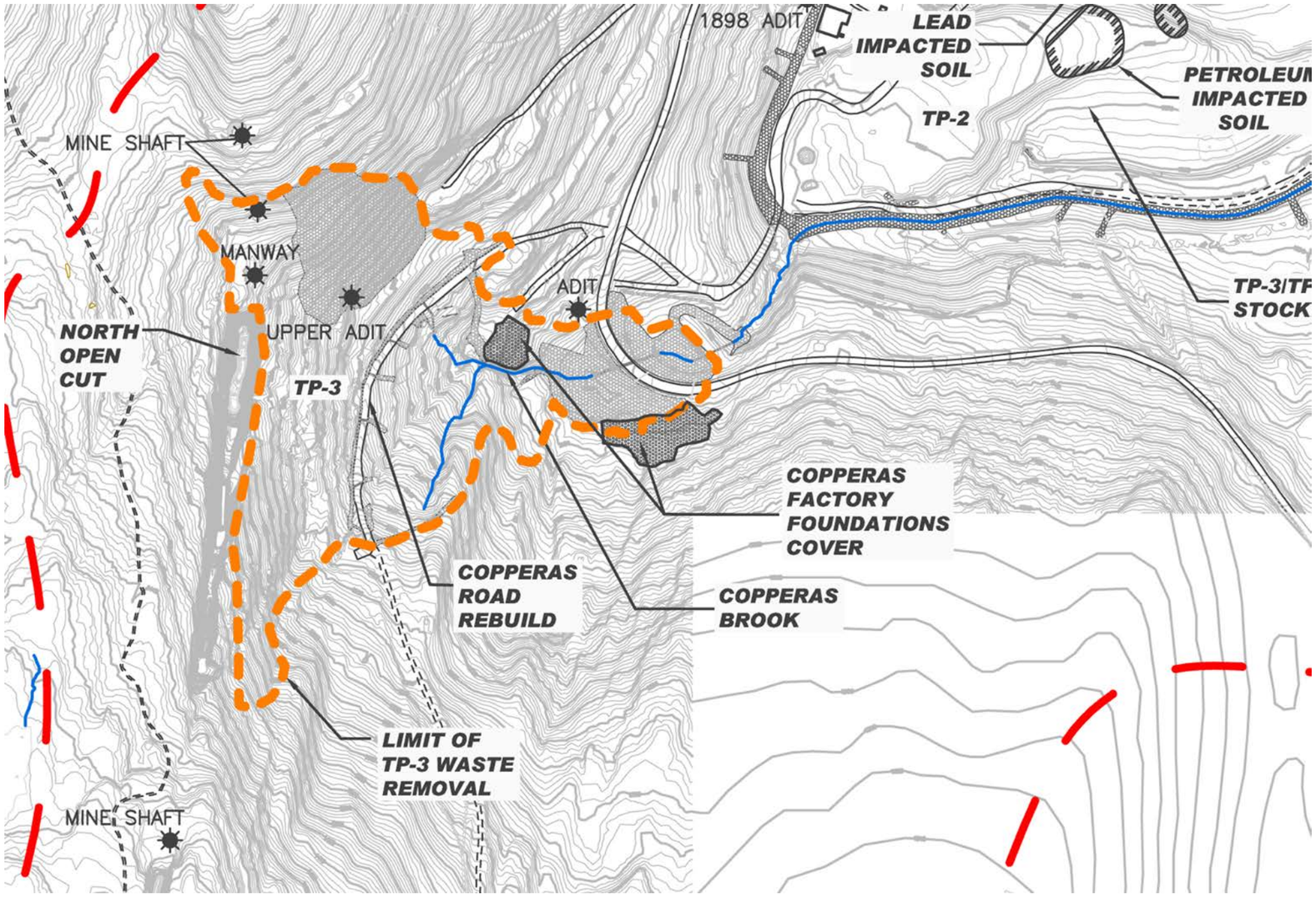

Figure 1-3. Outline of Tailings Pile 3 (TP 3) cleanup area as delineated by EPA (source: URS March 2011).

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Prior to the current investigations, the site had been studied as part of the EPA's compliance with Section 106 of the National Historic Preservation Act and its implementing regulations, 36 CFR Part 800. The initial cultural resources study, titled *Statement of Limits, National Register Eligibility, and Potential Resources in the Proposed APE, Elizabeth Mine, South Strafford, Vermont*, was prepared by Hartgen Archaeological Associates, Inc. (Hartgen 2000). The supplemental report, titled *Historical Context and Preliminary Resource Evaluation, Elizabeth Mine Site, South Strafford, Orange County, Vermont* (PAL 2001), and an addendum report, titled *Addendum to Historical Context and Preliminary Resource Evaluation of the Elizabeth Mine, South Strafford, Orange County, Vermont* (PAL 2001), were both prepared by PAL under contract with Arthur D. Little, Inc. on behalf of the EPA. In 2002 PAL was contracted by the USACE to conduct *Historic/Archaeological Mapping and Testing, Elizabeth Mine Site, Stratford and Thetford, Vermont* (Cherau et al. 2003) to locate, identify, photograph, map, and in some cases draw visible structural, artifactual, and landscape features associated with the Elizabeth Mine Site. The project fieldwork was conducted in 2002; the report was submitted in 2003. Limited subsurface testing was also conducted to locate and identify prehistoric and historic period resources within the preliminary Area of Direct Potential Effect (APE). The 2002 Project APE encompassed an estimated 170 acres characterized by Tailing and Mine Waste Piles (TPs) 1, 2 and 3 and surrounding lands.

As a result of the 2002 historic/archaeological mapping and testing, the Copperas Factories Subsite at the eastern side of TP 3 was identified. The 2002 investigations determined that the copperas factories subsite had a high potential to yield archaeological data that could be used to address important research questions related to understanding the historical copperas manufacturing process that took place within and adjacent to the factories. The structural and artifactual remains identified in the copperas factories area were assessed as having excellent physical integrity.

The Upper Copperas Factory and its associated Copperas Brook features are located at the east side of TP 3, at the bottom of the hillside. The masonry foundation remains of the Upper Copperas Factory itself are located just north of Copperas Brook. The stone walls and terraces of the Upper Copperas Factory run north into the Office area (part of the North Village subsite). The eroded Copperas Brook channel contained inclined timber and plank structural remains and eroded masonry brick features. The Lower Copperas Factory is located just south of the bend in Mine Road and consists of a large L-shaped stone foundation and associated features. Similar to the Upper Copperas Factory, the Lower Factory foundation is built into the hillside. The Inter-Copperas factory area is located west of the Lower Copperas Factory foundation. This area was identified in 2002 as containing discrete stacked masonry features, possibly foundations, and a cluster of six mounds and rectangular earth berms.

The North Berm, Copperas Brook corridor and Pine Grove area were not specifically identified in the PAL 2003 report as components of the Copperas Factories subsite. The data recovery test trenching and/or removal monitoring work conducted concurrently with the 2009 data recovery investigations identified previously unknown cultural features in these areas, which then necessitated additional data recovery investigations in 2010. The North Berm was identified as a linear earth mound located at the foot of Copperas Hill, west of Mine Road, immediately east of the Upper Copperas Factory remains and north of Copperas Brook. The Pine Grove area was located west of the Upper Copperas Factory remains and was one of the few areas on TP 3 containing mature tree vegetation. The Copperas Brook corridor was located between the Upper Factory and Inter-Copperas factory areas.

The archaeological monitoring work was conducted in the areas listed above as well as in the area of the sedimentation basin straddling Mine Road, portions of the barren hillside where copperas manufacturing-related related ore roasting and heap leaching took place, and at the documented (but unidentified in 2003) Tyson No. 1 Shaft and Upper (1831) Adit/Cob Shop/Blacksmith Shop areas within TP 3.

Project Personnel

The data recovery investigations and construction monitoring were conducted from May 2009 to August 2010 (see Table 1-1). PAL personnel involved in the project include Suzanne Cherau (project manager/principal investigator), Matthew Kierstead (senior industrial historian), Erin Timms (project/industrial archaeologist), and Kristen Jeremiah, Michael Hubbard, Carrie Zwang, Tyler Beebe, Sean Luttge, and Amelia Bidwell (archaeologists). Erin Kuns (laboratory supervisor) oversaw the processing and cataloging of the recovered cultural material.

Disposition of Project Materials

All project information (i.e., excavation records, maps, photographs, artifacts removed from the site) is currently on file at PAL, 26 Main Street, Pawtucket, Rhode Island, until such time as the USACE and/or EPA designates a permanent repository in accordance with the State of Vermont laws and the private landowners. Appendix A contains the comprehensive inventory of all artifacts removed from the site during the 2009 and 2010 data recovery excavations, including the objects illustrated in Appendix B.1.

CHAPTER TWO

METHODOLOGY

Goals and Objectives

Data Recovery Program

By definition, a data recovery program "is the systematic removal of the scientific, prehistoric, historic and/or archaeological data that provide a historic property with its research or data value" (36CFR Part 66). A data recovery program impacts a site, often as completely as a construction project. Through the data recovery process, however, artifacts are recovered and significant data are recorded for analysis and dissemination.

The goal of the data recovery program was to acquire sufficient information to mitigate the construction project (mine waste removal) impacts on the archaeological remains of the Elizabeth Mine Copperas Factories Subsite and related areas on TP 3 within the Cleanup Action's Area of Potential Effect (APE). The intention of the data recovery was not to fully excavate the site, but to focus investigations at locations that were predetermined by a sound research design. By explicitly stating the problems and hypotheses to be answered by the excavation it was possible to establish an efficient sampling methodology and to locate proposed testing before beginning the fieldwork.

Construction Monitoring

The 2009 data recovery test trench program and other cleanup activities at TP 3 indicated that significant data relating to the copperas factories could be recovered as a result of direct observation (monitoring) during the 2009 and 2010 construction activities. PAL provided archaeological monitoring of these activities, at times conducted concurrently with the data recovery excavations, within and surrounding the Copperas Factories Subsite portion of TP 3. The monitoring revealed features and artifacts relevant to copperas manufacturing that were considered as part of the interpretation of the data recovery results.

Evaluating Significance and Historic Contexts

The different phases of archaeological investigation (survey, evaluation, and data recovery) reflect preservation planning standards for the identification, evaluation, registration, and treatment of archaeological resources (National Park Service 1983). An essential component of this planning structure is the identification of archaeological properties that are eligible for inclusion in the National Register, the official federal list of properties that have been studied and found worthy of preservation. Archaeological properties can be a district, site, building, structure, or object, but are most often sites and districts (Little et al. 2000). The results of professional surveys and consultation with Native American or other ethnic communities are used to make recommendations about the significance and eligibility of archaeological properties.

An archaeological property may be pre-contact, post-contact, or contain components from both periods. Pre-contact (or what is often termed "prehistoric") archaeology focuses on the remains of indigenous American societies as they existed before substantial contact with Europeans and resulting written records (Little et al. 2000). In accordance with the NPS guidelines, the term "pre-contact" instead of

"prehistoric" is used unless directly quoting materials that use the term "prehistoric." The date of contact varies across the country and in the New England region. There is no single year that marks the transition from pre-contact to post-contact.

Post-contact (or what is often termed "historical") archaeology is the archaeology of sites and structures dating from time periods since significant contact between Native Americans and Europeans. Documentary records as well as oral traditions can be used to better understand these properties and their inhabitants (Little et al. 2000). Again, for reasons of consistency with the NPS guidelines, the term "post-contact" instead of "historical" is used when referring to archaeology unless directly quoting materials that use the term "historical."

The National Park Service (NPS) has established four criteria for listing significant properties in the National Register (36 CFR 60). The criteria are broadly defined to include the wide range of properties that are significant in American history, architecture, archaeology, engineering, and culture. The quality of significance may be present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association. The criteria allow for the listing of properties:

A. that are associated with events that have made a significant contribution to the broad patterns of our history; or
B. that are associated with the lives of persons significant in our past; or
C. that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
D. that have yielded, or may be likely to yield, information important to prehistory or history.

Archaeological properties can be determined eligible for listing in the National Register under all four criteria (Little et al. 2000; Parker and King 1998). Significance under any of these criteria is determined by the kind of data contained in the property, the relative importance of research topics that could be addressed by the data, whether these data are unique or redundant, and the current state of knowledge relating to the research topic(s). A defensible argument must establish that a property "has important legitimate associations and/or information value based upon existing knowledge and interpretations that have been made, evaluated, and accepted" (McManamon 1990:15).

The criteria are applied in relation to the historic contexts of the resources. A historic context is defined as follows:

> A historic context is a body of thematically, geographically, and temporally linked information. For an archaeological property, the historic context is the analytical framework within which the property's importance can be understood and to which an archaeological study is likely to contribute important information (Little et al. 2000).

The formulation of historic contexts is a logical first step in the design of an archaeological investigation and is crucial to the evaluation of archaeological properties in the absence of a comprehensive survey of a region (National Park Service 1983:9). Historic contexts provide an organizational framework that group information about related historic properties based on a theme, geographic limits, and chronological periods. A historic context should identify gaps in data and knowledge to help determine what significant information may be obtained from the resource. Each historic context is related to the developmental history of an area, region, or theme (e.g., agriculture, transportation, waterpower), and identifies the significant patterns of which a particular resource may be an element. Only those contexts important to understanding and justifying the significance of the property must be discussed.

Historic contexts are developed by:

- identifying the concept, time period, and geographic limits for the context;
- collecting and assessing existing information within these limits;
- identifying locational patterns and current conditions of the associated property types;
- synthesizing the information in a written narrative; and
- identifying information needs.

"Property types" are groupings of individual sites or properties based on common physical and associative characteristics. They serve to link the concepts presented in the historic contexts with properties illustrating those ideas (NPS 1983; 48 FR 44719).

The following historic research contexts have been developed to organize the data relating to the Elizabeth Mine Copperas Factories subsite identified within the Project APE:

1. Historic land use and settlement patterns of South Strafford, ca. 1650 to the present.

2. The mining history of the Elizabeth Mine Site, ca. 1809-1958.

3. Copperas production on site, ca. 1809-1882.

Site Description/Survey Work Prior to 2009

The following narrative description was extracted from the Historic/Archaeological Mapping and Testing Final Report, Elizabeth Mine Site (Cherau et al. 2003). Figure 2-1 depicts the visible structural remains and subsurface testing recorded within the Copperas Factories subsite area during the 2002 field investigations. Figure 2-2 (back pocket) shows the visible structural remains recorded within the larger TP 3 landscape during the 2002 field investigations. Figure 2-3 is an aerial photograph showing TP 3 and the copperas factory locations.

Upper Copperas Factory

The Upper Copperas Factory and its associated Copperas Brook features were located at the bottom of the hillside, at the eastern extreme side of TP 3. The 2002 PAL survey identified substantial timber construction in the area where Copperas Brook forms, later designated as the Copperas Brook Corridor. The area contained a 30 ft x 3.5 ft (9.14 m x 1 m) in diameter timber with shorter timbers and sections of plank abutting it, and additional upright timbers protruding from between them (Figure 2-4). Twenty feet northeast a second large timber 10 ft (3 m) in length with attached vertical planks extended north at an oblique angle from the first timber. The second large timber associated with this feature was covered by a temporary haul road in 2009. It was unclear from the 2002 survey investigations if these timbers were part of a copperas liquor conveyance or storage system, or part of a structure foundation. A system of in-situ crossed timbers supporting a plank deck was located in the Copperas Brook streambed (Figure 2-5). In some areas the structure had been in filled with a natural occurring ferricrete. In some areas the structure appeared to be built on an incline and in other areas it appeared to be built in level platforms. Sections of the structure had been partially exposed or damaged by water flow and erosion. The level of exposed wood preservation in the streambed was impressive with some timbers retaining adze marks and mortises. The brook fell in two distinct engineered levels in the east part of the subsite.

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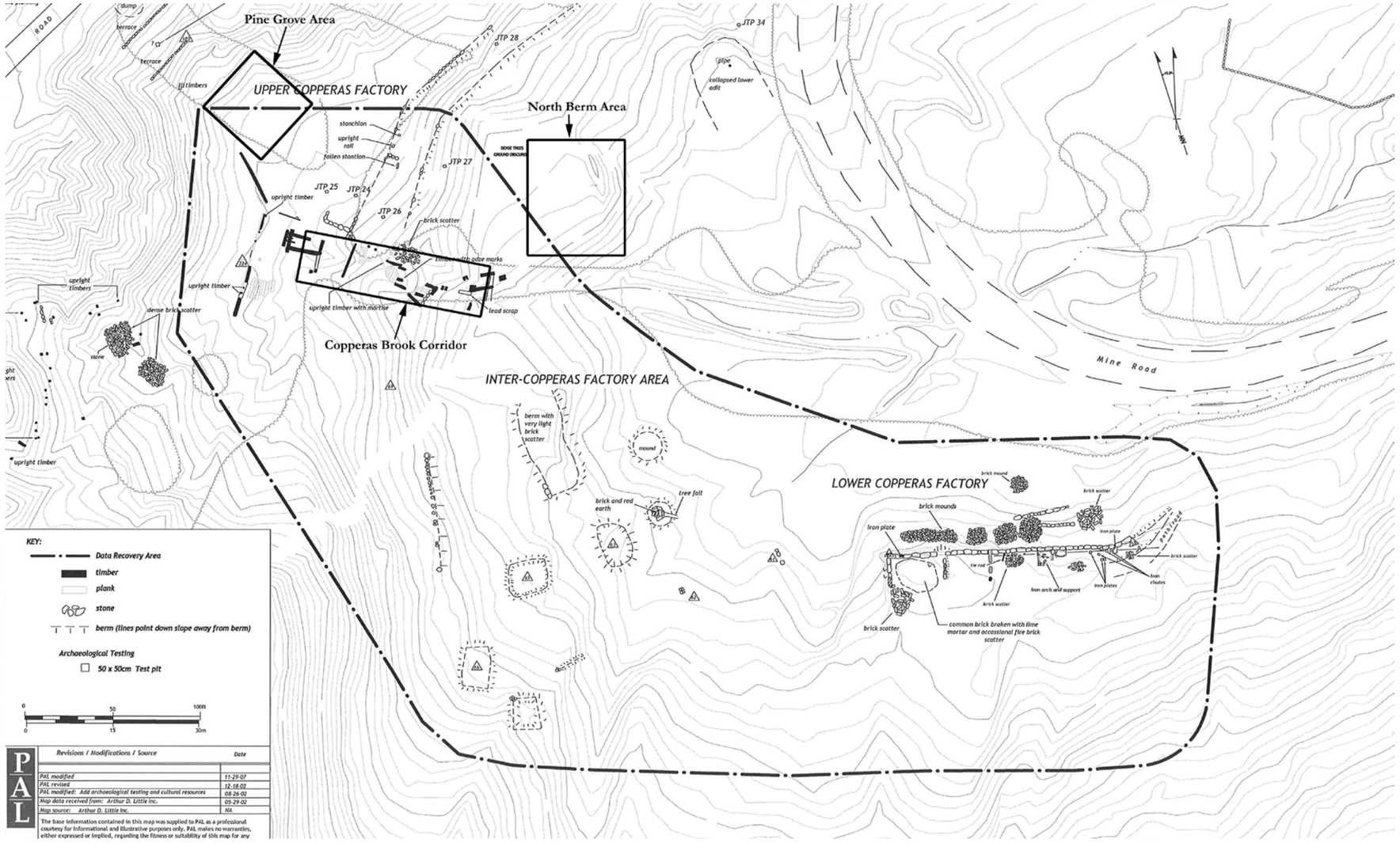

Figure 2-1. Locations of the Upper and Lower Copperas Factories, Inter-Copperas Factory Area, North Berm Area, Pine Grove Area, and Copperas Brook Corridor within TP 3 at the Elizabeth Mine Site, subjected to data recovery investigations in 2009 and 2010.

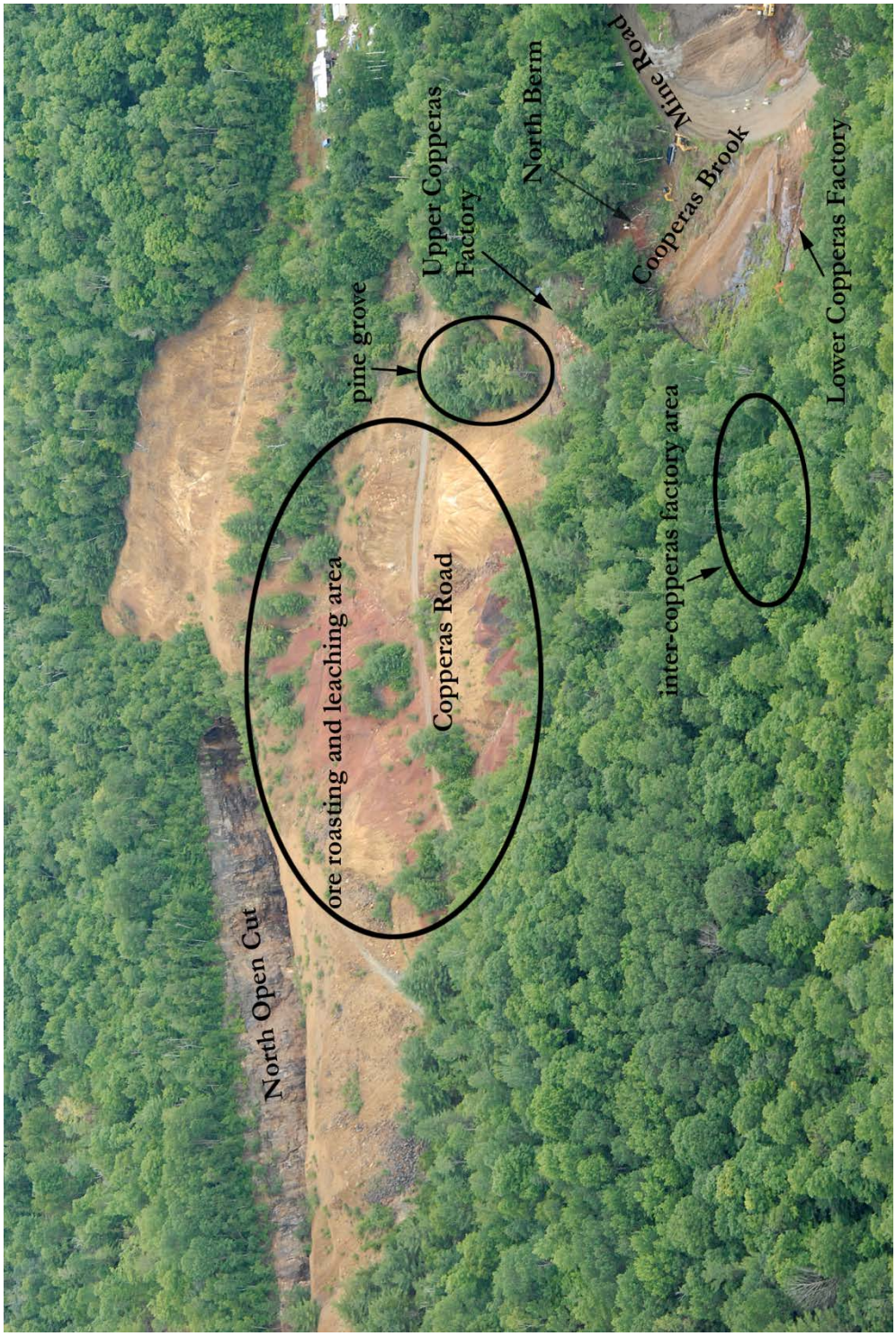

Figure 2-3. Aerial Photograph showing TP 3 and the locations of the copperas factories in relation to roadways, Copperas Brook, and historic mining areas prior to data recovery.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 2-4. Photograph of timber and plank structure above Upper Copperas factory, with roast beds in background, looking southwest prior to data recovery.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 2-5. Photograph of timber and plank deck structure in Copperas Brook bed, looking west prior to data recovery.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

The west drop consisted of a 1.5-m boulder retaining wall supporting timbers and the plank deck. The downstream, 1.8-m high east drop incorporated boulders and several large in situ timbers (Figure 2-6).

Immediately north of the Copperas Brook channel is a stone wall that was thought in 2002 to be the foundation of the Upper Copperas Factory itself (Figure 2-7). The wall, which was preserved and remains intact and partially buried, is a U-shaped split stone structure with a short east-west oriented south wall, and a longer north-south oriented east wall and a less distinct west wall extending to the north. The wall was built into the hillside with the southeast corner rising 2 m above the ground and the southwest corner at approximately ground level. Upright and fallen cast-iron stanchions and railroad rail (not removed from the site; left in situ) were visible 19 m north of the southeast corner of the wall (Figure 2-8). Beyond these corners it was difficult to distinguish the factory foundation from the other retaining walls in the area, as the walls had been washed out in a number of places. The long-east wall bent to the east 29 m from its south end, possibly marking the north end of the factory. The wall then extended for an additional 21 m. A level area with evidence of a retaining wall along its eastern margin ran parallel to the long east wall. This level area was interpreted in 2002 as a possible road bed. A second, less well-defined flat area was noted directly east of the first level area.

The 2002 archaeological survey testing in the Upper Copperas Factory area consisted of five test pits (see Figure 2-1). These test pits were placed west of the L-shaped stone walls, within them, and on both level areas to the east, in addition to one pit on the upper terrace north of the foundation. The majority of these pits were excavated through fill layers that appeared to be the result of human activity and erosion from upslope. A total of 62 cultural materials[1] was recovered from 0 to 70 cmbs in various fill and disturbed subsoil deposits in these test pits. The majority of the material consisted of fire bricks stamped "Boston Firebrick Company," and common bricks (some handmade) which were sampled, and flat glass. JTP-24 contained a plank at 88 centimeters below surface (cmbs), and JTP-27 contained a burned wood plank feature at 60 cmbs. JTP-26 contained materials interpreted at that time as evidence of the demolition of the copperas factory in its upper stratum and a jumble of planks between two layers of finely laminated soils beginning at 58 cmbs. The laminated soils were interpreted at that time as thin layers of sediment possibly deposited by flooding from Copperas Brook. Additionally, JTP- 25 produced one yellow ware ceramic sherd, and JTP-28 yielded a substantial amount of American stoneware and earthenware.

Lower Copperas Factory and Inter-Site Copperas Area

The Lower Copperas Factory is located just south of the bend in Mine Road, 340 ft (104 m) southeast of the Upper Factory and was identified in 2002 as consisting of a large L-shaped stone wall and associated features (Figure 2-9). The wall, which remains standing, measures 140 ft (42.7 m) long on its east-west axis. The wall is constructed of large fieldstones and boulders with occasional tabular quartzite stones incorporated for structural integrity including quoins in the northwest corner of the foundation. Similar to the Upper Copperas Factory, the Lower Factory was built into the hillside with the north edge extending 7.4 ft (3.05 m) above the ground and the south end descending to ground level. The area within the L-shaped walls contained several subareas demarcated by transverse stone walls. A transverse stone wall 37 ft (11.4 m) from the west end of the main west wall defined the edge of a slight platform covered with a scatter of common and fire bricks. Another transverse wall, located 20 ft (6.1 m) east of the first wall, defined a possible second internal partition.

[1] All of these artifacts were removed from the site during the 2002 survey and are temporarily curated at the PAL facility, Pawtucket, RI.

Figure 2-6. Photograph of east drop in Copperas Brook, looking west prior to data recovery

Figure 2-7. Photograph of Upper Copperas factory wall (right), also showing exposed timbers in Copperas Brook, looking west prior to data recovery

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 2-8. Photograph of iron stanchions at Upper Copperas Factory, looking south during 2009 data recovery. ***Note: the iron stanchions were not removed from the site; they were reburied in situ following the data recovery excavations. See Appendix B.2-2 for cross-section of starchion/upright rail identified in data recovery Feature 6 at the Upper Factory.***

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 2-9. Photograph of Lower Copperas Factory, looking south across Mine Road and Copperas Brook prior to data recovery

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

The third section within the main walls occupied the center of the structure. In this space were two standing cast-iron stanchions nearly identical to those found at the Upper Copperas Factory, connected by a 3.4 ft (1.04 m) long iron tie rod, and a scatter of brick.[2] To the east of the center section was a fourth division within the structure, a 6.6-x-13.1 ft (2-x-2.4 m) depression lined with stone on its south and west margins. The depression contained cast iron plates and two, rectangular, funnel-like cast iron objects, interpreted as furnace flues or chambers, with bricks attached to their inner surfaces (Figure 2-10).[2] Both objects exhibited reddening, melting and flaking indicating exposure to high heat. A second 3.28-x-5.25 ft (1-x-1.6 m) depression was located just east of the depression containing the flues. The easternmost section within the walls contained a scatter of rolled wrought-iron plates and additional cast iron chutes or flues with attached brick[2], possibly for heat insulation. No clear east end wall was identified during the 2002 survey. East of the iron artifacts the wall curves gently to the north before ending in a berm that continues at the same arc. This transitional area was interpreted as the end of the factory and start of a possible cart path east of the factory, leading up to or perhaps into it from the direction of the East Village subsite. North of the factory wall, between it and Mine Road were two stone walls. The closer wall was parallel to the wall and 14 ft (4.27 m) away and partially buried by one of several piles of brick in the area north of the Lower Factory. The second wall ran at a slightly acute angle to the foundation at a distance of approximately 20 ft (6.1 m).

The Inter-Copperas factory area was identified to the west of the Lower Copperas Factory wall in 2002 (see Figure 2-3). Two discrete masonry structures were identified at eight and 30-m west of the factory. It was unclear at that time if they were the remains of structural foundations. Also identified in 2002 were a cluster of six mounds and square berms north and west of the stone features, three with depressions in their centers. Some of these mounds were more clearly defined than others, but an arrangement or pattern to their configuration could not be discerned at that time. They were interpreted as likely cultural features and not natural aberrations on the landscape. It was unclear at that time if they were associated with the copperas process or some other industrial activity. No test pits were excavated at the Lower Copperas Factory in 2002, but a tree fall in the immediate vicinity unearthed quantities of brick and fire-reddened earth.

Research Design

The data recovery research design/questions expanded on the themes presented in the 2003 PAL final report including the general process of copperas manufacture, particularly within the factories where the boiling, cooling, crystallizing and packing took place. The 2003 report subsite area descriptions along with the research themes and specific questions to be addressed for each subsite area during the data recovery are discussed in detail below.

Upper and Lower Copperas Factories

The boundaries of the TP 3 area at the Elizabeth Mine encompass the entire working area historically used for copperas production. These include sites of outdoor activity including ore mining, roasting, heap leaching and copperas liquor transportation, evaporation and collection. The area also includes the sites of the factories housing the indoor steps of the process including boiling, cooling, crystallizing the copperas-bearing liquor and packing the dried crystals. Historical accounts explain the general process of copperas manufacture, and describe the relative spatial arrangement of the steps in the historic operations, a cascading process that took great advantage of gravity for materials handling. The production process involved outdoor features including an open cut mine, ore roasting piles, heap leaching pads, gravity

[2] None of these artifacts were removed from the site during any of the PAL field investigations; they were reburied near their original locations during the site remediation/capping activities.

Figure 2-10. Photograph of large iron chutes or flues in Lower Copperas Factory prior to data recovery. ***Note: These artifacts were not removed from the site; they were reburied near their original locations during the remediation/capping activities.***

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conveyance features, evaporator towers, and holding cisterns for collecting the copperas liquor. Within the factory buildings the process utilized boilers and other rectangular lead and mortar-lined wood and masonry tanks for the successive steps for concentrating, cooling and crystallizing the copperas liquor. The descriptions of the works found in narrative travelers' accounts and scientific literature written between the 1820s and 1870s offer consistent descriptions of the simple manufacturing process and indicate incremental improvements in efficiency made over time. Most of the improvements took advantage of natural processes including oxidation and evaporation to increase production and conserve fuel. Ore roasting, a largely self-sustaining combustion, was added to enhance the effectiveness and output of the subsequent heap leaching step. Evaporator towers were introduced that slightly raised the concentration of the copperas liquor naturally before its excess combined water had to be boiled off using wood fuel. Spent copperas crystallizing liquor was recycled and reboiled. Minor improvements to the crystallization equipment were also made.

Information about the steps in the Elizabeth Mine copperas manufacturing process and how it evolved between 1809 and 1882 appears in the historical literature, however, no maps, drawings or particularly informative photographs of the site, process, equipment, or buildings has been located to date. Cartographic and photographic documentation is limited to one schematic map from 1874 and two indistinct exterior photographs taken after the works closed. The historic descriptions include some details of the process vessels, but there are no descriptions of their locations or relative relationships. There is no information regarding which of the factories was built first, what the relationship between them was, or whether they were independent or interdependent operations.

Historical/archaeological survey, mapping, and recordation of the Copperas Factories Subsite by PAL in 2002 and the archaeological monitoring of adjacent areas on TP 3 in 2006 identified an array of landscape features, structural remains and artifacts across the TP 3 hillside that appeared to correspond with the various copperas manufacturing steps noted in the nineteenth-century process descriptions. Prior to the data recovery investigations, the copperas factory foundations were identified to contain in-situ and displaced cast- and wrought-iron stanchions and railroad rails. These artifacts were interpreted as possibly having supported copperas liquor vessels. The vessels are described in historic literature as heavy, lead-lined structures. Also prior to the data recovery investigations, the Lower Copperas factory foundation was identified to contain heavy fragments of cast-iron plate; rectangular, brick-lined, funnel-like iron castings, and piles of common and fire brick. These artifacts were interpreted as being part of the furnaces or flue systems associated with boiling and concentrating the copperas liquor. The areas within both factory foundations were assessed as having the potential to contain additional artifacts as well as specific interior construction and engineering features associated with the copperas processing steps. Archaeological investigation in these areas was expected to yield information about building construction and equipment configuration associated with the final stages of early copperas manufacturing not found in documentary sources.

Site-specific research questions for both of the factories were as follows:

- Are the "foundation" walls actually outer foundation walls of the factories, or interior walls dividing production and/or packing levels, or retaining walls located outside the factory for access roads?

- Did the copperas factories have engineered floors or substructures to support the heavy pans and boilers?

- If engineered floors or substructures were found and mapped, what would they reveal about the arrangement and flow of the copperas manufacturing steps, boiling and concentrating pans, associated heating furnaces and flues, and packing floors within the copperas factories?

- Are there any differences between the interior features and their relationships within the two copperas factories? If so, what do they reveal about differences in function, process, and evolution of the two factories?

- What was the function of the upright railroad rails/stanchions, iron plates, and iron and brick "flues"?

- And, for the Upper Factory, what, if any, is the structural relationship between the foundation and the heavy timbers located in the erosion gully immediately south of the south wall?

Inter-Copperas Factory Area

Interpretation of the Inter-Copperas factory area in the PAL January 2003 report was inconclusive as to the construction and historic function of the features in this area. The location in the TP 3 area, and between the two known copperas factories, suggests association with copperas manufacture. The rectilinear mounds do not resemble building foundations found elsewhere on site and do not appear to be associated with miner or copperas factory worker dwellings. The presence of brightly colored red earth in the piles and tree fall soil resembles the red waste material remaining from copperas ore roasting and heap leaching. The red brick present in the tree fall soil was thought to be associated with the brick evaporation chambers described in nineteenth-century travelers' accounts of the copperas works, possibly analogous to the concentrated piles of brick located at the foot of TP 3, also interpreted as remains of evaporation structures. It was also considered possible that the features in the Inter-Copperas Factory area may be the remains of early copperas ore roasting and heap leaching, and copperas liquor evaporation associated with pyrrhotite mining from the South Mine, said to be the location of the earliest copperas ore mining, and that these remains were never subsumed and buried by the later roasting and leaching activity at TP 3. These features may or may not also be associated with the subsequent copperas liquor boiling and concentration steps that may have been conducted at the adjacent Lower Copperas Factory. Archaeological investigation in this area was expected to yield comparative information about the configuration and construction of early copperas manufacturing at the Elizabeth Mine.

Site-specific research questions for the Inter-Copperas Factory Area were as follows:

- Are the rectilinear mounds and stone wall remains identified in the Inter-Copperas Factory Area associated with human occupation, or copperas ore roasting, heap leaching, and copperas liquor evaporation, or both?

- Do the mounds and stone wall remains date from the same period(s) of occupation and site use as the nearby Copperas Factories?

Archival Research

PAL's prior historic and archaeological investigations at the Elizabeth Mine Site provided the basis for the historic research contexts for the data recovery program and construction monitoring. These investigations include: *Historical Context and Preliminary Resource Evaluation, Elizabeth Mine Site, South Strafford, Orange County, Vermont* (PAL 2001), and an addendum report, titled *Addendum to Historical Context and Preliminary Resource Evaluation of the Elizabeth Mine, South Strafford, Orange County, Vermont* (PAL 2001); and *Historic/Archaeological Mapping and Testing, Elizabeth Mine Site, Stratford and Thetford, Vermont* (PAL 2003).

Additional historic research focused on careful reexamination of primary and secondary documentary sources including travelers' accounts, scientific literature, maps and photos previously collected by PAL

and others. Gwenda Smith, historian and curator of the Strafford Historical Society, and Johnny Johnsson, mining engineer and historian, contributed new documentary information regarding the Elizabeth Mine copperas works. Oral interviews were conducted with geologist and Appalachian sulfide geochemistry expert Robert Seal of the United States Geological Survey, chemists James Baird of Brown University and George Dombi of the University of Rhode Island, and Vermont industrial archaeologist Victor Rolando. Additional information on early copperas manufacturing in Great Britain was found in the publications of Tim Allen and Geoffrey Pike of the Canterbury Archaeological Trust.

Pre-Construction Landscape Assessment

Prior to the initiation of the TP 3 component of the NTCRA and Remedial Action (RA) construction activities, PAL performed a site reconnaissance in the spring of 2009 to determine if any additional features had been exposed or identified since the original recording on the PAL 2003 GIS maps and the historic industrial landscape documentation. The landscape assessment included an existing conditions field documentation consisting of mapping, photography, and the generation of a pre-construction GPS site map.

Mapping

PAL field staff mapped the Upper Copperas Factory (including timber features in Copperas Brook) and the Lower Copperas Factory and the immediate area surrounding each factory site including road features, etc. with a Total Station electronic transit in the spring of 2009 to create a topographic map to record test locations and any archaeological features, and to aid later site restoration and interpretation. PAL coordinated with the NTCRA and RA construction contractor (Weston Solutions Inc.) prior to commencement of mapping regarding data acquisition to insure that PAL's electronic data were compatible with the existing 2 foot (ft) contour mapping so that Weston could use the data to restore the original factory topography after site remediation. PAL established a number of site datums during the mapping effort to assist in the recordation of individual subsite area features during the data recovery excavations.

Photography

PAL conducted photodocumentation of the cleared site from multiple vantage points using a digital SLR camera. The images were captured as large size, high resolution .jpg files. The photograph vantage points were recorded with a hand-held Global Positioning Unit (GPS) and/or recorded with the Total Station. The photographs were also used to aid in restoration of the original topography after site remediation.

Upon completion of the field assessment tasks, the electronic mapping data and digital photograph files were submitted to USACE and Weston for approval and confirmation that they were compatible with the existing electronic 2 ft contour mapping and provided a useful resource for restoration of the original factory topography after site remediation. The archaeological data recovery work followed the approval of the pre-construction assessment mapping and photography documentation.

Data Recovery Program

The data recovery fieldwork in the 2009 and 2010 seasons was concentrated at the Upper Factory, Lower Factory and associated subsite areas within the east portion of TP 3 (see Figure 2-1). Data recovery consisted of a combination of hand (shovel/trowel) and machine (small backhoe with small bucket) assisted excavations (Table 2-1). The machine-assisted excavations included stripping and trenching

Table 2-1. Archaeological Data Recovery Excavations, 2009 and 2010 Field Seasons, Elizabeth Mine Copperas Factories Subsite.

Location	Testing	Designation	Size
Upper Copperas Factory	Machine trench	TR-1-UC	4-x-20 ft (1.2-x-6.1 m)
“	Machine trench	TR-2-UC	16-x-24.6 ft (4.9-x7.5 m)
“	Machine trench	TR-3-UC	5.5-x-11.6 ft (1.7-x-3.5 m)
(North Berm)	Machine trench (exploratory)	TR-4-UC	4.5-x-20 ft (1.4-x-3.5 m)
“	Machine trench	TR-5-UC	4-x-43.5 ft (1.2-x-13.3 m)
“	Machine trench	TR-6-UC	4.6-x-52 ft (1.4-x-16 m)
“	Machine trench	TR-7-UC	7-x-31 ft (2.1-x-9.5 m)
“	Machine trench	TR-8-UC	6.5-x-18 ft (2-x-5.5 m)
“	Machine trench	TR-9-UC	4.2-x-16 ft (1.3-x-4.9 m)
“	Machine trench	TR-10-UC	4.9-x-21.6 ft (1.5-x-6.6 m)
Upper Copperas Factory	Machine trench	TR-11-UC	4-x-16.7 ft (1.2-x-5.1 m)
“	Machine trench	TR-12-UC	5-x-8 ft (1.5-x-2.4 m)
“	Machine stripped area	ST-1-UC	12-x-26 ft (3.7-x-8 m)
“	Machine stripped area	ST-2-UC	18-x-26 ft (5.5-x-8 m)
“	Machine stripped area	ST-3-UC	14.7-x-19.9 ft (4.5-x-6.1 m)
Lower Copperas Factory	Machine trench	TR-1-LC	6.5-x-22 ft (2-x-6.8 m)
“	Machine trench	TR-2-LC	4-x-23.5 ft (1.2-x-7.2 m)
“	Machine trench	TR-3-LC	4.8-x-15 ft (1.5-x-4.6 m)
“	Machine trench	TR-4-LC	4.4-x-13 ft (1.4-x-4 m)
“	Machine trench	TR-5-LC	4-x-6.3 ft (1.2-x-1.9 m)
“	Machine trench	TR-6-LC	4.4-x-9.3 ft (1.3-x-2.8 m)
“	Machine trench	TR-7-LC	3.2-x-9.2 ft (.98-x-2.8 m)
“	Machine trench	TR-8-LC	4.45-x-19.4 ft

Location	Testing	Designation	Size
			(1.4-x-5.9 m)
“	Machine stripped area	ST-1-LC	13.5-x-20 ft (4.1-x-6.1 m)
“	Machine stripped area	ST-2-LC	33-x-35 ft (10.1-x-10.7 m)
“	Machine stripped area	ST-3-LC	17-x-34 ft (5.2-x-10.4 m)
Inter-Copperas Factory Area	Machine trench	TR-1-IC	4.3-x-17.8 ft (1.3-x-5.4 m)
“	Machine trench	TR-2-IC	14-x-23 ft (4.3-x-7 m)
“	Machine trench	TR-3-IC	3.75-x-44 ft (1.1-x-13.4 m)
(South Berm)	Machine trench	TR-4-IC	4.7-x-12.5 ft (1.4-x-3.8 m)
Inter-Copperas Factory Area	Machine trench	TR-5-IC	4.6-x-11.3 ft (1.4-x-3.4 m)
“	Machine trench	TR-6-IC	4.3-x- 9.5 ft (1.3-x-2.9 m)
“	Hand excavation unit	EU-1-IC	3.3-x-3.3 ft (1-x-1 m)
“	Hand excavation unit	EU-2-IC	3.3-x-3.3 ft (1-x-1 m)
“	Hand excavation unit	EU-3-IC	3.3-x-3.3 ft (1-x-1 m)
Copperas Brook Corridor	Machine trench	TR-1-BC	23-x-34 ft (7- x 10.4 m)
“	Machine trench	TR-2-BC	4-x-12.8 ft (1.2-x-3.9 m)
“	Machine trench	TR-3-BC	20.5-x-22 ft (6.25-x-6.7 m)
“	Machine trench	TR-4-BC	13.5 ft-x-15.5 ft (4.1-x-4.7 m)
“	Machine trench	TR-5-BC	14-x-14.4 ft (4.3-x-4.4 m)
“	Machine trench	TR-6-BC	22-x-36 ft (6.7-x-11 m)
“	Hand excavation unit	EU-1-BC	6.6-x-6.6 ft (2-x-2 m)
“	Hand excavation unit	EU-2-BC	6.6-x-6.6 ft (2-x-2 m)
“	Hand excavation unit	EU-3-BC	6.6-x-6.6 ft (2-x-2 m)
“	Hand excavation unit	EU-4-BC	6.6-x-6.6 ft (2-x-2 m)
Pine Grove Area	Machine trench	TR-1-PG	7.5-x-13.5 ft (2.3-x-4.1 m)

Location	Testing	Designation	Size
	Machine trench	TR-2-PG	9.4-x-34.75 ft (2.9-x-4.2 m)

within and adjacent to the previously identified factory foundations. In areas where site protection and preservation in place was not deemed feasible, identified features were excavated vertically to sterile subsoils or bedrock ledge. In areas where site protection and preservation in place was feasible, features were excavated to depths needed only to expose their composition and function (see additional discussion in Chapter 7).

A total of 32 machine-assisted trenches were excavated in the Copperas Factories Subsite and adjacent construction monitoring areas subjected to additional data recovery. In addition to the trenching, six areas were machine-stripped and seven hand units (1-x-1-meter, 2-x-2-meter) were excavated. These data recovery excavations exposed 20 previously identified and newly identified features in the Copperas Factories subsite (see Chapter 4 discussion). Feature numbers were assigned to discrete structural remains that were readily discernable in the surrounding soil matrices and factory foundations. In areas where structural remains were unclear and/or intermixed with complex soil matrices and not readily discernable as discrete entities, context numbers were assigned. In some cases, distinct feature numbers were later assigned within the context numbers as discrete structural elements were identified.

Subsurface Testing

Upper and Lower Copperas Factories Including North Berm

The data recovery fieldwork at both factory areas consisted of a combination of machine-assisted trenching and stripping excavations. These excavations were focused inside and outside the visible L-shaped stone wall/foundation remains. Five machine trenches of varying sizes were placed along the suspected outer (or exterior) sides of the walls to identify the presence of external structural components and/or outside work areas as well as to investigate construction methods and configurations including presence/absence of builder's trenches for both factory buildings.

The suspected interior portions of both factory building footprints were investigated by machine removal (stripping) of all fill/overburden soils to the bedrock ledge and/or constructed subfloor remains. The fill was removed from the interior of both structures in an attempt to determine the horizontal and vertical boundaries of the buildings, and to locate and identify any masonry remains of interior walls and/or timber structural or copperas manufacturing equipment bases or features, or in-situ or disturbed machinery, or equipment or other artifacts. A combination of machine-assisted and hand shovel scraping techniques were used to more fully expose internal site elements to facilitate their recordation in situ or as close to original positioning as possible. Since the factory remains were capped following the removal of contaminated soils, the foundation walls and identified below ground structural features including brick and stone masonry and wood planking/platforms were not excavated. This resulted in the preservation of these features for future research and study (see Chapter 7 discussion and Figures 7-1 and 7-2).

Approximately 2-4 machine-assisted trenches were proposed at the Upper Copperas factory foundation. The actual excavations included five (5) trenches (TR-1-UC, TR-2-UC, TR-3-UC, TR-11-UC, and TR-12-UC) placed perpendicular to the west and east sides of the main stone wall of the factory foundation. Interior portions of the factory foundation to either side of the foundation wall where soil remediation was to take place was also subjected to machine-stripping in three contiguous stripped areas (ST-1-UC thru ST-3-UC) (see Table 2-1).

The North Berm was a linear earth mound located at the foot of Copperas Hill, west of Mine Road and north of Copperas Brook, immediately east of the Upper Copperas Factory at the transition of the slope to the west and the flat area of mine waste to the east. The North Berm was identified as a cultural feature in the 2009 field season. The berm was an approximately 40 ft wide east-west by 60 ft long north-south sloped rectangular earth mound approximately 15 ft (4.6 m) high on its east side. It included a flat, rectangular central plateau flanked by slightly lower terraces to the north and south. A large white pine was growing from the center of the berm with several smaller coniferous and deciduous trees covering the structure. Scattered brick and reddish brown soil were visible in some areas; however most of the surface was covered by a thick organic layer. The North Berm was slated to be impacted by slope regrading associated with 2010 construction of TP 3's Sedimentation Basin immediately to the east. The data recovery work was preceded by a contractor exploratory trench (TR-4-UC), and was followed by construction monitoring (see Chapter 5 detailed discussion). Approximately 4-6 machine-assisted trenches were proposed across the top of the North Berm portion of the Upper Factory. The actual excavations included seven (7) trenches (TR-4-UC thru TR-10-UC) across the top and east slope of the berm feature (see Table 2-1).

Approximately 2-4 machine-assisted trenches were proposed at the Lower Copperas factory foundation. The actual excavations included five (5) trenches (TR-1-LC thru TR-5-LC) placed parallel or perpendicular to the north and west (suspected exterior) sides of the prominent stone wall/foundation. Four of these trenches were placed north and one trench west of the stone wall. The suspected interior (south side) of the factory foundation was investigated through the excavation of three trenches (TR-6-LC thru TR-8-LC) and three discontiguous stripped areas (ST-1-LC thru ST-3-LC) (see Table 2-1).

Inter-Copperas Factory Area

The 2009 data recovery fieldwork in the Inter-Copperas Factory Area consisted of six machine-assisted trenches and three hand excavated units (see Table 2-1). A representative sample of three of the seven raised mounds identified in this area was investigated by machine excavation of one trench dug across the center of each mound feature to determine its internal composition and construction (TR-1-IC thru TR-3-IC). One trench (TR-4-IC) was excavated across the center of a fourth mound designated the South Berm, containing deep red earth and brick. The South Berm was initially interpreted during the PAL 2002 survey as associated with copperas ore roasting, heap leaching, and evaporation. In the other three excavated mounds, cobble flooring and wood planks were encountered. One 1-x-1-meter excavation unit (EU-3-IC) was placed at the location of the cobble flooring in one of the raised mounds where trenching was conducted (TR-2-IC). Two 1-x-1-m excavation units (EU-1-IC and EU-2-IC) were placed on the interior and exterior of one of the berm depressions not subjected to machine trenching. The stone wall identified to the west of the mounds was investigated by the excavation of two machine-assisted trenches (TR-5-IC and TR-6-IC). These trenches were placed on the east and west sides of the wall to investigate the presence of additional wall remains and other features to aid in determining function. These trenching investigations were sufficient to interpret the stone wall as a retaining wall.

Copperas Brook Corridor

The 2010 data recovery fieldwork for the Copperas Brook Corridor consisted of six machine-assisted trenches (TR-1-BC thru TR-6-BC) and four hand excavation units (2-x-2 m) (EU-1-BC thru EU-4-BC) (see Table 2-1). Four of the trenches (TR-2-BC thru TR-5-BC) were placed north of the brook east of the Upper Factory foundation. One trench (TR-6-BC) was placed in the center "island," an un-eroded area in the brook corridor located between two separate north and south brook channels. One trench (TR-1-BC) was placed on the north side of the adjacent haul road in an area suspected to contain a copperas liquor evaporator structure feature. The four hand excavation units were placed in areas of visible surface features including concentrations of brick.

Pine Grove Area

The Pine Grove Area is a cluster of pine trees west of the Upper Copperas Factory at the north edge of TP 3 containing a foundation, possibly associated with a bank barn, identified during PAL's 2002 field investigations. The 2010 data recovery fieldwork for the Pine Grove area consisted of two machine-assisted trenches (TR-1-PG and TR-2-PG) placed in a proposed mine waste removal excavation area down slope from the stone foundation (Figure 2-11). This testing was conducted to determine the presence of any belowground cultural remains associated with the foundation. The foundation itself was not proposed for cleanup excavations and no testing was conducted within the visible stone remains.

Artifact Recovery and Recordation

All hand units were excavated by shovel in arbitrary 10-cm levels to sterile subsoil or until it was impractical to dig (an average of one meter). All hand excavated soil was hand-screened through ¼-inch (in) hardware cloth, and all cultural materials remaining in the screen were bagged and tagged by level within each unit. A representative sample (approximately 10 percent) of the machine-excavated fill and overburden soils was also screened for cultural materials greater than ¼-inch in diameter. The count and type of all recovered cultural material were noted on standard PAL test unit forms. Soil profiles, including depths of soil horizons, colors, and textures, and artifacts were recorded for each test unit either in relation to the site datum (Total Station) or the ground surfaces. All trenches, stripped areas, and hand units were left open following the archaeological excavations and remediation for the remediation work, which consisted of large-scale soil removal and replacement with rocks and gravel materials. The trenches and units within the Inter-Copperas Area including the South Berm where no remediation work was needed were backfilled following the archaeological excavations and recordation.

The types of artifacts recovered include building construction materials (e.g., window glass, iron nails, and hardware) and domestic or personal items (e.g., ceramics, bottle glass, clay pipes, shoe leather, and belt leather, and buckles) discarded or lost by the site occupants/workers. These materials were collected to assist in more precisely dating the construction/occupation/abandonment of the Copperas Factories subsite and to understand the types of activities that took place at each factory (see Appendix A and B.1). Large, non-portable artifacts such as iron plates, bars, flues, wood timbers, etc. were mapped in situ, then removed by hand or machine as appropriate, measured, and photographed and stockpiled on site. The removal and stockpiling activity was largely confined to the upper level of the Lower Factory where dense concentrations of large iron artifacts obscured features. The large Lower Factory artifacts were found within the footprint of the lead-contaminated area and were stockpiled and buried within the contaminated area at its southeast corner. One large cast iron stanchion within the Upper Factory was relocated from its original location at the stone wall to the tree line at the north edge of the contaminated area. All of the nonportable artifacts described in the report and illustrated in Appendix B.2 were reburied at or near their original locations during the remediation/capping activities, unless otherwise noted in the Chapters 4 and 5 results text.

Photographic and Cartographic Documentation

Measured plans and profiles (cross sections) of hand excavation units, machine-assisted trenches, and machine stripped areas were drawn in relation to the ground surfaces. Measured plans and profiles (cross-sections) of the exposed portions of identified features were drawn in relation to the ground surfaces and site datum(s) (Total Station). The plans and profiles recorded detailed information regarding the site stratigraphy, structural elements within the Copperas Factories Subsite including industrial features, and associated work spaces. None of the structural remains or features including wood planks, posts and timbers; cut stones, brick paving/floors etc., was removed from the site unless otherwise noted in the Chapter 4 and 5 results text. They were either left in situ and reburied or removed to TP 1 during

Figure 2-11. Photograph of Pine Grove area, looking southwest during 2010 data recovery.

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the remediation/capping activities. The surveyor Total Station was used to augment the profiles and plans for precision horizontal and vertical accuracy. A detailed site plan along with feature-specific plans and profiles were generated in CAD using the Total Station mapping and feature data (over 10,000 digital points and elevations). Over 5,000 digital photographs were taken of the overall site areas and all excavations and identified structural features as well as large, non-portable artifacts encountered at, but not removed from, the site. The vast digital photographic field record was used to assist in the analysis and interpretation of identified structural remains and activity areas/work spaces.

Laboratory Processing and Analyses

Processing

All cultural materials recovered during the data recovery fieldwork were organized by site and provenience. Cultural materials were sorted by type and either dry brushed or cleaned with tap water depending on the material or artifact type and condition.

Cataloging and Analyses

All cultural materials recovered from the site and inventoried in Appendix A of the report were cataloged using a customized computer program designed in Microsoft Access 2000. The program is a relational database, which provides the flexibility that is needed when cataloging archaeological collections that often contain disparate cultural materials such as stone, ceramics, and/or glass. Artifacts with similar morphological attributes are grouped into lots, which allows for faster and more efficient cataloging. The artifacts are stored in 2-millimeter thick polyethylene resealable bags with acid-free tags containing provenience identification information. The artifacts are placed in acid-free boxes that are labeled and stored in PAL's curatorial facility in accordance with current NPS standards.

Post-contact period artifacts were cataloged by material (e.g., ceramic, glass, coal, synthetic) and functional (e.g., plate, bowl, bottle, building material) categories. Artifacts having known dates of manufacture such as ceramics were also identified in terms of type (e.g., redware, pearlware, whiteware) when possible. When possible, temporally sensitive artifacts such as ceramics were identified in terms of type (e.g., redware, pearlware, whiteware). Ceramic sherds and bottle glass were also examined for distinguishing attributes that provide more precise date ranges of manufacture and use. These include maker's marks, decorative patterns, embossed or raised lettering, and seams/scars. Dating of post-contact period artifacts was performed using ceramic indices according to Noël Hume (1969), Miller (1990, 1991), Miller and Hurry (1983), and South (1977). An analysis of the different nail and bottle types was used to refine the tentative date ranges of historic occupation generated by the ceramic assemblages

The application of Moir's regression formula for the thickness of window glass was considered for this site to assist in the temporal dating of the two factories. This analysis involved measuring the thickness of the glass with a micrometer or digital caliper and using the linear least squares regression method to predict the approximate year of manufacture of window glass from its thickness. Moir's (1987) resulting regression formula (Glass Manufacture Date = 84.22 X (Glass Thickness in Millimeters) + 1712.7) can be accurate to plus or minus seven years in 60 percent of the cases studied (Moir 1987:78). The reliability of this dating method depends on a variety of factors, which were also considered. These factors include the fact that copperas production at the site has a documented occupation period of 73 years (1809-1882), which is more than 13 years over the recommended less than sixty year length of occupation. Additionally, the site is a remote, rural, industrial copperas works where building materials were recycled during the life of the factories and scavenged after they closed in 1882. And furthermore, due to variances in glass manufacturing, Moir's formula becomes increasingly inaccurate as one approaches the beginning

or ending of the nineteenth century; therefore, the information gleaned from his formula must be taken as a part of the artifact assemblage as a whole and not a stand-alone, definitive value (Moir 1977, 1987).

The analyses of the cultural materials recovered during the archaeological investigations also included mapping the density and horizontal and vertical distribution of these materials within the project area. Statistical analyses resulted in estimations of frequency and distribution of archaeological materials including portable and non-portable artifacts.

Curation

Following laboratory processing and cataloging activities, all recovered cultural materials inventoried in Appendix A of this report were placed in acid-free Hollinger boxes with box content lists and labels printed on acid-free paper. These boxes are temporarily stored at PAL in accordance with state and federal curation guidelines.

In comments on the data recovery program dated February 25, 2009, the VT SHPO recommended that portable materials recovered from the site be curated in perpetuity at the VT Archeology Heritage Center (AHC) in South Burlington, Vermont. PAL anticipated a total of 15 banker size boxes of cultural materials including accompanying laboratory excavation records (maps, field forms, photographs). PAL currently has filled nine (9) Hollinger size boxes containing artifacts, with an additional 23 oversized items (e.g., wooden barrel staves, a mine car rail, a pulley and wheel, metal mining tools and machine parts) that are being temporarily curated at PAL. The USACE/EPA will coordinate a “deed of gift” from the private property owners to the VT AHC for any archaeological materials that will go to the AHC. PAL will coordinate with the USACE/EPA to ensure that recommendations on the need and prioritization for artifact conservation are in accordance with the VT AHC Collections Policy.

Construction Monitoring

The data recovery fieldwork was supplemented by construction (mine waste removal) monitoring conducted in several areas within or adjacent to TP 3 (Figure 2-12). The North Berm, Sedimentation Basin area, Copperas Brook Corridor area and Ore Roasting and Leaching area contained resources associated with copperas ore and liquor processing. The North Berm, Sedimentation Basin area, and Copperas Brook corridor were not specifically identified as components of the Copperas Factories subsite in the PAL 2003 report. The Upper Adit/Cob Shop/Blacksmith Shop site and the Tyson No. 1 Shaft site were associated with copperas and copper ore mining and were identified in the PAL 2003 report. Minimal monitoring in the Pine Grove Drainage Trench area led to data recovery in the adjacent Pine Grove area.

The 2009-2010 mine waste removal monitoring work identified previously unknown cultural features associated with copperas manufacturing in some of the above areas. All monitoring consisted of observation and photodocumentation from a safe distance of soil and mine waste rock removal conducted by the contractor’s backhoe and bulldozer. Photographs were taken of soil profiles, features and artifacts using a digital SLR camera with images captured as large size, high resolution .jpg files. Munsell soil colors and feature measurements were taken by the PAL monitor when safe conditions allowed this level of detail to be recorded. Weekly monitoring field reports describing site conditions, removal work performed and including observations and preliminary interpretations were prepared. The results and interpretations of the monitoring for the North Berm, Sedimentation Basin area, Copperas Brook Corridor area, and a portion of the Ore Roasting and Leaching area, which all contain resources associated with copperas crystal production, are included in Chapter 5 of the report. These results were also considered as part of the interpretation of the data recovery results. The field reports for the monitoring conducted at the Upper Adit/Cob Shop/Blacksmith Shop site and the Tyson No. 1 Shaft site, which were associated

with ore mining as opposed to processing for copperas, are included in Appendix F of the report. The field reports for the remainder of the monitoring in the Ore Roasting and Leaching Area and the Pine Grove Drainage Trench are also included in the same appendix.

North Berm

The North Berm was a linear earth mound located immediately east of the Upper Copperas Factory remains and north of Copperas Brook. The North Berm, and the flanking South Berm opposite it to the south across Copperas Brook were discovered as part of the 2009 data recovery excavations. The North Berm had to be removed as part of construction of the adjacent Sedimentation Basin; the South Berm was retained and preserved in exchange. The North Berm was first investigated by data recovery trenches on its upper and east sides (Figure 2-13). Its immediate subsequent removal was documented though construction monitoring.

Sedimentation Basin

The Sedimentation Basin area straddles the sharp bend in Mine Road immediately east of the Upper Factory, immediately north of the Lower Factory and immediately northeast of the Inter-Copperas factory area (Figure 2-14). Deposits of alluvial soils flanking and under Mine Road had to be removed from the buried original banks and channel of Copperas Brook to construct a rock-lined basin to collect potential sediments washed downstream by the temporary removal activities upslope on TP 3. Mine waste and structural materials removal was documented though construction monitoring in 2009.

Copperas Brook Corridor

The Copperas Brook Corridor, located immediately south and southeast of the Upper Factory, contained visible remains of brick structures and a sloping grid of heavy timbers and planks (see Figures 2-4 through 2-7). The corridor bedrock had to be partially removed as part of construction operations to create an adequate channel to convey runoff from the barren surface of the reclaimed TP 3 area above to the west. Mine waste and factory structure removal was documented though construction monitoring in 2010.

Ore Roasting and Leaching Area

Mine waste removal in a large portion of open barren hillside east and west of Copperas Road was monitored during the winter of 2009-2010 (see Figures 2-3 and 2-4). Monitoring revealed discolored soils associated with ore roasting and subsequent chemical alteration and large-scale structural features and artifacts associated with copperas ore mining, roasting and heap leaching.

Upper Adit/Cob Shop/Blacksmith Shop

The Upper Adit/Cob Shop/Blacksmith Shop site was located in the northern portion of the open TP 3 hillside, west of the Pine Grove area and Copperas Road. Monitoring of removal in 2010 documented the mouth of the Upper (1831) Adit (horizontal mine tunnel) in the bedrock, which was temporarily re-buried with rock pending design of a safety grate that will allow it to remain visible for interpretation and to allow free flight of bats into the mine (Figure 2-15). (Waste rock removal also uncovered a vertical shaft east of the Adit and Copperas Road; this feature was also temporarily covered pending its safe closure (Figure 2-16).

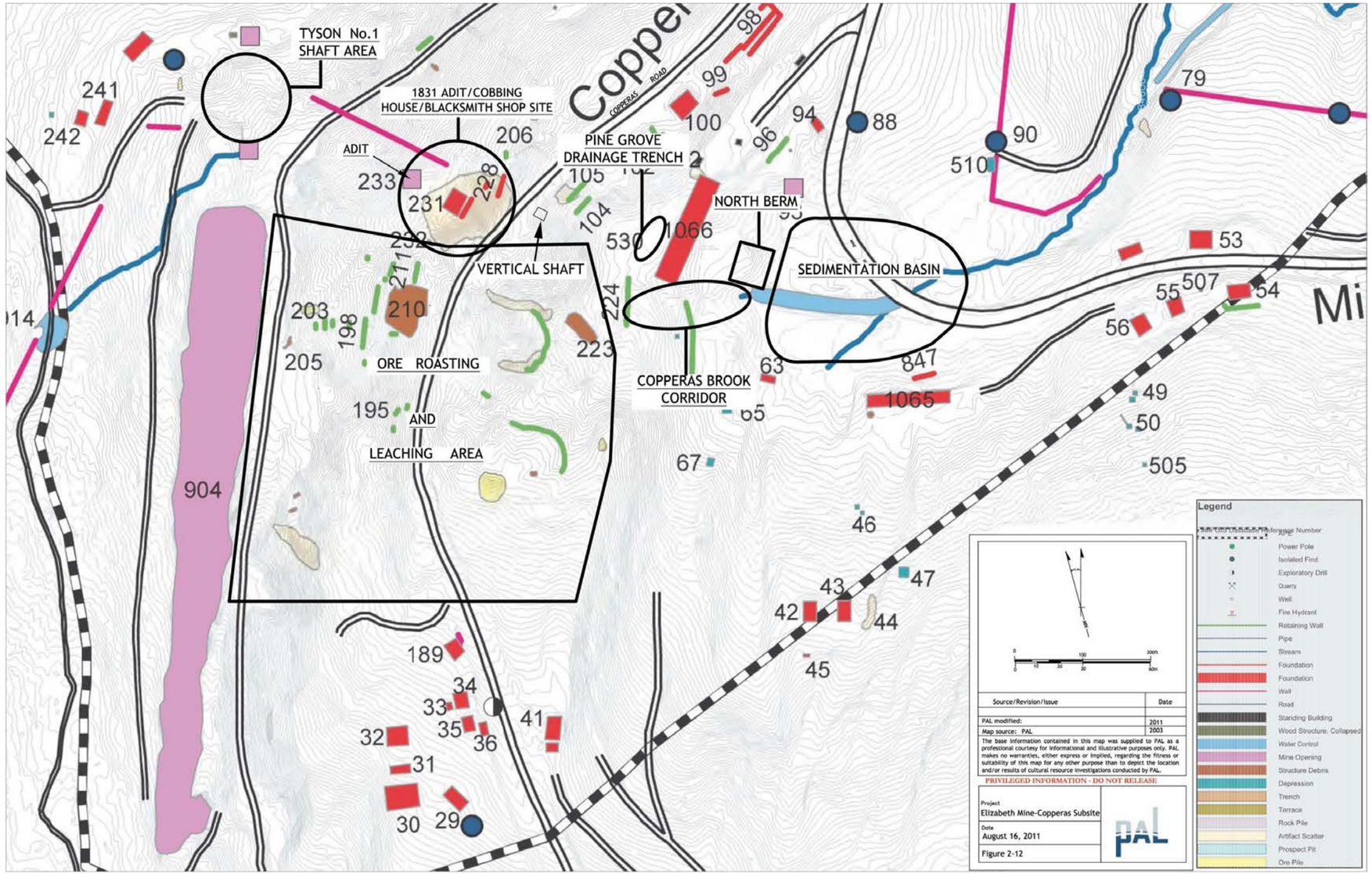

Figure 2-12. Map of Locations of the North Berm, Sedimentation Basin area, Copperas Brook Corridor area, Pine Grove Drainage Trench area, Ore Roasting and Leaching area, 1831 Adit/Cobbing House/Blacksmith Shop site and Tyson No. 1 Shaft site at the Elizabeth Mine site, subjected to construction (waste rock removal) monitoring in 2009 and 2010.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 2-13. Photograph of North Berm during 2009 data recovery, looking southwest.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 2-14. Photograph of Sedimentation Basin area prior to basin construction, May 2009, looking north showing Mine Road and Copperas Brook channel.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 2-15. Photograph of 1831 (Upper) Adit, looking west during mine waste removal.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 2-16. Photograph of shaft uncovered between Copperas Road and the Pine Grove area during mine waste removal (see Figure 2-12 for location).

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Tyson No. 1 Shaft

The Tyson No. 1 Shaft site was located at the northwest extremity of TP 3, north of the North Open Cut. A circular depression at the tree line containing decayed heavy timbers marked the location of the 1880s vertical mine shaft. Monitoring of removal of mine waste rock in this area in 2010 revealed a flat area of packed ore, possibly the floor of the ore cobbing house; evidence of a blacksmith shop including coal pile, tools and metal waste; and vertical threaded iron rods, possibly associated with the mine shaft hoist engine. The mouth of the shaft was encountered, documented by PAL and sealed by the site contractor.

Pine Grove Drainage Trench

The Pine Grove Drainage Trench is a rock-lined trench located between the Upper Copperas Factory and Pine Grove areas, immediately west of a former temporary cleanup project haul road (see Figure 2-11). Monitoring associated with soil characterization for the trench construction in the fall of 2009 identified features requiring subsequent data recovery in the Pine Grove area in 2010.

Public Education and Outreach

The National Park Service guidelines require that archaeological data recovery programs include a public education and outreach component. The VDHP guidelines for archaeological data recovery also mandate the need to interpret site results for the public benefit and to present those findings to the public. The public education and outreach component for the data recovery and monitoring investigations at the Elizabeth Mine Copperas Factories and adjacent cleanup areas at TP 3 have included: a public presentation for the Strafford Historical Society at Barrett Hall in South Strafford, Vermont (September 29, 2009); a public presentation for the Elizabeth Mine Community Advisory Group/ Technical Advisory Group (EMCAG/TAG) in Thetford, Vermont on January 20, 2010 with EPA; the 2010 Society for Industrial Archeology Vermont Fall Conference including an afternoon tour of the Elizabeth Mine Site on September 18, 2010 with EPA; and a research paper on the Elizabeth Mine Site copperas works presented at the SIA New England Chapters 24th Annual Symposium on New England Industrial Archaeology at Clark University in Worcester, Massachusetts on March 5, 2011 and at the Society for Industrial Archaeology 2011 Annual Conference in Seattle, Washington on June 2-5, 2011.

PAL project staff Matthew Kierstead and Erin Timms coordinated and presented these public outreach and scholarly events that presented the findings of the data recovery investigations and monitoring at TP 3 (see Appendix D).

In addition to the above public education and outreach conducted as part of the data recovery program, the Project's MOA Stipulation VI (B) and (C) provides for the development and distribution of popular reports and other educational products including a documentary video, an internet-based exhibit, and a traveling interpretive exhibit that could include a 3-D model of Elizabeth Mine showing the original site topography and key site features such as the North and South Open Cuts, and TP-3. The popular report and other educational products are beyond the scope of the current archaeological data recovery and monitoring efforts.

CHAPTER THREE

HISTORIC CONTEXT

(Note: The prehistoric, community, and mining historic contexts for the Elizabeth Mine are provided in *Historic/Archaeological Mapping and Testing, Elizabeth Mine Site, Vol. 1* (Cherau et al. 2003). This chapter provides the nineteenth-century reports and traveler's accounts of the copperas works from that volume, including additional technical commentary, as well as additional historical materials located since 2003. Chapter 6, Site Interpretations, includes additional analysis of these sources).

Copperas and the Copperas Manufacturing Process

Copperas is a fourteenth-century term for crystalline green hydrous iron sulfate, an important early industrial chemical compound first derived from processing iron sulfide ores. Copperas had a multitude of agricultural and industrial applications over the centuries. It was used to blacken and color leather, as a disinfectant and sheep dip, as an astringent medicine, and as a drier in ground pigment manufacture. It was used as a wood preservative, a quality that may have played some part in the preservation of buried timber and plank structures and wood artifacts in the copperas production area at the mine. It was used in the manufacture of Prussian blue, indigo dye, and could be processed to make paint and polishing powder. It was used for water and manufactured gas purification. It was used for production of sulfuric, nitric and hydrochloric acids and in metallurgical processes including precipitation of dissolved gold. It was used as a dye mordant, which fixes dyes by combining with them and turning them into insoluble compounds. It added color permanence to black and brown wool dyes and fabric printing inks, and was widely used in the dyeing and tanning industry. (Agricola 1950:572; Biringuccio 1990:97; Brady 1947:272–273; Diderot 1751: Plate 151; Wagner 1988:32). The copperas from South Strafford was used primarily by the woolen, cotton, dyeing and hatmaking industries (Smith *Copperas* 2001:11).

Copperas production was a simple process that is documented in a handful of sixteenth and seventeenth-century accounts, and appears to have changed little until the late nineteenth century. The raw material was iron sulfide, or pyrite-bearing soil or metallic ores that were gathered by excavation. The process was a "cascading" one that made use of water and took advantage of gravity, with successive manufacturing steps typically located on a hillside. Typically, the pyritic material was piled into mounds, or beds, where it was left exposed to the elements to oxidize, for months or even years. The beds were usually placed on an elevated, inclined and impervious surface. Sometimes, the material was roasted to promote breakage of the ore and release of the sulfur. After a period of oxidation water was allowed to flow through the beds, releasing a liquor of ferrous sulfate and sulfuric acid. The resulting liquor was collected through troughs and directed to a large holding vessel. The liquid was then drawn into boilers or evaporators and boiled to raise its acidity and iron concentration. When the liquid was sufficiently concentrated, it was tapped off into cooling vessels where it cooled and particulate contaminants settled out. Next the liquid was run into flat, shallow crystallizing pans where it crystallized on the inside surfaces and sometimes on tree branches, chains or rods hung from the tank. The vessels were lined with lead, and sometimes cement, to withstand the action of the acidic liquor. The copperas crystals were scraped off and packaged for shipment and sale (Agricola 1950:576–578; Biringuccio 1990:95–97; Diderot 1751: Plates 151 and 152; Wagner 1988:32).

Examination of illustrations of copperas manufacture from sixteenth- and seventeenth-century accounts clearly shows the individual steps, associated manipulated landscapes and buildings, and infrastructure associated with the process. Agricola's 1556 illustrations from *De Re Metallica* (Figures 3-1 and 3-2) clearly show the process. In Figure 3-1 the broken ore is being loaded into a roasting stall ("A"), then it is shown being carried by wheelbarrow to an enclosed leaching pad ("B") where the roasted ore is sprinkled with water. The resulting liquor is being boiled in a cauldron ("E") and the resulting concentrate is drawn off by a launder ("F") to a holding reservoir ("G"). These processes are conducted outdoors. In Figure 3-2 the process has moved inside a building, where liquor is further boiled (evaporated) ("A") and then placed in a tank ("B") with a system of ropes suspended by crossed sticks ("C") on which the copperas crystallizes (Agricola 1950:571, 575).

Illustrations in Diderot's 1751 *Encyclopedie, ou Dictionnaire Raisonne des Sciences, et des Arts et des Metiers"* show the same essential process for making the chemical compound alum (Figure 3-3). In a portion of Figure 3-3 broken ore was heaped in conical mounds ("A"), two of which appear to be undergoing combustion. The ore was then piled in a layered and stepped heap ("B"), which was constantly recycled to keep up a supply of properly roasted ore. The roasted ore was conveyed by wheelbarrow to a series of leaching tanks. The tanks were fed fresh water from the right which ran into a perimeter trough ("F"). The water then flowed through pipes ("H") into the leaching tanks ("C" and "D"). The saturated liquor was then drawn into a row of settling tanks on a central conduit, and then conveyed by a launder to a final holding reservoir ("F") above the factory. The burning and leaching operations were continuous and individual tanks were in different stages of leaching "for several days before a given portion of liquor worked its way to the final reservoir," indicating the complexity of the system which, presumably, involved some sort of gates or valves for the leaching and settling tanks (Diderot 1751: Plate 152).

Another plate from Diderot shows the indoor portion of the copperas manufacturing process (Figure 3-4). The copperas liquor is held in the outdoor reservoirs ("g") directly above the factory. The liquor was then evaporated in a large evaporator or boiler built into the top of a high wall ("a") above the factory floor. It was boiled in rectangular pan ("d") over a fire in a firebox ("b"), with the hot gases pulled under the pan and up a draft stack ("e") on its opposite side. The masonry boiler structure included an ash pit arch ("c") under the firebox. The concentrated liquor was drawn off in an oak log pipe into a portable wheeled crystallizing tank ("k"), where it cooled and part of the liquor crystallized. The excess liquor was poured down to a lower level with a perimeter trough ("m") that fed two rows of crystallizing pans (n). The copperas crystals were then scraped off, and shoveled into barrels for shipment (Diderot 1751: Plate 151). This simple process was employed and improved upon over the course of about 75 years of copperas manufacturing at the Elizabeth Mine.

Diderot's illustration of the interior workings of an alum factory resembles the vitriol factory process as well as aspects of the historical accounts of the South Strafford works that follow (Figure 3-5). Unlike the copperas process as conducted at South Strafford, where only the spent crystallizing liquor was re-circulated to the initial boilers, in the alum process as shown by Diderot, all of the crystals and liquor were recycled for a second circuit of evaporation, concentration and crystallization to obtain the pure product. The Diderot alum factory view is notable, and relevant to the South Strafford operation, for illustrating an elevated boiler wall supporting multiple boiling furnaces, for the system of elevated launders for returning spent liquor to the boilers, and for the primitive manual "bucket brigade" method of transferring the liquor from vessel to launder (Diderot 1751: Plate 152).

Figure 3-1. Drawing of copperas process from Georgius Agricola, *De Re Metallica*. 1556.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

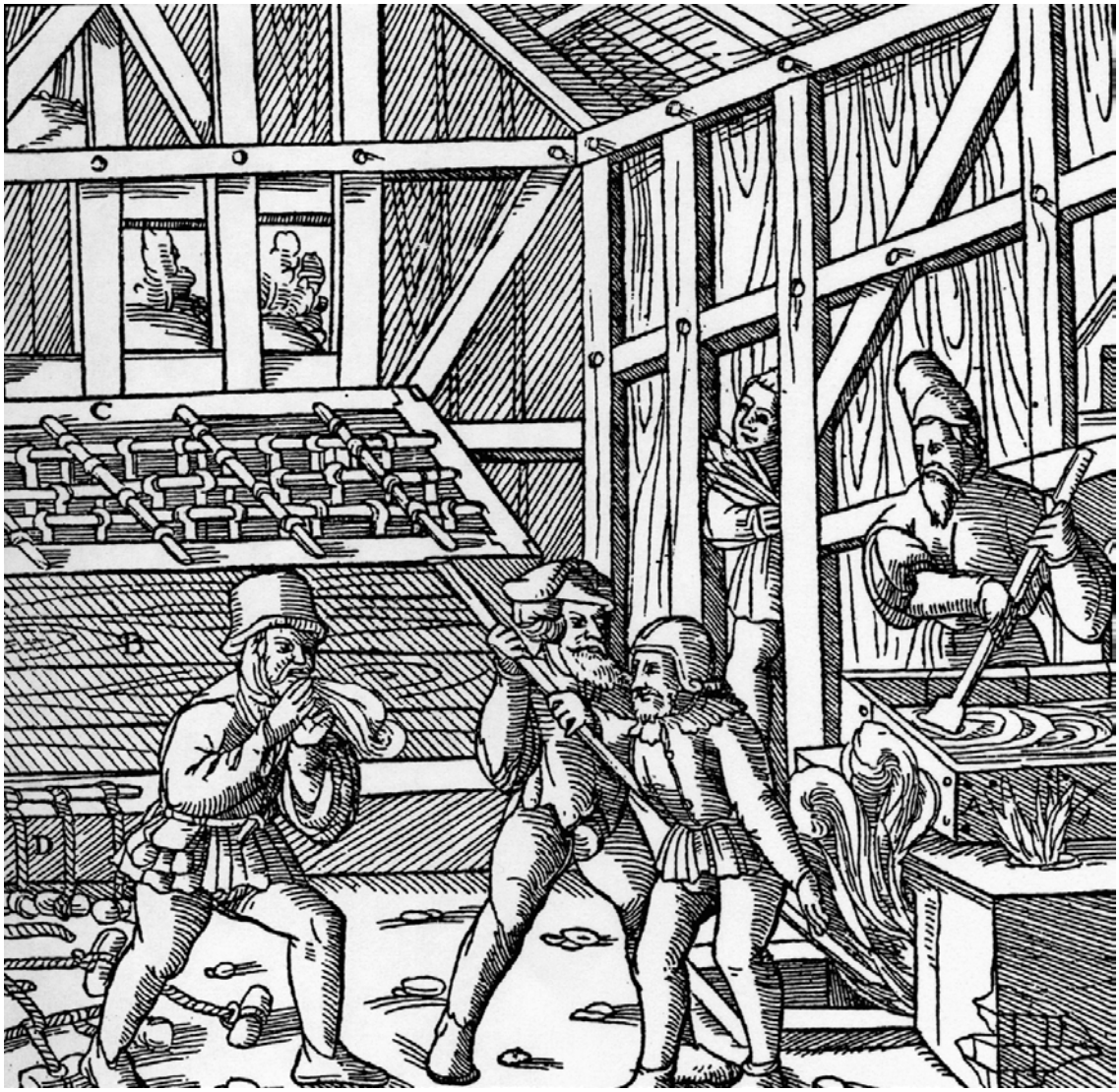

Figure 3-2. Drawing of copperas process from Georgius Agricola, *De Re Metallica*. 1556.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

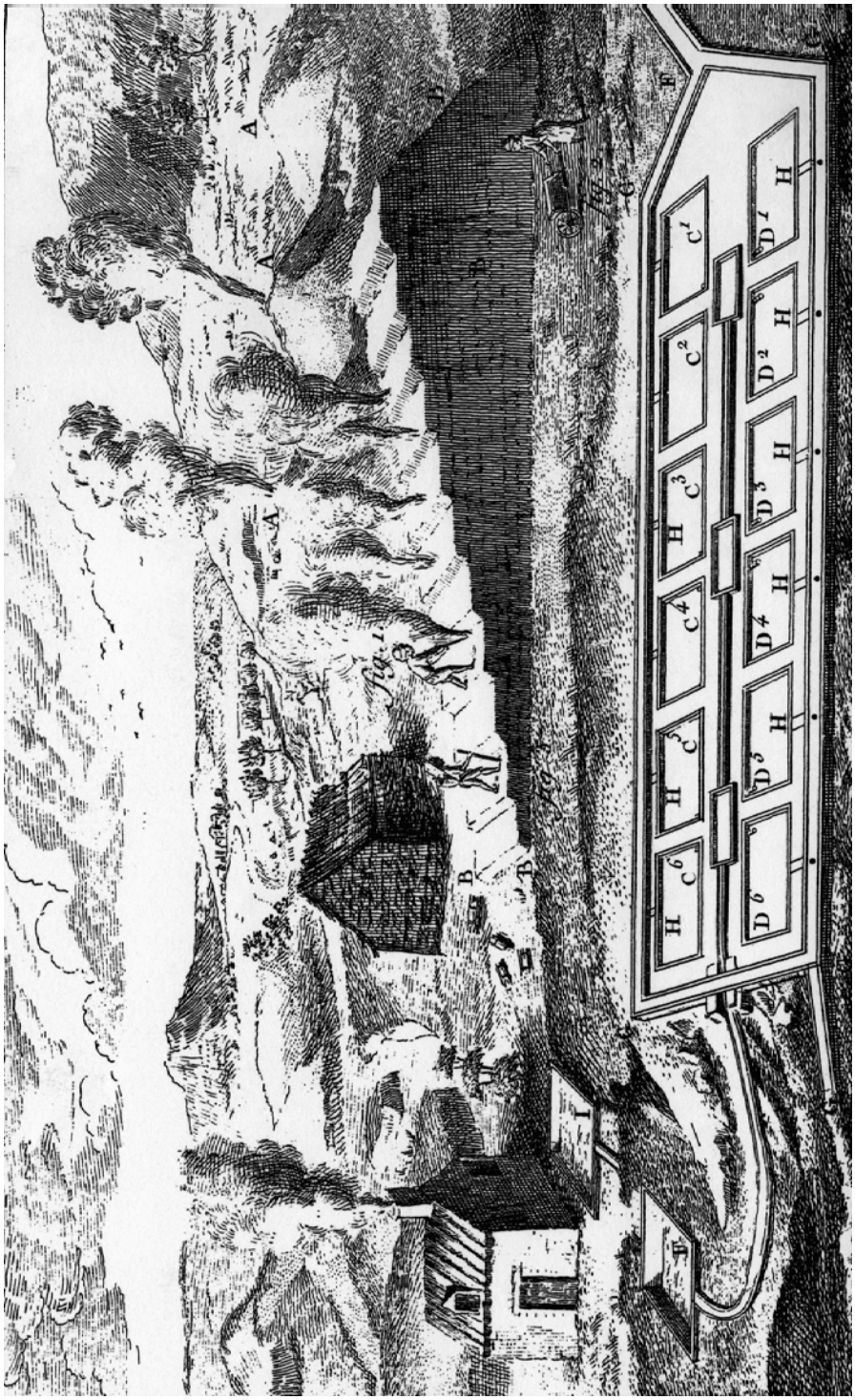

Figure 3-3. Drawing of alum process (outdoor portion), Plate 152, from Denis Diderot, *L' Encyclopedie, ou Dictionnaire Raisonne des Sciences, des Arts et des Metiers.* 1751.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

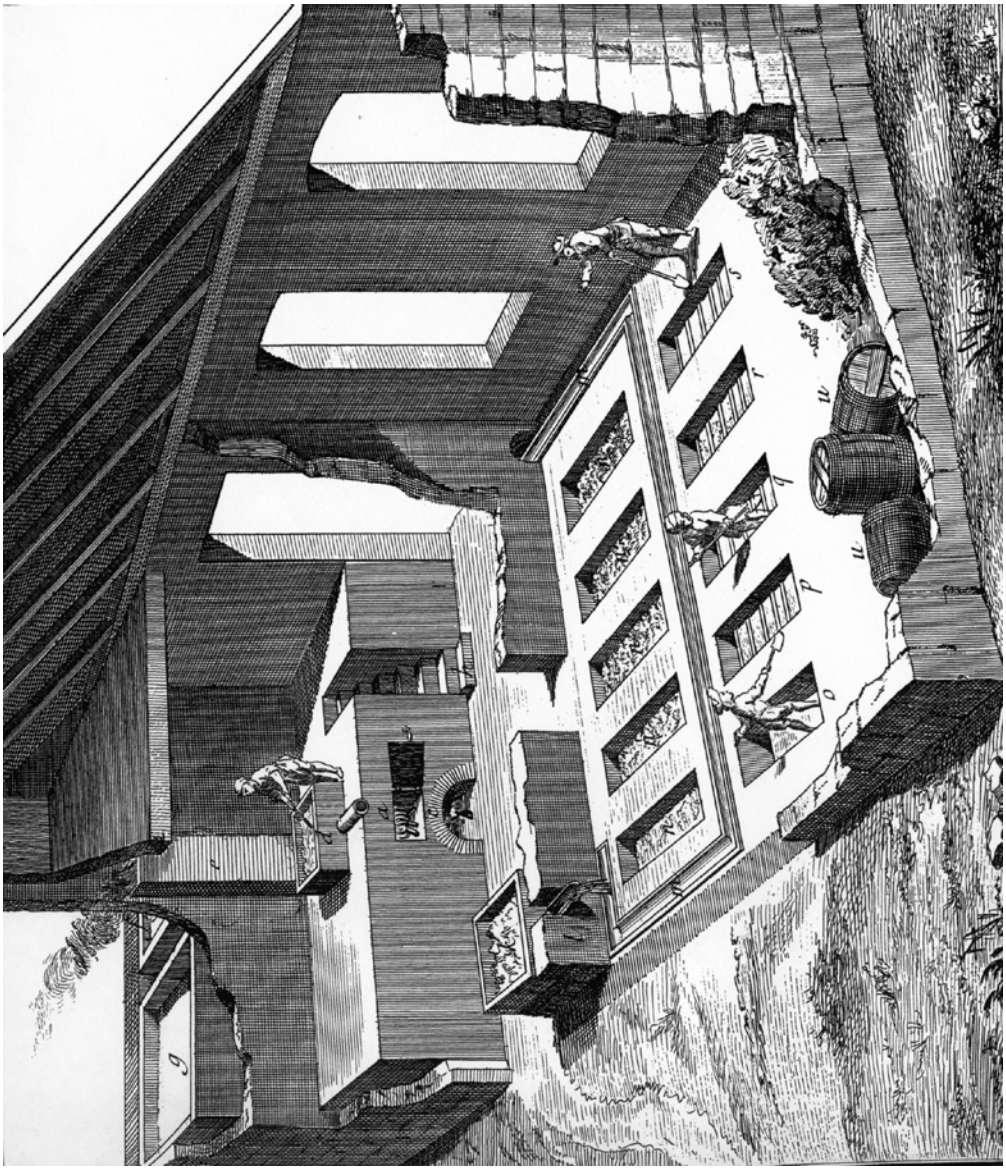

Figure 3-4. Drawing of copperas (vitriol) process, Plate 151, from Denis Diderot, *L' Encyclopedie, ou Dictionnaire Raisonne des Sciences, des Arts et des Metiers.* 1751.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

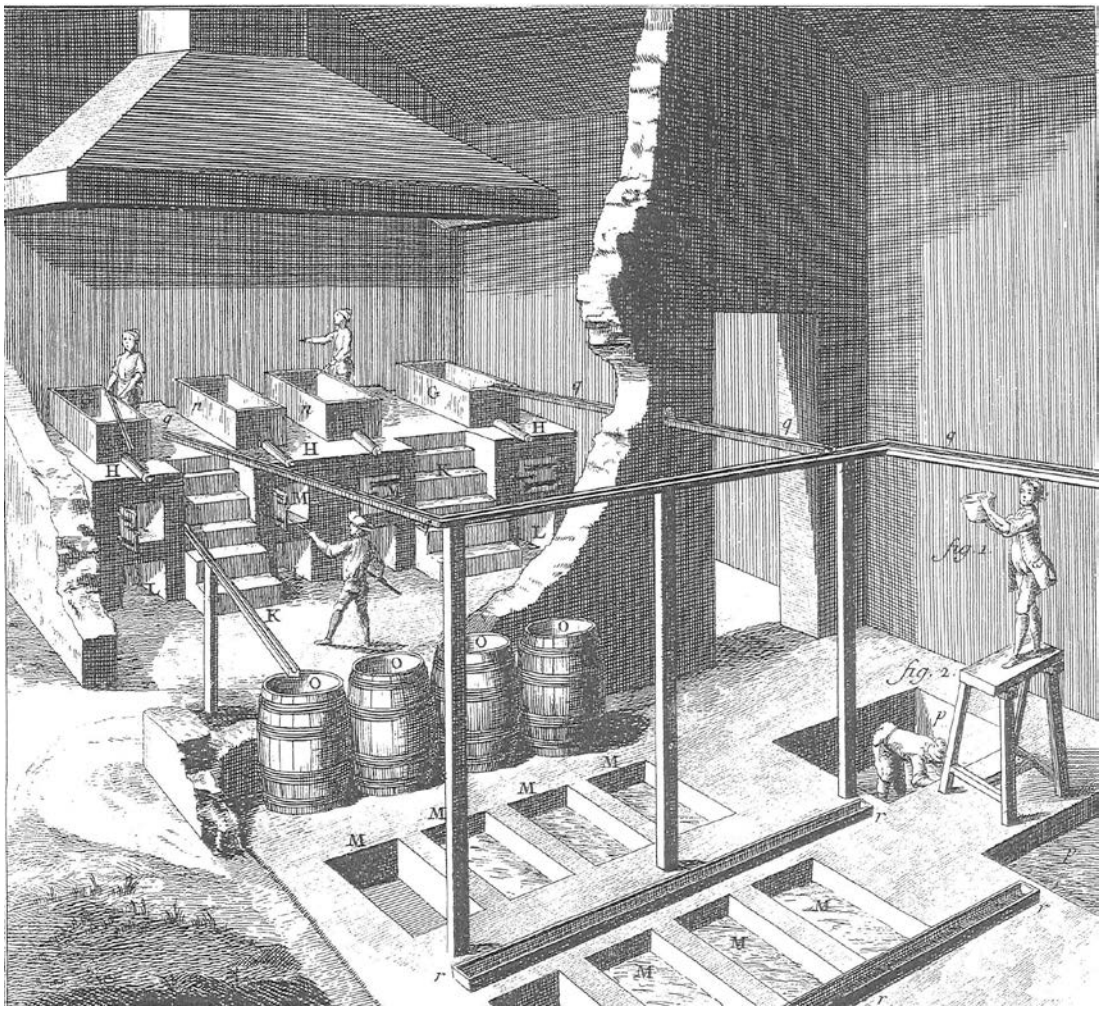

Figure 3-5. Drawing of alum process (indoor portion), Plate 152, from Denis Diderot, *L' Encyclopedie, ou Dictionnaire Raisonne des Sciences, des Arts et des Metiers.* 1751.

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History of Copperas Manufacturing at South Strafford, Vermont

(Note: Figure 3-6, a chronological chart that presents annual South Strafford copperas production in tons, variations in factory size, and a corresponding timeline of significant historical, economic and local events, provides a helpful complementary visual reference to the copperas works history).

Copperas was an important chemical in eighteenth-century colonial America. Like iron and other products, its domestic manufacture was discouraged by the British, and the Revolutionary War created opportunities for its production. Late eighteenth-century copperas works were set up in locations including Brookfield and Hubbardston, Massachusetts, areas known for strongly pyritic bedrock (Smith *Copperas* 2001:6–7).

The weathered iron oxide outcrop of the Elizabeth Mine sulfide orebody was discovered in 1793, allegedly by two men who were tapping sugar maples on the east slope of what was then called Prospect Hill, and discovered discolored water draining from the deposit. Regardless of the mode of discovery, the unusual phenomena associated with this geochemical anomaly incited local curiosity before its specific value was understood. Deeds associated with the land on which the ore outcropped from the late 1790s contain references to iron ore mining rights. In 1798, Asahel Chamberlain sold a parcel of land to Jacob Stevens, but reserved the right to mine the ore for himself. This land was where the Vermont Mineral Factory Company set up a copperas works about ten years later. The identification with iron was typically associated with the discovery of Appalachian sulfide orebodies, as the gossan or weathered cap of the ore consisted of limonite, an iron oxide leached of metals (such as copper, zinc and lead) and sulfur. The primary constituent of the South Strafford orebody is pyrhhotite, an unoxidized iron-sulfur mineral that lay below the gossan. The belief that this material could be smelted for iron persisted until 1809, when a misguided attempt to smelt this unsuitable ore choked the Franconia, New Hampshire, iron furnace and caused it to shut down (Abbott *GMC* 1964:2–12). Mining work on the outcrop at this time likely consisted of open-cut excavation of the soft oxidized layer in the vicinity of the north end of the North Open Cut. After the failure to produce iron from the South Strafford ore at Franconia, attention shifted from iron to copperas production, and Prospect Hill became known as Copperas Hill.

The earliest people to dig the South Strafford ore were local men, but the deposit was not worked profitably until the arrival of the financial and technical aid of outside experts. A September 30, 1809 deed notes that the South Strafford deposit was being mined and copperas was being made by that date. Between 1809 and 1812 several companies were formed to mine and produce copperas in Strafford and the adjacent towns of Thetford, Norwich, Hartford, and Sharon. Starting in January 1809 a series of outside figures, several from New Hampshire, began to buy up the land around the South Strafford ore outcrop. On October 31, 1809, this group officially incorporated as the Vermont Mineral Factory Company, and continued to acquire additional land around the deposit. Key figures in the Vermont Mineral Factory Company were Colonel Amos Binney, a Boston merchant, and his son, Amos Binney Jr. The senior Binney figured prominently in the early Vermont copperas industry. In 1826 the junior Binney became a partner in the copperas business, and later pursued the first attempts at extracting copper from the ore (Abbott *GMC* 1964:7–11).

The initial operations of the Vermont Mineral Factory Company's South Strafford copperas works took place during a period of unfavorable economic conditions. Until 1807, all copperas was imported from Europe. The 1807 Embargo Act restricted trade with the belligerents in the Napoleonic Wars. Restrictions on imports of chemicals and minerals affected Vermont industries, and served as an inducement for the domestic production of compounds including copperas, the production of which was so important that copperas workers were exempted from some militia duty. In 1810, the first full year of

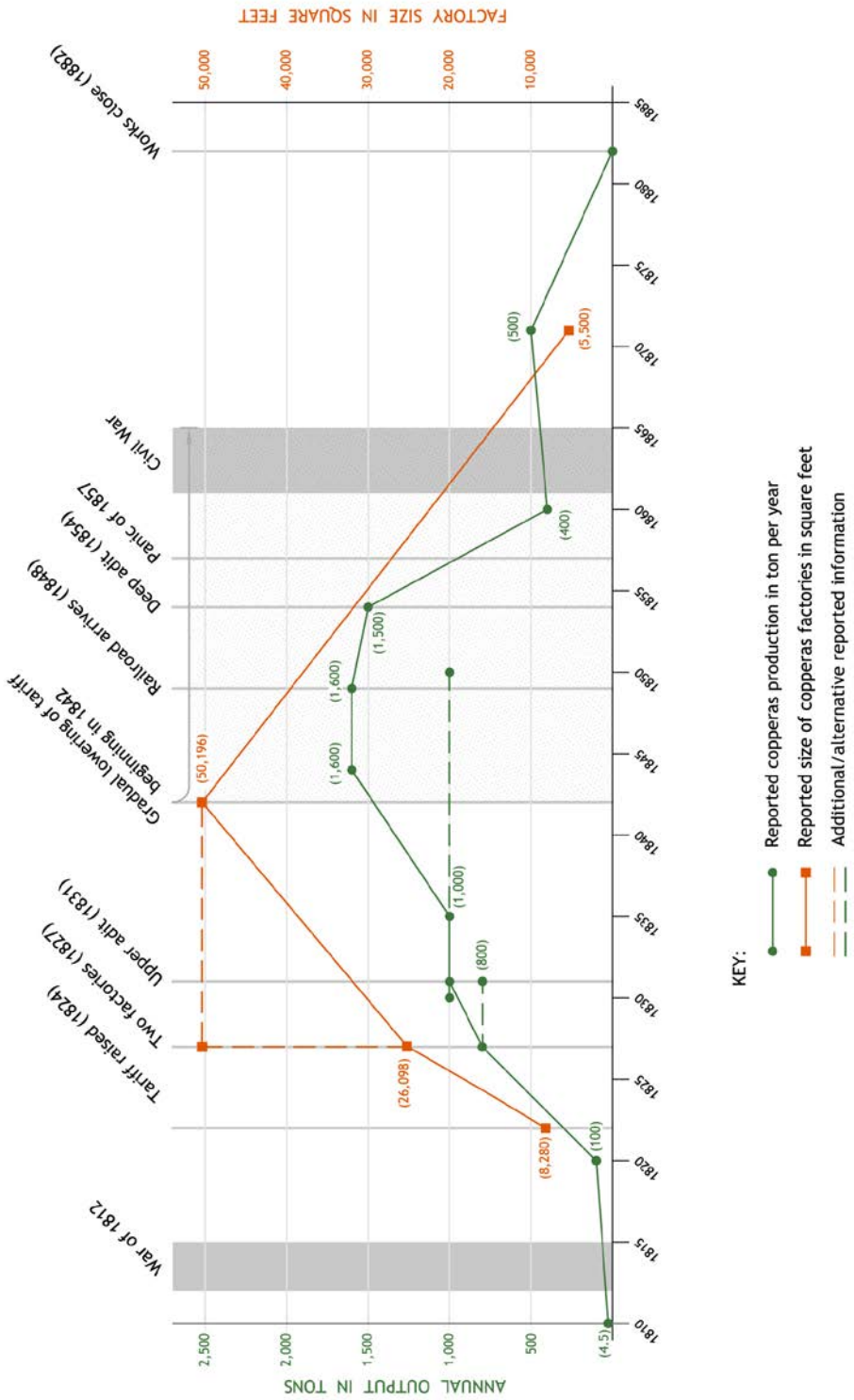

Figure 3-6. Chronological chart of copperas manufacturing at Elizabeth Mine showing annual production, square footage of factories, and important dates and events.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

production, the Vermont Mineral Factory Company produced 8,960 lbs. (about 4.5 tons) of copperas valued at $1,200. Before the War of 1812, copperas sold for 4 or 5 cents per lb. In 1812, Josiah Quincy petitioned Congress on behalf of the Vermont Mineral Factory Company to place a duty on foreign copperas. The company was confident that it could supply the country's entire demand and wanted a protective tariff in place to protect its interests. During the war the price of copperas rose from 12 to 16 cents per lb. and the operation became more profitable. After the War of 1812, the English flooded the copperas market and the Vermont Mineral Factory Company copperas works were unprofitable during the depression that lasted until 1822. Congress did establish a duty of 1 dollar per 100 lbs. on imported copperas in 1816, but it proved ineffective (Abbott *GMC* 1964:11–13).

In 1817 President James Monroe undertook a tour of the United States that included Norwich as the northernmost stop in eastern Vermont. Amos Binney had previously served as agent of the U.S. Navy Yard in Boston, where he had met Monroe. Binney encouraged Monroe, who had a deep interest in domestic manufacturing, to change his Vermont tour itinerary to include a visit to the Vermont Mineral Factory Company at South Strafford. As a major manufacturer of copperas, Binney wanted to influence Monroe's future support of the industry. Finally, in 1824 Congress raised tariffs on foreign chemical importation, which doubled the copperas tariff from 1 cent to 2 cents per lb. According to Binney, this 1824 tariff was the key to profitability for the domestic copperas industry, and allowed the Vermont Mineral Factory Company to become profitable and to develop into a major American supplier. Before 1823, production averaged 25 tons per year, but had increased to 800 tons by 1826 (Abbott *GMC* 1964:12–15).

The importance of the 1834 tariff to the chemical, and particularly, copperas industry was expressed in 1831 by Baltimore, MD chemical industry figure Isaac Tyson, Jr., who also had copperas and copper mining interests in the South Strafford operation. According to Tyson, "By this act, and not until after its passage, was the manufacture of chemicals established in the United States." According to Tyson, "Copperas was subject to greater fluctuations, varying with the vacillating policy of the importer, or the foreign manufacturer, or the contrivance of the speculator. The price was…sometimes below the cost of importation." Tyson stated that "The protection offered to several chemicals has not only reduced process, but almost entirely excluded the foreign article. Indeed, as to alum and copperas, the exclusion seems complete, for the treasury tables of 1830 do not show that one lb. of either was imported" (Tyson 1831:178-179).

In 1828 Amos Binney, Jr., formed the Green Mountain Manufacturing Company to exploit another iron sulfide deposit at Cuttingsville in Shrewsbury for copperas production. Statistics for the period are not entirely consistent but give some idea of the magnitude of the operations. The Cuttingsville plant produced 200 tons of copperas in 1829, 400 tons in 1830, and 600 tons in 1831. The South Strafford works averaged 750 tons annually from 1824 to 1831, with production of 1,000 tons in the last year. According to Binney, the combined output accounted for 75 percent of United States production, with Ohio and several other states producing the balance (Abbott *GMC* 1964:17–18).

The dominance of the Vermont copperas operations in eastern U.S. markets was corroborated in 1831 by Isaac Tyson, Jr., who stated that "Beds of iron pyrites…exist of great extent in the towns of Stafford and Shrewsbury, Vermont–from which the country east of the Allegheny Mountains has been principally supplied with copperas for many years. They are worked by two incorporated companies, manufacture 2,500,000 lbs [1,250 tons] per annum, employ 75 men, consume 3,000 cords of wood, pay for transportation by wagons, canal, river-craft and coasting vessels, $20,000–using considerable quantities of lead, iron and gunpowder" (Tyson 1831: 180).

Until about 1830 the South Strafford copperas works drew its raw material exclusively from an open pit, the North Open Cut, located near the top of Copperas Hill. About 1829 Amos Binney began developing

underground workings to access the ore more efficiently. He started to drive the Upper Adit (horizontal tunnel) west toward the orebody from a point about halfway down the hillside to the east, and sunk a 100 ft air shaft to ventilate the workings. The miners advanced only one foot per day using hand drilling and black powder for blasting. After tunneling 313 feet the Upper Adit intersected the orebody. By 1831 ore was being hauled out the new entrance in wheeled cars running on rails, possibly the first railroad operation in Vermont (Richardson 1832). This development gave access to new sources of pyrhhotite for copperas, and with it larger quantities of copper ore for Isaac Tyson's copper smelting efforts at Furnace Flats.

Copperas production through the 1830s and 1840s remained around 1,000 tons annually. The Shrewsbury operation was closed in 1837. In 1844 and 1849, production was reported at 1,600 tons, and an 1854 report listed production at 1,500 tons. The Connecticut & Passumpsic Rivers Railroad reached Pompanoosuc (Norwich) in 1848, greatly improving the transportation situation for the copperas works. Copperas was shipped to major cities including Baltimore, Boston, Charlestown, SC, Hartford, Richmond, and Troy, NY (Abbott *GMC* 1964:19, 35). Between 1842 and 1862 the tariff on foreign copperas was gradually lowered, allowing foreign sources to make inroads and prices to drop. In November 1854 another tunnel, the Deep Adit, was begun at a point lower down the hill, roughly west of the sharp bend in the road below the copperas works at TP 3 (Abbott *GMC* 1964:272).

After the Civil War, in 1867, the mine was taken over by the New England Chemical Company, which operated two copperas plants and a paint works, the latter at Furnace Flats, over a mile to the north of the copperas operations. Soon the New England Chemical Company was taken over by the New England Chemical Manufacturing Company, which operated the copperas works during the 1870s under William H. Foster and Joseph W. Cleaveland. Around 1880 the copperas works employed 50 workers. In 1882 it was deeded to the Strafford Mining Company, but subsequently shut down, possibly in 1884, because of competition from new sources of copperas (Abbott *GMC* 1964:273–276). Nationally, the manufacture of copperas from natural materials largely ended in the 1880s when large, inexpensive sources of iron sulfate became available as a by-product of the burgeoning steel industry. Iron sulfate was extracted from waste sulfuric acid that was used to pickle (wash) iron oxide scale from steel sheet and wire prior to galvanizing or finishing. The spent sulfuric acid was boiled with scrap iron and the resulting liquor was processed to yield large quantities of inexpensive by-product iron sulfate (Day 1885:952).

Process and Production at Copperas Hill

The owners of the South Strafford copperas works expanded and improved their works several times. The scale of the works in terms of its landscape and factory buildings far exceeded any other manufacturing concerns in the area. The process generally followed the simple method described above, with some steps, notably ore roasting, employed to accelerate ore decomposition and increase production and concentration of copperas liquor. Figure 3-7 shows the general process in a schematic way. An important general aspect of the arrangement of the works was the way that it took advantage of the steep slope to promote the cascading nature of this process, using gravity and water to move the materials (Smith *Copperas* 2001:13–14). The affairs of the copperas works were documented in several mid-nineteenth-century travelers' accounts and scientific reports, which are reproduced in full below. Not all of these include descriptions of the works themselves, but many provide information about the operations that can be used to interpret the general location and arrangement of the various phases of the operation and the function of the various features on the hillside. Data from the U.S. Census of Manufactures provides additional information on production capacities and employment.

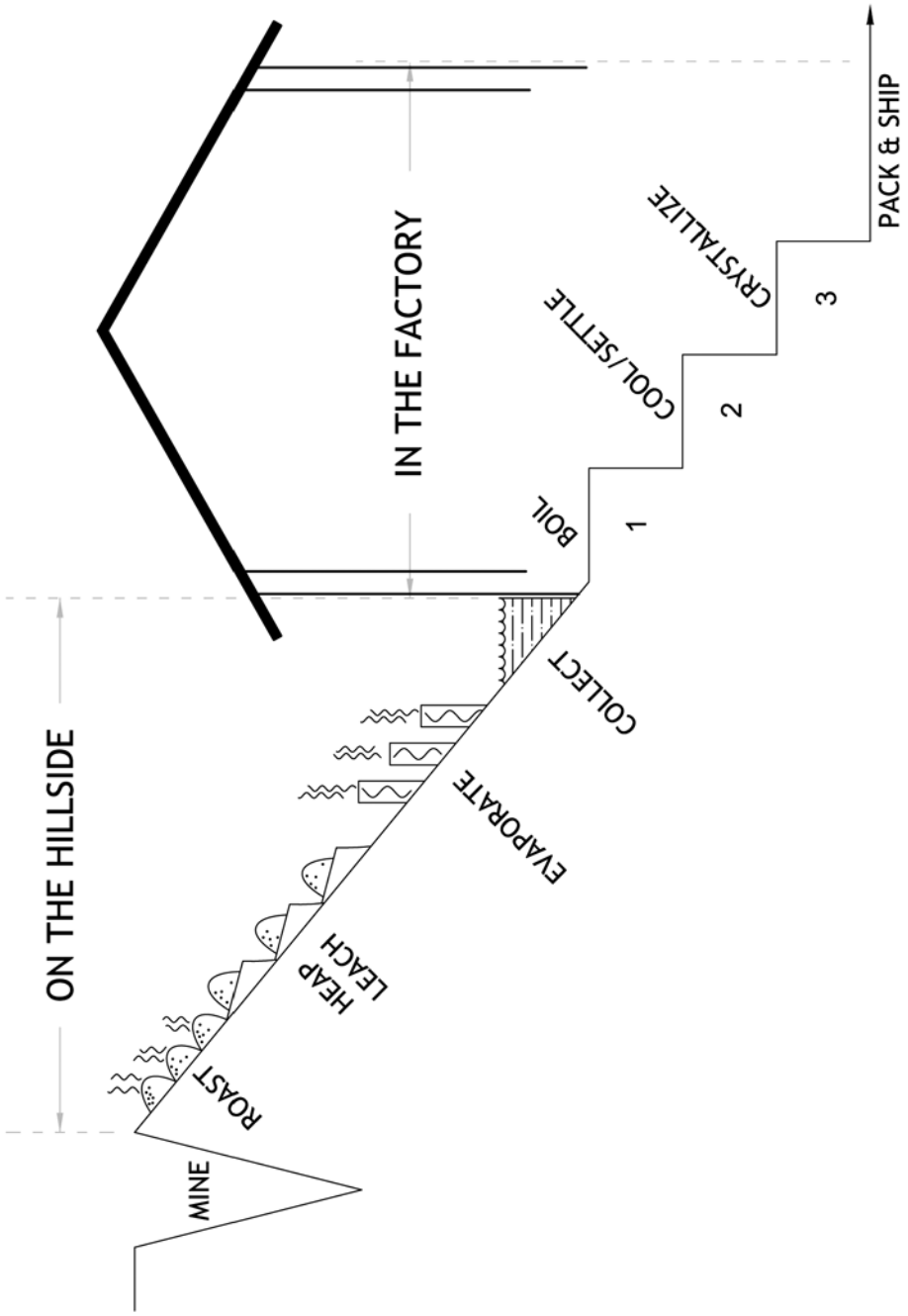

Figure 3-7. Process flow diagram of general copperas manufacturing process, South Strafford, VT ca. 1809-1882.

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The U.S. Census of Manufactures for 1810 notes that 20,000 tons of ore were blasted, and 12 scaffolds were built and filled with the ore, yielding about 4 tons of copperas (U.S. Census of Manufactures 1810). This indicates that the ore was placed in heaps or beds confined by some sort of structure, presumably made of timber. These were apparently for leaching rather than roasting, as that process was not adopted until later. This is supported by an 1821 account by Dr. John Locke, who reported that originally the ore had been simply leached for its copperas content, and later was roasted to speed decomposition:

> For several years the manufacturers effected the decomposition in the following manner: the ore was broken into fragments of a foot or less in diameter, and heaped upon inclined scaffolds erected and floored with plank for the purpose. Thus exposed to the action of air and moisture, it very gradually decomposes at the surface. Thus from the same mass of ore a solution was obtained, year after year, either by the rains or by the application of water by other means. The solution was received from the inclined scaffolds in plank cisterns.

[This process was slow, had limited throughput, and may have resulted in diminishing returns. Soon, they added a roasting step, which accelerated and increased the output of the leaching process, allowing greater throughput of ore, and production of more copperas]:

> For three or four years past [since 1817 or 1818] they have adopted a more expeditious method of decomposition, which was discovered in the first place by accident. They break the ore into much smaller fragments, three inches and less in diameter, and throw them into a convenient heap, taking care to leave air holes at the base so as to allow the air to pass freely through the heap. On applying water the decomposition commences, and so much heat is evolved as presently to raise the temperature of the heap . . . [so that] in the course of three or four weeks the whole becomes disintegrated and ready to fall into the state of powder. It then by lixiviation with water yields all its copperas at once; the process is performed in a plank cistern.
>
> The manufactory in which the processes of evaporation and crystalization are performed is placed on the declivity quite below the mine. This gives great facility to all the operations, allowing the various reservoirs to be so arranged one above another that the liquor may be transferred from one process to another merely by means of a trough.

[It is unclear what this “trough” or trough system was made of or how it functioned. Diderot’s description mentions boiled liquor being transferred through an oaken pipe, which would have been replaced often as the action of the concentrated acid on the wood must have been rapidly destructive. Considering the multiplication of boilers (as many as four) and crystallizers (as many as ten) per factory indicated in the accounts below, the “trough” system may have been more sophisticated, possibly in-ground, as shown in the Diderot illustrations, or elevated, and possibly lead-lined].

> The bottoms of the evaporating vessels are of lead, and about ten feet square; the sides are of wood about three or four feet high. The bottom is supported by a number of parallel brick walls, placed at a small distance from each other. The avenues or arches between these walls communicate at one end with the arch in which the fire is placed, and at the other with the common flue.
>
> The ore is a sulphuret of iron with a small proportion of copper; and the solution, first obtained, is a sulphate of iron and copper with an excess of acid. During the process of evaporation a leaden vessel, having its sides perforated and containing fragments of old iron, is suspended in the liquor. The iron at the same time that it neutralizes the excess of acid decomposes the sulphate of copper and the copper is precipitated in the form of fine powder which the workmen call "copper mud."

[Iron is more chemically active than copper permitting it to replace copper in solution causing copper to form a precipitate. Adding scrap iron to the acid also maximized the amount of available iron in the solution to form the iron sulfate product].

> After the liquor has been sufficiently evaporated it is drawn off into cisterns to crystalize. Branches of trees are put into them as a nucleus for the crystals. When the crystalization has proceeded as far as it will go, the remaining fluid is drawn off and returned to the evaporating vessels. The cistern remains lined several inches in thickness with crystals, like a geode. The branches have a fine crop of foliage and fruit composed of beautiful green crystals. The crystals are very large and perfect, presenting numerous brilliant facets which are often several inches broad. . . .

[Returning the spent, iron-depleted copperas liquor from the crystallizers back to the initial boiling step conserved useful materials. This recycling step appears in process descriptions throughout the history of the operation (see below)].

> An ingenious method has been contrived to catch the wash of the whole mine. There has been cut in the compact ore, quite across the lower edge of the mine, a channel, into which by its inclination the mine discharges the wash of every shower, together with the natural oozing from the hill above. A trough conveys the fluid from the channel to the boilers. To increase the effect of this natural brook of copperas, the ore has been broken into large fragments, and heaped along the upper side of the channel, there to undergo a slow decomposition precisely as it does upon the scaffolds mentioned above (Locke 1821:326–330).

The 1820 U.S. Census of Manufacturers lists eight leaches, two reservoirs, eight vats, three boilers, and six crystallizers at the works. It indicated that annual production had risen to 100 tons, and the works were described as "in good condition—establishment declining" (U.S. Census of Manufacturers 1820).

In 1824, Zadock Thompson reported that:

> In 1822 . . . the works having been considerably enlarged . . . The building in which the manufacture is carried on is 180 feet long and 46 wide. . . . The ore is . . . beaten to pieces with hammers and thrown into heaps several rods in length, about 12 feet in width, and seven or eight in height. Here it is suffered to lie exposed to the action of the air and moisture until a spontaneous combustion takes place, and the whole heap is converted from the sulphuret to the sulphate of iron, which usually takes several weeks. . . . After the process of burning is completed, the residue is removed to the leaches, where water is passed through it which dissolves the copperas and leaves the earthy matter behind. The water [liquor] is then conveyed to the boilers, which are made of lead, four in number, and weigh about 2500 pounds each. Here it is boiled and evaporated to [a] certain extent, and suffered partially to cool. It is then transferred to the crystalizers, where the copperas continues to crystalize, while cooling, and when the crystalization ceases, the water is again returned to the boilers, mixed with water from the leaches, and again evaporated (Thompson 1824:251–253).

[At this early phase of factory operations, after the liquor was boiled to the correct density, it was allowed to partially cool in the boiler, which may have lengthened the time lag between boiling fresh batches of liquor, and likely required more fuel to reheat the cool boiler for a fresh batch of hot liquor].

In 1827, the following description of the works appeared in the *Columbian Centinel*:

> Upon the highest extremity of the hill is the *Magazine,* which is almost inaccessible, and such a distance from the other buildings, that in case of an explosion, no other injury would be occasioned; a few rods below this is a *Blacksmith's Shop,* in which a workman is constantly employed in making and repairing drills, and various other utensils; a few yards distant from this, is the *Upper Factory,* so called; northeast of this, is the brick boardinghouse, adjoining which is the *Counting House*; directly opposite this, is the lodging house of the workmen. Descending the hill still farther (about ten rods distant) is another *Factory,* which is 267 feet long, and 94 wide, including the packing apartment; the two factories contain ten leaden vats, the average size is 10 feet by 12, and 21 inches in depth. In the southern part of the works are several temporary buildings, erected for the preservation of the copperas (sulphate of iron).
>
> The ore, by the following process, is converted into copperas: First with the use of a drill, a perforation is made from 10 to 30 inches in depth, and by means of powder large portions are separated from the fodina, which are broken into small pieces and conveyed to a suitable spot, until a sufficient quantity is accumulated for a *heap,* which in the space of a few days will ignite spontaneously. In this condition it remains burning without cessation for about two months, which mostly consumes or expels the sulphur with which the pyritous rock is saturated. Sometimes the heaps are set on fire by the workmen to hasten process, and entirely pulverizes the integral heap. The surrounding objects wear a sterile and deleterious appearance, but the health of the workmen is completely preserved. From these disintegrated heaps the pyrites is thrown upon leaches, and the lye [liquor] drawn into reservoirs, from thence into leaden vats. Lead is the only metal which endures the operation of the liquid. The lye is boiled in these vats until it arrives at a proper degree of strength, when it is drawn off into wooden vats, where it remains for crystalization, upon the sides, and the boughs of trees, which were formerly thrown into it to form crystals upon, but of late an improvement has been introduced—a stick of wood, about 6 feet long and 2 inches in diameter, through which at proper distances holes are bored, and small sticks inserted about 18 inches in length and 3/4 of an inch in circumference, on which the crystals formed much larger and has occasioned the entire abandonment of the old method. The crystals are somewhat quadrangular, and in color a beautiful transparent green (anon., *Columbian Centinel* December 1, 1827:1).

In 1835, the copperas works were described in *Niles Weekly Register:*

> The copperas mines of Strafford, in Vermont, are owned and worked by a company of individuals in Boston. The drift or excavation which was made to reach the ore, has been pushed into the side of the hill to the distance of seven or eight hundred feet, and a rail road has been laid to the extremity of the drift for the purpose of bringing out the ore. After the ore has been blasted, the following process is pursued:
>
> The most valuable portion of it which contains a large amount of copper, is selected and carried off to the copper furnaces–situated a short distance from the hill. The remainder is broken into small pieces; large quantities of water are then pumped on the heap, which causes the ore to slack. The water passing through becomes highly impregnated with copperas, and at the bottom of the hill is received into drains which convey it into reservoirs. From there it is let off into the furnace boilers; when sufficiently heated it is again let off into vats called coolers, and from there it passes into other vats where the process of crystalization takes place. Rods having pins of a bout a foot in length stuck in them, are laid across the vats, and around those pins the copperas collects in large crystals of a bright color. When fresh from the vats they have an exceedingly beautiful appearance. Nearly 1,000 tons of copperas are annually attained by one of the establishments (*Niles Weekly Register* 1835:395).

[This is the first mention of a cooling step between boiling and crystallizing. The addition of a separate cooler may likely conserved fuel by allowing boiler temperature to be maintained, and also allowed settling of impurities (see below)].

In 1842, Zadock Thompson, in his *History of Vermont*, described the copperas works:

> Strafford Copperas Works. . . . There are 2 factories, each about 267 ft. in length by 94 in width. These contain 8 vats made of lead, 10 ft. by 12 ft., 21 inches in depth and three fourths of an inch in thickness, used for boilers. Lead is the only metal that will endure the operation of the copperas liquor, and this requires constant repair. . . . The process of making [copperas] is as follows. The ore is blasted from the bed by means of powder. It is then broken into pieces with sledges, and afterwards the miners sort and break it up still finer with hammers. It is then thrown into large heaps, where it ignites spontaneously, or fire is sometimes set to it to hasten the process. In this condition it generally burns for the space of two months; in that time the sulphur is converted into sulphuric acid, and unites itself with the iron, forming sulphate of iron, or copperas. . . . These heaps of pyrites, being now thoroughly pulverized by fire, are carried to places where water, from a fountain on the summit of the hill, is made to run upon and leach this mass of crude sulphate of iron. The lye is now drawn off into large wooden reservoirs, and thence into the leaden vats as fast as wanted. In these vats the lye or liquor is boiled to a certain strength, tested by acidimeters, and then drained off into wooden vats, where it remains to crystalize. Branches of trees were formerly thrown in for the crystals to adhere to; but Mr. Reynolds, the present agent, has made an improvement. Pieces of joist 3 inches square, 6 ft. long, laid across the top of the vats, with holes bored, and round sticks 18 inches long by 3/4 of an inch in diameter, inserted at intervals of about 6 inches, are now used with great advantage. This makes a great saving of labor, although it has in some measure destroyed the fanciful shapes which the crystals formerly assumed upon some favorite branch. . . . The crystals are multiangular, and of a beautiful transparent green color. . . . After crystalization takes place the liquor is drained off, and the copperas is shoveled into the packing rooms. When dry it is usually put into casks holding about half a ton each, but frequently into casks of every size (Thompson 1842:167–168).

[Labor costs were clearly a concern, addressed by addition of the crystallizing dowels which apparently made harvesting the finished product a more efficient affair].

In 1844, geologist Charles T. Jackson made the following observations at the copperas works (Figure 3-8):

> [At Strafford] not only the inexhaustible quantity and purity of the ore, but its situation also give unusual facilities for the manufacture of the copperas. The vein is worked to the open air - large blocks of ore being blasted out and with sledges broken to the size of an egg. These fragments are then removed a little down hill and formed into an immense conical heap, in which air and moisture sustain a smothered combustion, which has been only commenced by wood fuel and which, if not checked by an excess of water, would be sufficient to drive off the sulphur, and to vitrify the mass. In this process, the water flows from a higher level to the top of the heap, and the only inconvenience attending the manufacture is the limited supply of water in dry weather. In this process, by the oxygen of the air, the sulphur is converted into sulphuric acid (oil of vitriol), and the iron into oxide of iron, which, combining together, constitute copperas. This, being soluble in water, is leached out by the stream of water, and the lye runs down into a vat, in which it is concentrated. It is then drawn down into other vats for crystalization. Stalactites of copperas are seen pendant from the troughs, and, with the exception of the green tinge, exactly resemble icicles - a singular spectacle in the heat of summer (Adams 1845:56).

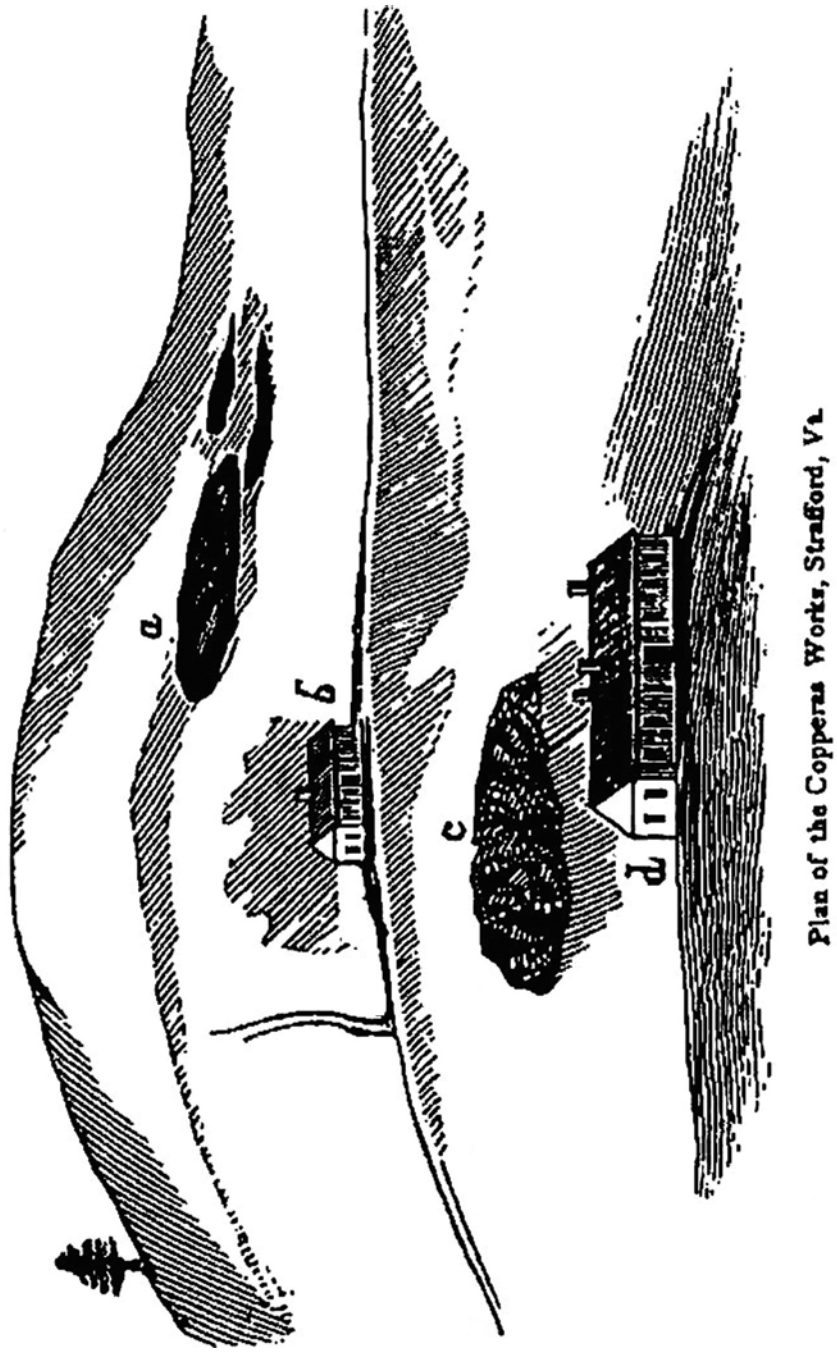

Figure 3-8. Sketch of the Copperas Works, Strafford, Vermont: *a* indicates the mine, *b* the cobbing shed, *c* the roasting heaps and *d* the factory (Source: Adams 1845).

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> The 1850 U.S. Census of Manufacturers indicated that the Vermont Copperas Company was making a variety of products. Annual production included 4,000 tons of copperas with a value of $10,000, 1 ton of alum with a value of $20.00, and 4 tons of paint with a value of $4,000. The production figure of 4,000 tons of copperas appears anomalous, representing a twofold increase over previous figures, with no documentation of corresponding factory expansion. According to the census, the company used both manual labor and waterpower (U.S. Census of Manufacturers 1850). The 1860 census lists only 400 tons of annual copperas production worth $3,480 and 60 tons of copper worth $24,000 (U.S. Census of Manufacturers 1860).

In 1861, Edward Hitchcock, in his *Report on the Geology of Vermont*, reported:

> The process consists in first raising the ore from the bed, which is principally done with the help of gunpowder. The blocks of ore are then broken up into small pieces to facilitate the decomposition, by suffering the oxygen contained in water and the atmosphere to come more directly in contact with the material composing the ore. Large heaps of these pieces, called leaches, are made upon a tight plank bottom, or upon a sloping ledge of solid rock, where the liquor or lye that subsequently runs from them may be saved.
>
> In dry weather, a small stream of water is made to flow upon, and penetrate these leaches, in order to produce a spontaneous combustion, which in warm weather commences in a few days, and if properly managed will continue several weeks. When combustion is taking place, great care is requisite in order to have the work go on successfully, for if too much water is suffered to penetrate the leach or heap, the decomposition is checked by the reduction of temperature, and the lye or liquor issuing from it is too weak to be valuable; and if there is not water enough put on the leach, the decomposition is also arrested by the absence of the oxygen found in the water, which is necessary to convert the sulphurous acid into the sulphuric, that sulphate of iron or copperas may be produced.
>
> The liquor that runs from the leaches is collected in reservoirs, from which it can be taken at pleasure. Below the reservoirs upon the hillside, buildings are erected, called evaporators, to which the liquor is conducted in troughs from the reservoirs in small streams, that are divided and subdivided by means of perforated troughs, brush, etc. Several tiers of brush are arranged in the building, through which the liquor is made to pass to facilitate the process of evaporation. In dry, windy weather, the evaporation is oftentimes so rapid that the brush and other substances with which the liquor comes in contact during the latter part of its journey, often have an incrustation of copperas formed upon them; but upon the return of rainy weather, the humid atmosphere checks the evaporation, and the crust of copperas is dissolved and passes with the liquor into reservoirs prepared to receive it.

[Addition of the evaporator towers took advantage of the natural process of evaporation to remove water from the copperas liquor, increasing its acidity (lowering its pH) without expending fuel, which in turn conserved energy by slightly reducing fuel consumption in the first, boiling phase of the factory process].

> The liquor which is now very strongly impregnated with copperas, is conducted into leaden boilers, where heat is applied and the liquor reduced to a strength indicated by the acidimeter to be right for the production of copperas. The liquor is then placed in vats of lead or of brick and water cement, called crystalizers, and after remaining from eight to ten days, a crust of copperas is formed upon the bottom and sides of the vats, composed of nicely formed crystals. The water remaining in the crystalizers is then pumped back into the boilers, the crust of copperas removed, and, after being sufficiently drained, it is packed in casks ready for market (Hitchcock 1861:829–832).

[Use of an acidimeter (acid hydrometer) to measure the specific gravity (density), and therefore, pH of the acid indicates that the operators had adopted standardized industrial chemical apparatus to measure the quality of their process liquor. The lead or cement lining for the insides of the crystallizers is very likely common to the previous descriptions; mention of "wood" vessels in previous descriptions may refer to exterior sheathing of the brick structure].

The 1870 U.S. Census of Manufacturers includes data for the copperas works, then owned by the New England Chemical Company. It indicates annual production of 500 tons of copperas worth $7,750 (U.S. Census of Manufacturers 1870).

The last detailed account of the copperas works appeared in Hemenway's 1871 *Vermont Historical Gazetteer*. The works as described are probably close in configuration to the works as depicted on the 1874 Vermont Copperas Company map (Figure 3-9). This is perhaps the most detailed description, and contains information about the preparation of the roast bed and heap leaching ground surface:

> The copperas works of the New England Chemical Co. . . . may be briefly described to consist of a prepared bed or bottom upon which the ore is burnt and leached. This bed is upon the hillside just below the vein. It is prepared by simply scraping the earth clean from the ledge and stopping all the seams and fissures in the ledge with moistened clay. The bed so prepared is nearly an acre in extent and is called the leaching ground. On the lower side of the leaching ground a trench has been dug in the ledge and this trench is connected, by means of spouts, with four large reservoirs near by, holding 20 hogsheads each. Still further below are two high sheds, open at the sides, with loose floors and each floor filled with brushwood these are called Evaporators. Upon a level spot below are the two factories of the Company, each 110 feet in length by 25 feet in width. These factories contain the evaporating pans, two pans in each factory, each pan being 26 feet long by 10 feet wide, and 16 inches deep. They are made of very heavy lead 1/4 inch in thickness. Lead is the only cheap metal which is not quickly destroyed by the action of the copperas. Beneath the evaporating pans run a series of flues, commencing at the fire arches at one end of the pans and terminating in the stack at the other end. There are also two lead coolers and 20 cemented brick crystalizers in each factory, each crystalizer being 14 feet by 7 feet by 18 inches deep. Directly beneath the crystalizers is the packing room.

The process of manufacturing copperas is described as follows:

> The ore is blasted from the vein, broken up so that it can be easily handled, wheeled to the sheds by means of handcars where it is again broken into pieces the size of large apples; it is then shoveled into cars again and run out upon the leaching ground and placed in large heaps containing from 500 to 3000 tons each. A quantity of wood is placed under one side of the heap and set on fire. The heat of the burning wood raises the temperature of the ore, so that the sulphur is ignited, and by degrees the whole mass is heated, the interior portions often red-hot. Great care is exercised in burning, to prevent the heap from being overheated, as in that case the iron of the ore would be melted and run into large solid masses and the sulphur would be driven into the atmosphere as sulphurous acid gas. To prevent this, a stream of water is applied at frequent intervals to cool the burning ore, but not enough to put out the fire. In this way a large heap will burn during four months, and frequently after it has been thoroughly drenched with water and has shown no signs of fire for six months, it will be ignited by spontaneous combustion and burn again with great vigor, when it is again treated with water as before. The object of the burning is simply to oxidize and decompose the ore. The oxygen from the water and the air striking upon the heated ore forms a weak sulphuric acid, which acts upon the iron of the ore and thus sulphate of iron in its crude state is formed in the heaps. A heap, if properly burned, will in a year's time become thoroughly decomposed and ready for leaching.

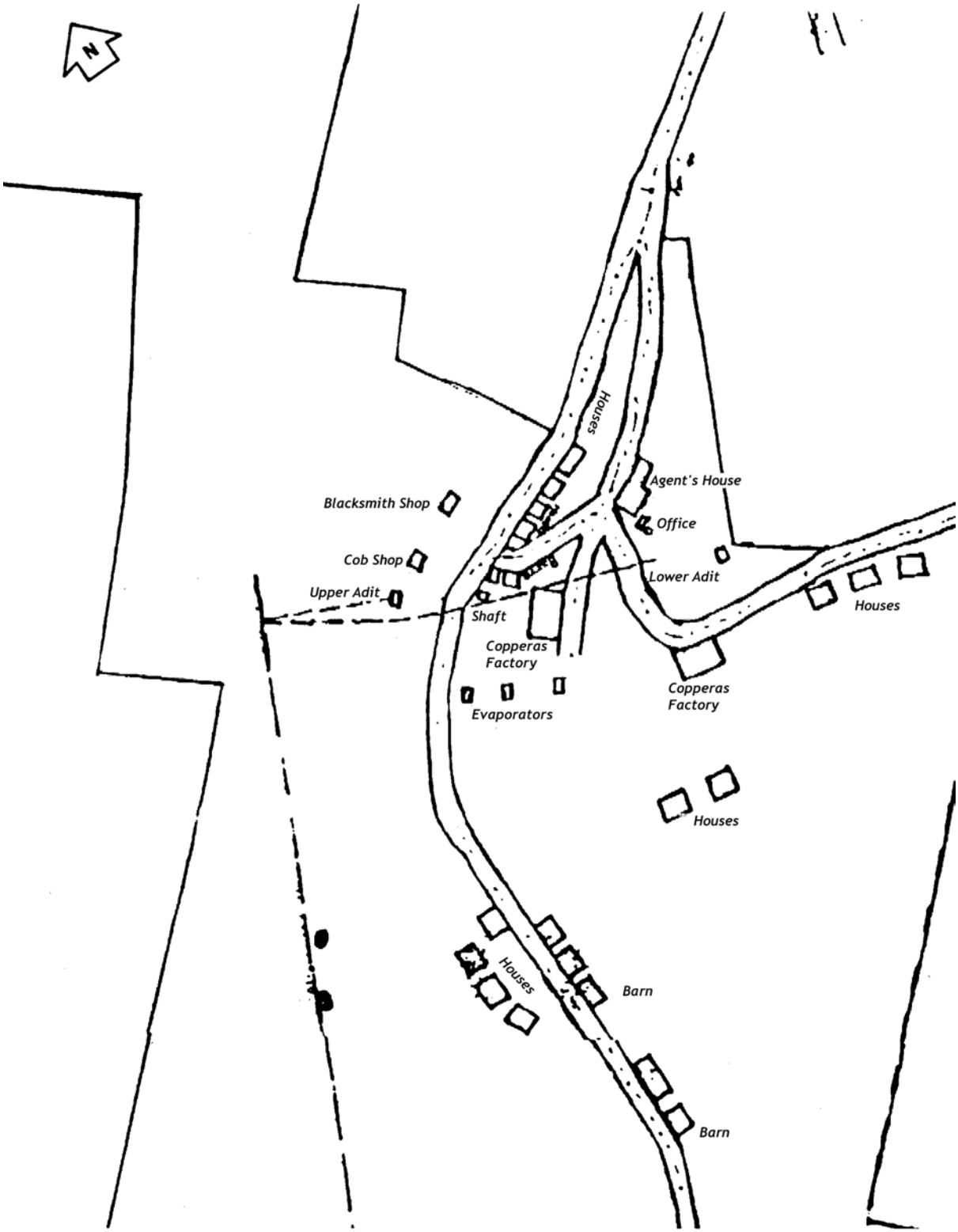

Figure 3-9. Detail showing Copperas Works, from Plan of Property of The Vermont Copperas Co., Copperas Hill (South Strafford), VT, 1874.

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> The process of leaching and evaporating has for its sole object the conversion of the crude copperas, as it exists in the heaps, into the beautiful green crystals, as found in the packing room, when ready for market. To accomplish this, a small stream of water is run upon the heaps and so directed as slowly to soak into and saturate the whole mass of decomposed ore. When the ore can contain no more moisture, the water settles to the bottom of the heap, falls upon the prepared surface, runs into the trench below and is conducted to the reservoirs near by. It is now called copperas liquor and its specific gravity or strength is measured by hydrometers manufactured for this purpose. The liquor generally shows a density of from 10º to 20º, water being 0º, and this density, as ascertained by the hydrometer, shows its strength or goodness. This liquor is crude sulphate of iron in a liquid state. After being allowed to stand and settle in the reservoirs two or three days, it is conveyed in spouts to the top of the evaporators, where it is run over a surface so arranged that it is sprinkled in drops through the brush of the successive stories and by this expedient a portion of the water is taken out by the influence of the sun and air. On a clear summer's day, the liquor will be increased from 3º to 5º in strength, in passing through these two sheds. From the lower evaporator the liquor passes directly to the factories where it is received in large reservoirs, whence it is drawn into the evaporating pans as needed. In these pans it is boiled down till it reaches the strength of 35º when it is drawn into the lead coolers and there allowed to stand two or three hours in order to settle any impurities which may still remain. When quite cool it is passed into the cemented crystalizers. Here it usually remains a week, during which time the process of crystalization takes place. The liquor of crystalization is then drained off and pumped into the evaporating pans, where it mingles with the fresh liquor. This process is repeated with the liquor of crystalization ad infinitum.

[10 degrees Baume (Be) approximates the pH of a dilute sulfuric acid; 20 degrees approaches the pH of a dilute hydrochloric acid. Fresh sulfuric battery acid measures 34 degrees Be. Acid of this strength will corrode and quickly degrade organic materials such as cloth, leather and wood. Settling impurities from the liquor resulted in a greater quantity of clean, marketable product].

> The crystals of copperas are deposited in a thick, heavy coating on the sides and bottoms of the crystalizers; this coating is frequently 5 inches in thickness. The appearance of the interior of the crystalizers, after the liquor has been drained off and before the crystals have been disturbed, is extremely beautiful. The crystals are of a brilliant, transparent, emerald green, assuming various forms and sizes - some are spear-like and sharp as needles, while others assume the shape of German letters and fanciful devices. The figures formed on the bottom of the crystalizers by the grouping and arrangement of the crystals afford a beautiful and interesting study. One of the more common forms observed is that of perfectly defined rosettes of various sizes, raised an inch or two above the surrounding level. Sometimes these bottoms are broken up into regular successions of little rippling waves, as when a lake is agitated by a gentle breeze. The copperas is broken from the sides and bottoms of the crystalizers and shoveled down into the packing-room below. It is packed in strong casks holding 2000 lbs. and 500 lbs. each. In this state it is shipped to Pompanoosuc Station, on the Connecticut and Passumpsic Rivers Rail Road 10 miles from Copperas Hill, whence the larger portion is sent to Boston and there sold (Duncan 1871:1085–1088).

Post-1882 Activity and Site Conditions

After the Vermont Copperas Company works were deeded to the Strafford Mining Company in 1882 operations ceased in the face of competition from new sources (Abbott *GMC* 1964:273–276). Only two photographs of the copperas works area have been located to date. A ca. 1880s view in the collection of the Strafford Historical Society shows the Upper Factory looking west from Mine Road (Figure 3-10). This photograph shows the large barn-like Upper Factory building, which is missing some of its vertical

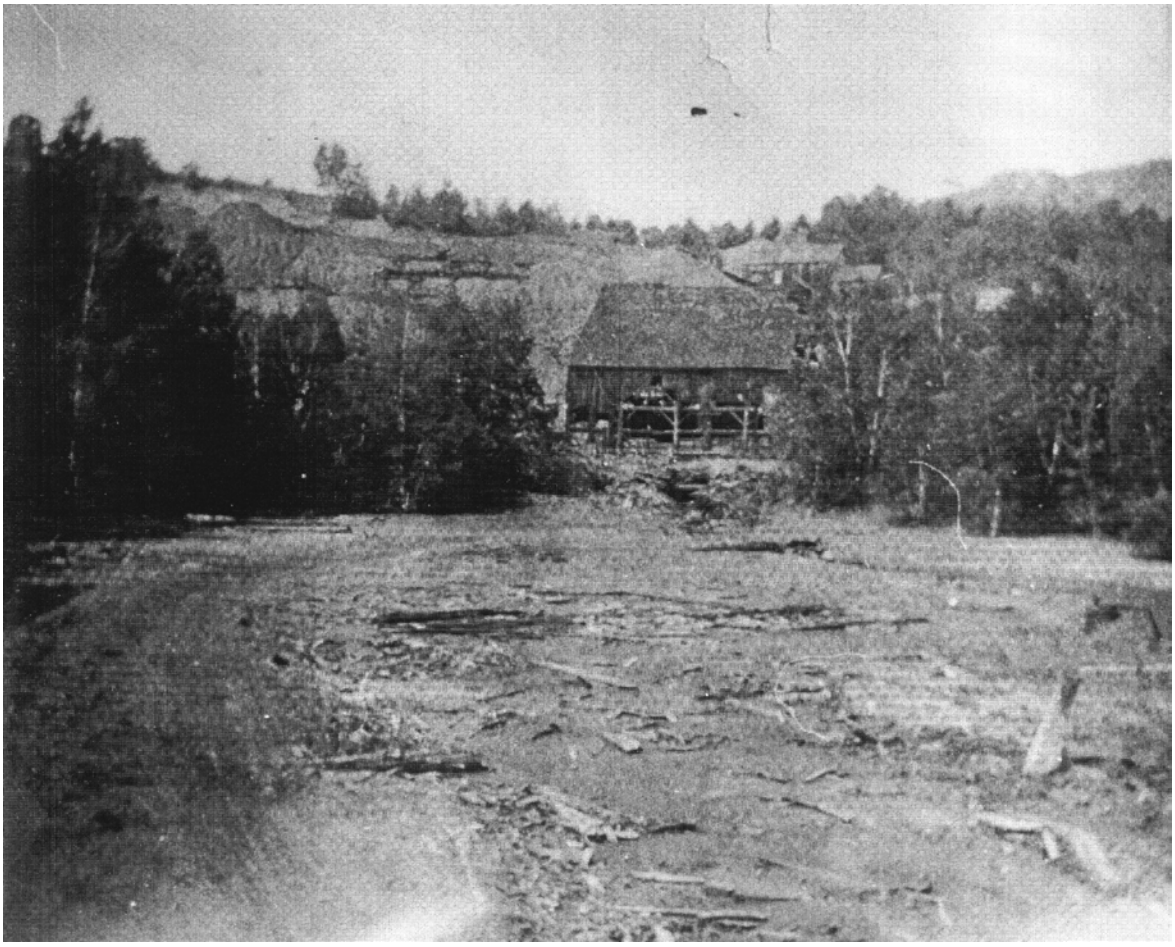

Figure 3-10. Photograph of Copperas Works, looking west, showing the Upper factory ca. 1880s (Source: Strafford Historical Society).

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plank siding. Buildings at the Upper Adit/Cob Shop/Blacksmith Shop site are visible to the northwest above the factory to the west of Copperas Road. The slope below the North Open Cut is open, and contains conical piles of eroded mine waste and indistinct dark horizontal lines west of Copperas Road. The gully containing Copperas Brook extends below the Upper Factory. The area east and west of the bend in Mine Road containing the original Copperas Brook banks and channel is already filled with sediments and wood debris, and a short bridge spans the brook below the factory.

The other photograph was taken in the 1920s and shows the TP 3 hillside above the Upper Factory, including partially collapsed, corral-like timber structures for holding ore roasting or leaching piles (Figure 3-11) (Smith 1927). This photograph indicates that open-cast copperas ore mining activity had extended the full length of the surface exposure of the orebody by 1882, and that over the 73 years of copperas operations, including the disposal of waste and roasting and leaching operations, the entire hillside was utilized, leaving the extent of the barren landscape largely as it appeared in modern times.

In the approximately 130 years after copperas production ceased about 1884, the piles of associated mine waste rock and ore leach piles and roast beds across the steep open TP 3 hillside remained largely barren, and the landscape was further impacted by new cycles of mining activity and subsequent erosion. In the 1880s copper mining activity conducted at the north end of TP 3 by the Tyson family contributed to the further alteration of the landscape in and below that area of activity. In the early 1950s the Vermont Copper Company, Inc. mined out the remaining ore in both the South Open Cut and North Open Cut to increase production. The North Open cut was mined out to its present depth, requiring road construction across the upper slope of TP 3 and deposition of large volumes of barren waste rock in the area below. The original Copperas Road across the middle of the TP 3 slope was a historic road that was kept open since the mine closed in 1958 for private access for logging by the property owner. The road cut across an unstable slope and was rebuilt and repaired with fill brought in from elsewhere on site. The road embankment was full of mid- twentieth-century mine-related debris, including dishware, drill core segments, electrical equipment, rubber hoses, etc. that were visible in the eroded area below the roadway all the way down slope to the Upper Factory. Groundwater continued to chemically leach and alter the soils and waste material and physically move and redeposit it in flatter areas at lower elevations down the hillside. The headwaters of Copperas Brook carved a gully through the steep area at the south side of the Upper Factory, and deposited fine-grained mine waste across the flatter area below. A trench in the sediment filling the Copperas Brook channel west of Mine Road was excavated to control drainage at least once in the last ten years (Cherau et al. 2003:71-72, 89).

Copperas Manufacture in England

The existence of copperas manufacturing works operating in Great Britain in the sixteenth through twentieth centuries has been documented. The only other copperas works known to have been investigated archaeologically is a seaside site in Tankerton, Whitstable, on the coast of Kent, England, which was excavated by Tim Allen and Geoffrey Pike of the Canterbury Archaeological Trust in 1999. The following excerpts from Allen's work on the earlier British industry and Tankerton site inform and complement the historical information on the industry and process presented above (Allen 2002).

According to Allen, "Copperas manufacture was wholly unlike the traditional, small-scale chemical industries of the medieval and early modern period such as brewing and baking. It was heavily capitalised. It required huge investment in plant and materials; and the chemical took four years to produce. Such investment required a financial return, and profits were consequently high." Allen states that "The copperas industry in the south of England prospered mightily and by 1764 England was the principal European producer, exporting over 2,000 tons annually in the 1780s."

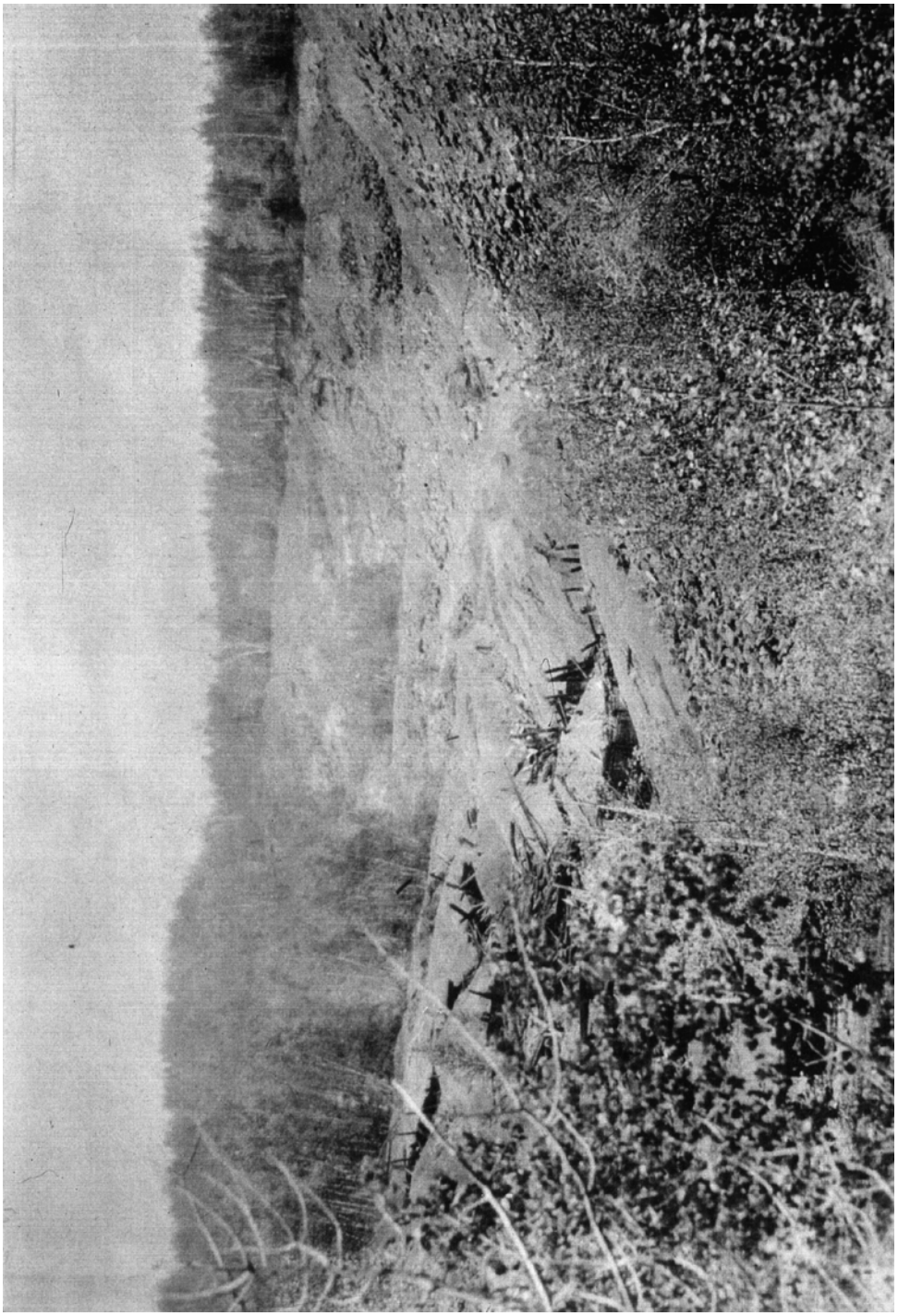

Figure 3-11. Photograph of Copperas Works, looking south, showing TP 3 hillside, ca. 1927 (Source: Smith 1927, Collamer Abbott Collection, University of Vermont, Bailey- Howe Special Collections Library, Burlington, VT).

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Allen provides a description of the “dangerous, complicated and highly noxious industrial process” involved in early copperas manufacturing:

> A combination of water and air has a remarkable chemical effect on the metallic fossils known as copperas stones. If you pick one up, wet, and put it in your pocket, it will have burned a hole in the material within three hours. It will be hot to the touch.
>
> This natural chemical reaction formed the first part of the copperas manufacturing process in the 16th-18th centuries. Copperas stones (FeS2) were collected and placed in troughs on the foreshore. There the stones, washed by the sea, would oxidise and be colonised by bacteria. After about four years, they produced 'liquor' - a dilute solution of hydrated ferrous sulphate (FeSO4.7H2O) and sulphuric acid (H2SO4), which flowed via a planked channel to a cistern.
> The Deptford cistern of chalk-caulked oak boards was subdivided to reduce loss from leaks. One Whitstable cistern measured 15 feet by 6 feet, one measured 80 feet by 9 feet and one 60 feet by 9 feet. However, in the earliest Whitstable works, liquor was pumped into '18 greate butts', probably sunk into the ground as shown in a print in the German writer Agricola's De Re Metallica (1556). At Queenborough, the liquor was conveyed to old barrels, then to 'a great tub'.
> From the tub or cistern, the liquor was taken to a boiler where the liquid was concentrated and reduced. At Deptford, the boiler measured 8 feet square and at Whitstable one measured 12 feet square. The copperas boiler was raised above one or more furnaces by a grid of iron bars suspended between brick walls. The boiling process, fuelled using Newcastle or Sunderland coal, lasted about 20 days and required immense quantities of coal. The Queenborough works consumed 300 tons annually up to 1640, and Whitstable received about 13,250 tons of coal yearly from Sunderland in the late 18th century.
>
> About 100lb of scrap iron was placed in the boiler before the introduction of the liquor and a further 1,500lb was added later, along with more liquor to stop the boiling solution becoming too dense and acidic and melting the boiler. The reason for adding iron was to convert the sulphuric acid (H2SO4), condensed through the boiling process, into copperas (FeSO4).
>
> The strength of the liquor was tested by pouring small quantities into a small pan and observing how long it took to crystallise. When sufficiently concentrated, the liquor was conducted into a cooler [cooler/crystallizer], where it remained for about 14 days. The coolers often contained rods or branches to increase the surface area on which the liquor could crystallise.
>
> The 17th century writer Cecilia Fiennes, in The Journey of Cecilia Fiennes 1685-1696, describes the process as follows: 'They place iron spikes in the panns full of branches so, as the liquid boyles to a candy, it hangs on these branches. I saw some taken up. It look't like a vast bunch of grapes, the coulleur of the Copperace not being much differing . . .'
>
> Although usually of lead, in Deptford the cooler was made of tarras, a cement which, like lead, did not dissolve in the acidic solution.
>
> Crystallised copperas in the cooler, or shaken from the rods, was shovelled onto a board, allowing any excess liquor to drain into a second cooler, along with any liquor left in the first cooler, for later reboiling. Saleable copperas was shipped in barrels weighing roughly half a ton.

In addition to the Fiennes source, Allen also draws the process information above from “An Account of the Way of Making English Green-Copperas,” from a late seventeenth-century volume of the *Philosophical Transactions* of the Royal Society (Colwall 1678: 1056-1059). This account contains

additional details associated with the copperas process and equipment at Deptford, England, that are relevant to the interpretation of the South Strafford operation:

> …the liquor is pumped into a boiler of lead, about eight feet square, containing about twelve tons, which is thus ordered. First they lay long pieces of cast iron, twelve inches square, as long as the breadth of the boiler, about twelve inches from one another, and twenty four inches above the surface of the fire. Then crosswise they lay ordinary flat iron bars, as close as they can lie, the sides being made up with brickwork. In the middle of the bottom of this boiler is laid a trough of lead, wherein they put a hundredweight of old iron. The fuel for boiling is Newcastle coals (Colwall 1678: 1058).

[This suggests that the heat of combustion flowed longitudinally from a firebox, between the uneven bottom formed by the long 1 ft square iron bars, and up a draft flue, forming separated bands of hot gas that heated the iron straps and lead copperas liquor trough above. The shape of the trough and area and degree of surface contact with the iron strap boiler floor is unknown. Heat transfer would have been irregular and poor. Coal was likely used because, unlike New England, wood was in short supply. Use of coal, which burns hotter than wood, indicates the need for careful fire tending and temperature control to keep the trough below the 621.4 degree farenheit melting point of lead].

The boiling process was time- and energy-consuming. At Deptford, the boilers incorporated a component to pre-heat the copperas liquor and hasten the boiling:

> By degrees, is the boiling, they put in more iron, amounting in all to fifteen hundred pound weight in a boiling. As the liquor wastes in boiling, they pump in fresh liquor into the boiler. Whereby, and by a decent ordering of the fire, they were wont to be above twenty days before it was enough… But now of late by the ingenious contrivance of Sir Nicholas Crisp, the work is much facilitated. For at his work at Deptford, they boil off three boilers of ordinary liquor in one week. Which is done, first by ordering the furnace so, as that the heat is conveyed to all parts of the bottom and sides of the furnace. Then whereas they were wont to pump cold liquor into the boiler to supply the waste in boiling, whereby the boiler was checked sometimes ten hours: Sir Nicholas hath now a vessel of lead, which he calls a heater, placed at the end of the boiler, and a little higher, supported by bars of iron as before, and filled with liquor, which by a conveyance of heat from the furnace, is kept near boiling hot, and so continually supplies the waste of the boiler, without hindering the boiling (Colwall 1678: 1058-1059).

[The phrase "ordering the furnace so, as that the heat is conveyed to all parts of the bottom and sides of the furnace" suggests that the internal configuration of the furnace and therefore heat distribution may have been improved from the one described earlier. Use of a preliminary heater at South Strafford to hold hot liquor for recharging the boiler is not mentioned in the historical accounts above; however, the word "heater" does appear in the copperas company correspondence (see below)].

According to the Colwall account, the boiling process had to be carefully controlled by the addition of additional scrap iron during the boil:

> Thirdly, by putting in due proportions of iron from time to time, into the boiler. As soon as they perceive the liquor to boil slowly, they put in more iron, which will soon quicken it. Besides, if they do not continually supply the boiling liquor with iron, the copperas will gather to the bottom of the boiler and melt. And so it will do, if the liquor be not presently drawn off from the boiler into a cooler, so soon as it is enough…Copperas may be boiled without iron, but with difficulty. Without it, the boiler will be in danger of melting (Colwall 1678: 1058-1059).

[Clearly the boiling operation was not as simple as boiling water. The density (strength) of the acid liquor had to be monitored and regulated, taking into account the variables of temperature, dilution from fresh and recycled spent liquor, and addition and dissolving of scrap iron, in order to make liquor of the proper strength, and without damaging the lead vessel. The use of a pre-heater and the need to draw off the copperas liquor when it had reached a certain density to protect the bottom of the trough from burning out from solidifying copperas deposits suggest that the process could have been a continuous one involving a liquor density gradient across the boiler trough, as is the practice in maple sugar pan operation, but the phrase "if the liquor be not presently drawn off from the boiler into a cooler, so soon as it is enough" suggests a carefully monitored batch process using less sophisticated apparatus].

The Deptford works also recycled the spent copperas liquor for later reuse. After the copperas crystallized, "…they convey the liquor into another cooler [cooler/crystallizer], and reserve it to be boiled again with new liquor (Colwall 1678: 1059).

Additional South Strafford Operations Information

Just prior to completion of this report additional information regarding the South Strafford copperas works came to light in the form of handwritten notes transcribed from the "Nash Papers" at the Rauner Special Collections Library at Dartmouth College, Hanover, NH by Vermont mine historian Collamer Abbott in the 1970s and 1980s (Abbott n.d.). According to Abbott's notes from 1993 (1998?), the "Nash Papers" may no longer be in the Dartmouth collection. PAL contacted the Rauner Special Collections Library staff; they were unable to locate these papers. Abbott's transcriptions include information on copperas works activities, employment and production taken from records of the Strafford Mining Company, Vermont Copperas Company and the New England Chemical Co. including payroll records, letter books, daybooks, production figures, and expenditures. The records and correspondence include names of mine agents such as J.W. Cleaveland, William H Foster, and George. B., James B., and William. B. Reynolds. The notes also include selections from period newspaper articles associated with the mine, mostly from the Bradford or National Opinion, Bradford, VT. The original sources date from approximately 1860 to 1885, with significant gaps. The notes contain numerous monthly and scattered annual figures for quantities of copperas manufactured, stored and shipped; employment and payroll; number of copperas liquor "boils" per month, cords of wood consumed, etc. for the years 1863-1864, 1872-1877, and 1882-1885. Statistical analysis of the production-related information was unfortunately outside the time constraints for completion of this report. Some of the information regarding business conditions, factories, equipment and process are included below. Some refinements to production indications in Figure 3-6 were made as appropriate.

On December 12, 1879, an article in the *Bradford* Opinion stated that in 1822 the works made 100 tons of copperas, and that in 1823 it made 158 tons (Abbott n.d.: 198) (see Figure 3-6).

In a March 6, 1863, letter to William B. Reynolds, James B. Reynolds reported that in 1857, 483.8 tons of copperas were imported into the U.S, equally split between the ports of Boston and New York City (Abbott n.d.: 75). (James B. Reynolds had been the Vermont Copperas Company manager of the mine for 40 years as reported in 1854, and still held that position in 1861. The Reynolds brothers, including William B. and George B. were all involved in copper and copperas production at the mine during the mid-nineteenth century (Abbott n.d.: 75).

In a March 11, 1863 letter to a "Henry," James B. Reynolds stated that there were two factories, and that the "new" factory "will be put in order for boiling." It is known that there were two factories at this time (see accounts above). It is unclear if the "new" factory is a completely new structure or one rebuilt or reequipped with new vessels on the footprint of an old one. The March date for the start of boiling

indicates the seasonal nature of the operation. In a March 11, 1863 letter to W.H. Clayton, George B. Reynolds indicated that they “do not plan to build new factory this season” (Abbott n.d.: 75).

In a March 12, 1863 letter to William B. Reynolds, James B. Reynolds indicated they had “set lead kettles for making the boilers" (Abbott n.d.: 75). This indicates use of the pre-production down time to repair or rebuild the boiler linings, and that some sort of specialized lead kettle or melter was used for the purpose.

In a March 20, 1863 letter to William B. Reynolds, James B. Reynolds reported that copperas imports into the U.S. in the ten months between June 1860 and March 1861 totaled 1,996 tons, with 1,965 tons “under ad valorem duty,” and 30.5 “under specific duty.” This copperas was valued at 50 cents per 100 lbs ($10.00 per ton). James asked "Would it not be good to put up another factory. Above amount is more than we ever made in one year” (Abbott n.d.: 76).

In a March 28, 1863 letter to William B. Reynolds, James B. Reynolds reported that they had “Made boilers, heaters, & coolers of new factory. Commenced running on water for making liquor. Hope to have copperas for market by April 20” (Abbott n.d.: 76). It is unclear if the “new” factory is a completely new structure or one rebuilt or reequipped with new vessels on the footprint of an old one. This also indicates use of the pre-production down time to repair or rebuild the boiler linings. The inclusion of the word “heater” suggests that the boiler included a compartment to pre-heat the copperas liquor, possibly similar to, and for the same reasons as the coopers described in the Colwall account of the seventeenth-century Deptford, England works. The March 28 date for the startup of leaching ore for raw liquor on the hillside above the factory indicates the seasonal nature of manufacturing operations.

In an April 2, 1863 letter to William B. Reynolds, James B. Reynolds reported that in 1860 they had made 540 tons of copperas, and in the 1861 “season” they made 405 tons. These figures are consistent with the 400 tons for 1860 reported by (and presumably to) the U.S. Census of Manufactures (see above). It took 1,136 cords of wood to make 930 tons of copperas (.81 cords per ton). According to James Reynolds, they were “Running water on the heap. Ready to make crystallizers. May begin to boil by 10th April” The following day, he reported “Liquor coming out of ore heap.” The next day he reported that they had “placed spouts to carry liquor to factory. To clean boilers and heaters in old factory.” On April 7, he reported that they were to “Begin to boil tomorrow in both factories before we make copperas. Have to make "mother liquor" first in both factories” (Abbott n.d. 76-77). These reports indicate that the various copperas vessels were periodically rebuilt or serviced. Raw leached liquor was conveyed from the collection and settling cisterns into the factory by means of ‘spouts,” possibly wood or metal troughs.

In a November 10, 1863 letter to William B. Reynolds, James B. Reynolds, they reported they were “Putting No. 2 factory in condition for making copperas early in spring.” On November 17, James B. Reynolds reported that they had completed 675 boilings that season, and had made either 92.5 tons or 67.5 tons (writing unclear). In 1875, they reported making 441 boilings to make 375.5 tons. During the mid-1870s the works typically made copperas from mid to late April to early December. They shipped copperas year-round, in many dozens of whole or half hogsheads. The lbs-to-hogsheads ratios reported are inconsistent, making it difficult to exactly calculate annual tonnage shipped. The company typically kept from 500 to 700 tons of copperas on hand at any given time (Abbott n.d.: 99, 107-108).

On November 13, 1875, the *Bradford Opinion* reported that J.W. Cleaveland (New England Chemical Manufacturing Company), agent of mines, was ordered to build new copperas factory in the spring. According to the item, “That will make 3 large ones and will give farmers a chance to dispose of their wood at good price.” The works were reported to “Have been running night and day all summer & sold fast” (Abbott n.d.: 170). This suggests that a third factory may have been built somewhere at the bottom of Copperas Hill during the last decade of operations (Abbott n.d.: 170).

On November 23, 1878 the *Bradford Opinion* stated that the copperas season was about over, and that the works had made 1,200 tons that season (Abbott n.d: 188). That figure is 2.4 to 3 times higher than the 400 to 500 ton figures reported by (and presumably to) to the U.S. Census of Manufactures in 1860 and 1870, and much closer to the 1,500 to 1,600 tons per year reported in the various historical accounts between 1844 and 1854 (see Figure 3-6). This discrepancy is unclear; presumably orders would have been up during the Civil War and down after the Panic of 1873. The increased production may have been from a third factory, if one was ever built.

On November 1, 1879, the *Bradford Opinion* reported that the works shipped 84 tons of copperas shipped the previous month, with still more to go. At this point in the transcription, Abbott wrote "This don't look like closing out business, does it?" (Abbott n.d.: 195). This appears to be Abbott recording an editorial comment appearing in the article rather than his own editorial commentary (personal commentary is absent from the transcriptions); if so it appears to be a sarcastic editorial comment by the *Opinion* author refuting talk that the business was in decline. On June 18, the *Bradford Opinion* reported that the Copperas Mining Co. employed 50 hands and wanted more (Abbott n.d.: 200). The Strafford Mining Company payroll book for the period April 1882-April 1885 appears to indicate that $9.60 in wages were paid for copperas manufacturing in March, 1884, although copperas was not usually made until April. No payroll entries for "copperas" appear in the payroll book after that date (Abbott n.d.: 72).

The last chronological entry in Abbott's transcriptions that mentions copperas dates from February 21, 1885. In a letter to N.W. Hardy from William H. Foster (new proprietor, Strafford Mining Company), Foster indicates that they have "no clean copperas on hand, have about 2 tons of dirty copperas. Flour barrel holds about 300 lbs. Can deliver at Pomp(anoosuc) [depot] for $1.02 [sic?] per lb. Makes fine dressing for land [sic (lambs?)]. We use on our farm" (Abbott n.d.: 113-114).

CHAPTER FOUR

RESULTS OF DATA RECOVERY

This chapter presents the results of the 2009 and 2010 data recovery programs conducted in the Elizabeth Mine Copperas Factories Subsite. The 2009 field season work was conducted within the Upper Copperas Factory, Lower Copperas Factory, and the Inter-Copperas Factory areas. The 2010 field season continued work in and around the Upper Copperas Factory within the Copperas Brook Corridor and Pine Grove Area, approximately 100 feet (ft) west of the Upper Factory foundations identified by PAL during the 2002 survey.

The combined data recovery field investigations resulted in a total of 32 machine-assisted trenches, six machine-stripped areas, and seven hand excavated units (three 1-x-1-m; four 2-x-2-m) excavated during the data recovery program (Figure 4-1 [back pocket]; see Table 2-1). Activity areas and associated cultural features located in the testing areas were defined based on an examination of structural remains, stratigraphy, and the artifact assemblage. The 20 cultural features identified and investigated during the data recovery relate to the copperas works infrastructure and industrial manufacturing of copperas (Table 4-1). These features are described in detail below within each of the subsite testing areas. A total of 1,636 cultural materials was recovered from the Copperas Factories Subsite during the combined 2009 and 2010 data recovery fieldwork (see Appendix A)[3]. The artifacts include structural materials (e.g., brick, mortar, wood, nails, window glass); personal and household items (e.g., ceramic sherds, bottle glass, leather belt and shoe fragments, buckles, pipe bowls); and industrial items (e.g., metal tools, machine parts, and various iron hardware). Representative examples of artifacts recovered and/or exposed during the data recovery are included in Appendix B[4].

Table 4-1. Cultural Features Identified and Investigated During the Data Recovery Excavations, 2009 and 2010 Field Seasons, Elizabeth Mine Copperas Factories Subsite.

Feature #	Location / Testing Area	Depths Below Ground Surface	Description
FEA-1-UC	Upper Copperas Factory ST-1-UC	0-.33 ft	Soil stain
FEA-2-UC	Upper Copperas Factory TR-2-UC	2.7-3.14 ft *	Inclined planks
FEA-3-UC	Upper Copperas Factory TR-3-UC	.2-3.5 ft	Brick and mortar crystallizer remains
FEA-4-UC	Upper Copperas Factory TR-7-UC	1.2-6.3 ft	Brick-lined boiler fire arch
FEA-5-UC	Upper Copperas Factory ST-2-UC	.5 ft *	Brick and mortar flooring and collapsed sidewall of a possible crystallizer
FEA-6-UC	Upper Copperas Factory ST-1-UC	.6 to 3.7 ft *	Brick cooling vat remains
FEA-7-UC	Upper Copperas Factory	1.3 to 2.1 ft *	Stone and brick boiler remains

[3] These artifacts are temporarily curated at the PAL facility, Pawtucket, RI.

[4] The artifacts illustrated in Appendix B.1 are included in the Appendix A cultural material inventory. The objects illustrated in Appendix B.2 were recorded on site and reburied at or near their original locations, or removed to TP 1, during the remediation/capping activities.

Feature #	Location / Testing Area	Depths Below Ground Surface	Description
	ST-3-UC		
FEA-1-LC	Lower Copperas Factory ST-1-LC	CI 0-3 ft CII 1.5 ft * CIII 1.8 ft *	Brick boiler remains with charcoal staining and large iron artifacts
FEA-2-LC	Lower Copperas Factory ST-2-LC	CI .5-1.5 ft * CII .3 ft* CIII .5-.8 ft * CIV.3 ft * CV .2 ft * CVI 0-.3 *	Brick cooling vat remains and adjacent work area
FEA-3-LC	Lower Copperas Factory		Rooms within foundation absent of artifacts and structural remains
FEA-4-LC	Lower Copperas Factory ST-3-LC	CI 0-.8 ft CII .3 ft * CIII .2 ft *	Brick platform with concentration of iron artifacts
FEA-1-IC	Inter-Copperas Factory Area TR-1-IC	.2-1 ft	Cobble and wood staining (planks) – suspected subfloor and floor of temporary storage sheds
FEA-2-IC	Inter-Copperas Factory Area EU-1-IC	1.6 ft *	Cobble floor of temporary storage sheds
FEA-3-IC	Inter-Copperas Factory Area TR-2-IC and EU-3-IC	.7 to 1.1 ft	Cobble floor of temporary storage sheds
FEA-4-IC	Inter-Copperas Factory Area TR-4-IC	1.7 ft *	Brick boiler
FEA-1-BC	Copperas Brook Corridor TR-6-BC	0-2.3 ft *	Wood timbers in the brook
FEA-2-BC	Copperas Brook Corridor TR-6-BC	0-1.1 ft	Brick concentrations
FEA-3-BC	Copperas Brook Corridor TR-3-BC and TR-6-BC	.2-3.3 ft *	Schist stone wall
FEA-4-BC	Copperas Brook Corridor TR-4-BC	.8-1.6 ft *	Wood deck consisting of five planks
FEA-5-BC	Copperas Brook Corridor TR-3-BC	.3-2.3 ft *	Brick midden with charcoal and ash deposit
FEA-6-BC	Copperas Brook Corridor TR-4-BC	0-4 ft *	Two drylaid schist fieldstone walls (flanking FEA-4-BC)
FEA-7-BC	Copperas Brook Corridor TR-5-BC	.3-2.8 ft *	Brick and mortar crystallizer, with logs, beams, and floor planking
FEA-1-PG	Pine Grove TR-2-PG	1.7-3.6 ft *	Structural remains (beams, planks, log, large fieldstones) of probable barn

*Feature continues in depth beyond the limit of data recovery excavations.

Upper Copperas Factory

The Upper Copperas Factory is located approximately 570 ft (174 m) below the North Open Cut at the bottom of the hillside at the eastern extreme of TP 3, west of Mine Road. Excavations at the Upper Copperas Factory consisted of five trenches and three combined machine and hand stripped areas (Figure

4-2). The factory can be divided into three parallel north-south levels or "tiers" separated by north-south oriented stone walls. Two trenches (TR-1-UC and TR-3-UC) were placed in the middle tier, east of the standing internal drylaid fieldstone and tabular granite and quartzite block wall ("standing interior wall") and west of a less distinct collapsed stone wall to the east. One trench (TR-2-UC) was placed on the lower tier, east of the collapsed east wall. Two trenches (TR-11-UC and TR-12-UC) were placed on the upper tier, west of the standing interior wall and east of a less distinct north-south stone wall to the west. Those two walls are connected by a short section of standing east-west stone wall. Two stripped areas were placed in the upper tier of the factory, one at the south end (ST-2-UC) and one 17 ft (5.2 m) to the north (ST-3-UC). The latter was contiguous with a third stripped area (ST-1-UC) placed to the east in the middle tier of the factory. A total of 332 cultural materials was recovered from 0 to 4.3 ft (0 to 1.3 m) below ground surface (bgs) in overburden consisting of alluvial, colluvial and fill deposits (see Appendix A-Upper Copperas Factory (UC); Table 4-2).

Trench 1 (TR-1-UC)

TR-1-UC was placed in the middle factory tier just east of the standing interior wall, 43 ft (13.1 m) north-northeast of the wall's prominent southeast corner. The trench measured approximately 4-x-20 ft (1.2-x-6.1 m) along a general northwest-to-southeast axis (see Figure 4-2). The trench west wall was bound by the standing interior wall and the west end of the trench north wall by a short east-west section of exposed fieldstone wall. The trench was excavated on a slope from the standing interior wall east to the lower tier averaging a depth of 3.3 ft (1 m) bgs. Excavation reached a total depth of 7.1 ft (2.2 m) from the highest to lowest point within the slope of the trench. The excavation encountered another, buried interior north-south oriented drylaid fieldstone wall to the north measuring 1.4-x-6 ft (.43-x-1.8 m). The trench was divided into northwest and southeast sections by the wall, which was encountered at .20 ft (.06 m) bgs and extended vertically to the bottom of the trench (Figure 4-3). The wall consisted of decomposing schist stones and granite boulders with no apparent mortar. An east-west oriented single course of in-situ common brick was exposed in the south wall of the east end of the trench at .06 ft bgs (.18 m). The brick course was underlain by a layer of decomposing wood with three wrought iron L-brackets forming a northwest-pointing corner at a depth of .06 to 1.7 ft bgs (.18 to .52 m). The brick became loose and un-coursed north of the coursed section. The brick feature, designated FEA-3-UC was further explored in TR-3-UC (see discussion below). The stone wall exposed in the trench appears to be a secondary interior factory wall.

The trench, like others in the Upper Factory, contained soils associated with natural and human mine waste re-deposition including distinctive yellow jarosite-rich (iron hydroxysulfate) soils generally associated with naturally-weathered metallic sulfide ores, which may have washed or blown across the site and may also have been used as fill material. In the west side of the trench, below a thick deposit of overburden, tapering north to south from 0 to 2.7 ft (0 to .83 m) bgs, was a deposit consisting of decomposing schist mottled with yellow (2.5Y 8/6) silty fine to medium sand and yellow (2.5Y 8/8) sandy clay (Figure 4-4). A thin lens of yellowish red (5YR 5/6) silty fine to medium sand was within the mottled deposit from 1.2 to 1.6 ft (.37 to .49 m) bgs. The mottled deposit tapered north to south from .6 to 2.1 ft (.18 to .64 m) bgs and was followed by a brownish yellow (10 YR 6/8) silty very fine to fine sand, also tapering north to south from 1.2 to 3.2 ft (.37 to .98 m) bgs. The deepest stratum exposed in the western portion of the trench was a deposit of olive (5Y 5/6) silty clay from 1.8 to 3.2 ft (.55 to .98 m) bgs.

Table 4-2. All Recovered Cultural Materials By Unit, Upper Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	Monitoring	Stripped 01	Stripped 02	Stripped 03	TR 01	TR 01-N	TR 01-S	TR 02	TR 03	TR 05	TR 06	TR 07	TR 08-SE	TR 11	Unprov.	Total
Buckle			2													2
Redware, Lead Glaze		1		1												2
Brick		1									2					3
Molded Glass Holloware								2		1						3
Bottle/Jar		6						2								8
Curved Glass							1	1								2
Flat Glass								2								2
Animal Shoe			1													1
Boiler		1									5					6
Bolt							1									1
Damper Wheel		1														1
Handle			1													1
Iron Misc. Hardware			2													2
Nail		12		2	3	4	30		119							170
Plate										9	1			1		11
Pulley														1		1
Sheet		1														1
Slag						1			24							25
Unidentified				13			1	3			2	4				23
Wedge				1												1
Wrench			1													1
Lead Industrial Waste								5								5
Lead Misc. Hardware		1														1
Lead Sheet								2			2				1	5
Lead Spatter		6		1					1			1	1		1	11
Lead Trimmings		1		1	1		2			1						6
Lead Unid.							1									1
Lead Utility Pipe			1													1

Table 4-2. All Recovered Cultural Materials By Unit, Upper Copperas Factory, 2009/2010 Data Recovery Excavations.(cont)

Object	Monitoring	Stripped 01	Stripped 02	Stripped 03	TR 01	TR 01-N	TR 01-S	TR 02	TR 03	TR 05	TR 06	TR 07	TR 08-SE	TR 11	Unprov.	Total
Lead Washer				1												1
Boot/Shoe	5															5
Unid. Leather							1						1			2
Mortar					5											5
Whiteware, Undecorated		3														3
Unid. Refined Earthenware														2		2
American Stoneware, Salt Glaze		1														1
Industrial Waste									1							1
Misc. Structural/Industrial							1									1
Unid. Wood	7														5	12
Wheel	1															1
Grand Total	13	35	8	20	9	5	38	17	145	11	13	5	2	4	7	332

Figure 4-3. Photograph of TR-1-UC looking east (Note: masonry wall in the mid-ground with the brick courses to the east (FEA-3-UC).

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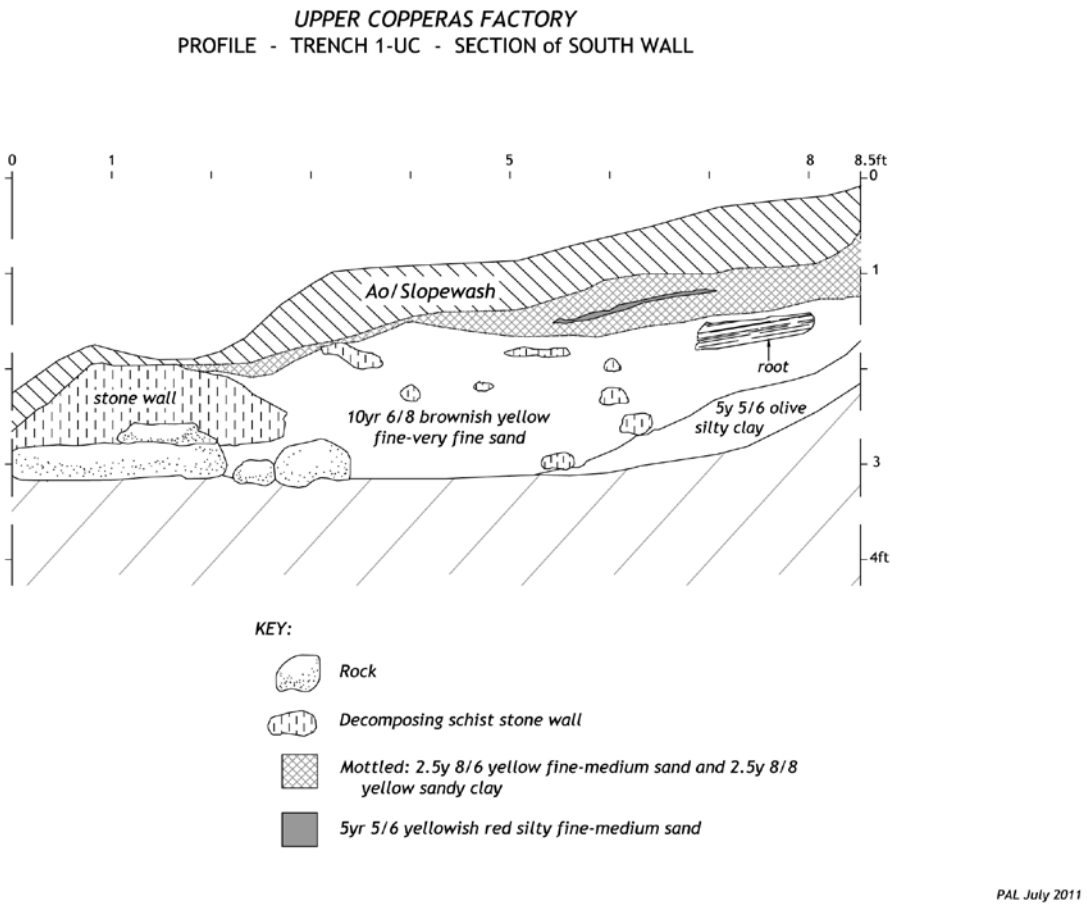

Figure 4-4. South wall profile section of TR-1-UC.

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The stratum surrounding the masonry wall consisted of a mottled olive yellow (2.5Y 6/6 and 6/8) fine sand intermixed with a brownish yellow (10YR 6/8) silty fine sand. East of the wall and north of the brick feature (FEA-3-UC), the matrix consisted of four distinct areas of fill. The matrix included pockets of decaying wood and brick fragments with a small amount of dark yellow brown (10YR 4/6) fine sand, dark yellow brown (10YR 4/6) fine sand with thin lenses of strong brown (7.5YR 4/6) clayey loam intermixed with a concentration of charcoal that averaged approximately 90 percent by volume, a dark yellow (10YR 4/4) fine brown sand, and a brown silty fine to medium sand with decaying cement mortar that was found closest to FEA-3-UC (Figure 4-5).

Artifacts noted on the ground surface prior to trench excavation included a cast iron pipe measuring .17 OD- x-13.7 ft (.05-x-4 m) with threaded elbow fittings, a metal rod, and an iron stanchion [.1-x-7.15 ft [.30-x-2.18- m]]. These artifacts were documented in the 2003 PAL survey report[5]. Other structural materials observed in this trench included a thin layer of wood across the middle of the trench from .48 to .86 ft bgs.

A total of 52 cultural materials were collected from 0 to 3.3 ft bgs (0 to 1 m) in overburden and mine waste (see Appendix A; Table 4-2). These materials include machine cut nails, sampled mortar, unidentified leather fragment, curved clear glass, unidentified lead, lead trimming, an iron bolt, unidentified iron, slag, and a metal strap with fastener holes. Of the nails identified 30 were found in the southern half of the trench. The machine cut nails include 16 sheathing, 10 unidentified, 1 clout, 3 box, 2 shingle, 2 fine finished, and 3 common types.

Trench 2 (TR-2-UC, FEA-2-UC)

TR-2-UC was excavated approximately 17 ft (5.2 m) south to southeast of TR-1-UC (see Figure 4-2). The trench was placed to further explore exposed timbers on the hillside. The initial trench was expanded several times, reaching a total area that measured approximately 16 ft (4.9 m) along its north-south axis and 24.6 ft (7.5 m) along its east-west axis. The trench was excavated on a slope reaching a total depth of 6.7 ft (2 m) with an average depth of 3.9 ft (1.2 m) bgs. Trench strata consisted primarily of colluvial and alluvial overburden deposits intermixed with brick and rubble. Excavation exposed a complex, three-dimensional inclined timber feature (FEA-2-UC) that extended the entire east-west length and most of the north-south width of the trench (Figure 4-6).

When completed, the trench contained different sloping timber construction in its north and south sections and different offset north soil profiles. In the south section of the trench, the structure incorporated wood members including four upright posts. Three wood posts were encountered in the west part of the trench. Two were 5.75 ft (1.75 m) apart opposite each other across a layer of inclined planks. The third post was offset 2 ft (.61 m) to the northwest at a distance of 5.16 ft (1.57 m) from the middle post. The last post was at the northeastern wall approximately 16 ft (4.9 m) east of the middle post. The horizontal members included a series of east-west oriented round log beams with adze-hewn flat upper surfaces and square cut north-south timber stringers. This floor system supported wood planks that were inclined at a 17.8 percent slope and longitudinally oriented approximately 42 degrees east of magnetic north. The planks were encountered between 2.7 and 3.14 ft (.81 and .96 m) bgs (see Figure 4-6). Two vertical planks were located at the eastern and western limits of the inclined planks. The vertical planks had the same 42 degree compass orientation and were 14.7 ft (4.5 m) apart. The west vertical plank had a rise of 1 ft (.3 m) to 1.2 ft (.37 m) above the inclined planks to the east. The east vertical plank had a rise of .75 ft (.23 m) and was adjacent to a cluster of stacked north-south oriented logs at the east edge of the trench. The top of some of the logs were heavily deteriorated, with their heartwood rotted out (Figure 4-7). A similar

[5] None of these artifacts were removed from the site. They were reburied at or near their original locations during the remediation/capping activities.

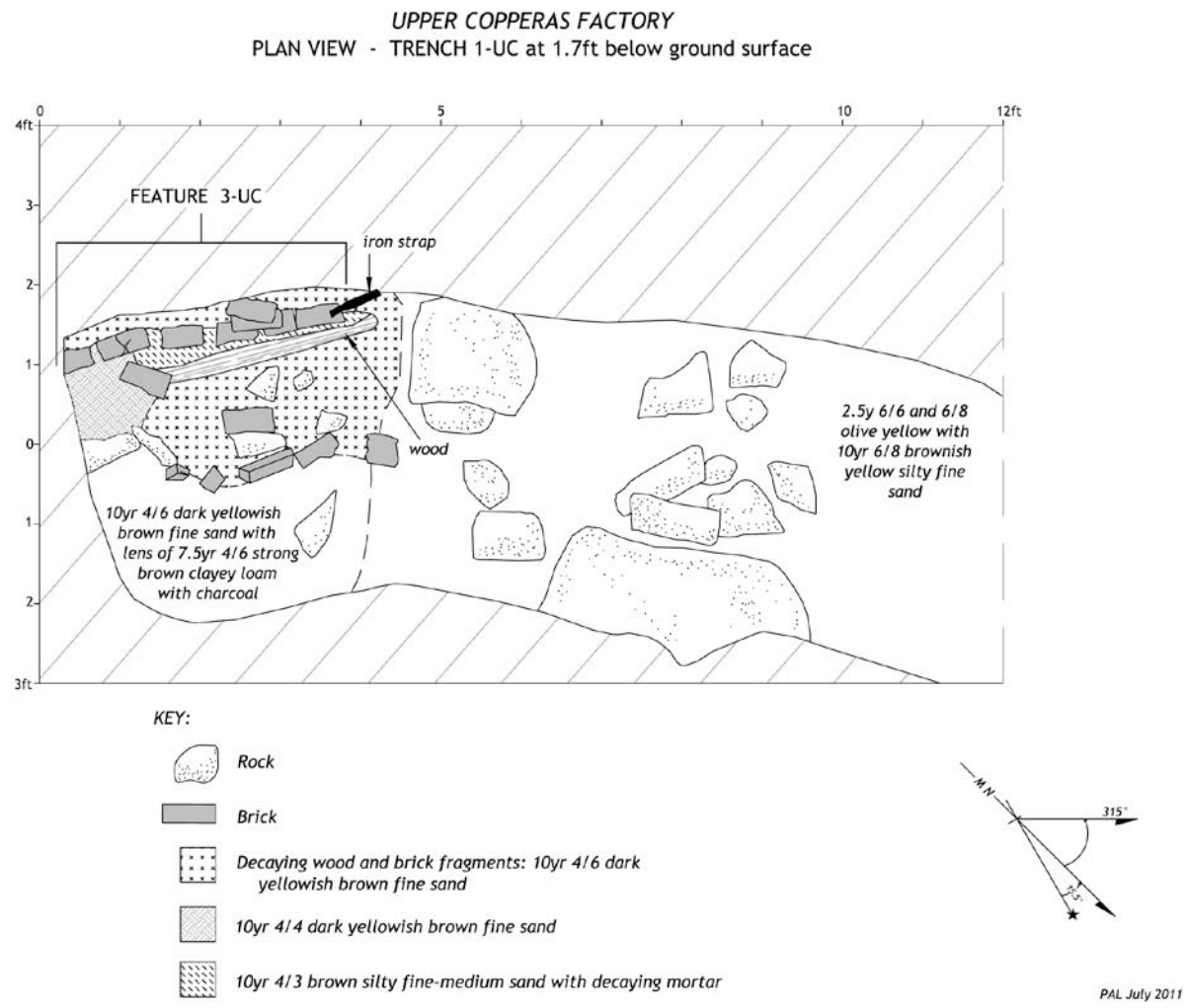

Figure 4-5. Plan of TR-1-UC at 1.7 ft below ground surface, showing detail of stone wall and brick courses.

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Figure 4-6. Plan of FEA-2-UC (inclined wood planks) from 2.7 to 3.14 ft below ground surface in TR-2-UC.

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Figure 4-7. Photograph of FEA-2-UC (inclined wood planks) in TR-2-UC.

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stacked log feature, possibly an extension, was found 2 ft (.61 m) to the north of TR-5-BC directly west of the remains of a brick copperas crystallizer vessel (Feature-7-BC) (see discussion below).

These stacked logs, and indeed, the larger timber and plank structure recorded in the trench, can be interpreted in several possible ways. If the inclined timber and plank system below was part of a structure designed to support the factory and facilitate drainage in the steep wet Copperas Brook ravine and/or to facilitate the cascading gravity-fed liquor transport from vessel to vessel, it could be a wall to support earth fill packed under a crystallizer or process vessel and/or to create a step between factory floor levels. If the inclined plank deck below was the floor of a copperas crystal packing chute/bin, it could have been a wall to stop the flow of crystals and/or to collect copperas liquor draining from the drying crystals for collection and recycling to the boilers. If the inclined plank deck below was the floor of a raw copperas liquor storage cistern for another factory located below to the east operating at another, presumably earlier time, it could be part of an east wall "dam" with a "stoplog" at its crest. The logs that appear to be hollowed out may have been used as simple troughs for conveying copperas liquor between vessels, however, they would have to have had lead sheet linings to withstand the pH of the boiled copperas liquor, unless they were intended to be frequently disposed of and replaced. If they were liquor troughs, they were either found in situ for transverse flow of liquor, or simply stacked in a pile (see additional discussion of the inclined timber and plank structure in TR-6-BC below and in Chapter 6).

The northern extension of the trench contained two short .65 ft (.20 m) stringers lying directly on the inclined plank surface. Three east-west square cut beams were laid on the stringers rising an additional .65 ft (.20 m) giving an overall rise of 1.3 ft (.40 m) above the planks to the south. These beams were inclined at a slightly steeper angle down toward the east than the beams in the section of the trench to the south. One of the beams was removed; unlike the section of the trench to the south, no planking was encountered above or below the timber structural system.

The stratigraphy differed between the north profile of the north trench extension and the north profile of the east half of the original trench. The profiles were offset approximately 6 ft (1.83 m) due to the irregular shape of the trench. The north profile of the north trench extension contained structural features including, from west to east, a drylaid schist and granite boulder stone wall, and a cluster of loose and mortared common bricks lying on wood planking. The wood planks were found at the bottom of the trench between 2.2 to 2.6 ft (.67 to .79 m) bgs. The wall extended .5 ft (.15 m) into the trench. The matrix surrounding the structural features included colluvial overburden of dark yellowish brown (7.5YR 4/4) coarse sand with gravel from 0 to 1.4 ft bgs. (0 to .43 m) followed by a black (10YR 2/1) decomposing wood from .5 to 1.6 ft bgs (.15 to .49 m). Subsequent fill deposits included a mottled strong brown (7.5YR 5/6) with brownish yellow (10 YR 6/8) coarse sandy clay .8 to 1.9 ft (.24 to .58 m) followed by a brick, mortar and charred wood deposit from 1.2 to 3.5 ft (.37 to 1.1 m). The charred wood deposit was a reddish brown (5YR 4/4) clay mottled with a strong brown (7.5YR 4/6) sandy silt with a large amount of building debris. The majority of the building debris consisted of brick concentrated on the east side of the wood planks. The bricks were disarticulated in no discernable pattern. Excavations continued below the wood planking in the northern extension of the trench. A yellow silty fine sand deposit was present in this area, and excavations ceased at 4.0 ft (1.2 m) bgs. The north elevation of the east half of the original trench contained an upright wooden post with overburden deposits from 0 to 3 ft (0 to .91 m) bgs followed by thinly banded alluvial deposits of brown (7.5YR 4/4) fine sand, yellowish red (5YR 4/6) fine sandy clay, light yellowish brown (2.5Y 6/4) medium to coarse sand and olive brown (2.5Y 4/4) sandy clay intermixed with yellow clay nodules from 1.5 to 4.0 ft (.46 to 1.2 m) bgs (Figure 4-8).

A total of 17 cultural materials was collected from 0 to 3.9 ft bgs (0 to 1.2 m) in association with FEA-2-UC and in alluvial and colluvial deposits (see Appendix A; Table 4-2). Artifacts found in association with FEA-2-UC include flat glass, curved glass, unidentified iron fragments, and lead trimmings and lead

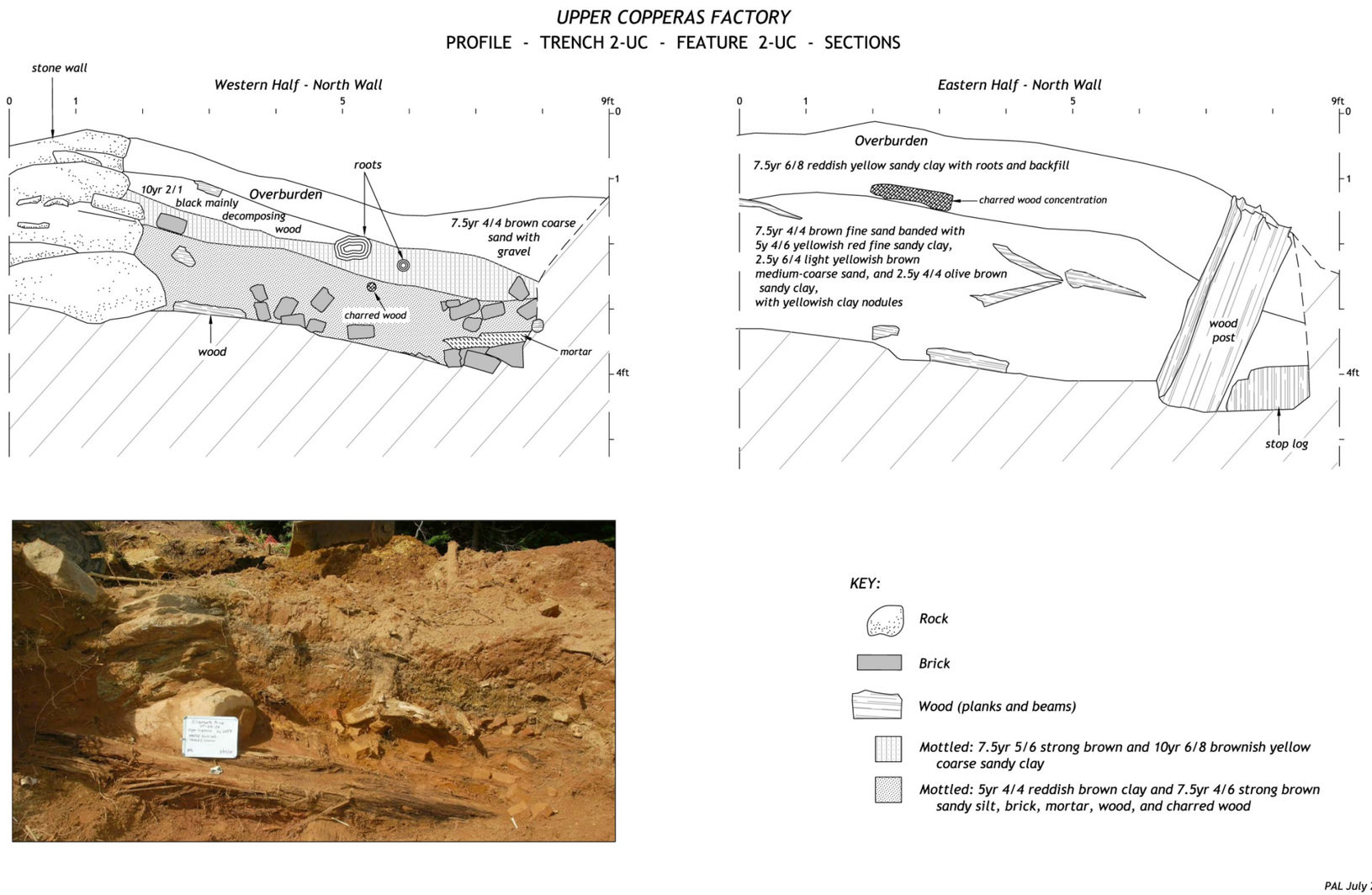

Figure 4-8. North wall profile of FEA-2-UC in TR-2-UC

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sheet fragments used for copperas vessel repairs. One lead sheet found in the northern extension area of the trench between the two western stringers was bent into a U-shape and appeared to be a possible copperas liquor spout or trough. This artifact was located in the deepest fill deposit at a depth of 3.8 ft (1.16 m) bgs. The three iron fragments were found from 2.7 to 3.9 ft (.82 to 1.2 m) bgs in the southeastern side of the trench. The iron artifacts are unidentifiable because of high oxidization from the wet acidic soil conditions. The two flat (window) glass fragments were recovered directly on the surface of the inclined planking. If applied, Moir's regression formula for this glass suggests a date range of 1865 to 1879 (±) seven years.

Other artifacts recovered in alluvial deposits in the eastern part of the trench above the inclined planking consist of two fragments of molded bottle glass, one glass bottle jar lid, and one glass milk bottle fragments. All of this glassware has date ranges of manufacture between 1809 and the 1950s.

Trench 3 (TR-3-UC, FEA-3-UC)

TR-3-UC was placed 5.9 ft (1.8 m) north of TR-2-UC, in a level area in the middle tier of the factory. The trench adjoined and ran roughly perpendicular to the southeast corner of TR-1-UC on a north-south axis, between the parallel north-south oriented stone retaining wall marking the east edge of the middle tier and the wall exposed in TR-1-UC, which were 7 ft (2.1 m) apart (see Figure 4-2). The trench measured 5.5-x-11.6 ft (1.7-x-3.5m). It was placed to further expose FEA-3-UC, a stretcher course of bricks identified in the southeast wall of TR-1-UC. Excavation of the trench reached a total depth of 3.5 ft (1.07 m). The horizontal extent of the brick feature was first exposed, revealing a rectangular mass of loose brick with some visible coursed sides. After that was documented, the loose bricks were removed to expose the intact floor and side wall courses of the rectangular structure. The structure was then bisected longitudinally to expose its construction and substructure in profile.

Hand excavations in the trench first exposed a thin layer of decomposing wood found below the A_o (partly decomposed leaf litter) at .19 to .32 ft (.06 to .10 m) bgs, followed by a concentration of loose brick. Below the thin wood layer in the center of the brick concentration, a wood timber measuring 0.5-x-2.9 ft (.15-x-.89 m) was located above the brick rubble adjacent to two disarticulated iron L brackets (Figure 4-9). The thin layer of wood, timber and brackets were in overburden soils between .19 and .37 ft (.06 and .11 m) bgs above the brick concentration. The L-brackets were ¼ in thickness and ranged in width between 1.5- to- 2 in and in width from .75-to-1 ft on each side[6]. The larger bracket had two nails still in place. Deteriorated wood paralleled the outside edges of the north and west coursed brick walls. Three in situ L-brackets first exposed in TR-1-UC were located in the northwest corner of the brick concentration. The brackets were ¼ to 3/8 in thick and ranged in width between 1- to- 2 in and in width from .75-to-1 ft on each side[7]. The exposed rectangular brick structure measured 6-x-12.5 ft (1.8-x-3.8 m) with a raised brick course delineating the north, west, and east feature limits and in situ L-brackets. Tree roots prevented excavation to the south and to the east, but the brick was assumed to continue to the eastern stone retaining wall delineating the east edge of the factory middle tier. The parallel retaining walls on the east and west sides of the brick concentration feature were exposed and incorporated drylaid fieldstone and boulder construction. Removal of the loose brick rubble exposed a .02 ft (.06 m) thick layer of solid natural mortared cement followed by a flat laid brick surface (Figure 4-10). The single brick layer was excavated to expose its construction and structural supports. A wood plank layer was found below the bricks. The planks were oriented on a north-south axis and were supported by three east-west oriented wood beams. The west wall profile incorporated a brick wall four courses in height with two possible additional collapsed courses. The east profile contained the same arrangement of wood planks and beam supports with one course of bricks and cement mortar (Figure 4-11).

[6] The brackets were recorded in situ and reburied following excavations at this location during the remediation/capping activities.
[7] The brackets were recorded in situ and reburied following excavations at this location during the remediation/capping activities.

Soil strata observed in the trench varied from the east and west wall profiles. On the east wall, the overburden was a colluvial deposit of yellow (10YR 7/8) sandy clay with brick waste from 0 to 1.1 ft (0 to .34 m) bgs, followed by the prepared brick and cement mortared surface. On the west wall, the colluvium was mottled with an olive yellow (2.5Y 6/6) sand intermixed with a rubble building fill that extended below the brick and mortar surface from 0 to 2.1 ft (0 to .64 m) bgs. On the east wall, the strata above and below the feature are more clearly defined with a subfloor building fill below the structure from 1.4 to 2.9 ft (.43 to .88 m) bgs. The subfloor building fill lower stratigraphy is more consistent with the soil matrix identified within the northeastern soil profile of TR-2-UC. The matrix consisted of thinly banded laminated deposits of dark brown (10YR 3/3) coarse sand, with reddish brown (5YR 4/4) fine sand, and brown (7.5 YR 4/4) silty fine sand (see Figure 4-11).

FEA-3-UC can be interpreted as a copperas liquor crystallizer based on its size, shape and construction materials compared to crystallizers described in the historical descriptions. The crystallizers described in the 1871 *Vermont Historical Gazetteer*, about a decade before copperas operations closed, were 7 ft by 14 ft, slightly larger than the partially-exposed brick floor (Duncan 1871:1085–1088). The crystallizer interpretation is reinforced by the subsequent excavation and comparison of an adjacent larger, deeper brick structure interpreted as a copperas cooler vessel (FEA-6-UC) at a higher elevation immediately adjacent to the northwest, as well as comparison with other similar features interpreted as copperas crystallizers adjacent at lower elevations to the east at the Upper Factory, as well as elsewhere on site. The associated iron corner brackets appear to have been part of an exterior wood bracing system designed to keep the heavy masonry vessel stabilized. The single brick bottom layer was most likely the floor of the crystallizer, supported by planks and timbers on sandy fill.

A total of 145 cultural materials was collected from 0 to 1.5 ft bgs (0 to .46 m) in overburden (Fill 1) deposits and in association with FEA-3-UC (see Appendix A; Table 4-2). Artifacts found in association with FEA-3-UC include 79 machine cut nails (see Appendix B.1-3 and B.1-4) and an additional 40 unidentifiable nails as well as one complete piece of lead spatter. These materials were collected from the southeast corner of the feature. Other materials include 24 pieces of melted iron and one piece of industrial waste. The nails came out of the colluvial overburden/rubble building fill and were highly oxidized. A total of seven iron L-brackets (structural supports) were present in this trench in association with FEA-3-UC (see Appendix B.2-1) [8].

Trench 11 (TR-11-UC)[9]

TR-11-UC was placed approximately 35 ft (10.7 m) northwest of the standing interior factory wall dividing the upper and middle tiers, 3.7 ft (1.12 m) west of the indistinct stone wall at the west edge of the upper tier (see Figure 4-2). The trench measured 4-x-16.7 ft (1.2-x-5.1 m) and had a long northwest-southeast axis. It was placed to locate the west edge of the factory building footprint. No structural remains were identified within the trench, which contained colluvial overburden from 0 to 2 ft (0 to .61 m) bgs, followed by three heavily mottled fill layers (Figure 4-12). The fill layers contained brick rubble intermixed with glacial till. Excavation terminated at 3.5 ft (1.07 m) bgs due to a lack of cultural features. The fill layers may have been associated with the documented reservoir(s) on the upper, exterior side of the Upper Factory (see Chapter 5 Copperas Brook Corridor for additional discussion). The lack of

[8] These brackets were recorded at the site and reburied following excavations at this location during the remediation/capping activities.

[9] The narrative proceeds from Trench 3 to Trenches 11 and 12 to complete the description of data recovery excavations conducted in the Upper Copperas Factory subarea.

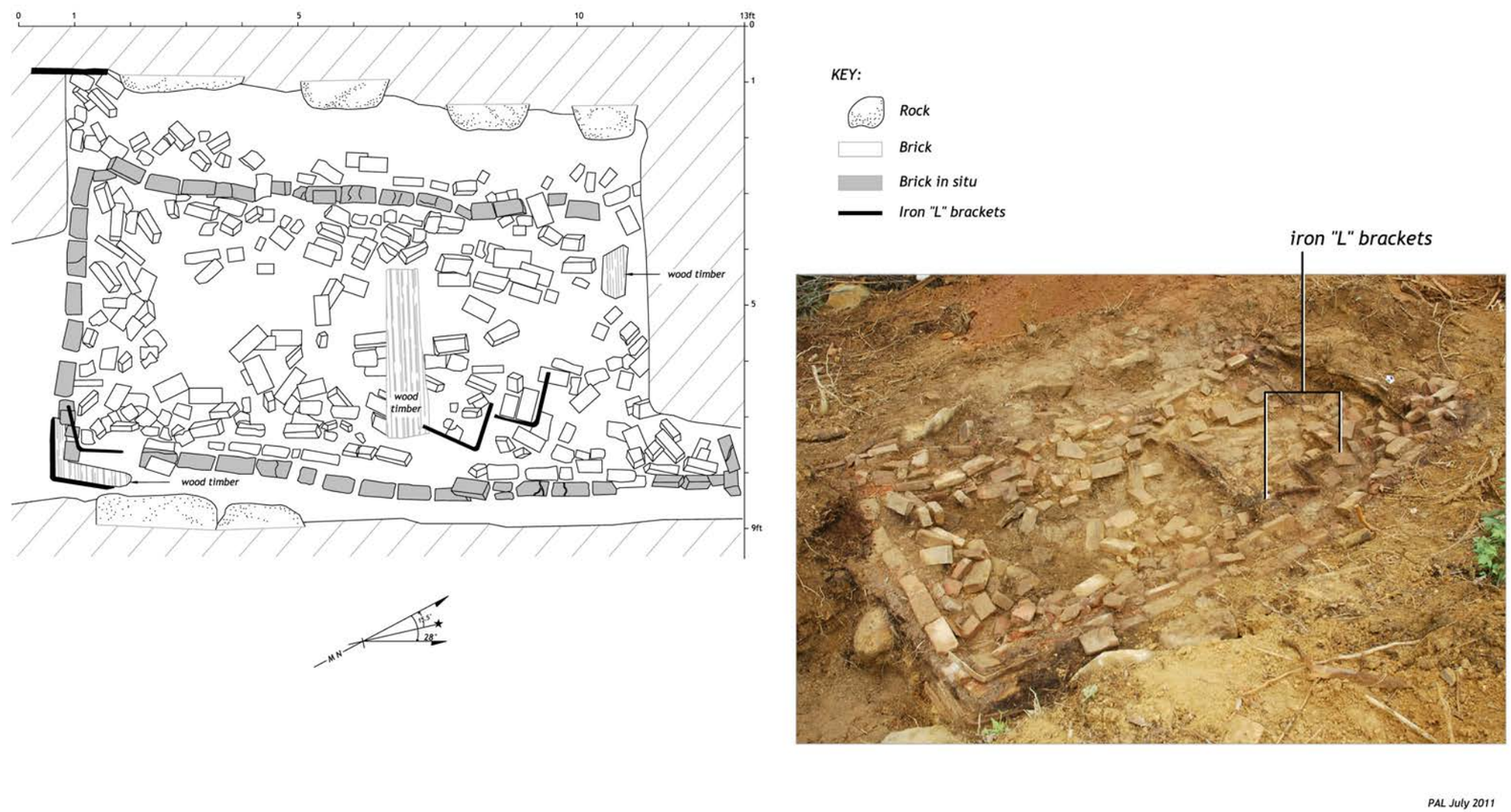

Figure 4-9. Plan of FEA-3-UC (crystallizer) from .19 to .37 ft below ground surface in TR-3-UC (Note: raised course of in situ bricks delineating the horizontal extent of the feature.).

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Figure 4-10. Photograph of FEA-3-UC, the crystallizer brick and concrete floor, looking south.

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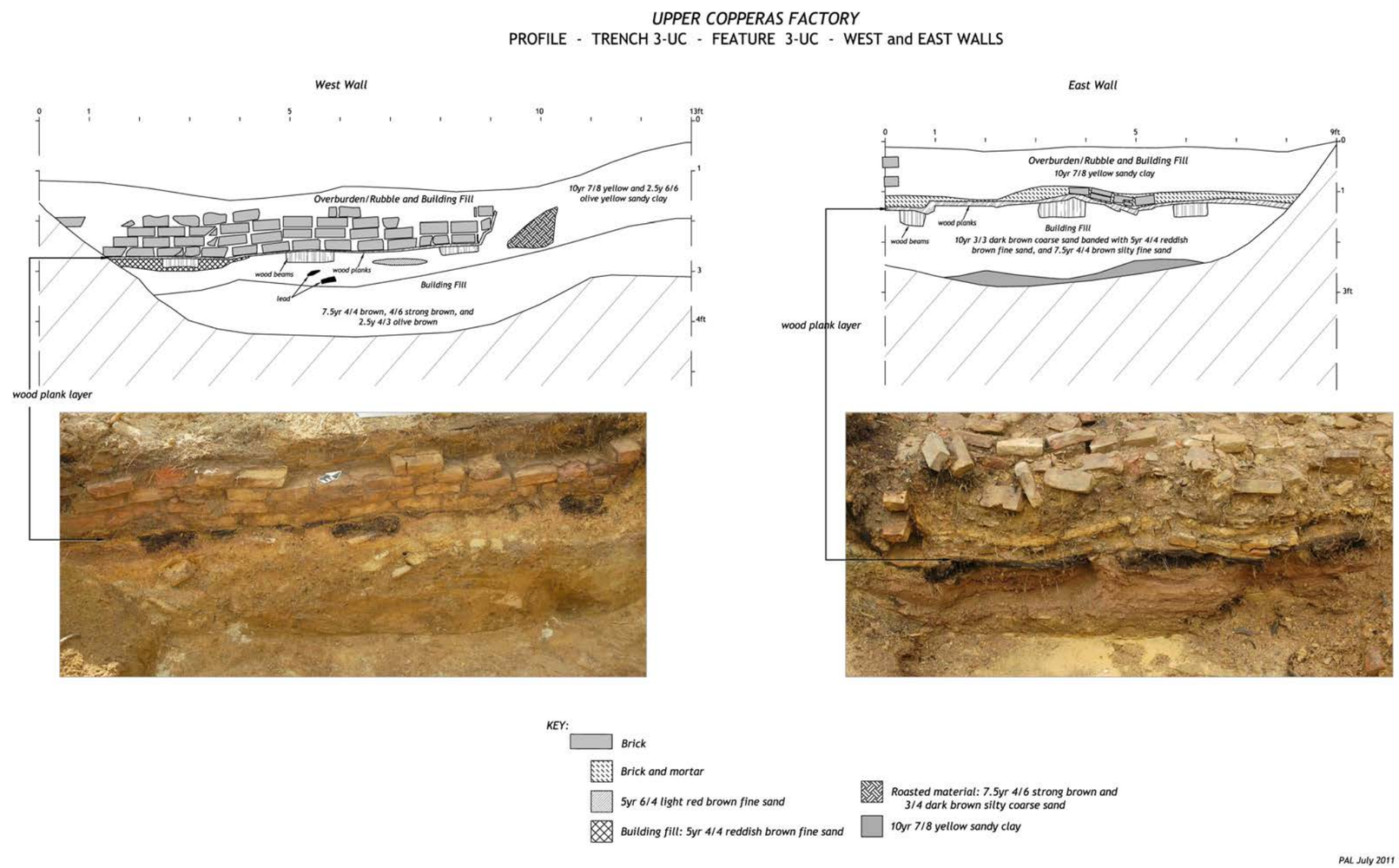

Figure 4-11. East and west wall profiles of FEA-3-UC in TR-3-UC.

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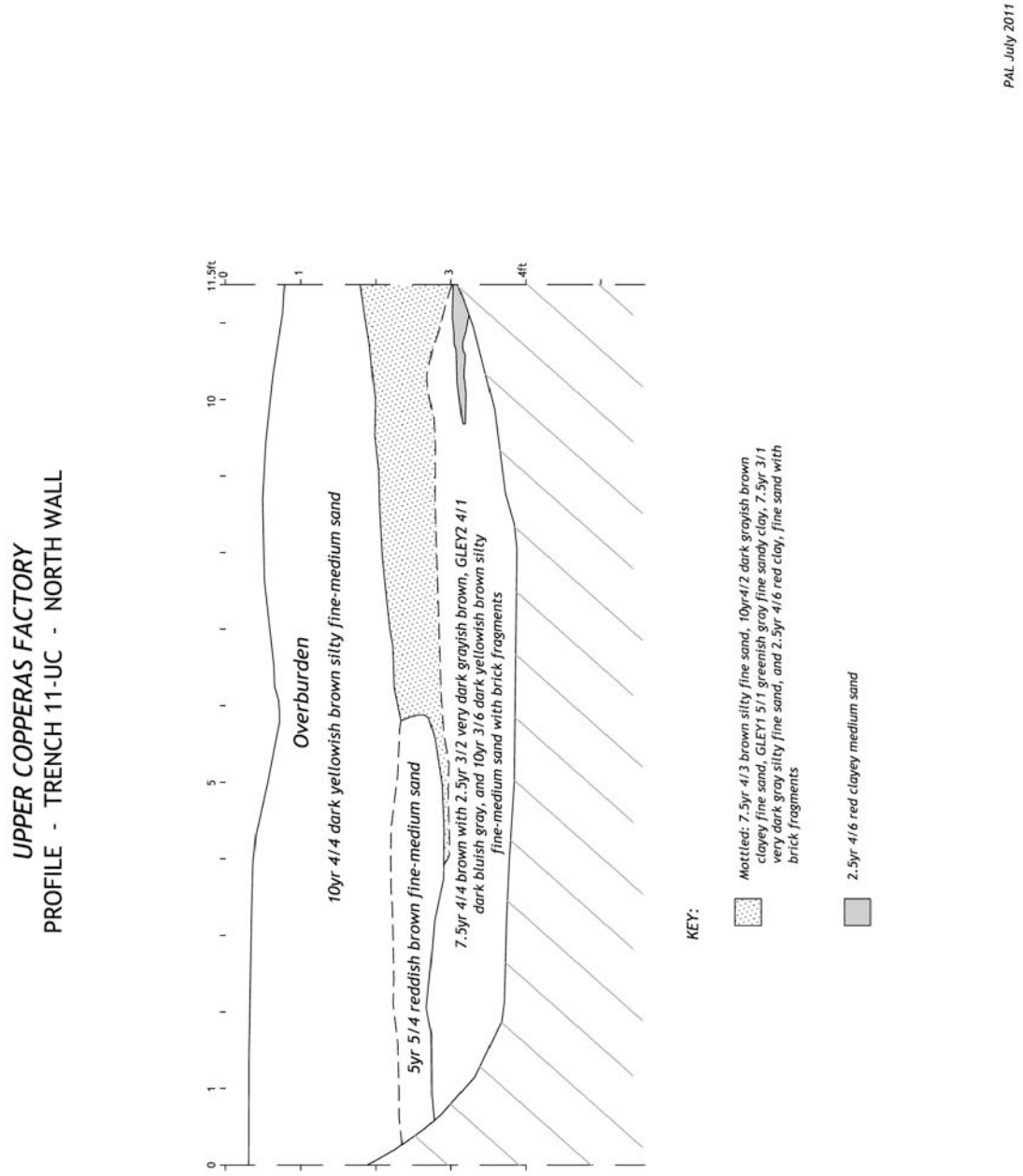

Figure 4-12. North wall profile of TR-11-UC

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structural remains in the trench suggests that the indistinct stone wall defining the west edge of the upper tier is the west wall of the factory building proper.

A total of four cultural materials was recovered from .3 to .9 ft bgs (.09 to .28 m) (see Appendix A; Table 4-2). These materials were found clustered within 1.4 ft (.43 m) of the eastern edge of the trench within the colluvial overburden at a depth of 0.3 and 0.9 ft (.09 to .28 m) bgs. They include an iron pulley, two brown-white refined earthenware ceramic sherds (undateable), and perforated iron plates[10]. The two perforated plates were fairly uniform being .08 to .125 m (.03 to 04 m) thick and .05 ft (.15 m) in the center and tapering to .42 ft (.13 m) at the ends. The diameter of the holes were .17 to .19 ft (.05 to .06 m) and were placed in .10 ft (.03 m) intervals slightly off center within the plate. These plate fragments are similar to perforated plates found in the Lower Copperas Factory area in association with FEA-1-LC, FEA-2-LC, and FEA-4-LC (see discussion below). The plate fragments resemble complete and fragmentary perforated iron boiler firebox grate bars, some with cement in their outboard holes, found near a copperas boiler feature and associated artifacts at the Lower Factory (discussed below). These single bars are cruder than later nineteenth-century cast iron single, double or triple-plate grate bars found on site, but are similar in length, and incorporate the air circulation hole patterns and shallow "fishbelly" curved bottoms common to smaller boiler furnace grate bars, as well as possible thermal cracks.

Trench 12 (TR-12-UC)

TR-12-UC was placed 16 ft (4.9 m) northeast of TR-11-UC at the north end of the indistinct west wall of the factory (see Figure 4-2). The trench measured 5-x-8 ft (1.5-x-2.4 m) with an overall depth of 2.5 ft (.76 m) bgs. The soil stratigraphy revealed eight colluvium and fill horizons (Figure 4-13). The trench contained four colluvial deposits: dark yellowish brown (10YR 4/6); olive brown (2.5Y 4/3) mottled with brown (7.5YR 4/3); dark yellowish brown (10 YR 3/6); and yellow brown (10YR 4/3) silty fine to medium sand from 0 to 1.9 ft (0 to .58 m) bgs. The colluvium was followed by distinct red soils (10R 4/8 and 10R 3/3) from disintegrated brick likely associated with the adjacent boiler feature (FEA-7-UC). The reddened soil strata were intermixed with wood and brick debris. No structural features were present within the trench. Its close proximity to the boiler feature (FEA-7-UC) as well as the mottled soil stratigraphy indicate a probable refuse-waste disposal area for the Upper Factory boiler. No artifacts were encountered in TR-12-UC.

Stripped Area 1 (ST-1-UC, FEA-1-UC and FEA-6-UC)

ST-1-UC was located 14.5 ft (4.4 m) east of TR-12-UC within the middle tier of the factory, east of the long north-south standing interior wall (see Figure 4-2). The stripped area consisted of a combination of hand and machine excavations measuring 12-x-27 ft (3.7-x-8 m) with a long north-south axis. This area was selected for machine stripping because of the presence of structural remains on the ground surface. The features included a short east-west axis stone wall (visible at the north side of the west end of TR-1-UC) intersecting the standing interior wall and a brick scatter to the east, and two upright iron structural supports (stanchions) bordering a brick concentration. Due to the unclear nature of the various structural remains and their relationships, excavation was divided into separate spatial contexts and later by feature number where possible.

Hand excavation revealed FEA-1-UC (originally designated Context I), which included a semi-circular soil stain within a level area north of the east-west retaining wall at the north side of the west end of TR-1-UC. The retaining wall measured 1.4-x-5.3 ft (.41-x-1.6 m) and sloped to the east. Stones appeared to have fallen to the south into TR-1-UC, creating an unintentional 33 percent slope. The flat area contained

[10] Only one of the iron plates was removed from the site and temporarily curated at PAL. The other identical plate was recorded in situ and reburied at its original location during remediation/capping activities.

an oval stain consisting of an area of olive brown (2.5Y 4/3) silty sand that measured 5 ft (1.5 m) in diameter at 0 to .33 ft (0 to .10 m) bgs (Figure 4-14). The surrounding matrix included a thin organic lens of very dark brown (10YR 2/2) silty loam outlining the stain. The lens was followed by a dusky red (10R 3/4) silty sand at 0 to .33 ft (0 to .10 m) bgs. Three wood beams were found to the north, south, and west of the stain at 0 to .33 ft (0 to .10 m) bgs. Hand excavations included bisecting the feature stain at a 30 /210 degree angle. Evidence of heating and possible charred wood was noted on the surface, but as excavation continued .33 ft (.10 m) bgs the wood and red staining ceased. The excavated fill below the circular stain was a continuation of the olive brown (2.5Y 4/3) silty sand that was mottled with reddish brown (2.5YR 4/4) sand from .33 to 4.5 ft (.10 to 1.4 m) bgs. Excavation continued vertically to examine the depth of the brick feature (FEA-6-UC) to the east.

A total of 30 cultural materials was recovered from 0 to 4.3 ft (0 to 1.31 m) bgs in association with FEA-1-UC (see Appendix A; Table 4-2). Prior to stripping this area, one boiler grate bar, one bolt fragment, and two machine cut nails were collected on the ground surface. Other artifacts collected on the feature surface or within the surrounding soil matrix include: lead spatter and lead trim; one glass fragment; ceramics sherds (three whiteware, one stoneware, one lead-glazed redware); a brick fragment; an iron stove damper wheel; an iron sheet; machine-cut nails (1 sheathing, 1 floor, 1 shingle, 1 common, and 4 heavily corroded). Artifacts noted but not saved included pieces of thick iron plate (possible boiler components) and lead sheet[11]. The majority of artifacts were found on the feature surface below a thin layer of $A_{o.}$ The iron plates were found west of the circular stain approximately 1.5 ft (.46 m) east of the upper wall and boiler. The damper wheel (see Appendix B.1-1) was found 2.4 ft (.73 m) to the southwest of the iron plates below a large cut stone associated with the boiler (FEA-7-UC) (see discussion below). The presence of a grate bar and a damper wheel in this location supports the interpretation of FEA-7-UC as a boiler. Firebox doors typically contained damper wheels (see Appendix B.1-1) to control furnace draft. One dark olive, glass bottle/jar lip fragment (manufacture date 1850-1920) was found .82 ft (.25 m) bgs within the feature fill. The ceramic sherds were found in a cluster on the northeast side of FEA-1-UC below the A_o. The stoneware is a gray, salt glazed handle fragment, manufacture date of 1760-1870. The redware is a rim fragment with a lead glaze that spans a broad period dating between 1600 to present. The whiteware sherds also have a long span of manufacture from 1820 to present.

FEA-1-UC was initially thought to be a base for a chimney stack associated with the boiler, FEA-7-UC (see below) in the Upper Factory foundation. Subsequent confirmation that FEA-7-UC excavated to the west was a boiler and FEA-6-UC to the east was a cooling vessel makes the location of a draft stack on the east side of the boiler unlikely. A boiler furnace draft stack is typically located opposite a furnace firebox, so that the furnace can draw a draft to provide oxygen for and control combustion. The Diderot illustration of a copperas boiler (see Figure 3-4) clearly illustrates this furnace configuration, which would be desirable for raising the heat required to rapidly boil a large volume of liquid, and for the temperature control required to manipulate the density of the liquor and keep the lead pan from melting. Copperas boilers constructed in this configuration were reported throughout the life of the operation: “The avenues or arches between these walls communicate at one end with the arch in which the fire is placed, and at the other with the common flue (Locke 1821:326–330), and “Beneath the evaporating pans run a series of flues, commencing at the fire arches at one end of the pans and terminating in the stack at the other end” (Duncan 1871:1085–1088). Additionally, no masonry substructure to support a heavy chimney was found below the soil stain. If the stain is at the original working floor surface of the factory, it could be a work area, likely for charging the boiler and/or tapping the furnace to fill the immediately adjacent cooling vat. The three wood beams encountered in the feature could have possibly supported a wood floored work area.

[11] Only these artifacts were recorded on site and reburied at their original locations during the remediation/capping activities.

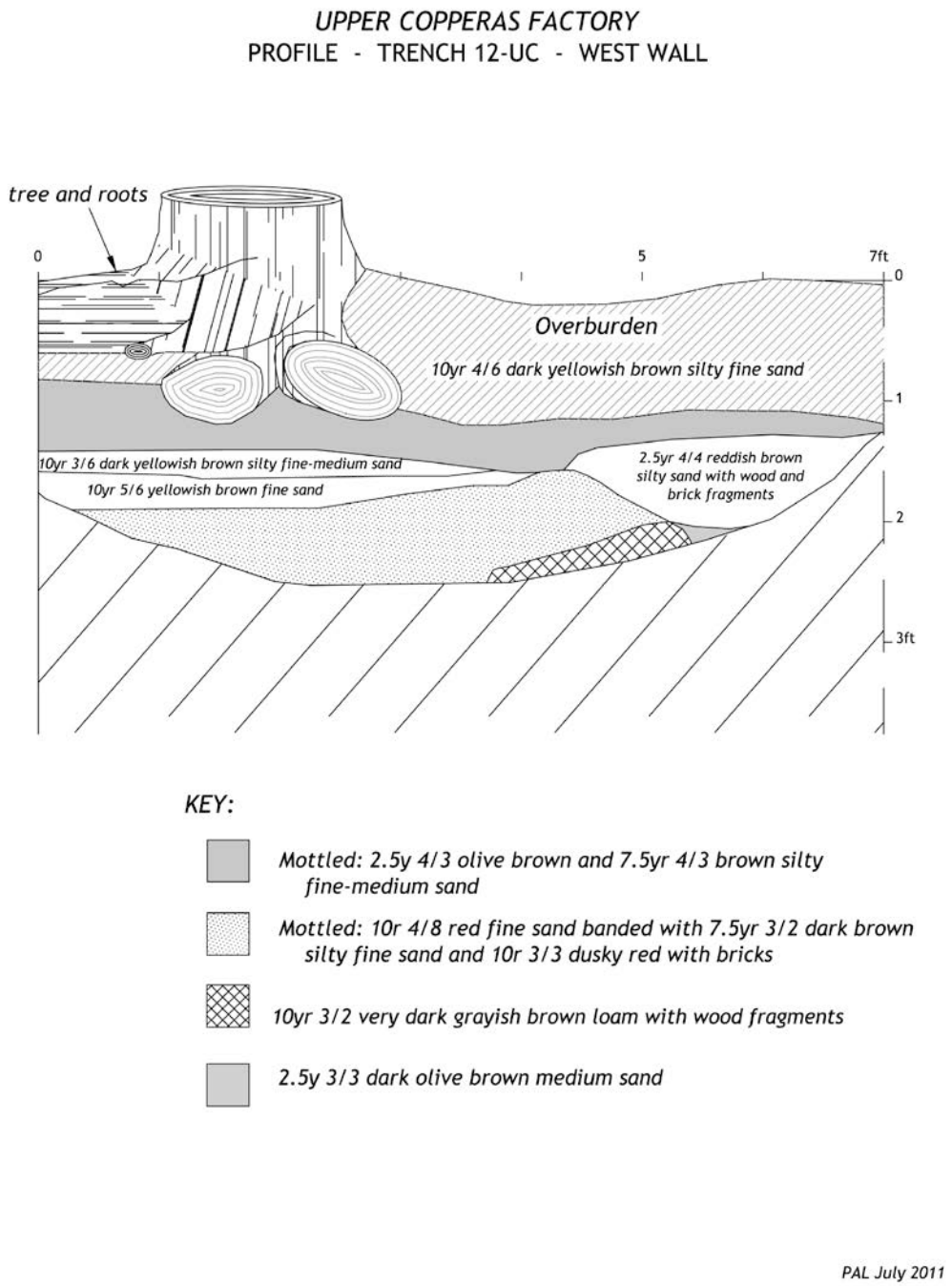

Figure 4-13. West wall profile of TR-12-UC.

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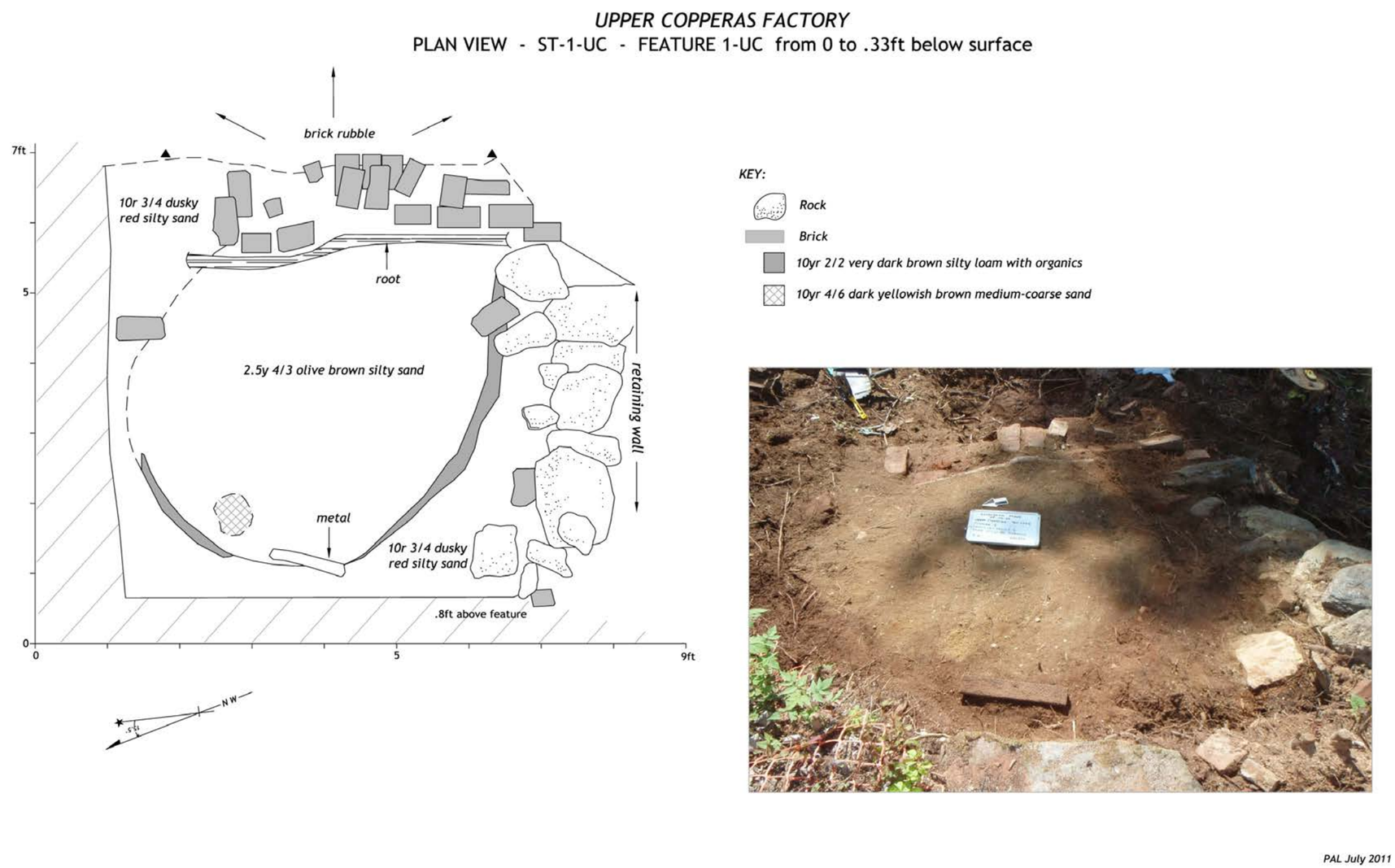

Figure 4-14. Plan of FEA-1-UC from 0 to .33 ft below ground surface in ST-1-UC

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FEA-6-UC (originally designated Context III), was a rectangular brick structure originally encountered as a brick scatter east of FEA-1-UC (Figure 4-15). Removal of the A_o and loose bricks exposed a three course wide, stretcher bond, brick wall oriented on an axis of 25 degrees east of magnetic north, at .6 ft (18 m) bgs. Further exposure of the feature revealed additional brick walls forming a rectangle in plan. The structure's overall dimensions measured 5.4- x-18.5 ft (1.65-x-5.6 m) on its long north-south axis. The majority of the bricks within the feature were unmarked common red brick. The feature also incorporated No. 1 size silica fire bricks stamped with manufacturer's marks that included "J.M.Craig Kilmarnock," "Lister," "Anness & Muller," "Anness & Muller Boston No. 1", and "Boston." These bricks were in no particular relative orientation. Continued excavation to the southwest exposed 20 courses of brick forming a west interior wall extending down over 4.5 ft (1.4 m) bgs. A piece of sheet lead was found at the bottom of the excavated pit, but was not collected due to its large size[12]. An in situ vertical cast iron stanchion and a section of upright rail (dating to the 1850s based on its section profile) (see Appendix B.2-2), located 2.5 ft (.75 m) apart, were present adjacent to the western wall of the brick feature, approximately 2 ft (.61 m) north of FEA-1-UC (see Figure 4-15). A loose stanchion was found on the ground surface 5.1 ft (1.6 m) to the southeast of the feature[13].

North of FEA-1-UC and west of the stanchion and rail, thin wood planks were encountered above fieldstones at .5 to 1 ft (.15 to .30 m) bgs. The wood was heavily deteriorated and its poor preservation made it difficult to determine its function. The wood could have been possible flooring or disarticulated material from the wall above to the west. The stones were also interpreted as possibly having fallen from the wall. Fallen bricks from FEA-6-UC were scattered above the wood and stones. The soils within this area ranged from dark grayish brown (10YR 4/2) slope wash, yellowish red (5YR 5/6) sandy clay with broken brick and roasted ore mottled with dark yellowish brown (10YR 4/4) tailings. To the north at .5 to 1 ft (.15 to .30 m) bgs was yellow (2.5Y 8/8) sandy clay material similar in consistency to that encountered in the west side of TR-1-UC.

A total of five cultural materials was recovered from 0 to 4.3 ft (0 to 1.3 m) bgs in association with FEA-6-UC (see Appendix A; Table 4-2). These materials include one early to mid twentieth century brown beer bottle base fragment, and four clear pattern molded glass fragments with a manufacture date range of 1825 to present. The beer bottle and clear glass fragments were found in colluvial soils.

The brick structure, FEA-6-UC can be interpreted as a copperas cooling vessel based on its dimensions, particularly its depth as indicated in the height of its exposed west wall (see FEA-1-UC above). Also, the structure is positioned within the factory middle tier 5.5 ft (1.7 m) east of a feature interpreted as a boiler (FEA-7-UC, see below) and 12 ft (3.7 m) to the northwest of the feature interpreted as a crystallizer (FEA-3-UC). The drop in elevation between the boiler (FEA-7-UC) and the top of the cooling vessel is (FEA-6-UC) 2.2 ft (.68 m) and the drop between the cooling vessel and the crystallizer (FEA-3-UC) is approximately 6 ft (1.8 m). The descending west-to-east elevations of the three successive features corresponds to the cascading, gravity-fed copperas manufacturing process as described and illustrated in historical sources (Figure 4-16). The heavy vertical iron stanchions appear to have been used to hold the sides of the masonry vessel together. Side reinforcement would have been important in a longitudinal brick vessel subjected to the outward forces from the heavy, dense copperas liquor. Similar in-situ stanchions straddling another cooler at the Lower Copperas Factory (FEA-2-LC) were connected by a horizontal iron binder rod. The heavy iron castings demonstrate the factories' reliance on outside suppliers such as iron foundries, and the incorporation of iron rail is an example of adaptation and recycling of materials. The 1850s profile for the rail does not necessarily help date the factory, as the rail could have been reused over time.

[12] This item was recorded in situ and reburied at its original location during the remediation/capping activities.

[13] None of the stanchion or rail artifacts were removed from the site. They were recorded in situ and reburied at their original locations during the remediation/capping activities.

The fire bricks are examples of the refractory industry's most common standard No. 1 shape, and were manufactured and transported to the mine from distances ranging from Boston, MA to Scotland based on the manufacturers' names molded into the bricks. Boston and Taunton, MA were centers of mid- to late-nineteenth century fire brick manufacture associated with stove making, although the raw materials for large-scale firebrick manufacture are not found near there. Scottish towns including Glasgow on the River Clyde were major European fire brick manufacturing centers. The fire brick marked "J.M. Craig Kilmarnock" is an example of a type made at the Perceton Fireclay Works, Dreghorn, Scotland, between 1855 and 1906 (Graves 1995). The presence of imported brick in the U.S. well past the ca. 1820s establishment of early domestic suppliers such as at Woodbridge, NJ using Raritan River clay deposits is not uncommon. Brick made convenient ship ballast and, like some other domestic products, it suffered from prejudice favoring accepted imported materials long after the similarity or even superiority of the domestic counterpart had been established.

Stripped Area 2 (ST-2-UC, FEA-5-UC)

ST-2-UC was located 21 ft (6.4 m) south of FEA-1-UC in the southern section of the upper tier of the factory on the east side of the standing interior wall (see Figure 4-2). The stripped area measured 18-x-26 ft (5.5-x-8 m) on its long north-south axis. The area was initially observed as a brick concentration exposed on the surface 10 ft (3.1 m) north of the southeast corner of the standing interior wall. A large pine and two birch trees were growing from the structure causing the roots to displace bricks and pieces of mortar at the ground surface. ST-2-UC was excavated by hand and features were encountered close to the surface. The stripped area exposed FEA-5-UC at .5 ft bgs (.15 m), which consisted of two areas of brick and mortared floor surface and a portion of a collapsed sidewall. Once the trees were cut and the feature was stripped, the loose brick was removed exposing the intact sections of brick floor (Figure 4-17). Wood timber staining and fragments were interspersed within and north of the feature. Collapse of the factory main internal wall east of the brick structure had caused the brick work to slump to the east. Missing sections of brick floor and the eastern side wall were assumed to have fallen into the lower tier of the factory.

The in situ and collapsed structural remains provided insight into the possible original configuration of the feature. The collapsed wall lying over the floor had retained its original stretcher bond coursing. The collapsed wall appeared to have been 16 to 20 courses tall which would have given it a height of 36 to 45 in (.91 to 1.1 m). The bricks in the floor had mortared joints and were laid in an irregular pattern with the bricks with their wide faces up (Figure 4-18). Patches of mortar on the upper surface indicated that the floor may originally have been coated with a layer of mortar. The first area of brick measured 5.3-x-14 ft (1.6-x-4.3 m) with a long north-south orientation. To the west, east and north of the first brick section trace amounts of wood were encountered at .07 to .65 ft (.02 to .20 m) bgs. The wood, which was poorly preserved, appeared to be the remains of two north-south oriented timbers supporting planks and also possible east-west oriented beams supporting the brick structure. It measured 1.4 ft (.43 m) east of the first brick section at .5 ft bgs (.15 m). It measured 4.9-x-5.6 ft (1.5-x-5.7 m) in size. Missing brick and mortar exposed remnant wood timbers to the southeast at .5 ft bgs (.15 m). Three heavily deteriorated timbers were noted as a soil change 4.7 ft (1.4 m) north from the brick flooring at .19 ft (.05 m) bgs. An east-west timber was flanked by two of the timbers 5.75 ft (1.75 m) apart extending to the north.

The soil strata overlying FEA-5-UC included an A_o from 0 to .33 ft (0-.10 m) bgs, followed by a developing A, from .33 to .5 ft (.10 to .15 m) bgs that covered the brick scatter and surrounding wood timbers. A small area at the northwest corner of the feature was excavated to a depth 2.5 ft (.76 m) bgs. This excavation and the stripped surface west of the brick feature revealed a yellowish red (5YR 4/6) mottled with yellow (10YR 8/6) fine to medium sand with trace amounts of silt. To the north of FEA-5-UC the consistency of texture remained the same as that to the west, however, the soil was a brown

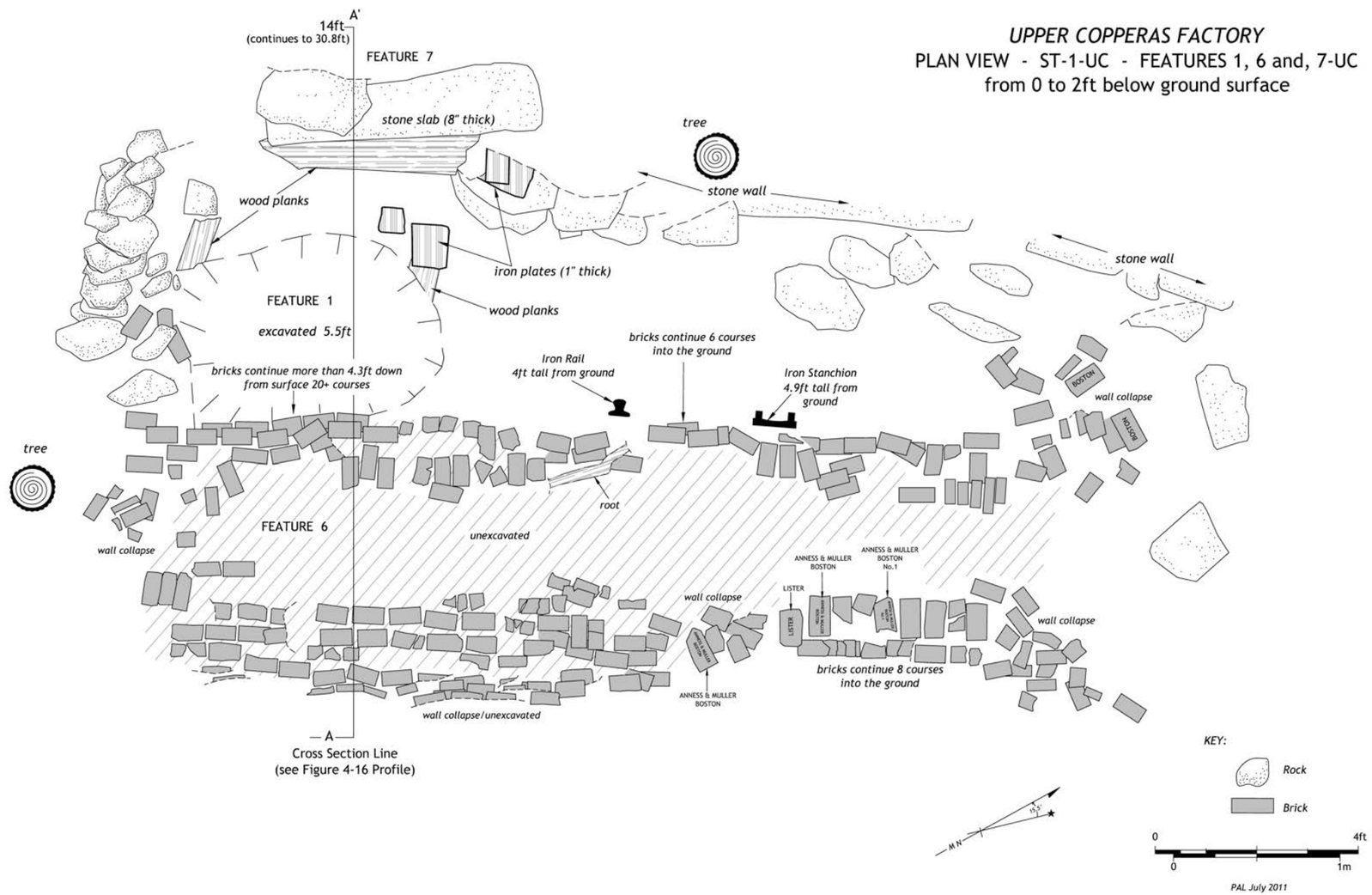

Figure 4-15. Plan of FEA-1-UC, FEA-6-UC, and FEA-7-UC at 0 to 2 ft below ground surface in ST-1-UC

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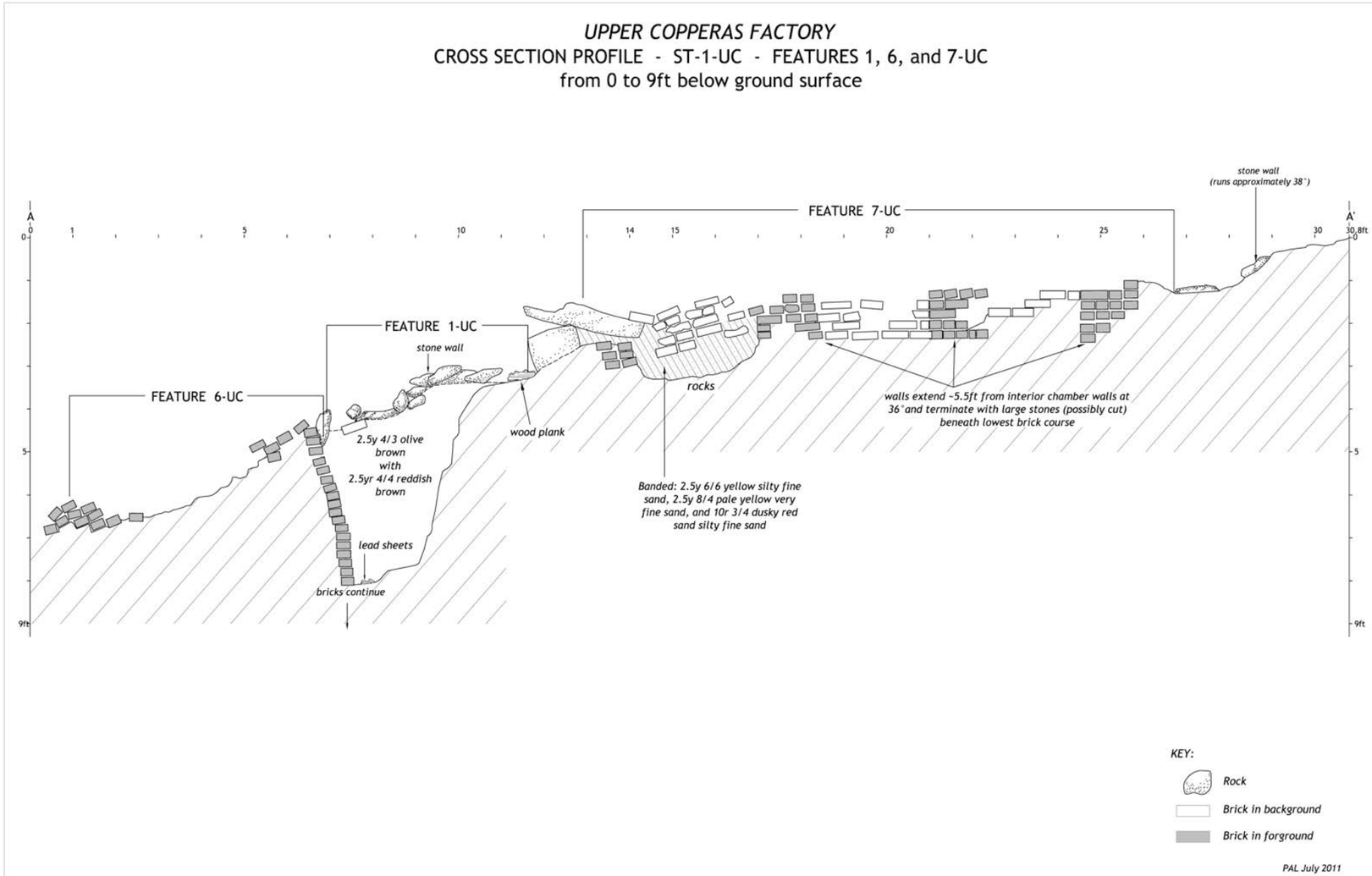

Figure 4-16. Cross section of FEA-1-UC, FEA-6-UC, and FEA-7-UC from 0 to 9 ft below surface in ST-1-UC, looking south.

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Figure 4-17. Photograph of FEA-5-UC in ST-2-UC, looking north.

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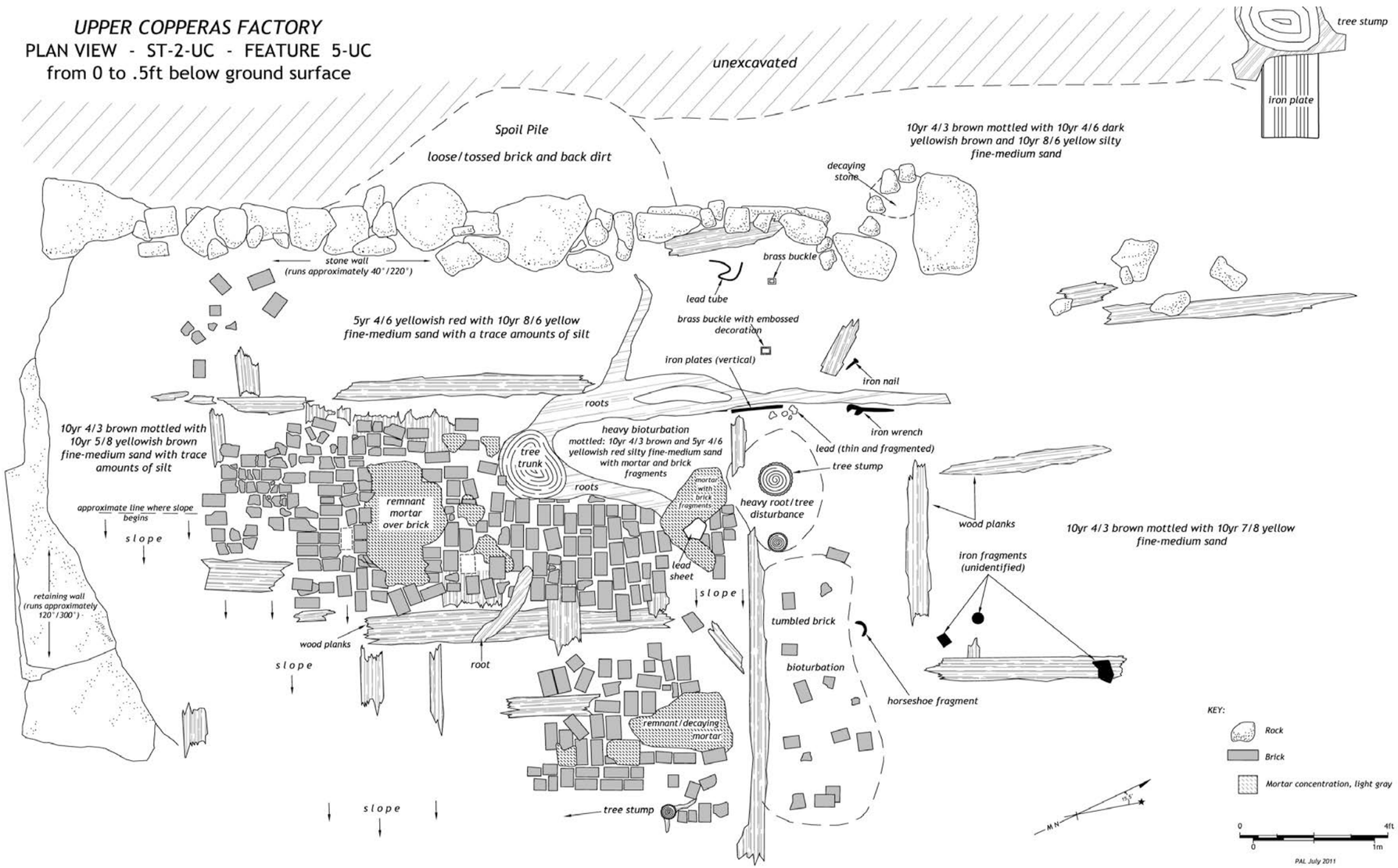

Figure 4-18. Plan of FEA-5-UC from 0 to .5 ft below ground surface in ST-2-UC.

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(10YR 4/3) mottled with yellow (10YR 7/8) hue. To the south of the feature the soils consisted of a brown (10YR 4/3) mottled with yellowish brown (10 5/8) fine to medium sand with trace amounts of silt.

A total of eight cultural materials was recovered from 0 to .5 ft (0 to .15 m) bgs in association with FEA-5-UC (see Appendix A; Table 4-2). These materials included brass buckles, a wrench, a handle, an iron bolt, a horseshoe fragment, a small diameter lead pipe, and an iron spike. Most of the artifacts associated with FEA-5-UC were found within the northern third of the feature. The artifacts found within the loose brick rubble over the brick floor included a large lead sheet lead, a boiler plate, sheet metal, the iron spike, the horseshoe fragment and the wrench. The lead sheet, iron boiler plate, and sheet metal were noted in the field, but not collected[14]. The segment of lead pipe and the two brass buckles were found within the northwest corner in the fill deposit or at the A1 horizon-fill interface. The wrench has an open end measuring .15 ft (.04 m) and is over 1.3 ft (.39 m) in length and has a heavily corroded curved handle (see Appendix B.1-2). The lead pipe has a .001 ft (.003 m) wall thickness, with a .06 ft (.02 m) diameter opening and is approximately 2.25 ft (.69 m) in length. The presence of lead plumbing is consistent with historical accounts stating that lead was the only material that could withstand the action of the acid copperas liquor. One of the two brass buckles has a rectangular frame with bowed sides and is stamped with a wavy line motif bound by beaded edge with a cord pattern (see Appendix B.1-6). None of these artifacts could be assigned date ranges of manufacture.

Although this brick feature is located on the upper tier of the factory, where boilers were typically located, and it is adjacent to a feature interpreted as a possible copperas liquor boiler in FEA-7-UC (see below), the lack of bright red, thermally altered hematite-rich soils surrounding features interpreted as the lower sections of boilers in FEA-7-UC and the boiler in TR-5-UC at the North Berm (see below), and the presence of surviving wood remains, suggest that this feature was not subjected to high heat, and therefore was not a copperas liquor boiler. The 5.3-x-14 ft (1.6-x-4.3 m) exterior dimensions of the section of brick floor with the collapsed side wall correspond somewhat with the 7 ft by 14 ft (presumably interior) dimensions of the crystallizers as reported in the 1871 *Vermont Historical Gazetteer*. However, the extrapolated height of the collapsed wall in the feature is 1.5 to 2.25 ft deeper than the 18 inch depth indicated in that account (Duncan 1871:1085–1088). Comparison of a feature with such a lack of distinct corners or edges with the dimensions of the vessels in the historical accounts is of questionable value as damage and possible scavenging (see Chapter 6) have left such an irregular edge that while overall measurements for the feature can be taken, their relationship to intact corners or walls of a vessel may not correspond. The historical accounts describe lead or "cement" linings for the crystallizers, and the feature could be interpreted as a cooler or crystallizer based on the remnant mortar lining. It could be an internal holding tank for copperas liquor drawn into the factory from the outdoor cisterns to the west, which could explain the apparent fallen side wall. This structure could also simply be a section of interior factory floor and a section of wall that served another, unknown function. The brick feature may be analogous to the single-layer brick floor over flat stone slabs in FEA-4-LC in the west end of the Lower Factory, although FEA-5-UC lacks some of the elements of that Lower Factory feature (see below).

Stripped Area 3 (ST-3-UC, FEA-7-UC)

ST-3-UC was located 20 ft (6.1 m) northeast of ST-2, west of ST-1-UC, in the north end of the factory upper tier (see Figure 4-2). FEA-7-UC was initially identified as Context II on the western boundary of ST-1-UC, bounded by the west edge of the brick cooler vessel feature FEA-1-UC. The north-south standing interior factory wall divided activity areas that were noted through differences in soil stratigraphy. The stripped area measured 14.7-x-19.9 ft (4.5-x-6.1 m). The soil matrix between 0 and 1.3 ft (0 and .40 m) bgs consisted of dark red (10R 3/6) mottled with red (10R 4/8) silty fine sand, decomposing roasted ore, and disintegrated brick fragments. Continued excavation exposed a rectangular

[14] These artifacts were reburied near their original locations during the remediation/capping activities above.

configuration of masonry brick and stone block walls from 1.3 to 2.1 ft (.40 to .64 m) bgs between the two north-south fieldstone walls marking the factory upper tier (Figure 4-19). The configuration of walls consisted of two east-west brick walls joined by four north-south-oriented brick, forming three north-south chambers with interior dimensions of approximately 2.5 x 4.75 ft (.76 x 1.45 m) (Figure 4-20). The walls were bounded on the east side by a large cut granite block that was part of the standing interior factory wall. The brick walls were as many as six courses high and ranged between four to five courses wide with an average 1.5 ft (.46 m) wall thickness. Decaying schist and mortar were intermixed with dark red (10R 3/6) mottled brown (10YR 4/3) silty sand within the chambers. Two of the chambers contained iron boiler plates above the decaying schist and mortar[15]. Many of the brick courses were missing from the north side of the feature, exposing three rectangular split granite blocks between 1.5 and 1.9 ft (.45 and .59 m) bgs supporting the outer brick walls. The overall width of the masonry feature between the factory upper tier stone walls was 18.2 ft (5.5 m), and the area of exposed in-situ brick work measured 8 ft (2.4 m) x 14 ft (4.3 m) (see Figure 4-20).

A total of 20 cultural materials was recovered from 0 to 2.5 ft (0 to .76 m) bgs (convert to cm/m as well) in association with FEA-7-UC (see Appendix A; Table 4-2). These materials include a wedge, a spike, machine-cut nails, a redware ceramic sherd, a flat lead washer, small diameter iron pipe fragments, and lead trim and spatter fragments. The redware sherd is identified as hollowware with a lead glaze that places it in a very broad date range of manufacture (1600 to the present). The lead washer has a center opening of .01 ft (.003 m), and an overall width of .1ft (.03 m) and may have been part of the lead boiler vessel lining system. The spike and nails are heavily corroded. The spike is 1 ft (.31 m) in length. Four pieces of iron boiler plate were noted within the feature, but they were not collected[15].

FEA-7-UC can be interpreted as a copperas liquor boiler. Its location-n in the upper tier of the factory, above and adjacent to an apparent copperas cooling vessel, is consistent with historic illustrations of the cascading process and the written descriptions of the South Strafford operation. The dominance of bright red soil around and under the brickwork is consistent with the thermal alteration halo of red hematite soil found in and around features interpreted as boilers in the North Berm and South Berm (see below). The presence of materials associated with the copperas boilers including lead spatter and pieces of iron plate support this interpretation. The presence and east-west orientation of the multiple parallel brick walls match descriptions of the heating passages in the South Strafford boilers in two descriptions spanning the life of the operation:

> The bottoms of the evaporating vessels [boilers] are of lead, and about ten feet square…The bottom is supported by a number of parallel brick walls, placed at a small distance from each other. The avenues or arches between these walls communicate at one end with the arch in which the fire is placed, and at the other with the common flue. (Locke 1821:326–330).

> These factories contain the evaporating pans [boilers]…each pan being 26 feet long by 10 feet wide, and 16 inches deep…Beneath the evaporating pans run a series of flues, commencing at the fire arches at one end of the pans and terminating in the stack at the other end. (Duncan 1871:1085–1088).

The 10 ft by 26 ft dimensions given for the ca. 1871 boiler do not match the 8 ft (2.4 m) x 14 ft (4.3 m) dimensions of the in situ brick wall feature, however, the brick feature appears to represent the bottoms of the heating flue walls at the base of the boiler and do not necessarily reflect the possibly greater dimensions of the base or the heating pan supported above.

[15] The iron boiler plates were recorded in situ and reburied near their original locations during the remediation/capping activities.

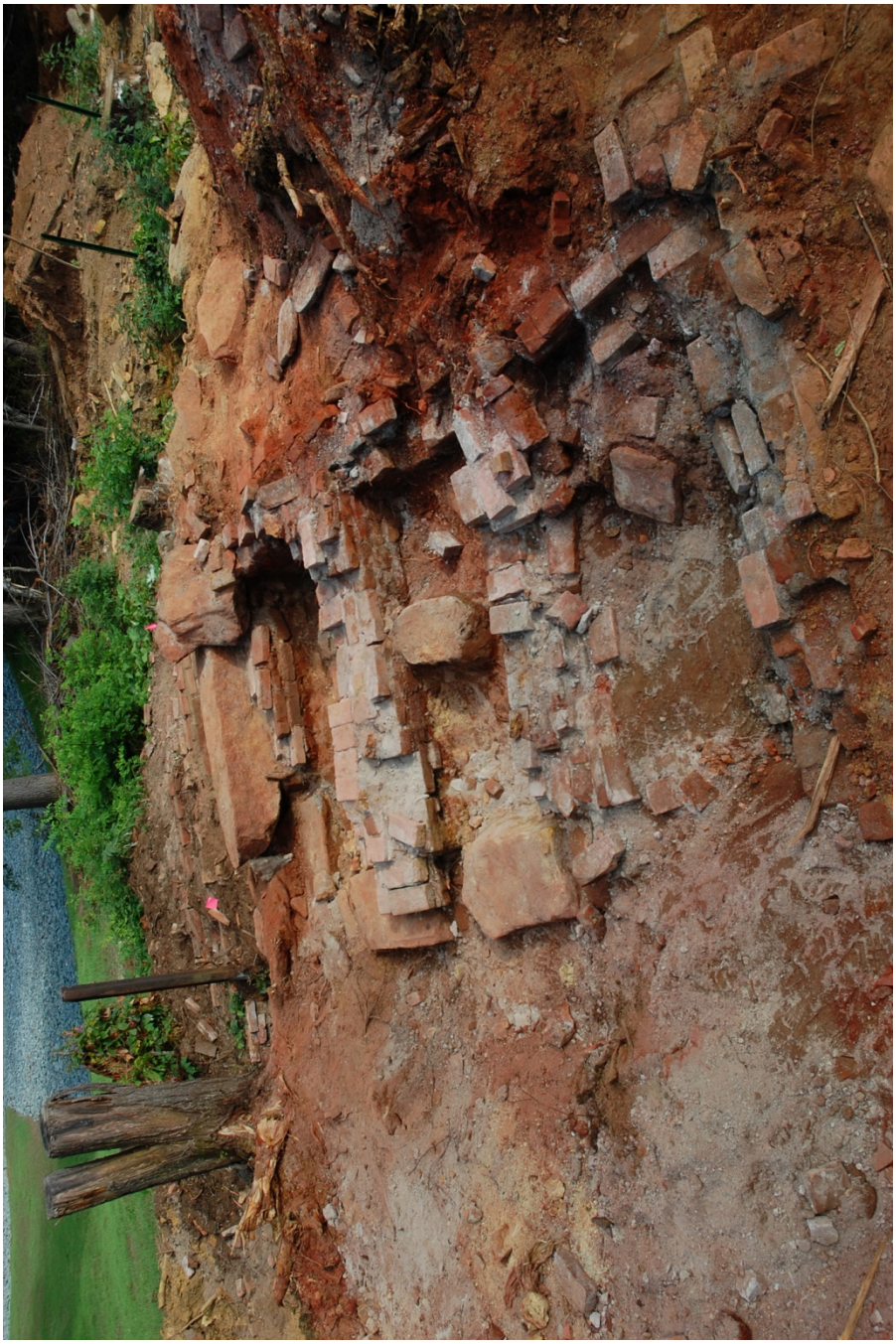

Figure 4-19. Photograph of FEA-7-UC in ST-3-UC looking southeast.

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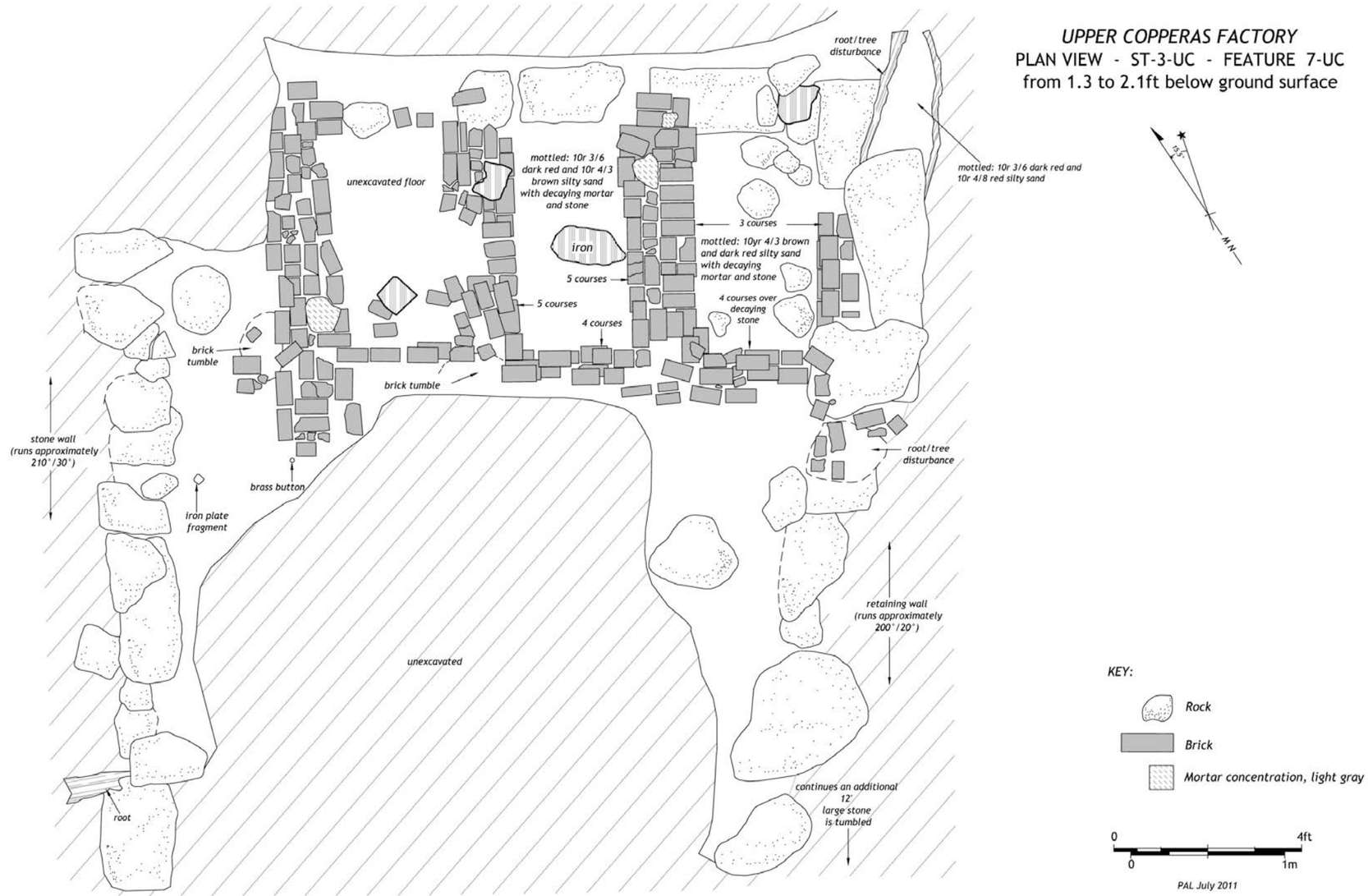

Figure 4-20. Plan of FEA-7-UC from 1.3 to 2.1 ft below ground surface in ST-3-UC.

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North Berm

The North Berm was a linear earth mound located at the foot of Copperas Hill, west of Mine Road and north of Copperas Brook, immediately east of the Upper Copperas Factory at the transition of the slope to the west and the flat area of mine waste to the east (see Figure 4-2). Seven trenches (TR-4-UC thru TR-10-UC) were excavated in the North Berm area to the far southeast side of the upper, middle, and lower tiers of the Upper Factory area. A total of 31 cultural materials was recovered from 0 to 5.1 ft (0 to 1.5 m) bgs in overburden and rubble fill soils (see Appendix A-Upper Copperas Factory North Berm; Table 4-2).

Trench 4 (TR-4-UC)

PAL monitored excavation of a northwest-southeast oriented exploratory engineering trench (TR-4-UC) excavated into the east face of the North Berm located 100 ft (30.5 m) east-northeast of TR-3-UC (see Figure 4-2). PAL identified the berm as having potential subsurface features similar to the South Berm, a boiler feature located in the Inter-Copperas area (see description below). The contractor excavated the trench to identify the depth of mine waste for construction of a sedimentation basin to capture runoff-borne sediment from cleanup operations on the open slope of TP 3. PAL monitored the trenching to identify any historic industrial structural remains. The trench measured approximately 4.5-x-20 ft (1.4-x-6.1 m) and contained an upper layer of red (2.5YR 4/6) silty clay over several feet of decomposing brick and schist. The fill strata consisted of a mottled yellow (2.5Y 8/6) silty medium to fine sand, yellow (2.5Y 8/8) sandy clay and a yellowish red (5YR 5/6) silty clay intermixed with decomposing brick and stone cobbles and blocks. The fill deposit also contained structural materials. A horizontal wood timber on a northeast-southwest axis was encountered at approximately 3.5 ft (1.1 m) bgs. The fill layer also contained a short northwest-southeast oriented wall of split granite blocks. The fill deposit continued for an additional foot and was followed by a yellowish brown (10 YR 4/6) silty fine sand followed by an organic black layer, possibly a decomposing wood layer, at approximately 8.5 ft (2.6 m) bgs (Figure 4-21). The trench was excavated down approximately 10 ft bgs where the mine waste deposit ended. No artifacts were observed in the exploratory trench during the contractor excavations.

Excavation of TR-4-UC suggested that the North Berm contained a large masonry structure. The bright red soils within the upper strata indicated the possibility of a copperas boiler, where long periods of heat converted iron in the surrounding soil to hematite. The red soil and yellow sandy clay fill deposit containing decomposing schist and brick below the upper stratum was similar to that seen at the boiler structure found in FEA-7-UC and in the South Berm in FEA-4-UC (see below). A large granite block from the short northwest-southeast wall had triangular flat wedge quarrying marks identified as cape chisel marks (Figures 4-22 and 4-23). The flat wedge quarrying method using the triangular cape chisel and hammer was commonly used in New England from the late eighteenth century to about 1830. The cape chisel was used to create shallow slots (roughly 1½ to 2 inches wide by 2 inches deep) into which were forced flat wedges and sheet iron shims to split the rock. The manual cape chisel was replaced by machine flat wedge chisels about 1849. From about 1803 on, the plug & feather method using metal wedges in round holes 3 to 4 inches deep began to be used concurrently with the cape chisel, and eventually its use outstripped the use of triangular chisels in general (Gage & Gage 2002: 42-48; Garvin 2001:43-45). The presence of the cape chisel marks is certainly consistent with the early nineteenth-century period of operations at the South Strafford copperas works. The documented history of multiple factories and apparent scavenging and recycling of associated building materials during and after operations makes the date of this feature or associated factory structure in TR-4-UC difficult to date in relation to other copperas processing features.

Figure 4-21. Photograph of exploratory engineering trench (TR-4-UC), north wall profile.

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Figure 4-22. Photograph of quarried stone in TR-4-UC.

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Figure 4-23. Detail of flat wedge splitting (cape chisel) marks in the quarried stone.

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Trench 5 (TR-5-UC)

TR-5-UC was placed approximately 2 ft northwest of TR-4-UC on the flat plateau of the North Berm. The trench originally measured approximately 4-x-33 ft (1.2-x-10.1 m), with a long northwest-southeast axis (see Figure 4-2). The trench was expanded to the northeast an additional 10.5 ft (3.2 m). The excavations followed structural features ranging in depth from .5 to 3.9 ft below datum (bd) (.15 to 1.2 m). The trench revealed a deteriorated brick and fieldstone structure (Figure 4-24: back pocket) that appeared to have been exposed to high heat based on the characteristic red hematite soils and brick fragments found within the trench and feature. In many areas, the structure consisted of decomposing schist blocks and deteriorating brick. Often the decomposed material was evident through soil changes with a deeper red (2.5YR 4/8 and 10R 3/6) stratum indicating disintegrated brick within the structure followed by a white to light greenish gray (Gley1 8/N to 7/10Y) silty fine to coarse sand within the schist substructure. Evidence of the structure was discernable in the shallow soil profiles on the eastern side of the plateau that indicated that it continued in the same plane to the edge of the berm's eastern face. The brick and stone construction appeared in bands that had been partially impacted by erosion stepping down the east face of the berm. Apparent intact portions of the structure consisted of brick courses laid in a northwest-southeast orientation above medium to large schist and granite boulders at .2 to 1.4 ft (.06 to .43 m) bd. In the east section of the trench, courses of brick were laid over rubble fieldstone from 2.3 to 3.9 ft (.7 to 1.19 m) bd (see Figure 4-24).

The trench was expanded to the north, where there was little evidence of brick. The in situ surface features were covered by an overburden of dark yellowish brown (10YR 5/8) medium to coarse sand that extended from 0 to .5 ft (0 to .15 m) bd. Reddish brown (5yr 5/4) clay with broken brick and mortar inclusions was encountered at .5 to 1.3 ft (.70 to 1.2 m) bd and is interpreted as a transitional soil deposit between the overburden and the decomposing brick. The excavation continued vertically and encountered large schist boulders at 1.9 ft (.58 m) bd. A brownish yellow (10YR 6/8) medium to coarse sand was interspersed between the boulders at depths of 1.9 to 4.1 ft (.58 to 1.25 m) bgs. A decaying schist block wall was present at .2 ft (.06 m) bd in the northwestern limit of the trench. The wall was constructed on a northeast to southwest axis and appeared to be the northwestern limit of the structure. The excavated portion of the wall measured 1 to 1.4 ft (.31 to .43 m) in width and extended 10.5 ft (3.2 m) to the northeast following the edge of the trench and trench expansion (see Figure 4-24).

A total of 11 cultural materials was recovered from 0 to 1.9 ft bgs (0 to .58 m) (convert to cm/m as well) in TR-5-UC (see Appendix A; Table 4-2). These materials include iron plates, a small piece of lead, a glass tumbler base, and an iron drive wheel shaft fragment. The artifacts were found at the top of the boiler feature and within the transitional reddish brown clay matrix. The lead fragment ranges from .28 to .34 in (7 to 8.6 mm) thick and was possibly associated with the lead lining of a copperas boiling vessel. The lead fragment contains five small diameter holes, one still containing a fragment of a nail fastener. The glass tumbler base fragment was found in the northern extension. The base has a rough unfinished star pontil mark that has a manufacture date range from 1809 to 1884 (see Appendix B.1-5). The iron plates range from .02 to .08 ft (.006 to .03 m) in thickness. The thicker plates could have supported and leveled a copperas boiling vat within a boiler heating chamber. One of the boiler plates was found apparently in situ at 1.2 ft (.37 m) bd, roughly aligned with a cluster of other plates 21.9 ft (6.7 m) to the southwest in TR-6-UC.

The drive wheel shaft fragment appears to be a possible spoke from a belt drive line shaft system, similar in shape and size to a more complete wheel recovered from the blacksmith shop in the 2002 PAL survey (see Appendix B.1-1). Line shaft power transmission systems were common in industrial facilities during the period of copperas factory operations. Line shaft systems were used to distribute rotational mechanical power from a central source through a system of drive shafts, pulleys and belts to drive machinery, often on multiple levels, within a factory, machine shop, etc. There is no historical

documentation for such systems within the copperas factories, and no water wheel pits or steam engine bases for equipment to drive such a system were encountered. It is possible the wheel may be part of a system for conveying copperas liquor, as pumps are mentioned in the historical accounts.

Trench 6 (TR-6-UC)

TR-6-UC was located 12 ft (3.7 m) south of and parallel to TR-4-UC and TR-5-UC, running across the top plateau and east face of the North Berm (see Figure 4-2). The trench measured 4.6-x-52 ft (1.4-x-16 m) and reached a maximum depth of 2.9 ft bgs (.88 m). The trench contained similar parallel brick and stone masonry walls or structures and materials to those found in TR-5-UC; decomposing brick and schist were prevalent (Figure 4-25). A rubble schist stone wall was noted at .78 ft (.24 m) bgs along the west side of the trench. The trench also contained two in-situ iron plates at 1.18 and 1.5 ft (.36 to .46 m) bgs that were adjacent to two brick courses at 1.28 to 1.5 ft (.39 to .46 m) bgs with a north-south orientation on the plateau of the feature. The plates were situated 3.5 ft (1.1 m) east of the wall. The in situ plates and brick courses were found at the north end of the feature (see Figure 4-25). Erosion had impacted the masonry structures east face of the berm.

East of the iron plates and brick courses the elevation dropped (.77 ft) (.23 m), possibly due to decomposition of the brick. A few brick fragments were noted in the sidewalls with decomposing schist below. At .79 ft (.24 m) bgs above the east-west courses in this section was a north-south course along the east wall of the trench that ended at the rubble stone section. The stone section extended down slope approximately 6 feet (1.83 m). Two more parallel sections of brick followed, with a distinct drop in elevation in between the courses. The drop in elevation ranged from 1.2 to 1.7 ft (.35-.53 m) and was followed by another stone section. Additional bricks were encountered downslope with no evidence of intact course work. Wood staining and rubble extended down slope approximately 8 ft (2.44 m). At the base of the trench between .6 and 1.4 ft (.19 and .43 m) bgs was a large southwest-northeast oriented log resting on a possible wall made of rounded and flat stones (see Figure 4-25). East of the wall was an irregular cluster of long, straight sticks with diameters ranging from .04 to .08 ft (.01 to .02 m), with the majority having a diameter of ¾ in. The sticks were irregularly arranged and appeared to be part of possible slope wash. The presence of so many sticks of similar diameter in one place was a unique phenomenon for the factory excavations. If the sticks were part of an intentional grouping, they may have been associated with the copperas crystallizing process as described in the earlier historical accounts. The large log appears to have been intentionally placed on the stones, possibly at the base of the boiler structure.

A total of 13 cultural materials was recovered from 0 to 2.9 ft (0 to .88 m) bgs in TR-6-UC (see Appendix A; Table 4-2). These materials include lead sheet, iron boiler plates, a handmade brick, a common red brick fragment, unidentifiable wood, and unidentifiable iron. The iron plates range between .06 and .1 ft (02 to .03 m)[16]. One of the pieces of lead sheet recovered was curled up and measured .01 ft thick (.003 m) x 1.4 ft (.43 m) in length and approximately .7 ft (.2 m) wide. Lead sheet was used for lining the boiler vessels and for repairing the linings. No other artifacts were encountered within the trench.

Trench 7 (TR-7-UC, FEA-4-UC)

TR-7-UC was located 7 ft (2.1 m) north-northeast of TR-5-UC (see Figure 4-2) over an existing gully on the east side of the berm. The location was chosen based on this topographic feature. Hand excavations initially focused on the east face of the berm. Excavations revealed a collapsed brick lined void (FEA-4-UC) at 2.3 ft (.70 m) bd. in the face of the west wall of the trench. Above the void at 1.5 ft (.46 m) bd was an east-west field stone wall at the top of the berm. A combination of machine and hand excavations

[16] Includes the two iron plates adjacent to the two brick courses, discussed above.

were used to further expose the masonry feature containing the void. TR-7-UC measured 7 ft (2.1 m) x 31 ft (9.45 m) and followed the contours of FEA-4-UC at the west end of the trench. Excavations focused on the west face of the brick feature and its flanking north and south masonry walls.

The void opening was 5.1 ft (1.5 m) high and 6 ft (1.8 m) wide and filled with collapsed brick (Figure 4-26). The south wall of the void had two brick faced walls at the base followed by five courses of brick curving or sloping to the north. The brick wall blended into the arch to the west and stepped down to east. In the center of the void was a charcoal ash deposit mixed with dark yellowish brown (10YR 3/6) medium coarse sand and dark red silty sand at 3.8 ft (1.16 m) bgs. There was no corresponding curved or leaning brickwork on the north side of the void, which was filled with fallen brick and stones at 1 ft (.30 m) bgs. Two courses of brick were found on the north side of the void, over decaying schist at 3.3 ft (1 m) bgs, similar to the wall extending east from the opposite brick wall in the south side of the arch.

Southeast of the wall at the north side of the void, slumping brick courses lay above schist stones from 4.2 to 7.3 ft (1.3 to 2.2 m) bd. The brick courses and schist stones were banded in a northeast-southwest direction and stepped down the southeast slope of the berm (Figure 4-27). This construction continued down the face of the berm for 8.4 ft (2.6 m) to the southeast. The void opening was heavily damaged on the northeast side. Collapse was evident on the north side with tumbled brick and stone. Further excavation revealed parallel schist stone walls extending southeast from the north and south edges of the void. The north wall consisted of medium to large schist fieldstones. Fieldstones were piled north of the wall at depths of 5.2 to 7.3 ft (1.6 to 2.2 m) bd with no clear alignment.

Based on its location low in the downhill side of the masonry structure in the North Berm, the void in the brickwork could be interpreted as a possible east-facing opening into a boiler structure, possibly for an ash pit under grates or a firebox door for loading wood fuel. Similar openings are shown in the eighteenth-century Diderot illustration of a copperas boiler (see Figure 3-4). The original face of the structure has collapsed making any brick arch or doorway coursing indistinct. The parallel walls flanking the opening could be the walls of an ash pit or fuel charging area for a boiler.

A total of five cultural materials was recovered from 0 to 5.1 ft (0 to 1.6 m) bgs in TR-7-UC (see Appendix A; Table 4-2). These materials include unidentified iron and lead spatter. One of the iron fragments consists of a 1/8-inch piece of iron plate. These materials were found in the collapsed rubble in the void. Fallen brick and weathered ore were noted, but not collected.

Trench 8 (TR-8-UC)

TR-8-UC, the northernmost trench placed within the berm, was located 5.6 ft northwest of TR-7-UC (see Figure 4-2). The trench measured 6.5 ft (1.98 m) x 18 ft (5.5 m) and reached a maximum depth of 3.85 ft bgs (1.2 m). Excavation revealed wood planks and a substantial cut schist stone wall along the southwest trench edge. The wall and plank had a northwest-southeast orientation. The wood plank was found on the north side of the trench at 2.9 ft (.88 m) bgs, while the wall was found along the trench's south wall between 1.2 to 2.5 ft (.37 to .76 m) bgs. A reddish brown (5YR 5/4) clay with brick rubble was found above the wall and planks. None of the bricks appeared to be in situ. Artifacts recovered include one lead spatter and one leather fragment found from 0 to 2.9 ft (0 to .88 m) bgs within the southeast corner of the trench in the brick rubble overburden (see Appendix A; Table 4-2).

Structural features to the south in TR-5-UC were found at higher elevations than those identified in TR-8-UC (Figure 4-28). A column was cut and excavated into TR-8-UC's southwest trench wall revealing more of the northwest-southeast stonewall at 4.1 ft (1.25 m) bd and the schist substructure in TR-5-UC to the south. The substructure rose 2.2 ft (.67 m) above the stone wall in TR-8-UC. The northeast-southwest

fieldstone wall above the void in TR-5-UC to the south was 3.3 ft (1 m) above the wall in TR-8-UC. The stone wall in TR-8-UC terminated 2 ft (.61 m) northwest of the wall containing the void.

The plank and wall identified in TR-8-UC may correspond to the northern boundary of the possible boiler exposed in TR-6-UC. The plank may have been the remains of a floor located outside the structure, and the stone wall may represent the northern extent of the feature. The lower elevation of the wall and the presence of the disarticulated brick may indicate that the stone wall and the substructure to the south were originally covered by brick. No other structural features were encountered in TR-8-UC.

Trench 9 (TR-9-UC)

TR-9-UC was located 13.6 ft (4.14 m) southwest of TR-8-UC (see Figure 4-2). The trench was placed to further investigate the western boundary of the possible boiler feature. The trench was placed 1.4 ft (.43 m) northwest of the drylaid schist stone wall found at .2 ft (.06 m) bd in TR-5-UC. The trench measured 4.2-x-16 ft (1.3-x-4.9 m). Excavations revealed a colluvial deposit of (10YR 6/6) brownish yellow loamy sand from 0 to 1.3 ft bgs (0 to .40 m) followed by a heavily mottled deposit consisting of a strong brown (7.5YR 5/8) silty sand, with light olive brown sandy clay and a yellowish red (5YR 5/6) sandy clay (Figure 4-29). A lens of black ash (.6 ft [.18 m] thick) was found within the mottled deposit from 1.6 to 2.7 ft (.49-.82 m) bgs. Brick rubble fill was encountered from 2.2 to 3.3 ft (.67 -1 m) bgs followed by remnant wood planks (Figure 4-30). Five pieces of wood plank were exposed in the northeast side of the trench at 3.3 ft (1 m) bgs. Wood staining was evident in areas where planks had deteriorated. No artifacts were encountered in this trench.

The planks were most likely a work area floor with ash and brick deposits accumulated over years of operation. A boiler would have produced accumulations of ash and charcoal. Common brick subjected to intense heat would have deteriorated in a relatively short period of time and required regular repair and replacement. This maintenance would result in brick refuse. Similar brick and dark ash stratigraphy was encountered in TR-10-UC 30 ft to the south. In the 2010 field season, a similar brick and ash deposit was noted 35 ft (11 m) southwest of TR-10-UC in FEA-5-BC. Monitoring within the Copperas Brook Corridor further exposed the FEA-5-BC brick and ash strata, which proved extensive in that vicinity and to the east (see Chapter 5 discussion). Wood planks were also found below the brick and ash deposit in these areas.

Trench 10 (TR-10-UC)

TR-10-UC was located 30 ft (9.1 m) southeast of TR-9-UC and 10 ft (3 m) south of TR-6-UC at the southern edge of the North Berm (see Figure 4-2). The trench measured 4.9-x-21.6 ft (1.5-x-6.6 m) and reached a maximum depth of 4.3 ft (1.37 m) bgs. Combined machine and hand excavations revealed four fill layers with no structural features (Figure 4-31). This stratigraphy indicated that the trench was placed outside of the possible boiler feature. The trench contained two distinct brick rubble fill and ash deposits. The first brick rubble fill stratum was red (2.5YR 4/6) medium to coarse sand from 1.3 to 2.2 ft (.4 to .67 m) bgs. The rubble was followed by a compacted ash deposit that was mottled with dark yellowish brown (10 YR 4/6) silty medium to coarse sand. The ash deposit was found from 2.1 to 3 ft (.64 to .91 m) bgs. The second brick rubble stratum was mottled with a dark yellowish brown (10YR 4/6) silty medium to coarse sand encountered from 3 to 4.5 ft bgs (.91 to 1.37 m). The second rubble stratum was between the two ash deposits. The second ash deposit was found between 3.7 and 4.3 ft bgs in the northwest corner. No artifacts were encountered in this trench.

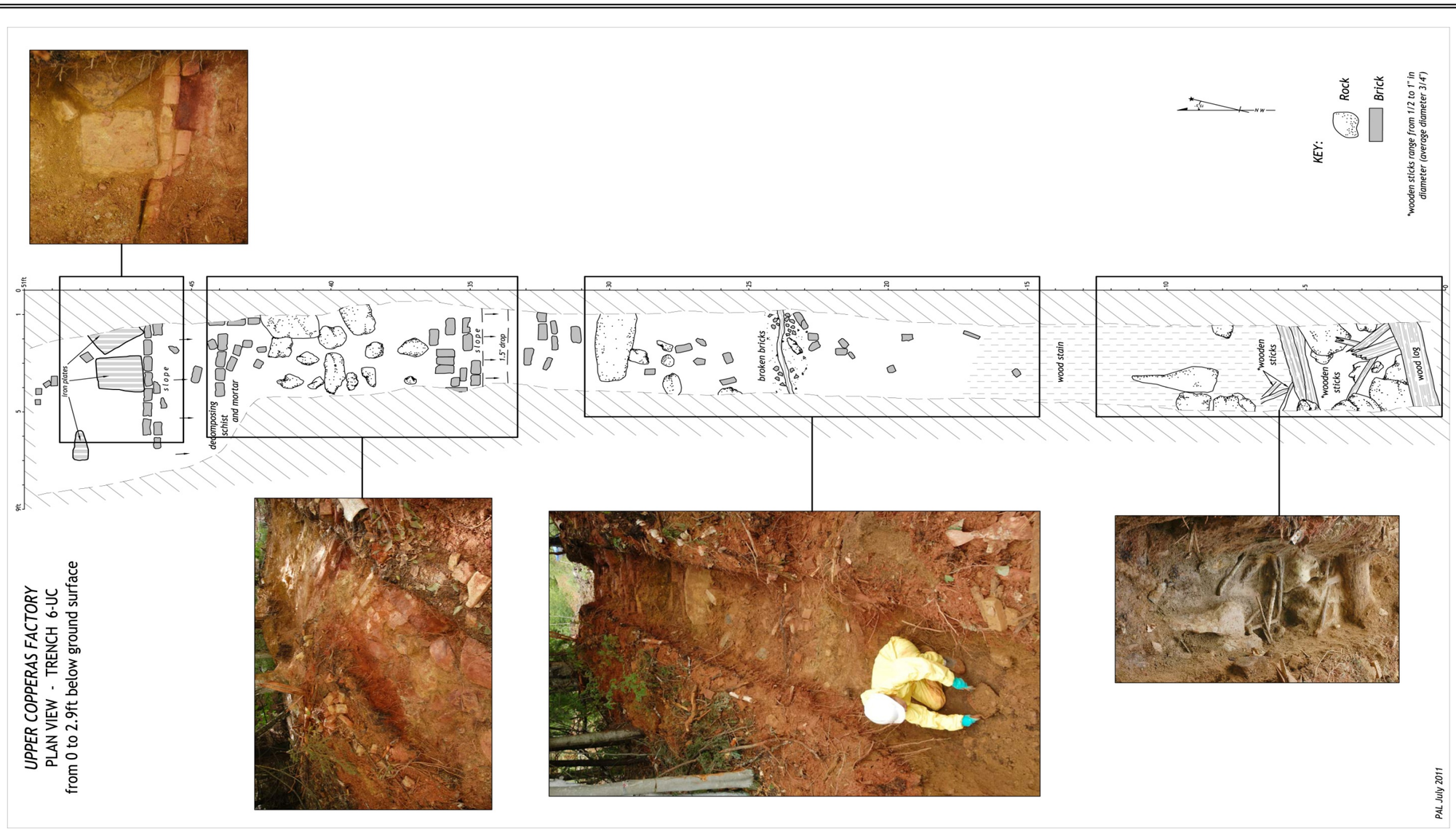

Figure 4-25. Plan of TR-6-UC from 0 to 2.9 ft below ground surface in the North Berm.

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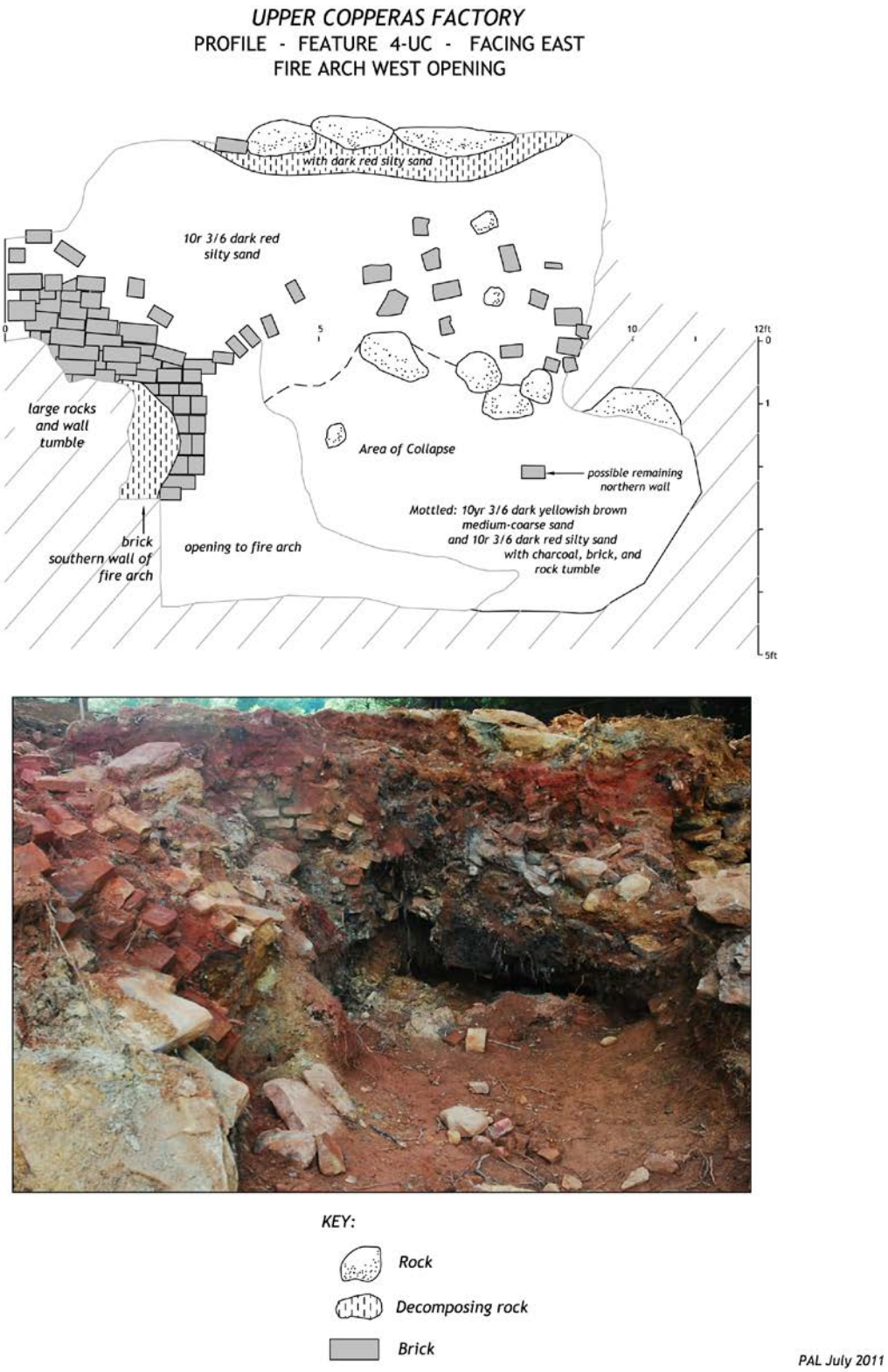

Figure 4-26. Profile of FEA-4-UC (fire arch).

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Figure 4-27. Photograph of the south side of the fire arch approach (Note: coursed brick and schist construction).

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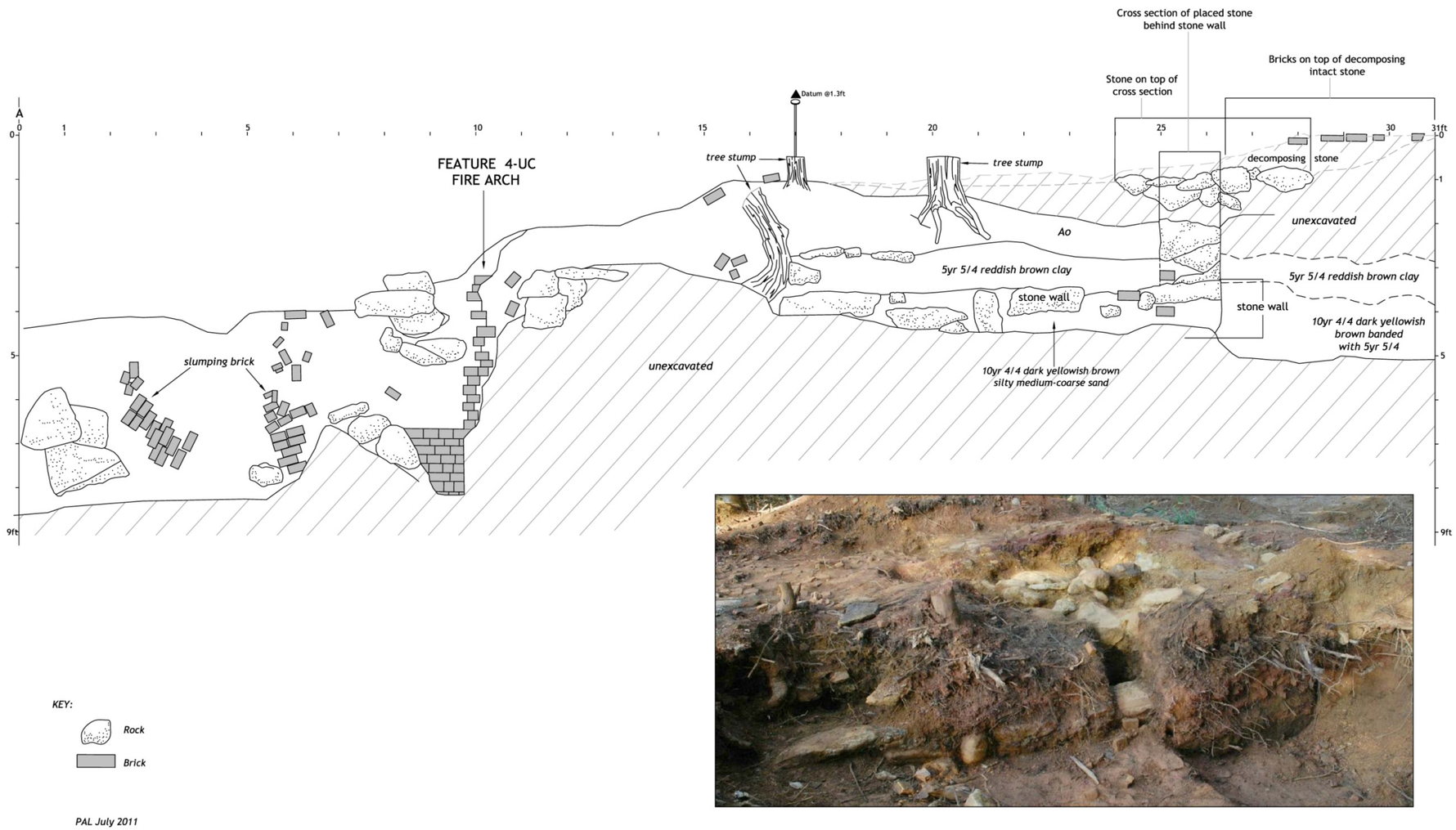

Figure 4-28. Cross section of TR-5-UC, TR-7-UC, and TR-8-UC, North Berm.

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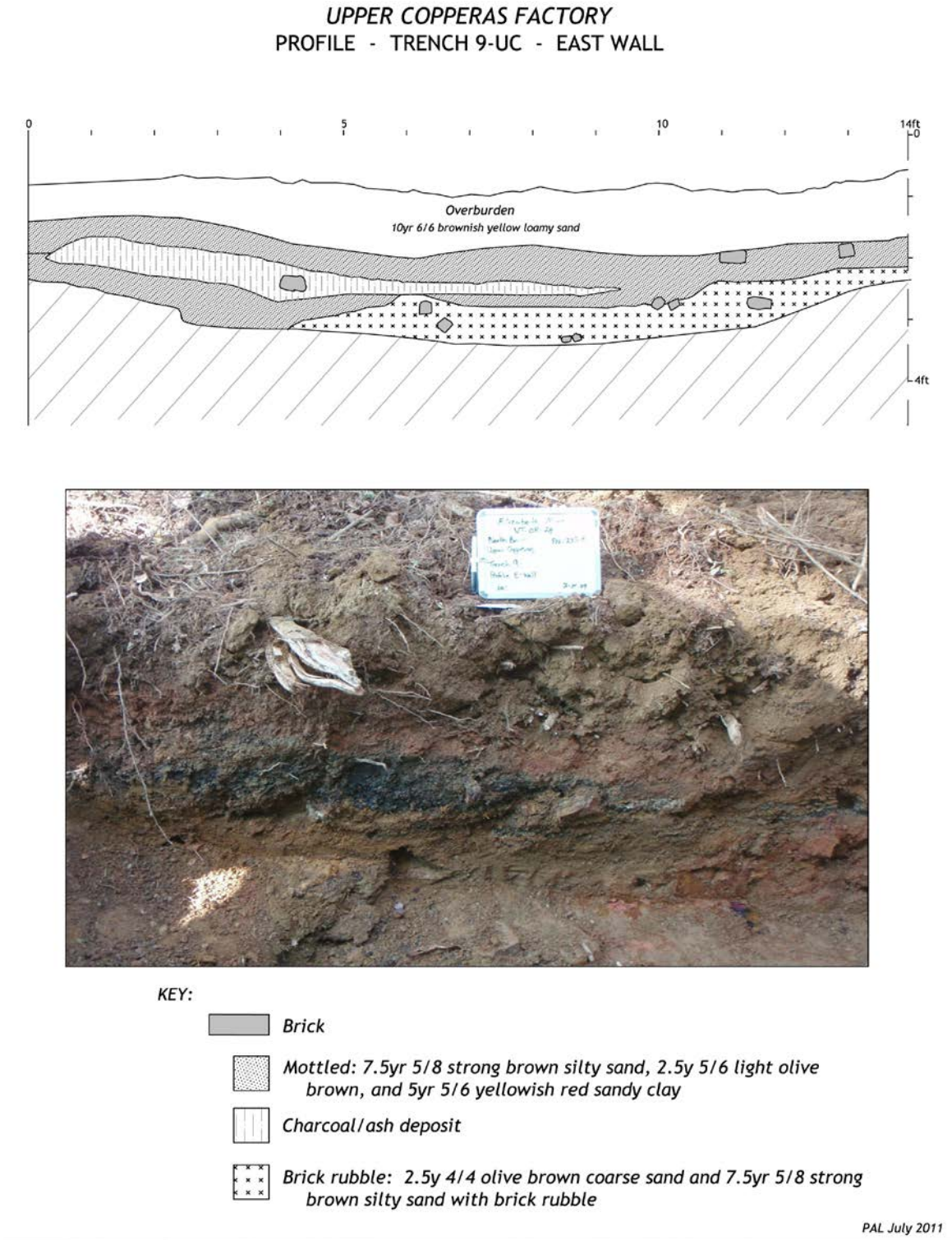

Figure 4-29. East wall profile of TR-9-UC.

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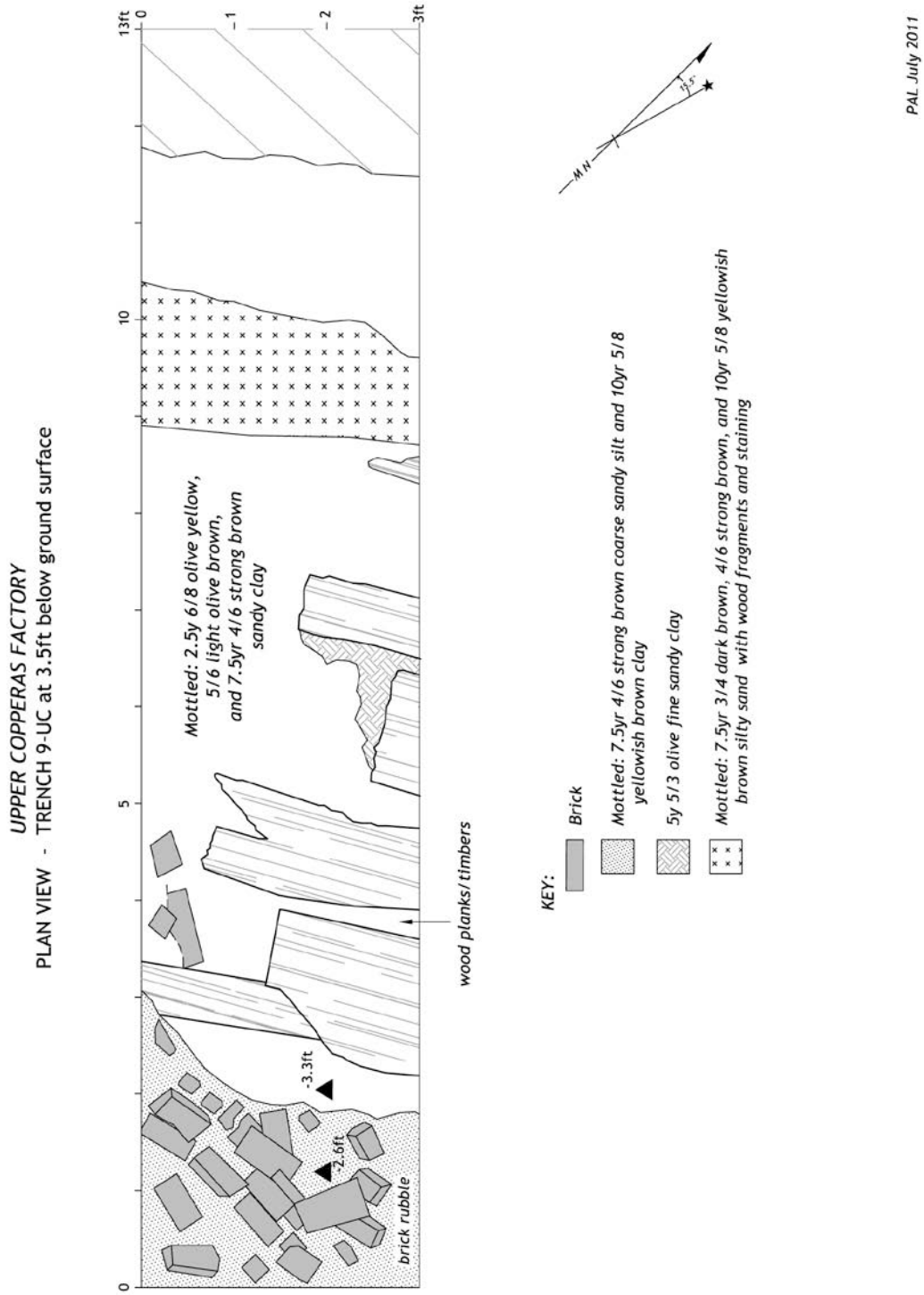

Figure 4-30. Plan of brick rubble fill and wood planks at 3.5 ft below ground surface in TR-9-UC.

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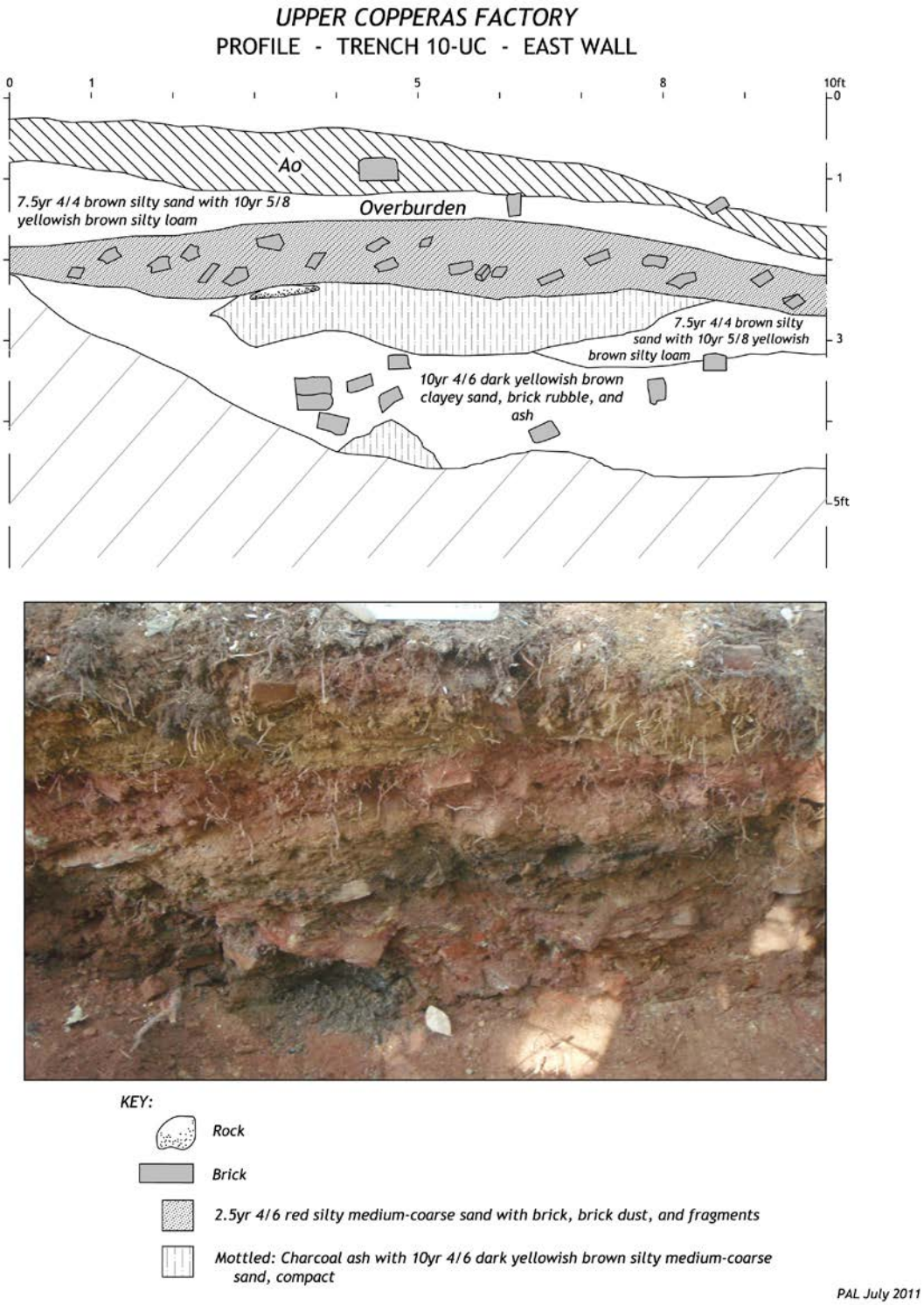

Figure 4-31. East wall profile of TR-10-UC.

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The North Berm was subsequently removed as part of mine cleanup[17]. Removal monitoring supported interpretation of the masonry structure as a copperas boiler, possibly part of another copperas factory (see Chapter 5).

Lower Copperas Factory

The Lower Copperas Factory is located just south of the bend in Mine Road and consists of an L-shaped stone wall and associated features (Figure 4-32: back pocket). Data recovery excavations at the Lower Factory included the excavation of five trenches (TR-1-LC through TR-5-LC) placed along the suspected exterior sides of the factory's prominent L-shaped wall. Four of the trenches (TR-1-LC, TR-2-LC, TR-4-LC, and TR-5-LC) were placed on the north side and one trench (TR-3-LC) on the west side of the foundation. Three additional trenches (TR-6-LC through TR-8-LC) were placed within the foundation along with three stripped areas (ST-1-LC through ST-3-LC). The stripped areas within the factory targeted the western platform, the center of the foundation, and the eastern end of the building, areas divided by transverse stone walls identified during the PAL 2002 survey. A total of 1,039 cultural materials was recovered from 0 to 3 ft (0 to .91 m) bgs in feature context, overburden and fill soils (see Appendix A-Lower Copperas Factory (LC); Table 4-3).

Trench 1 (TR-1-LC)

TR-1-LC was placed at the west end of the Lower Copperas Factory 4.6 ft (1.4 m) northeast of the visible corner of the foundation (see Figure 4-32). The trench measured 6.5-x-22 ft (2-x-6.8 m) and had a long east-west axis, parallel to the long east-west leg of the L-shaped stone wall. The trench reached a maximum depth of 4.8 ft (1.5 m) bgs. Excavations were terminated prior to reaching subsoil because of the steepness of the slope below the wall. A concentration of brick was noted on the surface approximately .11 ft (.03 m) north of the trench.

The trench stratigraphy consisted of an A_o from 0 to .5 ft (0 to .15 m) bgs followed by overburden of dark yellowish brown (10YR 4/6) mottled with yellowish brown (10YR 5/6) and light olive brown medium sand (2.5Y 5/3) containing loose brick and mortar debris from .5 to 2.5 ft (.15 to .76 m) bgs (Figure 4-33). To the west, the south wall extended 1.5 ft into the trench and contained an upper deposit of slopewash, A_o, and slumping organic material consisting of very dark grayish brown (10YR 3/2) mottled with black sandy silt from 0 to 4.2 ft (0 to 1.3 m). A deteriorated wood timber was noted at 1 ft (.3 m) bgs in the overburden at an oblique angle to a wood concentration found from 2 to 2.8 ft (.61 to .85 m) bgs. The wood was heavily deteriorated, however, it appeared to be in situ planks with supporting beams and loose brick and mortar fill below (2 to 4.5 ft, .61 to 1.37 m). The fill found below the wood layer consisted of yellowish brown (10YR 5/8) medium to course sand (see Figure 4-33). Structural material encountered within the trench included brick, mortar, and wood, none of which was removed from the site. A deposit of mortar was found toward the east end of the trench from 2.5 to 4 ft (.76 to 1.2 m) bgs and a small deposit of what appeared to be roasted ore was found at the west end of the trench from 3.8 to 4.8 ft (1.16 to 1.5 m) bgs. No artifacts were found.

[17] All of the structural materials and nonportable artifacts were removed from the North Berm and brought to TP 1 during the remediations activities.

Table 4-3. All Recovered Cultural Materials By Unit, Lower Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	Stripped 01	Stripped 02	Stripped 03	TR-02	TR-03	TR-04	TR-05	Unprov.	Total
Mammal		2							2
Charcoal		6							6
Coal	6								6
Brick		5		2					7
Copper		10							10
Bottle Jar		10							10
Curved Glass	1	21							22
Flat Glass		136				1			137
Misc. Glass Tube		2							2
Cast Iron Shovel								1	1
Unid. Cast Iron		2							2
Wrought Iron Ladle		1							1
Animal Shoe		1	18						19
Axe	1	3	5						9
Boiler		2							2
Bracket		2	2						4
Chisel			1						1
Handle		2						1	3
Hinge		1							1
Hook		1	2						3
Industrial Waste		25							25
Lock/Latch		1	1						2
Misc. Hardware		2							2
Nail	1	58	4						63
Iron Plate	1								1
Rake			1						1
Rivet		130							130
Iron Rod			2						2
Shovel	2								2
Spike		2	1						3
Unid. Iron		49	6			2	2		59
Unid. Tool		1							1
Utility Pipe		1							1
Lead Rivet		2							2
Lead Sheet		19							19
Lead Solder Rod		2							2
Lead Spatter		223	1						224
Lead Trimmings		74	3						77
Lead Pipe		5							5
Whetstone		1							1
Boot/Shoe	7								7
Unid. Leather	2	17							19
Mortar		1		13					14
Nutshell		1							1
Smoking Pipe								1	1

Object	Stripped 01	Stripped 02	Stripped 03	TR-02	TR-03	TR-04	TR-05	Unprov.	Total
Whiteware, Undecorated	3					1			4
Rubber Button		1							1
Unid. Rubber	19								19
American Stoneware, Albany Slip	4								4
American Stoneware, Albany Slip/Salt Glaze	4								4
Tin Sheet	2								2
Unid. Tin		27							27
Bullet		1							1
Currency/Token			1						1
Misc. Structural/Industrial		7							7
Industrial Waste		35							35
Wood Handle		4							4
Packing Barrel Stave					4				4
Unid. Wood		14							14
Grand Total	53	910	48	15	4	4	2	3	1039

Trench 2 (TR-2-LC)

TR-2-LC was placed 17 ft (5.3 m) east of TR-1 and 3.3 ft (1 m) north of the long stone wall (see Figure 4-32). The trench measured 4-x-23.5 ft (1.2 x 7.2 m) on its long east-west axis and reached a maximum depth of 4.5 ft (1.4 m) bgs. The trench contained wood planks and beams, and loose bricks from 1.5 ft (.46 m) bgs to the limit of excavation. The structural materials were disarticulated and appeared to be debris from collapse or demolition. A thin lens of wood was present below the overburden. Wood planks were encountered at 1.7, 2, and 3 ft (.52, .61, and .91 m) bgs. A second section of wood planking was encountered 2.4 ft (.73 m) bgs on the east side of the trench. Other material encountered within the trench included a iron pipe found in the north wall 1 ft (.31 m) bgs and an unidentified iron object, likely a tool, found 2 ft (.6 m) bgs in the center of the trench.

The north profile of the trench contained a combined A_o, overburden and ground disturbance from 0 to 1 ft (.3 m), while the south profile had a similar overburden from 0 to 2.8 ft (.85 m) bgs (Figures 4-34 and 4-35). The pipe was found in the north wall on the west side of the trench within a pocket of yellowish brown (10YR 5/8) mottled with dark yellowish brown (10YR 4/6) sandy clay from .7 to 1.8 ft (.2 to .55 m) bgs. No opposite end of the pipe was evident in the south wall. Above and below the fill layer containing the pipe was another fill deposit of yellow (2.5Y 7/8) mottled with yellowish brown (10YR 4/6) sandy clay from .5 to 1.1 ft (.15 to 3 m) and 1.5 to 2.5 ft (.46 to .76 m) bgs. The south wall also contained a slightly different stratum comprised of the same dark yellowish brown banded with yellow (2.5Y 8/6) sandy clay from .7 to 3.6 ft (.21 to 1 m) bgs. To the east of the pipe was a heavily disturbed mottled deposit consisting of brown (10YR 4/3), yellowish brown (10YR 5/8), dark yellowish brown (10YR 4/6) and yellow (2.5Y 7/8) sandy clay from 1.5 to 4.5 ft (.46 to 1.37 m) bgs.

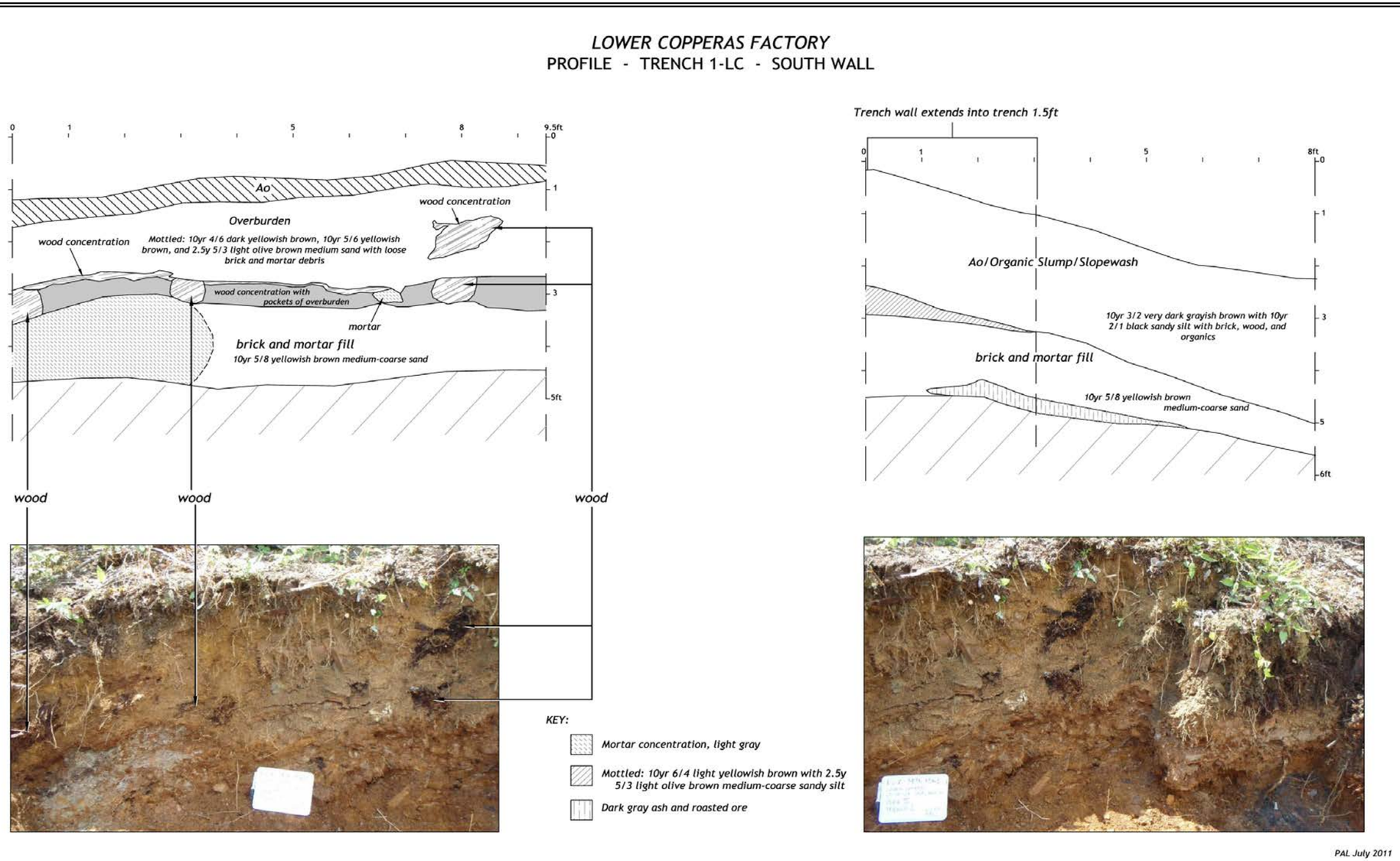

Figure 4-33. South wall profile of TR-1-LC .

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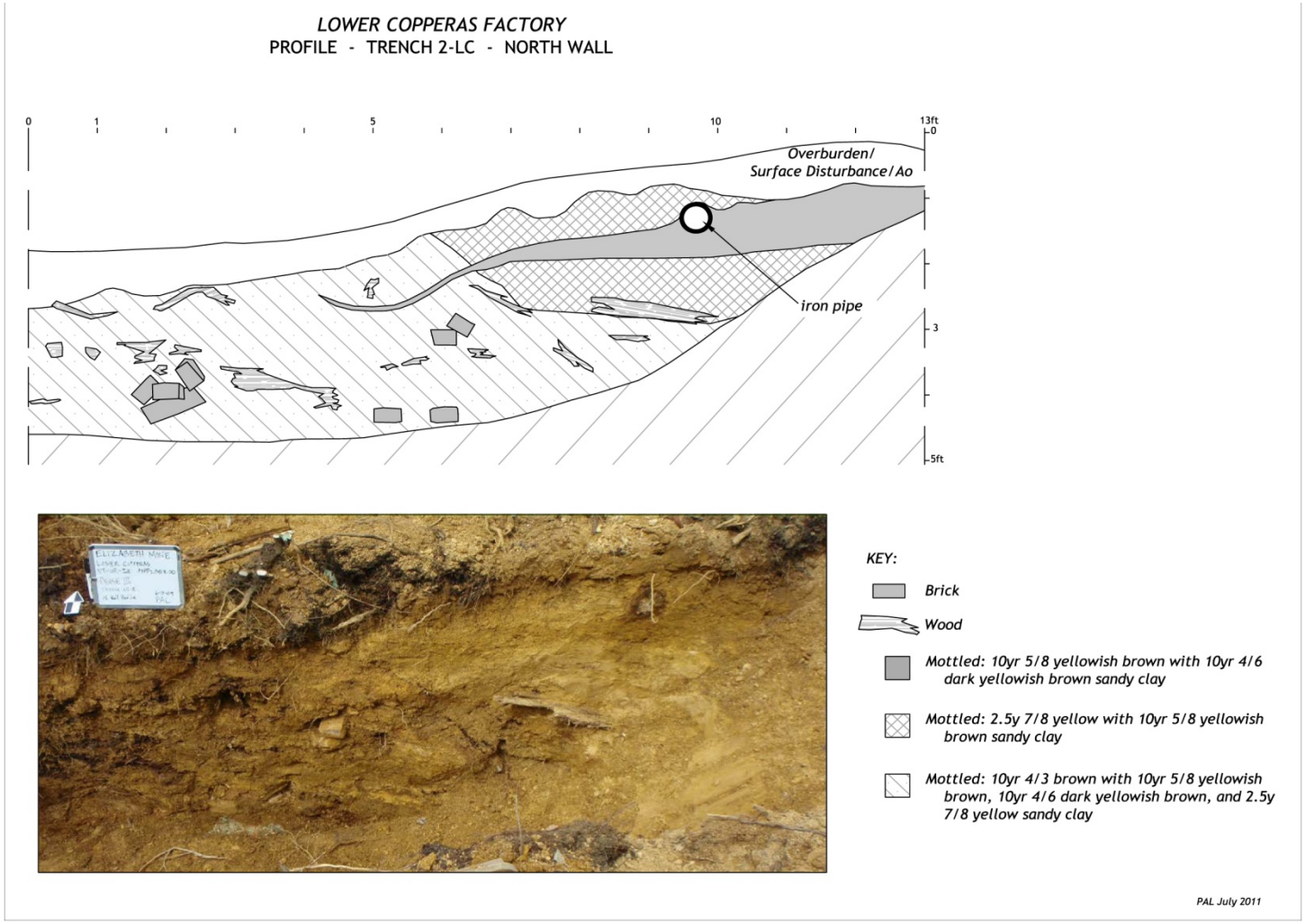

Figure 4-34. North wall profile of TR-2-LC.

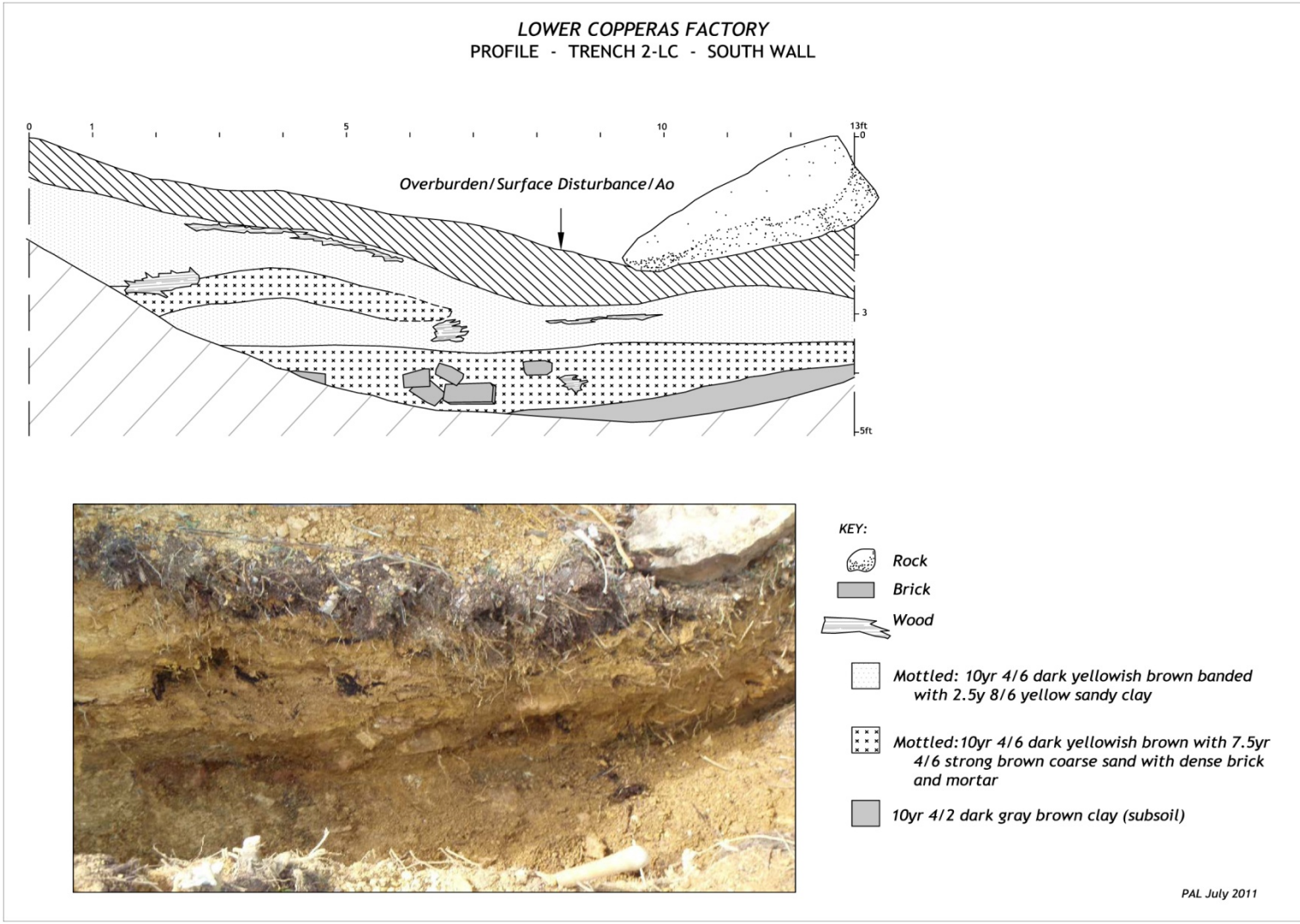

Figure 4-35. South wall profile of TR-2-LC.

To the west, a thin lens of collapsed planks and supporting beams were present from 3 to 4 ft (.94 to 1.2 m) bgs. Loose bricks were found above and below the lower wood concentrations (see Figure 4-34). The south wall, however, contained a less disturbed, more level deposit of dense brick and mortar fill followed by glacial till. The brick and mortar fill consisted of dark yellowish brown (10YR 4/6) mottled with strong brown (7.5YR 4/6) coarse sand. The fill deposit was also encountered from 3.5 to 4.2 ft (1.1 to 1.3 m) bgs. No intact courses of brick were observed. In the west portion of the trench glacial till was encountered from 3.9 to 4.3 ft bgs. The till was a dark grayish brown (10YR 4/2) clay (see Figure 4-35). All four fill layers appeared to be mottled decomposing mine waste similar to that encountered at the Upper Factory, with the yellow stratum being consistent with the jarosite-rich material encountered in TR-1-UC, below FEA-3-UC, and in ST-1-UC. At the lower limit of trench excavation (4.5 ft [1.4 m] bgs), soil stains with what appeared to be roasted ore and substrata were encountered.

A total of 15 cultural materials was collected from 2.6 to 3 ft bgs (.79 to .91 m) in TR-2-LC (see Appendix A). These materials include two samples of brick and 13 samples of mortar. The two samples of brick fragments are handmade and can be cross-mended. The iron tool and one of the wood timber fragments were drawn, measured and photographed in the field, but not collected (see Appendix B.2-3)[18]. The timber plank was found in the south wall 2.6 ft (.79 m) bgs and showed evidence of a circular cut that would have had a circumference of .75 ft (.23 m). The tool was a wrought iron bar 3.2 ft (.98 m) long, split into two parallel forks at one end. The bar had a long shank, and an intentional .04 ft (.01 m) long offset bend two-thirds of the way along its length, just before the fork.

Trench 3 (TR-3-LC)

TR-3-LC was located 48 ft (14.5 m) southwest of TR-2-LC (see Figure 4-32). The trench was placed 4.5 ft (1.4 m) west of and parallel to the short, west factory stone wall. The trench measured 4.8-x-15 ft (1.5-x-4.6 m) and reached a maximum depth of 3.1 ft (.94 m) bgs. The upper soil strata consisted of an A_o horizon from 0 to 1 ft (0 to .30 m) bgs, followed by dark yellowish brown (10YR 4/4) silty medium sand overburden from .4 to 1.5 ft (.12 to .46 m) bgs. Below the overburden was a brick and mortar rubble fill from .9 to 2.1 ft (.27 to .64 m) bgs. The rubble fill layer consisted of a strong brown (7.5YR 4/6) medium to coarse sandy clay, followed by an ashy very dark grayish brown (2.5Y 3/2) sandy wet clay from 1.3 to 3.1 ft (.40 to .94 m) bgs. Bricks were found at the top of the dark grayish brown deposit, which appeared to be disturbed glacial till. At the south end of the trench, bedrock was exposed at .9 ft (.27 m) bgs sloping to down to 2.5 ft (.76 m) bgs to the north. The trench began to fill with water at a depth of 2 ft (.6 m) bgs (Figure 4-36). No evidence of intact structural remains or features were encountered in this trench.

A total of four cultural materials was collected from in TR-3-LC (see Appendix A; Table 4-3). These materials include four wood barrel staves found in the brick and mortar fill from 0.7-2 ft (.2 to .6 m) bgs. The staves vary in thickness (3/32, 1/8, and ¼ in [2.4, 3.2, and 6.4 mm]). One piece has an obvious indentation on the outside for a wire or metal strap, while another has two distinct nail holes and a piece of oxidized iron still in place. One L-bracket and one iron plate fragment were also found in this fill from .9 to 2.1 ft (.27 to .64 m) bgs. These items were photographed, drawn and measured in the field (see Appendix B.2-4)[18]. The L-bracket was similar to those found around the crystallizer (FEA-3-UC) identified at the Upper Factory. Iron plates are associated with boiler structures at the site.

Trench 4 (TR-4-LC)

TR-4-LC was placed 114 ft (35 m) east of TR-3-LC, parallel to the long leg of the factory wall (see Figure 4-32). The trench measured 4.4-x-13 ft (1.4-x-4 m) with a long east-west axis. The trench was

[18] These items were recorded at the site and reburied near their original locations during the remediation/capping activities.

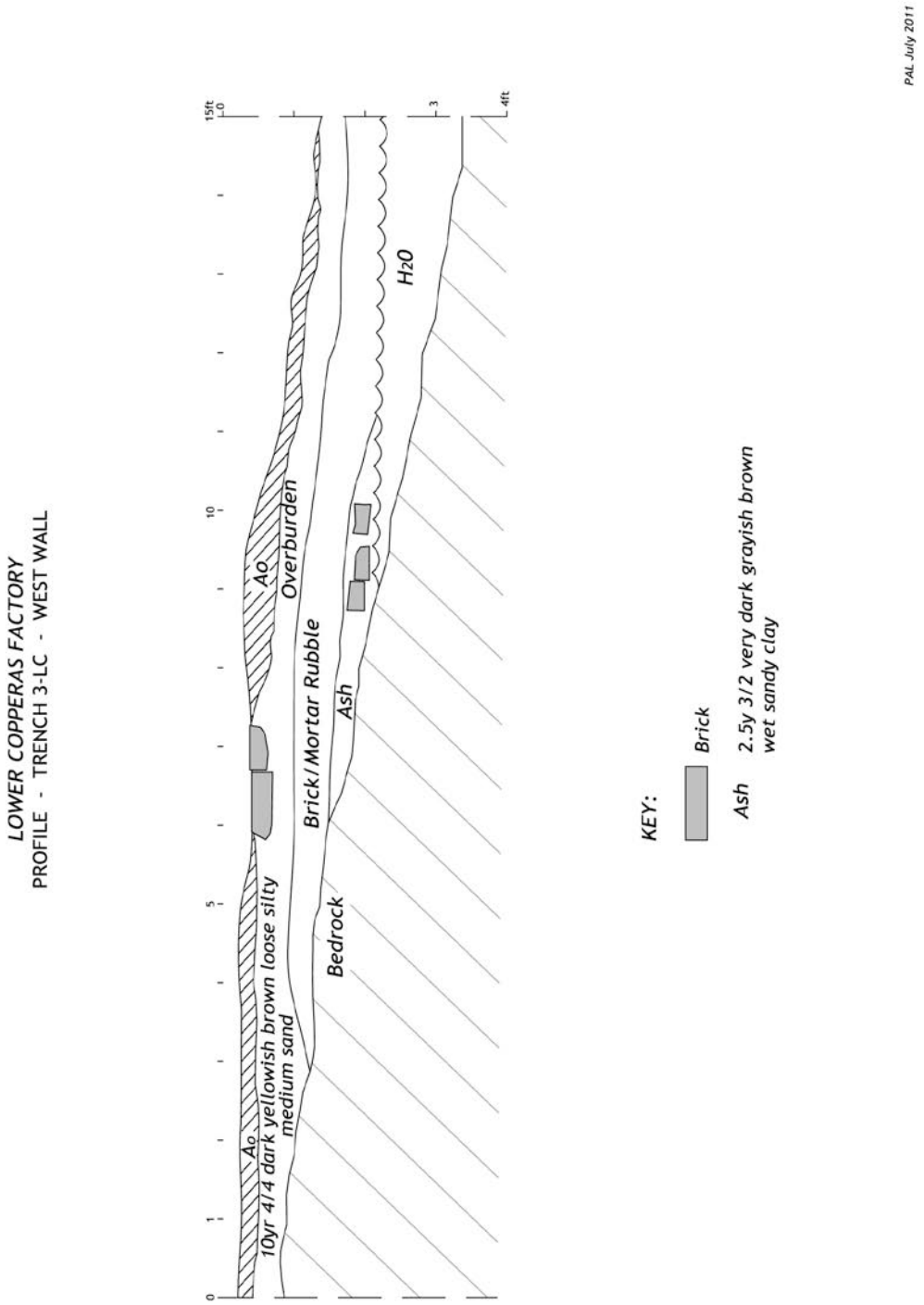

Figure 4-36. West wall profile of TR-3-LC.

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situated 6.5 ft (2 m) north of the wall and reached a maximum depth of 2.9 ft (.88 m) bgs. The upper soil strata consisted of an A_o horizon from 0 to 1.8 ft (0 to .55 m) bgs followed by a fill deposit of strong brown (7.5YR 4/6) medium to coarse sandy clay with dense brick and mortar from .5 to 2.9 (.15 to .88 m) bgs (Figure 4-37). The brick and mortar fill deposit was followed by glacial till from 1.5 to 2.9 ft (.46 to .88 m) bgs.

A total of four cultural materials was collected from 0.5 to 2.9 ft (.15 to .88 m) bgs in TR-4-LC (see Appendix A). These materials include one piece of window glass, one whiteware ceramic sherd, and two unidentifiable iron fragments. If applied, Moir's regression formula for this one glass fragment suggests a date of 1889 (± seven years). The whiteware ceramic date range of manufacture extends from 1820 to present. A tool fragment, a broken piece of cast iron L-section, and five bricks were also recovered from the trench. These items were drawn and photographed in the field, but not collected (see Appendix B.2-5)[19]. The tool fragment was a tapering wrought iron object with an overall length of 18 in (.46 m) with a rectangular solid shaft and circular head. The head was hollow with one broken edge with an extrapolated circumference of .17 (.05 m). The cast iron L-section was 1.17 ft (.36 m) long, .06 ft (.02 m) thick, with .27 ft (.08 m) flanges, one broken at the end. The bricks were handmade and varied slightly in size. No features were encountered.

Trench 5 (TR-5-LC)

TR-5-LC was placed 14.5 ft (4.4 m) west of TR-4-LC (see Figure 4-32). The trench was placed 1.25 ft (.38 m) north of the long factory wall and extended perpendicular to the structure. The trench measured 4-x-6.3 ft (1.2-x-1.9 m) and reached a maximum depth of 3.2 ft (.98 m). A slumped course of brick was noted at .45 to 2.5 ft (.14 to .76 m) bgs in the south wall above a pulverized brick layer followed by remnant wood planks (Figure 4-38). Some of the bricks were covered in a thick coating of mortar. The brickwork appeared to be one course wide and a minimum of four courses in height. Not enough of the brick was exposed in the trench to indicate the bond of the coursework. The brick was built in the fill deposit. The planks were found at the interface between the pulverized brick and fill deposit. The fill deposit was from 1.5 to 2.5 ft (.46 to .76 m) bgs consisting of dark yellowish brown (10YR 4/6) mottled with olive brown (2.5Y 4/4) sandy clay. The fill deposit was followed by dark grayish brown clay (10YR 4/2) identified as glacial till from 2.4 to 3 ft (.73 to .91 m) bgs. The glacial till may have been used as fill around the foundation.

The in situ wood with the pulverized brick layer may indicate that the brick had slumped rather than fallen from above. Two rough cut schist stones were present at 2.1 ft/m bgs adjacent to the south wall of the trench. The stones appeared to have fallen out of the upper foundation wall. Four plank fragments, oriented in a north-south direction, were present from 1.5 to 2.4 ft (.46 to .73 m) bgs north of the stones. The planks were found within the fill deposit. Two pieces of unidentified iron (see Appendix A; Table 4-3) and a boiler or furnace grate bar were recovered in the overburden from 0 to 1 ft (0.3 m) in TR-5-LC. The grate bar was measured, drawn, and photographed in the field, but not collected (see Appendix B.2-6)[19]. Grate bars were typically associated with boilers, so this item is assumed to be out of context in this location.

A small section of the trench (1 x 1.3 ft [.30-x.40 m]) was extended south to the foundation wall. No builder's trench was identified; however, the base of the stone wall was determined to extend vertically an additional 3 ft (.91 m) bgs, giving the intact portion of the wall a total height of 10 ft (3.05 m).

[19] These items were recorded at the site and reburied near their original locations during remediation/capping activities.

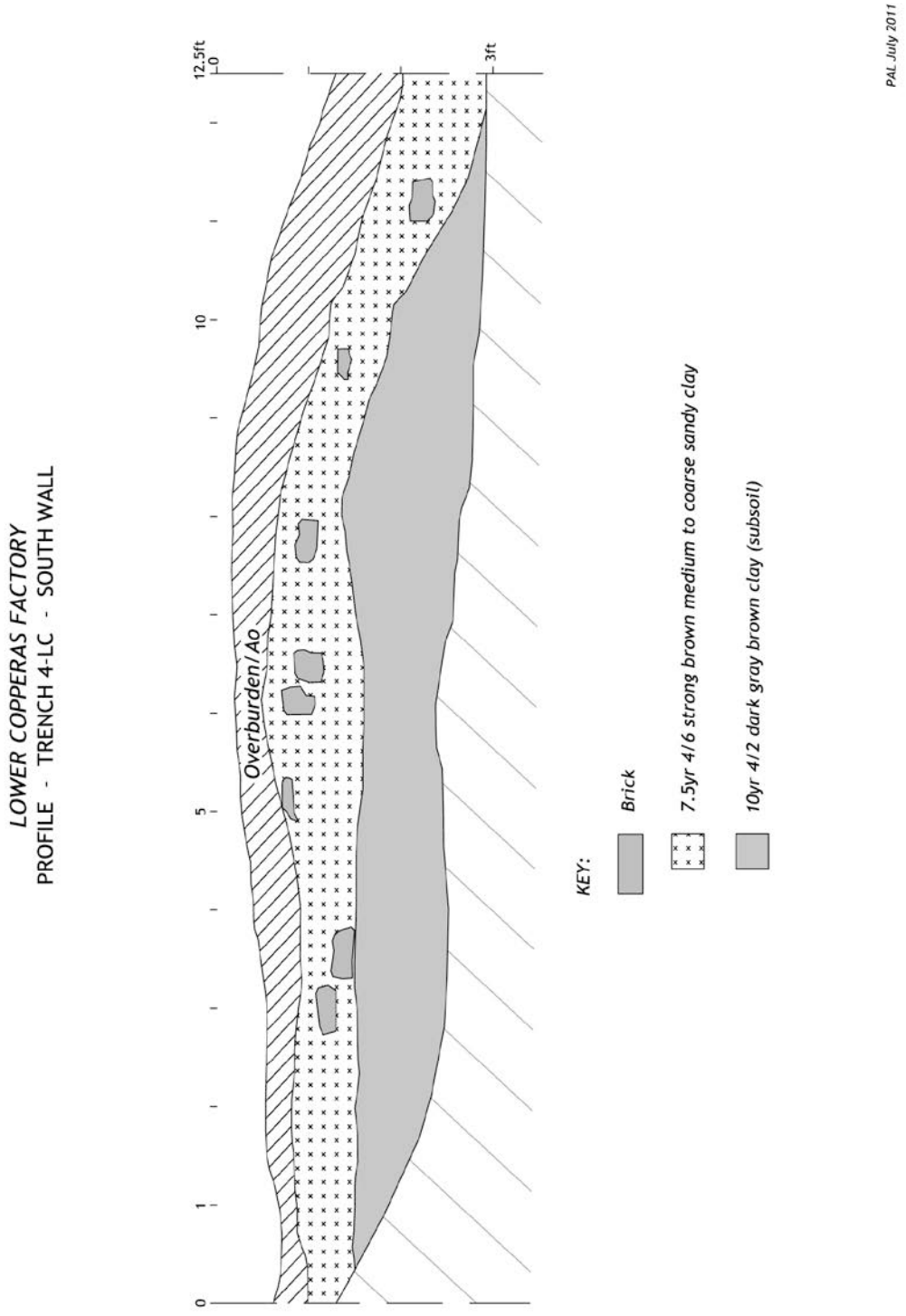

Figure 4-37. South wall profile of TR-4-LC.

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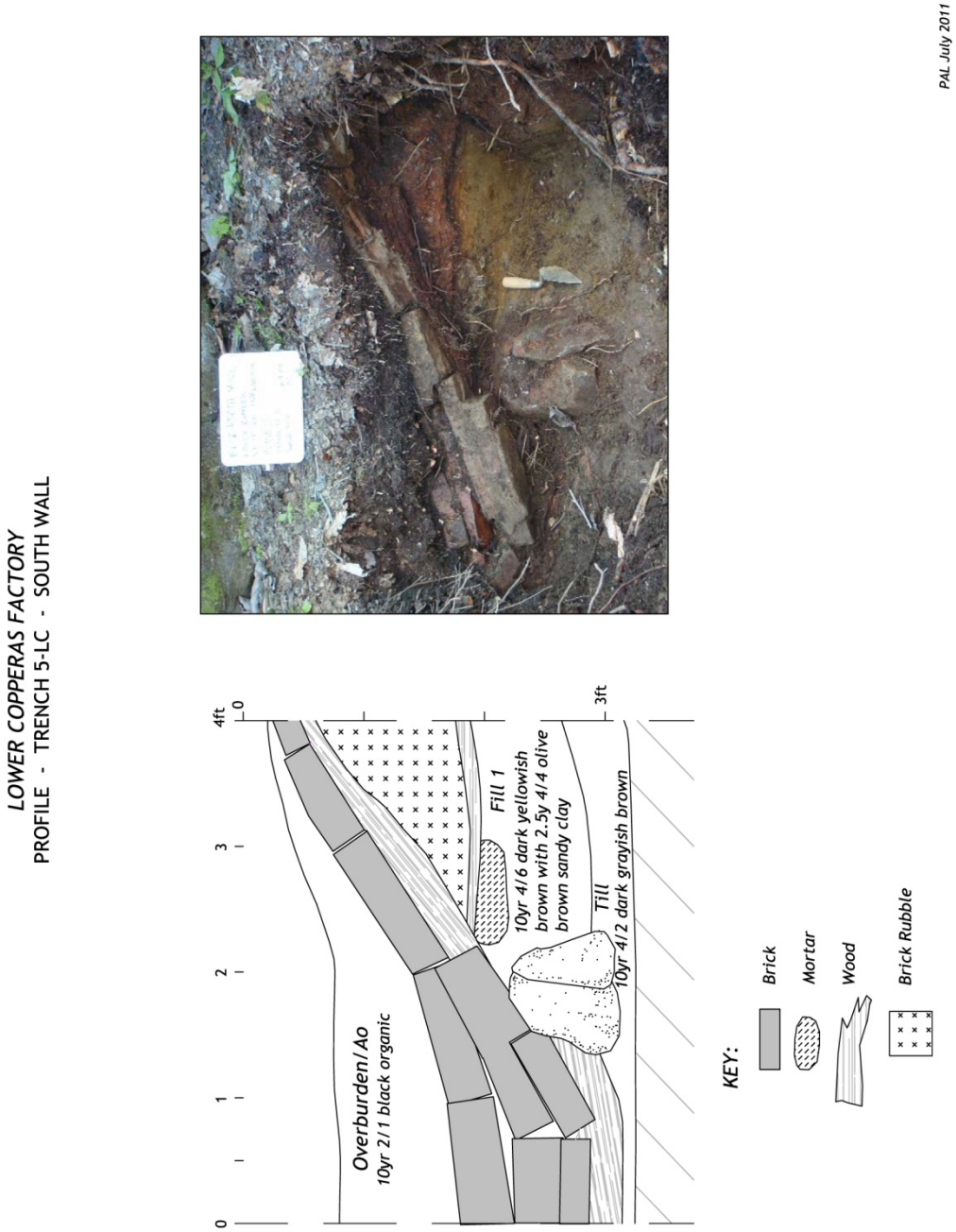

Figure 4-38. South wall profile of TR-5-LC.

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The sequence of coursed brick structural remains over planks over fill corresponds to the strata profile recorded in the Upper Copperas factory in the crystallizer identified in TR-3-UC (see Figure 4-11). The similar strata sequences of brick rubble, decaying plank and similar fill below, as well as the wrought iron L-bracket, found in other trenches along the north side of the long factory wall discussed above suggest that this was a lower, interior factory level containing one or more rows of copperas crystallizer vessels. This strata was also clearly revealed at the Lower Copperas Factory after the data recovery (Figure 4-39) when contaminated soil was removed from below the wall in same area during monitoring, further supporting the crystallization function of this lower section of the factory.

Trenches 6, 7, and 8 (TR-6-LC, TR-7-LC, TR-8-LC)

TR-6-LC, TR-7-LC, and TR-8-LC were placed within the Lower Copperas Factory foundation between interior stone wall divisions (see Figure 4-32). Secondary transverse low masonry walls appear within both the upper and lower factories. These walls may have served as supports for structural timber sills or posts. In some cases they appear to have marked internal divisions between rooms and may have served to compartmentalize industrial activities. The walls demarcated identifiable activity areas with dense artifact concentrations. Little information was gained from trench excavations within these interior areas as opposed to the adjacent larger stripped areas ST-1-LC, ST-2-LC, and ST-3-LC. Distinguishable features in the trenches were limited to a flagstone floor present in TR-7-LC. TR-6-LC and TR-8-LC contained post-abandonment fill strata distinguishable through color and texture as unrelated to industrial activities. The absence of artifacts within these areas contrasted dramatically with the dense assemblages found within the adjacent stripped areas. TR-8-LC yielded one artifact found on the ground surface, however, no other non-structural materials were encountered.

TR-6-LC and TR-7-LC were placed between two north-south walls that were approximately 8.5 ft (2.6 m) apart in the western half of the factory. The ground surface of TR-6-LC contained a light scatter of broken bricks. The trench measured 4.4-x-9.3 ft (1.3-x-2.8 m) and reached a maximum depth of 2.5 ft (.76 m) bgs. Excavation revealed an A_o horizon from 0 to .7 ft (0 to .21m) bgs, followed by an overburden and fill stratum from .7 to 1.5 ft (.21 to .46 m) bgs (Figure 4-40). The overburden/fill consisted of yellowish red (5YR 4/6) sandy clay mottled with a yellowish brown fine sandy silt with pockets of olive fine sand (5Y 5/4) and small amounts of decomposing brick. A second fill deposit was encountered from 1.3 to 2.5 ft bgs (.4 to .76 m). The fill soil was olive brown (2.5Y 4/3) sand mottled with dark yellowish brown sandy silt.

TR-7-LC was placed 4.5 ft (1.4 m) east of TR-6-LC. It measured 3.2-x-9.2 ft (.98-x-2.8 m). The upper soil stratum in the trench consisted of a thin A_o deposit from 0 to .22 ft (0 to .7 m) bgs. Five flat medium sized stones were present at .22 ft (.7 m) below the organic matter (Figure 4-41). The stones were arranged in close proximity to one another and were found at the same elevation as the common brick floor 10 ft (3 m) to the southeast (FEA-2, Context IV, see discussion below). The stones appeared to be part of a larger floor feature.

TR-8-LC was placed 38 ft (11.6 m) east of TR-7-LC. Similar to TR-6, TR-8 consisted of two strata sloping toward the north wall. The strata consisted of overburden of very dark grayish brown (2.5Y 3/2) fine sandy loam from 0 to 3.3 ft (0 to 1 m) bgs followed by dark yellowish brown (10YR 4/6) silty fine sand from 1 to 6.1 ft (.30 to 1.9 m) bgs (Figure 4-42). An iron furnace grate bar with a shallow "fishbelly" curve on its lower surface and mortar stuck to its ends was found on the surface at this trench location, approximately 6 ft (1.8 m) to the east of a scatter of boiler plates adjacent to ST-2-LC (see

Figure 4-39. Photograph of the profile of the crystallizer exposed during monitoring, looking west to the Lower Copperas factory long wall.

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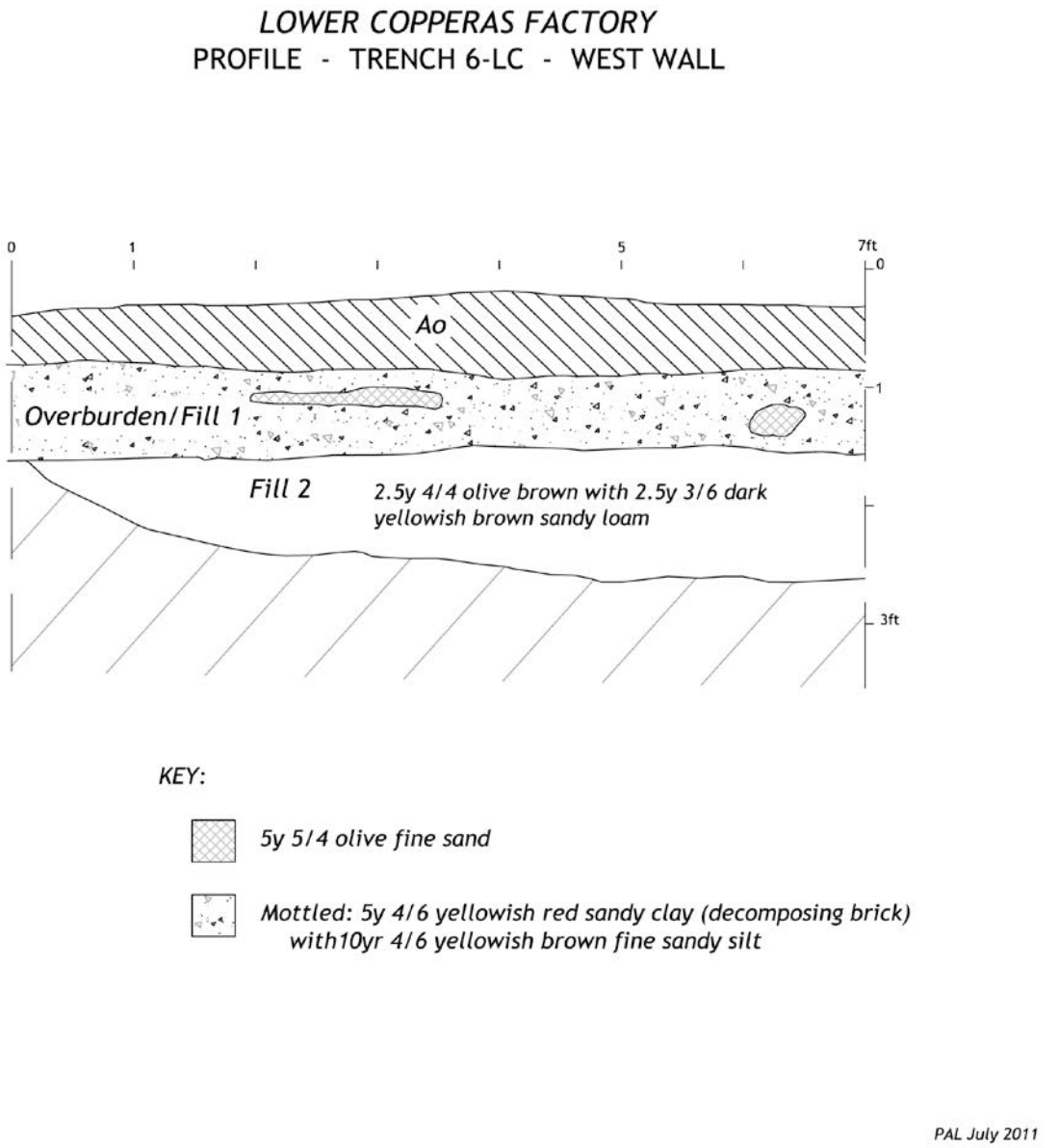

Figure 4-40. West wall profile of TR-6-LC.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 4-41. Photograph overview of the flagstone floor in TR-7-LC.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

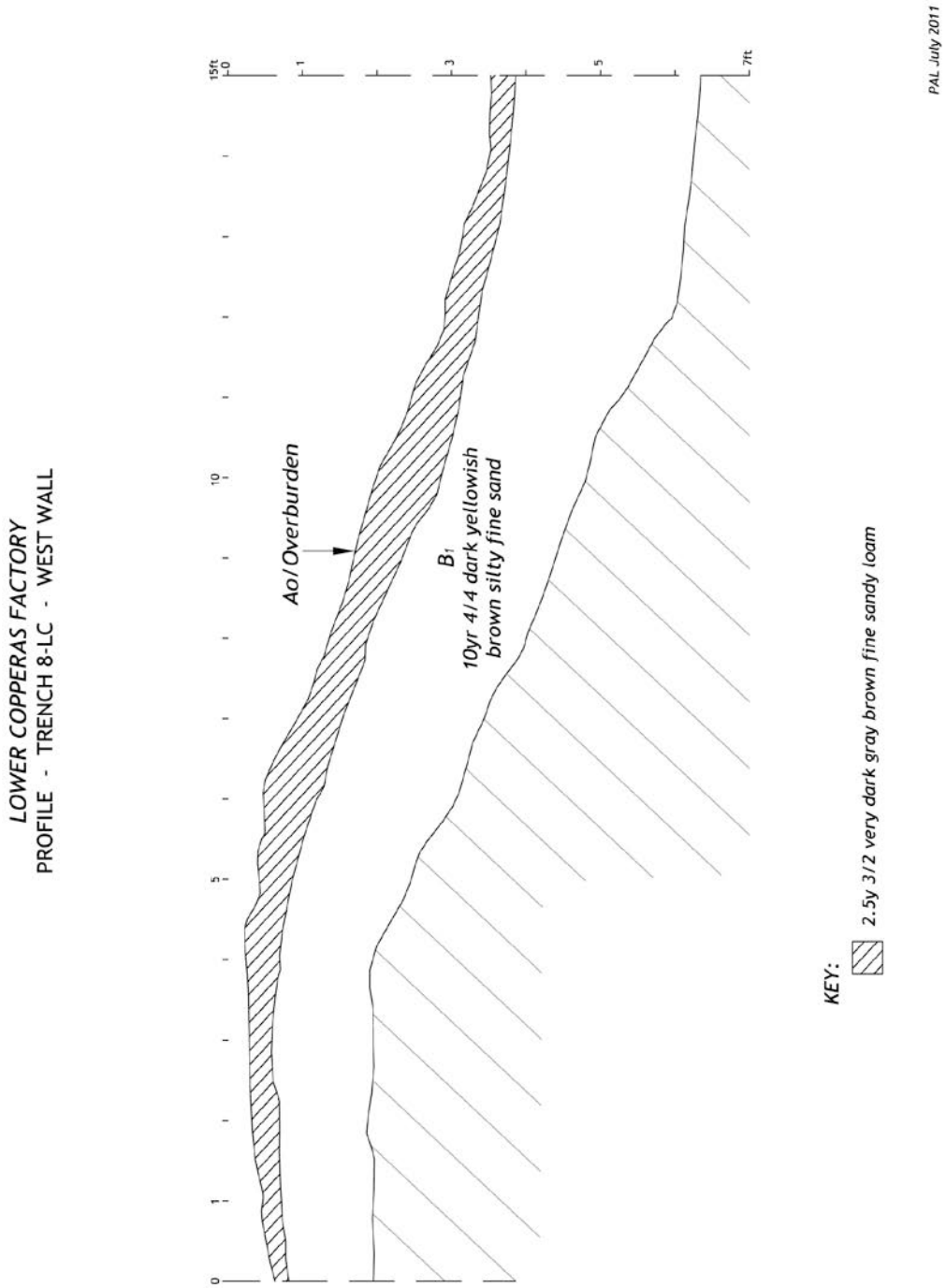

Figure 4-42. West wall profile of TR-8-LC.

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discussion below). The artifact was measured, drawn and photographed in the field, but not collected (see Appendix B.2-7)[20].

Stripped Area 1 (ST-1-LC, FEA-1-LC)

ST-1-LC was placed 14 ft (4.4 m) east of TR-8-LC (see Figure 4-32). The area was initially identified in PAL's 2002 survey as a surface scatter of brick and iron northwest of the cart path or road leading into the east end of the factory building above the long east-west oriented stone wall. The stripped area measured 13.5-x-20 ft (4.1-x-6.1 m). The upper strata from 1.5 to 2 (.46 to .61 m) bgs consisted of brick rubble with a large concentration of iron artifacts within a depression along the north wall of the factory foundation. Data recovery machine stripping south of the iron artifacts exposed brick masonry structural remains designated FEA-1-LC. The area was subdivided into three spatially distinct contexts (Contexts I, II, and III) to control documentation of relationships between structural materials, soil anomalies, and horizontal and vertical distribution of artifacts. Context 1 consisted of the concentration of large iron artifacts adjacent to the north factory wall. Context II included the brick structure located approximately 10 ft (3 m) south of the wall. Context III consisted of a dark, burned area with stones and lead spatter located 2.5 ft (.76 m) west-southwest of the structure (Figure 4-43).

Context I included previously identified iron chutes and plates on the ground surface at this location. The scatter of iron objects was remapped at the onset of the 2009 data recovery field investigations, and measured approximately 9.5-x-13 ft (2.9-x-4 m) overall (Figure 4-44). Machine stripping in this area uncovered a concentration of large iron artifacts extending vertically over 3 ft (.91 m) in depth. The artifacts were intermixed with an A_o and developing A horizon. These materials include four brick-lined iron chutes, three boiler furnace grate bars (including perforated examples), four splined shaft fragments, four perforated iron plates, approximately 20 pieces of iron boiler plate of varying size and thickness and 13 miscellaneous unidentifiable iron objects. Many of the unidentifiable iron objects were tentatively identified as furnace hardware including seven possible door frame fragments and a lintel. Many of the boiler plates retained part or all of all four original sides, allowing their original dimensions to be recorded. A representative sample of the artifacts from Context I were measured, drawn and photographed in the field, but not collected (see Appendix B.2-8)[20].

The concentration of iron objects in Context I is most likely the discarded pieces of a copperas boiler furnace structure. The iron artifacts exhibited reddening, scaling, cracks and pits consistent with exposure to high heat. It is possible some pieces of discarded furnace hardware may have been broken up and mixed with other scrap metal used for charging the sulfuric acid copperas liquor with iron. Common red and silica fire bricks were also found in this area, and may have been part of the furnace, or have fallen into this area from adjacent Contexts II and III (see below). The majority of the bricks are unmarked common red brick. Marks on the fire bricks included "J. & M. Craig Kilmarnock" and "Annes & Muller Boston No. 1." One unmarked trapezoidal ("wedge") specialty shape firebrick was also found in this area.

Contexts II and III were identified at 1.5 and 1.8 ft (.46 and .55 m) bgs below a thick layer of brick rubble, possibly demolition debris from the upper sections of a copperas liquor boiler (Figure 4-45). Context II contains what appears to be the rectangular bottom of a brick furnace or hearth structure. The long axis of the structure was oriented east-west, parallel to the long north factory wall. The structure, a rectangular brick chamber, was exposed at 1.5 ft/m bgs. The outside dimensions of the chamber were 2.6-x-4.8 ft (.79-x-1.5 m) and the inside dimensions were 1.4-x-4.5 ft (.44-x-1.4 m). The coursing in the

[20] None of these items were removed from the site. They were recorded in situ and reburied near their original locations during the remediation/capping activities.

Figure 4-43. Photograph of FEA-1-LC in ST-1-LC, with associated Contexts I, II and III.

Figure 4-44. Photograph of Context I surface scatter of iron chutes and plates identified in FEA-1-LC .

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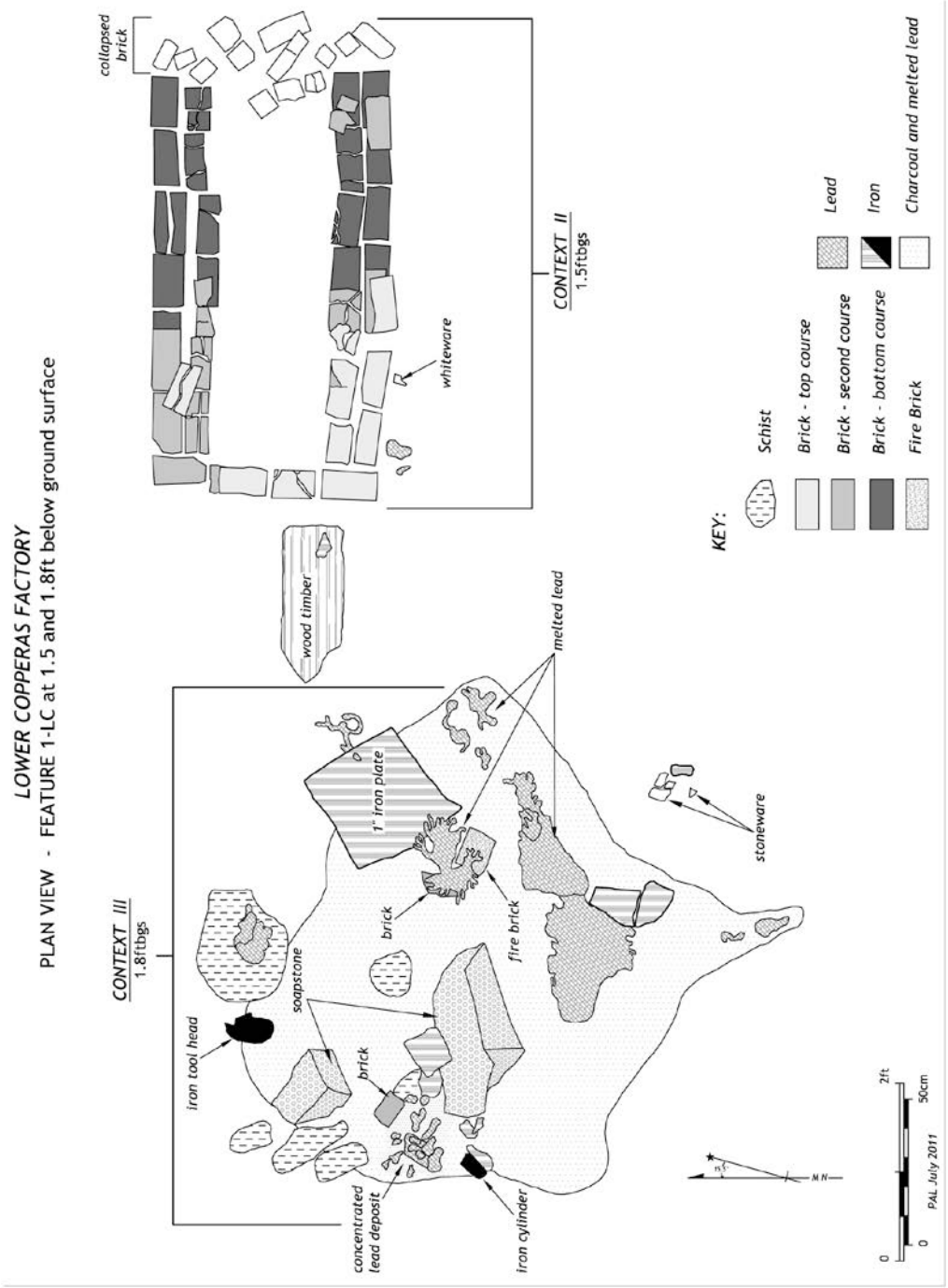

Figure 4-45. Detail plan of Context II (brick feature) and Context III (burned area) at 1.5 and 1.8 ft below ground surface.

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chamber contained charcoal at 1.8 ft (.55 m) bgs. Brick faces inside the chamber, particularly at its west end, were covered in soot. The mortar on the upper surface of one in situ brick on the southeast corner of the south wall was stained green, indicating the presence of copper-bearing fluids that were converted to copper carbonate through contact with the lime in the mortar.

This brick structure can be interpreted as the lowest portion of a furnace firebox or some sort of hearth. The internal ash deposit and soot staining suggest this was the ash pit under a set of grates for burning fuel. Similar to the two other possible boilers (Upper Factory, North Berm) investigated during the data recovery, common brick was found in the highest quantities in association with this feature. It was located close to the large piles of iron objects containing many pieces identified as furnace components. However, the much smaller overall size, simple rectangular single-chamber configuration with no sign of additional flanking walls, and lack of extensive halo of heat-reddened hematite soils make this feature different from the other structures interpreted as copperas boilers. It may have been a smaller furnace for boiling copperas or for a different function, or the lowest portion, or even the base of a draft stack, of a boiler that was demolished and extensively scavenged for brick. A small area of lead splatter and whiteware sherds were found south of the brick feature. West of the west wall, a heavily deteriorated timber fragment extended toward Context III.

Context III contained charcoal stains, melted lead spatter, iron plates, tools, ceramic sherds, fragments of sawn soapstone blocks, fire bricks, and schist stones found at 1.8 ft (.55 m) bgs (see Figure 4-45). These materials were present beneath overburden containing fragments of common brick and mortar residue that largely comprised the overburden found in Context III. The charcoal-stained area and artifact concentration were amorphous in shape. The expansive charcoal staining indicated the area had been used for burning fuel, discarding ash, or some process requiring high heat. The large amounts of melted lead spatter strongly suggest this was a work area used for boiler construction and repair. Silica refractory bricks are uncommon at the site despite the presence of multiple furnaces. The presence of soapstone is even more unusual; it has been found as discarded refractory material at Elizabeth Mine copper smelter sites on both banks of the Ompompanoosuc River at the Furnace Flats area. The presence of refractory bricks and soapstone in Context II indicate the possible location of a specialty furnace requiring higher heat than a copperas boiler. Vermont Copperas Company correspondence from March of 1863 contains the entry: “Set lead kettles for making the boilers” (John Reynolds to William B. Reynolds, March 3, 1863). This brief entry indicates that specialized heated vessels were used for melting the lead (melting temperature 621 degrees f) required to fabricate the copperas boiler linings. It is possible the brick structure in Context II may be associated with activity in Context III.

A total of 53 cultural materials was collected from .48 to 3 ft (.15 to .91 m) bgs in ST-1-LC (see Appendix A; Table 4-3). These materials include personal items, tools, hardware, domestic items, and fuel/waste products. Tools include one wedge double-bit axe head and one shovel fragment (see Appendix B.1-2). The two items were found in the burned area (Context III) west of the Context II structure and north along the north wall of the factory foundation in a low-lying area filled with iron plates (Context I). Personal items include leather boot/shoe fragments found within Context I. Hardware includes a door knob plate and a machine cut nail. Unidentifiable objects include rubber fragments, a clear curved glass fragment, and one tin plate. Samples of coal (n=6) were collected from Context I, including four pieces of anthracite coal. Anthracite, only found in and transported from eastern Pennsylvania, was a premium, low-volatile coal, tricky to burn, and typically used in specially-constructed stoves for domestic heating. Once ignited it burns with intense heat and may have been used to heat the workspaces in coal-burning “salamander” heaters, or to heat a lead melting kettle. Domestic ceramics were found in both Contexts I and III, and include utilitarian whiteware and American stoneware body and base sherds. Four of the stoneware sherds are cross-mendable as a jug with an Albany slip interior and a salt glazed exterior. This jug type was manufactured from 1800 to 1880. The

other stoneware sherds have manufacture dates between 1840 and 1930, and the whiteware was commonly produced from 1820 to the present.

Stripped Area 2 (ST-2-LC, FEA-2-LC)

ST-2-LC is located 29 ft (8.8 m) west of ST-1-LC and measured 33-x-35 ft (10.1-x-10.7 m) (see Figure 4-32). Cultural deposits including artifacts and features were encountered close to the ground surface below a thin layer of A_o, requiring most of this stripped area to be cleared by hand. Four large trees had grown into the area, and stumps and roots obstructed excavation and had caused bioturbation of soils and artifacts. The excavation of ST-2-LC revealed FEA-2-LC, a rectangular masonry brick feature and an adjacent work area (Figure 4-46: back pocket). The feature was divided into five contexts to control recordation of distinct activity areas on the basis of in situ artifact distribution, cultural material types, and structural remains.

Context 1 consists of a large rectangular masonry brick structure located in the north section of the stripped area, adjacent to the east-west oriented north foundation wall (see Figure 4-46). The feature measured 5.6-x-18.7 ft (1.7-x-5.7 m) with a long east-west axis. It was flanked to the north and south sides by in situ tilted vertical cast iron supports (stanchions) connected by horizontal wrought iron tie rods (Figure 4-47)[21]. This structure was very similar in construction and size (5.4 x 18.5 ft [1.6-x-5.6 m]) to FEA-6-UC in the middle tier of the Upper Factory, interpreted as a copperas cooling vessel. The cast iron stanchions were identical in form to the ones recorded in FEA-6-UC at the Upper Factory. The Lower Factory brick vessel abutted a large wood beam at .2 ft (.06 m) bgs to the north and adjacent to the north factory wall. The structure contained large amounts of fallen brick rubble and a few large cut schist stones found on the ground surface. The structure's walls were made of common and fire brick laid in an American or common bond pattern three courses wide (approx. 12 in [.31 m]). The firebrick was found in greatest concentration on the east side of the vessel at .3ft (.09 m) bgs. One iron plate, similar to other perforated plates identified within the upper and lower factories, was found in alignment with its long axis. The plate's surface was pitted and it is split lengthwise. Similar long, narrow perforated iron plates with one curved side found here and elsewhere on the site (Upper Factory) are identified as boiler firebox grates. This feature can be interpreted as a copperas liquor cooling vessel based on its size, construction, associated iron stanchion supports, all of which closely resemble the FEA-6-UC structure in the Upper Copperas Factory. The indiscriminate use of firebrick in the structure and presence of a broken furnace grate do not necessarily support its function as a boiler.

Context II consists of a roughly dark charcoal ash stain found at .2 ft (.06 m) bgs adjacent to the long south side of the brick structure in Context I (see Figure 4-46). The stain is bound at the west end of the south side by three bricks in an east-west line, and on the north side by a line of five bricks that touch, but appear to be different from, the bricks on the south side of the Context I structure. Several bricks lie at its west end but do not clearly indicate a wall. The feature has overall dimensions of 3-x-5.5 ft (.91-x-1.7 m) with a long east-west axis. The only bright red soil (soil thought to be characteristic of the heat of a copperas boiler) was a small area on the east side of the feature. The area inside the bricks contained a dense concentration of charcoal and a large quantity of sheared iron rivets at .2 ft (.06 m) bgs (Figure 4-48). The rivets were deeply pitted and eaten away to a mushroom-like section shape with knife-edged rims on the heads. Several bricks had charcoal staining on one surface.

The charcoal feature with possible brick walls could be interpreted as some sort of heating apparatus for the brick structure in adjacent Context I. This interpretation could possibly change the interpretation of that feature from a cooler to a boiler, despite its similarity to the structure identified as a cooler in the

[21] The iron stanchions and tie rods were recorded in situ and reburied at their original locations during the remediation/capping activities.

Figure 4-47. **Photograph of Context I, FEA-2-LC combined boiling/cooling vat, looking west.**

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Figure 4-48. Photograph of Context II, FEA-2-LC firebox, looking northwest.

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Upper Factory's FEA-3-UC based on its location between features interpreted as a boiler and a crystallizer. The presence of the eroded rivets, which based on their eroded condition and advantageous ratio of size to surface area, appear to be scrap metal used in a copperas boiler, could also suggest that the structure in Context I was a copperas boiler, and not a cooler. This interpretation in turn calls the function of the very similar supposed cooler in FEA-3-UC in the middle tier of the Upper Factory into question. Knowing how the boilers were constructed from the site historical accounts, Diderot illustrations, and other examples on site, it is difficult to visualize how the feature in Context II could have been physically integrated into the structure in Context I to function as a heater based on its size, as well as its location opposite the factory wall to the north, where location of the ash pit and firebox of a copperas boiler would be expected. If the structure in Context I was indeed a boiler, the stain could possibly be the location of a draft chimney at its rear, opposite a firebox at the front, above the factory wall. The possible function as a combined copperas boiler and cooler seems unlikely, although the earliest boilers were allowed to partially cool in the earliest iterations of site operations: "The water [liquor] is then conveyed to the boilers, which are made of lead, four in number, and weigh about 2500 pounds each. Here it is boiled and evaporated to [a] certain extent, and suffered partially to cool. It is then transferred to the crystallizers…" (Thompson 1824:251–253). This pause to cool the liquor in the boiler itself is not mentioned again in the site histories; hot liquor was subsequently tapped into a separate cooler for cooling and settling prior to crystallizing. Boilers and coolers were later described as different and separate specialized structures to facilitate function, differences documented in the historical record and in seen in the features documented at the Upper Copperas Factory. It would require a great deal of heat energy, labor and time to bring the masonry and metal mass of a boiler to operating temperature to make a fresh batch of mother liquor, and then let it cool down again. This cycling would be wasteful of fuel and extend, not shorten, the time to make each batch of copperas in what may have been a semi-continuous process (fresh liquor boiling while boiled liquor is cooling/crystallizing). None of these interpretations explain the concentration of rivets in the charcoal. One possible explanation for the function, but not necessarily the location, of the Context II feature is that it is the remains of a small firebox or hearth for heating iron scrap metal on a wood fire prior to charging into the boiling copperas liquor in an adjacent boiler, possibly the one in Context II in ST-1-LC, so that it did not cool the liquor down, which would have then required extra time and fuel to regain the proper boiling temperature. A similar rivet-filled charcoal stain was also found in the Lower Factory (see below).

Context III was identified directly west of Context II (see Figure 4-46). It consists of a large concentration of burned ore at 1.15 ft (.35 m) bgs, underlain by quarried schist stones and fieldstones between .2 and 1.2 ft (.06 and .37 m) bgs. The area was loosely defined, but measured approximately 6-x-8 ft (1.8-x-2.4 m). A large sheet of lead was present on the ground surface just south of the cast iron stanchion at the southwest corner of Context 1 (Figure 4-49) and was underlain by a concentration of iron ore just west of the Context II feature. The machine stripping in this area uncovered three large quarried stones at 1.05 ft (.32 m) bgs, which were 1.1 ft (.34 m) lower in elevation than Context II. The cut stones were north of rough fieldstones found between .2 to .6 ft (.06 to .18 m) bgs. The stones appear to have been a subfloor for this part of the factory (see Figure 4-49). A small amount of scattered loose bricks were present between 0 to 1.2 ft (0 to .37 m) bgs above the stones; however, no intact courses were evident. The machine stripping was terminated on the west edge at a north-south oriented alignment of three large cut stones located on the ground surface.

Context IV was located approximately 4 ft (1.2 m) to the south of Contexts II and III (see Figure 4-46). It consisted of a brick floor and work area to support factory activities in the flanking contexts. The floor was partially cleared by hand to reveal an approximate 7-x-25 ft (2.1-x-7.6 m) section on the southern side of FEA-2-LC. The brick floor area had a long east-west axis and appeared to continue to the west. To the south, a heavily deteriorated east-west oriented wood timber measuring approximately .5-x-13.3 ft (.15-x-4.05 m) ran along the south edge of the floor at .2 to .3 ft (.06 to .09 m) bgs. This timber appeared

Figure 4-49. Photograph of Context III, FEA-2-LC stone subfloor, looking north.

to be a structural sill at the south edge of the factory building. The brick floor incorporated an approximately 16 ft (4.9 m) long east-west seam dividing it into north and south sections (Figure 4-50), suggesting that the floor was built in sections, possibly at different times. The bricks in the northeast corner of the floor area were of uniform shape and arrangement, forming an apparent border (see Figure 4-46). Bricks were not noted to the north and east.

Context V was identified approximately 3 ft (.91 m) to the northeast of Context IV and 2 ft (.61 m) south of Context I (see Figure 4-46). Context V was another charcoal and ash deposit with a high concentration of sheared rivets, similar to the deposit of charcoal ash and rivets in Context II. The function of these charcoal and rivet features is unclear; they may have been used for preheating iron scrap before lowering it into the boiling copperas liquor in baskets as described in the historical accounts. There is no historical record of the factory being used during or after copperas operations for tube boiler assembly or general ironworking, which would have involved heating rivets in a small forge.

Context VI was identified 12 ft (3.7 m) southwest of Context V and south of the beam in Context IV (see Figure 4-46). The area was suspected to be outside the factory building footprint. A shallow 3.7-x-8 ft (1.1-x-2.4 m) exploratory trench (1 ft deep) was excavated south of the beam. A low density artifact scatter was found just west of the trench from 0 to .3 ft (0 to .09 m), however, no cultural material or features were encountered within the trench.

A total of 910 cultural materials was collected from ST-2-LC in association with the five contexts attributed to FEA-2-LC. This assemblage represents 55 percent of the total artifacts collected during the data recovery investigations. Most of the artifacts were found near the surface and in situ feature contexts from 0 to .30 ft (0 to .09 m) bgs (see Appendix A; Table 4-3). A total of 470 cultural materials was recovered in association with the brick floor (Context IV) (see Appendix A; Table 4-3). Context II, contained the second highest density of cultural material with 321 artifacts coming from the fire box. A total of 39 cultural materials were collected from Context I and 69 from Context V. A low density of artifacts were recovered from Context III and Context VI. Context III contained only six cultural materials and Context VI having only five cultural materials.

Cultural material collected from Context IV consists of cast iron artifacts including two rim fragments, one plate, and one forged iron ladle bowl (see Appendix A). The rim fragments may be parts of an iron utility pipe; they are cross-mendable and would form a .27 ft (.08 m) diameter pipe opening. No other distinguishable marks or shape could be identified from the fragments. The ladle bowl, which is missing its handle, measures 1 ft (.31 m) x .79 ft (.24 m) and is .33 ft (.1 m) deep. The bottom of the bowl interior is encrusted with lead spatter, suggesting that it was used in constructing and repairing the lead copperas vessels (see Appendix B.1-7).

Other materials recovered in association with FEA-2-LC include lead artifacts likely used for vessel repairs and plumbing (see Appendix A). Context IV contained one lead solder rod, one rivet, 49 pieces of trimming scraps, 19 sheets, 86 pieces of lead spatter and two fragments of .05 ft (.02 m) diameter pipe. Context II contained 136 pieces of spatter and 25 pieces of trimming scraps, while only one piece of spatter was collected from Context I. Context V contained three additional .05 ft (.02 m) diameter pipe fragments and one solder rod. The pipe fragments collected from Context IV and V may be associated with plumbing used between copperas vessels. No lead materials were collected from Context III and VI.

Structural materials recovered from the FEA-2-LC area include door hardware, nails, and window glass in Contexts I, II, III, IV, and V (see Appendix A). A total of 50 machine cut and eight unidentified nails were recovered including common, sheathing, and spike types. Context II contained 21 machine cut nails.

Figure 4-50. Photograph of Context IV, FEA-2-LC brick floor, looking west.

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Context IV contained 22 machine cut and 7 unidentifiable nails, and 1 spike. Context V contained 6 machine cut nails and one spike; while Context I only included two machine cut nails. Door hardware includes one hinge and one door latch/lock. The latch/lock was found on the western side of the brick floor (Context IV) associated with FEA-2-LC. The door latch/lock was found in a cluster of artifacts that included an iron plate, banding, a pin, a lead fragment and window glass. The artifacts were found close to the surface below a thin layer of organic matter from 0 to .3 ft (0 to .09 m) bgs in Context IV. Tin plating, window glass, a horseshoe, and an iron spool that is possibly a piece of door hardware were also found on the east-west oriented wood beam adjacent to the brick floor (Context IV) suspected to be the southern boundary of the factory building. The hinge was found 5 ft (1.5 m) east between the brick floor and the southwestern stanchion in Context III.

A total of 136 pieces of window glass was collected from 0 to .3 ft (0 to .09 m) bgs in Contexts I, II, III, IV, and IV (see Appendix A). The majority of the window glass [116 of the 136] pieces were found near the latch and lock and along the southern boundary of FEA-2-LC, in Context IV running both east and west and on the southern boundary of the brick floor. The second largest concentration was in Context V with 11 flat glass fragments. Smaller densities were found within Context II (6), Context I (2), and Context III (1). If applied, Moir's regression formula for these glass fragments suggests a date of 1881 (± seven years).

Other glass artifacts collected include ten bottle/jar fragments, 21 pieces of curved glass, and two glass tube fragments from 0 to .3 ft (0 to .09 m) bgs in Contexts III, IV, V and VI (see Appendix A). Context III contained one bottle/jar fragment, Context IV contained eight bottle/jar and 19 curved glass fragments, and Context V contained one curved and one bottle fragment. Two of the bottles collected from Context IV are canning jars with manufacture date ranges of 1850 to 1910 and 1890 to 1920, the latter of which would place the jar post-copperas factory occupation. The glass tube fragments collected from Context IV and VI are cross-mendable. The opening of the tube is .03 ft (.01 m) with a varying wall thickness that ranges between .007 to .01 ft (.002 to .003 m). The tube fragments may be from a test tube or acidimeter (acid hygrometer) that could have been used for sampling the copperas liquor.

Several tools were found from 0 to .3 ft (0 to .09 m) bgs in Context III, IV, and VI, including five axe heads (see Appendix B.1-8), one hoe fragment, two iron handles, and one wood and metal handle, one sharpening stone, and two flat wrenches (see Appendix A). Three of the axe heads were found near preserved wood chips within Context VI on the working surface. The axes and wood chips were located in an area suspected to be an exterior workspace outside of the factory building. These tools and waste may be associated with splitting wood for fuel for boilers, the charcoal and rivet-filled hearths, or cooperage activity for making shipping barrels. The other tools and axe heads were located in the interior of the structure on the brick floor (Context IV). The tool handles were found in Context III, IV, and V. Spatters of lead, leather and metal fragments were also found on the brick floor which appeared to have been a work space to support a variety of activities for the adjacent contexts.

Four leather strap fragments, possible belt fragments, were found in a cluster of artifacts in Context IV from 0 to .2 ft (0 to .06 m) bgs near the western excavation boundary (see Appendix A). The material is .08 ft (.025 m) wide and .01 ft thick (.003 m) with two of the fragments having small holes in the center. One of the fragments is large enough to indicate that the holes are spaced approximately every .01ft apart (.003 m). Nine unidentifiable leather fragments were also collected from Context IV and Context V. Food refuse consisted of two butchered mammal (cow) bone fragments collected from 0 to .3 ft (0 to .09 m) bgs in Context II (see Appendix A). One bullet casing was also collected from Context II. Personal items recovered in association with FEA-2-LC are limited to a vulcanite rubber button (see Appendix B.1-6) found outside the feature in Context VI from 0 to .3 ft (0 to .09 m) in the stripped area 2 ft (.61 m) west of the axe heads and wood chips. The button is marked "N.R. Co. Goodyear's Pat. 1851." The Novelty

Rubber Company manufactured these buttons from 1855 to 1870 (http://www.anthro.utah.edu/IMACs/475-Buttons.pdf).

Other recovered artifacts include 130 sheared rivets found from 0 to .3 ft (0 to .09 m) bgs in Contexts I, II, IV and V. A 10 percent sample was collected from Context II and V, where artifact densities were the highest (see Appendix A). Seventy-eight rivets were sampled from Context II (see Appendix B.1-9), which accounted for approximately 98 percent of the total rivets at the Lower Copperas Factory. A sample of 31 rivets were collected from Context V. Samples of charcoal (n=6) were also collected from the firebox (Context II) (see Appendix A). A 100 percent sample of the cultural material was collected in areas where a lower density of sheared rivets were encountered, such as in Context I and IV. Two sheered rivets were collected from Context I and 19 from Context IV (see Appendix A).

Heavily oxidized iron was collected from Contexts I, II, IV, and V. The material was corroded and unable to identify the original function. Context II contained five unidentified iron and Context V contained two fragments. Context I contained only one unidentifiable iron fragment but had 27 unidentified tin fragments and 4 unknown copper fragments. Context IV contained 41 unidentified iron fragments, two unidentified cast iron fragments and four unknown metal fragments (see Appendix A).

Other material sampled from these contexts includes roasted ore and heavily oxidized iron cataloged as industrial waste. A sample of one was collected from Context V. Context II had 31 sample fragments collected six identified as a copper, while 25 were listed as Iron. A sample of 20 was collected from Context IV (see Appendix A).

Stripped Area 3 (ST-3-LC, FEA-4-LC)

ST-3-LC was 18 ft (5.5 m) west of ST-2-LC and extended west to the south end of the north-south oriented factory west wall (see Figure 4-32). The stripped area measured 17-x-34 ft (5.2-x-10.4 m) with a long east-west orientation. Six large tree stumps limited excavation to the north and east. The area was first characterized by PAL in 2002 as a surface scatter of common and fire bricks with lime mortar. Similar to ST-1-LC and ST-2-LC, the stripped areas in ST-3-LC were divided into contexts to control the recordation of distinct activity areas on the basis of in situ artifact distribution, cultural material types, and structural remains. The upper soil strata in the stripped area consisted of an A_o deposit followed by overburden of red (2.5YR 4/6) silty clay intermixed with brick and mortar fragments from 0 to 1.1 ft (0 to .34 m) bgs. Below the overburden was a mottled yellow (2.5Y 8/6) silty medium to fine sand and a yellowish red (5YR 5/6) silty clay from1.1 to 1.5 ft (.34 to .5 m) bgs. An extensive brick surface or platform was encountered from .48 to 1.1 ft (.15 to .34 m) bgs below the overburden (Figure 4-51). The brick surface supported several short stacks of roughly rectangular thick iron plate. The brick area (Context II) was bound by a timber and a stone wall on the west side, and underlain by a stone subfloor on the west side that extended to the west factory wall. The brick surface measures 4.5 to 4.75 ft (1.4 to 1.5 m) higher in elevation than the boiler chamber identified as Context II in FEA-1-LC on the east side of the factory.

The excavated section of the Context II brick platform measured approximately 10-x-24 ft (3-x-7 m) (see Figure 4-51). The platform was covered in a thick layer of natural mortared cement and was bound by two parallel rows of brick one course high along the exposed outer edges. Five iron plates were found in situ on the brick surface along the south and east walls, just inside the brick border (Figure 4-52)[21]. The iron plates extended vertically .08 to .17 ft (.025 to .05 m) above the brick. Two of the plates had a second plate stacked on top of the first. Several sections of the brick row edging were missing. At the northeast corner of the mortared brick surface, the remnant brick border extended 3.5 ft (1.1 m) east, then

[21] These items were recorded in situ and reburied near their original locations during the remediate/capping activities.

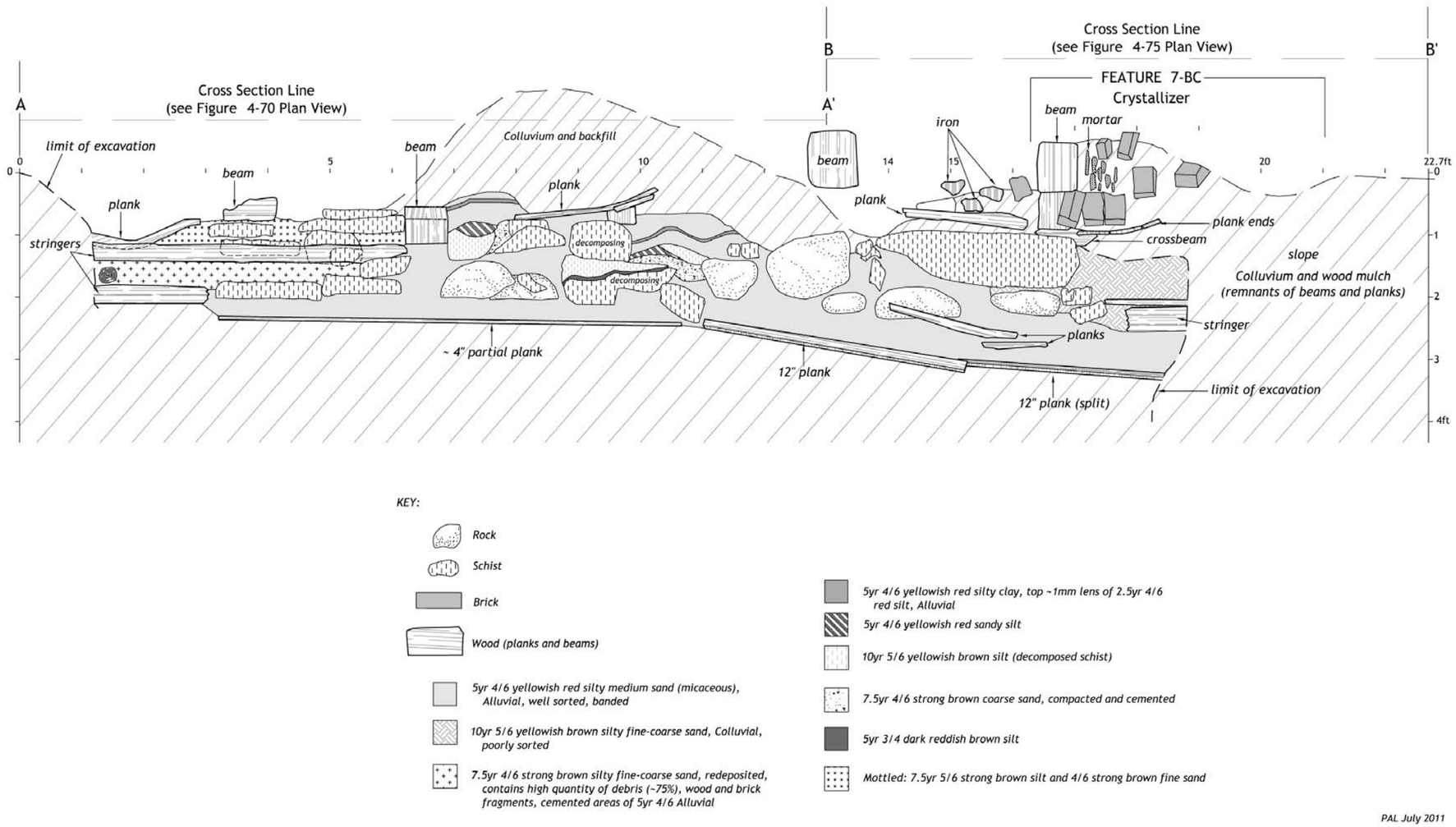

Figure 4-51. Plan of FEA-4-LC at .48 to 1.1 ft below ground surface in ST-3-LC.

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Figure 4-52. Photograph of FEA-4-LC Context II showing iron plates, looking west.

turned at a 90 degree angle to the north, and extended for an additional 2.75 ft (.84 m), before turning 90 degrees to the east extending for an additional 1.2 ft (.35 m). This configuration formed a rectangular area with overall dimensions of 2.6-x-4.8 ft (.79-x-1.5 m) (see Figure 4-51). A furnace grate bar and an iron plate were found at the west edge of this rectangular area, at the east edge of the larger brick platform[21].

The walls at the south and west sides of the brick platform were excavated and the outer edge of the north wall was mapped, but not completely defined due to the presence of large roots and stumps obstructing the area. The brick platform is suspected to continue approximately 3 ft (.91 m) to the north beyond the limit of machine stripping to where the structure would have abutted the factory north wall. In the southwest corner, bioturbation and settling had displaced the brick, exposing a rough schist and fieldstone subfloor platform (see Figure 4-51). Loose bricks were removed and the structure was found to continue an additional 2 to 5 ft (.6 to 1.5 m) west giving it an overall estimated length of 26 ft (7.9 m).

The overall estimated dimensions of the FEA-4-LC brick platform are close to the 10 ft X 26 ft (3-x-8 m) dimensions of the copperas boilers reported in 1871 (Duncan 1871:1085–1088). Unfortunately, obstructions from tree stumps and backhoe logistics prevented complete excavation of the platform all the way to the north factory wall. The platform could be interpreted as the floor of a workspace, but that does not explain the stacked iron plates. The area could speculatively be interpreted as the floor of a heating chamber for copperas liquor, possibly associated with some sort of boiling pan, which could have been supported and leveled by the stacked iron plates, and possibly additional iron supports to resist the heat. Hot gases from a firebox (not located), if properly manipulated by furnace construction and draft control, could have passed through a flue formed by the void between the brick floor and the bottom of the evaporating pan. A firebox could have been located above the short west factory wall, so that the hot gases could pass under the pan longitudinally to the east. The rectangular brick structure at the east end of the platform could be the location of the draft stack, however, no dark ash deposit was seen within or around it. Its elevation above the cooler vessel in FEA-2-LC to the east would have facilitated gravity flow of the boiled liquor. The halo of red hematite earth surrounding the boiler features at the Upper Copperas Factory and North Berm appears to be absent in this feature. The red soil halo may not necessarily always be an indicator for a copperas boiler structure, and may be a factor of a more iron-rich soil composition in the Upper Copperas Factory location. If this structure is indeed the remains of a large, late copperas liquor boiler, it would be the most intact surviving boiler in terms of areal extent. Based on its apparent dimensions, it would also confirm that the Lower Copperas Factory is one of the two paired factories that were the last to operate on the site.

Several aspects of this brick platform suggest that it is simply a working floor. Aspects of confirmed boilers at the Upper factory and North Berm, including parallel brick walls and other general indications of deep masonry construction, are absent. The brick is only one layer thick, supported by flat stone slabs. It has banded brick edging, a wood timber, possibly a sill near its south edge (see below), and a random rectilinear plan configuration at the east end, suggesting that it is a floor that followed interior and exterior plank-walled rooms. The presence of the stacked iron plates could be explained by the use of this location for an interior raw copperas liquor holding tank. The Lower Factory is located several hundred feet from the reported raw copperas liquor holding cisterns at the bottom of the slope above the Upper Factory. That liquor had to be conveyed to the Lower Factory, presumably in an elevated pipe or launder, and may been received in a holding tank prior to being let off into the boiler in batches. The location of the feature within the building is closest to the Upper Factory, and the iron plates could have been used to level the bottom of a vessel.

[21] These items were recorded in situ and reburied near their original locations during the remediation/capping activities.

Figure 4-53. Photograph of FEA-4-LC Context I iron object concentration, looking east.

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Context I was identified as an approximately 2-x-3 ft (.61-x-.91 m) concentration of loosely piled, heavily corroded iron objects (Figure 4-53) found 4.5 ft (1.4 m) east of FEA-4-LC (Context II), 3.3 ft (1 m) west of an interior north-south wall. A large stump was located near the objects and it is possible that bioturbation caused them to shift from their original location (see Figure 4-51). Artifacts collected from the iron concentration include 18 animal shoes, one chisel, five axe heads, two hooks, one lock/latch, two threaded rods, two L-brackets, four unidentifiable nails, one spike, and six unidentified iron (see Appendix A). Five iron plates were also found within the concentration, but not collected[22]. The shape and approximate size of the animal shoes would indicate one donkey shoe and 17 horseshoes (see Appendix B.1-14). Four out of the five axes recovered were heavily oxidized and incomplete (see Appendix B.1-8). The shape of the one almost complete axe head suggests that it is a single bit axe of a type available from the onset of the nineteenth century American axe industry. Other collected artifacts include hardware such as an .71 ft (.22 m) cabin hook door latch. The tight clustering of the objects suggests that they were intentionally piled. This pile of iron scrap may or may not have been scrap metal for charging into a copperas boiler.

Context III was identified as a decomposing east-west wood timber beam or structural sill located 1.4 ft (.4 m) south of and parallel to the south FEA-4-LC brick platform brick edge border (Figure 4-54). The timber was 11.5 ft (3.5 m) southwest of the Context I iron artifact concentration. The exposed section of brick and beam measured approximately .65-x-5 ft (.20-x-1.5 m) and are parallel to FEA-4-LC (see Figure 4-51). The brick portion of the feature consisted of two rows of half bricks at its furthest distance 20.7 ft (6.3 m) south of the prominent factory foundation wall. The machine stripping in this area terminated at the horizontal extent of tumbled broken brick and natural cement mortar 1.6 ft (.5 m) to the south.

A total of 48 cultural materials was recovered from 0 to .5 ft (0 to .15 m) bgs in association with ST-3-LC and FEA-4-LC (Contexts I, II, and III) (see Appendix A; Table 4-3). The majority of these artifacts were recovered from Context I, the concentration of iron objects (see discussion above). Artifacts found outside of Context I include one rake, one penny, one grate bar, an iron plate and an L-bracket, one piece of lead spatter and three lead trimmings. Of these, only the penny and the rake fragment were collected (see Appendix A)[23]. The penny is heavily tarnished, and no marks or a date were legible.

Inter-Copperas Factory Area

The Inter-Copperas Factory Area is approximately 120 ft (37 m) west of the Lower Copperas Factory foundation and 100 ft (30 m) south-southeast of the Upper Factory foundation (see Figure 4-1). Data recovery excavations focused on hand testing (excavation units) and machine-assisted trenching around six previously identified features, including several surface depressions that were suspected to be building foundations and several raised rectangular berms. Three excavation units (EUs 1 through 3) and four trenches (TR-1-IC through TR-4-IC) were placed in or adjacent to the berms. Two trenches (TR-5-IC and TR-6-IC) were excavated around a north-south oriented stone wall. Cobble and wood flooring were identified in three of the seven features. One of the trenches excavated on a slope containing wood staining over an earth ramp terminating at one of the square berms. A low density of artifacts (n=18) was recovered from 0 to 2 ft (0 to .6 m) bgs in and around the foundations (see Appendix A-Inter Copperas Factory (IC); Table 4-4).

[22] The iron plates were recorded in situ and reburied near their original location during the remediation/capping activities.
[23] The remaining artifacts were recorded in situ and reburied near their locations during the remediation/capping activities.

Figure 4-54. Photograph of FEA-4-LC Context II and III, looking west.

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Table 4-4. All Recovered Cultural Materials By Unit, Inter-Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	EU03	TR-01	TR-02	TR-04	Total
Nail	9	1	2	1	13
Lead Spatter				2	2
Wood	3				3
Grand Total	12	1	2	3	18

The arrangement of the features and the limited artifact assemblage in the south/southwest part of the Inter-Copperas Area suggests that it was not a high activity area. Historical records indicate that this area, particularly features including the cobble stone floors (FEA-1-IC and FEA-3-IC) may have been used for temporary storage. According to an 1827 account, "In the southern part of the works are several temporary buildings, erected for the preservation of the copperas (sulphate of iron)" (anon., *Columbian Centinel* December 1, 1827:1). In the northeast part of the subsite, a trench was excavated in the South Berm approximately 100 ft (30.5 m) southeast of the Upper Factory standing interior wall. The berm incorporated stacked stones visible at the surface. Excavation revealed FEA-4-IC, a rectangular brick masonry structure and bright red soils interpreted as a copperas liquor boiler (see discussion below).

Trench 1 (TR-1-IC, FEA-1-IC)

TR-1-IC was placed 186 ft (56.7 m) southwest of the Lower Copperas foundation and 238 ft (72.5 m) southeast of the corner of the Upper Factory standing internal wall (see Figure 4-1). The trench was placed across a roughly-defined, berm-ringed depression measuring approximately 14-x-20 ft (4.3-x-6.1 m). TR-1-IC measured 4.3-x-17.8 ft (1.3-x-5.4 m) (Figure 4-55: back pocket). TR-1 contained a dark olive brown (2.5 Y 3/3) mottled with black (10 YR 2/1) loam overburden from 0 to 1.2 ft (0 to .4 m) bgs (Figure 4-56). The overburden was followed by a fill deposit that consisted of reddish brown (5YR 5/4) clayey silt from .6 to 1.6 (.2 to .5 m) bgs. A flat deposit of small to medium cobbles was encountered between .2 to 1 ft (.05 to .31 m) bgs. The cobbles ranged from .3 to .7 ft (.08 to .21 m) in diameter and extended the entire length of the trench. Deteriorated planks and wood staining were present above the cobbles. The cobbles and plank remnants are interpreted as subfloor and floor structural remains (FEA-1-IC) (Figure 4-57). Grayish brown (2.5Y 5/2) glacial till was present from 1.2 to 2.6 ft (.4 to .8 m) bgs.

One machine-cut iron nail was recovered from 1 to 1.1 ft (.3 to .34 m) bgs in the fill stratum in TR-1-IC in association with FEA-1-IC (see Appendix A; Table 4-4). The nail was heavily corroded and its manufacturing type could not be determined. One piece of decaying wood was noted above the cobbles in the Fill stratum.

Trench 2 (TR-2-IC) and EU 3

TR-2-IC was placed in a berm feature located 12 ft (3.7 m) northwest of TR-1-IC (see Figure 4-55). The berm was roughly trapezoidal in shape, and measured approximately 14-x-23 ft (4.3-x-7 m). TR-2-IC measured 3.7-x-19.7 ft (1.1-x-6 m) and was placed within the berm along its western edge. Trenching revealed dark organic staining suspected to be possible remnant wood. To the north a series of cobbles were inadvertently disturbed by the machine excavations before they were determined to be part of a cobble floor. To further define the floor feature and preserve possible in situ artifacts and features, machine excavations ceased and a 3.28-x-3.28 ft (1-x-1 m) unit (EU-3) was placed at the north side of the

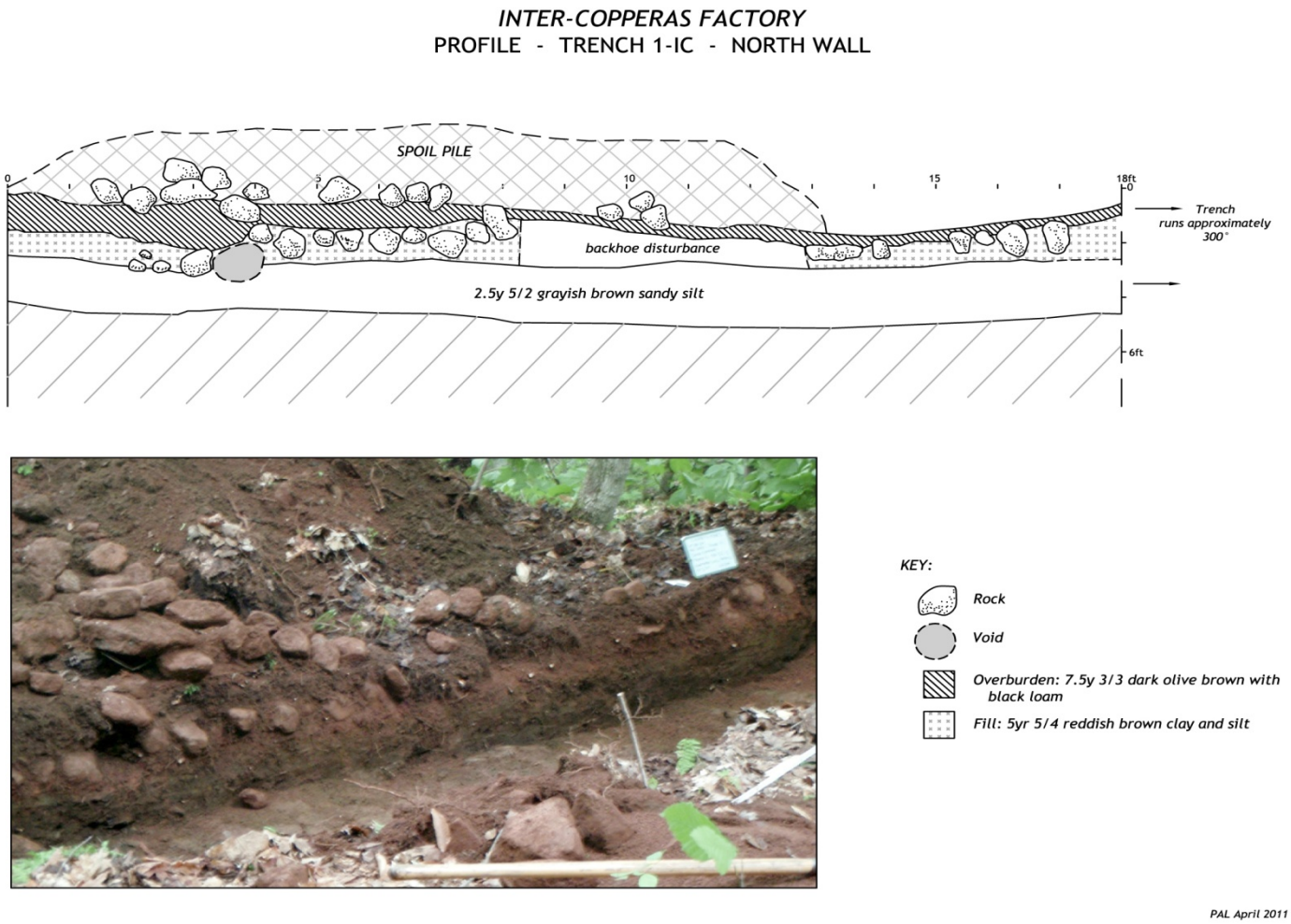

Figure 4-56. North wall profile of TR-1-IC.

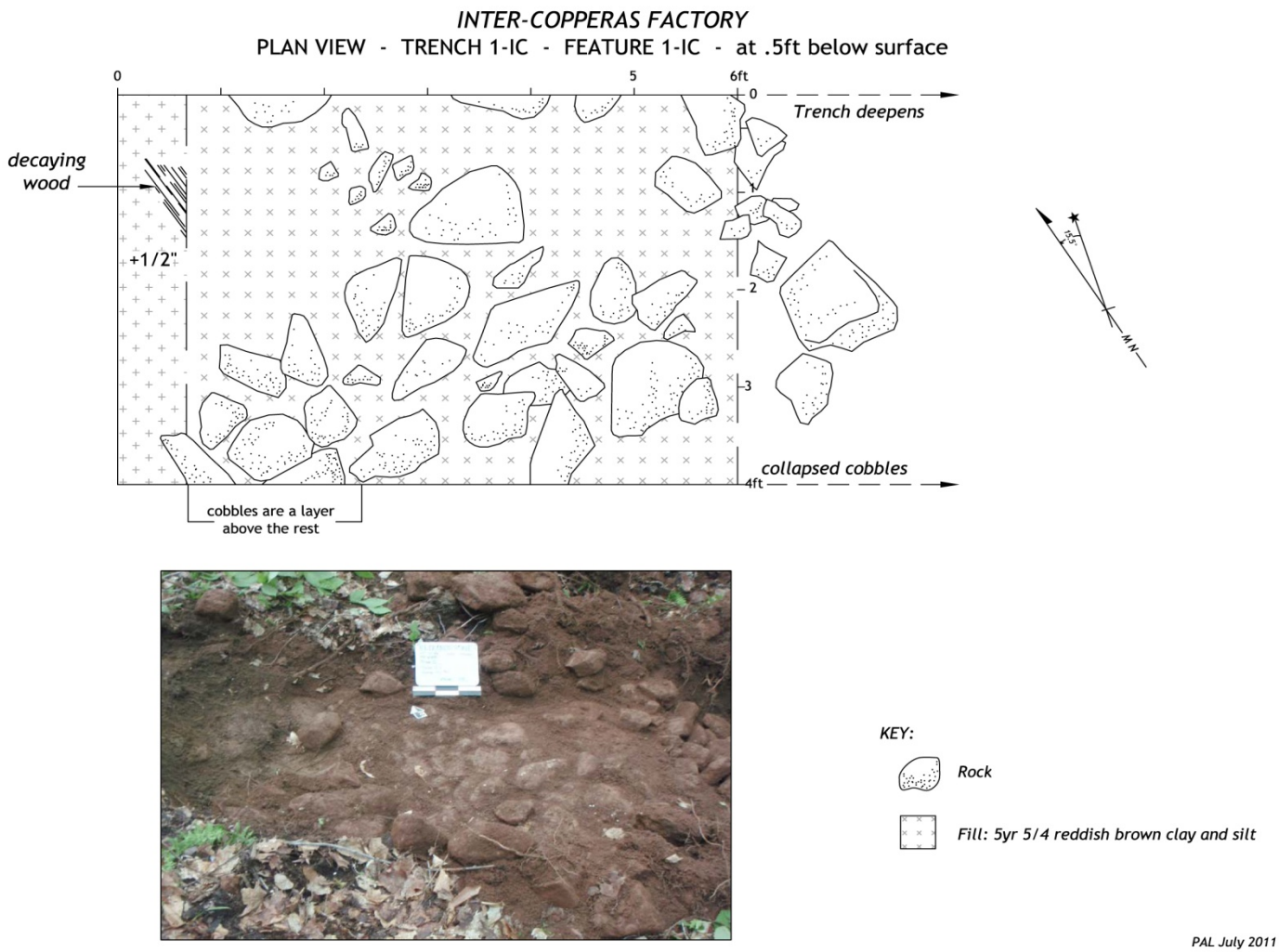

Figure 4-57. Plan of FEA-1-IC cobble floor at .5 ft below surface in TR-1-IC.

trench to further investigate the feature. EU-3 contained small to medium cobbles from 7 to 1.1 ft (.21 to .34 m) bd that ranged from.3 to .7 ft (.08 to .20 m) in diameter and covered 95 percent of the unit (Figure 4-58). The cobble floor, FEA-3-IC, was exposed and excavation ceased as the trench began to fill with groundwater.

TR-2-IC and EU-3 contained an overburden consisting of dark olive brown (2.5Y 3/3) mottled with black (10YR 2/1) loam from .3 to .9 ft (.09 to .3 m) below datum. The floor features were found within the building fill deposit. The fill consisted of red (2.5YR 4/6) clay with small to medium cobbles and decomposing wood from .7 to 1.1 ft (.21 to .34 m) bd. A small amount of subsoil was present 1.5 to 1.8 ft (.46 to .55 m) bd before water started to pool in the trench and unit (Figure 4-59).

TR-2-IC and EU-3 yielded a total of 14 cultural materials (see Appendix A; Table 4-4). Two machine cut nails were recovered from the ground surface of the trench and nine additional machine cut nails and three wood fragments from 0 to .33 ft (0-.1 m) bd in EU 3. The nails and wood fragments were found within the building fill. The wood fragments were part of a plank situated at the interface of the overburden and building fill in the southern side of the trench.

Trench 3 (TR-3-IC)

TR-3-IC was placed 25 ft (7.6 m) west of TR-2-IC along a sloped, north-south oriented earth ramp that terminated at one of the berm-ringed depressions (see Figure 4-55). The trench was oriented on a long north-south axis and measured 3.75-x-44 ft (1.45-x-13.4 m). The trench crossed the feature and extended 14 ft (4.3 m) to the north. Wood staining was noted within the feature; however, staining was not present north of the earthen ramp. The ramp may have been a materials handling feature for a building located on the berm.

The trench stratigraphy consisted of a thin developing A deposit characterized as brown sandy silt from .6 to .8 ft (.18 to .24 m) below the A_o (Figure 4-60). A dark yellowish brown (7.5YR 4/6) sandy silt fill deposit with pebbles was found from .8 to 1.2 ft (.18 to .37 m) bgs. Glacial till was present from 1 to 3 ft (.31 to .91 m) bgs. No artifacts were found in association with the wood staining and earthen ramp.

Trench 4 (TR-4-IC, FEA-4-IC)

TR-4-IC was located 55 ft (17 m) northeast of TR-3 within the South Berm, a north-south oriented rectangular earth mound south of Copperas Brook. The mound had with a light scatter of brick on its upper surface and stacked stone at its southwest corner (see Figure 4-55). The trench had a north-south orientation and measured 4.7-x-12.5 ft (1.4-x-3.8 m). Excavation of the South Berm revealed reddened soils intermixed with disintegrated brick. Brick rubble, decaying mortar, and red soil were removed to reveal a feature incorporating common brick and iron plates. (Figure 4-61).

Two vertically-oriented iron plates were encountered at the south end of the trench against the east and west brick pit walls at 5 to 7 in (.13 to .18 m) bgs[24]. The plates may have been disturbed and moved upwards by the excavator. Two horizontal iron plates were encountered 1.7 ft (0.52 m) bgs at the same location within the brick pit, above a brick surface of unknown depth[24]. The south end of the trench contained three east-west rows of brick. Another, less intact east-west band of three rows of brick was located approximately 1 ft (.30 m) to the north. The north end of the trench contained a rectangular

[24] The iron plates were recorded in situ and reburied near their original locations during the remediation/capping activities.

Figure 4-58. Photograph of FEA-3-IC Cobble floor.

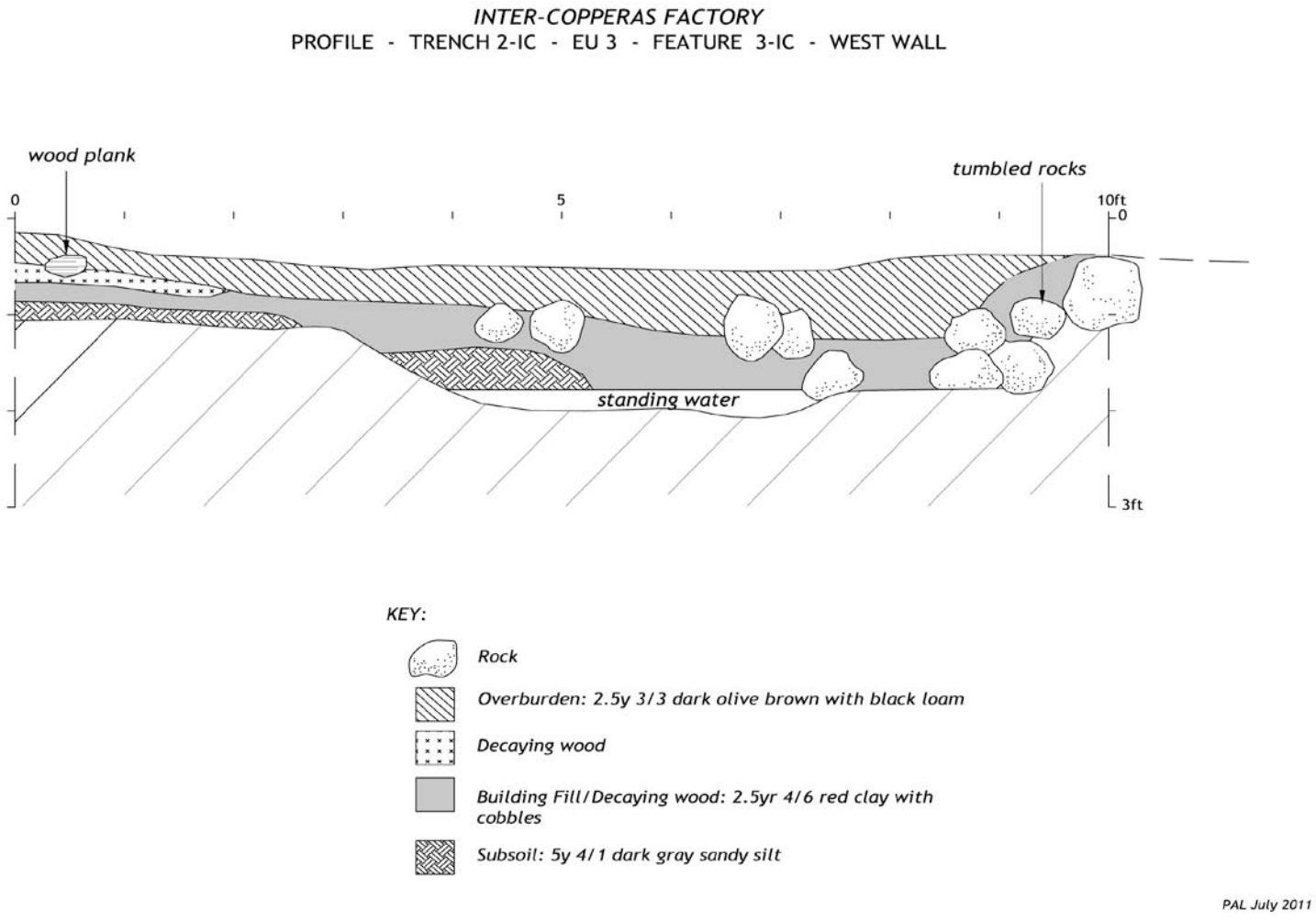

Figure 4-59. West wall profile of FEA-3-IC in TR-2-IC.

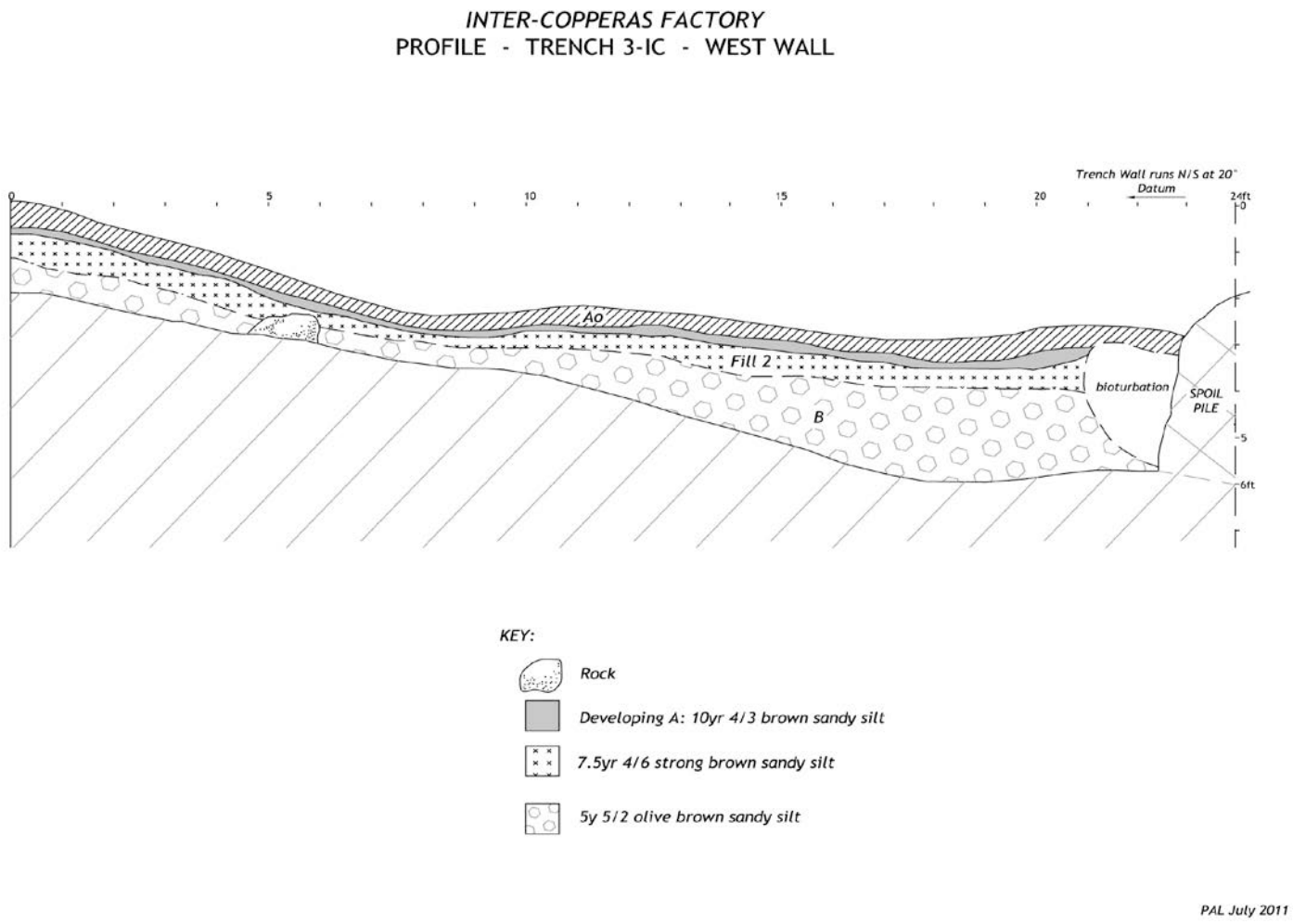

Figure 4-60. West wall profile of TR-3-IC.

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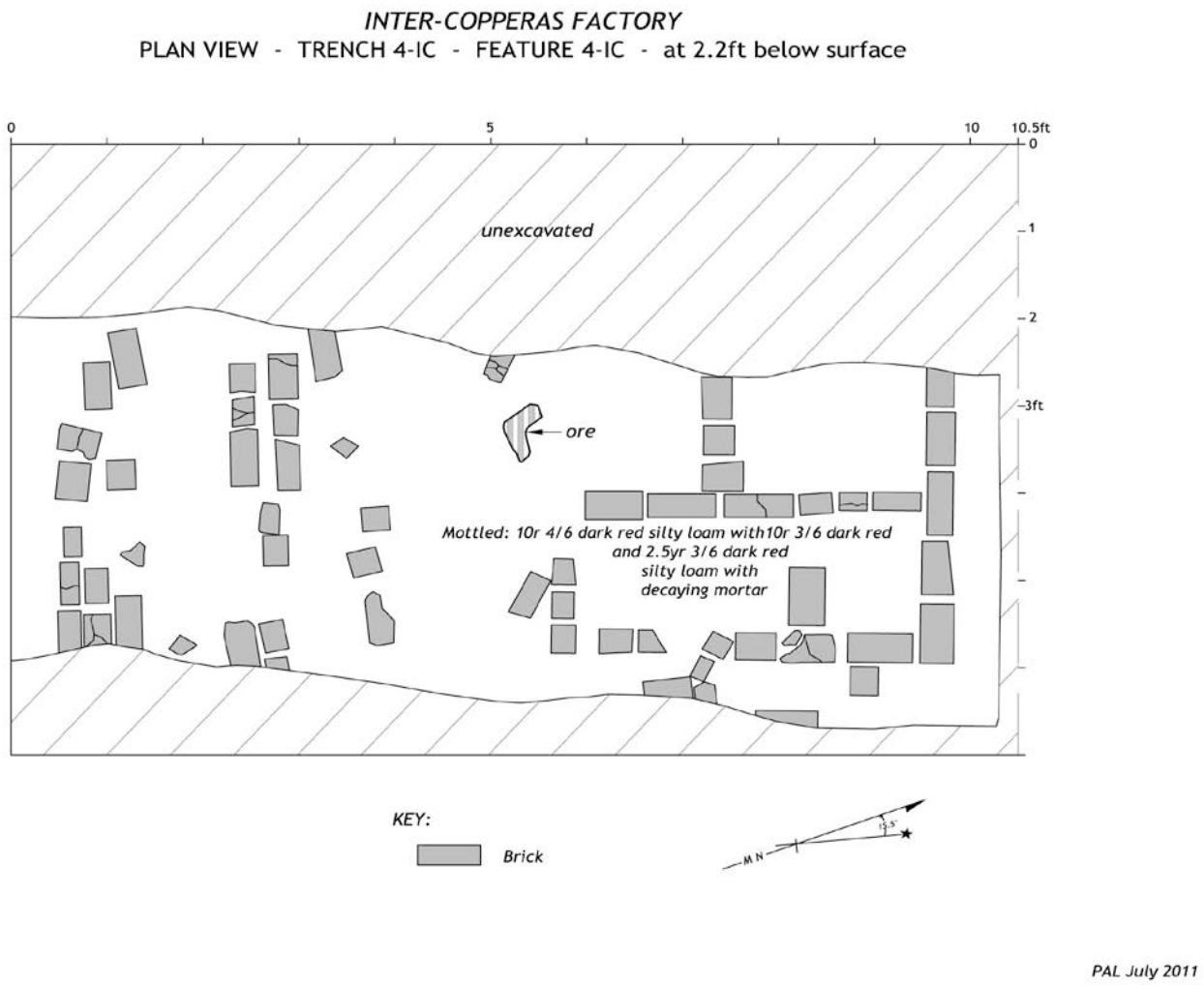

Figure 4-61. Plan of FEA-4-IC (boiler) at 2.2 ft below surface in TR-4-IC (South Berm).

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arrangement of bricks forming a box five bricks long north-south by three bricks wide east-west, with a row of bricks extending west from the west side (see Figure 4-61). The bricks below the iron plates at the south end of the trench were at a slightly higher elevation (.8 to 1 ft [.24 to .30 m]) than the rows of brick to the north. The plates, bricks and associated soil in and immediately around the trench were all bright red.

The west wall profile contained seven soil horizons (Figure 4-62). An A_o horizon and overburden was found from 0 to 1.7 ft (0 to .52 m) bgs. The overburden was followed by dark brown (7.5YR 3/4) mottled with dark red (2.5YR 3/6) silty fine to medium sand. The deposit was found from .3 to 1.8 ft (.09 to .55 m) bgs and contained the first level of broken brick. A pocket of red (2.5YR 4/8) clay was mottled with a yellowish brown fine to medium sand from .6 to 1.7 ft (.18 to .52 m) bgs south of the iron plate. North of the iron plate from .8 to 2.1 ft (.24 to .64 m) bgs was brown (10YR 4/3) mottled with dark brown (10YR 3/3) fine sandy silt. A deposit of weak red (10R 4/4) mottled with dusky red (10R 3/4) and yellowish brown (10YR 5/8) silty clay was found from 1.2 to 2.7 ft (.37 to .82 m). The stratum around the brick chamber on the north side consisted of a dark red (10R 3/6) mottled with dusky red (10R 3/2) fine to medium sandy clay. Disintegrated brick and schist were prevalent from .8 to 2.7 ft (.24 to .82 m) bgs. Excavation ceased at the surface of the bricks at the bottom of the trench as it was determined in consultation with the VT SHPO that the entire South Berm would be protected from mine waste cleanup in exchange for monitoring of the removal of the North Berm.

Three cultural materials were recovered from 1 to 2 ft (.3 to .6 m) depth in TR-04-LC (see Appendix A; Table 4-4). These materials include one machine cut nail and two lead spatter.

The brick and iron plate structure excavated in the South Berm can be interpreted as the remains of a copperas liquor boiler based on the presence of the characteristic red hematite soils, large sub-rectangular pieces of iron boiler plate, lead spatter, and parallel brick walls and rectangular chambers, some or all of which are similar to aspects of confirmed or suspected boilers found in the Upper Copperas Factory, North Berm, and Lower Copperas Factory. The proportions and narrower dimension of the structure do not closely correspond with those that appear in the historical record. The presence of copperas processing structures in this location, as well as the adjacent North Berm, was an unanticipated discovery. These features may be the remains of the primary boiling step located within one of the other half-dozen factories of different reported dimensions located at the bottom of the hill below the storage cisterns as reported in the historical record in 1827, 1842 and 1871 (anon., *Columbian Centinel* December 1, 1827:1; Thompson 1842:167–168; Duncan 1871:1085–1088).

Trench 5 (TR-5-IC)

TR-5-IC was placed 57 ft (17.4 m) west of TR-4-IC (see Figure 4-55). The trench measured 4.6-x-11.3 ft (1.4-x-3.4 m) and was placed perpendicular to a visible north-south stone wall approximately 70 ft (21 m) in length built of drylaid schist fieldstones. The trench was excavated to investigate the function of, and possible activities related to, this stone wall. No cultural material was recovered from the trench. The lack of artifacts indicates little activity within this area. The length and location suggest that it was a retaining wall.

The trench contained four shallow deposits of natural stratum above eastward-sloping bedrock (Figure 4-63). The A_1 consisted of a dark yellowish brown (10YR 3/6) fine sandy loam with organic material from 0 to .17 ft (0 to .05 m) bgs followed by a B_1 deposit consisting of a dark reddish brown (5YR 3/4) medium to coarse sandy loam found from .5 to 1.25 ft (.15 to .38 m) bgs. The B_2 consisted of very dark brown (5Y 2.5/3) mottled with dark yellowish brown fine to medium sandy silt 1.25 to 1.75 ft (.4 to .5 m) bgs. The C stratum consisted of a very dark brown (5Y 2.5/3) silty fine sand with decomposing bedrock.

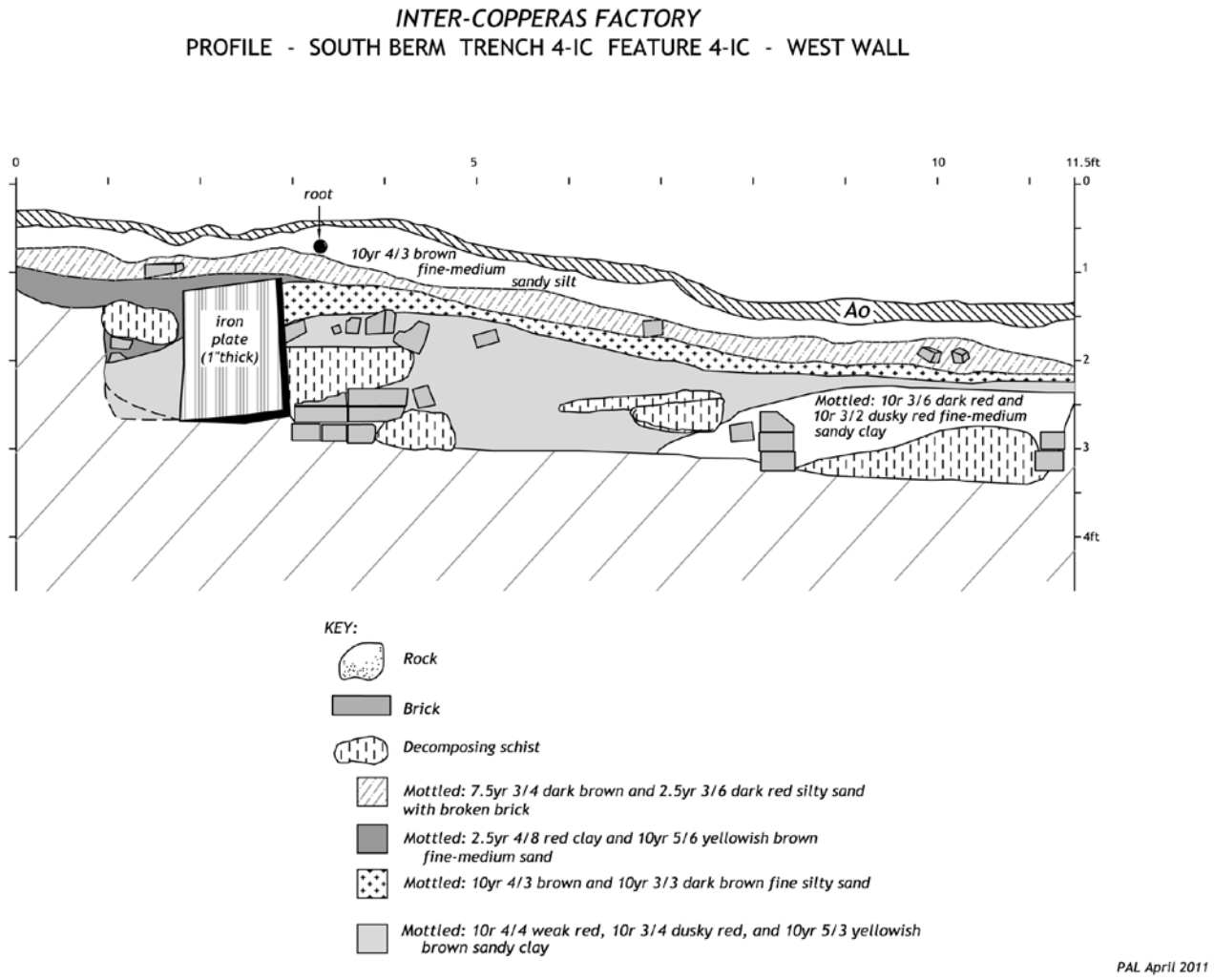

Figure 4-62. West wall profile of FEA-4-IC in TR-4-IC (South Berm).

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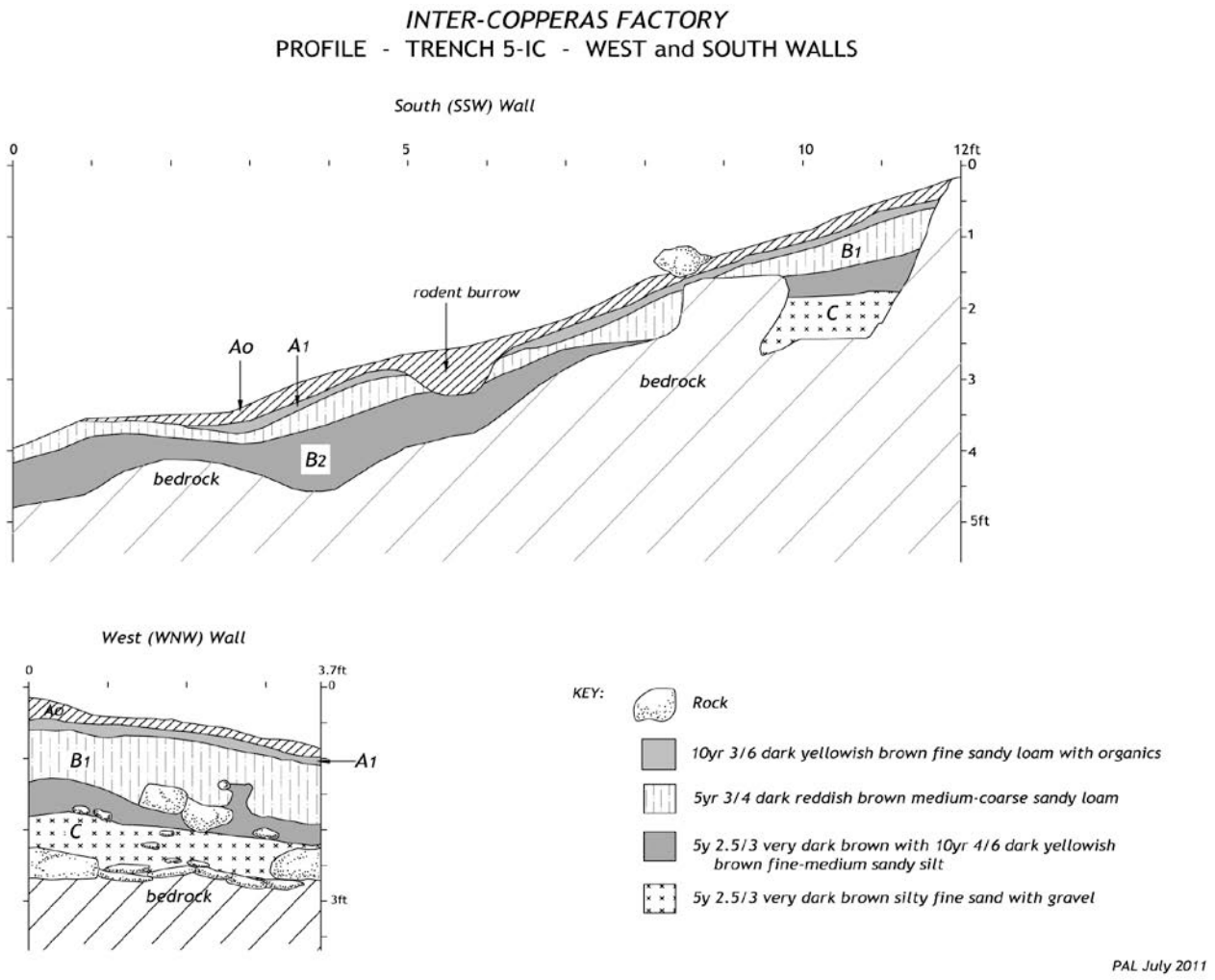

Figure 4-63. West and south wall profiles of TR-5- IC.

Trench 6 (TR-6-IC)

TR-6-IC was placed 50 ft (15 m) to the south of TR-5-IC along the west side of the wall (see Figure 4-55). The trench had a long north-south axis and measured 4.3-x- 9.5 ft (1.3-x-2.9 m). Similar to TR-6-IC, the trench did not contain any artifacts or structural features. The soils in both trenches exhibited natural soil horizons that did not indicate any industrial activity. The stratigraphy consisted of overburden consisting of dark yellowish brown (10YR 4/4) silty fine sand from .3 to 1.2 ft (.09 to .4 m) bgs (Figure 4-64). The overburden was suspected to be slope wash that was followed by olive brown (2.5Y 4/3) silty fine sand from 1.2 to 2.1 ft (.37 to .64 m) bgs. The previously identified wall was confirmed to be a retaining wall for the storage facilities and boiler features to the east.

Excavation Unit 1 (EU-1-IC)

EU-1 was located 80 ft (24.4 m) southeast of TR-6-IC (see Figure 4-55). The unit measured 3.3-x3.3 ft (1-x-1 m) and was placed along the west side of one of the identified berm-ringed depressions. The unit was placed outside of the suspected structure to identify any evidence of a wall. The unit was excavated in arbitrary .33 ft (.1 m) levels. Groundwater began to pool at 1.3 ft (.40 m) bs and excavation ceased at 1.5 ft (.45 m) bgs. The strata consisted of four natural deposits and one pocket of re-deposited B/slope wash along the southwest wall (Figure 4-65). The A_1 consisted of dark grayish brown (10YR4/2) sandy loam was found .16 to 1 ft (.05 to .31 m) bgs. The $A_1$was followed by B_1 consisting of dark yellowish brown (10YR 4/6) fine sandy loam from.26 to 1.1 ft (.08 to .34 m) bgs. The B_2 was found from .5 to 1.4 ft (.15 to .42 m) bgs and consisted of very dark grayish brown (10YR 3/2) fine sandy silt. The C horizon consisted of dark grayish brown (2.5Y 4/2) silt found from 1.2 to 1.5 ft (.36 to .46 m) bgs. The re-deposited B/possible slopewash was noted along the southwest side of the unit from .59 to 1.5 ft (.18 to .46 m) bgs. No evidence of a wall or artifacts was encountered.

Excavation Unit 2 (EU-2-IC, FEA-2-IC)

EU-2 was placed 1 ft (.31 m) east of EU-1 within the berm-ringed depression (see Figure 4-55). The unit measured 3.3-x3.3 ft (1-x-1 m) and was placed along the east side of the berm. The unit's location was chosen to identify any possible structural remains within the suspected building. The soil stratigraphy inside the structure consisted of an overburden of dark brown (10YR 3/3) mottled with dark yellowish brown (10YR 4/4) fine sandy silt from the 0 to 1.3 ft (0 to .40 m) bgs (Figure 4-66). The overburden was part of the berm that was followed by a fill deposit similar in color to those identified with trenches containing the cobble flooring. The fill deposit consisted of strong brown (7.5YR 5/8) fine sandy silt that covered the entire unit found from .7 to 1.6 ft (.20 to .50 m) bgs sloping to the east. Cobbles were found 1.6 ft (.48 m) bgs along the eastern side of the trench within the fill deposit (FEA-2-IC). The western side of the trench contained very dark grayish brown (10YR 3/2) mottled with gray (10YR 5/1) fine sandy silt. A few stones were found in the gray deposit. The soil line within the unit corresponds to the suspected edge of wall. Water began to pool in the unit at 1.6 ft (.50 m) and excavation ended at this depth.

Copperas Brook Corridor

The Copperas Brook Corridor was located at the bottom of the open TP 3 slope, immediately south of the Upper Copperas Factory. Four contiguous stripped areas and trenches were placed north and east of TR-2-UC on the north bank of Copperas Brook. One large stripped area (TR-6-BC) was excavated at the east end of the long narrow "island" dividing the north and south brook channels, west of the first significant drop in the brook south of the factory. Two 6.6-x-6.6 ft (2-x-2 m) units were placed west of TR-6-BC within the island in the brook corridor. One trench (TR-1-BC) was placed west of the haul road to

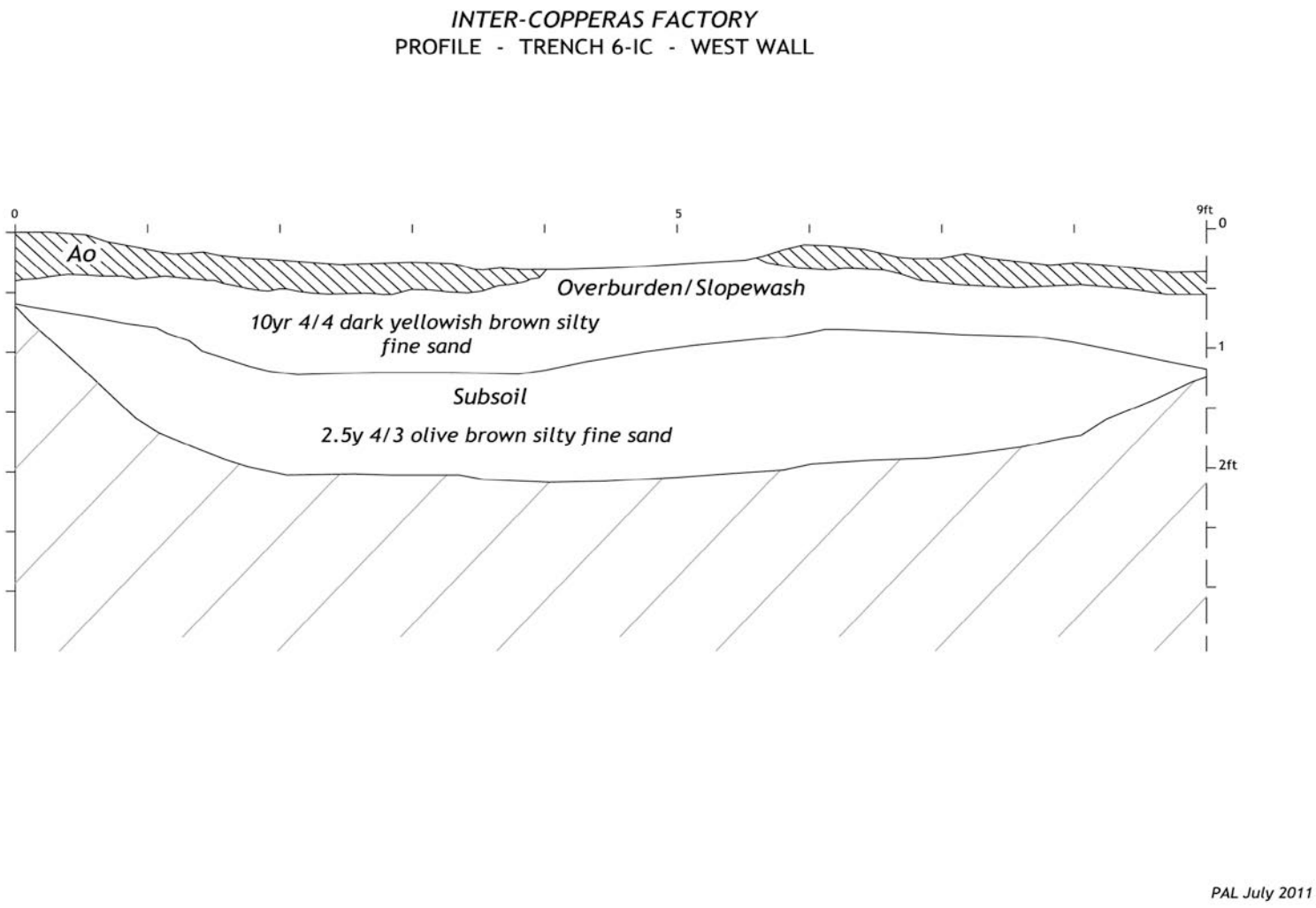

Figure 4-64. West wall profile of TR-6-IC.

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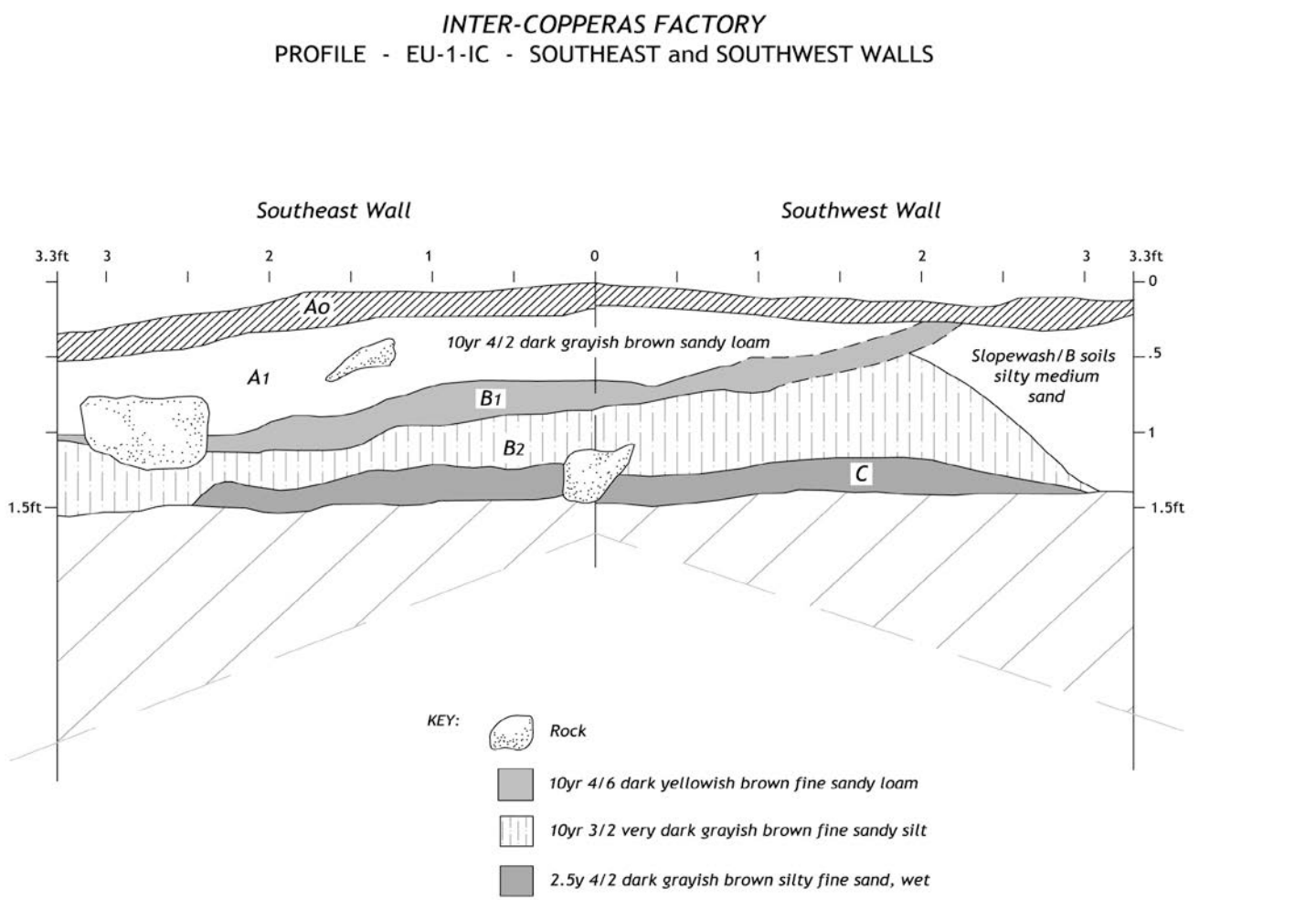

Figure 4-65. Southeast and southwest profiles of EU-1-IC.

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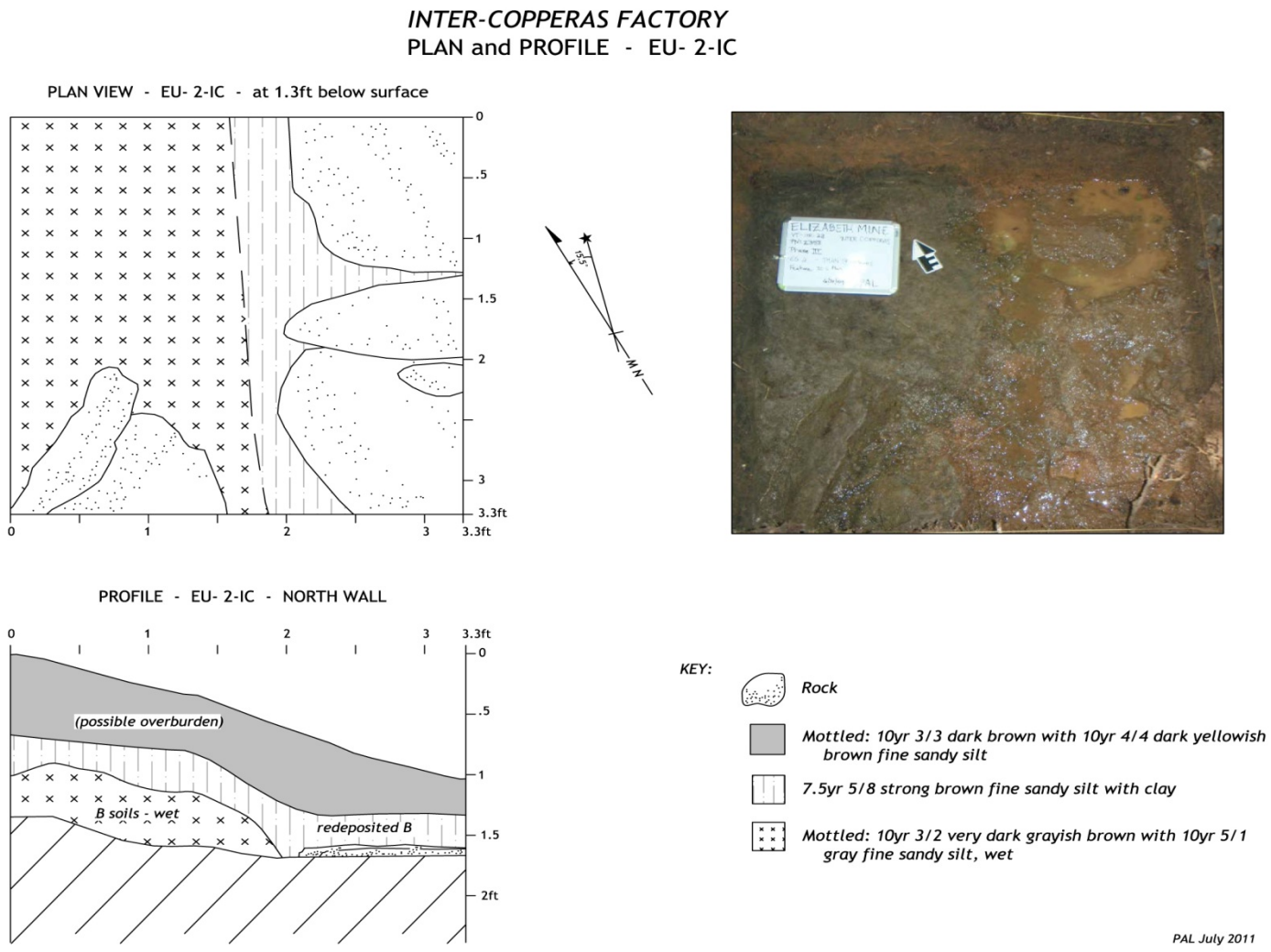

Figure 4-66. North wall profile and plan views at 1.3 ft below surface of EU-2-IC.

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investigate a possible brick copperas liquor evaporator tower structure. Two additional 6.6-x-6.6 ft (2-x-2 m) units were placed east of the haul road and west of the Inter-Copperas Area. A total of 134 cultural materials was recovered from 0 to 2 ft (0 to .61 m) bgs from the ground surface and in alluvial, overburden, and rubble fill soils (see Appendix A-Copperas Brook Corridor (BC); Table 4-5).

Trench 1 (TR-1-BC)

TR-1-BC was placed 152 ft (46 m) southwest of the corner of the standing upper factory wall and adjacent to the temporary mine waste removal haul road built in 2009 (see Figure 4-2). The trench was placed in the approximate location of three evaporator towers shown on the 1874 Vermont Copperas Company map. The 2002 survey identified two dense brick scatters within this approximate location, at the east edge of several large conical ore roast bed and/or leaching heaps ringed by the decayed remains of corral-like timber structures. The temporary mine waste haul road built in 2009 buried one of the brick scatters; TR-1-BC focused on the second, remaining one. The trench measured 23-x-34 ft (7 x 10.4 m) and reached a total depth of 8.5 ft (2.6 m) bgs. It was stripped back in shallow passes with a smooth backhoe bucket in hopes of finding a section of one of the remaining evaporators. Timber posts, possibly associated with the structures surrounding the ore heaps were noted at 6.2 and 7.1 ft (1.9 and 2.2 m) bgs. The timber structures were similar to those seen in other roast beds observed during the archaeological monitoring. A few loose bricks were noted at 7.3 ft (2.2 m) bgs below the timbers; however, no structural evidence of a foundation or support substructure was encountered.

Due to safety concerns excavation of the roast bed stripped back the upper 5.5 ft of overburden, the stratigraphy of the bottom three feet were recorded within the west wall profile (Figure 4-67). The truncated roast bed contained a $fill_1$ from 5.5 to 6.8 ft (1.7 to 2.1 m) bgs that consisted of a yellowish red (5YR 4/6) silty medium to course sand (Figure 4-67). A second fill ($fill_2$) deposit consisted of strong brown (7.5YR 4/6) fine to medium sand was found from 6.1 to 7.5 ft (1.9 to 2.3 m) bgs. Decomposing schist was identified within the $Fill_2$ from 6.1 to 6.9 ft (1.9 to 2.1 m). $Fill_3$ followed from 6.9 to 8.1 ft on the south side of the trench. The fill consisted of strong brown (7.5YR 5/6) course sand. $Fill_4$ was located on the west side of the trench from 6.6 to 7.7 ft (2 to 2.35 m) bgs and consisted of yellow (2.5Y 7/8) silty fine sand with decomposing ore. Excavation terminated at 8.5 ft (2.6 m) bgs within a composite rock/ferrocrete deposit. No cultural materials other than the timber structures were encountered.

Trench 2 (TR-2-BC)

TR-2-BC was placed on a north-south orientation, 70.6 ft (21.5 m) east of the corner of the standing upper factory wall, approximately 40 ft (12.2 m) southwest of the North Berm, (see Figure 4-2). The trench measured 4-x-12.8 ft (1.2 x 3.9 m) and reached a total depth of 3 ft (.91 m) bgs. TR-2-BC was placed adjacent to and east of a broken brick and mortar and ash concentration within FEA-5-BC (see TR-3-BC discussion below) to determine if it was the location of a possible decomposing boiler structure or midden for discarded structural debris. No intact brick courses were found and bricks encountered in the trench were broken and decayed. No cultural materials other than the brick fragments were encountered.

The trench stratigraphy was similar to previously observed deposits outside the North Berm in trenches TR-9-UC and TR-10-UC. The charcoal deposit identified on the north side of the trench's west wall was found in a strong brown (7.5YR 4/6) silty fine to medium sand that extend to north and west and then south following an eroded gulley (Figure 4-68). The deposit ranged from .2 to 1 ft (.06 x .31 m) in depth and was followed by three additional fill deposits before reaching glacial till. The second fill deposit consisting of yellowish brown (10 YR 5/6) medium sand was present between .8 to 1.3 ft (.24 to .40 m) and 1.6 to 2 ft (.49 to .61 m) bgs. The third fill deposit was characterized as brown (7.5YR 4/4) silty medium to coarse sand from 1.1 to 1.8 ft (.34 to .55 m) bgs. The fourth fill deposit was the similar in color and texture to Fill 3, but was mottled with olive yellow (2.5Y 6/6) fine to coarse sand between 1.4

Table 4-5. All Recovered Cultural Materials By Unit, Copperas Brook Corridor, 2009/2010 Data Recovery Excavations.

Object	EU01	EU02	EU03	EU04	Surface	TR03	TR03-SW	TR04	TR05	TR05-SW	TR06	Total
Mammal Bone									1			1
Redware, Lead Glazed	1											1
Brick	1		4									5
Unid. Ferrous Item									1			1
Bottle/Jar		1				3	1	3	7			15
Molded Glass, Curved						2	2	4	3			11
Unid. Curved Glass						2		12	10			24
Flat Glass	1	1						2	1			5
Lens						1						1
Quarry Debris						1						1
Unid. Igneous Item			1									1
Animal Shoe					3							3
File					1							1
Misc. Hardware					1							1
Nail				2								2
Plate											1	1
Pulley									2			2
Unid. Iron				20	1				4	6	1	32
Unid. Tool				1								1
Wrench					1							1
Iron Ore			7									7
Lead Spatter			5									5
Lead Trimmings			2	2								4
Whiteware, Molded Rim								1	1			2
American Stoneware, Bristol/Albany Slip								2				2
Tar	1								2			3
Wood	1											1
Grand Total	5	2	19	25	7	9	3	24	32	6	2	134

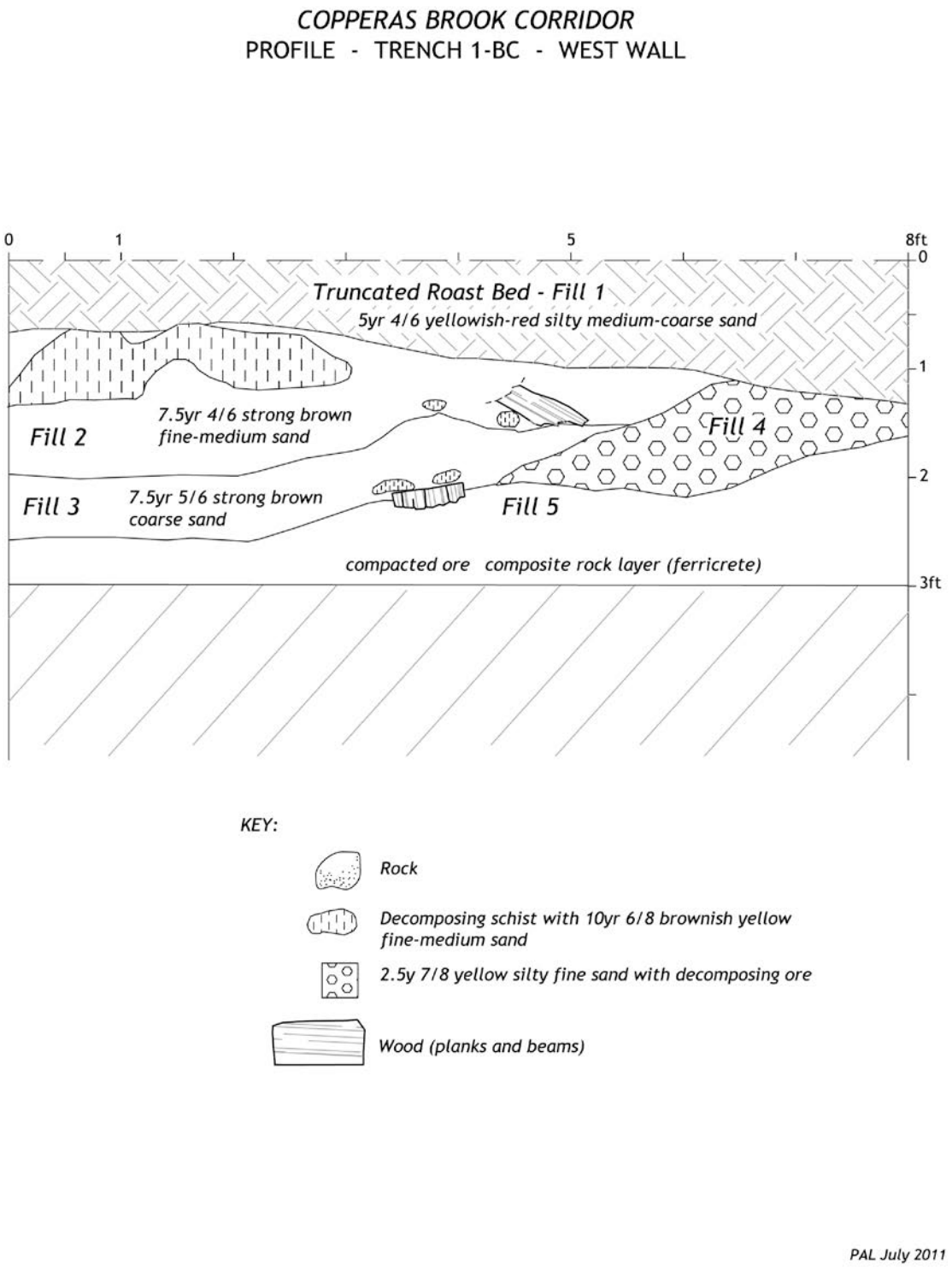

Figure 4-67. West wall profile of TR-1-BC.

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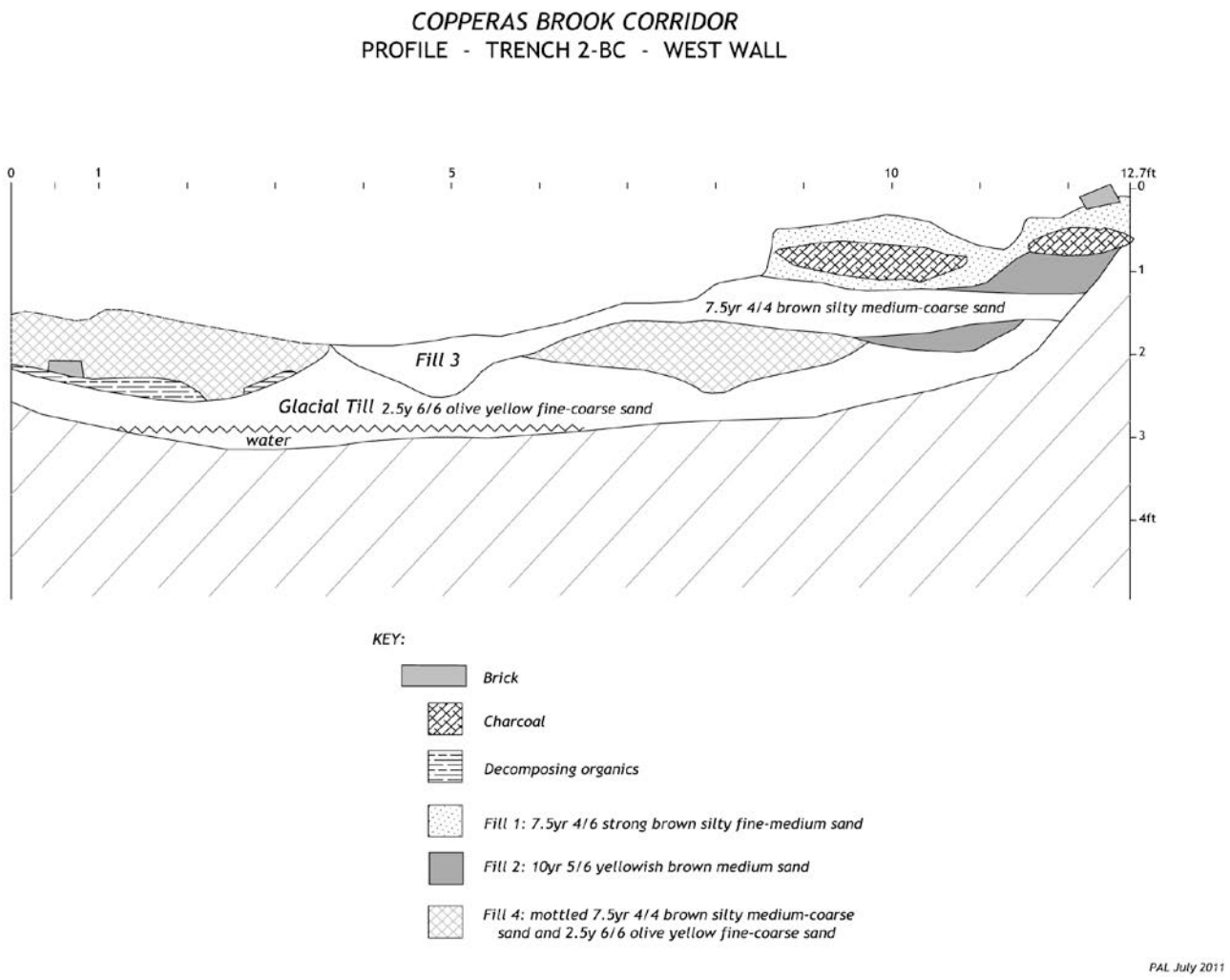

Figure 4-68. West wall profile of TR-2-BC.

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to 2.6 ft (.43 to .79 m) bgs. Glacial till was encountered from 2.6 to 3 ft (.79 to .91 m) bgs at the limit of excavation.

Trench 3 (TR-3-BC, FEA-5-BC)

TR-3-BC was placed immediately west of TR-2-BC (see Figure 4-2), north and east of an erosion gulley. Stacked stones (FEA-4-BC) were present at the bottom of the slope adjacent to the gulley. TR-3-BC was placed just north of the stacked stones to examine the gulley and the area west of TR-2-BC. Excavations began within the flat area at the bottom of the slope and then extended west up the slope towards the Upper Factory. TR-3-BC was stripped using a combination of hand and machine excavations that uncovered an expanse 20.5-x- 22 ft (6.25-x-6.7 m) and that reached a total depth of 1ft (.3 m) bgs. The elevation difference was 7.4 ft (2.25 m) from the features found mid-slope to those at the bottom of the excavation to the east. The depth of excavation closely followed the contours of the features on the hillside, often removing less than 1 ft (.31 m) of A_o, colluvial and alluvial overburden (Figure 4-69).

Excavation exposed FEA-5-BC, a brick midden at the bottom of the slope at .6 ft (.19 m) bgs adjacent to TR-2-BC and a section of a schist stone wall (FEA-3-BC) found at .5 ft (.15 m) bgs approximately 2.7 ft (.82 m) east of FEA-5-BC (Figure 4-70). The axis of the stone wall was 38 degrees east of magnetic north and it extended 14.3 ft (4.4 m) to the south. An extension of this wall was exposed 14.5 ft (4.4 m) to the south and continued across the brook for an additional 21 ft (6.4 m). This area of exposed wall was investigated in TR-6-BC (see discussion below). The area in between the two wall sections (in TR-3-BC and TR-6-BC) was left unexcavated and was assumed to contain the middle section of the wall (see dotted line on Figure 4-2). West of the stone wall was a crystallizer (FEA-7-BC) identified in TR-5-BC (see discussion below). The wall was parallel to the standing Upper Factory foundation wall to the west and may have been an outer foundation wall dividing interior processes from other activities outside the factory, or it could have been a structural support for copperas liquor processing-related masonry features.

Between the stone wall and the brick feature, wood timbers were found at various elevations and at different angles across the hillside. A .4- x-.9 ft (.12-x-.27 m) timber stringer was laid directly on FEA-5-BC 2.5 ft (.76 m) below the stone wall (FEA-3-BC) and extended 4.7 ft (1.4 m) to the northeast before extending into the unexcavated slope (Figure 4-71). Two 1 ft (.31 m) planks were found .1 and .9 ft (.03 and .3 m) above the stringer. One of the planks ran parallel to the wall, was 8.2 ft (2.5 m) in length and had a split down the middle. The second plank was offset by a few degrees crossing the split plank and extending 4.7 ft (1.4 m) to the southwest. The plank was not level but rose .65 ft (.20 m) to the southwest. Heavily deteriorated wood timbers were found between .12 and 1.63 ft (.04 and .5 m) above the stringer to the east and west. A partially exposed plank extended 6.7 ft (2 m) to south with a rise of .5 ft (.15 m) running parallel and 1.8 ft (.6 m) below the wall. South of the plank was a stringer that extended for 1.9 ft (.60 m) at .55 ft (.17 m) below the wall before reaching the southern limit of trench excavation. The stringer had a northeast/southwest orientation and was .5 ft (.15 m) above the planks to the east and .25 ft (.08 m) above the plank to the north. The stringer ended at a southeast/northwest oriented plank measuring .35-x-2 ft (.11-x .62 m) at 1.7 ft (.52 m) below the wall. The plank aligned with a beam .63 ft (.19 m) to west above the wall. The beam was one of two exposed on the western side of the trench. The beams were 2 ft (.61 m) apart and were laid over planks at .5 ft (.15 m) below (depths). Stonework was present in between the beams but ended at the wall (FEA-3-BC).

Further south a series of planks and beams overlaid the stonework at .4 ft (.12 m) above the southwestern stringer. The heavily deteriorated timbers were located at the southern and western limits of the trench. The majority of the planks had a northeast/southwest orientation; however, the planks east of the wall and stringer alternated in orientation between northeast to southwest and east to west, with the supporting planks oriented northwest/southeast. The planks and beams appeared to radiate out to the south towards Copperas Brook. Bricks and pieces of weathered sulfide ore were interspersed between the planks

between 1.1 and 1.4 ft (.34 and .43 m) below the wall. A few of the bricks appeared to be supports for some of the planks and one of the stringers on the east side of the wall. However, no intact brick coursework was evident and the majority of the bricks appeared to be loose and may have fallen from above.

A total of 12 cultural materials was recovered from 0 to 1ft (0 to .3 m) bgs in re-deposited soils in TR-3-BC (see Appendix A; Table 4-5). These materials include 11 glass fragments and one piece of exploratory mine drill core. The glass items consist of four bottle/jar fragments, six curved glass, and one non-optical lens. The majority (n=7) of the glass was molded. The only dateable artifacts are two modern base fragments (1940-present). The lens fragment is complete, but its function is not known. The drill core fragment measures 7/8 inches in diameter. All of these artifacts appear to have washed down the hillside from the recorded twentieth-century dump site on TP-3 approximately 350 ft (107 m) west of the trench.

Trench 4 (TR-4-BC, FEA-4-BC and FEA-6-BC)

TR-4-BC was placed at the bottom of the slope south and east of TR-3-BC and southwest of TR-2-BC, 4 to 6 ft (1.2 to 1.8 m) north to northwest from the edge of Copperas Brook (see Figure 4-2). The trench was placed over the stacked stone feature (FEA-6-BC) south of the erosion gulley and was excavated by hand to the south and east. The hand cleared area measured 13.5-x-15.5 (4.1-x- 4.7 m) east-west by north-south. The stratigraphy consisted of an A_o from 0 to .2 ft (0 to .06 m) bgs, followed by a dark yellowish brown (10YR 4/6) coarse sand from .2 to .4 ft (.06 to .11 m) bgs. The sand consisted of a mixture of alluvial and colluvial deposits. To the west along the slope was a heavily compacted ore intermixed with a strong brown (7.5YR 4/6) coarse sand from .4 to 2 ft (.11 to .61 m) bgs. Excavations terminated at 2 ft (.6 m) bgs within the cleared area (TR-4-BC).

Two drylaid, east-west oriented schist fieldstone walls (FEA-6-BC) were revealed in this trench from 0 to .32 ft bgs (Figure 4-72). The walls were parallel to each other, built into the slope, and extended east. They flanked a wood deck feature (FEA-4-BC) encountered at 1.95 ft (.59 m) bgs. The axes of the planks and stone walls were 113 degrees east of magnetic north. The walls decreased in height following the slope and ended approximately half way through the wood plank feature (Figure 4-73). Excavation west of the features continued in TR-3-BC, but compacted material prevented any further excavation of the walls.

The wood feature (FEA-4-BC) consisted of five .17 ft (.05 m) x 1 ft (.31 m) planks. The planks were not completely excavated but were approximately 8 ft in length and continued to the east towards the brook. The planks were level and supported by three stringers placed on an axis of 26 degrees east of magnetic north. The planks may have continued east towards Copperas Brook. Wood structural features were present from 1.9 to 3.7 ft (.58 to 1.13 m) below the wood planking and east of the trench and included a timber stringer, plank, a post and four beams. The planks may have been a floor or landing between the refuse area identified to the north and Copperas Brook to the south.

A total of 24 cultural materials was recovered from 0 to 2 ft (0 to .6 m) in TR-4-BC (see Appendix A; Table 4-5). These materials include 16 pieces of curved glass, three bottle/jar fragments, two pieces of flat glass, and three ceramic sherds (one whiteware, two stoneware). The two bottle/jar fragments and one of the pieces of curved glass have twentieth-century manufacture dates (1940-present, 1938-1970s). If applied, Moir's regression formula for the two window glass fragments suggests a date range of 1855 and 1872 (±) seven years. The stoneware consists of hollowware body fragments with a Bristol glaze exterior and an Albany slip interior that dates from 1850 to 1930. The whiteware sherd is a molded rim that dates from 1820 to the present.

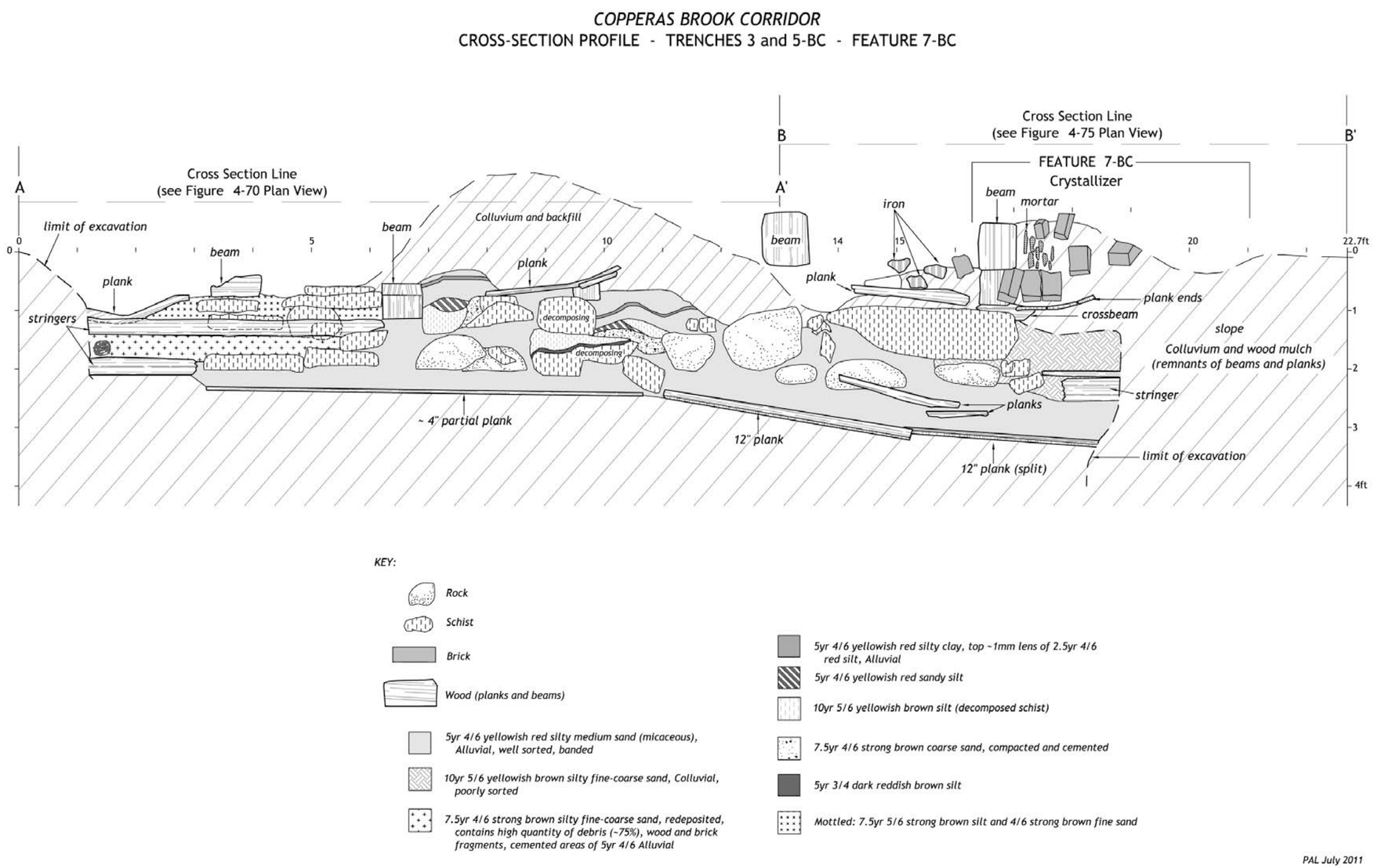

Figure 4-69. Cross-section profile (west walls) of TR-3-BC and TR-5-BC showing FEA-7-BC (crystallizer).

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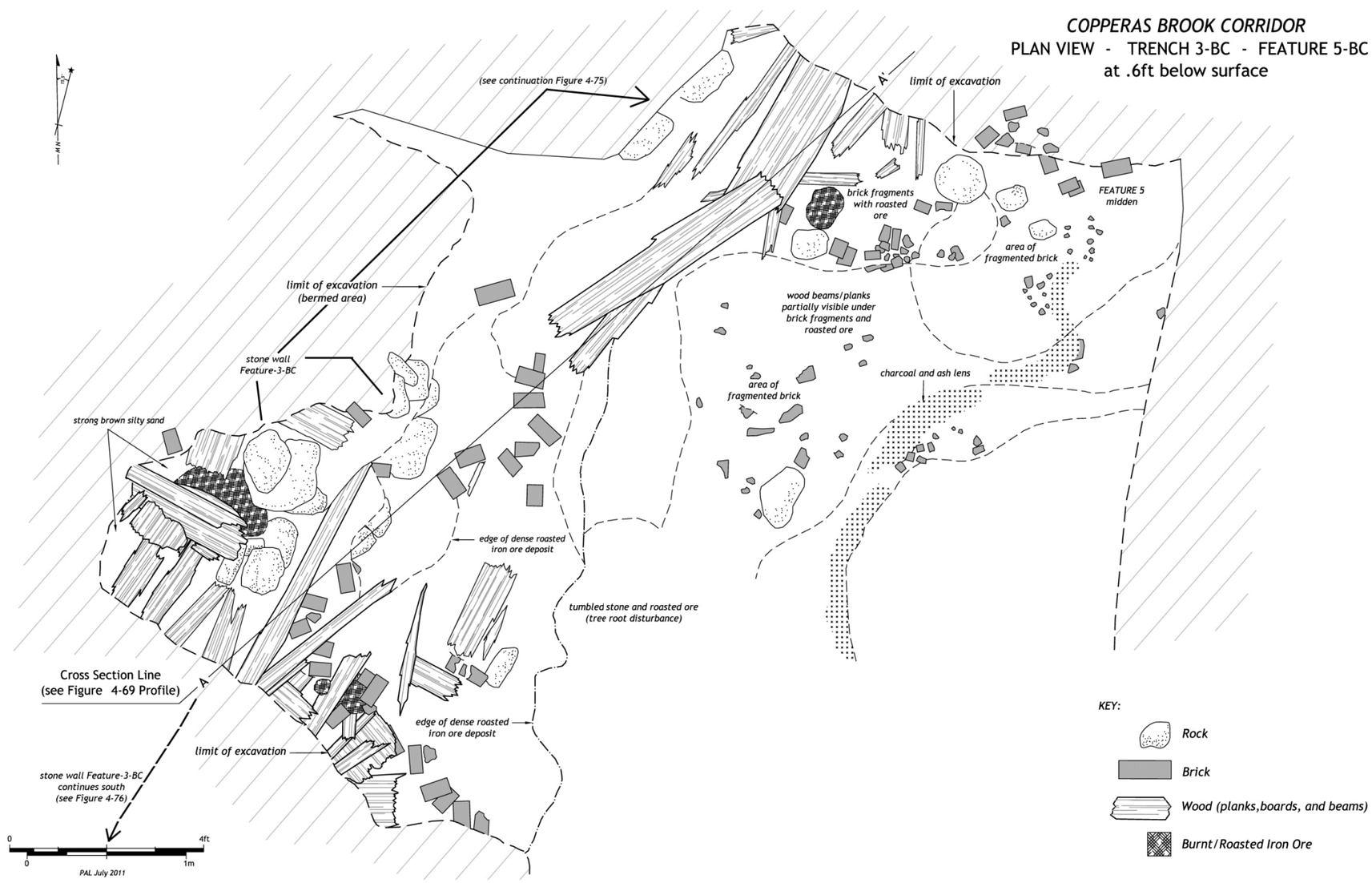

Figure 4-70. Plan of TR-3-BC at .6 ft (.19 m) below ground surface showing FEA-5-BC.

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Figure 4-71. Photograph of TR-3-BC showing wood timbers, facing northwest.

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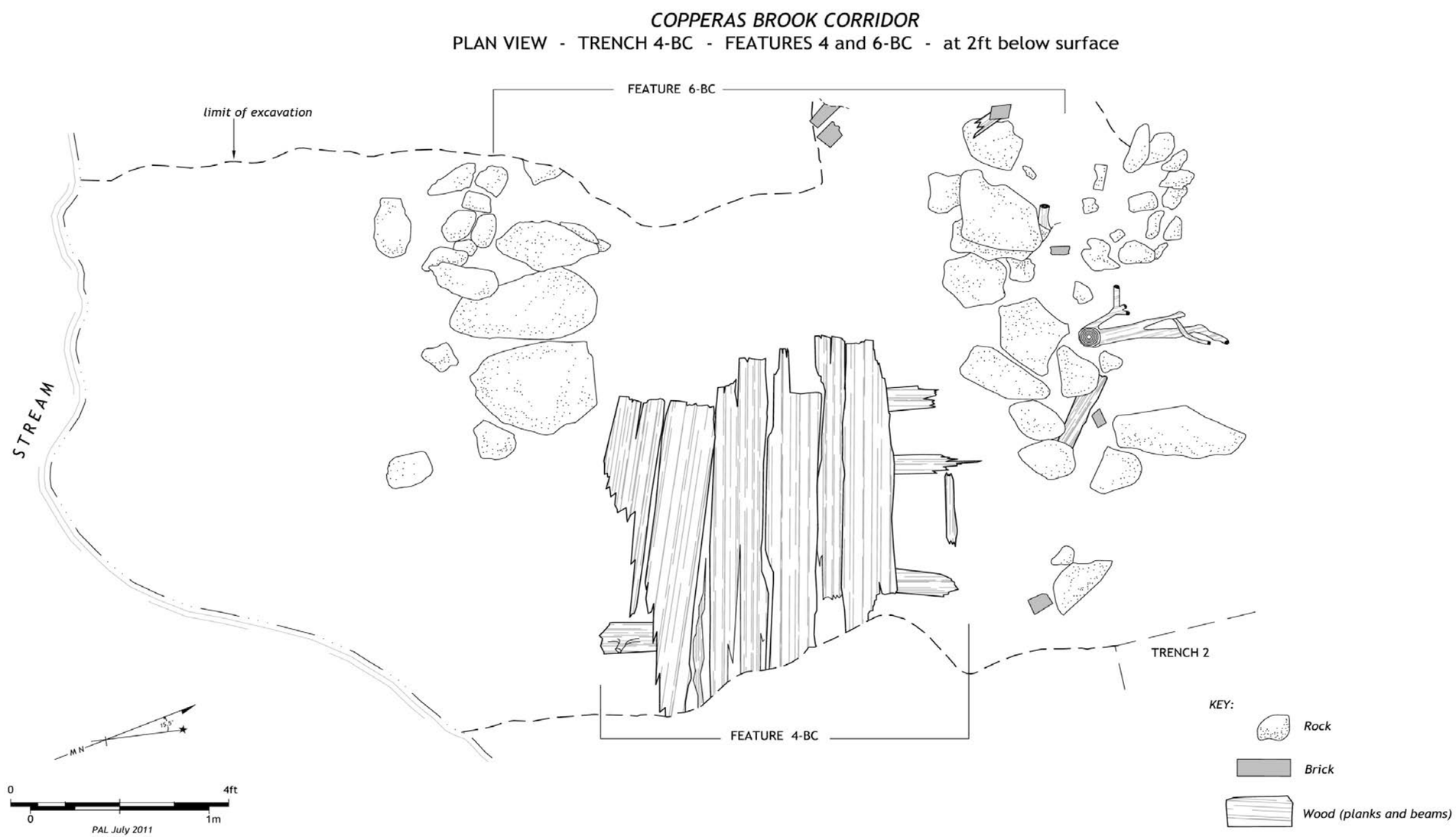

Figure 4-72. Plan of TR-4-BC showing FEA-4-BC and FEA-6-BC at 2 ft (.61 m) below ground surface.

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Figure 4-73. Photograph of FEA-4-BC and FEA-6-BC, looking east.

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Trench 5 (TR-5-BC, FEA-7-UC)

TR-5-BC was placed .41 ft (.13 m) north of TR-2-UC and bordered TR-3-BC to the west (see Figure 4-2). The excavations in this area were chosen to investigate the slope north of FEA-5-BC. Backhoe movement in this area had exposed wood planks, a beam, and a few bricks just under the ground surface. Hand clearing in this area exposed a 14-x-14.4 ft (4.3-x-4.4 m) arrangement of logs, beams, planks and a rectangular brick feature (FEA-7-BC) exposed just below the A_o, in a colluvial yellowish brown (10YR 5/6) silty fine to coarse sand with poorly sorted gravel that covered the features from 0 to 1.55 ft (0 to .5 m) bgs (Figure 4-74).

In the western portion of the trench, a cluster of northeast/southwest oriented logs were located at elevations between 1.9 and 2.8 ft (.58 to .85 m) bgs (Figure 4-75). The logs were stacked to form a 33 percent slope stepping down to the brick feature to the east. The logs were deteriorated on the top giving them a trough-like shape. Logs were also found in TR-2-UC, 2 ft (.61 m) south to southwest of the logs in TR-5-BC. The westernmost log in TR-5-BC aligns with the inclined planks found in TR-2-UC, with successive logs lying parallel to the east.

Two heavily deteriorated beams lay on top of the logs between 1.3 and 1.5 ft (.4 and .45 m) bgs crossing them to the southeast and east (see Figure 4-75). The east-west beam aligned with the northwest corner of the brick feature, which had a northwest/southeast orientation and measured approximately 7-x-12 ft (2-x-3.7 m) from 0 to .60 ft bgs. The bricks were interspersed with pieces of broken natural cement mortar. The bricks were supported by two large northwest/southeast oriented beams at .3 ft (.09 m) bgs approximately 6 ft (1.8 m) apart. Settling below the feature may have caused the walls of the brick feature to collapse (see Figure 4-74). Several bricks were excavated along the southwest wall showing evidence of stretcher bond coursing that had collapsed to the north, while the in situ floor to the north was laid with the header side in an upright position. A high concentration of loose brick was also found north of the feature.

A layer of wood planks lay directly below the brick feature's northwest/southeast support beams between .9 and 1.3 ft (.3 and .4 m) bgs. On the north and south side of the bricks the planks had buckled. On the north side of the feature, the buckled floor planks had collapsed in the center, exposing three northeast/southwest timber support stringers at 1.3 ft (.4 m) bgs (see Figure 4-75). To the south of the feature, two beams extended parallel to the brick at .3 ft (.09 m) bgs. The beams were 1.2 ft (.37 m) apart and .90 ft (.27 m) from the south beam (see Figure 4-75).

The stone wall (FEA-3-BC) first identified in TR-3-BC continued along the southeast edge of the brick feature (FEA-7-BC) at .64 ft (.20 m) bgs (see Figures 4-2 and 4-75). The wall was obstructed by colluvial and alluvial overburden and wood features to the northeast. The wall was assumed to continue bordering the brick feature to the southeast (see Figures 4-2 and 4-70).

The brick feature appears to be one of the cement-lined crystallizer vessels reported within the factory throughout the 1809-1871 historical accounts. The long axis of the vessel is perpendicular to the FEA-3-UC crystallizer found in TR-3-UC to the northwest.

A total of 38 cultural materials was recovered from 0 to 1.55 ft (0 to .47 m) bgs in TR-5-BC (see Appendix A; Table 4-5). These materials include curved glass, bottle/ jar fragments, flat glass, unidentified iron, an unidentified small iron ring, one butchered animal bone, two pulleys, a hand-painted whiteware ceramic sherd, and tar fragments. The two tar fragments range in thickness from 1/8 to 3/16th inch with wood grain marks and chunks of excess tar. The fragments appear to be wood impregnated with

Figure 4-74. Photograph of FEA-7-BC in TR-5-BC, looking northeast.

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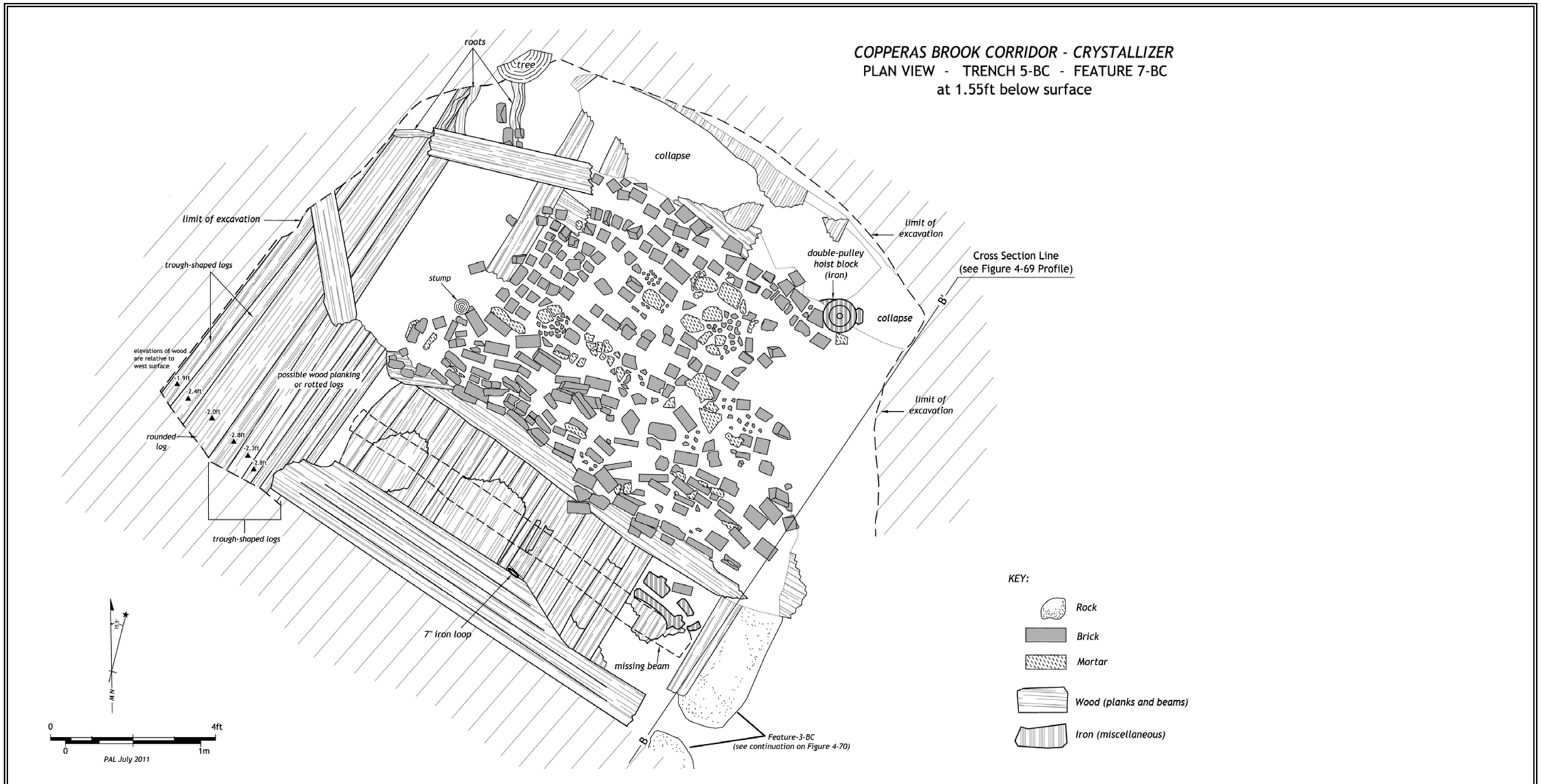

Figure 4-75. Plan of TR-5-BC showing FEA-7-BC at 1.55 ft (.47 m) below ground surface.

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tar measuring 1 ¼ and 1 ¾ in width by 2 to 3 ½ in in length. Dateable artifacts in this assemblage include four fragments of an Owens liquor bottle, manufactured post-1935, and the gold hand painted whiteware rim sherd dating from 1820 to the present. One of the glass fragments had evidence of melting.

The lightweight artifacts could have possibly been transported through erosion to this location, however, several of the large iron artifacts appear to be in situ[25]. A double-pulley hoist block was found northeast of the crystallizer next to one of its disarticulated side plates (see Figure 4-75). The block has an iron shaft, two iron hubs, a hook, wood frame, and an attached side plate (see Appendix B.1-10 and B.1-11). A cluster of iron artifacts was found directly south of the pulley, on the south side of the feature. The iron objects were heavily corroded and were catalogued as unidentifiable, however, some appeared to have diagnostic characteristics. Some of the clumps were a conglomeration of multiple objects including a possible T-bar and rail fragment. Two possible spikes and a handle were also found within this cluster. One of the large unidentifiable objects appears to be wrought iron with a possible gear shaft attached to a larger conglomeration. An iron ring was found 3 ft (.91m) west of the iron cluster. The ring band is 1¼ inch wide, with an inside diameter of 6½ inches and an outside diameter of 6¾ inches. The function of the ring is not known.

Trench 6 (TR-6-BC, FEA-1-BC, FEA-2-BC, and FEA-3-BC)

TR-6-BC was located in the bed of Copperas Brook, 30 ft (9.1 m) south of TR-5-BC and 23 ft (7 m) southeast of the corner of the standing Upper Factory wall (see Figure 4-2). The trench was placed over the system of wood timbers and planks (FEA-1-BC) within the brook and the exposed brick concentrations (FEA-2-BC) within the "island" dividing the brook into north and south channels. The center island was 1 to 1.75 ft (.31 to .53 m) higher in elevation than the planks in the brook bed below. The features were excavated across the slope with a drop in elevation of 9.7 ft (3 m) between the top and bottom of the trench.

Excavation began at the base of the remaining wood timbers at the confluence of the north and south channels of Copperas Brook and extended 36 ft (11 m) to the northwest terminating at EU-2-BC (Figure 4-76: back pocket). The north-south excavation extended 22 ft (6.7 m) from remaining timbers in the south channel and extended across the north channel. The exposed upper faces of the wood timbers and planks in the brook bed, most of which had been revealed by recent erosion since the 2002 PAL survey, exhibited distinct adze and saw marks a high degree of preservation likely the result of prolonged burial away from oxygen and saturation with water bearing acid and metals inimical to biological life (Figure 4-77). A combination of alluvial and colluvial soils and transported debris covered other areas of wood timbers in the brook bed (Figure 4-78). The higher elevations within the center island were covered by A_o followed by a thin layer of alluvium at depths from 0 to .25 ft (0 to .08 m) bgs. Heavy rains during the data recovery investigations often resulted in the re-deposition of soil over the excavated features within the brook. Two artifacts were recovered from the center island, a door plate and a U- shaped piece of iron, from 0 to 1.9 bgs (see Appendix A; Table 4-5).

The center island was divided into east and west areas containing similar timber and plank (FEA-1-BC) and brick concentrations (FEA-2-BC) (see Figure 4-76). The east group measured 5-x-14 ft (1.5-x-4.3 m) and the west 5-x-18 ft (1.5-x-5.5 m), 1.5 ft (.46 m) apart. The two areas had an elevation difference of 1.1 ft (.34 m) and sloped to the east (see Figure 4-76). The first brick concentration bordered the western trench wall and EU-2-BC at .25ft (.08 m) bgs. The bricks appeared to be shifted from their original position, but retained an apparent north-south orientation with one fallen section of courses extending into the east side of EU-2 (see below). This north-south brick scatter was 5 ft (1.5 m) west of another cluster of bricks with a general east-west orientation.

[25] All of these artifacts were recorded from the site and are temporarily curated at the PAL faculty in Pawtucket, RI.

Figure 4-77. Photograph of FEA-1-BC, FEA-2-BC, FEA-3-BC, looking southeast.

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Figure 4-78. Photograph of FEA-1-BC, FEA-2-BC, FEA-3-BC, looking northwest.

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The two brick concentrations in the east portion of the island were approximately 6 ft (1.8 m) apart and found below a thin layer of organic matter at 0 to .10 ft (0 to .03 m) bgs (see Figure 4-76). Two small birch trees were growing out of the center of each concentration. The west concentration measured 3.5-x-7 ft (1.1-x-2.1 m) and consisted of a brick scatter with broken mortar and one identifiable brick course at .5 ft (.15 m) bgs. The east brick concentration was 4-x-6.8 ft (1.2-x-2.1 m) and was identified at the ground surface and extended down with six visible stretcher bond courses and pieces of attached and loose mortar. Both of these areas with remnant coursed bricks were supported by three east-west oriented beams at .45 to .6 ft (.14 to .18m) bgs. The beams were splintered, but appeared to range between .6 and 1 ft (.18 and .31 m) square. The beams ranged in length and appeared to be incomplete. The support beams for the west brick concentration measured 11.1, 12.7, and 15.7 ft (3.4, 3.9, and 4.8 m) in length and were on an axis 90 degrees east of magnetic north and had a slope that ranged between 14 to 17.7 percent. These beams were supported by two stringers to the east and stones to the west from 1 to 1.5 ft (.31 to .46 m) below the beams. Large schist fieldstones were present from 0 to 1.5 ft (0 to .46 m) bgs on both the north and south sides of the feature. Stacked boulders were first identified on the ground surface .7 ft (.2 m) southwest of EU-2-BC. Stones continued within the unit and then to the east of FEA-3-BC. The stringers were 1.2 ft (.37 m) bgs and 3 ft (.91 m) to the east of the stones. The stringers were 4 ft (1.2 m) apart and remnant planks were located between the beams and stringers. The support beams for the east brick concentration, which appeared to have shifted south at the east ends, measured 7.2, 7.5, and 14 ft (2.2, 2.3, and 4.3 m) in length and sloped down to the east at grades between 3 and 7 percent. The underlying support structure was difficult to distinguish. On the north side, slumping brick extended down from the top of the beam to broken splintered planks at 2.5 ft (.76 m) bgs that appeared to be a continuation of the planks identified on the south side of the feature. The planks sagged with few distinct planks. Directly below the planks, an east-west rounded timber supported the eastern feature.

The tiered brick, plank and timber clusters in FEA-2-BC and in adjacent EU-2-BC (see below) can be interpreted as the possible remains of perhaps three of the many copperas crystallizer vessels that were located in one of the several iterations of the Upper Copperas Factory. The remaining brick coursing in small lengths and sections of wall, presence of mortar between and on faces of the bricks, the thinness of the brick deposit, relationship similar underlying soil, and the presence of crossed timber and plank structural support systems are all similar to aspects of the crystallizers documented in TR-3-UC and TR-5-BC. All of these are topographically below the copperas boiler feature found at the upper level of the factory in ST-3-UC. The crystallizers found in TR-3-UC and TR-5-BC line up in the same north-south orientation with the bricks and timbers in the EU-2-BC structures and the east brick concentration on the island, respectively. These relationships are, in turn, normal to the overall orientation of visible factory walls. The elevations of the bricks and timbers found in EU-2-BC on the island and the brick surface at the bottom of the crystallizer found in TR-3-UC are only .8 ft (.24 m) apart. The elevations of the brick in the island lower mound and the crystallizer floor in TR-5-BC are only .4 ft (.12 m) apart. These topographic relationships suggest that these crystallizers may have been arranged in north-south rows within the lower tiers of a factory.

The eastern stringer abutted a post at 2.1 ft (.64 m) bgs to the south. The post was .64-x-.88 ft (.20-x-.27 m) in width and 1.5 ft (.47 m) in height and was broken at the top. A vertical timber was adjacent to the base of the western structure and to the eastern stringer at .75 ft (.23 m) bgs. The structure aligned with the inclined planks to the east. The vertical wood feature was 1 ft (.31 m) wide and extended 5.06 ft (1.5 m). Southeast of the structure, a beam was located at 2.26 (.69 m) bgs at an axis of 90 degrees east of magnetic north that divided two plank features. The inclined planks extended on an axis of 42 degrees east of magnetic north, underpinning the eastern features. To the south the stepped plank structure was parallel to the beam at 2.26 to 2 ft (.69 to .61 m) bgs. The beam was .11 ft (.34 m) higher in elevation than the inclined planks to the north. The beam was flush with the first level of the stepped feature, but was eroded to the east.

The inclined planks within the north channel were a continuation of the planks underlying the island in the brook bed. Round and square hewn support beams were exposed in the channel bed where planks were missing 3 ft (.91 m) below the brick features to the south (FEA-2-BC) (see Figure 4-77). The supporting beams were at an axis of 90 degrees east of magnetic north and the planks were on an axis of 42 degrees east of magnetic north. The western section had two posts 8 ft (2.4 m) apart, the southern post was 2.5 ft (.76 m) bgs while the northern post rose approximately 4 ft above the surface within the channel bed. Cut support beams and inclined planks were found between .2 and 1.5 ft (.06 and .46 m) bgs extending 13.6 ft (4.1m) to the east of the posts. Two east-west beams exposed 1.2 ft (.4 m) bgs bordered the plank feature to the north. The beams were laid on the planks along the trench wall. One of the rounded beams at the base of the western section appeared to be cut. The rounded beam ended at an alignment with a series of logs to the north and the wood feature to the south. Planks continued 1.75 ft (.53 m) to the east of the western planks and extended approximately 14 ft (4.3 m). The western planks were on a 17 percent slope, while to the east the planks were on a shallower, 6 percent slope.

Directly east of the planks at the bottom of the slope, east of the excavated trench there was a large boulder wall (FEA-3-BC) visible on the ground surface, resulting in a drop in elevation of 3.4 ft (1 m) within the north channel (see Figure 4-76). The stone wall was on an axis of 38 degrees east of magnetic north and extended across the brook for 21.7 ft (6.3 m). The wall terminated 5.7 ft (1.7 m) south of the brick concentration (FEA-2-BC) and was followed by exposed ledge rock in the south channel. A disarticulated beam crossed the wall to the east. A splintered stringer was laid on top of the stone wall underpinning east-west beams. As noted above, this wall was suspected to be a continuation of the wall identified in TR-3-BC.

The inclined timber and plank structural remains recorded at the Upper Copperas factory, in the bed of Copperas Brook and in TR-2-UC (see above) can be interpreted several ways. It could have been part of extensive site preparation engineering associated with the Upper Factory or one of the other factories known to have been built at or near the Upper Factory location to provide a stable factory substructure for the tiers of masonry process vessels in the wet environment of the sloping ravine where the copperas-bearing hillside runoff gathered. It may or may not have played a direct or indirect role in conveying copperas liquor, and could have facilitated the cascading gravity-fed liquor transport from vessel to vessel. It could be the floor of a raw copperas liquor storage cistern for another factory located below to the east operating at another, presumably earlier time, possibly associated with the copperas processing vessel remains found at the North Berm and/or South Berm. It could be the floor of a copperas crystal packing chute/bin for another factory located above to the west operating at another, presumably earlier time (see additional discussion of the inclined timber and plank structure in Chapter 6).

Excavation Unit 1 (EU-1-BC)

EU-1 was located 43 ft (13 m) west of TR-6-BC and 23.5 ft southwest of the standing Upper Factory wall to investigate the construction of the center island within the brook corridor (see Figure 4-2). The unit was placed on an axis of 19 degrees east of magnetic north and measured 2-x-2 m (6.6-x-6.6 ft). Wood timbers, brick and mortar were present on the ground surface. The unit was placed in an elevated area 3 to 4 ft (.91 to 1.2 m) higher than features to the northeast within the brook. The unit contained six fill deposits and an overburden containing surficial structural debris (Figure 4-79). The fill and overburden consisted of various colluvial and alluvial overburden soils. These soils were comprised of a strong brown (7.5 YR 4/6) silty to medium to coarse sand that extended from 0 to .66 ft (0 to .2 m) bgs followed by Fill 1, a yellowish brown (10YR 5/6) silty medium to coarse sand from .16 to 1.15 ft (.05 to .35 m) bgs. Fill 2 and 3 were next to one another and were both heavily mottled and contained high amounts of roasted ore and brick fragments. Fill 2 consisted very dark grayish brown (10YR 4/6) greasy silt, light olive brown (2.5Y 5/6) silty fine to medium sand, and olive gray (5Y 5/2) medium sand from 1.15 to 1.6 ft (.35 to .48 m) bgs. Fill 3 consisted of a dark yellowish brown (10 YR 4/6) silty fine sand, dark grayish brown (2.5Y

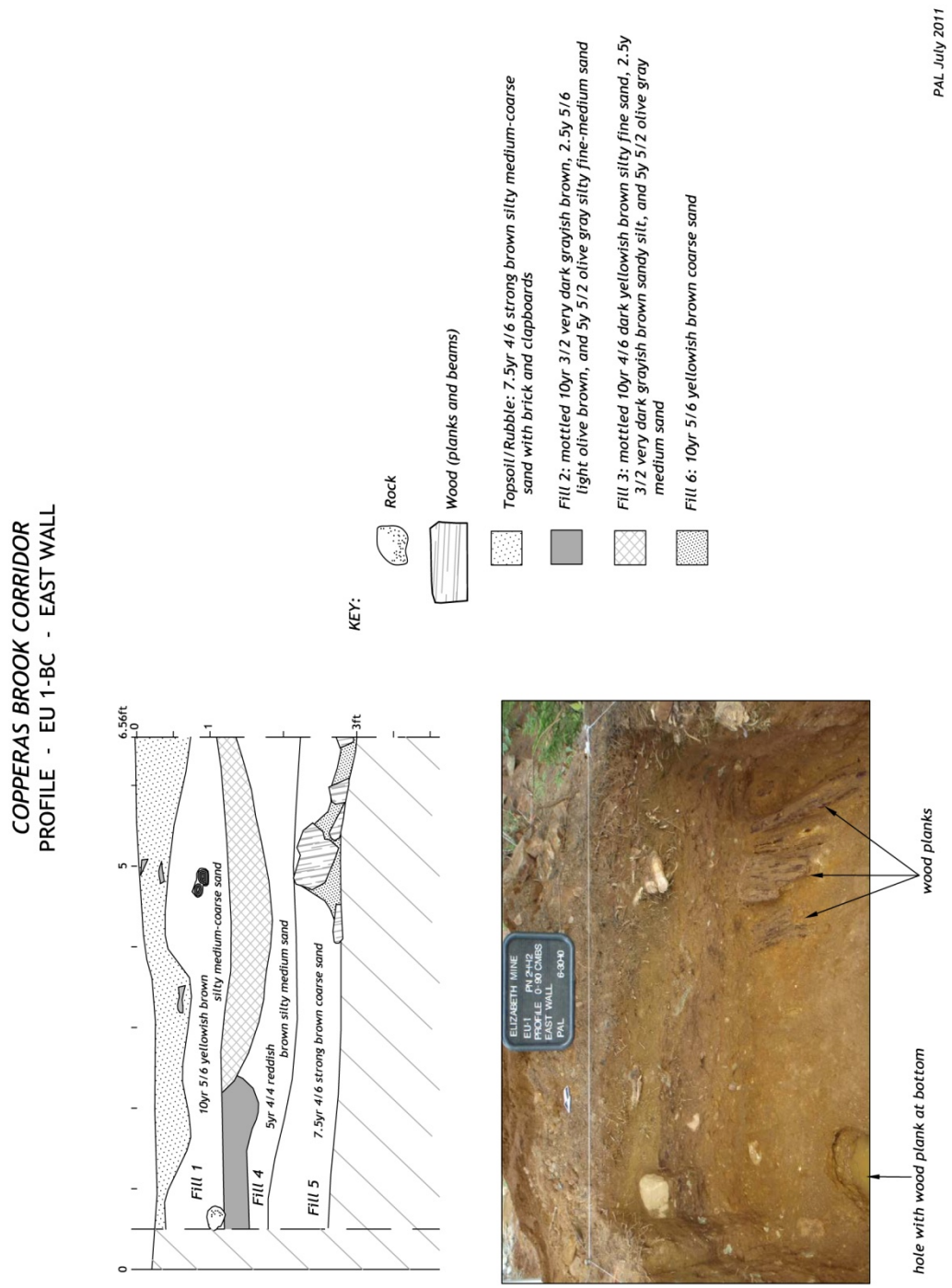

Figure 4-79. East wall profiles of EU-1-BC.

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3/2) sandy silt, and an olive gray medium sand from 1.15 to 1.8 ft (.35 to .55 m) bgs. Fill 4 was underneath the mottled deposits and comprised of a reddish brown (5YR 4/4) silty medium sand from 1.3 to 2.2 ft (.40 to .68 m) bgs. Fill 5 was a strong brown (7.5 YR 4/6) coarse sand from 1.8 to 2.6 ft (.55 to .80 m) bgs. Fill 6 consisted of a matrix surrounding wood planks from (.60 to .90 m) bgs. Fill 6 was characterized as yellowish brown (10YR 4/6) coarse sand. A compacted hardpan began in the northwest corner 1 ft (.30 m) bgs and continued to expand in the unit through successive levels. The unit was terminated at 3 ft (.90 m) bgs when the compacted hardpan became the dominant soil type.

A total of five cultural materials was recovered from .33 to .66 ft (.10 to .20 m bgs) in the overburden soils in EU-1-BC (see Appendix A; Table 4-5). These materials include one piece of flat glass, one tar-impregnated wood fragment, one brick fragment, one redware ceramic sherd, and one piece of charred wood. The tar and wood fragment is similar to fragments found in TR-5-BC and measured ¼ x 1.5 x 2.5 in. The lead glazed redware sherd has an approximate manufacture date range of 1600 to the present. The artifacts were found close to the ground surface and were probably transported down the slope from TP-3 by water and erosion.

In situ structural remains in this unit were limited to five planks identified along the east wall from 2.3 to 3 ft (.70 to .90 m) bgs. The planks were in the southern corner and ranged between .6 to 1 ft (.18 to .31 m) in width and extended 1 to 2.3 ft (.31 to .70 m) into the unit (see Figure 4-79 and Figure 4-80). The planks were situated .05 to .55 ft (.02 to .17 m) above an east-west beam to the north within the brook. A hole appeared in the northeast quad of the unit at 1.3 to 1.6 ft (.40-.50 m) bs and continued down to 3.9 ft (1.2 m) bs. The hole was 1.15 ft (.35 m) in diameter and had an east-west oriented plank at the bottom. The plank was submerged in water.

Excavation Unit 2 (EU-2-BC)

EU-2 was located 37 ft (11.3 m) southeast of EU-1 and bordered the west wall of TR-6-BC (see Figure 4-2). The unit was placed within the center island to investigate a stacked stone feature .85 ft (.26 m) west of the unit. The unit measured 6.6-x-6.6 ft (2 x 2 m) and was oriented on a 356 degree axis west of magnetic north. A scatter of glass and bricks were noted on the ground surface prior to excavations. The unit contained two alluvial fill deposits, from 0 to 1.3 ftbs (0 to .41 m) a strong brown (7.5YR 5/6) silty medium to coarse sand followed by a strong brown (7.5YR 4/6) silty medium to coarse sand to 3.5 ftbs (10.7 m) (Figure 4-81).

Two artifacts were collected: one lip/neck bottle fragment and one piece of flat glass. The bottle fragment was found on the surface, while the flat glass fragment was found from .3 to .7 ftbs (.10 to .20 m) in alluvial fill (see Appendix A; Table 4-5).

Several timbers were found within the upper fill deposit. The timbers all appear to be shifted slightly deviating from the 42 and 90 degree orientation of other timbers recorded within the brook corridor. A plank was encountered from 0 to .33 ft (0 to .10 m) bgs. The plank measured .5 x 6 ft (.15 x1.8 m) and was lying at approximately the same orientation as a second beam 2.8 ft (.85 m) to the east. The plank lay over stones to the south and west, and was supported by a stringer to the east and had alluvial deposits to the north. The plank sloped down to the east at an 18 percent grade. The stringer was oriented on an axis of 45 degrees east of magnetic north. A beam fragment was found at the surface in northeast corner of the unit and dipped to the east at a 48 percent grade at 1.2 ft (.4 m) bgs.

Large schist stones extended 7 ft (2.2 m) to the north and 10.5 ft (3.2 m) to the east from the stacked boulders west of the unit. The stones covered the west side of the unit at 3 ft (.91m) bgs (Figure 4-82). The stones may have been structural supports to bolster the sloping wood timbers within the “island” soils and the brook bed.

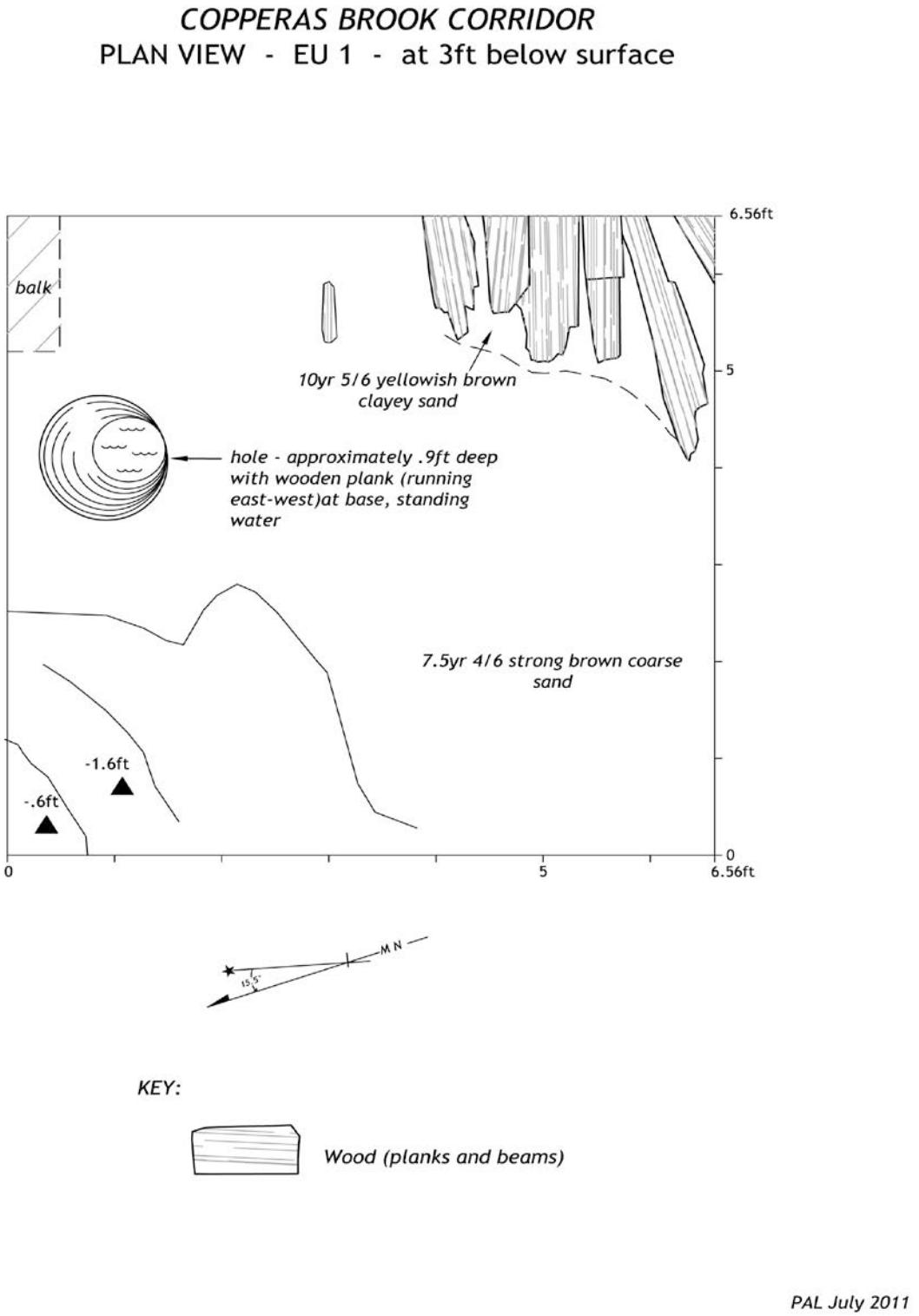

Figure 4-80. Plan of EU-1-BC at 3 ft (.91 m) below ground surface

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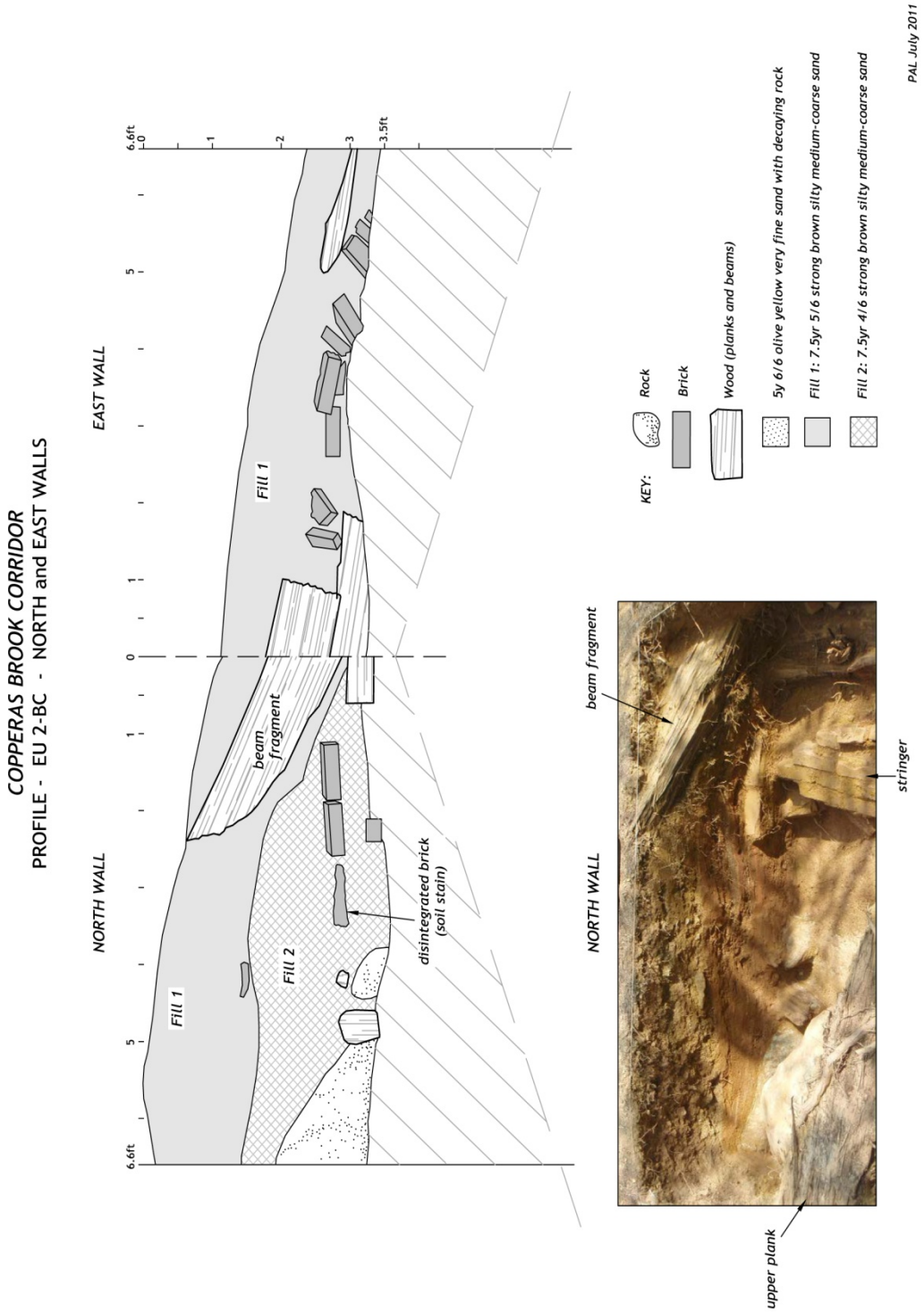

Figure 4-81. North and east wall profiles of EU-2-BC.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

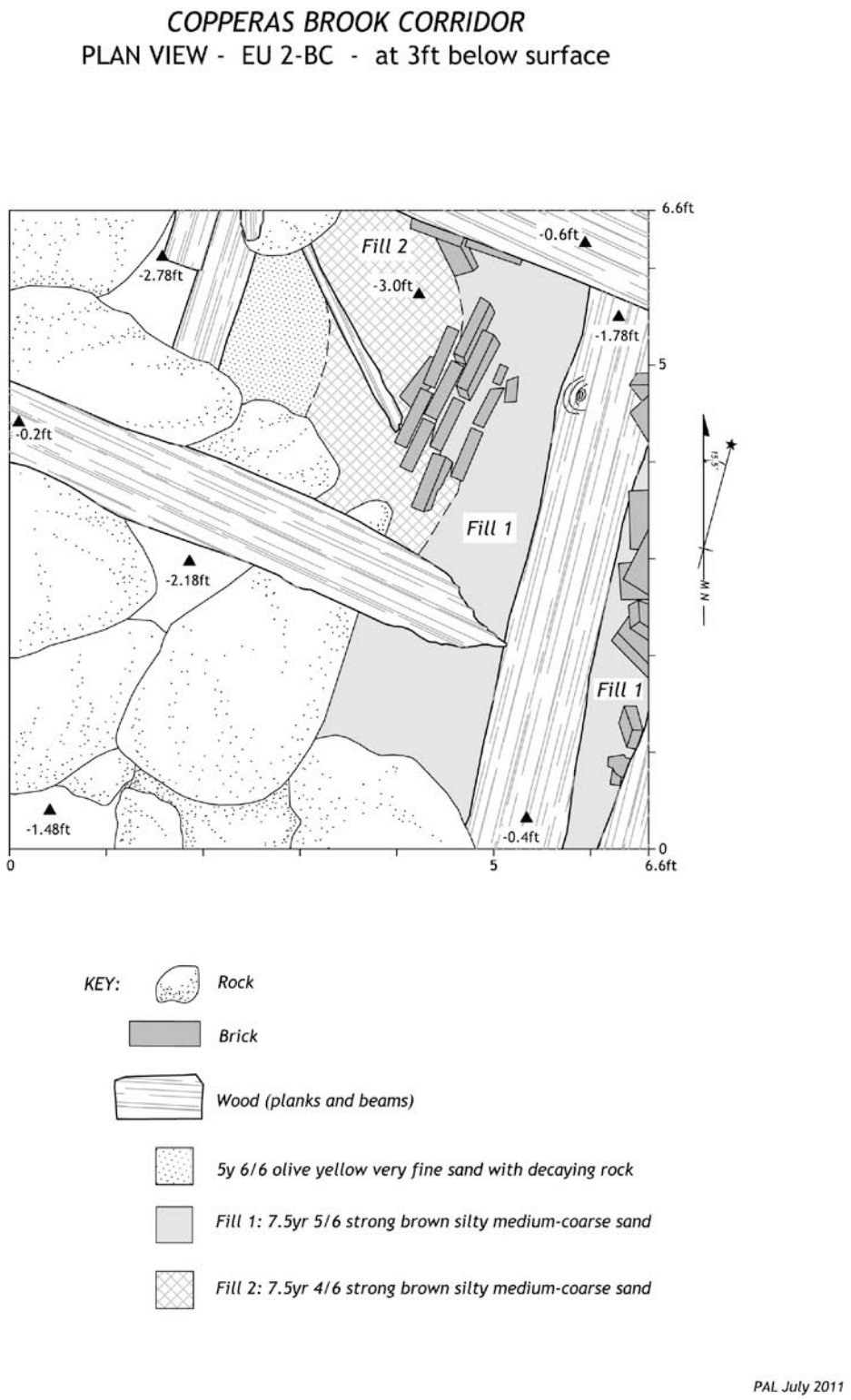

Figure 4-82. Plan of EU-2-BC at 3 ft (.9 m) below ground surface.

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A single course of brick was noted in the north wall from 2.6 to 2.9 ftbs (.79 to .88 m). Two of the bricks were intact, while the third had disintegrated and was evident as a soil stain (see Figure 4-81). Fallen brick was located due south of the in situ brick. Loose bricks followed a section of five stretcher bond courses that appeared to have tumbled from an east to west direction. Disarticulated bricks on a general north-south orientation were visible in the east wall profile. The bricks were on top of the stringer and may have shifted with the stringer (Figure 4-83).

Interpretation of the brick and timber structural remains in EU-2-BC are discussed in the interpretations of FEA-2-BC (see above).

Excavation Unit 3 (EU-3-BC)

EU-3 was located 59.3 ft southwest of EU-2 on the south bank of Copperas Brook (see Figure 4-2). The unit measured 6.6-x-6.6 ft (2 x 2 m) and was oriented on a 356 degree axis west of magnetic north. The unit had a high density of brick on the surface and was placed to investigate the nature of the brick scatter. The 1874 site map placed three brick evaporator towers in this general area. The unit was shallow with ledge rock just below the surface. The unit was terminated at 1.6 ftbs (48 m) where the ledge rock occupied over two-thirds of the unit.

The soil stratigraphy consisted of two fill deposits over bedrock (Figure 4-84). Fill 1 consisted of red (2.5YR 4/6) silty medium to coarse sand with a high density of decaying brick and roasted ore from 0 to 1 ftbs (0 to .31 m). Fill 2 was reddish brown (5YR 4/4) silty fine to medium sand from 1.05 to 1.6 ftbs (.32 to .48 m).

A total of 19 artifacts was sampled from the unit and returned to the PAL facility for laboratory processing and analysis: seven lead, four brick fragments, and seven roasted ore (see Appendix A; Table 4-5). Of the 19 samples collected, 16 came out of northwest, northeast, and southwest quads within the Fill 1 deposit from 0 to .3 ft (0-.10 m). Roasted ore and brick fragments were noted, but not saved in successive levels. One piece of lead spatter and two lead sheet trimmings were sampled from .7 to 1 ft (.20 to .30 m)[26].

The bricks encountered in this unit were disarticulated, leaving no evidence of an evaporator structure. Bioturbation was noted on the east side of the unit. One plank was found from .7 to 1 ftbs (.20 to .30 m) and extended to 3.3 ft (1 m) from the south wall. The plank was found in the brick and stone concentration and was suspected to continue into the east wall.

Excavation Unit 4 (EU-4-BC)

EU-4 was located near the treeline at the base of the open TP 3 slope, in a depression east of the roast beds and west of the Inter-copperas Area (see Figure 4-55). The unit measured 6.6-x-6.6 ft (2 x 2 m) and was oriented 356 degrees west of magnetic north. The unit was placed at the edge of sloping ledge rock that extended east into the unit. The unit was 56 ft (17 m) south of EU-3 and 20 ft (6 m) southeast of a tool scatter (see discussion below of recovered cultural materials). The tool scatter was on a ridge of exposed ledge rock, and was suspected to be associated with a possible undocumented blacksmith shop in the vicinity (see Appendix B.1-12).

The unit contained two fill deposits directly over sloping bedrock (Figure 4-85). Fill 1 consisted of strong brown (7.5YR 5/6) silty medium to coarse sand from 0 to .7 ftbs (0 to .20 m). Fill 1 contained a high

[26] The unsampled materials were recorded in situ and removed to TP 1 during the remediation activities.

Figure 4-83. Photograph of EU-2-BC, plan view at 2.75 ft (.85 m) below ground surface, looking east.

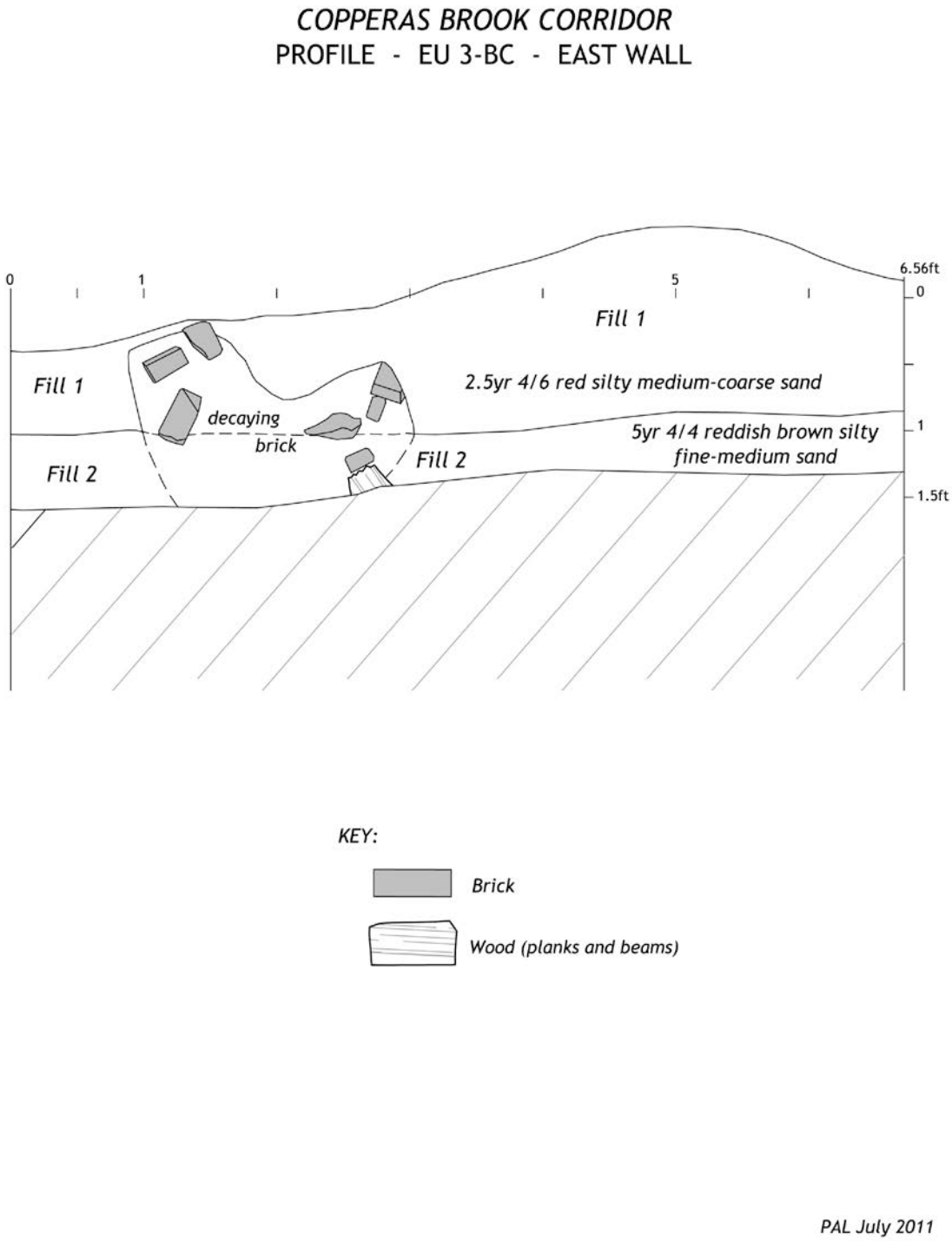

Figure 4-84. East wall profile of EU-3-BC.

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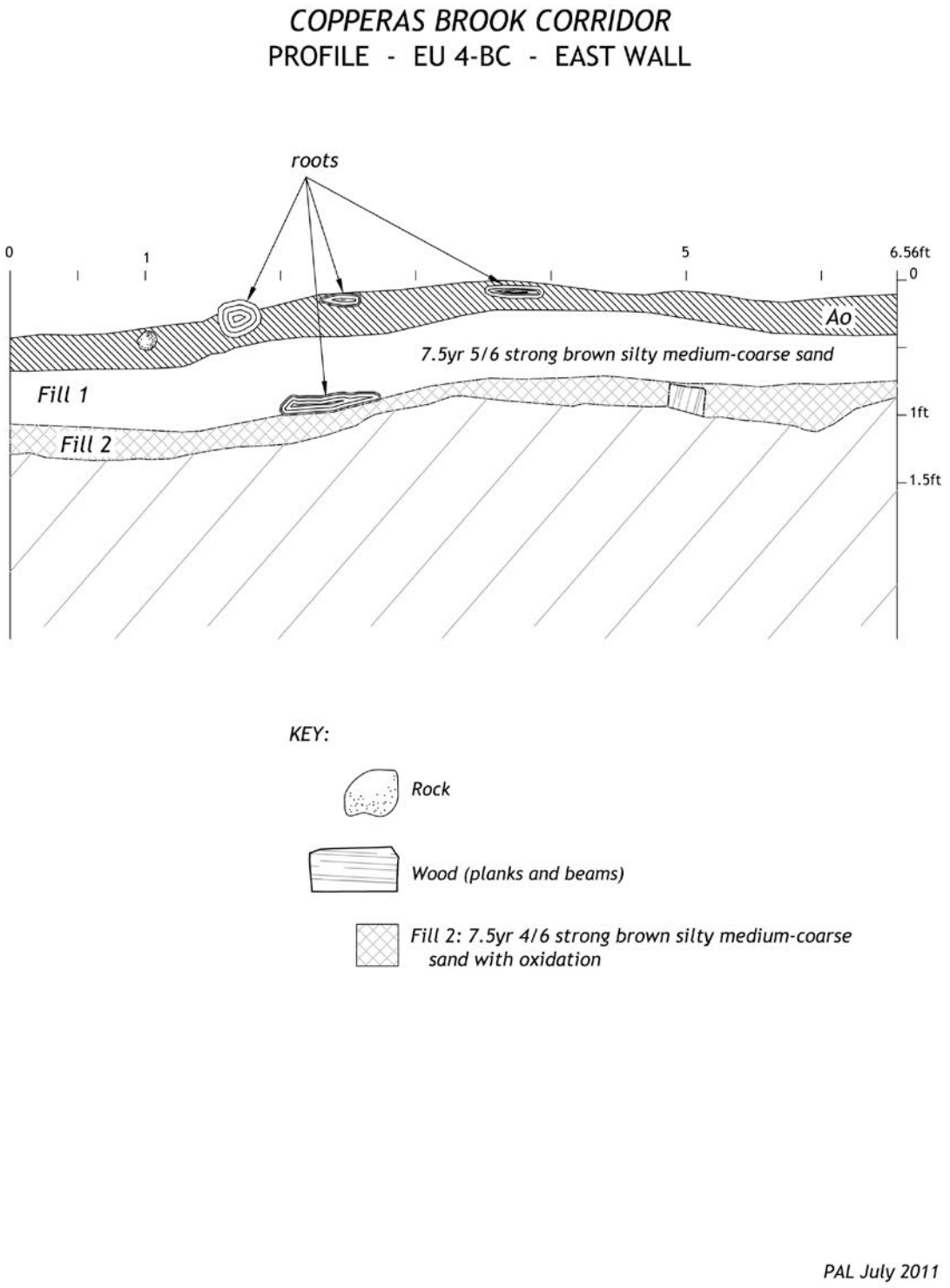

Figure 4-85. East wall profile of EU-4-BC.

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density of roasted iron ore and some brick fragments. The Fill 2 contained a high density of roasted ore and a low to moderate density of fractured bricks. The deposit was a compacted strong brown (7.5YR 4/6) silty medium to coarse sand from .3 to 1 ftbs (.10 to .30 m). The Fill 2 deposit included a large amount of heavily oxidized iron including four draught animal shoes. Three randomly oriented planks were found at the bottom of the unit in Fill 2. The unit was terminated at 1.3 ft (.4 m) depth due to the difficulty of excavation and the lack of cultural materials. No evidence of intact structural remains or features related to a possible blacksmith shop were encountered.

A total of 25 cultural materials was recorded from 0 to 1.3 ft (0 to .4 m) bgs in EU-4 (see Appendix A; Table 4-5). Fill 1 contained two unidentified nails, one church key/can opener, and three unidentified iron objects. The Fill 1/Fill 2 interface yielded one lead and one unidentified iron objects, one church key/can opener, and one possible file. Fill 2 contained seven iron fragments from one single animal shoe, three unidentified iron, and one lead. The lead consisted of trim fragments 1/16 inch thick. Four animal shoes were found at the bottom of the Fill 2 horizon, but only one was collected because of severe deterioration[27]. The collected animal shoe was in two fragments when transported from the field, but it was so oxidized and corroded that it fractured into seven fragments by the time it was catalogued.

Pine Grove Area

The Pine Grove Area is a cluster of pine trees west of the Upper Copperas Factory, at the north edge of TP 3, containing two north-south oriented stone walls identified during PAL's 2002 field investigations. The stone walls were thought to be possible foundations for a bank barn. Two trenches were excavated within the Pine Grove area. One trench (TR-1-PG) was located on the slope southeast of the lower tier foundation and the second (TR-2-PG) was located further east at the bottom of the slope. The second trench contained structural remains of a previously unidentified building. A total of 113 cultural materials was recovered from 2 to 4 ft (.61 to 1.2 m) bgs feature fill soils. (see Appendix A-Elizabeth Mine Pine Grove (PG); Table 4-6).

Table 4-6. All Recovered Cultural Materials By Unit, Pine Grove Area, 2009/2010 Data Recovery Excavations.

Object	TR02-NE	TR02-W	Total
Mammal		1	1
Redware, Lead Glazed	1		1
Redware, Trailed Slipware	1		1
Brick	1		1
Cork	1		1
Bottle/Jar	1		1
Molded Glass, Curved	4	1	5
Unid. Curved Glass	3	5	8
Flat Glass	41	7	48
Nail	3		3
Smoking Pipe	1		1
Belt		2	2
Boot/Shoe		2	2
Unid. Leather	3	6	9
Plastic	1		1
Whiteware, Mocha	1		1

[27] The other three animal shoes were recorded in situ and removed to TP 1 during the remediation activities.

Whiteware, Undecorated	7	3	10
Rubber	2	6	8
American Stoneware, Albany Slip	3	1	4
American Stoneware, Albany Slip/Salt Glazed	3	1	4
Textile	3		3
Misc. Structural/Industrial	2		2
Grand Total	79	34	113

Trench 1 (TR-1-PG)

TR-1-PG was placed 205 ft (62.5 m) northwest of EU-4-BC, 27 ft (8.2 m) southwest of the presumed bank barn foundation, and 5 ft (1.5 m) east of the proposed limit of construction disturbance (see Figure 4-1). The trench measured 7.5-x-13.5 ft (2.3 x 4.1 m) and reached a maximum depth of 5 ft (1.5 m) bgs. It was excavated on a steep slope with a change in elevation of 1.4 ft (.43 m) from the top to bottom of the trench (Figure 4-86).

The trench stratigraphy contained a thick overburden followed by four fill deposits and glacial till (Figure 4-87). The overburden followed the sloping topography to the east and consisted of a combined A_o, slope wash, and a buried A_o that extended from 0 to 1.5 ftbs (0 to .46 m). The Fill 1 deposit was characterized as dark olive brown (2.5Y 3/3) silty fine to medium sand found on the west side of the trench from 1 to 2 ftbs (.31 to .61 m). Fill 2 was directly below Fill 1 and consisted of very dark brown (10YR 2/2) fine to medium sandy silt from 1.5 to 2.7 ft (.46 to .82 m) bgs. The Fill 3 deposit extended the length of the trench and consisted of dark yellowish brown (10YR 4/3) coarse sand mottled with olive gray (5Y 4/2) fine to medium sandy silt from 2.5 to 4.2 ft (.76 to 1.3 m) bgs. Fill 4 consisted of a pocket of very dark brown (10YR 2/2) silty fine to medium sand mottled with very dark brown (7.5YR 2.5/2) fine to medium sand. The pocket was found along the southeast side of the trench from 3 to 4 ftbs (.91 to 1.2 m). Glacial till was at the bottom of the trench from 3.6 to 5 ftbs (1.1 to 1.5 m). The till was an olive gray (5Y 4/2) fine to medium sand with silt. The trench contained no cultural material or structural remains. Fill 3 was mottled with glacial till possibly from the excavations of the nineteenth century foundations to the northwest.

Trench 2 (TR-2-PG, FEA-1-PG)

TR-2-PG was located at the base of the slope, 4.8 ft southeast of TR-1-PG and 75 ft northwest of the Upper Factory west wall. The trench was oriented on an approximately north-south axis and measured 9.4 ft-x-34.75 ft (2.9 x 4.2 m) (see Figure 4-86). The trench cut across the toe of the slope excavating between .24 ft (.7 m) on the east side and 3.6 ft (1.1 m) bgs on the west side. Machine excavation worked around large pine trees and roots in the west part of the trench. In situ floor features and artifacts were encountered from 1.7 to 3.6 ftbs (.52 to 1.1m). The trench reached a total depth of 3.6 ftbs (1.1 m).

TR-2-PG contained two fill deposits below a thick overburden consisting of A_o followed by alluvium (slope wash) from 0 to 1.6 ftbs (0 to .49 m) (Figure 4-88). F ill 1 consisted of very dark grayish brown (10YR 3/2) medium to coarse sandy silt from 1.2 to 3.2 ftbs (.37 to .98 m). The Fill 1 deposit contained some very small brick fragments and large stones. At the bottom of Fill 1, small to medium cobbles and wood timbers were encountered. The Fill 2 deposit was below Fill 1 from 2.4 to 3.2 ft (.73 to .98 m) and consisted of dark grayish brown (2.5Y 4/2) silty fine to medium sand. Fill 2 appeared to be re-deposited glacial till underlying the floor features.

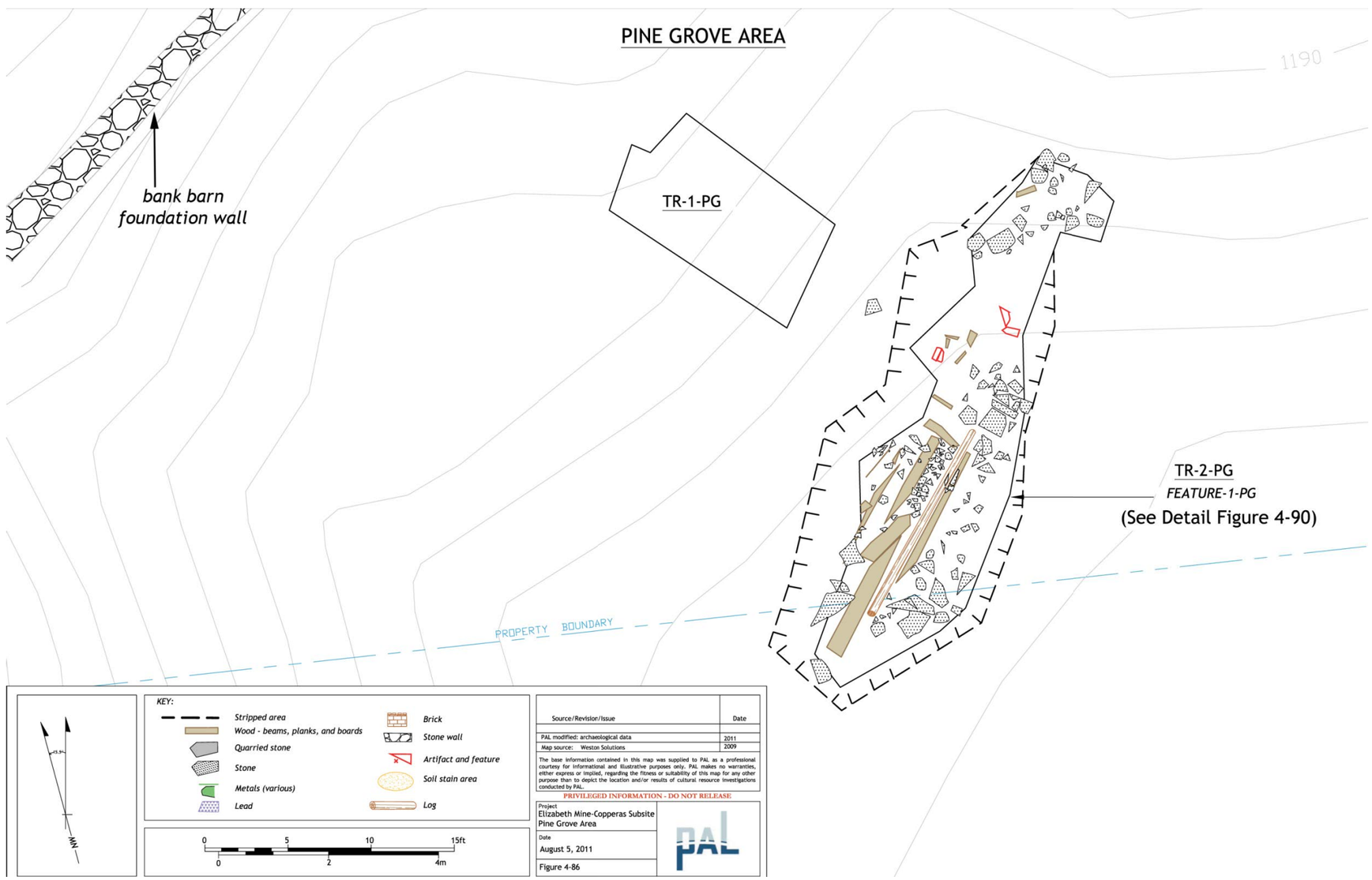

Figure 4-86. Map of Pine Grove Area, showing the locations of data recovery excavations and identified features.

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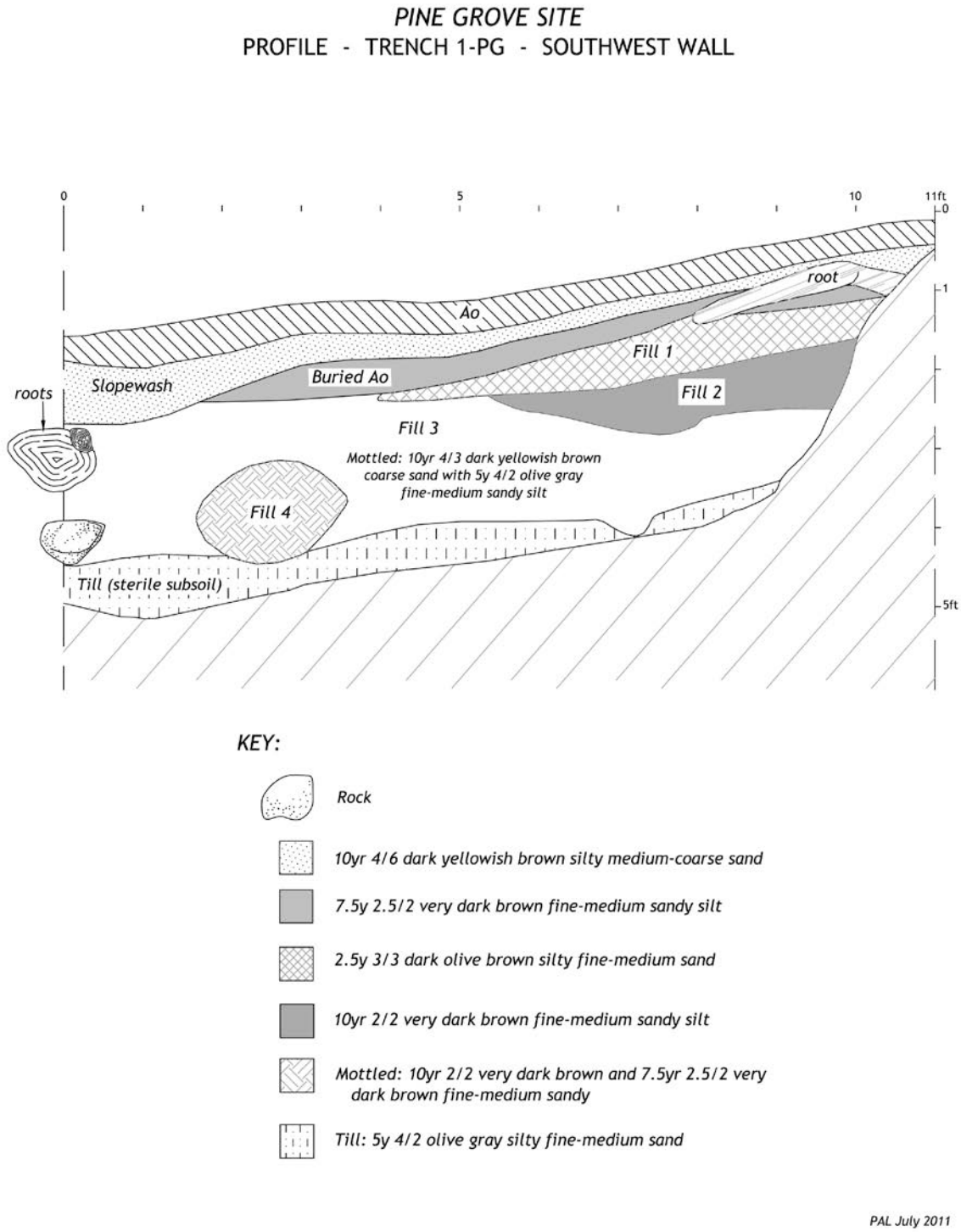

Figure 4-87. Southwest wall profile of TR-1-PG.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

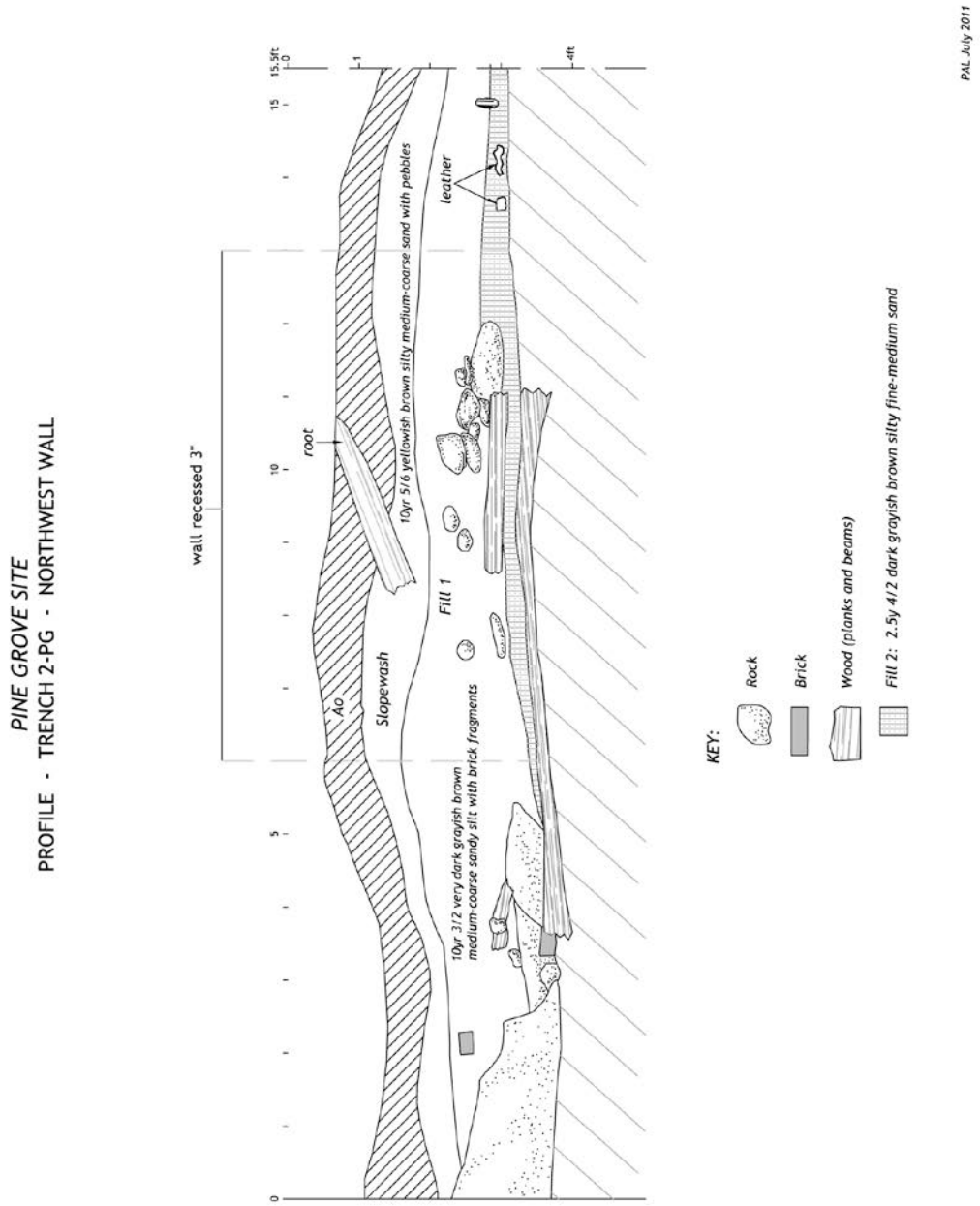

Figure 4-88. Northwest wall profile of TR-2-PG.

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Identified structural remains included beams, planks and a log with small to medium cobbles and a scatter of large fieldstones, designated FEA-1-PG (Figure 4-89). A log and horizontal wood timber on a northeast to southwest orientation were located at the eastern extreme of the feature (Figure 4-90). The log was .5 -x-12.6 ft (.15-x-3.8 m) long and had a notch cut into the top. The notch was .25-x-.8 ft (.08-x-.24 m) with a small piece of wood dividing the north and south side. The notch to the south was .25 ft (.08 m) long and was cut to a depth of .3 ft (.09 m). To the north the notch was .55 ft (.17 m) long and was cut to a depth of .15 ft (.05 m). The beam to east of the log extended parallel to and was .4 ft (.12 m) lower than the log.

A total of 113 cultural materials, 48 of which were flat (window) glass fragments, was recovered from 2 to 4 ft (.61 to 1.2 m) bgs in association with FEA-1-PG in TR-2-PG (see Appendix A; Table 4-6). If applied, Moir's regression formula for the window glass suggests 13 different dates of manufacture, from 1780 to 1923 (±) seven years, with 18.75 percent of the sample dating to 1872. The Fill 1/Fill 2 (2 to 3.4 ft [.61 to 1.04 m]) deposit contained 71 artifacts: 41 flat glass, seven curved glass, 13 ceramic sherds, one Kaolin pipe bowl fragment, two textiles, three unidentifiable nails, one piece of plastic, two lead caulking, and one brick. The ceramic sherds consist of seven whiteware dating from 1820 to the present, three American that date from 1800 to 1880, one mocha pattern on whiteware dating from 1820 to 1900, and one sherd of slip-trailed redware having a manufacture date range of 1700 to 1830 (see Appendix B.1-16).

The Fill 2 (3 to 4 ft [.91 to 1.22 m]) deposit yielded 42 artifacts: one cork, two rubber fragments, one textile, 15 unidentified leather, two boot/shoe fragments, two clothing belts, one bottle/jar, six curved glass fragments, seven flat glass, three whiteware ceramic sherds, one crock base/body, and one burned animal bone. The crock base/body sherd has a manufacture date range of 1800 to 1880. Seven of the unidentifiable leather fragments have small punch holes from sewing and nails (see Appendix B.1-13). Three 5/8 inch strip fragments were recovered, 1 inch, 3¼ inch, and 8½ inches long; the 1 inch and 8½ inch pieces have stitching holes running down both sides. The 1 inch and 3¼ inch fragments also have small holes slightly off center, with the 3¼ inch having grommet imprints around one of its two holes. The other four fragments appear to be possible shoe fragments. Three ¾ inch and smaller fragments have sporadic nail holes and the fourth has stitch holes along a curved edge measuring approximately 2 inches long.

Two bevel-edged barrel lid fragments were also observed in the trench fill, but not collected[27]. One measured .75 ft (.23 m) wide and .8 ft (.24 m) long, was split down the center, and partially embedded in the north-central trench wall (Figure 4-91). The other barrel lid fragment was .44-x-1.23 ft (.13-x-.38 m) and was located 4.1ft (1.25 m) to the northeast (see Figure 4-91)

[27] The barrel lids were recorded in situ and removed to TP 1 during the remediation activities.

Figure 4-89. Photograph of TR-2-PG, showing FEA-1-PG, looking west.

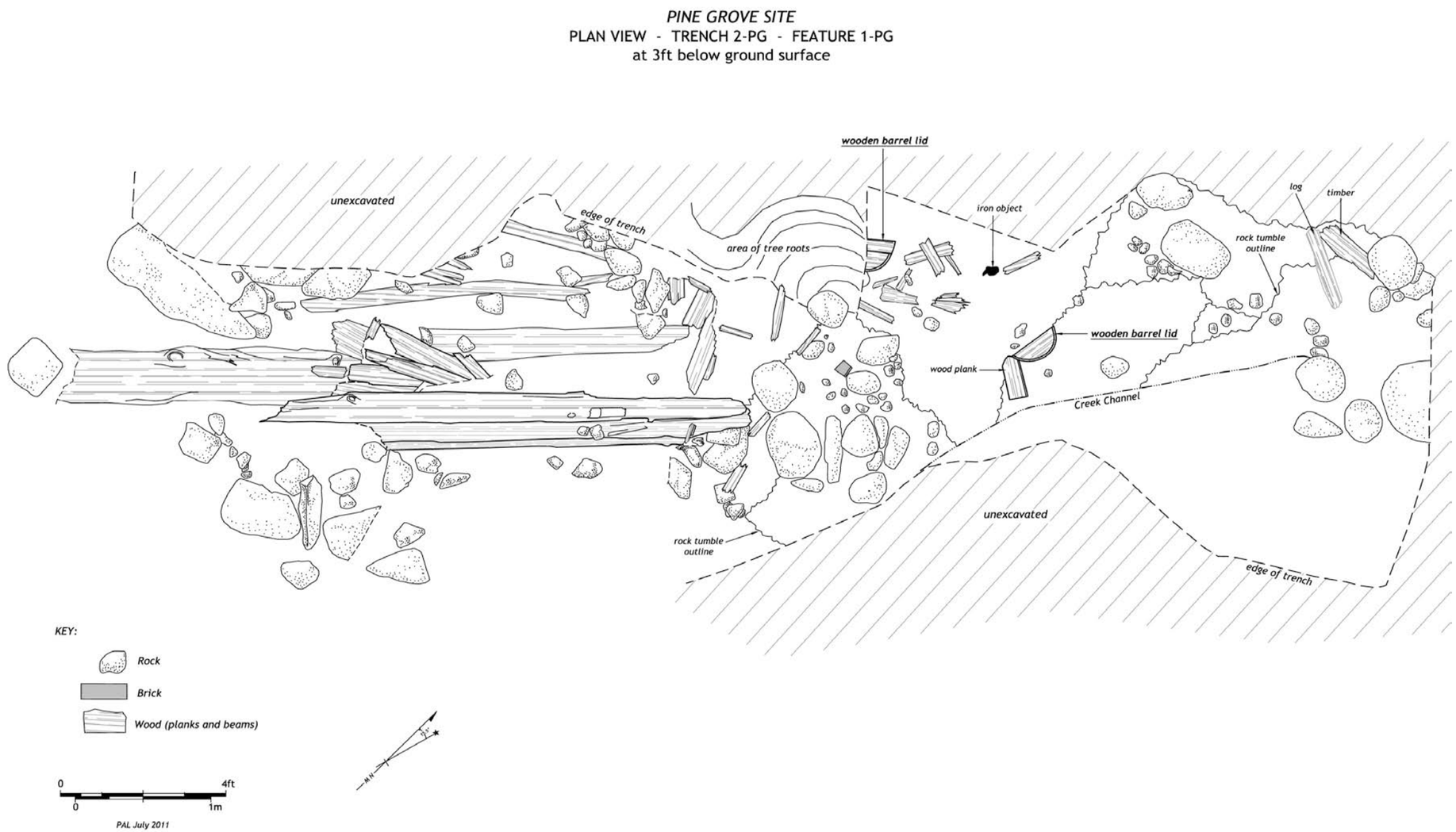

Figure 4-90. Plan of TR-2-PG at 3 ft (.9 m) bgs.

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Figure 4-91. Photograph of TR-2-PG, looking northwest (note: barrel lid fragments).

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CHAPTER FIVE

RESULTS OF CONSTRUCTION MONITORING

The 2009 and 2010 data recovery fieldwork was supplemented by construction (mine waste removal) monitoring. Mine waste consisted of barren and sulfide ore-bearing mine development (overburden) rock, lumps of pyrrhotite (iron sulfide) and chalcopyrite (iron-copper sulfide)-bearing pyrrhotite ore, weathered ore roast bed and heap leaching pile material and associated affected soil and sediment, all lying on glacial till or directly on bedrock. Removal of these materials included historic masonry and/or timber structural remains associated with mining activity. The removal monitoring was conducted in several areas within TP 3 (see Figure 2-2). Monitoring resulted in observations that supplemented and in some cases significantly informed interpretation of the data recorded in the adjacent and overlapping data recovery areas (see Chapter 6). This chapter reports the results and interpretations of the monitoring for the North Berm, Sedimentation Basin area, Copperas Brook Corridor area (see Figure 4-3), and a portion of the Ore Roasting and Leaching area, which contained resources associated with the final stages of processing raw copperas liquor into finished copperas crystals[28]. The Ore Roasting and Leaching area predominantly contained remains of structures associated with the preceding stages of generating, conveying and storing the raw liquor. The field reports for the remainder of the monitoring in the Ore Roasting and Leaching Area and the Pine Grove Drainage Trench, as well as the Upper Adit/Cob Shop/Blacksmith Shop site and the Tyson No. 1 Shaft site, which were associated with ore mining as opposed to processing for copperas, are included in Appendix F.

North Berm

The North Berm was an approximately 40 ft (12.2 m) by 60 ft (18.2 m) mound located at the foot of Copperas Hill, west of Mine Road, approximately 60 ft (18.2 m) east of the Upper Copperas Factory remains and north of Copperas Brook (see Figures 2-13 and 4-3). The North Berm, and the flanking South Berm opposite it to the south across Copperas Brook were not identified as discrete components of the Copperas Factories subsite in the PAL 2003 report. Both berms were discovered and found to contain copperas manufacturing features as part of the 2009 data recovery test trenching. The North Berm had to be removed during the week of July 20, 2009 as part of construction of the adjacent Sedimentation Basin; the South Berm was retained and preserved in exchange through consultation with the VT State Archaeologist. North Berm data recovery was conducted at the top and on the east slope of the mound, where a brick and stone masonry structure surrounded by bright red soil and containing pieces of cast iron was found in trench TR-5-UC (see Chapter 4 discussion).

The subsequent removal monitoring took less than one day and consisted of observing a bulldozer with a tall blade bisect the berm from north to south in narrow west-to-east passes that provided the opportunity to view it in section as it was removed. The first portion of the masonry structure encountered consisted of a series of north-south oriented parallel walls of brick and stone with reddened earth laid on foundations of split slabs and blocks of metamorphic schist that increased in size with depth and rested on

[28] Several portable items (see Figure 5-21 and 5-40) recovered during the monitoring efforts were returned to the PAL facility for temporary curation. All other non-portable objects and structural remains were removed to TP 1 during the remediation activities.

large rounded boulders (Figure 5-1). The surrounding soil was bright red. The brick structure included

Figure 5-1. Photograph of Upper Copperas Factory, 2009 North Berm removal monitoring, looking southwest.

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the stone wall and arched brick remains (FEA-4-UC in TR-7-UC) partially excavated during data recovery. Proceeding south two parallel vertical brick walls resting on rectangular stone blocks and separated by a vertical column of black charcoal and ash were encountered (Figure 5-2). Proceeding south the backhoe then encountered a cast iron plate approximately 12 inches (30.4 cm) on a side with a row of common brick laid along its east side and an approximately 3.5 ft (106.6 cm) long wrought iron bar lying along its west side (Figure 5-3). These structural remains were found relatively high up in the berm, at the surface in the bright red soil that had been previously recorded in TR-6-UC during data recovery. Deeper in the berm, below these structural remains, a stone wall incorporating two long narrow split granite blocks with triangular cape chisel marks, large round boulders, and flat schist slabs were encountered (Figure 5-4). One of the granite blocks had a square cast iron plate adhered to one side. Further removal of the berm proceeding south uncovered a stack of irregularly-shaped cast iron plates, many with rounded corners and edges as if they had been melted (Figure 5-5). Several cut rectangular granite blocks with rough finished faces were displaced by the bulldozer blade. The blade bisected a deposit of black charcoal and ash arranged in concentric synclinal layers toward the south extremity of the structural remains removed by the bulldozer (Figure 5-6). Several cast and forged iron furnace grate bars were encountered during the removal of the North Berm (Figure 5-7). Once the berm had been removed, further machine excavation east of the berm uncovered and removed several northwest-southeast oriented timbers approximately 20 ft (6 m) long and approximately 1 ft (30.4 cm) in diameter (Figure 5-8).

The bright red soil in the top of the mound over the masonry structures is similar to the red hematite soils observed in waste material throughout the site in locations were heat was applied to the iron-rich soil and waste material including in the ore roasting piles and around other copperas liquor boiler features.

The descending vertical sequence of brick and increasingly larger split and rounded stones found in the masonry construction for specialized masonry structures at TP 3, particularly the boilers at the copperas factories, corresponds with contemporaneous practice for general construction of large outdoor ovens. According to an 1882 technical volume on construction of large bread ovens for military field conditions,

> "Permanent ovens are usually made of bricks or refractory stone, sometimes adobe. It frequently occurs that bricks are not readily obtainable, and may require distant and expensive transportation, while stone can be conveniently and easily secured. When stone are not too friable they can be used for external work–sides, back, division walls and chimneys–and fillings, but the lining of the furnace and oven-chamber should be made of brick or refractory stone; the foundation of rubble-stone or brick, preferably the former" (Bell 1882: 39).

The presence of the masonry arch and flue, iron structural remains and ash deposits also identified in the data recovery investigations all suggest that the structure was a boiler for concentrating copperas liquor. A copperas boiler is described in "An Account of the Way of Making English Green-Copperas," from a late seventeenth-century volume of the *Philosophical Transactions* of the Royal Society.

> "…the liquor is pumped into a boiler of lead, about eight feet square…which is thus ordered. First they lay long pieces of cast iron, about twelve inches from each other, and twenty four inches above the surface of the fire. Then crosswise they lay ordinary flat iron bars, as close as they can lie, the sides being made up with brick-work. In the middle of the bottom of this boiler is laid a trough of lead…" (Colwall 1678: 1058).

This description is useful for visualizing the possible arrangement and function of features and associated structural remains observed during the monitoring. The vertical brick walls may have been part of the boiler firebox or copperas vessel heating chamber. The observed rounded brick opening is comparable to a firebox or ash pit door arch (not to be confused with an interior "fire arch" which was a transverse vault in the roof at the head of the horizontal draft flue under the boiler pan). The vertical, charcoal-lined open

Figure 5-2. Photograph of Upper Copperas Factory, 2009 North Berm removal monitoring, showing brick flue or ash pit feature in TR-5-UC, looking southwest.

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Figure 5-3. Photograph of Upper Copperas Factory, 2009 North Berm removal monitoring, showing iron plate and bar in TR-5-UC, looking southeast.

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Figure 5-4. Photograph of Upper Copperas Factory, 2009 North Berm removal monitoring, showing granite blocks in TR-5-UC, looking southwest

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Figure 5-5. Photograph of Upper Copperas Factory, 2009 North Berm removal monitoring, showing iron plates, looking south.

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Figure 5-6. Photograph of Upper Copperas Factory, 2009 North Berm removal monitoring, showing granite blocks, iron plates, ash deposit and granite boulders, looking southwest.

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Figure 5-7. Photograph of Upper Copperas Factory, 2009 North Berm removal monitoring, showing forged wrought iron furnace grate bars found in boiler structure.

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Figure 5-8. Photograph of Upper Copperas Factory, 2009 North Berm removal monitoring, showing timbers removed from east edge of berm, looking south.

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shaft resembles an ash pit or a draft stack at the top of a boiler as depicted in the mid-eighteenth-century Diderot illustration (see Figure 3-4). The cast iron plates that ranged in size from palm-sized to over 1 ft (30.4 cm) square, and varied in thickness from under an inch to approximately 2 inches (5 cm) may be analogous to the iron supports for the lead copperas liquor boiling supports noted in the seventeenth-century *Philosophical Transactions* account. The boiler firebox grate bars may have served their named intended function or have been used as boiler vessel supports inside a brick boiler chamber.

A technical illustration that is also helpful in visualizing how the rectangular walls and firebox grate system (but not the draft system) of a copperas liquor boiler may have been constructed is Diderot's eighteenth-century illustration of a granulated sugar furnace (Diderot 1751: Plate 41, Sugar V). In this illustration the furnace is a rectangular brick structure with a row of thick iron grates set into the walls above a simple firebox. The only notable difference in the sugar furnace is the frontal location of the draft stack, presumably located to provide a much cooler fire to heat, but not boil or burn the sugar in the granulation containers. The front draft stack rises from the top of, and is integral to and supported by, the furnace, and not from the ground (Figure 5-9).

Sedimentation Basin

The Sedimentation Basin area straddles the sharp bend in Mine Road immediately east of the Upper Factory, immediately north of the Lower Factory and immediately northeast of the Inter-Copperas factory area. This area contained a swampy wetland fed by Copperas Brook and drainage from Copperas Hill through the Inter-Copperas Factory Area to the southwest. Deposits of mine waste flanking and under Mine Road had to be removed from the buried original banks of Copperas Brook to construct a rock-lined basin to collect potential sediments from the temporary removal activities upslope on the open area of TP 3. The original Mine Road was a packed clay and gravel road. The proximity of a portion of the basin to the documented factory sites required PAL monitoring of the removal excavations in this area during the week of July 20, 2009. The road removal and replacement was a fast-track project as the sedimentation basin and new road had to be completed by the end of August to accommodate resumption of local school bus traffic.

The stratigraphy in the Sedimentation Basin area consisted of black organic muck and peat underlying yellow-orange sandy mine waste washed from the open slope of TP 3 (Figures 5-10 and 5-11). This material was excavated to glacial till to a total depth of as much as 17 feet (5.1 m). The stratigraphy became more complex containing lenses of different colors and textures of mine waste as removal of the roadbed progressed north toward the area opposite the Deep Adit and Office within the North Village subsite. One block of soapstone was found below the South Berm. The area east of the North Berm contained the greatest concentration of structural remains, almost entirely wood, and in both soil strata. These included a variety of timbers of varying lengths ranging from pine and birch trunks with the bark still on to square sawn beams up to 1 ft (30.4 cm) square. Close to the North Berm, several long, horizontal round east-west-oriented tree trunk timbers were pulled from the area at the base of the berm.

Closer to the road to the east, several of the round timbers were found arranged parallel to each other, roughly transverse to the road axis (Figure 5-12). One area in particular contained a dense concentration of timbers as well as planks. Several unusual, short, thick logs from 2 to 3 feet (60.9 to 91.1 cm) in diameter with chisel-shaped hewn ends were uncovered (Figure 5-13). Wood excavated from the organic layer was stained black on the outside but well-preserved inside. Several barrel staves were also observed. As removal of the road and flanking material progressed north the soil strata became more complex. An area of intact thick plank floor supported by short beveled-end logs and transverse planks and beams was encountered. Above the planks was a 4-inch (10.1 cm) thick stratum of brilliant orange

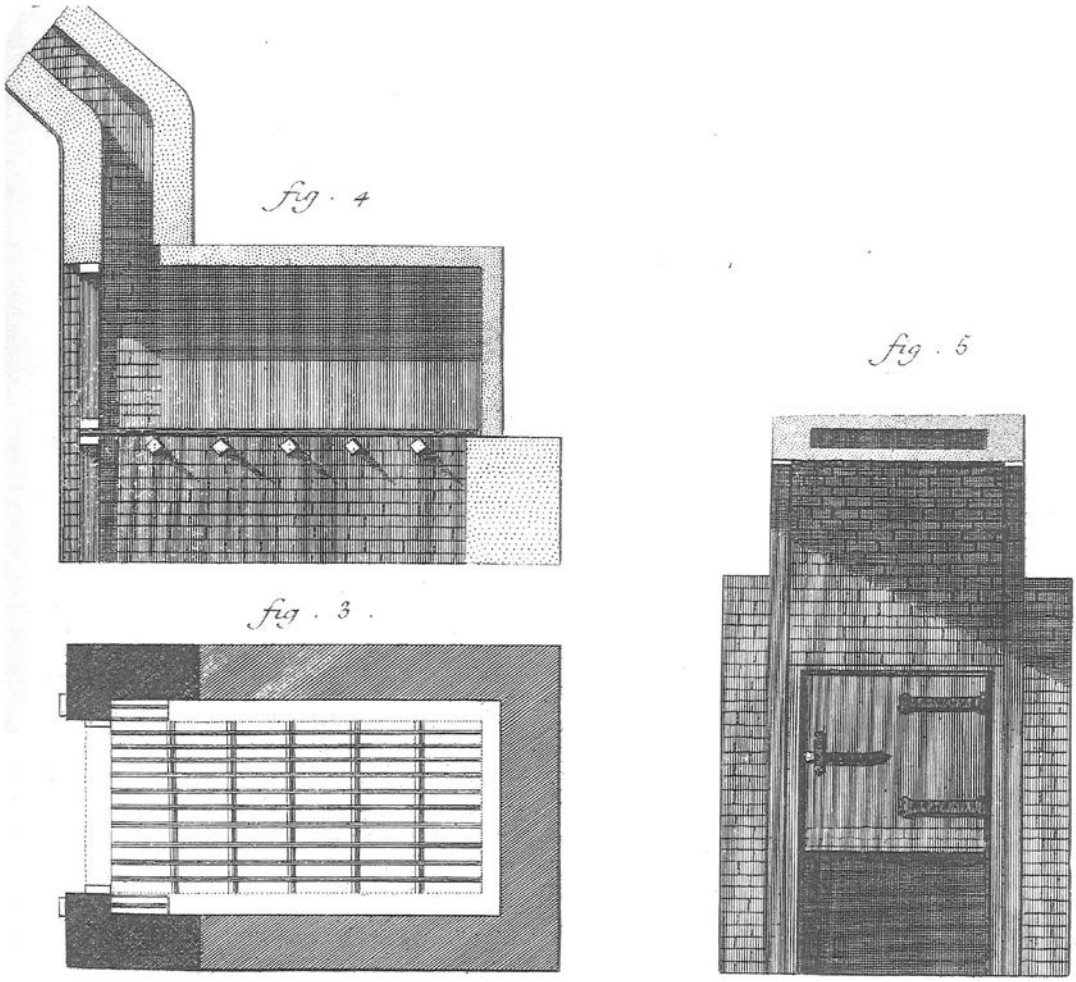

Figure 5-9. Drawing of sugar granulating oven, Plate 41, Sugar 5, from Denis Diderot, *L' Encyclopedie, ou Dictionnaire Raisonne des Sciences, des Arts et des Metiers.* 1751.

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Figure 5-10. Photograph of 2009 Sedimentation Basin removal monitoring, showing removal in area between Mine Road and North Berm, looking north.

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Figure 5-11. Photograph of 2009 Sedimentation Basin removal monitoring, showing general soil strata of organic muck underlying mine waste, looking northeast.

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Figure 5-12. Photograph of 2009 Sedimentation Basin removal monitoring, showing east-west oriented timbers, looking west.

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Figure 5-13. Photograph of 2009 Sedimentation Basin removal monitoring, showing example of large-diameter logs with cut beveled ends, looking east.

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gelatinous clay (Figure 5-14). A section of clay lying over black organic muck exhibited thin, sharply-defined, irregularly-spaced, light and dark orange bands (Figure 5-15). The waste in this area and to the north contained lenses of black peat, deep red soil, orange clay, a mixture of yellow-white clayey soil and black rocks, capped by the compacted clay and gravel road surface fill (Figure 5-16). Structural remains encountered included a few long round and square timbers as well as two large, long narrow cut granite blocks.

The stratigraphy indicated that portions of the Sedimentation Basin area had once been wetland that was subsequently buried by eroded and transported mine waste alluvium from the open area of TP 3 to the west. The parallel arrangement of some timbers transverse to the roadway may have been the remains of a corduroy road that was built across a former wetland or a small bridge over the Copperas Brook channel. The short, thick logs with the beveled ends resembled similar logs encountered in the removal monitoring in the Copperas Brook Corridor, at the southeast corner of the substructure supporting the timbers and plank deck in the bed of the brook. These logs may have been associated with structural foundations. The barrel staves may be associated with copperas packing house operations, however they were found loose in the waste material deposits. Wood stave barrels were generic nineteenth-century containers and the copperas was reportedly shipped in large, heavy casks weighing from 500 to 2,000 lbs (Duncan 1871:1085–1088; Thompson 1842:167–168). The presence of the fine-grained orange clay, particularly containing the thin distinct bands, indicates that the water in part of the Mine Road area was once deep and still enough to carry and deposit fine mineral grain particles. The presence of the orange clay above a small area of horizontal wood plank supported by timbers suggests that the deck may have been a floor or vessel that received water either intentionally to collect fine mineral grains or that was submerged in water draining from TP 3. Fine brightly-colored metallic oxides were historically used as pigments in paint manufacture. The Vermont Copperas Company was making 4 tons of paint according to the 1850 U.S. Census of Manufacturers, and the New England Chemical Company operated two copperas plants at TP 3 and a paint works at Furnace Flats site after 1867 (Abbott *GMC* 1964:273–276). The more complex soil stratigraphy and presence of cut granite blocks in that area may indicate industrial construction and activity. The block of soapstone found below the South Berm was likely brought to the site for use as refractory furnace lining; similar material is found at copper smelting sites at the Elizabeth Mine including Furnace Flats (Cherau et al. 2003:108).

Copperas Brook Corridor

The Copperas Brook Corridor, which passed the south side of the 2009 Upper Factory data recovery area, was not identified in the PAL 2003 report as a discrete component of the Copperas Factories subsite. The Brook Corridor began at a series of exposed timbers approximately 30 ft (9.1 m) southwest of the Upper Factory stone wall, at the west end of an approximately 90 ft (27.4 m) long narrow “island” that divided the brook into two, north and south channels (see Figures 2-5 and 4-3). The south channel collected drainage from the south and central portions of the Ore Roasting and Leaching area and the north channel collected drainage from the north portion of that area. The combined channels and island widened to approximately 40 ft (12.1 m) before joining south of TR-4-BC in a narrow channel with timbers and planks in the bed that passed over two approximately 6-8 ft (1.8 to 2.4 m) high north-south oriented stone walls (see Figure 2-6) before meeting the level area now occupied by the Sedimentation Basin.

Prior to the beginning of mining and copperas manufacturing about 1809, the east side of Copperas Hill formed the original headwaters of a brook that flowed east from the bottom of the hill. It appears that the brook was a surface feature west of Mine Road before mining began, when it passed through the future factory site and then flowed through a wetland. After 1809, manipulation of the hillside took place to direct the drainage of the copperas liquor toward the reservoirs and factories located in the narrow “declivity quite below the mine” (Locke 1821:326–330). After copperas manufacturing ended about 1882, rain and uncontrolled runoff on the barren slope remained focused toward the Upper Factory. The

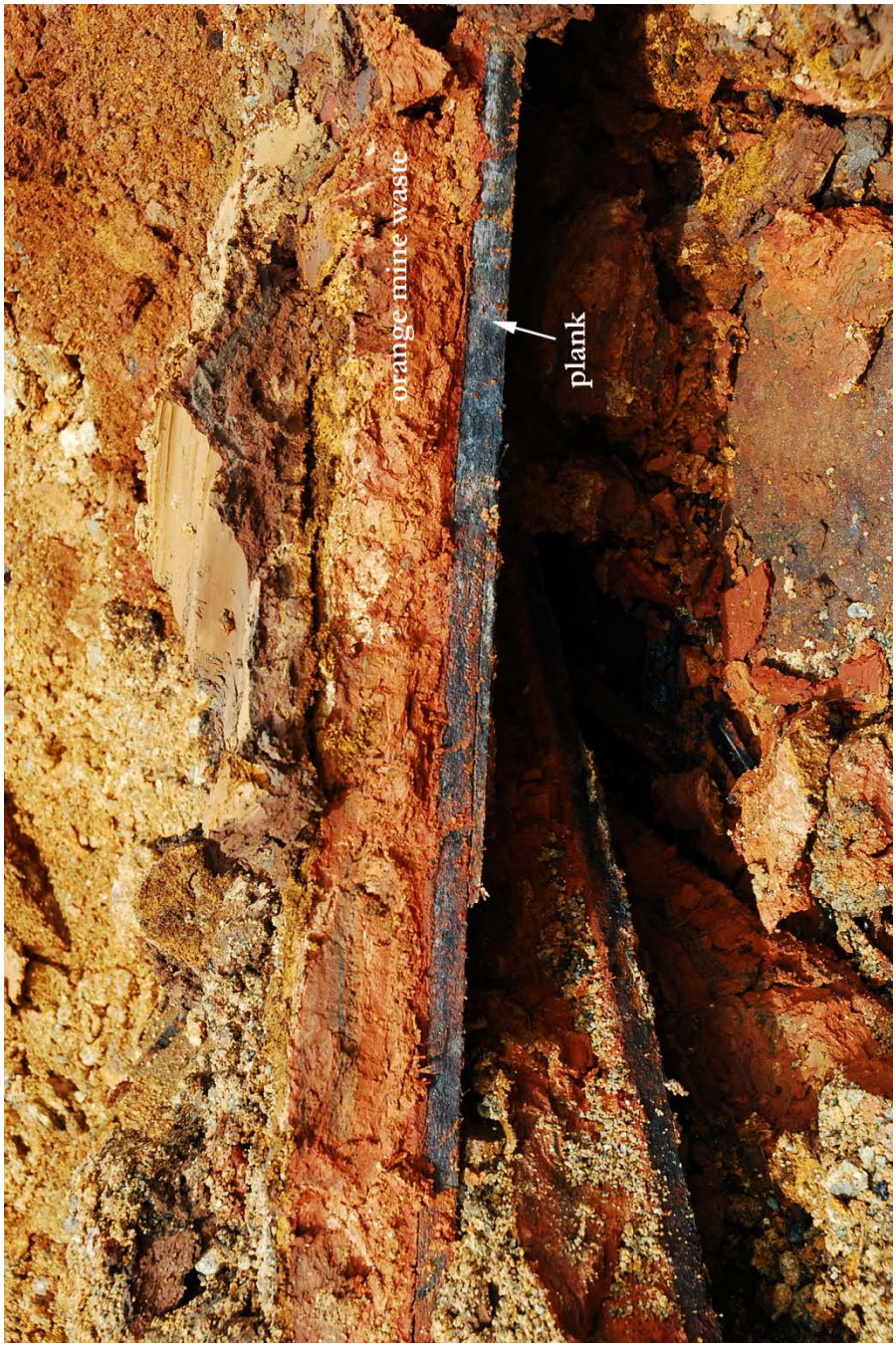

Figure 5-14. Photograph of 2009 Sedimentation Basin removal monitoring, showing fine-grained orange mine waste on plank layer, looking west.

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Figure 5-15. Photograph of 2009 Sedimentation Basin removal monitoring, showing banded gelatinous orange mine waste on organic muck, looking west.

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Figure 5-16. Photograph of 2009 Sedimentation Basin removal monitoring, showing mine waste strata under Mine Road, looking west.

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runoff carved the gully at the top of what became known as "Copperas Brook" through the remains of one or more of the several copperas factories that historically received and processed the controlled runoff from the hillside. As part of mine cleanup construction operations, waste rock in the Brook Corridor had to be removed and the bedrock had to be partially excavated to create an adequate channel to convey runoff from the surface of the reclaimed TP 3 slope above to the west. The bed of Copperas Brook south of the Upper Factory contained previously-identified visible remains of brick structures and a sloping grid of heavy timbers and planks (see Figure 2-2). PAL conducted data recovery in the Copperas Brook Corridor in the summer of 2010 (see Chapter 4 discussion). After the data recovery, removal of the Brook Corridor was conducted in two separate campaigns. The bulk of the corridor removal south and southeast of the Upper Factory ("lower section") was monitored during the week of August 2, 2010. The remainder of the corridor removal southwest of the Upper Factory where a temporary cleanup haul road was also removed ("upper section") was monitored during the week of August 16, 2010. The following description begins with the latter work, proceeding from west to east.

Upper Section

Removal of mine waste and the fill forming the temporary haul road southwest of the Upper Factory at the top of the Copperas Brook north channel during the week of August 16, 2010 revealed wood and masonry structural remains. This area contained a previously-identified, partially exposed, long, round timber and associated planks embedded in mine waste lying on a roughly north-south axis west of the brook. This timber was mapped during the 2002 field investigations (see Figures 2-2 and 2-4). Removal north of the timber exposed similar round timbers ranging from 2 to 2.5 ft (61-76 cm) in diameter extending 67 ft (20.4 m) on the same alignment. Some of these timbers had a flat planed side with angled planks lying against them. Removal revealed what appeared to be a northeast corner of this structure consisting of an intersecting square timber and planks extending at an oblique angle at least 20 ft (6.1 m) to the northwest.

Mine waste removal east of this location uncovered a plank platform that was recorded with the Total Station and in photographs and a plan view drawing. The feature consisted of a floor or deck measuring 7.2 ft (2.2 m) east-west by 4.5 ft (1.4 m) north-south consisting of three level horizontal parallel planks with a 2 inch (5 cm) high vertical plank lip attached to the north edge (Figure 5-17). At least one additional plank on the south side of the structure was removed by the backhoe prior to clearing and measuring. At the west end of the level portion of the deck a shorter section sloped down to the west along the south face of the exposed square timber. The level deck planks rested on a cribwork of square sawn timbers ranging from .5 ft (15 cm) to 1 ft (30 cm) thick consisting of three visible transverse square floor beams resting on two longitudinal square stringers which in turn rested on another set of transverse beams (Figure 5-18). The underside of the upper floor beams were notched at the ends resting on the stringers below. Removal of the angled section of planks and soil below the level part of the deck revealed that the stringers were connected to the bottom set of beams with vertical wood pegs. One of the lower beams had a horizontal rectangular mortise hole in its south end. The exposed lower beam on the west side of the structure was supported by stacked rough field stone and glacial till. Exposed soil below the east edge of the deck at the east side of the structure consisted of gelatinous thinly banded silty clay ranging in color from yellowish red (5YR 4/6), dark reddish brown (5YR 3/4), yellow (10YR 7/6), and a light brownish gray (10YR 6/2) that contained lumps of an ashy black (10YR 2/1) material (Figure 5-19).

The area containing the large round timbers mapped in 2002 and excavated during monitoring, and the plank deck feature observed during monitoring are located at the foot of the open ore roasting and heap leaching area, immediately above the Upper Factory. This is an area noted in historical accounts throughout the life of the copperas operation as the location of a "plank-lined cistern" or collection reservoir(s) at the foot of the bedrock trenches for diverting the copperas liquor that had been naturally partially concentrated by evaporation:

Figure 5-17. Photograph of 2010 Copperas Brook Corridor removal monitoring (upper/west section) , showing plank deck structure, looking east.

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Figure 5-18. Photograph of 2010 Copperas Brook Corridor removal monitoring (upper/west section), showing plank deck structure, looking east.

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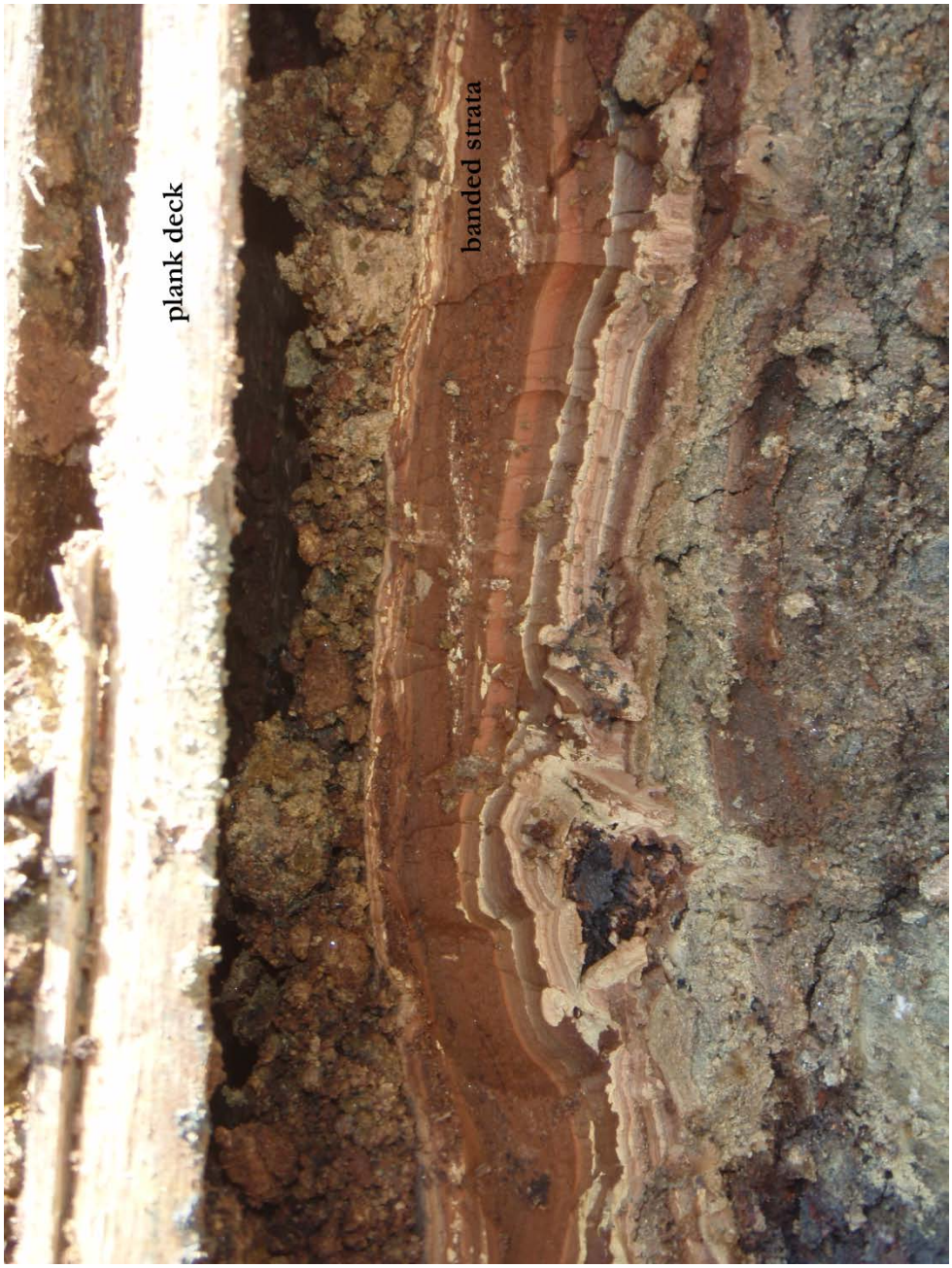

Figure 5-19. Photograph of 2010 Copperas Brook Corridor removal monitoring (upper/west section), showing banded strata under plank deck, looking north.

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> "…. The water passing through becomes highly impregnated with copperas, and at the bottom of the hill is received into drains which convey it into reservoirs. From there it is let off into the furnace boilers…"(*Niles Weekly Register* 1835:395).
>
> "…water, from a fountain on the summit of the hill, is made to run upon and leach this mass of crude sulphate of iron. The lye is now drawn off into large wooden reservoirs, and thence into the leaden vats as fast as wanted" (Thompson 1842:167–168).
>
> "…copperas is dissolved and passes with the liquor into reservoirs prepared to receive it. The liquor which is now very strongly impregnated with copperas, is conducted into leaden boilers…" (Hitchcock 1861:829–832).
>
> "…From the lower evaporator the liquor passes directly to the factories where it is received in large reservoirs, whence it is drawn into the evaporating pans as needed" (Duncan 1871:1085–1088).

The exposed timber mapped in 2002 had been tentatively interpreted as a possible dam component for a reservoir based on its location above the factory, materials and orientation (Cherau et al. 2003). The additional large round timbers and plank deck feature revealed during monitoring indicated the continuation of the timber structure and a possible corner opposite the Upper Factory. The planks placed along the flat side of the timber may have been part of a side wall for a "plank-lined cistern." Monitoring did not reveal any masonry foundation for the timbers or prepared masonry or wood interior floor. The section of plank deck at the apparent northeast corner of the structure may have been a sluice or passage for directing the stored copperas liquor into the boilers inside the west side of the factory. The deck's timber substructure is robust and apparently designed to carry great weight and/or resist movement. The planks are simply butted together rather than joined by tongue or spline and groove which would have swelled when wet and helped seal them. The inclined planks at the west end of the deck structure slope down to the west, opposite and counterintuitive to the east-to-west direction that the copperas liquor followed downhill on its path to the factory. A second possible interpretation for the timber structure and plank deck is that they are part of a factory outbuilding, however, monitoring did not reveal any masonry foundation or wood interior floor.

Mine waste removal monitoring south of the plank deck feature uncovered structural remains approximately 15 ft (4.5 m) south, at the top of the Copperas Brook north channel. The sandy mine waste in this area where runoff from the ore roasting and leaching area gathered was bonded with iron oxide forming "ferricrete," a tough rusty conglomerate. Removal in this area revealed a rough 10 ft (3 m) long east-west oriented fieldstone wall extending toward the large round timber found to the west, and ending at an east-west oriented wood beam to the east at the start of the north channel. The channel bed north of the wall contained heavy timber construction consisting of large diameter 2.5 to 3 ft (76-91 cm) east-west oriented logs supporting smaller, .5 to 1 ft (15.2 cm to 30.4 cm) diameter, north-south oriented, parallel wood beams supporting another upper layer of crossed east-west and north-south timbers. The upper timbers were located approximately 2 ft (60.9 cm) apart and set into notches in the timbers below. This timber crib arrangement was filled with stone and also contained an open void (Figure 5-20). The upper surface appeared to slope slightly to the east as it followed the brook channel. The only artifact collected from monitoring in this area and returned to the PAL facility for temporary curation was a portion of a wood wagon/cart wheel including attached sections of hub, spokes and rim found west of the timber crib feature (Figure 5-21).

The structural remains in this area appeared to be the westernmost extent of a sloping apron of heavy timbers and beams supporting a thick plank deck that was exposed in the north and south channels of

Figure 5-20. Photograph of 2010 Copperas Brook Corridor removal monitoring (upper/west section), showing beam and stringer timber crib construction, looking east.

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Figure 5-21. Photograph from 2010 Copperas Brook Corridor removal monitoring (upper/west section), wood wheel hub, spokes and rim.

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Copperas Brook and in FEA-2-UC in 2009 data recovery TR-2-UC (see Chapter 4 discussion). This structure appeared to be supported in the brook channel area by timber cribs and rock walls. These structural remains can be interpreted as being associated with the Upper Factory or one of the other factories known to have been built at or near the Upper Factory location. It could be part of extensive site preparation engineering required to provide a stable factory substructure for the tiers of masonry process vessels in the wet environment of the sloping ravine where the copperas-bearing hillside runoff gathered. It may or may not have played a direct or indirect role in conveying copperas liquor. It could also be the floor of a copperas liquor reservoir for a factory that once stood below the Upper Factory, possibly associated with the copperas processing vessel remains found at the North Berm and/or South Berm.

Removal of the temporary haul road west of the Lower Copperas factory exposed additional areas containing the same fill layers exposed in TR-11-UC, suggesting the area behind the factory may have been intentionally prepared for construction of the outdoor copperas storage cisterns noted in the historical accounts. Removal of mine waste in the area subjected to data recovery immediately below the Pine Grove exposed a level section of buried wood plank underlying a stratum of homogenous fine orange-red clay covered by a stratum of yellow sandy material. Like the similar clays lying on plank observed in the removal in the sedimentation basin, they appear to have been deposited intentionally on the planks, possibly by water, although no regular banding was observed in the clay (Figure 5-22).

Lower Section

Removal of mine waste south and east of the Upper Factory during the week of August 2, 2010 revealed wood and masonry features. Removal was accomplished by filling in the Copperas Brook north channel to create a ramp for a backhoe to reach the area at the bottom of the brook corridor at the "waterfall" at the easternmost tier of timber and stone where it met the completed Sedimentation Basin. Excavation then began southeast of TR-3-BC and removed that trench and FEA-5-BC, TR-4-BC and FEA-4-BC and FEA-6-BC, TR-5-BC and FEA-7-BC and the waste material below them, then removed the stone wall in the brook southeast of TR-4 BC and retreated uphill to the west, removing the tiers of stone walls and timber structure in the north brook channel and the "island" separating the north and south channels including TR-6-BC, FEA-1-BC, and EU-2-BC. The backhoe operator constructed boulder revetment on the north and south sides of the new brook bank as work progressed uphill. The new bedrock brook channel was deepened and straightened by cutting a trench in the bedrock with a pneumatic hammer.

Mine waste removal in the TR-3-BC/FEA-5-BC area encountered stratigraphy consisting of a yellow and gray till overlain by lenses of black ash or cinder, bright red decayed brick and brick fragments, and yellow fine-grained sandy waste material (Figure 5-23). Artifacts encountered included an approximately 2-ft (60.9 cm) long, 10-inch (25.4 cm) square unidentified forged iron bar and an unidentified bent 1-in (25.4 mm) square wrought iron rod, possibly a tool (Figure 5-24). As removal progressed west and closer to FEA-7-BC in TR-5-BC, an approximately 10-inch (25.4 cm) diameter horizontal round log with a hollowed out center was encountered at the interface of the till and the ash/brick layers above (Figure 5-24). Removal uncovered additional timbers and wide planks and a large rounded boulder in this area. The stratigraphy in places contained distinct, sharply-bound strata of ash and brick. At the point that excavation revealed the deepest intact stratigraphic column it consisted of a lower stratum of yellow stained till, an approximately 1-ft (30.4 cm) thick light brown sandy stratum, a horizontal layer of wood plank, an approximately 2-ft (60.9 cm) thick stratum of ash and brick lenses, an approximately 3-ft (91.4 cm) thick orange sandy stratum, and a thin layer of topsoil (Figure 5-25). As removal progressed westward toward FEA-7-BC, the plank and colorful ash and brick stratum pinched out and was replaced by a stratum of light brown sand and gravel overlain by the thick orange sandy stratum (Figure 5-26).

Figure 5-22. Photograph of 2010 Copperas Brook Corridor removal monitoring (upper/west section), red mine waste on plank in Pine Grove, looking west.

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Figure 5-23. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing strata in vicinity of TR-3-BC, looking west.

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Figure 5-24. Photograph from 2010 Copperas Brook Corridor removal monitoring (lower/east section), iron bar and possible tool from vicinity of TR-3-BC.

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Figure 5-25. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing strata and hollow log in vicinity of TR-3-BC, looking west.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 5-26. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing strata in vicinity of TR-3-BC, looking west.

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The layers of black ash and cinder and decayed red brick can be interpreted as fuel waste and structural debris from a furnace, possibly a copperas liquor boiler, apparently laying on a constructed level wood plank floor surface. The ash layer was approximately 60 ft (18.2 m) southwest of the North Berm boiler feature. The strata and plank sequence are similar to those found in nearby TR-9-UC and FEA-5-BC (see below), suggesting a widespread waste deposit. The elevation of the ash layer in FEA-5-BC was between 2 ft (60.9 cm) and 4 ft (121.9 cm) lower than the top of the boiler feature FEA-4-UC in TR-5-UC and 4 ft (121.9 cm) higher than the boiler fire arch structure found in TR-7-UC. The consistent diameter of the log's hollowed interior and consistent width of the longitudinal opening in the side suggest that it may have been intentionally hollowed out. It is questionable if it was used for copperas liquor transfer inside the factory; considering the low pH of the boiled process liquor, the trough would had to have been lined with lead to prevent rapid deterioration from the action of the acid. The level, north-south orientation of the timber is counterintuitive for the gravity-assisted flow pattern understood to be a fundamental component of operations. Additional round and square timbers with reasonable integrity but missing their upper surfaces and/or heartwood cores, and therefore resembling troughs or conduits, were found elsewhere in the Upper Factory during data recovery (see Chapter 4 discussion).

Removal in the area including FEA-7-BC in TR-5-BC revealed timber and bedrock structural elements supporting a feature identified and documented during the 2010 data recovery and identified as a copperas crystallizer (see Chapter 4 discussion). The backhoe scraped along the east side of the north-south timber located at the east side of the crystallizer brick floor layer, dislodging that timber and others along the west side of the crystallizer feature. The PAL monitor directed the backhoe operator to remove the brick layer in shallow passes revealing a layer of additional north-south oriented logs or timbers below the brick layer. The backhoe bucket encountered a horizontal void at the east edge of the crystallizer feature. Machine excavation ceased and the monitor shovel excavated the void to reveal two intact east-west oriented approximately 1-ft (30.4 cm) square timbers located approximately 4 ft (121.9 cm) apart, resting on a flat ledge cut into the bedrock and supporting the flat layer of north-south oriented timbers that supported the brick crystallizer layer above (Figure 5-27). The west side of the void ended at a 90-degree transverse horizontal square timber located approximately 4 ft (121.9 cm) from the void entrance.

Exposure of the void under the crystallizer provided a glimpse into factory construction methods, indicating use of heavy east-west timbers on flattened bedrock ledge for support of this copperas vessel. The flat bedrock was one of at least two man-made flat areas identified during the data recovery and monitoring at the Upper Factory, the other one located in the bed of Copperas Brook (see below). The dimensions and spacing of the timbers also resembles the timber structure found during monitoring of the upper section of the brook described above (see Figure 5-20). The level bedrock and timber construction indicates that the bottoms of at least some copperas vessels and the factory levels they rested on were level and not sloped on an angle like the timber and plank structure seen in the bed of Copperas Brook and FEA-2-UC in TR-2-UC.

Filling in the Copperas Brook north channel to create the temporary backhoe ramp required removal of the brick-strewn "island" that separated the north and south brook channels. Elevations on the island stepped down from west to east in rough mounds or levels with clusters of common brick on them (Figure 5-28). One of these brick clusters was explored in EU-2-BC as part of the data recovery. The portion of the island to the east was mapped and partially excavated as TR-6-BC, where the remaining brick mounds were recorded as FEA-2-BC (see Chapter 4 discussion). The brick mounds exhibited slumped and distorted brick coursing; the upper of the two deposits included bricks laid in an east-west row (Figure 5-29), and the lower one included a small section of wall (Figure 5-30) and a small uneven "apron" of bricks slumped over the irregular ground surface (Figure 5-31). Many bricks had a layer of white mortar adhering to their surfaces. The excavated brick and timber features in EU-2-BC and the two lower mounds of brick were flanked to the north and south sides by decayed east-west oriented timbers that sloped downhill to the east at a shallow angle (Figure 5-32). These timbers rested on decayed north-south

Figure 5-27. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing wood beam and stringer crib construction under crystallizer FEA-7-BC in TR-5, looking southwest.

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Figure 5-28. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section) "island" in Copperas Brook, showing timber and plank structure in brook bed (foreground) and FEA-2-BC crystallizer remains in TR-6-BC in background, looking south across north brook channel.

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Figure 5-29. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), FEA-2-BC crystallizer structure showing coursed mortared brick, looking north.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 5-30. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), FEA-2-BC crystallizer structure showing coursed mortared brick, looking north.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 5-31. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), FEA-2-BC crystallizer structure showing mortared brick, looking south.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 5-32. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), FEA-2-BC crystallizer structure showing wood beam and stringer crib supports, looking northwest.

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oriented timbers in a matrix of intercalated red-brown sandy soil lenses resting on the brick-strewn layer of planks sloping to the east that rested on the larger system of heavy timber beams and stringers underlying the north and parts of the south brook channels (Figure 5-33). A small area of level ground covered with what appeared to be a skim coat of mortar and decayed planks was located immediately south of the lower brick-covered mound (Figure 5-34).

Removal monitoring observations confirmed that the bricks were in a thin layer of yellow sandy soil and the timbers were in and above a stratum of soil lenses interpreted as a prep layer, and the bricks were not structural masonry piers descending to piles or bedrock (Figure 5-35). These observations support the interpretation of the brick and timber structural remains in FEA-2-BC as the possible remains of copperas crystallizer vessels. The remaining brick coursing in small lengths and sections of wall, inclusion of mortar, thinness of the brick deposit, and relationship to similar underlying soil, crossed timber and plank structural systems are similar to different aspects of the crystallizers found in TR-3-UC and TR-5-BC. The small area of level ground indicates another area where the substructure or floor of the factory was level, and in the vicinity of crystallizers.

The next step in the machine removal of the Copperas Brook Corridor was removal of the brook channel bed from east to west, retreating up the temporary fill ramp, removing visible structural remains including two approximately 6 ft to 8 ft (1.8 m to 2.4 m) high stone walls, heavy timbers, the ‘island” between the north and south channels, and the timber and plank structure in the brook bed to a point west of the stone foundation at the top of the Upper Factory.

The backhoe began removing material at the easternmost point of the Brook Corridor, immediately north of the easternmost of two north-south oriented stone walls that form small waterfalls in the brook. The backhoe removed several large, east-west oriented, level, parallel tree trunk timbers approximately 2 to 3 ft (60.9 to 91.4 cm) in diameter at three different elevations in the hillside east of TR-4-BC. The two lowest trunks were resting on what appeared to be horizontal prepared shelves in the bedrock ledge. The trunks consistently exhibited stages of decay, with well-preserved wood at the bottom, grading into orange rotted wood at the tops (Figure 5-36). The trunk timbers rested on and extended east from buried stone walls. The walls had been made of split pieces of schist that had decayed to a soft, yellow clayey and blue granular consistency. As the excavation proceeded south into the brook channel and west to the second stone wall, the upper layers of sandy sediment were solidified in an iron oxide matrix (ferricrete) (Figure 5-37).

The backhoe continued to encounter decayed stones and east-west timbers, which were nested in clusters of varying diameters in places. Several of the timbers were up to approximately 15 ft (4.5 m) long and 3 ft (91.4 cm) in diameter and had the ends sawn in chisel-shaped bevels (Figure 5-38). Long north-south round timbers were also encountered. The timbers just under the brook bed surface were encased in ferricrete, which broke off leaving impressions of the timbers. Once removal reached the east tip of the channel island, at the second stone wall, where the sloping grid of timbers and planks lay in the bed of the brook, major structural remains were encountered. At the lowest exposed elevation were east-west oriented timbers in a red coarse sand below decayed stones, transverse timbers and planks encased in ferricrete. The timbers included round logs as well as square hewn or sawn timbers with square or beveled notches in their ends. The timbers were not joined at the notches and simply appeared to have been recycled for use in building the cribwork structure (Figure 5-39). Three wood barrel staves in an excellent state of preservation were found loose in the excavated material, and were returned to the PAL facility for temporary curation (Figure 5-40). As excavation proceeded west the layer of red sand became the matrix for a wall of schist stones that had become softened from the action of low ph water so that the stones and matrix broke apart as a homogenous mass revealing their cross section (Figure 5-41). When

Figure 5-33. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), detail FEA-2-BC crystallizer structure showing underlying strata, looking northwest.

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Figure 5-34. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing (left to right) FEA-2-BC crystallizer structure and intact section of level plank floor on mortar, looking east.

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Figure 5-35. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing FEA-2-BC crystallizer in process of removal.

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Figure 5-36. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing decaying buried east-west oriented timbers in brook bed, looking south.

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Figure 5-37. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing timber and masonry construction in brook bed, looking south.

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Figure 5-38. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing large timber removed from brook bed.

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Figure 5-39. Photograph of 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing timber removed from brook bed.

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Figure 5-40. Photograph from 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing wood barrel staves retrieved during removal.

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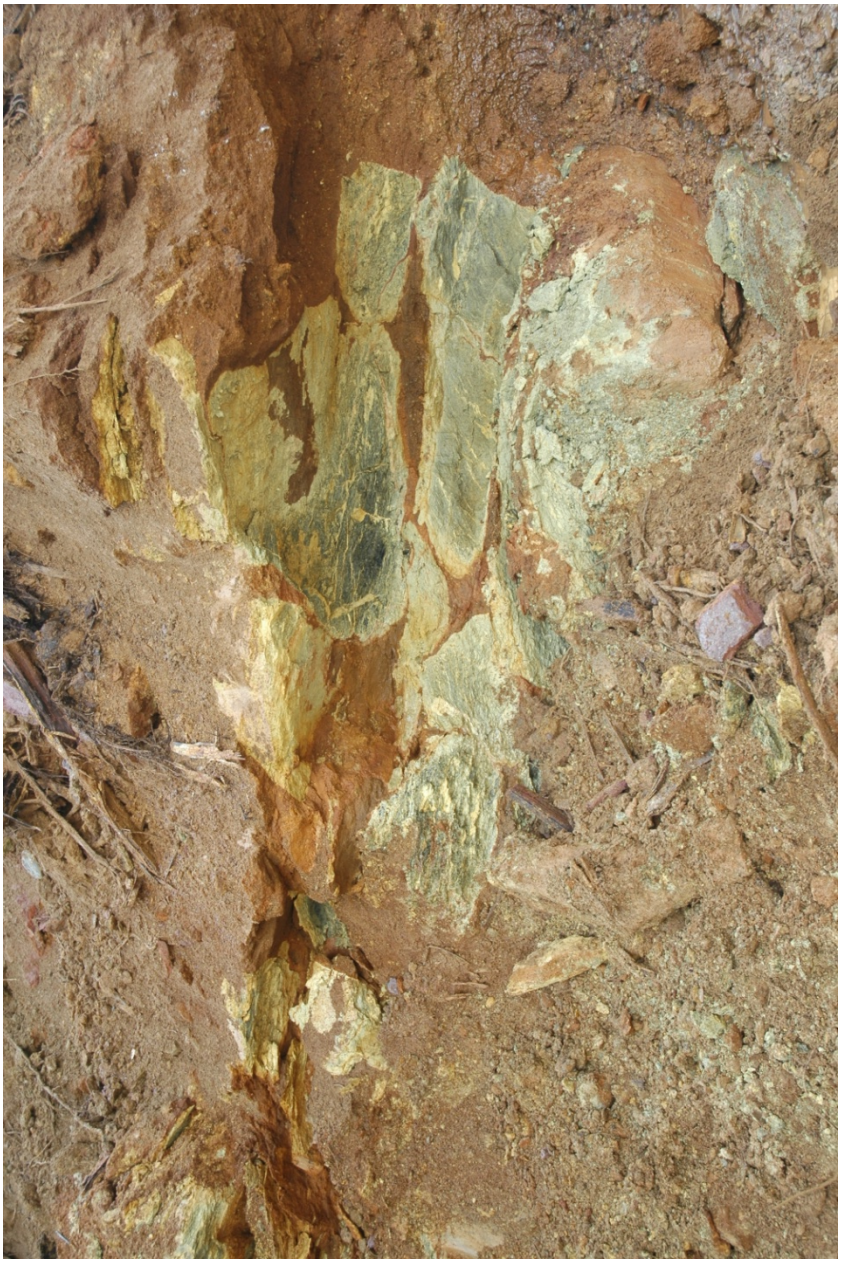

Figure 5-41. Photograph from 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing altered stone wall, looking west.

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the full height of this structural system was exposed it formed an almost 10 ft (3 m) high wall with large east-west timbers and round granite boulders at the bottom. These remains supported an approximately 4 to 5 ft (1.2 to 1.5 m) thick layer of decayed schist stones under an approximately 1 ft (30.4 cm) square long north-south timber backed by a layer of brown sand under an approximately 2 ft (60.9 cm) high section of mixed small rectangular stones and small north-south beams surrounding east-west oriented round timbers (Figure 5-42). This structure was capped by the east-west oriented plank layer exposed in the bed of the brook, and extended upslope to the west under the brook and the exposed and excavated crystallizers on the island between the brook channels.

The structural remains removed from the bed of Copperas Brook opposite and below the Upper Factory stone wall appear to be the eastern continuation of the sloping apron of heavy timbers and beams encountered during removal monitoring of the temporary haul road to the west. This structure is also similar to that encountered in TR-2-UC (see Chapter 4). The dense network of timbers and stone walls in the southeast corner of the structure appear to be the structural underpinnings of the southeast corner of a building. These structural remains can be interpreted as being associated with the Upper Factory or one of the other factories known to have been built at or near the Upper Factory location. It could be part of extensive site preparation engineering required to provide a stable factory substructure for the tiers of masonry process vessels in the wet environment of the sloping ravine where the copperas-bearing hillside runoff gathered. It may or may not have played a direct or indirect role in conveying copperas liquor. It could also be the floor of a copperas liquor reservoir for a factory that once stood below the Upper Factory, possibly associated with the copperas processing vessel remains found at the North Berm and/or South Berm.

Ore Roasting and Leaching Area

The Ore Roasting and Leaching area refers to the roughly triangular area of open barren hillside east of the North Open Cut and west of the Upper Copperas Factory, bisected by Copperas Road. This area is sometimes considered “TP 3” but that name also technically refers to the larger cleanup area including the open hillside but also extending east beyond Mine Road (see Figure 1-3). PAL assisted Weston Solutions, Inc. with archaeological monitoring of geotechnical test pits on TP 3 in 2006. This monitoring indicated that ore roasting took place in a broader area across the hillside than indicated by the presence of characteristic red hematite waste material visible at the surface, and revealed the unusually colorful soil stratigraphy associated with the roasting and leaching and subsequent chemical alteration of the waste material (see Appendix E).

PAL monitored removal of mine waste from much of the open hillside during the winter of 2009-2010. The presence of the characteristic red hematite waste material at the surface and in the removal excavations further indicated that ore roasting and leaching took place across a large portion of the hillside below the North Open Cut, and narrowed toward the Upper Copperas Factory. Monitoring across the hillside revealed the remains of roast beds, ore leaching piles, timber and masonry structures and copperas liquor conveyance features, as well as artifacts including mine car track, pipe, cable, and wood troughs. The objective of the EPA cleanup removal was to remove mine waste until either clean glacial till or bedrock was reached. This methodology resulted in removal of waste to bedrock on the majority of the hillside south of the Upper (1831) Adit/Cob Shop/Blacksmith Shop area, and removal to till and capping with crushed rock in the area to the north. This transition zone may reflect the northern extent of the “prepared bed or bottom upon which the ore is burnt and leached…upon the hillside just below the vein…prepared by simply scraping the earth clean from the ledge...nearly an acre in extent…called the leaching ground” in the 1871 description of the works (Duncan 1871:1085–1088). The mouth of the Upper (1831) Adit (see Figure 2-15) and a vertical shaft (see Figure 2-16) were also located, opened, and

Figure 5-42. Photograph from 2010 Copperas Brook Corridor removal monitoring (lower/east section), showing timber and masonry construction in brook at east edge of TR-6-BC, looking west.

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temporarily sealed pending installation of grates to allow bat passage and safe public viewing and interpretation (see Figure 2-12). The Upper Adit is depicted on the 1874 plan of the Copperas works, and the identified vertical shaft is likely the one shown adjacent to the east side of the road on this same plan (see Figure 3-9). The monitoring field notes and photographs are included in this report as Appendix F.

Monitoring in the Ore Roasting and Leaching Area during the week of January 11, 2010 included a mound covered with dense brick scatter near the center of the slope, approximately 100 ft (30.4) southwest of the Upper Adit and approximately 50 ft (15.2 m) west of Copperas Road. The PAL monitor observed the Caterpillar backhoe encountering timbers, posts, beams and planks within the mound. As excavation continued the beams and posts appeared to be interlocked making it difficult to expose the structure. Shallower passes with the arm of the backhoe exposed a concentration of bricks. Further excavation revealed intact portions of north and west brick walls. The monitor directed the backhoe operator to make narrow north to south passes across the feature to bisect it. Excavation revealed pieces of cast iron bar and plate, burned common brick, deep red soils, and vitrified red clay. Large rectilinear blocks of split granite were observed in the center of the structure (Figure 5-43). A forged wrought iron bar was also encountered (Figure 5-44). Wood beams with mortise and tenon joints, possibly supports for the structure, were found around the feature. As removal progressed extensive horizontal deposits of red mine waste and black ash were encountered.

The only documentation of a structure at this location is an 1845 "Sketch of the Copperas Works, Strafford, Vermont" by geologist Charles T. Jackson that appears in C.B. Adams' *First Annual Report on the Geology of the State of Vermont* (see Figure 3-8). The feature in question appears to correspond with the building "*b* the cobbing shed" which is shown between "*a*" the mine and what appears to be Copperas Road, above "*c* the roasting heaps and *d* the factory" which is shown at the bottom of the sketch (Adams 1845:56). The feature in question could be interpreted as the remains of a heat-related masonry structure inside the cobbing shed such as a blacksmith's forge for heating, sharpening and annealing the drills and other tools used for mining the ore, or possibly a boiler for heating the structure, which had one chimney as indicated in the Jackson sketch. Blacksmith's shops were ubiquitous structures at hard rock mines, commonly located close to the mine workings. No other buildings are indicated in the Jackson sketch. The masonry materials, iron artifacts and extensive red and black soils are also consistent with the materials and scale of structures interpreted as copperas liquor boilers within the Upper Copperas Factory and North Berm (see Chapter 4). Considering the apparent size of the structural remains, it is also reasonable to interpret it as a copperas liquor boiler, possibly part of an undocumented early, smaller copperas factory located higher on the side of Copperas Hill, closer to the source of ore at the North Open Cut.

Figure 5-43. Photograph of 2010 Ore Roasting and Leaching Area removal monitoring showing remains of masonry structure, looking east.

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Figure 5-44. Photograph of 2010 Ore Roasting and Leaching Area removal monitoring showing iron bar retrieved from remains of masonry structure.

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CHAPTER SIX

ANALYSIS AND INTERPRETATIONS

The universe of information available to analyze and interpret the results of the copperas factories data recovery and address the research questions is limited to the collected written travelers' accounts, mine company records and associated historical background information (see Chapter 3); the evidence presented in the field results themselves and interpretation of those results (see Chapters 4 and 5); local history; the specific constraints and phenomena of applicable chemistry and geology; the collective knowledge of historic mining and chemical processing in general; and an understanding and application of contemporaneous economics and best practices. This chapter presents discussion and analysis of some aspects of this universe of information applicable to the copperas factories to establish realistic constraints on interpretation. It then presents the original research questions from the 2003 PAL survey report, and responds to those questions in the light of the results and constraints. Analysis and interpretation of the artifacts are also included in this chapter. Many features and artifacts documented during data recovery (Chapter 4) and monitoring (Chapter 5) have already been interpreted in those chapters. Not all of those results and interpretations will be addressed in this chapter; only the ones most fundamental to the research questions and major unanticipated findings will be revisited. The most fundamental questions posed before or during the field work include the purpose of the buried timber and plank structural system at the Upper Factory, the function and relationships of the major features in the Lower Factory, and the functional and historical relationship of the features in the North Berm and South Berm to the rest of the site.

Impacts of Natural Processes

The Elizabeth Mine copperas factories presented an unusual, if not unique set of natural and man-made circumstances for an archaeological excavation. The steep topography, history of soil disturbance and erosion and redeposition, unusually low ph soil chemistry, rock alteration, and timber preservation and decay presented unusual phenomena that challenged traditional understandings. Natural processes appear to have played a significant part in the selective degradation or preservation of features and artifacts during the 70+ years of copperas manufacturing and approximately 130 years since manufacturing ceased. As noted in Chapter 3, after copperas production ceased about 1884, the waste rock, ore leach piles and roast beds on the TP 3 hillside remained largely barren. The landscape was then impacted by additional cycles of mining activity, erosion and road maintenance from copper mining in the 1880s and 1942-1958, as well as later modern logging road maintenance. Erosion removed material in some areas and redeposited it in others at lower elevations on the hillside. The headwaters of Copperas Brook carved a gully through the steep area at the south side of the Upper Factory, exposing structural timbers and depositing fine-grained mine waste across the flatter area below.

On a more discrete scale, the mine groundwater has continued to chemically leach and alter the soils and mine waste and the masonry and timber features and various artifacts embedded in them. As documented in USGS and other studies, the ph of the TP 3 groundwater is as low as between 2 and 3. In addition to relative isolation from free oxygen, which tends to preserve materials, features and artifacts buried in soil and/or located at or below the water table have been infused with dilute iron sulfate, itself a wood preservative inimical to microscopic biological life. This low oxygen, low ph environment contributed to a generally high degree of preservation for wood structures, some of which retained adze and saw marks.

It also contributed to preservation of wood artifacts including barrel staves, tool handles, chips, and a wagon wheel, and other organic materials such as leather. Conversely, exposure to weak sulfuric acid and wet conditions resulted in pronounced deterioration of ferrous metal objects and artifacts, as well as selective deterioration of calcareous lime mortar and local building stones, particularly schist blocks which were softened through leaching of their aluminous components (micas).

Analysis of Historical Accounts

The written historical documentation for copperas manufacturing at Copperas Hill include multiple travelers' accounts spanning from 1817 to 1871, and U.S. Census of Manufactures information from 1810 to 1870. Additional information in the form of company records for several years between the 1860s and 1880s came to light as this report was being finalized (Abbott n.d.); not all of this information was included in this analysis. This new information does not appear to have the potential to change feature interpretations; however; it does appear to change the understanding of conditions during the latter two decades of operation. Previously the works were thought to have been in decline with reduced output (400 tons per year ca. 1870 according to the U.S. Census of Manufactures), particularly in the 1870s, with a shutdown date of 1882. It now appears that the works were more productive (1,200 tons in 1878) and may have sold, if not made, their last copperas as late as 1884 (Abbott n.d.: 188). The travelers' accounts and geological reports provide information about the factory buildings, dimensions and annual output; and equipment construction, sizes and process that are useful for the interpretation of the archaeological data recovery results. The descriptions of the manufacturing process are generally consistent, dimensions for factory buildings and process vessels given are specific, and additions and changes to the process and equipment over time are recorded. Upon careful analysis, comparison, and application to the archaeological findings, repetition or omission of information does call the accuracy of some written information into question.

Employment

The available employment statistics for the copperas works suggest that employment may have been seasonal, or highly variable. The figures sometimes appear inconsistent compared to corresponding reported plant output statistics and sizes.

The *Columbian Centinel* indicated that from thirty to forty workmen were employed in 1827 (anon., *Columbian Centinel* December 1, 1827:1). In 1831, there were 75 workers reported at the Strafford and Shrewsbury, VT works, although it is unclear if that is the total for both works or the number at each (Tyson 1831: 180). A note in an early 1830s ledger from the Copperas Hill store operated by Justin Morrill contains the following quote: "August 1833 there are 210 men employed on the copperas workings on the hill . . . there is not one now, Nov. 28, 1834 (Vermont Historical Society, Justin Morrill Papers). The high August figure may include workers associated with the copper smelting operations conducted by Isaac Tyson at that time, and associated support workers. The zero employment figure for late November may indicate that the work was seasonal and stopped when the ground froze or was covered in snow. According to the 1850 census, the company employed an average of only 15 hands (U.S. Census of Manufacturers 1850). The 1860 census notes an average of 45 employees (U.S. Census of Manufacturers 1860). The 1870 census includes data for the copperas works, then owned by the New England Chemical Company, indicating that only seven men were employed (U.S. Census of Manufacturers 1870). The 1880 U.S. Census of Manufacturers lists the greatest number of hands employed at any time of the year as 30, with two-thirds of the work force aged 16 years or younger (U.S. Census of Manufacturers 1880). (Note: The Nash Papers transcripts by Collamer Abbott (Abbott n.d.) (see Chapter 3) contain monthly employment figures for several years in the 1860s through 1880s; the late discovery of that information precluded analysis of employment information for this report.

Factory Buildings: Dimensions and Output

The copperas factory area hosted several factories, including at least one early one of unknown dimensions, and at least five later ones of known dimensions, which appear to have operated in at least two successive pairs (see Figure 3-6). The Upper Factory site including the North Berm and South Berm appears to be the location of most of these factories, in "the declivity quite below the mine" on a slope to facilitate the gravity process (Locke 1821:326–330). The Lower Factory was located several hundred feet away from these factories, on more level, well-drained ground.

A factory of unknown size was operating by 1809 and made about four tons of copperas. (U.S. Census of Manufactures 1810). The 1820 U.S. Census of Manufacturers indicated that annual production had risen to 100 tons, and the works were described as "in good condition—establishment declining" (U.S. Census of Manufacturers 1820). Zadock Thompson reported in 1824 that in 1822 the works had been considerably enlarged, with one factory measuring 180 ft by 46 ft (8,280 sq ft) (Thompson 1824:251–253). This statement implies that there was an earlier factory of unknown size prior to 1822. The 1827 *Columbian Centinel* account indicated two factories, an "upper factory" (size not given) located approximately "ten rods" (165 ft) uphill from a "lower factory" 267 feet long and 94 feet wide (25,098 sq ft), including a packing department. This description also noted that in the south part of the works, there were several temporary buildings erected for preservation of copperas. Annual production at this time was about 800 tons (anon., *Columbian Centinel* December 1, 1827:1). In 1835 annual production was 1,000 tons (Niles Weekly register 1853:395). Zadock Thompson reported again in 1842 that there were two factories, both 267 ft by 94 ft., for a total of 50,196 sq ft. of production space. It is unclear whether the "upper factory" referred to in the 1827 account was the original 180 ft by 46 ft factory present in 1824, or a second 267 ft by 94 ft factory. In 1842 production averaged 1,000 tons annually (Thompson 1842:167–168). In 1844 and 1849, production was reported at 1,600 tons, and an 1854 report listed production at 1,500 tons (Abbott *GMC* 1964:19, 35). In 1860 annual production dropped to 400 tons (U.S. Census of Manufacturers 1870). (Hemenway's 1871 *Vermont Historical Gazetteer* indicated two factories, but of considerably smaller size. Each was 110 ft in length by 25 ft in width, for a total of only 5,500 sq ft. Annual production from these factories in 1870 was reported to be 500 tons (Duncan 1871:1085–1088, U.S. Census of Manufacturers 1870). The last factories are described as on level ground: "Upon a level spot below are the two factories of the Company, each 110 feet in length by 25 feet in width." (Duncan 1871:1085–1088).

The increases in the numbers of factories and increases and decreases in reported factory dimensions roughly correspond to increases and decreases in reported overall annual copperas output over time (see Figure 3-6). The ratio of dimensions to capacity for the 1870s factories suggests a more efficient operation than the previous pair of factories. It is unclear, however whether the dimensions given for any of the factories over the life of the works includes non-production areas such as storage for raw materials or packing and warehousing for manufactures copperas crystals. The 1850 U.S. Census of Manufacturers indicated that the Vermont Copperas Company made 4,000 tons of copperas. This appears anomalous, representing a more than twofold increase over previous figures, with no documentation of corresponding factory expansion (U.S. Census of Manufacturers 1850). This figure has been discounted for the purposes of this analysis (see Figure 3-6). New information from company records indicates that the works produced 1,200 tons of copperas in 1878 (Abbott n.d.: 188).

Factory Dimensions Analysis

The sizes of the factories as reported in the travelers' accounts are difficult to reconcile with the results of the archaeological mapping. All buildings are assumed to have been essentially barn-like, post-and-beam structures with their long (roof ridge) axis roughly parallel to ground contour lines (see building in 1880s photo, Figure 3-9).

In 1822, there was reportedly one factory measuring 46 ft by 180 ft (Thompson 1824: 251-253). The width of this factory could have matched the short, north-south dimension of the Lower Factory, especially if there were indeed crystallizers below the stone wall as observed in data recovery and monitoring. The length is a bit long for the Lower Factory, but could have fit if the building extended west past the short west wall and east covering part of the access ramp. This hypothesis conflicts with the interpretation of the lower factory as one of the last, 1870s-1880s factories, an interpretation supported by the quantity and date range of manufacture of the artifact assemblage as well as the good integrity of workspace floor features in the Lower Factory. It also conflicts with the description of the last factories as having been built on flat ground, a possible move away from the problematic steep, wet Upper Factory location. The 48 ft width could possibly match a factory building at the Upper Factory site, but only if it had crystallizers arranged in a narrow east-west band. The 180 ft length appears to be one third to one half too long for the documented Upper Factory remains.

In 1827 two factories were reported, one of them 94 ft by 267 ft (Columbian Centinel 1827:1). The 94-ft width could have covered all of the identified Upper Factory (not including North Berm, located some 60 ft away), but the length is grossly out of scale for the length of the recorded Upper Factory features. The estimated distances between buildings given in rods in this account appear questionable in this description. In 1842, two factories were reported with the same dimensions as the one reported in 1827. This may be a simple repetition and/or generalization using the same specific dimensions. It seems unlikely there were two buildings that large on site based on the archaeological results. The dimensions of the boilers in both accounts is also the same, although the reported number of them is different.

In 1871 two factories were reported, 25 ft wide by 110 ft long (Duncan 1871: 1085-1088). These dimensions appear to be too short in both length and width to fit the Lower Factory. The width fits the north-south span between the long stone wall and the rear (south) sill, but does not take into account the crystallizers on the lower (north) level. The length is too short to include the interior masonry features. The length could accommodate the north-south extent of the Upper Factory, but not the east-west width of recorded features.

The copperas factory in Figure 3-9 appears to be quite wide east-to-west, with a long, deep east roof plane following the slope of the hillside. The west plane was likely shorter. This building could have been 94 ft wide east-to-west, however, it does not appear to be anywhere near 267 ft long on its north-south axis.

Ultimately the reported dimensions appear to be somewhat ambiguous or of questionable accuracy, and are not much help in dating the Upper Factory or Lower Factory. In the case of the Upper Factory, this may be because it is the site of several overlapping factories constructed over time. The 1,200 ton company production figure for 1878 (Abbott n.d.: 188) is more consistent with the 1,500-1,600 annual production figures given during the period of earlier, much larger reported factory foundation sizes than the 500 ton figure reported to the U.S. Census of Manufactures in 1870, when reported factory dimensions were radically smaller (Duncan 1871:1085–1088).

Factory Buildings: Manufacturing Equipment

The historical accounts offer important details of the copperas manufacturing process; the numbers, materials and sizes of vessels; and additions and changes to the process and equipment over time.

Dr. John Locke reported in 1821 that the factory contained an unspecified number of "evaporating vessels" (boilers) with lead bottoms that measured about 10 ft square with sides three to four feet high. The bottoms were described as supported by a number of parallel brick walls at a small distance from each other, with "arches" in these walls connecting the firebox arch at one end with draft flue at the other. After boiling, the copperas liquid (liquor) was then drawn off into cisterns (crystallizers) to crystallize on branches. Once the crystals were formed, the remaining liquid was drawn off and returned to the boilers (Locke 1821:326–330).

The 1820 US Census indicates that the factory contained three boilers and six crystallizers, a 1:2 boiler-to-crystallizer ratio (U.S. Census of Manufacturers 1820).

Zadock Thompson described the 1822 conditions at the improved works in 1824. According to Thompson, the factory contained four lead boilers weighing about 2,500 lbs., where the liquor was boiled and then partially cooled. It was then transferred to the crystallizers. After crystallization, the liquid was returned to the boilers, mixed with fresh liquid, and boiled again (Thompson 1824:251–253).

The operation was described in the 1827 *Columbian Centinel* as having two factory buildings, an "upper factory" and a "second factory." The two factories were described as containing ten lead lined vats, presumably boilers, measuring about 12 by 10 ft, and 21 inches deep. The liquid was transferred from these vessels to wooden vats to crystallize. It is unclear from the description whether each factory contained ten boilers, or whether there were five in each, but the latter seems more likely. This account also indicated that in the south part of the works several temporary buildings were erected for preservation of copperas (anon., *Columbian Centinel* December 1, 1827:1).

The copperas works were described in *Niles Weekly Register* in 1835. The copperas liquid collected from the hillside was first partially evaporated in the boilers. It was then drained into vats called coolers, and from there into the crystallizers. This is the first mention of cooling vats between the boiling and crystallizing phases. This account was also the first to mention use of suspended rods instead of branches in the crystallizers (*Niles Weekly Register* 1835:395).

Zadock Thompson again described the works again in 1842. At that time there were two 267 ft by 94 ft factories. The factories contained eight lead vats (boilers) 10 ft by 12 ft by 21 inches deep, lined with ¾" thick lead. It is unclear from the description whether each factory contained eight boilers, or whether there were four in each, although the latter seems more likely. The liquid was drained into wooden vats where it crystallized on hanging dowels. The copperas crystals were then shoveled into packing rooms (Thompson 1842:167–168).

Edward Hitchcock, in his 1861 *Report on the Geology of Vermont*, reported that after boiling, the copperas liquid was placed in vats of lead or brick and "water" [hydraulic] cement, called crystallizers, where it took eight to ten days to crystallize. The remaining liquor was pumped back into boilers (Hitchcock 1861:829–832).

The last detailed account of the copperas works appeared in Hemenway's 1871 *Vermont Historical Gazetteer*, which described the equipment in each of two 110 ft long by 25 ft wide factories. Each factory contained two evaporating pans (boilers), each 26 ft long by 10 ft wide and 16 inches deep, lined with ¼ inch thick lead. Beneath the pans ran a series of flues, commencing at the "fire arches" at one end and in

a stack at the other. Each factory contained two lead lined coolers and 20 cemented brick crystallizers. These factories had a boiler-to-crystallizer ratio of 1:10. The 1871 larger, fewer boilers-to-more crystallizers ratio suggests a more efficient operation than the 1820 ratio of 1:2. After boiling the copperas liquid was drawn into the coolers and allowed to cool for 2 or 3 hours to settle impurities. The liquid was then passed into the cemented crystallizers in each factory, each crystallizer being 14 feet by 7 feet by 18 inches deep. The remaining liquid was drained off and pumped into the evaporating pans to mix with fresh liquor. The crystals were shoveled down into the packing room directly beneath the crystallizers (Duncan 1871:1085–1088).

Copperas Vessel Counts

The historical travelers' accounts and geological surveys list at least a half-dozen separate factory buildings at Copperas Hill over some 70 years. The Nash Papers transcriptions include several mentions of building "new" factories and building new or repairing existing brick and lead boilers, heaters, coolers and crystalizers in the factories. According to the accounts in Chapter 3, the works had three boilers and six crystallizers (1:2 ratio) in 1820. In 1822 the works had been "considerably enlarged" (assuming new equipment) with four boilers, and possibly eight crystallizers if the conservative1:2 boiler: crystallizer ratio is used. In 1872 the works had much bigger "upper" and "lower" factories (presumably with new equipment), with either ten or twenty "vats" (boilers) in each, and therefore possibly 20 or 40 crystallizers if the 1:2 ratio is used. In 1842 there were two factories of the same size, with either eight or sixteen boilers, and therefore sixteen or 32 crystallizers if the 1:2 ratio was still used. In 1871 there were two smaller factories (presumably with new equipment) with a total of four boilers, four coolers, and forty crystallizers (a 1:10 boiler:crystallizer ratio).

Over a span of 73 years there were, if conservatively interpreted, 21 boilers and 74 crystallizers, and, if liberally interpreted, 31 boilers and 94 crystallizers. There may well have been more vessels if the figures are interpreted differently and/or were rebuilt more often as suggested in the Nash Papers transcriptions, which indicate that rebuilding was an annual pre-production season activity. These constructions would have required a tremendous quantity of brick, some percentage of which was likely reused, but with considerable use of new brick, particularly in the high-heat boiler applications. The factory sites and surroundings contained considerable brick scatter, but no copperas vessel remains were visible above ground, and limited areas of brick floor survived under thin soil cover.

The lack of brick structural remains extending above ground (as well as low counts for other potentially valuable architectural and process materials such as well-cut stone and larger pieces of lead) suggests extensive post-shutdown scavenging for building materials. One documented account suggesting that activity was found in the records of the Stafford Historical Society. On March 24, 1891, the diary of Arthur and Jennie Judd, South Strafford, includes the entry "bought 150 brick of George Roberts for 75 cts." The Business Directory of Hamilton Child's Gazetteer of Orange County (1888) lists George W. Roberts of Copperas Hill as watchman for the Strafford Mining Co., in charge of the mines (Judd 1891). This diary entry suggests that the mine company (or at least Mr. Roberts) was selling brick from mine structures to local buyers. There is no record of the Tyson or any other mining concerns of the period manufacturing their own brick.

Copperas Vessel Materials and Construction

According to archaeologist Tim Allen, the "dangerous, complicated and highly noxious industrial process" involved in eighteenth-century copperas manufacturing "…was heavily capitalised. It required huge investment in plant and materials…" (Allen 2002). Indeed, the nineteenth-century South Strafford operation also clearly required major capital investment to construct and reconstruct factories, particularly brick and lead for copperas processing vessels.

The factory operators had to build and repair specialized masonry furnaces and vessels requiring both locally-produced common red brick and specialty refractory silica brick. The 2003 PAL survey indicated little or no presence of common brick at domestic and agricultural sites, suggesting it was little used, or simply scavenged at non-industrial sites. Sources of common brick documented in nineteenth-century atlases include the Connecticut River towns of Brattleboro, Bellows Falls, Putney, Springfield, Windsor, Hartford, etc. Obtaining common brick from these locations would have involved the transportation challenges and costs of moving the brick ten miles inland and up 800 ft of elevation. Less well-documented, but clearly an alternative, were local sources of brick from glacial or river terrace clay banks, which could have been fired in simple "scove" type kilns made of a shell of the raw bricks themselves. According to Strafford Land Records, Book 2, page 209, a deed dated October 15, 1803, from Isaac Libbee to Simon Libbee, for the "consideration five hundred dollars, conveys part of the north end of Lot number 36 in the 2nd division -- including half the bed of clay and half the wood needed to burn brick in the brickyard on [said] premises." This land is in the "Upper Village" (Strafford) (Strafford Land Records 1803). This indicates common brick was being "burned" (fired) from local clay as early as 1803, approximately six years before copperas operations started. A March 31, 1887 entry in the diary of Arthur and Jennie Judd, South Strafford, refers to someone going " up to the Upper Village to see about brick for [sugar house] arch" (Judd 1887). If this brick was made there, it suggests common brick may have been available locally throughout the life of copperas operations. Indeed, the presence of mid-nineteenth century brick buildings in South Strafford, and particularly Thetford Center, indicates the availability of locally-made brick. Silica firebrick had to be brought in from sources as far as Boston, MA, or even Scotland (see discussion of ST-1-UC in Chapter 4).

The erosive action of boiling acid in the copperas liquor boilers also reportedly consumed large quantities of lead, a metal not found or mined (in economic quantities) or smelted or fabricated in New England. According to Isaac Tyson, one of the early Copperas Hill works owners, “The smelters of the lead of our own mines in the Far West, here find an important ally. Large quantities of this metal are used in the construction of chemical works, and some is consumed in the manipulations” (Tyson 1831: 180). Again, at the Copperas Hill works: “Lead is the only metal that will endure the operation of the copperas liquor, and this requires constant repair. . . “ (Thompson 1842:167–168). Sulfuric acid at the strength of 35 degrees Baume reportedly required for the process approximates fresh sulfuric car battery acid in strength, which will cause serious flesh burns and rapidly deteriorate wood, leather, fabric and other organic materials. Lead was required in the boilers, but the succeeding cooling and crystallizing vessels were lined of lead, and later, "water cement," (hydraulic cement) which, like lead, did not dissolve in the acidic solution: “The liquor is then placed in vats of lead or of brick and water cement, called crystallizers... (Hitchcock 1861:829–832), and: “cemented brick crystallizers” (Duncan 1871:1085–1088).

The boiling process also included addition of large quantities of scrap iron that was likely scavenged and purchased from sources both near and far. The scrap iron was added in batches during a "boil" to maximize the percentage of dissolved iron in the concentrated copperas liquor. Dilute fresh and spent liquor was added periodically as well. This process required skilled operatives who paid careful attention to the addition of materials and the density of the liquor so that the acid reached, and was maintained at, the required strength without damaging the lead boiler lining. According to the late seventeenth century account, “About 100 lb of scrap iron was placed in the boiler before the introduction of the liquor and a further 1,500 lb was added later, along with more liquor to stop the boiling solution becoming too dense and acidic and melting the boiler. The reason for adding iron was to convert the sulphuric acid (H2SO4), condensed through the boiling process, into copperas (FeSO4)” (Allen 2002).

Possible similarities in construction and operation between a copperas boiler and a traditional maple sugar boiling pan have the potential to provide insight into the Copperas Hill boiler construction and operation. The PAL senior industrial historian had the opportunity to inspect and discuss a maple sugar shack and equipment located in Thetford, VT in May 2011 with owner Tig Tillinghast (Tillinghast, personal

communication 2011). A maple sugar boiler consists of a multiple-section combustion and boiling apparatus, with the hot combustion gases generated in a firebox at one end, and pulled under the boiling pan by a draft generated by a draft stack at the end opposite the firebox. The firebox is a hopper-shaped, rectangular, wood-fired iron firebox with conventional grate bars at the bottom. The combustion draft is let in at the bottom of the front of the firebox, through a low, wide hinged door that doubles as the ash pit door. The draft is pulled up through the grates, through the burning wood fuel, and through a passage called an "arch." This is not a conventional arch facing the fire with its barrel axis parallel to the air flow, like a simple tunnel. It is a transverse vault with its barrel axis perpendicular to the hot air flow. This "arch" directs the air through a horizontal aperture, forming and directing a narrow, laminar flow band of hot gas under the syrup boiling pan. This allows tight control of the radiant heat under the pan required to boil the syrup and not melt the pan itself. This same simple configuration and phenomenon could be used to heat the underside of a lead, or lead-lined iron vessel to the boiling point of copperas liquor, while keeping it well below the 620 degree melting point of lead (Tillinghast, personal communication 2011). This new understanding of possible furnace construction, as well as the specialized meaning of the word "arch," presents new implications for the copperas boiler construction as described in the historical accounts: “The avenues or arches between these walls communicate at one end with the *arch* in which the fire is placed, and at the other with the common flue" (Locke 1821:326–330), and “Beneath the evaporating pans run a series of flues, commencing at the *fire arches* at one end of the pans and terminating in the stack at the other end” (Duncan 1871:1085–1088) (author's italics).

Factory Economies and Efficiency

The South Strafford copperas factories appear to have been a quintessential “frugal Yankee” operation. According to the descriptions of the works found in narrative travelers’ accounts and scientific literature written between the 1820s and 1870s, the operators of the South Strafford works made incremental improvements over time to conserve energy and labor, increase efficiency, and increase volume and quality of product (see discussion in Chapter 3). They took advantage of natural processes including gravity, oxidation and evaporation to increase production and conserve fuel, and recycled process liquor and building materials. Indeed, the driving economic goal in all industrial processes is the reduction of energy input, materials consumption and labor, and increase in product quantity and quality. Copperas works owner and operator Isaac Tyson reported that “Almost every chemical process requires the aid of heat. Immense quantities of fuel are consequently consumed in the laboratories [factories]…The benefit accruing to the landed interest, by reason of this great demand, on the forests and the mines, and the employment given to the laboring class, in cutting wood and mining the coal, and in transporting it to these markets, cannot but be appreciated by all reflecting persons” (Tyson 1831: 180). The copperas works also required additional workers to mine ore, roast and leach it, pack copperas casks, and drive draught animal teams. All of this industrial activity was focused at a then-remote rural location, 800 feet above and ten miles from regional water or rail transportation at the Connecticut River. Transcriptions of correspondence in the Nash Papers confirm that copperas manufacturing was seasonal, with production taking place over eight months from mid-April to mid-December (Abbott n.d.).

At first the mined ore was simply watered in heaps at the top of the hill to slowly release the dilute copperas liquor. By 1818, after about a decade of operations, operators added a roasting step that quickly decomposed the ore and released the copperas much faster and in greater quantities. The works incorporated a cascading process that took great advantage of gravity and the flow of water for materials handling. The operators took advantage of the natural bowl-like topography on the east slope of Copperas Hill, creating a heap leaching and liquor collection system that was augmented by man-made channels in the bedrock. All the dilute copperas liquor generated on the hillside was directed by a giant funnel to a single point above the Upper Factory site in “the declivity quite below the mine” (Locke 1821:326–330). By 1861, the dilute liquor was percolated through branches in brick towers, using natural

evaporation to incrementally raise the density of the liquor instead of wood fuel in the initial boiling process.

From the beginning, advantageous use of topography and gravity was employed in the tiered production levels inside the factory as well: "This gives great facility to all the operations, allowing the various reservoirs to be so arranged one above another that the liquor may be transferred from one process to another merely by means of a trough. (Locke 1821:326–330). Several items of correspondence transcribed from the Nash Papers indicate that by the 1860s the boilers or boiling process may have included “heaters” to preheat the incoming liquor in the boiler to conserve energy (Abbott n.d.), a feature of copperas boilers used in England in the late seventeenth century.

In 1822 the copperas liquor at South Strafford was being "suffered" to partially cool in the boilers before being let off into the crystallizers, without a separate, intermediate cooling vessel yet employed. In the seventeenth-century British process, there was also no intermediate step between boiler and what we call a “crystallizer.” In the Deptford process the hot boiled copperas liquor went directly to a vessel where both cooling and crystallizing both took place. According to the written account of the Deptford works, regarding the copperas crystals: “That which sticks to the sides, and to the bushes, is of a bright green, that in the bottom, of a foul and dirty colour” (Colwall 1678: 1059). This process clearly had waste associated with it. No intermediate "cooler" phase is shown in the Agricola or Diderot illustrations. At South Strafford, a separate cooling vessel and step was added by 1835: "...when sufficiently heated it is again let off into vats called coolers, and from there it passes into other vats where the process of crystallization takes place” (*Niles Weekly Register* 1835:395). Coolers were reported in the last account of the works in 1871: "...the liquor passes directly to the factories where it is received in large reservoirs, whence it is drawn into the evaporating pans [boilers] as needed. In these pans it is boiled down till it reaches the strength of 35º when it is drawn into the lead coolers and there allowed to stand two or three hours in order to settle any impurities which may still remain. When quite cool it is passed into the cemented crystalizers” (Duncan 1871:1085–1088). This step allowed the unwanted particulates to settle out, resulting in a larger quantity of marketable copperas per batch. This may also have allowed for faster throughput and fuel conservation in the boiler itself.

Spent liquor from the crystallizers was reportedly recycled to the primary boilers and reboiled throughout the life of the Copperas Hill operation: “When the crystallization has proceeded as far as it will go, the remaining fluid is drawn off and returned to the evaporating vessels” (Locke 1821:326–330). “When the crystallization ceases, the water is again returned to the boilers, mixed with water from the leaches, and again evaporated” (Thompson 1824:251–253). “The water remaining in the crystallizers is then pumped back into the boilers, the crust of copperas removed, and, after being sufficiently drained, it is packed in casks ready for market” (Hitchcock 1861:829–832). “The liquor of crystallization is then drained off and pumped into the evaporating pans, where it mingles with the fresh liquor. This process is repeated with the liquor of crystallization ad infinitum” (Duncan 1871:1085–1088). By 1842 the labor involved in harvesting the crystals from the irregular armatures consisting of tree branches had been reduced by replacement of the branches with rows of wood dowels of regular length and spacing. The packing house was located directly below the crystallizers to facilitate efficient loading of shipping casks.

In addition to boiling and crystallizing the primary product, copperas, the South Strafford operation also realized profits from a process co-product, copper. The addition of the scrap iron in the boiling phase resulted in precipitation of black "copper mud," which was collected as early as the 1820s.

Research Questions

The following section presents the original research questions presented in the 2003 PAL survey report and the 2009 PAL data recovery plan, and responds to those questions in the light of the data recovery

and monitoring results, in the context of the historical information discussed above. Many features and artifacts documented during data recovery monitoring have already been interpreted in Chapters 4 and 5, respectively, including the Inter-Copperas Factory Area and Pine Grove. This chapter addresses results and interpretations fundamental to the original research questions regarding the Upper Factory, Lower Factory and Inter-Copperas Factory areas, as well as the unexpected finds at the North Berm and South Berm. The most fundamental questions raised before the fieldwork include the purpose of the buried timber and plank structural system at the Upper Factory and in the Brook Corridor, and the function and relationships of the major features in the Lower Factory. Additional questions associated with the unexpected finds at the North Berm and South Berm address the possible functional and historical relationship of those features to the rest of the site.

Research Question 1

Are the "foundation" walls actually outer foundation walls of the factories, or interior walls dividing production and/or packing levels, or retaining walls located outside the factory for access roads?

The "foundation" walls referred to are the prominent surviving standing L-plan walls comprising the primary visible stacked masonry structures at both factories, and demarcating the most pronounced topographic levels at each factory site. Results of data recovery clearly indicate that the walls at both factories were interior walls dividing production functions.

At the Upper Factory, where the short south wall and longer, less intact north-south section are the most prominent feature, additional long, parallel stone walls flanking the long north-south wall to the west and east were identified, partially excavated and mapped during data recovery. The exposed and buried remains of masonry copperas processing vessels were found both west and east of the wall. West of the wall, masonry remains interpreted as the bottom of a copperas liquor boiler were recorded in FEA-7-UC in ST-3-UC. Opposite that feature and east of the wall, at a lower level, masonry remains interpreted as a copperas cooling vessel were recorded in FEA-6-UC in ST-1-UC. The presence of copperas vessel features on both sides of the wall, representing different and successive processes known to have been conducted within the factory building, and the presence of additional long parallel north-south wall remains further east and west, confirms that the "foundation" wall at the Upper Factory is in interior wall dividing copperas process levels.

At the Lower Factory, where the long east-west wall and its shorter north-south section at the west end are the most prominent structural and topographic feature, the exposed and buried remains of masonry copperas processing vessels were found both north and south of the wall. South of the wall, in ST-2-LC, Context I, a collapsed brick masonry vat interpreted as a copperas cooler vessel (and similar in many ways to the Upper Factory cooler in FEA-6-UC) was recorded. North of the wall, and at a lower elevation, vertical sequences of masonry brick and wood planks and beams interpreted as the remains of copperas crystallizers were documented in several trenches, notably TR-5-LC. Additional evidence of these structures was observed during monitoring for construction of the adjacent Sedimentation Basin. The presence of copperas vessel features on both sides of the wall, representing different and successive processes known to have been conducted within the factory building, confirms that the "foundation" wall at the Lower Factory is in interior wall dividing copperas process levels. The tapering height and slight curve to the long wall's east end corresponds to the topography of the access road extending east to mine road, indicating that the east end of the wall served a second function as an access road retaining wall.

Research Question 2

Did the copperas factories have engineered floors or substructures to support the heavy pans and boilers?

The copperas factories had engineered substructures to support the heavy masonry and lead copperas process vessels. The largest and most substantial substructures supported copperas boilers (evaporating pans). The most substantial and deepest boiler substructure was recorded during monitoring of removal of the North Berm, where successive passes of a bulldozer blade bisected the structure, revealing a deep vertical sequence of granite boulder foundation supporting schist slabs, cut granite blocks, and mortared common brick walls and arch incorporating iron bars and plates within TR-5-UC and FEA-4-UC (see Chapter 5). Within the Upper Factory, the lower supporting structure of another boiler (FEA-7-UC) was found and recorded in the north end of the upper tier of the factory in ST-3-UC. This structure consisted of a network of two parallel and four transverse connecting brick walls and cut granite blocks analogous to the closely-spaced parallel brick walls with "arches" connecting a boiler firebox arch and draft flue as described by Locke in 1821 and Duncan in 1871. Two copperas cooler vessels were identified, one in each factory. The brick wall supporting the west side of the cooler in the Upper Factory (FEA-6-UC) was excavated to a depth of 4.5 ft (1.4 m), a dimension that helped confirm its function, as the deep cooler required a thick wall to support the outward force of the weight of the dense liquor.

Crystallizers were identified in both factories. One of these, in the Upper Factory (FEA-3-UC) was sectioned longitudinally (north-south) after it was excavated and mapped in plan. Excavation revealed a shallow sequence consisting of a single course of brick, a layer of wood planks, and three transverse (east-west) timbers, supported by a "prep layer" of coarse sandy mine waste. This sequence was also observed at other crystallizer remains found in TR-5-LC and other trenches below the wall at the Lower Factory, and in the Upper Factory (FEA-7-BC) and Copperas Brook Corridor (FEA-2-BC). The latter crystallizers were supported by additional square sawn timber cribbing and sandy fill that ultimately rested on the timber and plank deck underlying the south portion of the Upper Factory (see Research Question 6 below). FEA-7-BC, and possibly an eastern portion of FEA-2-BC, were resting on level areas of prepared bedrock.

Brick floors were recorded in both the Upper Factory and Lower Factory. At the Upper Factory, an area of flat-lying laid and mortared brick was uncovered and mapped in FEA-5-UC in ST-2-UC at the south end of the upper (west) tier of the factory. It was inconclusive whether this was simply a working floor or a portion of a copperas vessel. At the Lower Factory, two intact areas of flat-lying brick floor were uncovered and mapped. The floor in ST-2-LC, Context 4 appeared to be a working floor. The floor in ST-3-LC, Context 2, which also appeared to be a working floor or possibly the location of a copperas liquor tank, consisted of a single layer of brick over a leveling layer of flat-lying stone slabs.

Research Question 3

If engineered floors or substructures were found and mapped, what would they reveal about the arrangement and flow of the copperas manufacturing steps, boiling and concentrating pans, associated heating furnaces and flues, and packing floors within the copperas factories?

Engineered substructures were found and mapped. The standing and demolished factory walls were, in the grossest sense, supporting infrastructure associated with different processes, dividing the levels between the processes, and facilitating the cascading gravity flow of liquor down from one process step to another. More discrete engineered substructures for individual copperas manufacturing vessel features were found and documented above and below those walls. These included the substantial masonry underpinnings for boilers at the Upper Factory and North Berm, and the earth and timber substructures for crystallizers at the Upper Factory and associated adjacent Book Corridor (see above). The extent and construction of the expansive timber deck underlying a portion of the Upper Factory was also explored and documented. This structure may have also played a general, structural role in the gravity flow process (see Research Question 6 below). Documentation of these substructures revealed information about general and greater factory construction as well as specific substructure construction for types of

individual vessels. The cascading, sequential arrangement and flow of the copperas manufacturing steps, boiling and concentrating pans, associated heating furnaces and flues, and packing floors within the copperas factories was already largely understood from the historical record. The data recovery and monitoring confirmed, augmented or altered that information, as discussed in Chapters 4, 5 and in the other research question in this chapter, particularly Question 4 below.

Research Question 4

Are there any differences between the interior features and their relationships within the two copperas factories? If so, what do they reveal about differences in function, process, and evolution of the two factories?

There are differences between the interior features and their relationships within the Upper Copperas Factory and the Lower Copperas Factory. These differences imply differences in function, process and evolution of the two factories.

The Upper Copperas Factory presents a curious contradiction in that in some respects it is quite simple to understand, but yet it is the most complicated in terms of process for the two factories. The discovery of the sequential and descending topographic orientation of the remains of a copperas boiler in FEA-7-UC, a copperas cooler in FEA-6-UC, and a copperas crystallizer in TR-3-UC was perhaps the most rewarding find of the data recovery program, as these immediately adjacent features corresponded perfectly with the historical descriptions of the cascading copperas liquor treatment process. Discovery of these cooler and crystallizer features east of and below the prominent visible north-south stone Upper Factory wall revealed that the factory was much larger than originally thought. According to the historical record, the factories contained multiple boilers, presumably on their upper levels. The 1871 historical account of later operations described two, 10 ft by 26 ft boilers in each factory. Data recovery investigations at the Upper Factory confirmed the presence of at least one boiler, in FEA-7-UC. The presence of additional boilers, for instance in FEA-5-UC to the south, was inconclusive. A large area at the center of the upper tier of the Upper Factory was not stripped and investigated, and could contain another boiler. The cooler found below the boiler tier, in FEA-6-UC, was a large, distinctive structure with characteristic vertical iron stanchions. The 1871 account describes two coolers; however, only one was located. Data recovery in 2009 and in the Brook Corridor in 2010 identified at least three additional possible copperas crystallizers (FEA-7-BC, FEA-2-BC and EU-2-BC). These all appeared to have a long east-west axis, compared to the long north-south axis of the crystallizer in FEA-3-BC. It is unclear if these were all part of the same contemporaneous operation; however, the 1871 account described twenty crystallizers in each factory, which potentially explains the expanse of crystallizer remains extending south into the Brook Corridor area.

A factor that potentially complicates interpretation of the Upper Factory's evolution is that it was apparently the site of multiple, often paired factories over time. These all had to be built in a confined space at the bottom of the copperas liquor collection system. Multiple phases of overlapping construction, demolition, scavenging and reconstruction at the Upper Factory had the potential to create a dense, multi-layered site, and the features documented through the data recovery may represent remains of multiple phases of operation in separate factories. The boiler features and other structural remains found in the North Berm and South Berm, for instance, may be the partial remains of other factories. [For discussion of the possible relationships associated with the North Berm and South Berm features see the "Unexpected Finds" section below.]

The internal configuration of the Lower Copperas Factory was similar to the Upper Factory in that a prominent interior wall divided major steps in the process. A cooler very similar to the one at the Upper Factory was found above the wall in ST-2-LC (Context I), and a crystallizer structural sequence similar to

the Upper Factory's FEA-3-UC crystallizer was found below the wall in TR-5-LC and, although less distinct, in other trenches below the wall. Unlike the Upper Factory, where the boiling, cooling and crystallizing were arranged on clearly-defined topographic and structural levels, boiling (if it occurred there) and cooling were on one upper level, with crystallizers on a second level below. Although aspects of the single-bay brick hearth or ash pit feature (ST-1-LC, Context I) and the brick platform with iron plates (ST-3-LC, Context II) also found on the upper level resembled possible boilers, that interpretation is inconclusive. Features and numerous artifacts found in a portion of ST-1-LC (Context III) and the contexts at the center of the Lower Factory (ST-2-LC) indicated that these areas were associated with maintenance and other non-production activities such as lead boiler lining maintenance, cooperage activities, etc. The upper level of the Lower Factory also contained several distinct north-south stone walls interpreted as sills dividing the upper level into separate work areas. Features and artifacts found within these suggest that the Lower Factory was partially devoted to maintenance and other, non-production functions, more than the Upper Factory appears to have been. The surviving floor areas and sheer number and variety of artifacts also support the interpretation that the Lower Factory was one of the last to operate before the works shut down. The overall Lower Factory site is simpler than the Upper Factory site, implying that only one building was constructed there.

Research Question 5

What was the function of the upright railroad rails/stanchions, iron plates, and iron and brick "flues"?

Rectangular clusters of upright railroad rails/stanchions, some incorporating round binder rods, were documented (but not collected) as components of two features interpreted as copperas liquor cooling vessels: FEA-6-UC at the Upper Copperas Factory, and FEA-2-UC, Context 1 at the Lower Copperas Factory. The depth of these vessels as indicated in historical accounts and indicated by excavation of the west wall of FEA-6-UC indicates that the brick masonry sides would have required additional bracing to withstand the downward and outward force of the dense copperas liquor. The flat faces of the vertical stanchions and rails could have pressed directly on the outer brick walls. However, it is more likely that the vessels were also braced by horizontal wood planks on their upper surfaces and/or by earth on their partially-buried lower sides.

Iron plates were a common, almost ubiquitous industrial artifact at the copperas factories, with large intact plates and small weathered fragments found on the surface (particularly at the Lower Factory), in data recovery trenches (particularly those associated with boilers), and in waste removal monitoring near those boiler features. Vertical and horizontal plates were even found in situ in the south end of the rectangular brick boiler feature (FEA-4-IC) in the South Berm. These iron plates appear to have been used to line the sides and bottoms of copperas liquor boilers, possibly in intimate association with the lead boiler pan linings, and also as discrete structural components of the boilers in association with their brick structures. At the Lower Factory, in FEA-1-LC, Context I, the largest concentration, and largest and most intact plates, were found in association with many other cast and wrought iron furnace-related and apparently non-related objects (not collected) in clustered surface and subsurface deposits. Some of these may have been used as scrap iron to charge copperas liquor boilers, if used at the Lower Factory.

In the PAL 2003 survey at least four heavy, rectangular cast iron boxes, some with mortared common brick linings, were documented at the Upper Factory on the ground surface above the east end of the long north-south wall. These artifacts (not collected) were also documented as part of FEA-1-LC, Context I as part of the 2009 data recovery excavations. The specific function or original location of these artifacts was not determined; however, their location with other suspected furnace parts suggests they may be copperas boiler components. The brick lining suggests they may also have been at high-temperature, high air velocity locations, such as the lining of a firebox, ash pit, or draft stack base.

Research Question 6

For the Upper Factory, what, if any, is the structural relationship between the foundation and the heavy timbers located in the erosion gully immediately south of the south wall?

At the Upper Factory, the literal physical connection between the standing stone wall and heavy timbers ("deck structure") in the erosion gully (Copperas Brook bed) was not explored, as excavation at the base of the wall would have destabilized it and the wall and surrounding site were slated for preservation and capping.

The function of the deck structure has been a subject of curiosity and speculation since the beginning of archaeological and historical investigations at the mine in 2000, when portions of it became visible from erosion in the brook bed. The presence of horizontal structural elements including a section of plank decking and timber in the bed of Copperas Brook were documented as part of the 2003 PAL survey (Figure 6-1). Since that time, additional timbers and areas of well-preserved plank deck have been exposed. Portions of the deck structure were excavated and mapped in several other locations during data recovery, including TR-2-UC (FEA-2-UC) and TR-6-BC, which revealed the physical extent of this structure in plan view (see Chapter 4) Removal of the structure was monitored in 2010, when the depth and complexity of construction, including embedded timber cribwork, stone walls, etc. was revealed (see Chapter 5).
Multiple explanations for the timber structure have been offered since it was first observed:

Ore Leaching Platform

The timber structure includes inclined sections of plank floor, and therefore resembles the inclined timber decks and "scaffolds" described in the historical accounts for leaching freshly mined and roasted ore. The deck could possibly be interpreted as a roasted ore leaching pad for an earlier system of liquor collection cisterns and a factory or factories to the east, and that was buried by later Upper Factory construction, including the crystallizers in the brook bed (FEA-2-BC). However, the leaching activity was described as having taken place higher on the hillside, well above the liquor collection cisterns and factories, which were described as located in "the declivity quite below the mine (Locke 1821:326–330). The timber deck extended to the more level ground at the very bottom of the slope, making the presence of a system of cisterns and additional gravity-fed factories below to the east unlikely. The Upper Factory site and immediate surroundings were comparatively free of heavy deposits of the characteristic dark red to almost black decomposed roasted ore, which were found in intact, in situ deposits in timber structures located just above the Upper Factory site to the southwest.

Copperas Packing Bin

The inclined surface of the timber structure could possibly be interpreted as the floor of a copperas crystal packing bin for an earlier factory located on, or to the west of, the Upper Factory, that was buried by later Upper Factory construction. The inclined bottom could have facilitated shoveling crystals from the downhill side of the bin. The structure appears to be very large in physical area for such a function, and its upper surface included vertical posts and raised horizontal timbers oriented in east-west and north-south axes such as those found in TR-3-UC and the Brook Corridor, which would have impeded flow of loose crystals. At least two flat areas, which also would have impeded crystal flow, were documented during data recovery (TR-6-BC) and monitoring (under FEA-7-BC). No evidence of a factory was found above the west edge of the timber structure, which appeared to occupy a large portion of the south end of the Upper Factory and extend under the Copperas Brook bed to the east.

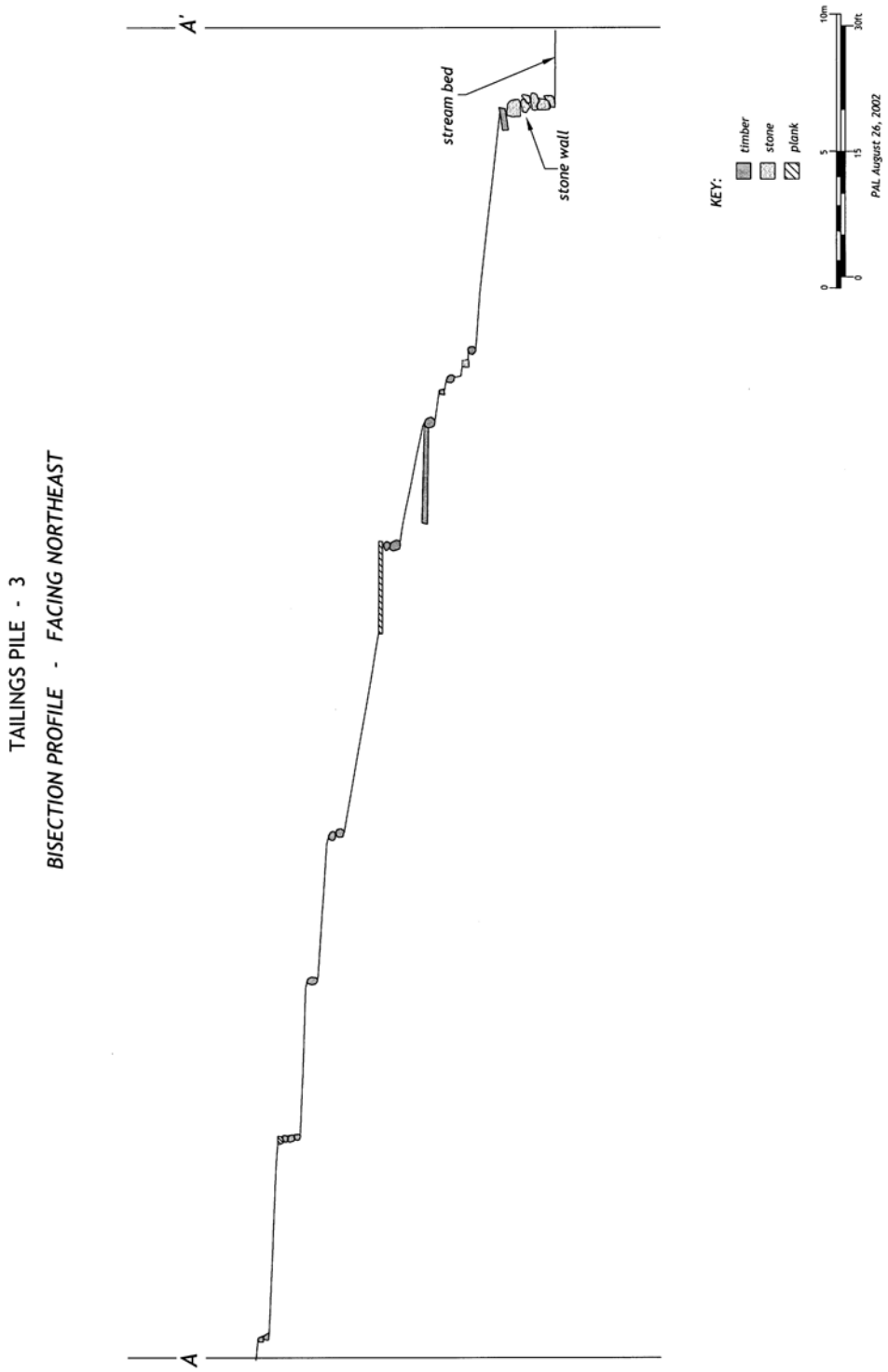

Figure 6-1. Cross-section of channelized Copperas Brook, lower Tailings Pile 3.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Raw Copperas Liquor Storage Cistern

The timber structure could possibly be interpreted as the floor of a raw copperas liquor storage cistern for another factory, or the South Berm boiler located below the Upper Factory site to the east. The deck structure would have been buried by later Upper Factory construction. The structure appears to be very large in physical area for such a function, and its upper surface included vertical posts and raised horizontal timbers oriented in east-west and north-south axes such as those found in TR-3-UC and the Brook Corridor, which would have impeded flow of liquid.

Copperas Liquor Conveyance System

The timber structure can be possibly interpreted as the upper surface of a copperas liquor conveyance system or part of such a system for the Upper Factory itself, over which processed liquor flowed from vessel to vessel. This is difficult to visualize for several reasons. The ph of the raw liquor was 10 to 20 degrees Baume, and the boiled liquor was 35 degrees Baume, the strength of fresh sulfuric electric battery acid. Acid of that strength would have rapidly destroyed exposed wood surfaces requiring frequent reconstruction to replace. The wood surfaces could be protected with a soldered sheet lead lining. However, lining such a large surface area with sheet lead would be prohibitive and no evidence of such a lining on the wood was found during the excavations. The masonry crystallizer vessels recorded in TR-5-BC and TR-6-BC all sat on timber and plank structures over fill strata ("prep layer") that lay on the timber deck structure itself, making it difficult to visualize how the deck could have been used to convey liquor through the fill. This fill, which appears to be lenses of sandy mine waste representing construction fill layers, was incorrectly identified as thin layers of finely laminated alluvial sediments deposited by routine flooding episodes in the 2003 PAL survey JTP-26, which was placed in the vicinity of 2009 data recovery TR-3-UC (PAL 2003: see Figure 6-29). This area is located between erosion gullies on the hill (Copperas Brook and the gully at the north treeline), and is shielded from runoff by the factory topography and wall, and could not have been regularly inundated by runoff from the hillside.

According to the first historical account of operations, the floor of the factory "...gives great facility to all the operations, allowing the various reservoirs to be so arranged one above another that the liquor may be transferred from one process to another merely by means of a trough" (Locke 1821:326–330). The copperas liquor conveyance system within the factory was more likely similar to that shown in the Diderot copperas and alum process illustrations, consisting of some more simple combination of permanent surface troughs and elevated launders, rather than a more complex underfloor or subterranean arrangement or system that could become blocked by sediment. The historical accounts consistently state that the processed liquor was simply "drained" or "drawn" or "let" from vessel to vessel, without any description of complicated apparatus or ingenious structures. A narrower portion of the timber structure in the vicinity of the brook bed could possibly have been an open trough for conveying raw liquor from holding cisterns to the west to boilers below to the east, possibly in the South Berm. This structure would have been buried by subsequent Upper Factory construction.

Factory Support Structure

The timber deck structure can also be interpreted as a structural support for the Upper Factory site. It is notable that the associated research question is directed at the Upper Factory only. The lack of a similar structural system at the Lower Factory suggests that the function may be site-specific, not process-oriented. It is also notable that the structure in question is not mentioned in any of the historical accounts, which reported consistently regarding process flow, cascading vessel arrangement, and associated equipment and processes. This lack of mention is presumably because the structure was buried and not visible. The timber and plank structure at the Upper Factory is extensive, underlies the southern half of the factory site, and extends from level ground at its west edge, down the Copperas Brook bed along the

south edge of the factory, and ends where the ground levels off again at the bottom of the slope to the east. The structure is not found above or below, but is only found under, the Upper Factory. The structure was once buried by the south end of the Upper Factory, including the crystallizer structures and their supporting fill. It has subsequently become exposed again by erosion from post-manufacturing runoff from the manipulated TP 3 ore leaching hillside, an expression of water seeking its original channel and its own level via the path of least resistance.

As previously discussed, the operators of the Copperas Hill copperas works were limited to a small area at the bottom of the heap leaching slope for placement of the factory buildings. The "declivity quite below the mine" where the liquor flowed and was collected in cisterns was on an area of steeply eastward dipping, northeast-southwest foliated bedrock that formed a steep ravine. The flanking soils were wet and consisted of sandy alluvium, devoid of stabilizing plant life, above clayey glacial till. This was not an ideal place to build one, let alone a series, of factories that required heavy, acid-bearing masonry vessels arranged on a slope. The timber structure can be interpreted as the exposed remains of extensive site preparation engineering or one of the other factories known to have been built at or near the Upper Factory location. This structure would have provided a stable factory substructure for the tiers of masonry process vessels in the wet environment of the sloping ravine where the copperas-bearing hillside runoff gathered. This site stabilization structure would be analogous to a modern concrete ore processing mill foundation, with its tiered arrangement of machinery pads built into a slope. The presence of the dense and deep network of timbers and stone walls in the southeast corner of the structure, where the brook ravine bedrock is deepest, appear to be the structural underpinnings of the southeast corner of a building. These remains, observed during removal monitoring, particularly support this interpretation (Figure 6-2).

The structure is sloped from west to east overall, with tiered sections sloping progressively downward from west to east, and also incorporating two short level sections (see Figure 6-1). Alteration of rock wall supports, bedrock and soil by low-ph groundwater may have resulted in some compaction under, and eastward slumping of, the structure. Upright timbers, presumably structural timber frame support posts, rise at a relatively normal (90 degree) angle to the inclined timbers, indicating the soil has crept to the east. The eastward-sloping angle of the structure could have facilitated construction of multiple stepped tiers of copperas vessels, supporting the fill and timber cribwork under vessels like the documented crystallizers, some of which appear to have sat on timbers on level surfaces cut from the bedrock. In this way the structure played an indirect role in the gravity feed for the copperas liquor, forming an inclined platform for the cascading gravity-fed liquor transport from vessel to vessel in troughs, either elevated or mounted in the floor. It could also have facilitated drainage of groundwater and lost liquor in the steep wet Copperas Brook ravine.

Research Question 7

Are the rectilinear mounds and stone wall remains identified in the Inter-Copperas Factory Area associated with human occupation, or copperas ore roasting, heap leaching, and copperas liquor evaporation, or both?

The rectilinear mounds and stone wall remains identified in the Inter-Copperas Factory Area are associated with both copperas manufacturing and storage. The cobble stone floors documented in FEA-1-IC and FEA-3-IC appear to be the leveled surface for a plank-floored room or rooms. These appear to be the remains of the several temporary copperas storage buildings noted in an 1827 account: “In the southern part of the works are several temporary buildings, erected for the preservation of the copperas (sulphate of iron)” (anon., *Columbian Centinel* December 1, 1827:1). Excavation in a larger mound to the north, later named the South Berm, revealed FEA-4-IC, the rectangular brick masonry structure surrounded by bright red soils interpreted as a lower section of a copperas liquor boiler (see Unexpected Finds below).

Figure 6-2. Photograph of 2010 Copperas Brook, east removal monitoring showing depth of stone and timber construction, looking southwest.

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Research Question 8

Do the mounds and stone wall remains date from the same period(s) of occupation and site use as the nearby Copperas Factories?

The mounds and stone wall remains investigated in the Inter-Copperas Factory Area date from the same general period of nineteenth-century copperas manufacturing as the nearby Copperas Factories (see Research Question 7 above). The possible copperas storage buildings represented by the cobble floors in FEA-1-IC and FEA-3-IC mounds and stone wall remains appear to date from 1827 or earlier, and may have been used subsequently as well. The relative date of the adjacent copperas boiler feature in FEA-4-IC in the South Berm is unknown. That feature, which was an unexpected find, may be an upper section of another, possibly earlier copperas factory that extended to the east, or part of larger, undocumented Upper Factory operations. It may or may not have been directly associated with the unexpected boiler feature identified in the adjacent North Berm (see Unexpected Finds below).

Unexpected Finds: North Berm and South Berm

The data recovery discovery of the copperas boiler features in the North Berm and South Berm was not expected following the 2003 PAL survey. Their presence and location raised additional questions that complicated interpretation of the Upper Factory and the greater copperas works, as well as the copperas manufacturing process itself: What was the temporal and functional relationship of these berm boilers to the rest of the Upper Factory site, or the overall copperas works? Why were there boilers located below (temporally "after," in terms of process steps) the documented crystallizers, if crystallizing was the last step of the manufacturing process? Did these "lower" boilers operate as part of Upper Factory operations, making them possible evidence of an unknown step in the manufacturing process not documented in the written historical record? Were they possibly associated with Lower Factory operations? Or were they the remains of the "upper" (temporally "first," in terms of process steps) part of another factory building, either earlier than, or operating in tandem with, the Upper Factory?

The North Berm boiler (and possibly South Berm boiler) may have been an undocumented part of Upper Factory operations not included in the written historical accounts. The location topographically below the copperas crystallizers suggests that the boilers could have been used to re-boil the liquor prior to recycling it to the boilers. This step is not mentioned in any of the historical accounts from 1821 to 1871, which report that the spend crystallizing liquor was simply "returned" or "pumped" back to the primary boiler. Both berm boilers are a considerable distance away from, and well below the upper level of the Upper Factory containing the interpreted FEA-7-UC boiler, much further away than the lowest and most distal recorded Upper Factory crystallizer features. Pumping large quantities of boiling hot, dense, very low ph liquor uphill over that distance would require considerable mechanical energy, possibly a steam-powered pump, as well as a considerable quantity of specialized, lead-lined plumbing. Construction of boilers as large as the one identified in the North Berm would have required considerable initial capital investment in construction labor and materials. Operation would have required additional material and maintenance costs for fuel and lead linings (and possibly scrap iron). Operation would also have required considerable labor costs including skilled operatives to monitor liquor density. All this investment would have duplicated that associated with the initial boilers, and all for just seasonal operation. Re-boiling the liquor would produce a strong acid, which is counterintuitive to the requirements of the process, which calls for dilute raw and spent liquor to be added incrementally to the initial boiler along with the scrap iron to predictably control the increasing density of the liquor to prevent damaging the lead boiler lining.

The North Berm and South Berm boilers could have been associated with Lower Copperas Factory operations. Data recovery results for the Lower Factory clearly indicate the presence of a cooling (and settling) vessel at the factory, but do not include strong evidence for a boiler, as none of the recorded

brick masonry features share a preponderance of formal aspects with structures interpreted as boilers found elsewhere on site. All raw copperas liquor from the ore leach heaps was collected in large storage cisterns at the bottom of the TP 3 slope, directly above the Upper Factory. The liquor processed at the Lower Factory, regardless of whether it was still raw or boiled when it arrived there, had to be conveyed somehow from the cisterns to the Lower Factory. Although no such structure or arrangement is mentioned in the historical accounts, the liquor was likely conveyed in a pipe or launder, possibly elevated on trestles. A simple valve could not be located at the bottom end of such an inclined structure because the descending liquid in a pipe would rupture it when shut off unless a standpipe or surge chamber was also incorporated. Instead, raw or boiled liquor may very likely have been stored in another holding tank inside the Lower Factory, as discussed in the interpretations of FEA-4-LC (see Chapter 4). It is possible that the North Berm and South Berm boilers supplied boiled liquor to the Lower Factory. A boiler-only interpretation for these features may explain the relative lack of additional structural materials found in association with the North Berm as compared to the Upper Factory. However, it is possible the structure was significantly scavenged for building materials at a later date (see below).

The North Berm and South Berm boilers may also be evidence of another separate copperas factory, one of the half-dozen or more of different dimensions, often operating in tandem, as reported in the historical record. As established, these factories had to be located in a limited space in or very near the bottom and focus of the raw copperas liquor "funnel" engineered on the hillside, above the storage cisterns described as being located just outside the factory. The need for multiple, successive, often paired factories in this spatially limited, steep, wet location as a possible explanation for the buried timber structure as part of the factory foundations has also been discussed. A separate factory in this lower, berm location could have operated alone, at a different time from a factory containing the sequential boiler-cooler-crystallizer features found above. It could also have been a separate but contemporaneous factory operating in tandem with the works above, taking both fresh and/or spent liquor from the cisterns and/or crystalizers above, and boiling, cooling and crystallizing the copperas liquor in a parallel, separate sequence of vessels. The structural remains and materials recorded to the east and south in the other North Berm trenches, including brick walls and bricks, stone walls and stones, large split granite blocks, large wood timbers and smaller-diameter poles collectively support interpretation as the remains of another factory that was extensively scavenged.

Artifact Assemblage

The artifact assemblage from the 2003 PAL survey, and 2009 and 2010 data recovery investigations includes 1,698 cultural materials recovered in trench and unit excavations as well as objects recorded and photographed in the field, but not collected for laboratory processing and analysis because of their large size. The recovered artifacts are described in the Chapter 4 Results by provenience and type, and are inventoried in Appendix A of the report[30]. The following discussion is focused primarily on the recovered artifact assemblage, which also does not include all of the construction materials (e.g., brick; mortar; cut stones; wood timbers, plank, logs, and sticks) encountered during the excavations that are described and interpreted above and in Chapters 4 and 5. The largest artifact assemblage was recovered at the Lower Copperas Factory (Table 6-1)[31]. These materials (n=1039) comprise 61.2 percent of the recovered artifact assemblage, and support the hypothesis that the Lower Factory was the last iteration of copperas works at the Elizabeth Mine Subsite in the late 1800s. The Upper Factory had the second highest recovered artifact concentration (n=394), with 23.1 percent of the total assemblage, followed by the

[30] A number of these artifacts are illustrated in Appendix B.1. Appendix B.2 provides illustrations of representative objects that were not transported to PAL for laboratory processing, analysis, and temporary curation.

[31] The rankings and percentages of artifact assemblages by area within the Copperas Factories Subsite are based on the amount of excavations conducted in each area during the 2009-2010 data recovery investigations. However, taken together with the site history and other archaeological data (i.e., structural remains and soil stratigraphy), it is assumed that they are statistically representative of the concentrations or density of artifacts that would have been present in the entirety of each area.

Table 6-1. Cultural Material Totals Recovered by Area within the Elizabeth Mine Copperas Factories Subsite, 2002 Survey and Data Recovery Excavations.

Location	Material Count	Percentage
2002 Upper Copperas Factory	62	3.6
2010 Upper Copperas Factory Including North Berm	332	19.5
Lower Copperas Factory	1039	61.2
Inter-Copperas Factory	18	1.1
Copperas Brook Corridor	134	7.9
Pine Grove	113	6.7
TOTAL	1698	100

Copperas Brook Corridor (7.9 percent), Pine Grove (6.7 percent), and the Inter-Copperas Area (1.1 percent).

The recovered cultural materials are organized into three primary functional categories: domestic/personal, structural/industrial, and organics (Table 6-2). The Lower Factory contained the largest amount of structural/industrial artifacts (58.8 percent) and domestic/personal items (4.5 percent),

Table 6-2. Types of Recovered Cultural Materials by Area within the Elizabeth Mine Copperas Factories Subsite, 2009/2010 Data Recovery Excavations.

Location	Material Type	Material Count	Sub-Area Percentage	Total Percentage
2010 Upper Copperas Factory (including North Berm)	Domestic/Personal	29	8.7	1.8
	Organics	0	0	0
	Structural/Industrial	303	91.3	18.5
Lower Copperas Factory	Domestic/Personal	74	7.1	4.5
	Organics	3	0.3	0.2
	Structural/Industrial	962	92.6	58.8
Inter-Copperas Factory	Domestic/Personal	0	0	0
	Organics	0	0	0
	Structural/Industrial	18	100	1.1
Copperas Brook Corridor	Domestic/Personal	58	43.3	3.5
	Organics	1	0.7	0.1
	Structural/Industrial	75	56.0	4.5
Pine Grove	Domestic/Personal	37	31.8	2.3
	Organics	1	0.9	0.1
	Structural/Industrial	75	67.3	4.6
TOTAL		1636	---	100

but the lowest amount (0.2 percent) of organics. The Upper Factory came next in structural/industrial artifacts (18.5 percent) and domestic/personal items (1.8 percent) combined, but had no organics. The Copperas Brook Corridor had slightly less structural/industrial artifacts (4.5 percent) than the Pine Grove area (4.6 percent), but a higher percentage (3.5 vs. 2.3) of domestic/personal items. Organics were the same in both the Copperas Brook Corridor and Pine Grove area (0.1 percent). The Inter-Copperas

Factory area contained only structural/industrial artifacts, which comprised a mere 1.1 percent of the total recovered artifact assemblage (Figure 6-3).

Upper Factory

The 2003 PAL survey included the excavation of five 50-x-50-cm test pits within the Copperas Factories Subsite. These test pits were all placed in the Upper Copperas Factory (Cherau et al. 2003: Figure 6-22). This testing resulted in the recovery of 62 cultural materials (structural/industrial, domestic/personal) from 0 to 70 cmbs in fill and disturbed subsoil deposits. The majority of these materials (n=48) consists of common and fire bricks (stamped 'Boston Firebrick Company'), some handmade, which were sampled during the field investigations. Two pieces of flat (window) glass, one piece of slag, one unidentified iron, and three pieces of mortar were also recovered along with seven ceramic sherds (one yelloware and four American stoneware). The stoneware has a manufacture date range of 1760-1870 and is similar to other stoneware sherds recovered during the data recovery investigations at the Upper Factory. The yelloware has a manufacture date range of 1830-1900. It is interesting to note that no additional yellowware ceramic sherds were recovered from the Upper Factory or elsewhere on the site during the data recovery investigations.

The data recovery investigations at the Upper Copperas Factory recovered artifacts from two of the three functional categories described above (see Table 6-2 and Figure 6-4). No organic remains were recovered at the Upper Factory. Structural/industrial artifacts (n=303) include miscellaneous hardware, boiler grates, iron nails and bolts, iron plates, iron pulleys, lead sheets, lead spatter, lead trimmings, a damper wheel, a wooden wheel, wood packing barrel staves, and industrial waste (e.g. slag, metal) (Table 6-3). Machine-cut nails comprise the majority (n=170) of these artifacts, and were found in both fill (including factory floor surface preparation) and overburden strata within the factory. Artifacts of note, as described in Chapter 4, include a lead sheet recovered in TR-2-UC that was bent into a U-shape and appeared to be a possible copperas liquor spout or trough; and iron perforated plate fragments recovered in TR-11-UC similar to ones recovered at the Lower Factory. The only tool recovered at the Upper Factory consists of a wrench found in association with FEA-5-UC, a collapsed crystallizer. Window glass collected in the Upper Factory foundation is dated to 1865 to 1879 (± seven years), using Moir's regression formula, although this date is very speculative since it is based on only two shards.

Domestic/personal items recovered in the Upper Factory (n=29) include a small assemblage of temporally diagnostic ceramic sherds (n=6) and curved (bottle/jar, hollowware) glass fragments (n=7) (Table 6-4). The ceramics consist of American stoneware (salt glaze), plain redware, and whiteware. The one American stoneware sherd was manufactured between 1760 and 1870, which represents one of the earliest date ranges of manufacture for diagnostic artifacts recovered at the site during the data recovery investigations. The other ceramics and glassware all date from the early/mid-1800s through mid-1900s, which are commensurate with the documented construction/occupation of the nineteenth-century Copperas Factories, associated worker housing, and twentieth-century mining operations at TP 3. Personal items are limited to two buckles and five leather boot fragments, none of which are temporally diagnostic. The domestic/personal items were likely discarded by the factory occupants themselves, or deposited during post-abandonment fill and slope wash episodes.

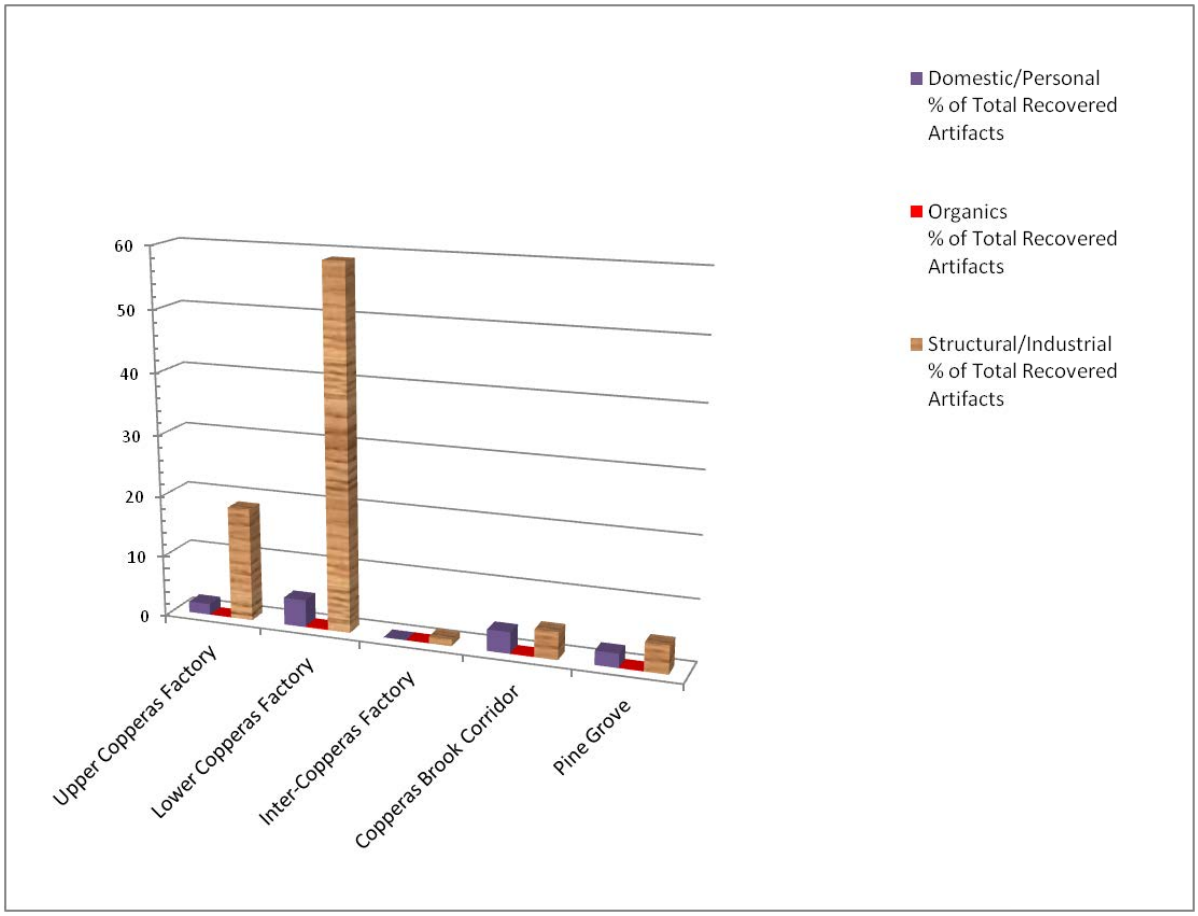

Figure 6-3. Bar graph, Copperas Factories Subsite, Elizabeth Mine, percentage of artifacts recovered by functional categories, 2009-2010 data recovery investigations.

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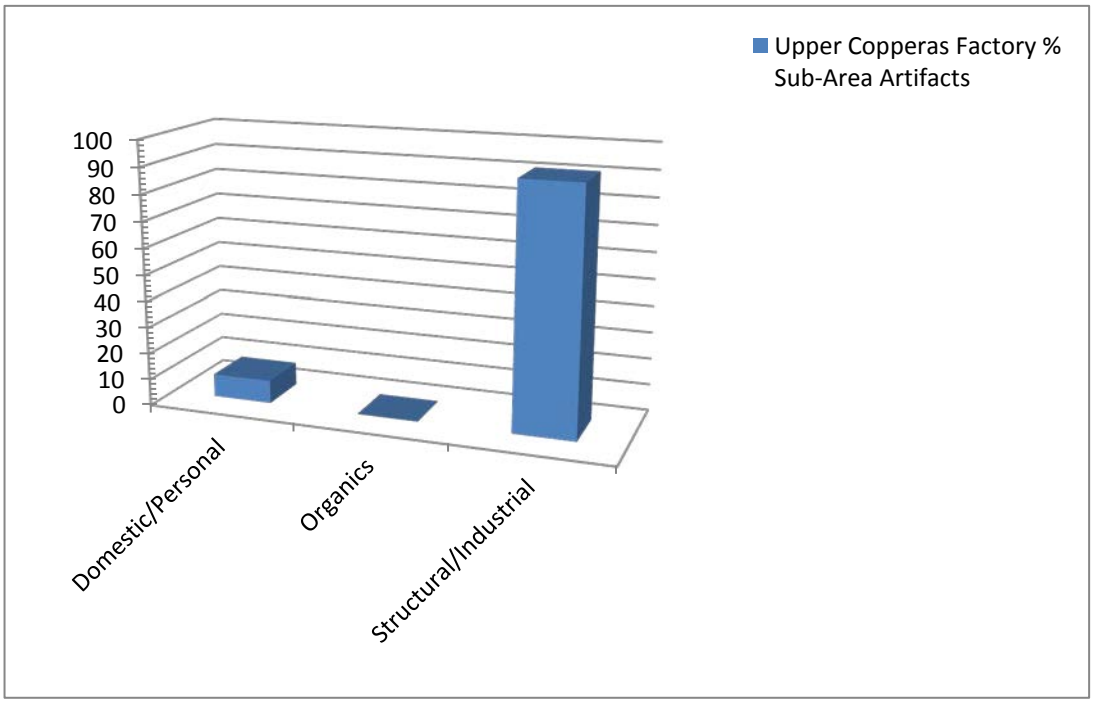

Figure 6-4. Bar graph, Upper Copperas Factory percentage of artifacts recovered by functional categories, 2009/2010 data recovery investigations.

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Table 6-3. Summary of Structural/Industrial Artifacts, Upper Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	Total
Boiler	6
Bolt	1
Brick	3
Damper Wheel	1
Flat Glass	2
Handle	1
Industrial Waste	6
Miscellaneous Hardware	3
Nail – machine-cut	170
Packing Barrel Stave	11
Plate	11
Pulley	1
Sheet	6
Slag	25
Spatter	11
Trimmings	6
Unidentified iron, lead, leather, mineral, wood	28
Utility Pipe	1
Washer	1
Wedge	1
Wheel	1
Wood	1
Wrench	1
Misc. Structural/Industrial	5
Grand Total	303

Table 6-4. Summary of Domestic/Personal Artifacts, Upper Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	Date Range	Total
Animal Shoe		1
Boot/Shoe		5
	unknown	4
	1850 1920	1
	1889 1950s	1
	1900 1922	1
Bottle/Jar	1910s 1950s	1
Misc. Curved Glass		2
Buckle		2
Whiteware	1820 Present	3
Indeterminate Ceramic		2
American Stoneware, Salt Glaze	1760 1870	1
	1809 1884	1
Holloware, Molded Glass	1809 1954	2
Redware, Lead Glaze	1600 Present	2
Grand Total		29

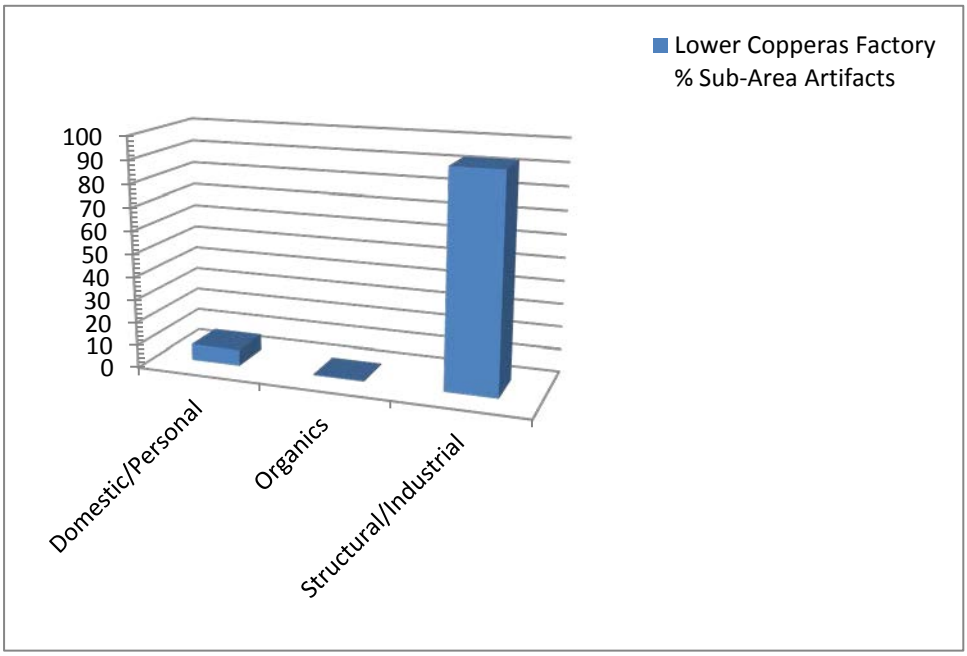

Figure 6-5. Bar graph, Lower Copperas Factory percentage of artifacts recovered by functional categories, 2009/2010 data recovery investigations.

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Lower Factory

The data recovery investigations at the Lower Copperas Factory recovered artifacts from all three functional categories described above (see Table 6-2 and Figure 6-5). Only three organic remains were recovered at the Lower Factory, two animal bones and one nutshell (Table 6-5). The animal bones were found in association with FEA-2-LC in ST-02-LC, the brick cooling vat remains and adjacent work area. The bones were butchered and identified as cow species. The one nutshell identified as walnut came out of this same area. These organics are likely food waste remains, but reveal little in the way of dietary habits of the factory workers.

Structural/industrial artifacts (n=962) include miscellaneous hardware, boiler grates, iron nails (common, sheathing, spike), iron plates and L-brackets, lead sheets, lead spatter, lead trimmings, utility pipes, wood fragments, wood packing barrel staves, and industrial waste (e.g. slag, metal) (Table 6-6). The four largest classes are lead spatter (n=224), unidentified metal (n=139), flat (window) glass (n=137), and sheared rivets (n=132), comprising 66 percent of the total artifact assemblage from the Lower Factory area. The lead spatter and unidentified metal were found throughout the foundation remains and adjacent work spaces, while the tools and rivets were more localized in the central part of the site in association with FEA-2-LC in ST-02-LC, centered around the brick cooling vat remains and adjacent work area. One-hundred and twenty-nine (129) of the sheared rivets were found in association with the firebox feature (Context II of FEA-2-LC), and are suspected to have been used to recharge the copperas liquor. FEA-2-LC and its associated contexts produced 55 percent of the total artifact assemblage recovered from the Lower Factory during the data recovery investigations.

The tool assemblage at the Lower Factory was the most interesting of the structural/industrial artifacts. The recovered tools were more numerous and varied than at the Upper Factory, consisting of axes,

Table 6-5. Summary of Organic Materials, Lower Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	Total
Mammal-butchered (cow)	2
Nutshell - walnut	1
Grand Total	3

Table 6-6. Summary of Structural/Industrial Artifacts, Lower Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	Total
Axe	9
Boiler	2
Bracket	4
Brick	7
Chisel	1
Flat Glass	137
Handle	7
Hinge	1
Hook	3
Industrial Waste	66
Ladle	1
Lock/Latch	2

Miscellaneous Hardware	2
Nail – machine-cut	63
Packing Barrel Stave	4
Plate	1
Rake	1
Rivet	132
Rod	2
Sheet	21
Shovel	3
Solder Rod	2
Spatter	224
Spike	3
Trimmings	77
Tube	2
Unidentified leather, rubber, copper, tin, iron, metal	139
Unidentified Tool	1
Utility Pipe	6
Whetstone	1
Wood	18
Misc. Struct/Industrial	20
Grand Total	962

shovels, hooks, a chisel, a ladle, a rake, and a whetstone. Other tools suggested from the shapes of "unidentified" metal objects include a hoe, tool handles, and flat wrenches. The tools were recovered from various feature surfaces identified as interior work spaces (brick floors) and exterior work areas. Five of the nine axe heads were located in an area near preserved wood chips suspected to be an exterior workspace associated with the firebox feature (Context II in ST-02-LC). These axe heads were made using nineteenth-century trip hammer manufacture techniques. The ladle, found in an interior workspace, is missing its handle, but has a complete 12-inch diameter bowl with residual lead spatters suggesting its use in lead repairs for the vats. A wrought iron "prong" tool was also found in the Lower Factory, although it was not collected for laboratory processing because of its large size (over 3 ft in length). A glass test tube that could have been used to sample the copperas liquor (acid hydrometer) was also found in association with FEA-2-LC, in the work area associated with the cooling vat remains.

In terms of structural materials, the majority of the window glass found at the Lower Factory (n=136) can be dated to 1881 (± seven years) using Moir's regression formula. These fragments were found along the southern boundary of the brick floor associated with the FEA-2-LC cooling vat, presumed to be near the exterior wall of the factory foundation remains. Marked fire bricks found in the Lower Factory were manufactured in both Scotland and Boston, MA.

Domestic/personal items recovered in the Lower Factory (n=74) include a number of temporally diagnostic ceramic sherds (n=12) and curved (bottle/jar) glass fragments (n=2) along with one dateable button and one dateable kaolin pipe stem fragment (Table 6-7). The ceramics consist of American stoneware (Albany slip/salt glaze) and plain whiteware. The Albany slip decorated stoneware was manufactured between 1840 and 1930. Four of the body/base sherds are cross-mended to a stoneware jug with an Albany slip interior and salt glazed exterior surface, manufactured from 1800 to 1880. The plain whiteware has a broad date range of manufacture from 1820 to present. The pipe stem fragment is dated from 1809 to 1884 and the black rubber button is from 1855 to 1870. The glass canning jar fragments range from 1850 to 1920. In addition to the smoking pipe and button, other personal items include seven leather shoe fragments and a heavily tarnished copper penny. The dateable domestic/personal items are

Table 6-7. Summary of Domestic/Personal Artifacts, Lower Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	Date Range	
Animal Shoe		19
Boot/Shoe		7
Bottle/Jar		1
		7
	1850 1910	1
	1890 1920	1
Misc. Curved Glass		22
Bullet		1
Button	1855 1870	1
Currency/Token		1
American Stoneware, Albany Slip	1840 1930	4
American Stoneware, Albany Slip/Salt Glaze	1800 1880	4
Whiteware, Undecorated	1820 Present	4
Smoking Pipe	1809 1884	1
Grand Total		74

commensurate with the documented construction/occupation of the nineteenth-century Copperas Factories, associated worker housing, and twentieth-century mining operations at TP 3. They were likely discarded by the factory occupants themselves, or deposited during post-abandonment fill and slope wash episodes.

Inter-Copperas Factory

The data recovery investigations at the Inter-Copperas Factory recovered artifacts from only one of the three functional categories described above (see Table 6-2 and Figure 6-6). No organics or domestic/personal items were recovered from this part of the Copperas Factories subsite. Further, only a limited number of structural/industrial materials (n=18) were recovered (Table 6-8). These materials consist primarily of machine-cut nails (n=13), one found in FEA-1-IC, interpreted as the remains of a cobble floor for a storage shed, 11 from fill along with three wood fragments associated with wood planks and cobble flooring of another storage shed structure in TR-2-IC and EU-3, and one from TR-4-IC placed in the South Berm. The lead spatter was also found in the South Berm. These structural materials confirm the presence of buildings at three of the previously identified berms. The South Berm was further identified as a boiler feature based on the presence of brick courses, roasted soils, lead spatter, and two iron boiler plates.

Table 6-8. Summary of Structural/Industrial Artifacts, Inter-Copperas Factory, 2009/2010 Data Recovery Excavations.

Object	Total
Nail – machine-cut	13
Spatter	2
Wood	3
Grand Total	18

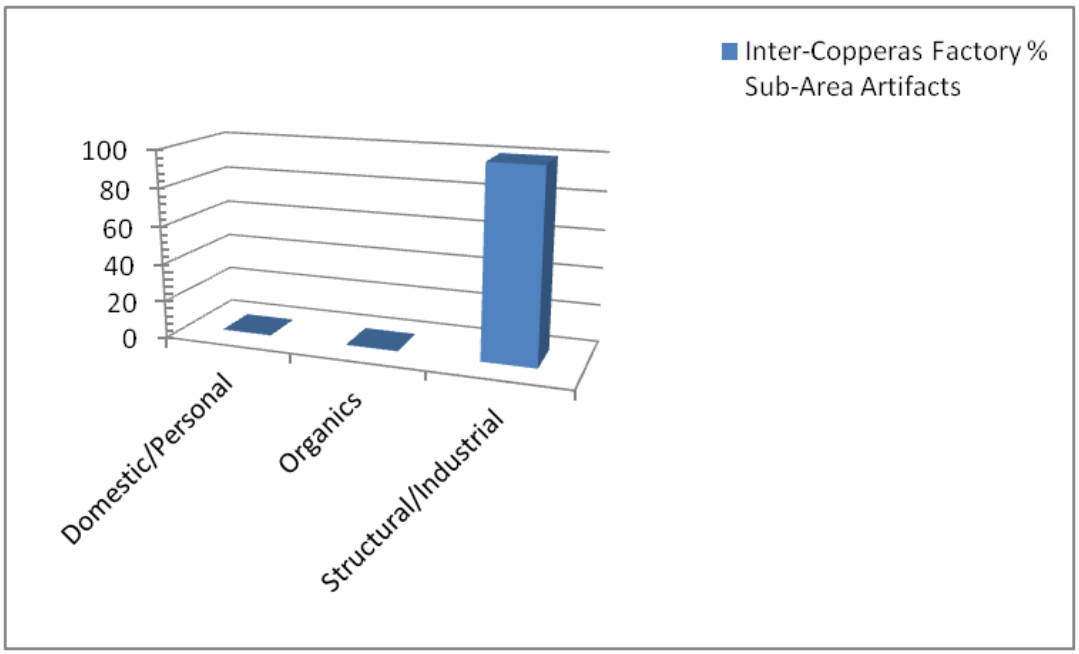

Figure 6-6. Bar graph, Inter-Copperas Factory percentage of artifacts recovered by functional categories, 2009/2010 data recovery investigations.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Copperas Brook Corridor

The data recovery investigations at the Copperas Brook Corridor recovered artifacts from all three functional categories described above (see Table 6-2 and Figure 6-7). Only one organic artifact, a butchered coyote/wolf bone, was recovered in slope wash overburden (Table 6-9). Domestic/personal items (n=58) were also recovered in similar overburden soils that appear to have been transported down slope into the brook corridor. These materials include temporally diagnostic ceramic sherds (n=5) and curved (bottle/jar) glass (n=9) (Table 6-10). The ceramic types (molded rim whiteware and lead glazed redware) have long nineteenth and twentieth-century date ranges of manufacture, while the dateable bottle/jar glass fragments all date from the twentieth-century. Given the presence of these materials in slope wash soils, their provenience from occupation and use of the brook corridor for copperas production is questionable. It is more likely that these materials were washed down from the upper portions of TP 3, probably in relation to the recorded dumpsite associated with twentieth-century mining operations.

Table 6-9. Summary of Organics, Copperas Brook Corridor, 2009/2010 Data Recovery Excavations.

Object	Total
Mammal – butchered coyote/wolf	1
Grand Total	1

Table 6-10. Summary of Domestic/Personal Artifacts, Copperas Brook Corridor, 2009/2010 Data Recovery Excavations.

Object	Date Range	Total
Animal Shoe		3
Bottle/Jar		4
	1910 -1920	1
	1935	4
	1938 -1970s	1
	1940 -present	3
		2
Misc. Curved Glass		35
Redware, Lead Glaze	1600 -Present	1
Whiteware, Molded Rim	1820 -Present	2
American Stoneware, Bristol/Albany Slip	1850 -1930	2
Total		58

Structural/industrial artifacts in the Copperas Brook Corridor were more numerous (n=75), but again they were found in the surficial slope wash deposits, and the smaller portable objects were likely transported down the TP 3 slope into the brook corridor. The smaller materials include flat (window) glass, miscellaneous hardware, nails, lead spatter and trimmings, and tar fragments (Table 6-11). The larger items such as the double pulley and a cluster of iron objects (mostly heavily corroded and unidentifiable) appeared to be in situ and associated to the copperas production around the identified brick crystallizer (FEA-7-BC) in TR-5-BC. Some of the clumps of iron included a possible T-bar and rail fragment along with possible spikes, a metal handle for a tool, and a wrought iron possible gear shaft. All of these iron objects are interpreted as having been used for recharging the liquor. Tools found on the ground surface and in slope wash include a file, a wrench, and two probable church key/openers (catalogued as unidentified tool/metal objects).

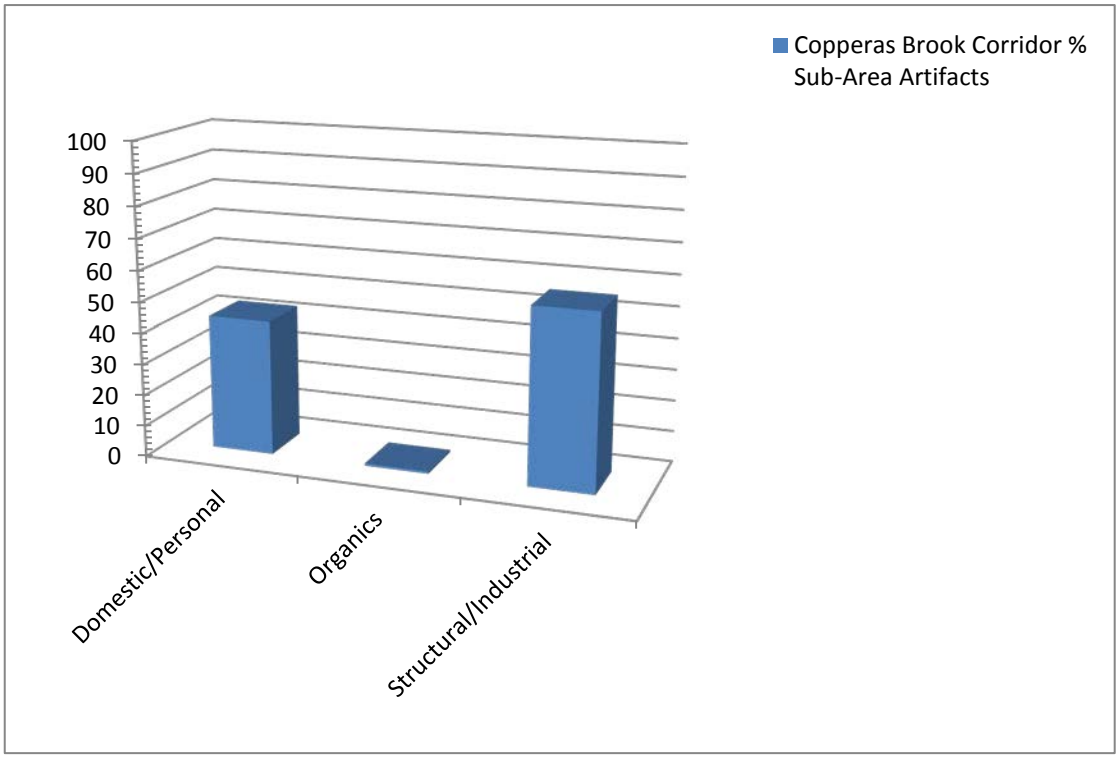

Figure 6-7. Bar graph, Copperas Brook Corridor percentage of artifacts recovered by functional categories, 2009/2010 data recovery investigations.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Table 6-11. Summary of Structural/Industrial Artifacts, Copperas Brook Corridor, 2009/2010 Data Recovery Excavations.

Object	Total
Brick	5
File	1
Flat Glass	5
Lens	1
Miscellaneous Hardware	1
Nail	2
Plate	1
Pulley	2
Quarry Debris – drill core	1
Spatter	5
Tar	2
Trimmings	4
Unidentified Iron	33
Unidentified Tool	1
Wrench	1
Misc. Structural/Industrial	10
Grand Total	75

Table 6-12. Summary of Organics, Pine Grove Area 2009/2010 Data Recovery Excavations.

Object	Total
Mammal – burned medium size unidentifiable species	1
Grand Total	1

Pine Grove Area

The data recovery investigations at the Pine Grove Area recovered artifacts from all three functional categories described above (see Table 6-2 and Figure 6-8). Only one organic, a burned bone of an unidentified medium size mammal, was found in fill deposits in this area (Table 6-12). The structural/industrial artifact category in the Pine Grove Area consists of 76 objects, all recovered from two to four ft below surface in TR-2-PG containing the foundation remains of a probable barn (Table 6-13). Two barns appear at this location on the 1874 map, which would place them on site during the period of Copperas Factory production. The majority of these materials (n=48) are window glass fragments, which have a mean manufacture date of 1872 using Moir's regression formula. Three unidentified nails along with one brick and lead caulking were also recovered in the same fill. The low density of nails recovered in this area is difficult to interpret; it could be the result of scavenging and re-use of these materials by the owners/occupations following abandonment of the documented barn. Other objects of note in TR-2-PG include two beveled (keg?) lid fragments that measured 5 and 9 inches in diameter (partially complete).

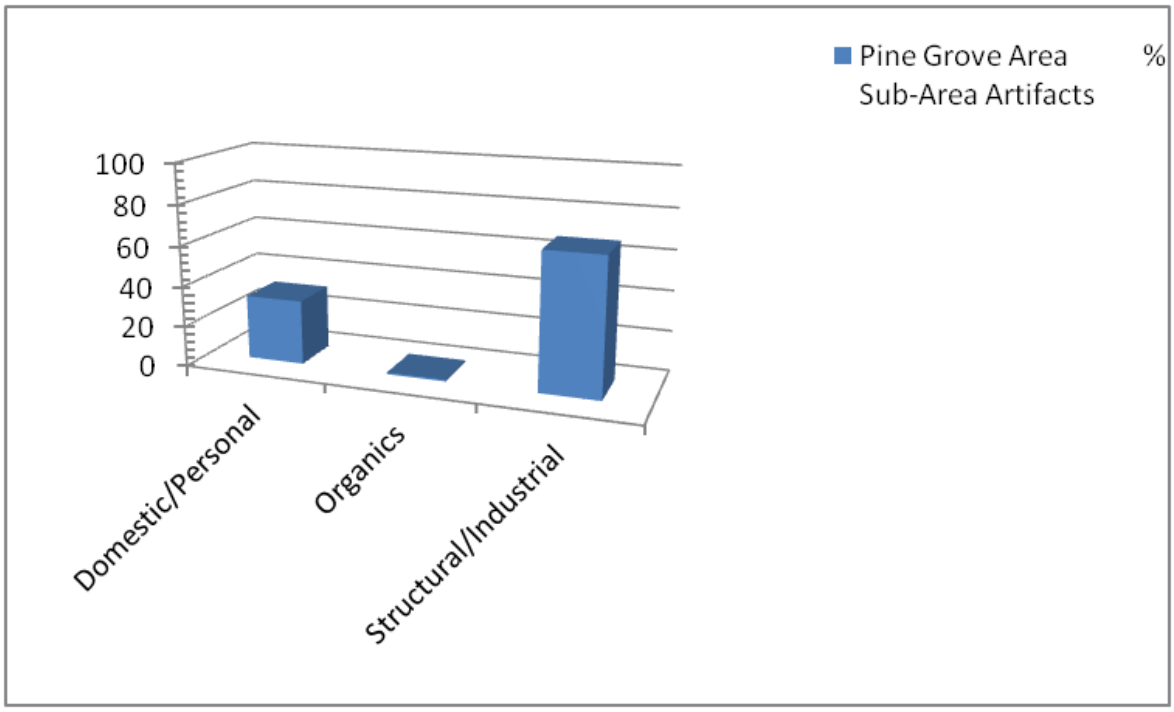

Figure 6-8. Bar graph, Pine Grove percentage of artifacts recovered by functional category, 2009/2010 data recovery investigations.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Table 6-13. Summary of Structural/Industrial Artifacts, Pine Grove Area, 2009/2010 Data Recovery Excavations.

Object	Total
Brick	1
Flat Glass	48
Nail - unidentified	3
Unidentified plastic, leather, textile, rubber	23
Lead Caulking	2
Grand Total	75

Domestic/personal items (n=36) were also recovered in the same fill deposits in TR-02-PG. These materials include temporally diagnostic ceramic sherds (n=17) and one medicine bottle fragment (Table 6-14). The ceramic assemblage is dominated by plain whiteware (n=10), having a broad date range of manufacture from 1820 to present. However, one piece of earlier mocha-decorated whiteware (1820-1900) along with four American stoneware sherds (1800-1880), and one trailed decorated redware sherd (1700-1830) are also present. The ceramic assemblage recovered in the Pine Grove Area includes the earliest date range of manufacture for ceramics recovered during the data recovery investigations, in addition to comprising the largest of the ceramic assemblages at the Copperas Factories Subsite. The ceramics along with other domestic/personal items including curved (bottle) glass, leather shoe and boot fragments, and a kaolin pipe stem fragment are commensurate with the use/occupation of this area associated with the documented North Village barns that appear at this location on the 1874 Vermont Copperas Company Map. The ceramics also suggest a possibly earlier (pre-copperas factory) construction date/use of the barns.

Table 6-14. Summary of Domestic/Personal Artifacts, Pine Grove Area, 2009/2010 Data Recovery Excavations.

Object	Date Range	Total
Belt		2
Boot/Shoe		2
Bottle/Jar – medicine	1840 -1880	1
Cork for medicine jar		1
Misc. Curved Glass		13
American Stoneware, Albany Slip/Salt Glaze	1800 -1880	4
Redware, Lead Glaze	1600 -Present	1
Redware, Trailed Slipware	1700 -1830	1
Whiteware, Mocha	1820 -1900	1
Whiteware, Undecorated	1820 -Present	10
Smoking Pipe		1
Total		37

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The 2009 and 2010 data recovery and construction (mine waste removal) monitoring at the Elizabeth Mine copperas factories uncovered extensive, and in some cases, unanticipated industrial archaeological features associated with copperas manufacturing. The 2009 field season work at the visible foundation at the Upper Factory uncovered tiered remains of copperas boiling, cooling and crystallizing process structures and vessels. The 2009 field season work at the visible foundation at the Lower Factory uncovered an unusually intact assemblage of workspace features and artifacts, as well as the remains of copperas processing equipment both comparable to and different from that found at the Upper Factory. Work in 2009 in the North Berm and South Berm areas and the 2010 work in the Copperas Brook Corridor revealed additional copperas processing features and factory structural remains, and revealed that the Upper Factory site as originally understood was more complex and much larger than anticipated and may have contained the remains of more than one of the reported factories at that location. Subsequent mine waste removal monitoring in several of these areas revealed additional information that contributed to the understanding of the site.

As discussed in Chapter 6, the 2009 and 2010 archaeological data recovery campaigns provided sufficient data to address the research questions for the Copperas Factories Subsite posed in the 2003 PAL survey report and data recovery research design. The data recovery investigations contributed to the understanding of the copperas manufacturing process and plant construction and layout at the Elizabeth Mine site. The excavations confirmed and documented locations, relationships and construction of vessel structures associated with the successive steps of copperas production. In the case of the Upper Factory the data recovered corresponded elegantly with the tiered boiler-cooler-crystallizer sequence on the landscape as described in the historical record. The different layout of the Lower Factory indicated an alternate arrangement of the manufacturing process, and the artifacts indicated an additional multi-use workshop function. The presence of additional boiler features in the North Berm and South Berm suggested the remains of another factory or factories, or steps in copperas manufacturing undocumented in the written historical record.

The data recovery investigations were also successful in documenting deep and/or expansive heavy masonry and timber substructures and brick and stone construction of copperas boilers, coolers and crystallizers that add to the understanding of nineteenth-century rural industrial site construction methods. The excavations demonstrated the site's three-dimensional, spatial and structural complexity and four-dimensional (temporal) complexity in remains that appear to reflect different factories operating in successive phases or in ways not described in historical record. The site analysis demonstrated the importance of the use of archival research materials and careful examination and creative use of the written historical record, which is not always accurate, for site interpretation. The site analysis also underscored the importance of consulting knowledgeable experts in the areas of applicable disciplines including mining engineering, chemistry, economic and structural geology, and even maple sugar pan construction and operation to inform an accurate understanding of industrial and natural processes and constraints affecting the manufacturing and post-manufacturing behavior of and impacts to the site and associated materials.

The 2009 and 2010 data recovery investigations also suggested that interpretation of archaeological data at similar types of industrial sites may be complicated by the action of mining and post-mining period natural and human-aggravated phenomena including steep topography, wet soils, waste material disturbance/movement/re-deposition, scavenging, erosion, unusual rock and soil chemistry, rock alteration, and timber preservation and decay. The appearance and behavior of these phenomena can challenge the traditional understanding of soil stratigraphy, artifact and structure preservation, etc. The universal physics of natural processes obviously apply everywhere, but topographic or chemical anomalies can accelerate those processes, and mining activity disturbance can violate the basic principle of stratigraphic superposition. What applies in an undisturbed, or residential, or agricultural, etc. setting may not always apply in an industrial or mining setting.

In sum, the data recovery successfully recorded data that can inform future investigations at this and other copperas manufacturing and similar early industrial chemical production sites.

Recommendations

Additional Research and Investigations

The late discovery of the transcripts from the Nash Papers in one of Collamer Abbott's notebooks (Notebook No. 51) not included in the holdings of the University of Vermont Bailey-Howe Special Collections Library suggests that additional archival information about the Orange County copper mines in general and the South Strafford copperas works specifically may exist in known or unknown repositories. Consultation with the Rauner Special Collections Library at Dartmouth College, Hanover, NH has concluded that the Nash Papers as identified by Abbott are no longer (or perhaps never were) at Dartmouth College. Future research on the copperas works may benefit from careful examination of Abbott's notebooks at UVM and other sources not yet identified. The Notebook 51 information used for this report should be more carefully examined for additional information. Other sources that could be re-examined include the 1865 Vermont Copperas Company Report, the 1862 Vermont Copperas Company Advertisement, and the 1838 description of the copperas works in the Penny Magazine of London.

Inquiry into maple sugar pan construction and operation shed important light on possible copperas liquor boiler construction and operation. Additional research into industrial, commercial and food production combustion theory, practice and engineering, and even "experimental archaeology" observation of sugar pan operation could possibly additionally inform the understanding of how copperas boilers were constructed and operated.

Future Archaeology

Despite the extensive data recovery efforts in 2009 and 2010, the surviving unexcavated portions of the copperas factories (Figure 7-1) still have the potential to provide information about copperas manufacturing at the Elizabeth Mine. EPA cleanup design elements for the copperas factories and small parts of TP 3 were changed during archaeological data recovery to balance the removal of mine waste with protection of significant archaeological resources. The South Berm, where a copperas liquor boiler was discovered, was set aside for preservation in exchange for the data recovery and monitoring of removal of the boiler feature at the adjacent North Berm in consultation and agreement with the VT State Archaeologist. At the Upper Factory and Lower Factory, instead of removing the mine waste after the data recovery, the archaeological sites were retained and covered with a geotextile fabric marker layer and capped with distinctive round tan granite river cobles, the boundary of which corresponds with the larger, lead-contaminated soil area and contrasts with the gray, irregular crushed rock of the sedimentation basin lining (Figure 7-2 and Figure 7-3). This capping and marking method delineates the

extent of cleanup archaeological investigations, protects the factory archaeological sites from looting, and preserves them for potential additional future archaeological investigations.

Should ongoing mine water or other environmental testing lead to a decision that the copperas factories or the South Berm are continuing to contribute to water quality issues, additional data recovery would add to the information collected during the 2009 and 2010 seasons. Data recovery within the unexcavated portions of the Upper Factory has the potential to reveal additional copperas manufacturing vessels, and most significantly, to expose the remaining underlying timbers and bedrock, potentially confirming interpretation of the sloping timber structure explored and documented in 2009 and 2010. Data recovery at the South Berm would confirm the function of the boiler feature located there; the apparent integrity of that feature suggests that careful bisection would add significantly to the understanding of its construction and operation. PAL does not recommend any additional data recovery at the Lower Factory; the 2009 data recovery uncovered the majority of the factory working floor and subsequent removal of mine waste at the north foot of the factory wall precludes work in that area. PAL's conclusion that the Inter-Copperas Area was associated with temporary copperas storage suggests that additional work in that area would not make a major contribution to the understanding of the manufacturing process and would not benefit from additional data recovery.

Future Public Education and Site Interpretation

The 2009 and 2010 data recovery and monitoring activities at the copperas factories and on TP 3 revealed information about the factory layout and operations that would be valuable for inclusion in future public "on-site/website" interpretation of copperas manufacturing at South Strafford, VT, the history of the Elizabeth Mine in general, and the inclusion of the cultural resource process in the mine site cleanup.

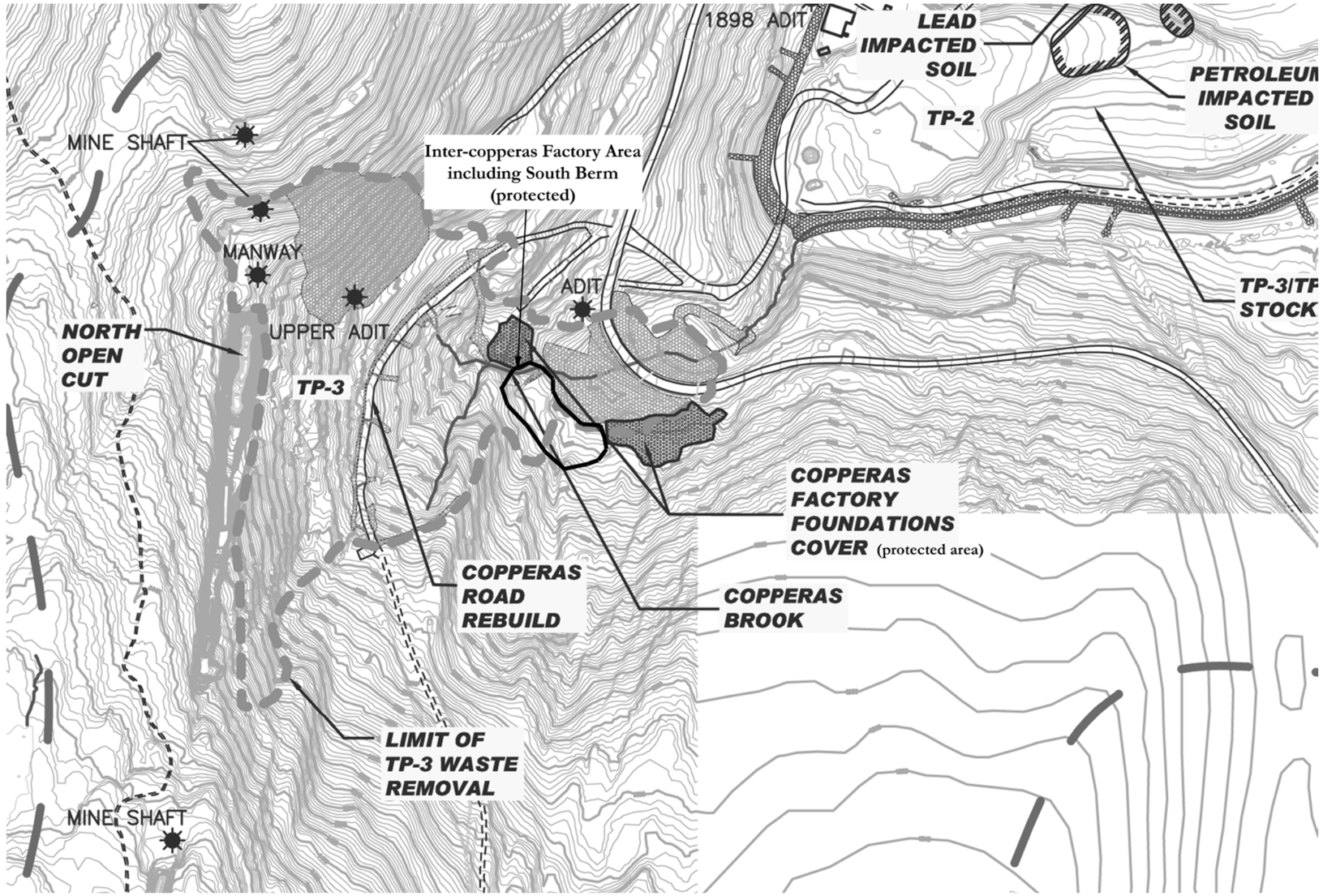

Figure 7-1. Map showing the protected unexcavated portions of the Copperas Factories Subsite at Elizabeth Mine, as of August 2010.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 7-2. Photograph of Upper Copperas Factory after data recovery and cleanup capping with round river cobbles, looking southwest with then un-reclaimed TP 3 in background.

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

Figure 7-3. Photograph of Lower Copperas Factory after data recovery and cleanup capping with round river cobbles, looking southeast, with sedimentation basin in foreground

Data Recovery and Monitoring Elizabeth Mine Site, TP3 2009-2010

REFERENCES

Anonymous

1827 *Columbian Centinel* December 1, 1827, p. 1.

1862 *Notice to Teamsters, from the Vermont Copperas Company, Dec. 1, 1862*. On File, Strafford Historical Society, Strafford, VT.

Abbott Collamer M.

1964 Green Mountain Copper (Long Version.) Manuscript on file, Special Collections Library, University of Vermont, Burlington, VT.

n.d. "Nash Papers," Rauner Special Collections Library, Dartmouth College, Hanover, NH as transcribed in Notebook 51, pp.71-119, 170-171, 188-189, 194-201, in possession of Johnny Johnsson (see List of Informants below)

Adams, C. B.

1845 *First Annual Report on the Geology of the State of Vermont.* Chauncey Goodrich, Burlington, VT.

Agricola, Georgius

1950 [1556] *De Re Metallica*. Translated by Herbert Clark Hoover and Lou Henry Hoover.

Allen, Tim

1999 "The Copperas Works at Tankerton" *Canterbury National Trust Annual Report*, http://www.canterburytrust.co.uk/annreps/pdfs/1999/002.pdf p.13-17.

Allen, Tim

2002 "The Forgotten Chemical Revolution," *British Archeology Magazine*. Issue 66, August 2002.

Bell, George

1882 *Notes on Bread Making, Permanent and Field Ovens, and Bake Houses*. Government Printing Office, Washington, DC.

Biringuccio, Vannoccio

1990 [1540] *The Piotechnia of Vannoccio Biringuccio: The Classic Sixteenth-Century Treatise on Metals and Metallurgy*. Translation, introduction, and notes by Cyril Stanley Smith and Martha Teach Gnudi. Dover Publications, New York, NY.

Brady, George

1947 *Materials Handbook: An Encyclopedia for Purchasing Agents, Engineers, Executives, and Foremen.* 6th ed. McGraw-Hill Book Company, Inc., New York, NY.

Cherau, Suzanne, Ben Ford and Matthew Kierstead
2003 *Historic/Archaeological Mapping and Testing, Elizabeth Mine Site, Strafford and Thetford, VT, Vol.* Prepared for: U.S. Army Corps of Engineers, New England District, Concord, MA. Prepared by PAL, Pawtucket, RI.

Colwall, Daniel
1678 ”An Account of the Way of Making English Green-Copperas,” *Philosophical Transactions*, The Royal Society, Vol. 12 (1667-1678), pp 1056-1059.

Day, David T.
1885 Copperas. *Mineral Resources of the United States, 1883-1884. United States Geological Survey,* United States Government Printing Office, Washington D.C.

Diderot, Denis
1751 *Diderot Pictorial Encyclopedia of Trades and Industry,* volume 1. Edited and by Charles Coulston Gillespie, Dover Publications, Inc., New York, NY.

Duncan, R. H.
1871 Copperas Hill and the Works of the New England Chemical Company. *Vermont Historical Magazine*, vol 2: 1085–1088.

Gage, James and Mary Gage
2002 *The Art of Splitting Stone.* Powow River Books, Amesbury, MA.

Garvin, James L.
2001 *A Building History of Northern New England.* University Press of New England, Hanover, NH

Garvin, James L.
2010 New Hampshire Bureau of Historical Resources. (July 1, 2010). *Report on the Gardner Towle House, 194 Wadleigh Falls Road, Lee, New Hampshire*. Retrieved Oct. 1, 2010 from nhdhr database on the world wide web: http://www.nh.gov/nhdhr/publications/documents/lee_towle_house.pdf

Graves, Jim
1995 “Brick Manufacturers by Brand Name,” unpublished manuscript from International Brick Collectors Association, Jim Graves, IBCA librarian, dated December 12, 1995 (courtesy of Victor Rolando).

Hitchcock, E., E. Hitchcock Jr., A. Hager, and C. Hitchcock
1861 *Report on the Geology of Vermont: Descriptive, Theoretical, Economical and Sceneographical,* vol II. The Claremont Manufacturing Company, Claremont, NH.

Locke, Dr. John
1824 [1821] Some Accounts of the Copperus Mines and Manufactory in Stafford, VT. *Manufacture of Sulphat of Iron, American Journal of Science and Arts,* 8(2):326–330.

Moir, Randall W.
1977 *Window Glass: A Statistical Perspective*. Manuscript on file, Archaeology Research Program, Southern Methodist University, Dallas, TX.

1987 *Socioeconomic and Chronometric Patterning of Window Glass in Historic Buildings, Material Culture, and People of the Prairie Margin*, edited by David H. Jurney and Randall W. Moir, pp. 73–81. Richland Creek Technical Series vol. V. Southern Methodist University, Dallas, TX.

Niles Weekly Register
1835 "The Copperas Mines of Strafford," Forth Series, No. 23, Vol. X11. Baltimore, MD August 8, 1835. Vol. XLVIII, Whole No. 1, 246. p. 395.

Reynolds, John
1863 Letter to William B. Reynolds, March 3, 1863. Vermont Copperas Company correspondence, Nash Papers, Baker Library, Dartmouth College, Hanover, NH.

Reynolds, William B.
1865 *Statement of the Property of the Vermont Copperas Co. Strafford, State of Vermont*. Alfred Mudge and Sons, Boston. On file, Strafford Historical Society, Strafford, VT.

Richardson,
1832 "Copper Ore of Stafford, Vt &c." extracted from a letter to Mr. C.U. Shepard, from Mr. Richardson of Franconia, H.H. Sept. 26, 1831. *The American Journal of Science, and Arts* 11 (Jan. 1832):383–384.

Smith, Gwenda
2001 Unpublished research notes on copperas. On file, Strafford Historical Society, Strafford, VT.

Smith, Warren S.
1927 "Vermont Copper: Pyrrhotite for Sulfide Works." Unpublished private report, September 1927. 19 pp. Collamer Abbott Collection, University of Vermont, Bailey- Howe Special Collections Library, Burlington, VT.

Society for the Diffusion of Useful Knowledge
1838 The Copperas-Mine of Vermont. In *The Penny Magazine*, No. 419, October 13, 1838. London, England.

Thompson, Zadock
1824 *A Gazetteer of the State of Vermont.* Montpelier, VT.

1842 *History of Vermont. . . in Three Parts, Part Third, Gazetteer of Vermont*, Burlington, VT.

Tyson, Isaac, Jr.
1831 "Report of the Committee on Chemistry, General Convention of Friends of Domestic Industry, New York, October 26, 1831," reproduced in "The First Report Upon the Chemical Industries of the United States and Their Relation to National Preparedness," C.A. Brown, in *The Journal of Industrial and Engineering Chemistry*, Vol. 9, No. 2, Feb. 1, 1917, pp. 177-181.

United States Census Bureau
1810 Census of Manufacturers. Vermont State Library, Montpelier, VT.

1820 Census of Manufacturers. Vermont State Library, Montpelier, VT.

1850 Census of Manufacturers. Vermont State Library, Montpelier, VT.

1860 Census of Manufacturers. Vermont State Library, Montpelier, VT.

1880 Census of Manufacturers. Vermont State Library, Montpelier, VT.

Vermont Historical Society
1833 Copperas Hill Ledger, Justin Morrill Papers. On file, Vermont Historical Society, Barre, VT.

Vermont Secretary of State
1918 *State Papers of Vermont Volume 1: Index to the Papers of the Surveyors-General*. The Tuttle Co., Rutland, VT.

Wagner, Rudolf
1988 [1872] *A Handbook of Chemical Technology*. Translated and edited by William Crookes. D. Appleton and Company, New York, NY. Reprinted by Lindsay Publications Inc., Bradley, IN.

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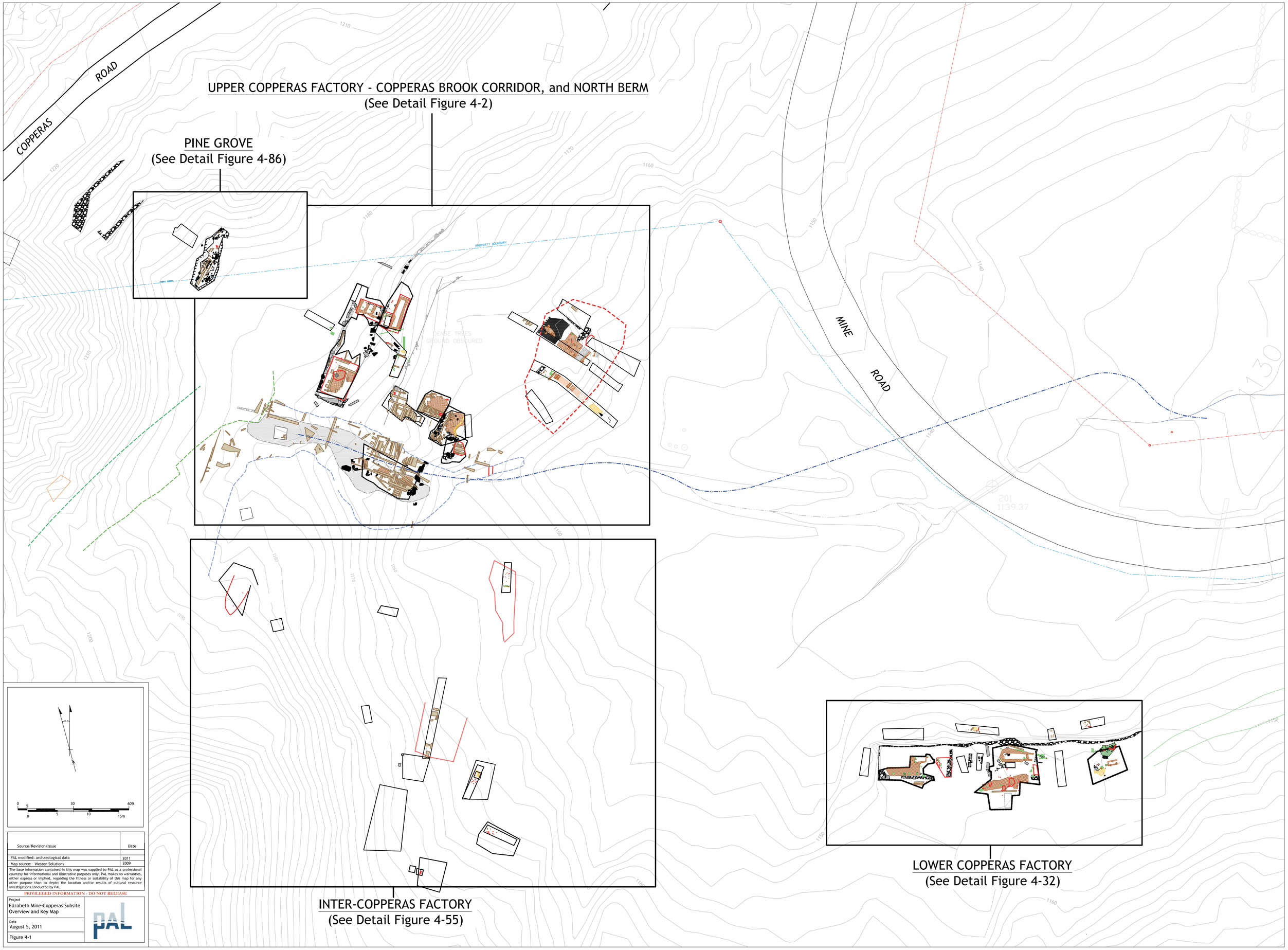

Figure 4-1. Overview and key map of the Copperas Factory Subsite, Elizabeth Mine Site, Orange County, VT.

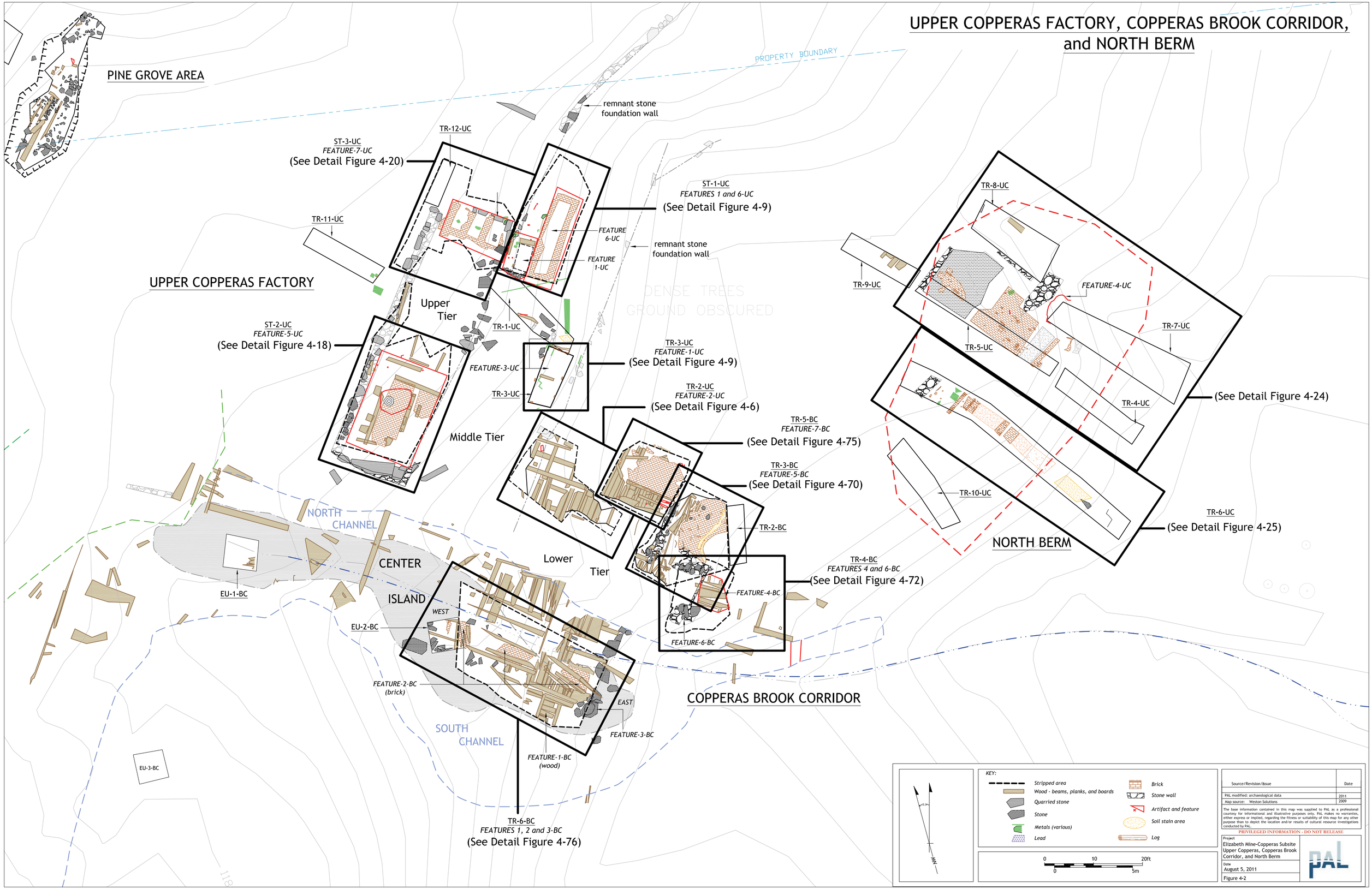

Figure 4-2. Upper Copperas Factory, Copperas Brook Corridor, and North Berm, Copperas Factory Subsite, Elizabeth Mine Site, Orange County, VT.

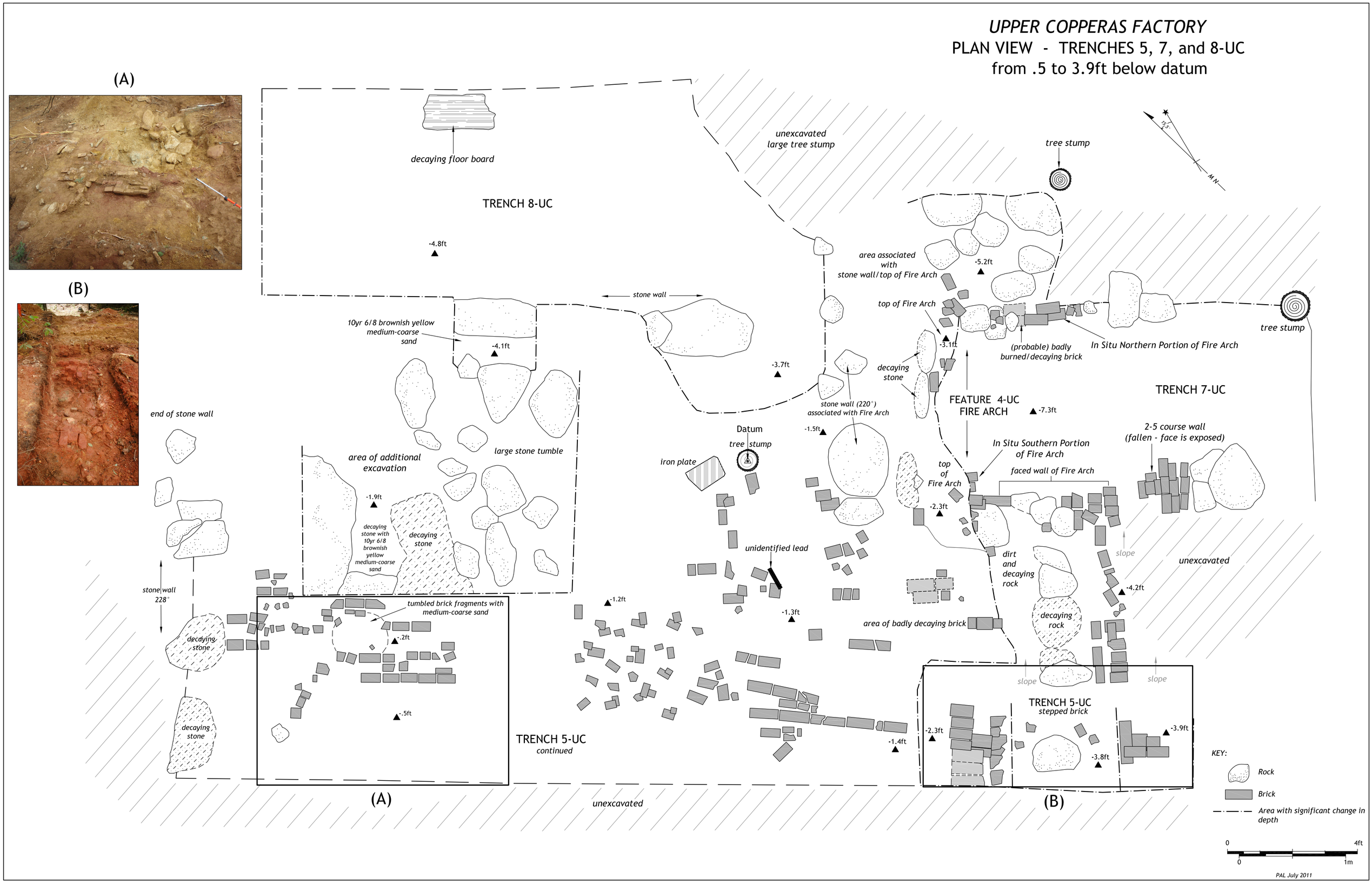

Figure 4-24. Plan views of TR-5-UC, TR-7-UC, and TR-8-UC in the North Berm.

LOWER COPPERAS FACTORY

TR-1-LC

TR-2-LC

TR-4-LC

TR-5-LC

TR-6-LC

TR-7-LC

TR-8-LC

CONTEXT I

CONTEXT II

CONTEXT III

CONTEXT IV

CONTEXT V

CONTEXT VI

exploratory trench

ST-3-LC
FEATURE-4-LC
(See Detail Figure 4-51)

ST-2-LC
FEATURE-2-LC
(See Detail Figure 4-46)

ST-1-LC
FEATURE-1-LC
(See Detail Figure 4-45)

KEY:

- Stripped area
- Wood - beams, planks, and boards
- Quarried stone
- Stone
- Metals (various)
- Lead
- Brick
- Stone wall
- Artifact and feature
- Soil stain area

0 10 20ft
0 5m

Source/Revision/Issue	Date
PAL modified: archaeological data	2011
Map source: Weston Solutions	2009

The base information contained in this map was supplied to PAL as a professional courtesy for informational and illustrative purposes only. PAL makes no warranties, either express or implied, regarding the fitness or suitability of this map for any other purpose than to depict the location and/or results of cultural resource investigations conducted by PAL.

PRIVILEGED INFORMATION - DO NOT RELEASE

Project
Elizabeth Mine-Copperas Subsite
Lower Copperas Factory

Date
August 5, 2011

Figure 4-32

Figure 4-32. Lower Copperas Factory, showing the locations of data recovery excavations and identified features, Copperas Factory Subsite, Elizabeth Mine Site, Orange County, VT..

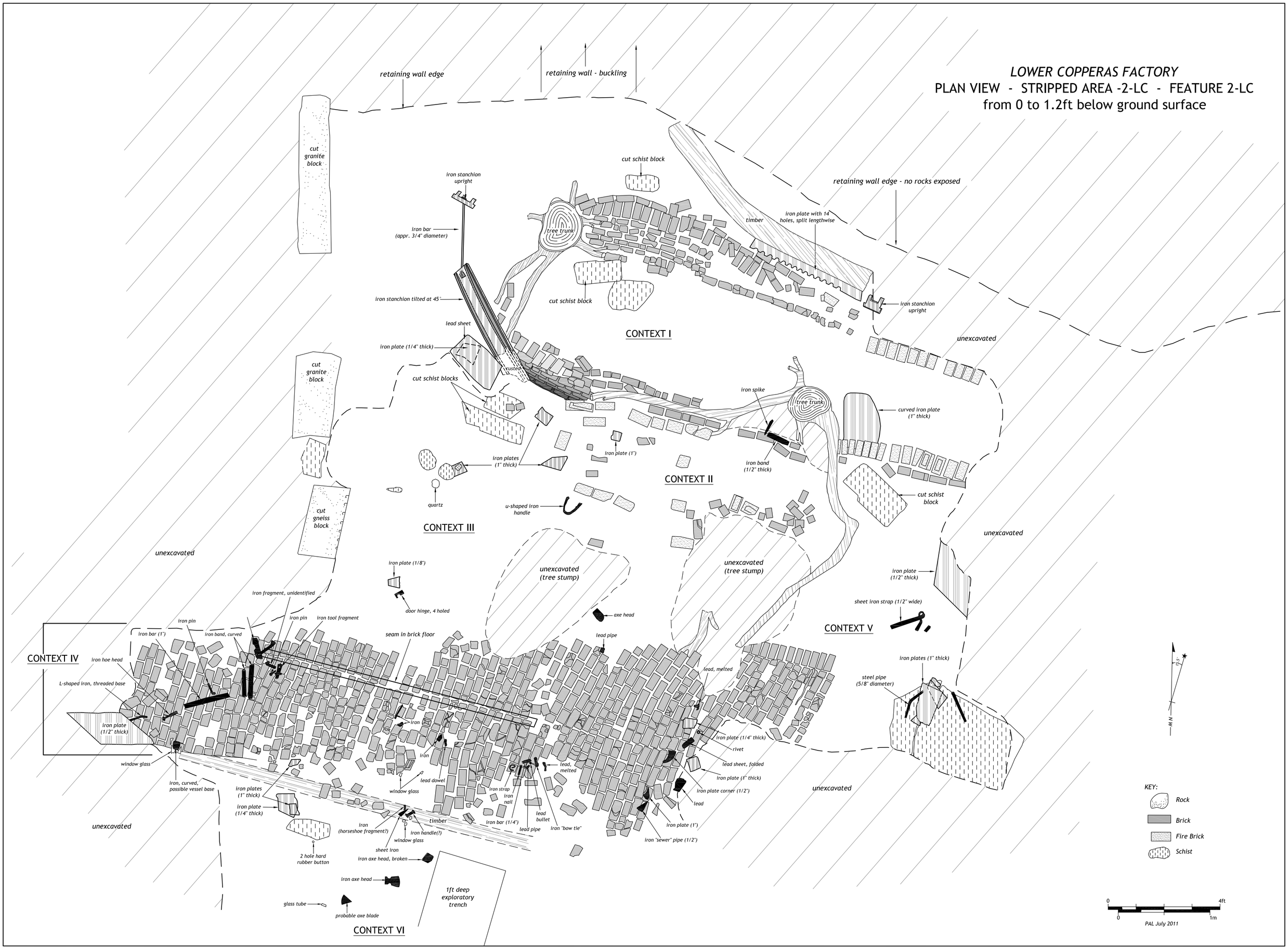

Figure 4-46. Plan view of FEA-2-LC.

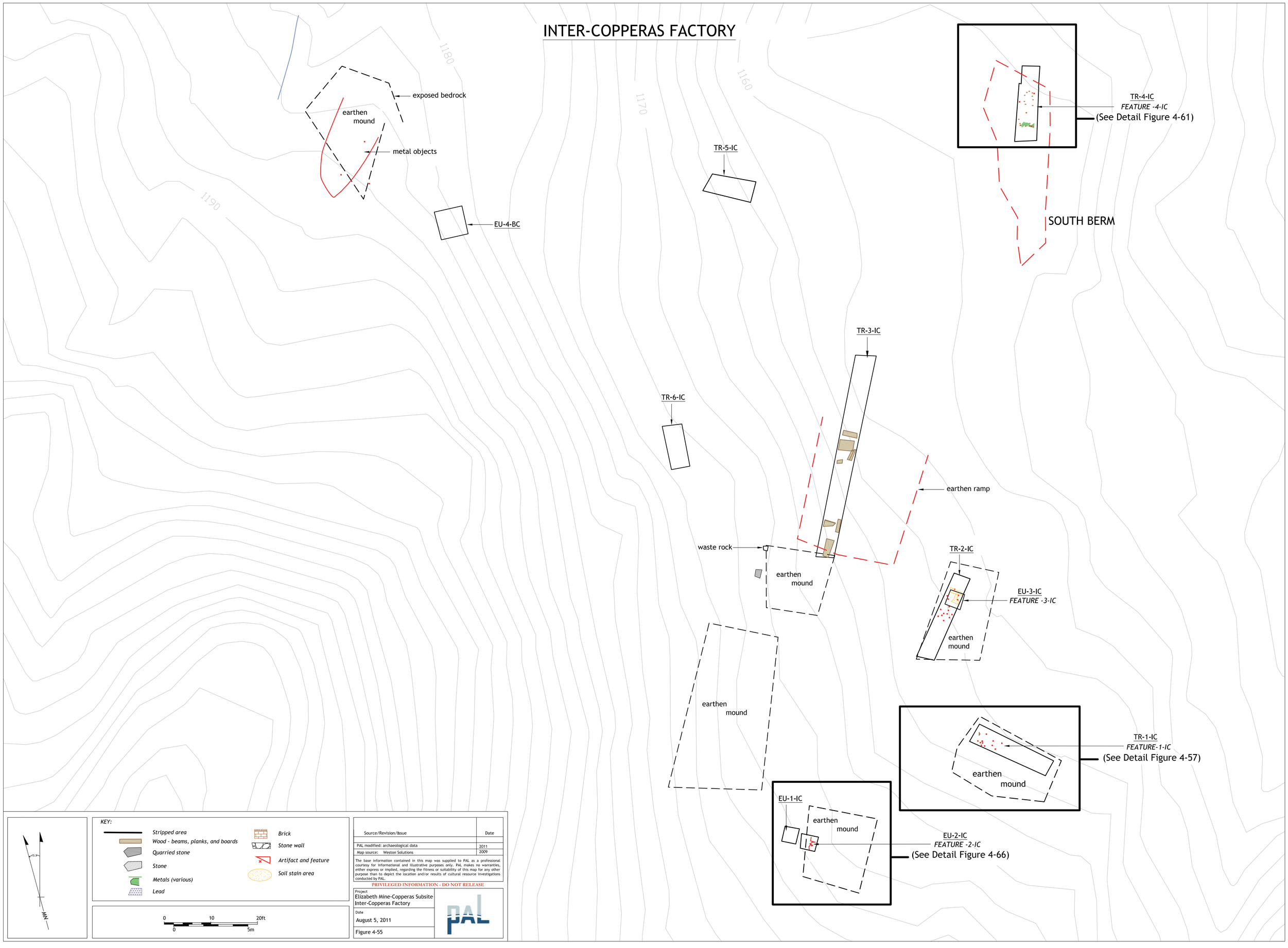

Figure 4-55. Inter-Copperas Factory, showing the locations of data recovery excavations and identified features, Copperas Factory Subsite, Elizabeth Mine Site, Orange County, VT..

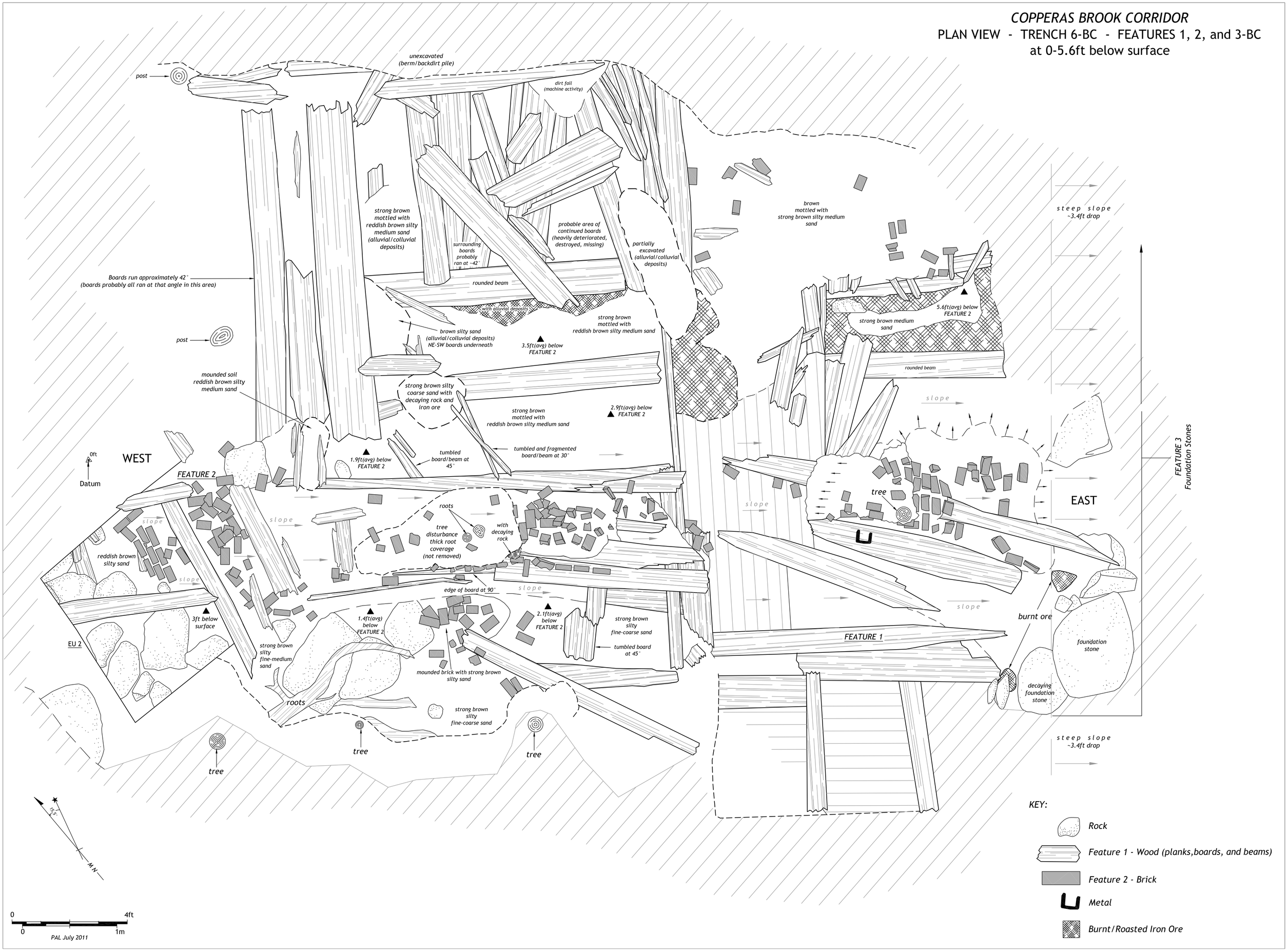

Figure 4-76. Plan view of TR-6-UC showing FEA-1, 2, and 3-BC at 5.6ft below surface.