The Old Water Works Archaeological Project, Bethlehem, Pennsylvania, 1964

by

Vincent P. Foley

April, 1965
Post Office Box #75
Westchester Station
New York 61, New York

Acknowledgements

The persons that can take credit for making the 1964 Old Water Works Archaeological Project a success are myriad. Primary thanks must be extended to the exceptionally "game" students from the University of Pennsylvania who undertook and carried out a task that would have been too great for most of their peers.*

Unprepared as they were, relative to trained muscle power, they pitched into a job that brings aches and pains to the best laborers. More than this, their general enthusiasm and motivation brought to the project the unbeatable combination of brains and brawn, never matchable in an excavation by hired laborers alone.

Even the three lady students ignored their stiffness and culturally prescribed feminine weaknesses and worked with vigor. One of the girls in particular rivaled all male project members with her dirt pitching and intelligent planning.

An example is warranted. It is estimated that 30 truckloads, or about 3,507 cubic feet of over-burden were removed from the interior of the water works building alone, and the student-workers were responsible for the vast majority. This is an even more awesome accomplishment when it is remembered that all the digging was done with hand tools, and every stage, phase, level and feature was accurately measured and recorded. Tired, hot and dirty, the day's "quitting time" only signaled several additional hours of thought and paper work on the part of each student.

We will always remember and be grateful to the many citizens of Bethlehem, who through their kindness, interest and public spiritedness, helped to make our stay a pleasant and productive period. For her hospitality and friendship, Mrs. James P. Bender must head our list. To Mrs. Byron C. Hayes for her assistance in the location of important materials already in Historic Bethlehem files. To Mr. and Mrs. Traver Schadler our appreciation goes for their hospitality and to Mr. Schadler, especially, for his many hours of volunteered dependable help in the excavation and laboratory phases of the project.

---

*Richard Ellis, Donald Friary, Virginia Knox, Barbara Liggett, Kenneth Pletter and Martha Rhoads.

To Mr. Joseph Mangan and Mr. Richard Riccaboni, heads of Bethlehem's Parks and Water Departments respectively, my thanks for their patience with requests for assistance and their more-than-willing aid.

Our appreciation is also extended to Mrs. Clara Magdasy, operator of Clara's Luncheonette on Main Street, who accepted the job of feeding the students during their stay, and went far "beyond the call" with special motherly attention for them.

Last, but immeasurably, my gratitude goes to my wife, Terry, whose indefatigable efforts in the field, laboratory and office, makes the archaeologist's life bearable, and projects successful. For her assistance in supervising the workers and students, processing the artifacts, typing and criticizing manuscripts, my especial thanks, for she is literally and figuratively my right arm.

Preface

During the spring of 1964 a contract was let to the writer by Historic Bethlehem, Incorporated for archaeological investigations in and around the old water works area along Water Street in Bethlehem, Pennsylvania.

The contract outlined two main tasks: primarily to undertake the scientific excavations already referred to, but also to supervise the work of six students from the University of Pennsylvania's graduate school of American Civilization. The said students were enrolled in the University's Course #772, Methods and Problems of Historic Sites Archaeology, under Dr. John L. Cotter.

As planned, the students were to work for the project for six weeks, while acquiring "on-the-job training," in archaeological field techniques. As originally envisaged (Contract Article II, Section B, Paragraph 2), the students were to supplement the regularly employed laborers and were, in general, to be considered as part of this force, aside from their observational training.

Once in the field, it became readily apparent that there was no regular labor force that the students could supplement, rather, during the major part of the excavational period, their labors were supplemented with one permanently-hired individual and one to three other sporatically-employed or contributed laborers.

Despite this regrettable lack of labor force, in six weeks the students did amazingly well in the scientific exposure of the internal features of the old water works, part of the pipelines to the old spring house, and the path, character and direction of the headrace which supplied the water works with the wheel-driving power. The path and physical remains of the last fresh water pipeline in the building were uncovered, as was a terminal receptical for this water. Along with these accomplishments, 452 bags of artifacts were collected covering the time span from cerca 1750 to the present day. Much of the later history of the water works' operations can now be reconstructed, as can some events since its abandonment as the pumping station.

The exposure of its physical plan breathes life into the historical accounts that are presently available. Furthermore, although there was insufficient extant evidence to warrant an unchallengeable reconstruction of the works' mechanisms, there are enough points of evidence to allow "educated guesses" and a hypothetical reconstruction plan.

It must be emphasized here, as it will be again, that the old water works has not yet yielded all its evidence. In recent days there has been talk of regret that more archival research had not been accomplished prior to archaeological excavation. The truth in this present objection cannot and must not be denied. At the same time it would be folly to overstate this lack.

It is true that the archival research promised by Historic Bethlehem, Incorporated to the contractor, prior to excavations was not realized, and that such research might have made what was uncovered more meaningful, but no features, artifacts or remains were ignored or lost because of the lack of the promised research. To hold this erroneous belief, or to proceed from it, reveals a serious lack of understanding of the aims, procedures and values of scientific archaeology.

Additional comment may be seen in the Recommendations section. Suffice it to say here, time prevented the wresting of a few more secrets from under the wheel pit floor, but vis-a-vis the average archaeological excavation, this project was a complete success.

Table of Contents

Historical Background

The interested citizenry of Bethlehem knows and is justly proud of the history of the Moravian settlement period. The renowned Bishop Joseph Mortimer Levering has made this history available to all in a single comprehensive volume. For those who may be new to "early" Bethlehem and the place of the old water works in it, a short historic sketch is now offered.

Bethlehem was settled in 1742 by a group of religious refugees, the Unitas Fratrum, now commonly called the Moravians. These people came to eastern Pennsylvania after an unhappy settlement period in Savannah, Georgia. Their common name, Moravians, is a misnomer, as there were many Bohemians, Germans, and a good sprinkling of Dutch, Danes and English among their colonists. Religiously, they did, however, spring from the "heresy" of John Huss, and spent much of their early period eluding persecution in Moravia.

Interesting as their religious history and struggles may be, their importance to the history of this country is only a reflection of their religious problems.

When they secured a measure of immunity from persecution in what is now East Germany, they became fascinated by the missionizing possibilities among the American Indian. As such, they planned a network of mission stations in this new country whose prime purpose

was the Christianization and protection of the Indian, and secondly, the unifying of unattached Caucasian Christian settlers. They very quickly organized satellite missions in North Carolina, the West Indies and Surinam.

There were well-known parallel sentiments among the Society of Friends, but the Moravians went further, believing that all material possessions, towns, funds, crops, etc. were only of value insofar as they served the primary aim.[1] There was no personal possession of real property; crops were public-use property. In effect, they were "communistic."[2]

The uniqueness of Moravian colonization goes still further. They were unparalleled town planners. They left Europe with a plan of attack, a plan for buildings, trades, farms and professions.

Historians can marvel at the ramifications implicit in the fact that a good portion of the settlers had passage on ships owned by the Moravian church, captained and crewed by persons sympathetic to

---

[1]Dr. Anthony N. B. Garvan of the University of Pennsylvania has recently pointed out that this wholistic approach to settlement evinces a more practical aim on the part of the European backers of the Moravians, other than pure altruism. That is, the Moravian Communities, though they may have served the missionizing desires of its members, were probably baronial extensions of European estates. This theory would comply with Baron and Baroness von Zinzendorf's relationships with the Moravians, and their acquisition and continual control of the American colonial lands. The thesis deserves encouragement for further detailed development.

[2]Hellmuth Erbe, Bethlehem, Pa. - A Communistic Herrnhut Colony of the 18th Century (Stuttgart: German Foreign Institute, 1929).

their cause, with passengers selected on the basis of trades, knowledge, education -- a self-sufficient community. The Church is justly proud that no early Moravian settler ever landed on American soil in bondage. If an individual desired to settle and had something to offer, he was provided berth and passage.

By 1754, the Bethlehem Moravians had erected an industrial quarter of nine acres including a grist mill, saw mill, oil mill, tannery, tawry, pottery, blacksmith, joiners, tile and brick plant, nailsmith, and the "first water works in America."

One of the main attractions of the Bethlehem site to its founders was the presence of a "copious spring" on the side of the hill between the center of town (Der Platz) and the Monocacy Creek. This spring served the citizens of Bethlehem as the major water supply from the first time Bishop David Nitschmann tasted it on December 23, 1740 until its abandonment in 1912. In recent years, before purer water had to be sought elsewhere, the spring yielded a calculated 1,200,000 gallons daily.[3]

During the first thirteen years of the colony, drinking and cooking water had to be secured in buckets by descending and ascending the hill several times daily. As the town grew and muscles softened, a more practical system was sought. The town's new millwright, a young Dane, Hans Christiansen began working on the problem, and with

---

[3]Benjamin LeRoy Miller. Northhampton County Pennsylvania Geology and Geography (Harrisburg: Pennsylvania Geological Survey, 4th Series, Bulletin C 48, 1939), p. 421.

the aid and advice of the missionary and pioneer John Boehner, evolved a system whereby the water could be pumped up to Der Platz. Boehner made a model pump for Christiansen, for he " . . . had some knowledge of such mechanism which he had seen successfully operated . . . . "[4]

Power to drive the pumps for the contemplated experiment was borrowed from the oil mill (a frame building which stood across the street from the present water works building and on which site the second oil mill stood until the 1930's). To house the equipment, a frame structure was constructed just north of the present building.

The fresh water was brought to the building from the spring in a trough. It was collected in a cistern from which it was drawn by the pumps, and on June 21, 1754, was forced through bored hemlock pipes up the hill and shot a stream in the air " . . . as high as the houses around the square in the town above . . . . "[5]

The success of the experiment caused a separate water wheel to be constructed, equipment improved, pipes properly laid and a water tower built on the west end of the wooden building which occupied the site of the present church at the corner of Main and Church Streets.

The water tower, 32 feet high,[6] received and stored the fresh water pumped to it from below. From the tower the water

---

[4]Bishop Joseph Mortimer Levering. A History of Bethlehem, Pennsylvania 1741 - 1892 (Bethlehem: Times Publishing Company, 1903), p. 289.

[5]Ibid.

[6]Erbe, n. 414.

was distributed through wooden and later lead conduits to strategically located standpipes around the town (see Plate I, B).

The initial water pumping station used a single pump constructed of lignum vitae,[7] an extremely hard durable wood that would have to have been imported for the purpose -- probably from a Moravian West Indian mission.

According to all the sources available to the writer, the wooden pipes used in the first water system were of hemlock.

The wearing of the pump, or the increased demands of the town, or both, shortly compelled improvements in the system. As such, Christiansen began in 1761 to construct new apparatus with triple pump capacity, all to be housed in a new masonry building laid just south of the original. It is this structure, first operative in 1762, which stands today, albeit modified.

The new water works mechanism was driven by an 18-foot wheel, by water diverted to it from the Monocacy Creek, through a channel called a "race." In general, there are two modifying words used in conjunction with the term race, i. e., "head" and "tail." The "headrace" is that portion which carries the volume-weight combination of water and by various means directs the force of the liquid against an axled wheel. To maintain effective water-power action,

---

[7] Robert Rau. Historical Sketch of the Bethlehem Water Works, Bethlehem, Pa. Compiled at the Request of Borough Council, Bethlehem, Pennsylvania (Bethlehem: 1877), p. 4.

a drain-off or fall must be provided to allow the expended water to flow away after turning the wheel; hence, a "tailrace." In the Bethlehem instance, the tailrace led from the south face of the building and ran back into the Monocacy Creek at a point probably under the present Hill-to-Hill Bridge.

It is known that the 1762 mill employed three pumps, of 4-inch inside diameter, whose pistons travelled 18 inches during each stroke. We also know that these pumps were single-acting force pumps. That is, each stroke of a pump's piston performed a different function. The first downstroke of the piston would cause a "vacuum" in a water-tight chamber. As the piston began its upstroke, fresh water collected below it would be "sucked" into the chamber through a pipe to fill the void. A valve or "clapper" would have to be present in the "intake pipe" so as to close when the "sucking" action of the rising piston subsided, and prevent the water from running out again. As the piston began its next downstroke, the compressed water would be allowed to escape through another, higher valve which constituted part of the pipeline to the water tower. Repetition of such action would "build" a column of water in the pipe leading to the tower, eventually spilling over into and filling this receptacle in the town square above.

Thus, the entire water works cycle depended on gravity to bring the fresh water from the spring to the water works pumps, water-wheel power to pump it to the water tower, and gravity again

to distribute the water supply through the town.

The documentary sources refer to the difficulties encountered in the pumping-pressure stage between the water works and the tower. The wooden pipes for the purpose were frequently bursting.

The first attempts to use lead for the pressure pipes apparently proved unsuccessful, for they next tried and depended upon gum wood until 1786.[8] By 1796 the pitch pine supply pipes between the tower and the consumers were replaced in lead.

The pride which the early Moravians had in their water system was vindicated by the praise of contemporary visitors. It has been claimed that the first Philadelphia water system was copied fromthe Bethlehem example.[9] Whether this is fact or fiction has not yet been irrefutably established, but it was interesting to learn that the chief engineer and draftsman for both the Center Square and the Fairmont Water Works in Philadelphia was one Frederick Graff,[10] a relative of one of Bethlehem's first settlers.

The 1762 Christiansen water works served Bethlehem well for 70 years, with normal modifications and repairs. In the 1830's the United States was overcome by a mania for steam power, and it was natural that Bethlehem should desire to modernize its water system using

---

[8] Ibid., p. 6.

[9] Erbe, p. 76.

[10] George B. Tatum, Penn's Great Town - 250 Years of Philadelphia Architecture (Philadelphia: American Institute of Architects, University of Pennsylvania Press, 1961), p. 64.

this new force. As such, the oil mill was selected to house the new works with a steam-driven double-acting pump.

From this time on, the story of the old water works building more or less passed into unrecorded history. The type of notation it received is exemplified by the 1874 discussion as to whether to let it for coal storage.[11] It is known that shortly before the 1964 excavations, it had served as a dwelling.

Bishop Levering recalls the time, 1892, when the building's history was recognized by the placement of a bronze plaque on one of its exterior walls.[12] When the archaeological project was initiated, even this remembrance was missing, and only a small wooden sign erroneously stating "Built 1754" graces the doorway.

The original hipped[13] and tiled roof has been replaced by synthetic shingling and the woodwork and masonry shows the results of fire, neglect and vandalism. Fortunately, in contrast to the oil mill (1763), this building still remains and can be saved.

---

[11] Elizabeth Lehman Myers, "Nature, History and Other Lore," Bethlehem Globe Times (Bethlehem: Bethlehem Globe Times, 1926 - 1927), August 3, 1927.

[12] Levering, p. 771 - 772.

[13] I owe Mr. Ralph Schwartz of the Ford Foundation a debt for illustrating through his extensive early Bethlehem picture collection, the fact that the building's roof was indeed once hipped.

Summary of Field Activities

The applicable land area was surveyed by the writer at the beginning of the 1964 field season. It was not yet firmly decided by the executives of Historic Bethlehem, Incorporated whether the majority of archaeological efforts were to be directed at the top of the hill, along Main Street, or at the water works building. The survey was thus aimed to include both areas. In addition, both were "staked" to conform to a grid system that could be reconstructed on a written plan. Stakes were placed in the ground every twenty horizontal feet, where possible. When man-made walls, walks, pavements or natural outcroppings prevented this, the grid point was marked with indelible paints. The most visible example is the "0" point of the grid system which was established on the west side of Main Street at the intersection of the Hill-to-Hill Bridge. (See Map I & II.) From this point, all distances in any direction, and variations in elevation were counted.

Eventually the 0N/0W point will weather, especially if more than one year elapses before renewal. In establishing this point, all possible future excavations in the "industrial area" were taken into account. It will most certainly simplify and expedite preparations of each new project if this point is used. Should weather obliterate the mark before work is resumed, the 0N/0W point can be re-established by taking a transit reading of $00^{o}45'$ True from the northwest corner

of the Brethren's House. The proper datum point could then be reset at 162 plane feet along that azimuth.

Archaeological excavations were approached in two ways, by the pit and the trench. Both are designated by a numbering system which conforms to the grid master plan. For test pits, a 20-foot square staked grid section was divided into four subareas, each 10 feet square and restaked accordingly. Thus, Test Pit I is placed on the master plan as 10N/180W, the stake in the southeast corner of the square being the designating number (Map I, #2). To precisely locate the area, it is that 10 square feet of earth 10 feet north of the east-west line and 180 feet west of the north-south datum line.

Very little archaeological excavation was undertaken at the top of the hill. No archival research, other than what was available from Bishop Levering had been supplied the archaeologist. The entire area is covered with rubble that should be removed before proper excavational study is undertaken.

Two trenches were initiated in the area (see Map I, #8 and #9). Trench #8 revealed a wall and part of a foundation which did not conform to what was known to be historically present, or to the recently razed structures. Continuation, without detailed study of the remains would not have been good procedure. Trench #9 revealed only that the City water utilities for the razed buildings were still active, with the result of a broken water line. Digging was thus discontinued here also.

Two points of attack were initiated in the old water works area. The first was to conform to the corporation's desire to gain information on the original hillside topography. The area was cleared and excavations along the modern retaining wall begun (see Plate IV and V, A). These efforts revealed a lower, earlier wall, whose construction is of a type which could relate to the 18th century. It has been suggested that this structure (Plate V, B) might conform to an early property boundary line. Such reasoning appears sound and should not require much time at the Moravian Archives to substantiate. It is obvious, however, that the erosion and drainage problems of the hillside are not restricted to modern times, and the wall's prime function was one of retention.

The opening or gateway in the wall should provide important clues to the research archivist on what to look for. Its presence and level will also be of aid in the topographic reconstruction of the area.

The second direction of attack, starting with Test Pit #1, sought information of the stratigraphic history of the area, and it was hoped, would intersect with the fresh water delivery system from the spring to the 1762 water works. At the same time there was the possibility of encountering the remains of the first, or 1754 water station.

An examination of Plates VI; VII; XII, B and Figure II will illustrate the information gained from this excavation. Test Pit #1 was ultimately taken to a depth of 10.5'. The water trough, pipes and copper jumper were in an excellent state of preservation. The

stratigraphic profile revealed 4.7' to 5.2' of accumulated and deliberate filling during the 19th and early 20th century. The earlier levels of this fill were probably associated with the change of water pumping equipment and placement.

With the exception of the exterior areas disturbed by pot-hunters and City "improvements" (see discussion of Artifacts and Artifact Analysis), the stratigraphy and associated artifacts of Test Pit #1 are enough alike to warrant its use as the "type" stratigraphy for the site.[14]

Zone I: The upper .4' of fill in Test Pit #1 was the humus zone, with the leaves and roots of the removed vegetative cover.

---

[14] It must be stated that in view of the desire of Historic Bethlehem, Inc. to bring the entire creek area back to grade, extreme caution must be exercised. Although it can be unequivocally stated that relatively nonapplicable 19th century fill is encountered as deep as 5.2', this statement applies only to the areas thus far scientifically excavated. One basic similarity of all the exterior features uncovered was their essential nature of being deliberately buried by their makers. Thus, it would be dangerous to assume from the present evidence that other important 18th century features will not be encountered at levels closer to the present surface. Whole-scale removal of late fill by machine, without more stratigraphic study, could very well destroy important remains.

It would be folly at this juncture to estimate the degree of this danger, but it should be kept in mind that complete and exhaustive study of the archives will not tell of every early Moravian structure that could hold important information. These can only be found and studied archaeologically.

An example of the danger of destruction from uncontrolled fill removal is the existance of a foundation corner of the old oil mill (1763) which is now a part of Water Street's surface. The example is not weakened by the fact that this foundation's presence is now known to several persons, or that the original site of the oil mill is well documented.

Several brick fragments, wire nails and Coca-Cola bottle fragments were associated.

Zone II: The next, or yellow clay zone, also had its share of brick fragments and dust and contained such items as wire and later square-cut nails, Coca-Cola bottles, broken electric light bulbs, electric heater coil, etc. The root of a large sycamore tree also intruded.

Between a portion of Zone I and II was a layer of fine and weathered furnace cinders.

Zone III: Designated as "grey-brown soil" in Figure II, this level is actually a transition zone between the upper and lower levels. The concentration of broken brick became greater as excavated, and lenses of mortar and brick-free clay became less frequent. Artifact examples: The wire frame to a "johnny mop," and late square-cut nails.

Zone IV: Heavy concentrations of building debris were encountered here, although it was abundantly clear that the rubble was not from any structure that had occupied the site.

Associated with this level were many pieces of badly oxidized scrub pails, some fragments of ceramic roofing tiles and several "medicine" bottles of the early 20th century.

Zone V: There were phases to this level. The upper portions were of the red soil remains of brick dust which mixed with abundant quantities of coarse cinder and ash. One small intrusive lense of brownish clay was also noted.

The artifacts were all of the late Victorian era, including nails, "S. Rau" prescription bottles, earthenware sherds, some with marks, and common Victorian ornamental brass work and clay tobacco pipe fragments.

Zone VI: A relatively narrow band of yellow-brown clayey soil with very few artifacts, none datable to any period finer than late 19th century.

Zone VII: This level showed evidences of once having been exposed to the elements for at least one growing season. There was trash, metal fragments (of containers), many square-cut nails, water-worn stones, 19th century bottles and ceramic ware whose manufacture was post-1863. Some of the artifacts intruded into the lower zone.

Zone VIII: Yellow-brown flood clay, with artifacts mainly in the extreme upper and lower portions, and center relatively sterile. All artifacts were Victorian in character, as illustrated in glassware, ceramic (imitation mahogany) door knob, ceramic sherds with modern marks, and various pieces of cast brass ornamentata.

Zone IX: The upper portion is more or less arbitrarily distinguished from Zone VIII by the culmination of a variable color change to a darker brown, although it becomes quite distinctive in its lower portions. Again, the soil can be characterized as "flood clay" but with humic inclusions in its mid and lower portions.

This level marks the first sign of pre-1850 artifacts to the ex-

clusion of later types. Most such pieces, cut nails with separately hammered heads, roof-tile fragments, early hand-cut eye-glass lense, etc. were centered at the bottom of the level. This level was the first to yield slip-decorated redware in this test pit. There were numerous roof-tile fragments at the transition point of this and the next lower zone, and a small hand-blown bottle was found intruding equally in both zones.

Zone X: Although the stratigraphic drawing (Fig. II) only illustrates the profile to a depth of around 9.5' (done for convenience and to enable its reproduction at proper scale), this zone information is applicable to the full 10.5' depth of excavation.

The level is characterized by various sub-levels. The entire fill directly over the features was of black-brown wet clay, blackest immediately surrounding the organic remains. There was an isolated inclusion of greenish clay in the western portion, probably replaced during an early burying operation. To the east was a demarcation of undisturbed strata, clearly showing the extent, in that direction of the original Moravian pipe-laying excavation.

The saturated soil of this zone contained few artifacts. There were some roof-tile fragments, a square cut spike with hammered head, and one of the few hand-wrought rose-head nails of the project (Plate XXI, C, nail "B").

Work on Test Pit #1 had been interrupted for almost a month by the seepage conditions. The work had reached the 7.5' mark by the second week in July, the last three feet under very adverse conditions.

The archaeologist suspended work here, for reasons of probable damage to indistinguishable artifacts or features, until a pump could be obtained. Such an instrument was subsequently borrowed from the City, but was in constant use within the water works building; hence, completion of Test Pit #1 was not able to commence until August.

Excavation Area 3:

It will be seen upon examination of Map I, the area designated by the figure "3" consists of a grouping of five adjacent excavational squares. As such, they will be considered here as a unit. The grouping includes Test II (27.9S/170W), Test Pit IV (30S/180W), Test Pit V (29.7S/160W), Test Pit XIV (20S/160W), and Test Pit XV (20S/170W).

With the exception of Pit IV all were carried to fruition, that is, to the exposure of historic features. Pit IV cut into an area which is now encompassed by Water Street. It was left incomplete at the 3.5' level because of the pressing need of the labor elsewhere. Stratigraphically those three feet differed slightly from the major portion of Area 3, with the exception of the remains of an early "driveway" preparation encountered at the 1-foot level and being .7' in depth. Associated artifacts definitely established this surface as modern.

The remaining, larger portion of Area 3 produced the remains of the old water works headrace and intake pipes. These were predominantly found in Pits II and XV, but impinged somewhat on the other two. Pits V and XIV showed that, unlike the historic excavations for the Pit I features, here the entire area was open to the headrace level at least once in the past.

The area was excavated to a depth of around 9.5', and yet all features were uncovered. The apparent disparity between the depth of features here, contrasted to the seemingly deeper pipe in Pit I is a result of present topographic differences. Each pit has its own "datum point" from which depths of artifacts and features are measured. This point is established at surface level of the pit's stake designation and treated as 0.0' for all vertical measurements. Relative to true elevations, Test Pit I's 0.0' point is at 228.58' above mean sea level (AMSL), whereas the 20S/170W point equalled 226.25' AMSL. Over the long run, the surface contours remain relatively stable in such an area, under present conditions. Thus, it is simpler to retain the use of field depths for the safe relocation of features. In view of the fact that non-archaeological individuals will in all likelyhood be employed to re-expose these features, it will be less confusing for them to expect to find a pipe in Test Pit #1 at 9.2' than to have to resurvey to find it at 219.38' AMSL.

The southern portion of Area #3 includes some of the levels despoiled by pot-hunters. This is reflected in the inverted stratigraphy for depths ranging from 1.0' to 3.5'.

Plate XI, A, illustrates the layout of Pits II, IV, and V, while photographs B and C of that plate show the exposed features and their relationships to each other.

The pedestaled dirt column in Plate XI, B represents the common corner between pits II, V, XIV and XV, and shows, still in situ the datum stake for 20S/170W.

Excavation Area 4:

In the grid system (Map I) Area 4 is located at 60 South between 160 and 180 West. This 20-foot length follows the south face of the old water works building from the base of the modern concrete steps in the east (Plate II, B) to Water Street on the west. Relative to features, it represents the area of the original "entrance" to the works from the south side, and the beginning of the tailrace (Plate XIII, A, B & D).

It can be seen from the photographs that the area was traversed by a fire hydrant and line. Invisible and below this was a series of other modern intrusive secondary mains which were deep enough to cause harm to the tailrace. One such pipe had a corporation braced by a bracket which was attached to the tailrace arch for security.

Such deep intrusions confuse the stratigraphic record in this area. Artifacts were badly superimposed, and for the most part, non-diagnostic.

The unusual reversed incised "signet" piece was recovered from this excavation at the 4.5' - 5.0' level. This artifact is illustrated in Plate XXII, A & B. (See Illustration Description section for details.) Comparative research for similarities or use information have to date revealed nothing conclusive. The specimen does deserve and will obtain further study.

Although the remains of the tailrace floor were exposed in the west half of Area 4, the eastern half could not be excavated to an equal depth. The water mains and hydrant line prohibited excavations here

deeper than 5.0'.

Excavation Area 5:

This area constitutes a single excavation, Test Pit III (170W), which was interrupted at 3.0' by the pressing need for labor in other areas. The strata encountered was similar to Test Pit I, except that Pit III bordered the north part of an open pot-hunter's hole. Thus, the surface initially was the highest point relative to sea level elevation of the surrounding excavational areas. This resulted from the amateur's excavated dirt forming a short ridge around 170W. This caused the natural proportions of strata to vary and invert. Here, the brick rubble and dust level was thicker, immediately proximate to the surface, and overlying the cinder level.

Excavation Area 6:

It was, of course, not known at the beginning of the project what or how many features of the old water works would be found. Also unknown was exactly where 18th century remains would be found. Area 6 represents a portion of Water Street adjacent to the water works building in which a City-loaned scarifying machine was employed to break through the road surface, thus permitting easier hand excavations. The upper one foot of the road surface was removed from about 20 feet south of the datum line to a point just south of the overhead Hill-to-Hill Bridge.

With the exception of Pit IV, no further detailed scientific excavations took place within these limits.

Excavation Area 7:

Discussed in the beginning of this section, this Area included all of the hillside west of the modern retaining wall, and between 30 South and 70 North of the east-west datum line. The earlier retaining/property wall uncovered has also been discussed. For applicable photographs, see Plates IV and V.

Excavation Areas 8 and 9:

The two trenches on top of the hill between the modern retaining wall and Main Street have already been mentioned.

Excavation Areas 10, 11 and 12:

These were "overtime" trenches cut on weekends, as the season drew to a close in an effort to find distant evidences of features already uncovered. Trenches 10 and 11 were oriented to intersect the pipeline from the spring. They were both taken to a depth of over 12 feet with negative results.

A secondary purpose of Trench 11 was to expose and test a cast-iron pipe which had appeared on City water maps. With the aid of City electronic equipment, the limits of this line were sought. It "coincidentally" lined up with both the old spring house and oil mill. The electronic apparatus followed the line to the reputed site of the spring house, where it abruptly ended.

As the trenches had not intersected any early wooden pipes, it is interesting to speculate on the possibility of this cast iron pipe representing all that remains, in that area, of the last pipeline from the

spring to the more modern water works housed in the old oil mill.

Trench 12, perpendicular to the Monocacy Creek was dug in the hope of contacting the creek end of the old water works headrace. Only some of the razed oil mill rubble was to be found.

Excavation of Old Water Works Building:

The modified remnants of the 1762 water works building is designated on Maps I and II by the digit "1."

Presently and historically, the ground level "floor" is divided into two, unequal sections by a solid masonry wall. For ease of discussion, these divisions will simply be referred to as east and west sections.

Before excavations, the principal access to the ground "floor" was through a pair of garage-type doors in the west face, off Water Street. Indeed, the west section had served recently as a garage. Other openings included six "windows," three each in north and south faces, almost level with the floor. The middle window on the north had been fitted with a hinged door and provided another access.

Entry to this level could also be gained from the first floor by means of stairs to the east section. To pass from section to section, one had to crouch low and pass through a narrow arched opening, 3.5' high, in the middle of the wall separating the two sections.

The floor in the center of the west section was slightly crowned about about 8" above Water Street. The floor in both sections was covered by a thin (1/2" - 3/8") layer of concrete over a bed of 4" - 6" cobblestone paving.

The excavational plan for the interior was laid out in six pits, two in the east section and four in the west. Plate XII, A, and Figure I reveal the type of overburden encountered between the soil surface (after concrete and cobble paving were removed) and the first features uncovered. The particular illustrations referred to depict the stratigraphy of the pit in the northeast quarter of the west section. As the strata was the same in all areas of this section, this example will suffice. The opening in the north wall, seen in the upper left of Plate XII, A is the "window" with hinged door referred to above.

Plan I provides a bird's-eye view of the masonry feature divisions in the excavated building. The portion of the plan labeled "C" represents the east section. The west section includes "A," the wheel pit; "B," the pipe pit and "D," the reservoir pit. For graphic illustration of masonry feature depths, two profile lines have been provided on Plan I for comparison and orientation when using Plan II.

It can be seen that relative to the great depths encountered on the west, the east section is relatively shallow. This section was divided into two parts. In the north was a section of brick paving (Plate XVI, A). Many of the bricks in the construction of this floor were of an early type, but it would not be safe to assume that it represents an original floor preparation. It can be stated, however, that it probably represents the original floor level. To verify this, a section of the brick floor along the separating wall was removed. With the exception of some cinder and ash debris which fell between the bricks, they lay on

sterile, clean brown sandy soil. At a point 1.9' below the brick floor, the partition wall between east and west sections terminated.

On the brick flooring was a layer of coal dust, coal ashes and around the wall at brick level was a heavy burning stain.

The south half of east section revealed a dirt "floor." The fill over this was alternately fine bands of dirt and clay and broad bands of coal, ash and cinder.

The overburden here was penetrated by several intrusive upright beams, three of which pierced the earliest level. These beams represent a late construction of a coal bin, or storage area subsequently used for coal.

Another feature in the east section worthy of note is a masonry patch in the east wall of the building. The breach is rectangular in shape, and obviously part of the original construction. It is closed over with cemented limestone fragments and only a 1" live water pipe now passes through.

This patched area is 2.83' to 2.9' in height and 1.25' wide. Its lower border lies 3.8' above the middle masonry pedestal in the section and 11.4' south of the north wall.

Along the same wall are three masonry supports, equally spaced, and all 1.6' square. Their depths conform closely with the earliest discernible levels, but their construction, including fragments of roofing tile and machine brick is most likely 19th century. Their placement suggests use as support pedestals for the floor above.

The inferior edge of the first floor joists is 11.16' above the brick floored portion. All are .25' thick, with a general width of .7', but the two most northerly are .96' in width. As far as could be ascertained, except for recent repairs, all the first floor joists were cut by a pit type of saw.

In the area of the central arch, the wall separating the east and west sections is thickened or buttressed (Plate XVI, C & D), as if to carry greater weight than the rest of the wall. Apparently, when the building was designed, the placement of a stove or fireplace was contemplated on the first floor over this point.

A second arch, south of the one in the center of the separating wall, was located. It was completely walled with heavy limestone masonry. Although viewed from the west section, two stages in the opening of this arch may be seen in Plate XIV, A & B. This passageway originally provided access within the building to the apparatus section from the living quarters upstairs.

A study of Plate X will reveal in detail the wood construction found in the wheel pit (Plan I & II, A). Plate VIII and Plate IX, A, C & D show this area photographically. It is unfortunate that Historic Bethlehem, Incorporated did not have the funds or space for the proper removal and preservation of this feature. Some of it was damaged by unnecessarily long exposure to air and water while its fate was being decided. The complete story of its unseen parts remains unanswerable. Also, the hint of the earlier structure found when part of

of the broken floor was removed, could not be properly studied.

The drawing in Plate X has several dots with associated numbers. These were included so that the depths of the relative parts could be enumerated. All the following depths are relative to the established datum point within the west section of the old water works building and which, although the original stakes were removed, were transferred in ink at several points on the walls and supporting columns.

Points on Plate X	Depth from Datum
28	9.2'
29	9.25'
30	9.0'
31	9.55'
32	9.44'
33	9.33'
34	7.3'
35	7.92'
36	6.85'
37	9.75'

In the west wheel pit wall is a niche, an integral part of the construction. Part of this feature may be seen in Plate VII, D. Its long axis is oriented vertically; the extreme north edge is 2.35' south of the pit's north wall. The base of the niche begins 1.0' above the crib floor. Total height is about 2.98', with an average width of 0.9'. The general depth is 0.4' narrowing to 0.25' at the top. The southern vertical edge of the niche is in line with the northern edge of the second upright beam of the wooden crib. This relationship might suggest some form of working mechanism using the upright beams for support and the niche as a guide, but there are no evidences of use wear on any of the parts, nor are there any special attachments or modifications of the cribbing proximate.

Another constructional inclusion occurs in the west wheel pit wall level with the wooden flooring, 9.4' north of the tailrace arch. This takes the form of the remains of a 0.25' x 0.75' wooden "joist" set perpendicular to the floor boards, but with no connections. As implied above, this joist receptacle was either built into the wall or the wall was built around the joist. In its present configuration it is severed flush with the wall and has no apparent function.[15]

Still another opening occurs at 4.35' north of the south arch, 0.15' wide and 1.1' high. The relative position of these slots can be seen in Plate IX, C. The first described, with stable wood remains included, is holding a marking arrow, in the lower right-hand side of the photograph.

A narrow secondary excavation was initiated in the wheel pit area, 3.0' wide, beginning approximately 3.5' north of the tailrace arch.[16] This area was chosen because of the poor condition of the pit's floor boards. The region had obviously suffered the most from the frictional action of wheel and water.

Immediately under the floor boards along the northern limit

---

[15] One lesson the investigator of early Moravian history soon learns is that caprice was not in their lexicon. At best, in accordance with present best evidence, only hypothesis can be offered and the reader is referred to the pertinent section.

[16] The planned excavation season had already closed, but decision on whether an attempt would be made to remove and preserve the wheel pit woodwork had not yet been given. This excavation then was undertaken from the necessary assumption that no attempt was to be made.

of this test was a child's shoe. At 0.7' below the present floor were the framing members of an earlier structure. Three large parallel beams running north and south underlay similar but smaller beams supporting the present flooring. Two of the earlier beams lay side by side along the east edge. Both were 0.5' thick. The easternmost was 0.6' wide; its companion, 0.33' wide. The former was separated from the present wheel pit east wall by a wall foundation 0.75' wide. It was impossible in this small area to determine whether this wall base was keyed into the present east wall, or whether the later was just laid over and slightly east of the earlier.

Separating the two companion horizontal beams on the east from the apparently single counterpart in the west was a 0.5' x 0.5' cross member, notched into the parallel beams (Plate IX, D). This crosspiece had ten large spikes visible in its surface. One fragment of the earlier flooring still clung under the southern edge of the central part of spikes. This piece demonstrated that the early flooring was about 0.2' thick.

The western horizontal main beam could not be measured completely. While it was 0.5' in thickness, part of its width underlies the wheel pit's present west wall. The visible portion of the member is 0.2' wide, and by probing, it is estimated that it extends under the west wall another 0.3'.

The entire earlier framing members rest, where it was possible to determine, on apparently undisturbed glacial gravel.

At an average of 6.0' to 6.3' above the wheel pit flooring the walls (east and west) have shoulders which could be used as worker maintenance walks as well as for the water wheel's axle support. The east shoulder wall has a 5.35' long recess, 0.37' in depth, as shown in Plan I and Plan II, #16. This undoubtedly not only provided support for the axle frame, but would, by its nature, help control wheel whip. Its companion cut, Plan II, #17, over the reservoir pit, must have aided in locking the wheel frame in position, and preventing the wheel from "walking" either east or west of center.

The shoulder of the west wheel pit wall has no such recess (Plan II, #15) at the present time, but has undergone quite a transformation since its period of use. Attention has been drawn elsewhere in this report to the modifications of the west building face. It is evident that in recent years the small arched doorway proper to the original building (Plate II, C) would have been all but buried by the modern ground level, or have become another "window." In more recent times the old arch was removed, as was much of the masonry above it, and the opening widened to accomodate a lintel from which were hung sliding garage-type doors (Plate II, A). This alteration was accomplished in the late 19th or early 20th century.[17] In order to support the new lintel, some of the wall of the old building was removed down to the

---

[17] Although the track for the sliding doors remains, some time in the recent past these were replaced by the shorter hinged swinging doors found today.

shouldered wheel pit wall. By a combination of wood framing, loose stone and iron pillars, the new door frame was completed. Such construction must have had its effect on the pit wall, though the extent is not known.

The hatched area shown in Plan II, #16 was excavated level with the shoulder of the west wheel pit wall for a width of 8' to gain comparative stratigraphic information on driveway fill, and the depth to which intrusive digging went in installing the modern doorway. The one conspicuous difference in this stratigraphic profile was a layer of well-placed brick, laid perpendicularly to the building wall at the 1.7' level below present surface.

The small original doorway, because of its proximity to a turning wheel, and with greater part of the west wheel pit wall occupied with support framing, must have served merely as a maintenance access to the west side of the wheel.

Area "B" in Plans I and II illustrates the placement of a masonry compartment, here simply called the "pipe pit." Through this area passed the octagonal fresh water pipe carrying the spring water to the "reservoir pit" (Area "D," Plans I and II). The pit area and the last used pipe itself can be seen in Plates IX, B and XIII, C. The entire masonry "square" was not excavated on its east side. It will be remembered that during excavations beneath the brick floor in the east section (cf. page 23), the inferior end of the separating wall was encountered. Thus, it was thought wise that a 1.5' - 2.0' baulk be left

between the separating wall and the excavated pipe pit at this point. Even so, the reserve baulk was not begun until the wall separating pipe and reservoir pits was exposed. The baulk is included in Plan II.[18]

From the evidence recovered, the pipe pit had no utilitarian purpose, in itself, other than pipe passage and maintenance. The major portion of the pit was excavated to undisturbed glacial gravels without additional features.

The upper portions of the walls forming the pit did have inclusions of note. Plan II shows three "steps" in the boundary walls. The first, directly beneath the "window-doorway," #21, mentioned elsewhere, lies in a plane between two others in the south wall. However, the lower of these two (although slightly exaggerated in the Plan) is only 0.03' out of plane with the one in the north wall. Both of these cuts are relatively narrow, thus demanding a good fit if a secure apparatus platform existed here.

The upper step in the south wall (separating pipe and reservoir pits) is shorter in length but of greater width. It lines up better with the reservoir area and was most likely functional to it.

Numbers 22 and 23 of Plan II designate the passageways for

---

[18]Safety had to be a consideration in all interior excavations. Supporting 4" x 4" and 6" x 6" beams, seen in the Plates resting on feature walls, were placed there as stable surfaces were uncovered to bolster the floor above. In addition to years of neglect, the first floor had been damaged by a vandal's fire only a month prior to the project's beginning.

the fresh water pipe.

Moving southward, the reservoir pit is shown on Plans I and II as area "D." The designation "reservoir pit" was given because it represents the terminus of the spring water pipeline. In the bottom of the area is a rectangular wooden container with interior dimensions of 3.2' x 4.27'. The long axis is oriented east and west. (See Plate XV, A and B.) This container or reservoir is constructed with 0.05' planks abutting nine upright supports. The uprights vary from 0.2' on a side to as wide as 0.55'. The vat walls are stabilized at each interior corner by mitred wooden braces. The present maximum interior depth of the vat is 2.07', and it is unlikely the original sides were much, if at all, higher.

The latest octagonal fresh water pipe, passing through the masonry wall from the pipe pit, enters the wood reservoir by way of an almost square opening, 0.8' x 0.75'. The west edge of this opening is 1.25' east of the vat's west wall. At the time of exposure, no remains of caulking for the spaces between the pipe and the squarish opening were encountered. The pipe, with 0.55' outside diameter, is 0.45' clear in the bore, and extends 0.07' into the vat at floor level.

The remains of an earlier round water pipe are visible protruding from both sides of the wall separating the pipe and reservoir pits. It had been severed as close to the wall on the pipe pit side as possible when replaced by the later octagonal pipe. The round pipe, similar to those found in Test Pit #1, had the bark still attached to

its surface. It is 1.0' in outside diameter with a 0.7' bore, and presently extends into the reservoir pit 0.2'.

There is no opening by which it could have entered the reservoir itself, nor is there any evidence of a patch covering an old opening. Thus, it can be concluded that the vat is either a replacement of an original, or the initial 1762 waterworks did not employ a wooden enclosure within the reservoir pit. The latter alternative would imply that the masonry bounding walls themselves contained the water. This alternative seems more plausible than the first.

Both pipes and their relationship to the vat may be seen in Plate XV, B. When the picture was taken, the pump had been removed to allow an unhampered photograph. The water level rose rapidly; hence, although blurred by submergence, the pipes can be seen at the right-hand side, between wall and vat. The octagonal pipe appears center-right with enough clay clinging to it to help distinguish it from upright beams. The visible remains of the round pipe appear as the only black object against the wall, between the octagonal pipe and the paired uprights in the upper corner of the pit.

In viewing the same photograph (Plate XV, B), attention is next drawn to the opening in the west wall of the reservoir pit, separating this area from the wheel pit. This breach is also shown on Plan II, #18 (on the X - X' profile line). The opening is 0.59' high and 0.71' wide, and its inferior margin is 0.55' below the superior edge of the vat. It undoubtedly served as an overflow for the area,

when the spring supply was more than plentiful, or when the works were shut down for repairs. The excess fresh water would pass through the opening into the wheel pit and flow to the Monocacy by way of the tail-race.

Two cuts in the masonry walls associated with the reservoir pit are shown on Plans I and II, #17 and #19. Similar to those found in the other walls, these, associated with the upright remains in the pit itself, were evidently designed to carry much weight.

Above the shoulder in the east reservoir pit wall is the central arched opening between the east and west main section. This was the only interior access, albeit small, to the east section from the west, before excavations began. It is doubtful, however, that it was originally intended for human passage. Its totally excavated maximum opening is 5.15' with its base forming a sill averaging 1.8' above the surrounding occupation level.

Access to the reservoir pit is gained by a series of three steps and a "platform" to the south of the vat. The platform takes the form of a wide bottom step or landing. With the exception of the third step, the others and the platform are constituted of irregular limestone, similar to all the feature types. This third step, however, is a single piece of sawn porous limestone of a red-grey color (Plate XV, D). The first and second steps (Plan I) contain two niches each, with the remains of beams in situ. The grain of the wood shows a clear horizontal alignment.

The reservoir pit stairs rise to a fairly large "floor" area. It is this portion (Plan II, #25; Plate XIV) that the 18th century visitor would first encounter upon entering the building from the original southern entrance. Plan II, #26 and #27 illustrate the position of this doorway. Point #26 marks the level of the old door stoop, and #27 represents the modern change to a window sill.

The remaining feature in the area is the previously described second arch, shown in Plate XIV.

Artifacts and Artifact Analysis

A total of 452 bags were expended in the collection, by level and sector, of artifacts recovered during the excavations. From these collecting sacks 19,060 individual artifacts were taken, washed, studied, catalogued, and where called for, given appropropriate treatments for preservation.

It is obvious, from the discussion of excavations, many of the more interesting finds had to remain in the ground. The extensive woodwork of the crib, sluice and flooring of the wheel pit, the fresh water intake pipes and reservoir inside the old water works, and those lying under 10 feet of earth in Test Pit #1, are still where found, awaiting executive decisions as to their final disposition.

The bagged artifacts were myriad, including all types of ceramic ware, metallic fasteners and ornaments, bottle fragments of all types and of all periods. Many of the studied stratigraphic layers were densely populated with "soup" bones of various mammalian genera and varied Mollusca.

For purposes of illustration, the total number of catalogued specimens have been separated into 15 basic diagnostic groups, and the percentile relationship of each group is represented on a graph (Figure III). The group divisions are as follow:

1) Metallic: (Total 3,069) Includes nails, screws, bolts, containers, tableware, knives, tools, barrel strapping, ornaments, etc.

2) Glass: (2,775) All artifacts normally accepted as being produced from a semiliquid substance and retaining relative translucence; bottles, jars, vials, certain tableware, lamp chimneys, etc.

3) Redware: (3,303) Common soft paste ceramic manufacture, extremely common during the 18th and early 19th centuries in this country, and the chief product of the first Bethlehem potters.

4) Redware (slip-decorated): (91) Same as above, but with added decorations produced by painting designs over the redware body in a contrasting color slip. The designs in these specimens are restricted to line variations, and the predominant colors are cream, yellow and green, with some blacks and browns.

5) Earthenware (decorated): (2,654) The common dinnerware of the last three centuries, mostly imported, and mainly from England. For purposes of differentiation between decorated and undecorated, in this report, specimens only bearing potter's marks are also included under this rubric.

6) Earthenware (undecorated): (3,189) The same as above, having only a white glaze, with no distinguishing designs, marks or added motifs.

7) Yellow-ware: (159) Similar to earthenware in history and periods, somewhat softer, more brittle and of an inferior clay.

8) Stoneware: (162) The typical hard paste, salt glaze ware found on all sites of the 18th, 19th and early 20th century. Generally grey in body and surface color, though sometimes black, green, and various other shades; it is found mostly in the form of jugs, crocks and bottles.

9) Porcelain: (37) The true hard paste aristocrat of ceramic wares, vitrified and translucent. All porcelain, despite misuse of the term, from the 18th and most of the 19th centuries, is imported ware, and in the utilitarian form never from England.

10) Clay pipes: (18) The ubiquitous kaolin smoking pipe.

11) Roofing tile: (847) That fired ceramic creation commonly used by American settlers with Germanic ancestry for covering the roofs of their buildings.

12) Stove tile: (69) Fired ceramic sections which Germanic immigrants, particularly "Moravians," used to construct elaborate stoves for heating purposes.

When speaking of ceramic specimens the term sherd is implied; that is, it is a rarity in western culture, when an artifact is found in an entire condition. More often specimens are only fragments of the original article.

13) Organic: (2,317) The skeletal remains of mammalian and molluscan food supplies. No burials were encountered on this project. Identified mammalian remains include bovine, pig, sheep,

deer and racoons. Mollusca included several varieties of mussels, snails, clams and oysters.

14) Inorganic: (91) Statistically speaking, this division is weighted on the light side. Such things as coal, slate, synthetic roofing, tar, cinders, etc. are included and only one or two specimens of many are collected as typical of a particular strata.

15) Miscellaneous: (279) A catch-all category for artifacts which do not properly fit in any other. The majority of these specimens comprised small brick chunks, mortar, etc. which were peculiar to a particular strata, and which the workers collected for the writer to study microscopically, and for color, composition and specific gravity information.

To the archaeologist, the rationale for collecting artifacts is based on a monolithic principle. What can be learned about the people or period under study from the remains of contemporarily manufactured articles? The amassing of artifacts in museums ' showcases is only an ancillary by-product of scientific archaeology; not a purpose or aim. Thus, the analysis of artifacts is approached purely from the viewpoint of the period, style and function. If a successful analysis is possible for a particular collection, certain interpretations can follow.

Several factors affect the analytical potentialities of any particular collection. Foremost is the reliability of the association of artifacts with the stratum in which they are found. That is, does the presence of a porcelain ceramic sherd of 1750 manufacture truly date

from that portion of earth from which it was recovered, as being deposited around that year? One obvious element affecting the apparently logical acceptance of such an association, in this example, is the peculiar tendency of man to save that which still has utility, or sentimental value. The latter factor may cause an heirloom to be passed on from generation to generation, and possibly to be discarded a century or more past its normally useful existence. To carry the example further, if such a porcelain vessel is broken and discarded in the 20th century, and its fragments or sherds are all the archaeologist finds in a particular segment of earth five feet square and six inches deep, it would not be reliable to assume that that stratum dated from the mid-18th century.

Leaving aside hypertechnical methods of dating the length of burial time of an artifact, other factors still remain. One of the most important, more closely affecting historic sites, is western civilization's need for interior plumbing and running water, and the sites' usual proximity to such activities. To lay water and sewer lines, trenches must be dug, which disturbs the natural stratigraphy of the ground and any accompanying artifacts. This eventuality, as a rule, results in at least some superimposition of artifacts; that is, in the reburial, earlier specimens are buried over artifacts of more recent date.

All these factors play a role in the analysis of this collection of artifacts, primarily, because most of the excavations carried to fruition outside the water works building revealed something of the early

water works complex. Their nature was such (pipes, raceways) that they were intentionally buried after original construction, for cosmetic reasons, but also exhumed several times during their useful life for repair and/or replacement. Hence, a superimposition of artifacts by the early Moravians themselves was inevitable.

A more critical factor in this project, however, is one that need not have existed. While the interior of the building was being archaeologically completed, excavations were undertaken along the north exterior face of the building (east of the headrace), in an attempt to obtain information on the ancillary history of the structure. It became obvious during the digging in this area that the upper 3' to 3.5' of strata were badly disturbed. The writer was later informed that amateur "pot-hunting"[19] had been officially condoned and/or encouraged in this area. To the scientific archaeologist all artifacts from these levels can only be noted as to presence -- analytically, they are now relatively useless.

Relative to the project as a whole, all catalogued specimens are represented in the "field catalogue," the original of which is in the files of Historic Bethlehem, Incorporated. An example of the type of form used is reproduced, with hypothetical collection, in Figure IV. The field catalogue contains one such page for each arti-

---

[19]The practice of "treasure hunting" by persons with little or no scientific orientation, who seek "prize specimens" for private collections without benefit of records as to provenance, statistics or proper analysis of the artifacts so removed.

fact bag used. In each case all the pertinent provenance information is included where possible or practical. The type-class of specimen is listed in similar fashion to graphic breakdown in Figure III, though with more detail. Sketches of unusual artifacts and potter's marks, when present on ceramic wares, are included.

After collecting and washing, each and every artifact receives a number according to a simple system. Specimens with compatible surfaces all are marked with the bag number in drawing ink, which is in turn covered with a protective layer of clear nail enamel. Articles with irregular surfaces have reinforced number tags attached.

With this system, any particular numbered artifact can, by referring to the applicable sheet in the field catalogue, be reconstructed as to date found, by whom, and where on the horizontal grid and vertical depth from the objective datum, in feet and tenths of feet below the surface, or the actual level above or below "mean sea level."

Artifacts are numbered with the materials as described, to withstand the abrasion of normal storage and examination, and yet allow for the removal and/or substitution of a museum catalogue number should such articles be desired for display.

Most artifacts, after cataloguing, are not benefitted by long storage or handling in paper sacks. Hence, they are segregated as to type in cartons of sufficient size, or placed on shelves. Furthermore, some artifacts collected are by nature not important after they have told their story, or are undecipherable because of poor preservation.

In such conclusive cases they are discarded after being catalogued. Their disposition is so noted by the letters "disc." after the field catalogue listing.

Another catalogue note that needs explanation is the phrase "bag emptied" at the bottom of many sheets. This simply means that the artifacts were placed in "class" cartons or, deemed too delicate for return to bag, were placed on shelves.

During, and especially after the cataloguing phase, the reconstruction of fragmentary artifacts, particularly ceramics, is attempted. This procedure allows for a more exact description of vessel type, motif analysis and dating of pottery. It is also at this stage where possible relationships of different levels crystalize. For example, assume twelve fragments of a single ceramic vessel are retrieved from three field bags representing three different horizontal and/or vertical archaeological areas. Such reconstructive association demands notice of a relationship between these levels, and tells of disturbance or difference in original contour at an earlier period, etc.

Ceramic group number 64-P-42-17 is an earthenware mug of a size and shape apparently directly copied from its pewter antecedents. The vessel is 95% restored, yet its parts were recovered in four bags on two separate days. The bag numbers were 233, 251, 263, 264. During the laboratory processing stage, when pieces were being reconstructed, the four relevant pieces were encountered, and they fit together. The piece numbers were then referred to the field

catalogue. The results are as follow:

Bag 233 - "Wheel Pit, North third, 6.5'"
Bag 251 - "Wheel Pit, South third, 7.8' - 8.5'"
Bag 263 - "Wheel Pit, North third, 7.0' - 7.6'"
Bag 264 - "Wheel Pit, Middle third, 7.0' - 7.6'"

Thus, all four sherds were found within a maximum horizontal area of 5' x 20', and with a vertical bracketing between 6.5' and a maximum depth of 8.5'.

This type of evidence, manifested in many other examples, illuminated a very interesting fact of the water house history. It is known historically that the water pumping function of the town was transferred from the building under discussion to the old oil mill directly across Water Street. This event occurred around 1832.

The age and distribution of artifacts such as the cup reveal a hiatus in the time of functional abandonment of the old water works and the time the races and wheel pit was intentionally filled in. This period was probably as much as ten years. During that time of disuse, mud collected in the unkept wheel pit. Material and garbage from upstream was dumped or fell into the creek only to flow into the wheel pit and become lodged in its decaying woodwork. This debris aided the collection of air-filled humic muck and stagnant water in the old works. A ceramic mug could be dropped, by accident or design into the headrace, only to fracture, with the heavier pieces becoming stuck in the ooze. The lighter, or stronger pieces, such as the bottom plate, possibly had enough air trapped in it to allow the slowing race water

to carry it towards the tailrace arch before being drowned and sucked into the mud.

Based on such evidence we can also state that as much as 2.5' to 3.0' of this black humic clay and its prisoner garbage was allowed to collect before a new use for the building or the sanitary senses of the populace were offended sufficiently to cause intentional burying of the building's once uniquely productive features.

Such reasoning is further bolstered by the very poor condition, or total absence of any original woodwork above the 7.47' mark. The time-collected earths, more compact as the depth increased, proportionately offered the old wood construction greater protection from decay.

The earliest part of the ceramic collection is composed of twenty-odd pieces of hard paste, blue and blue-brown decorated dinner ware, one of which carries a maker's mark of c. 1750 vintage. These few sherds may represent some of the remains of ceramic ware brought with the first Moravian settlers, though they also could have been imported any time in the 40 years following.

With the exceptions of the soil disturbed by the pot-hunters on the north side of the building and the pipe-layers on the south, other levels showed a very close correlation of artifacts with level. The preponderance of datable ceramics are post-1800, with the weight of these between 1840 and 1865. The scarcity of artifacts of pre-1800 periods should not be a surprise. Aside from the well-known frugality

of the Moravians, it must be remembered that the site was an industrial one. Thus, there would not be the amount of daily living refuse that is encountered on other sites of comparable date.

The Moravian frugality referred to reveals itself in the total absence of any original tools or machinery. This is quite in contrast to the upper, post-1870 levels of the area, which yield the usual groups of broken and cast-off tools, pottery, etc.

Discussion, Conclusions and Hypotheses

When one delves into the culture history of early Moravian Bethlehem, he is awed by the people's appreciation for order and detail. In modern-day terms the pairing of such adjectives usually is associated with insufferable bureaucracy. To be sure, the Moravians probably enjoyed their share of the civilized vice, but they could not have produced the comparative wonders that were theirs in 18th-century Pennsylvania if it were all-consuming.

On the contrary, the vastness of their works, vis-a-vis the available labor force displays an appreciation for records that must transcend occupation with petty detail.

The records already copied from the relatively untapped archival sources display maps and charts with detailed information on buildings, functions, sizes, associated constructions, and boundaries. The records of various trades have day-to-day accounts of expenditures and their purposes. There are plans of the internal mechanisms of the oil mill, bark mill and grist mill. The Brethren and Moravian superiors also kept daily diaries.

It is therefore somewhat paradoxical that so little has come to light on the old water works. To our knowledge, there are no extant drawings of the works, or pipeline plans below the hill. The

first stream of water Christiansen sent over the tops of the buildings in "Der Platz," that Levering and Rau say astounded everybody, receives only passing mention in the Brethren's Diary.

It is in this type of situation that archaeology has the most to offer. The science may not supply all the answers, but it does yield much data on unposed questions. It further orders such queries in a direction foreign to the archivist unaided.

One of the best clues to the possibility of an extant set of water works plans is given in Rau's work. On page 7 of his Historical Sketch of the Bethlehem Water Works he states, "In April, 1774, Baron von Reepsdorf, Governor-General of the Danish West India Islands, on a tour through the British Colonies, visited the works and was presented with a draft of the same by Christiansen."

In an attempt to locate any papers of this individual, in the hope the Christiansen plan might still be among them, an archival study was begun. The initial sources lacked any mention of the gentleman in question and indeed it appeared that the Baron could not have been the Governor-General of the West Indies at the time supposed. One Sir Ralph Payne was the "Governor in Chief"[20] and, although there were changes in the office of Lieutenant Governor, one John Fahie, Esq. seems to have held the post during this year. As another source which

---

[20]George Suckling, An Historical Account of the Virgin Islands in the West Indies (London; Horace's Head, 1780), p. 19.

contained the names of leading West Indian personalities also neglected the individual,[21] an attempt was made to contact the leading American expert on the subject, Dr. Waldemar Westergaard. This lead ended with the unhappy notification that Dr. Westergaard had died suddenly.[22]

In subsequent correspondence with the Royal Danish Embassy in Washington, the Governor of the Virgin Islands, the Rigsarkivet, Rigsdagsgarden, København and Det Kongelige Bibliotek, København, it was found that the gentleman's name was Count Ulrich Wilhelm de Roepstorff. All the agencies mentioned were extremely kind with their time and aid, especially the overseas offices.

In general, all sources supplied more or less the same information, much of it already translated. Count Roepstorff was Vice Governor General until his retirement in 1773. Furthermore, he apparently had an unusual respect for the Moravians. In one of the Count's letters, written on September 17, 1773, after his retirement, he announced " . . . his intention to visit North-America in the following winter before his return to Denmark. He wanted to do so in regard to his health which would suffer too much, if he had to return immediately from the tropical climate to the cold Danish winter."[23]

---

[21]Waldemar Westergaard, The Danish West Indies Under Colonial Rule (New York: The Macmillan Company, 1917).

[22]Letter from William V. Shannon, Esq., Executor of the Estate of Waldemar Westergaard, January, 1965 (in the files of the writer).

[23]Letter from Johan Hvidtfeldt, Rigsarkivet, København, February 2, 1965 (in the files of the writer).

However, his health was not his sole interest in the Bethlehem trip, as is shown in another letter dated April 19, 1774, from the Unitats - Altesten Conferenz of Herrnhut to Martin Mach, the leading Moravian missionary in the West Indies. In addition to Bethlehem, Roepstorff visited " . . . some of the Moravian centers in England, where he 'showed himself very friendly, yes even fraternal.'"[24] It is curious, and questionable that the Count was able to visit both Bethlehem and England in the same month of the same year.

After his return to his native land, the Count established considerable holdings on Fyn in Denmark and established a sugar refinery at Odense.[25] Communications are still awaited from those sources. Basically, at the present time, the question of whether his Christiansen draft still exists is unanswered. The question deserves, perhaps, further prosecution.

Until more documentary materials come to light to fill out the picture supplied by archaeology, or further scientific excavation takes place, some of the newly acquired evidence will have to be interpreted hypothetically. But before engaging in theoretical reasoning, let us review what definite information the project has supplied.

Apparently one of the principal questions motivating the initiation of the 1964 project was to acquire information on 18th century

---

[24] Ibid.

[25] Ibid.

ground levels. The excavations offer definitive information concerning this. The precise 1762 ground level has been established on the south side of the waterworks and by reasonable interpolation can be extended to much of the area. This general topographic similarity was substantiated by stratigraphic readings in Test Pit #1.

As implied earlier, many times problem-oriented archaeology, in answering an original query, raises more complex ones. Such is the case relative to topographic levels. This writer has been given to understand from Historic Bethlehem's "Master Plan"[26] that a reconstruction of the industrial area is envisaged. No firm time table has been established, and just what "reconstruction" means is not generally accepted or known.

At the initial discussions of the 1964 project, it was stated that the reconstruction here meant the return of the Monocacy Creek plane to its 18th century level, at least in the area from the oil mill to the grist mill.

Apparently the relationship of the present Monocacy Creek and water table level to such a plan has not been considered an important element. Early in the 1964 season, when the question was raised by the author, the then executive secretary of Historic Bethlehem, Incorporated did not entertain the problem as a concern. A short time

---

[26]Thomas J. Kane, "Master Plan for Historic Bethlehem," November, 1963 (in the files of Historic Bethlehem, Incorporated). (Multilithed.)

later, the secretary summoned Mr. Thomas Kane, in Bethlehem on a visit, for his opinion of my question. This gentleman, too, thinks it irrelevant. Both individuals conclude that the Monocacy maintains a level similar to its 18th century elevation.

This writer feels that the question is of immediate importance. The archaeologist's duties on this project did not include a definitive elimination of this question. It was already in fact treated as non-existant. Therefore, more study should be given the problem before it is considered unequivocally settled. However, we feel that the problem is not a simple one. If our interpretation of the evidence is correct, a complete revision in the plans of Historic Bethlehem, Incorporated is in order. Let us examine the evidence.

Geologically, that part of the Monocacy bottoms, applicable to the "industrial area," is a flood plane. The hills on both sides of the plane are fairly precipitous for an average of 30 to 50 feet. The entire area rests on a cavernous limestone substratum and is, therefore, filled with water pockets.[27]

Even without documentary evidence, it is obvious that the hill upon which the main part of Bethlehem is situated would always have presented a severe drainage problem relative to the area below.

---

[27] Benjamin LeRoy Miller, Northhampton County Pennsylvania Geology and Geography (Harrisburg: Pennsylvania Geological Survey, 4th Series, Bulletin C 48, 1939), p. 132.

There are many separate and connected retaining walls along the entire hillside.

Every informant interviewed about the area recalls the swampy condition of the industrial area as late as the 1930's and the subsequent truckloads of fill brought in during the WPA days that raised the area around the old spring house.[28]

A newspaper article of 4 March, 1927 tells of a member of the Bethlehem Water Board remarking on the care with which all land deeds in the area were preserved, " . . . for the drainage of that hillside had always been a troublesome matter."[29]

The collection of pertinent evidence gleaned from the 1964 project is weighty.

For illustration, assume the average elevation around the old water works building at 228' AMSL.[30] Also remember that the summer of 1964 was relatively dry. During the season, the Monocacy Creek level at the confluence of the old grist mill tailrace, measured 220.00 AMSL. Thus, at the initial survey reading, the creek was

---

[28]The informants recall the area cut by Trenches 10 and 11 on Map I. Several days after a normal rain one did not dare leave the road (Water Street), for the unpaved area would always have four to six inches of muddy water on it.

[29]Elizabeth Lehman Myers, "Nature, History and Other Lore" in the Bethlehem Globe Times, August 3, 1927.

[30]The elevation of interior features used 227.5' as its datum, which was established after the cobble and concrete pavement were removed. The difference is compensated for in this discussion.

8.0' below our discussion datum point. A hurried reading showed that the fall of the creek between the stone bridge across the Monocacy (on Ohio Road) and the confluence of the Lehigh is only 6' - 8'. This represents a considerable distance. Furthermore, that portion of the fall between the bridge and the grist mill tailrace confluence was so slight as to be hardly measurable. That is a distance of about 200 yards.

Recall is requested of the point at which the workers encountered water in the pits as they excavated. In the pipe pit very wet clay was met at 3.0', and water here and in the wheel pit at 4.0', or 224' AMSL. Remember that the water problem was severe enough at this level to necessitate continuous pumping.

At the same time the control creek level was read, there was 1.67' of water in the wheel pit. This amount had collected over a period of a week end, placing the surface at 221.33' AMSL, or 1.33' above the creek level. Contrary to practice, but at the request of the executive secretary, the excavations in and surrounding the water works were left open after the season ended. Without daily pumping, more water collected, especially from hillside drainage. At the end of August, the water level in the wheel pit reached 223.6' AMSL.

During the month of February, 1965, the writer was engaged in the Revolutionary Cemetery project, also in Bethlehem. It was a fickle month weatherwise, and during one week there were two days of continuous light rain accompanied by a thaw. The creek level, in

the pertinent area, rose an estimated 1.75', and the bottom lands were so saturated that one passing by the old water works tread through at least 1/2" of mud at the crown of Water Street. These conditions prevailed in the area for three to four days after the rain had ceased before any change was noticeable.

Historically, the sources contain many references to the creek water table problem. The following notes appear in the Brethren's Diary for 27 and 28 February, 1771:

> After having prepared everything in the oil mill yesterday evening for high water, water went even higher than expected. The Monocacy which usually gets higher when the Lehigh begins to go down, rose so rapidly that already at 2:00 A.M. entire water course was flooded, rose until towards 6:00 A.M. In oil mill, water so deep, that iron stove under water box was under water, 4 pigs of butcher Krause drowned in sty, and because Lehigh only rose to 106, Monocacy still had a free outlet which caused a powerful [flood] up here, taking along everything that was not fastened . . . .

28 February: "When water in Monocacy went down enough that one could get to oil mill without canoes, one could first see the damage caused by strong current, the shores and dam torn away, and so forth."

An objective account of floods is found in a modern source, and refers principally to the levels of the Lehigh River.[31] According to the accompanying data, here included in modified form, there

---

[31]Miller, pp. 134-35.

have been sixteen Lehigh floods at Bethlehem, of enough severity to be considered serious, between 1747 and 1936. The "major" floods were calculated as such when the overflow waters were known to exceed 15' above a datum point which was established from a level known to be a " . . . foot or two below the lowest water known to have been reached even in the most disastrous droughts."[32]

Bethlehem Flood Chart (after Miller)

Date	Height of Guage (in feet)
1747, February 28	? exceeded - amount unknown
1777, October 27	? exceeded - amount unknown
1786, October 4	18
1839, January 26	16
1841, January 8	23
1862, June 5	23.3
1869, October 4	23
1894, May 21	17
1901, December 15, 16	17.5
1902, February 28	25.9
1915, February 26	16.8 plus
1924, October 1	16.2
1926, November 17	16.5
1933, August 24, 25	20.8
1935, July 10	20.7
1936, March 12	19.0

If the inundation of February, 1771, described by the Brethren was not severe enough for inclusion in the chart, how much more disastrous must have been the floods that were? Should one argue the irrelevance of the Lehigh's flood record, its pertinence can be re-established entertaining the following hypothetical situation. Assuming the maximum elevation of a nonswollen Monocacy at 10' above the Lehigh at

---

[32] Ibid., p. 133

the point where the oil mill stood, there would have been some flooding simply from Lehigh back-up during the most severe floods. Adding to this the normal seasonal swelling of the creek, more inundations must result.

Before the chain of evidence is carried to its obvious conclusion, still another comparative factor should be examined. Again, remembering the maximum depth of around 5.2' of water that collected in the open wheel pit, it should also be considered that historically, in order to drive the water wheel that turned in that pit, a two-foot head of water had to be maintained.[33] In order to provide this head, a dam had to be employed. It was probably the same dam constructed for and alongside the oil mill. If a dam were needed, it obviously means that the natural level of the creek at that time was at least as low as two feet above the wheel pit floor, in which case, a dam would be redundant. That would place its surface, relative to today's elevation, at about the present 220' AMSL. But as the creek fall would have remained relatively stable as such, the natural head of two feet would not have been able to run off quickly enough to turn the wheel. Also, the wheel pit, pipes and reservoir would have to have been laid and maintained underwater. It is more likely that the creek's natural fall was at least equal to the head of two feet, at its junction with the waterworks tailrace, or no higher than 214' - 215' AMSL. If the

---

[33]Rau, p. 5.

level of the water house's south entryway is used as an average exterior grade, 224.24' AMSL, the maximum separation of normal water from soil grade would be around 9.24', or approximately 1.24' greater than the present separation.

Obviously, if the creek is not considered in the plans of Historic Bethlehem, Incorporated, and the ground surface is lowered an average of 3.76',[34] the creek/land level separation would be reduced from the present 8.0' to 4.24'. Furthermore, if the conditions observed in February of this year are at all typical, such a reduction of separation would turn the whole bottom area into a permanent swamp. Still further, if the 3.89' differential of water, that collected in the wheel pit over the greatest creek level, is any indication of typical ground water table, the situation is that much more serious. In short, any lowering of the pertinent industrial area ground level will have to be accompanied by a comparable lowering of the creek. If it is envisaged that "reconstruction" of the area includes the leaving of wheel pit and race open, a larger dredging operation is in order.

Returning to archaeological project interpretation, per se, though related to the flood information given above, there seems to be a very interesting correlation between the severe floods and stratigraphic evidence, and artifact information. Note the disposition of flood

---

[34]Certainly a minimum for the entire area, based on test pit information on the north side of the building. However, the caution expressed on page 12, footnote #14 is again invoked.

clay strata shown in Figure II, for Test Pit #1. When these soil profiles are compared with their type descriptions and artifact time periods (see Summary of Field Activities section), Zones VI through IX display an interesting severity/time resemblance to the 1839 through 1894 floods.

The following scheme is hypothesized, based on the above criteria, but with no present refuting evidence:

Strata	Flood
Zone VI	1884
Zone VII	1869 (?)
Zone VIII	1862
Zone IX	1839 and 1841

The Zone VII correlation tends to be the most tenuous. Being one of the most severe floods, a deeper deposit might be expected, but as shown in the Brethren's Diary description of the 1771 flood, the Monocacy did not always cooperate with the Lehigh.

The other associations work out well, especially that of Zone IX. The lower portion of the zone contains enough humic remains to represent the period of reburial after installing the jumper and new line to the oil mill, cerca 1832, and the inundation nine years later. Such a flooding would have drowned the vegetative growth of the intervening years and allowed the deposition of clays accounting for the zone's relatively sterile center region. The process would have then been repeated with more severity only two years later, tying the strata together in one unit.

The features in Test Pit #1 (10N/180W) present several in-

teresting points. First, there exists the partially covered trough and a bark-covered pipe paralleling each other, , heading in the direction of the old water works (1762). Is the pipe that was cut off and plugged really part of the same line that was exposed in the headrace and the pipe pit? We do not know definitely. It aims for the water works building, and through an instrument sighting, it lines up with the headrace portion, if a .5' error is allowed for variations in joint angles. However, the entire line was not exposed, and until a project with sufficient time and labor does so, the question, albeit a scientifically strict one, will remain unanswered.

Does the trough that parallels the pipe through Test Pit #1 represent an earlier or later fresh water carrier? It is here held that it is the remains of an earlier system, for it surely must have been subject to greater leakage, dirt and contamination than the log pipe line. Also, it was the pipe that was interrupted and its superior end jumped to supply the new water works (the oil mill) with fresh water, not the trough. To make the trough the later feature would necessitate the assumption that the jumper represents part of a water line to the oil mill before it had attained water station status. It is true that the oil and bark operations probably demanded their share of fresh water, but it would have been less costly of time and labor to pipe it from the water works. Again, if the pipe had been abandoned in favor of the trough, it must have been defective in some way. If so, why then use these defective materials to supply the oil mill, when it still would be

more economical by direct line from the water works?

We feel that this reasoning is sound enough to stand and label as inaccurate the recorded 1874 discussion about the supply line to the new water works (1832). The source concerns a meeting of the Bethlehem Water Board during which iron pipes were favored and it was thought best " . . . to take up the old trough and install a metal one . . . . "[35] The use of the word "trough" was evidently an unfortunate choice, but the reference would, by the by, explain why Trenches 10 and 11 (Maps I and II) did not locate the wooden pipes to the spring in that area, and why they did find the inactive cast iron pipe already mentioned.

The presence of the copper jumper and a wooden pipe with bark attached heading for the 1832 water works presents an interesting paradox. The sources are abundant, and already documented regarding the universal use of lead pipes in Bethlehem town after 1796. Philadelphia had started the abandonment of wood in favor of iron in 1817[36] and New York in 1823.[37] England was using iron pipes in the first half of the 18th century,[38] and immediately prior to them

---

[35]Myers, August 3, 1927.

[36]City of Philadelphia, Department of Public Works, Bureau of Water, Description of the Filtration Works and Pumping Stations also Brief Historical Review of the Water Supply 1789 - 1900, Booklet #3, 1909, p. 65.

[37]"Wooden Water Pipes" in The Chronicle of Early American Industries, Vol. II, No. 3, January, 1938, published by Early American Industries Association, Inc., p. 17.

[38]Rosamond Bayne-Powell, Housekeeping in the Eighteenth Century (London: John Murray, 1956), p. 118.

"earth pipes" were lauded.[39] Louis XIV had thought iron the proper pipe material as early as 1664 and as late as 1934, Germany could boast of three different municipal cast iron pipelines in service for 212, 249 and 273 years respectively.[40] It is amusing that in the United States wooden pipes in various forms were still being recommended as the best as late as 1922.[41]

If not the "first water works in America," though it still may be, the 1754 system was certainly the first in Pennsylvania. It led Philadelphia in the progressive change to metal pipes on the pressure delivery side of its system. The town adopted steam power before the fourth decade of the 19th century was three years old. It went to the expense and labor of beating out copper sheets in approximate two-foot squares and soldering them together to make a long-lasting leak-proof, flexible jumper for diverting water. Yet, at a time when cast iron certainly was no longer prohibitively expensive, they not only waited until 1874 to employ it, but continued in the meantime to lay new wood pipes. The pride in its novel and progressive water system evidently disappeared with the General Economy.

---

[39] Stephen Switzer, An Introduction to a General System of Hydrostaticks and Hydraulicks, Philosophical and Practical (London: the Rose; the Angel & Homer's Head, 1729), pp. v-vi.

[40] Thomas F. Wolf, Service Records of Existing Cast Iron Mains Laid in the 17th, 18th and 19th Centuries (Chicago: Cast Iron Pipe Research Association, 1934), n. p.

[41] Journal of the New England Water Works Association, Vol. XVIII (Boston: New England Water Works Association, 1904), pp. 375 - 395.

The sources refer to three types of pipe wood used during the history of the Bethlehem water works. Initially, hemlock logs were floated down the Lehigh to provide Christiansen with his first line.[42] Apparently, this wood was subject to frequent troublesome ruptures when subjected to water under pressure. Gum wood was substituted for the pressure side of the system, and pipes of pitch pine served as supply lines from the tower to the town taps.[43] It was one of the latter that made souvenir walking-sticks for Bethlehem's 1892 Chief of Police.[44]

The 1964 archaeological project has now added two other pipe woods to the inventory. Below is given the result of analysis of wood samples from most nonremovable features uncovered by excavations:[45]

Sample Number	Artifact Type and Provenance	Kind of Wood[46]
1	Waterpipe, S.W. corner Test Pit #1 (10N/180W)	Chestnut

---

[42] Peter Fritts et al, History of Northhampton County, Pennsylvania (Philadelphia and Reading: 1877), p. 289.

[43] Rau, p. 16.

[44] Myers, Vol. I, p. 121

[45] The analysis was graciously performed by the Forest Service of the United States Department of Agriculture in August, 1964. The report from the Service is in the files of the writer.

[46] The samples used for the analysis will be delivered to Historic Bethlehem, Incorporated should they desire them for any museum relic display to accompany drawings.

Sample Number	Artifact Type and Provenance	Kind of Wood
2	Water pipe, in north wall, Test Pit #1, in which copper jumper initiated change of water course.	Black Walnut
3	Headrace - race wall member	White Oak Group ~~Black Walnut~~
4	Water pipe, Test Pit #1, the interrupted and plugged pipe, consuming the greatest portion of excavational area, lying generally southeast to north west.	Chestnut
5	Water trough, Test Pit #1 (10N/180W).	White Oak Group
6	Crib siding, water works wheel pit.	Eastern White Pine
7	Water pipe, round, headrace excavation.	Chestnut
8	Water pipe, octagonal, headrace excavation.	Chestnut

Although neither head- nor tailrace was completely exposed, enough of their paths were seen to be able to place credence in many of the early Bethlehem maps.

There are two sources that supply some fundamental information dealing with the 1762 water works mechanisms. For the most part they agree, but on certain points there is confusion. In organizing the hypothetical reconstruction of these works (Plan III), the writer has accepted Robert Rau's statement of the facts. The other source, Hellmuth Erbe, has several inaccuracies throughout his text, which cause this writer to question his research.

The applicable portion of Rau's work states that the station consisted of

> . . . 3 single-acting force pumps (or iron, cast at Durham Furnace . . . of 4 inch calibre and 18 inch stroke, worked by a triple crank (forged by the resident blacksmith, Stephen Blum . . .) geared to the shaft of an undershot water wheel, 18 feet in diameter, and two feet clear in the buckets.[42]

This description, added to the archaeologically exposed features, allows the placement of the wheel as shown in the Plan. The wheel illustrated was one of the types prevelant in Europe at the time and especially in Germany.

Rau's description continues, "On the water wheel shaft was a wallower of 33 rounds, which geared into a spur wheel of 52 cogs, attached to the crank; the three piston rods were attached each to a frame or crosshead working in grooves to give them a motion parallel to the pumps."[43]

If the wording were not so explicitly stated, one could wonder if the source had not inverted the positioning of wallower and spur wheel. Reference to all the comparative sources will show relatively rare use of the combination. Generally, the spur wheel is attached to the water wheel shaft and the wallower to the cranks or beams. The classic water pumping mechanisms of Marli and Nymphembourg had either spur wheels or cranks attached to their wheels. One has to look to the blast furnace, gristmill and sawmill, primarily breast

---

[42] Rau, p. 5.

[43] Ibid., p. 5.

and overshot wheels, to find the wallower on the wheel. Even in the gristmill example the wallower on the wheel gears to a cog, which in turn meshed with another wallower to turn the stones.

Be that as it may, Rau appears definite and with no particular contrary evidence, this arrangement is included in the reconstruction.

His final pertinent sentence reads, "The crossheads were of wood, as also the parts containing the grooves for guides."[44] His choice of the word "grooves" rather than holes, notches or tracks is perplexing.

For traditional vertical-acting pumps, it is hard to see any other likely placement, than that which appears in the hypothesis. This position places them as close to the center of the reservoir as possible; placing them conveniently near the water, yet stabilized by available foundations and abundant beam remains presently within the pit. The four notches in the pit stairway must be kept in mind, but there are no complementary cuts of equal height in the opposite way. Also, if they were designed to in some manner support the pumps, the stairs themselves would have been a useless addition to the building. These stairway notches and the orientation of the wood remains in them have been taken to signify their use as cantilevered pump base braces designed to subdue inherent whipping reaction.

The unused space over the pipe pit still remains a sore point.

---

[44] Ibid., p. 5.

The beam rests in this area do not appear designed for much weight. When Rau's perplexing "grooves" are again heard, one is forced to the possible alternative that he meant what he said literally, and was referring to crosshead guides of horizontally-acting pumps. The economics of space would supportthis possibility. The spur wheel could then be placed on the north side of the wallower making wheel maintenance easier.

Furthermore, the pumps would be supported laterally over the pipe pit, an otherwise useless area, needing comparatively little maintenance access, and freeing the area immediately above the reservoir for pipes, chambers, valves, and maintenance.

The drawn plan has tended towards conservatism and remained with vertical pumps until such time as more clues are available. To do otherwise would probably be placing too much credence in one word. Furthermore, if, breaking with tradition, horizontal pumps were indeed used, it probably would have received mentioned as such.

When the hypothetical reconstruction (Plan III) was first under consideration, the writer had intended to include his theories on the types of pistons or plungers and clappers that were used. Should one wish to analyze the myriad contemporary narratives, the sources are available. There was no archaeological evidence whatsoever on this point. One reference in Erbe, relative to the question, apparently trustworthy, though admittedly unverified, is a direct quote from a January 13, 1759 Spangenberg report, stating, "'This water works is

now approaching its fifth year and so far has not required any further repairs, except that occasionally the leather on the buckets in the barels [sic] gets worn off.'"[45]

The reference is, of course, to the first, 1754 water works, which still used wooden barrels. The later 1762 pump barrels, as shown above, were of metal.

Historically, and hydrodynamically the second water works had three choices of sealing the pumps open to them. First, they could carry over the use of leather linings on the pistons; or second, they could use a tight-fitting bucket with packing around the shaft necks; or third, a combination of both. The latter two would necessitate a stably-guided shaft stroke, which the crossheads would have provided. In all likelihood the third alternative was the one employed.

Plates XVII through XX were reproduced and included to present evidence of a type of pump and accessory technology known in rural Pennsylvania. The similarity to Bethlehem pipe preparations and use is obvious. Plates XIX and XX show piston types and specifically #12, Plate XX illustrates the method the first water works probably used to seal the bucket. No evidence has been encountered that would lead one to believe that any change took place in this respect between the 1754 and 1762 works. The addition of shaft packing is offered simply because it seems to be a sophistication coming into vogue at the time.

The crank is designed in the drawing to give a sequential pump-

---

[45]Erbe, p. 76, n. #414.

ing action. The first pump is at extreme down stroke, the second at its mid-point and the third terminating its up stroke.

Based on compelling circumstantial evidence, the main feeder pipe leading to the tower in the square above is assumed to have passed through the underground closed breach in the east section. It is firmly believed that the central arch with its accompanying sill was for no other purpose than to support this pipe and its connections. There is no other presently visible means for the main pipe's egress from the pumping station.

Another feature demands discussion. That is, the woodwork frame beneath the present wheel pit floor, and apparently partially beneath the building. Its presence presents three alternatives. The first is simply an earlier, lower pit floor preparation which was found inadequate and unnecessarily low. The second, based on its impinging beneath the pit walls, could insinuate an undocumented destruction and rebuilding period.

We do know that the original oil mill from which the first 1754 water works borrowed its power, burned beyond repair in December, 1763. The water works budget books, however, only list expenses for clean-up, and new doors around that time as evidence of related harm. Surely if the damage to the water works had been extensive enough for wheel pit rebuilding, there would have been supply expenditures, and more than one day's labor for cleaning. A third alternative is that the remains represent the original race of the first, or 1754, water works.

Following Moravian frugality, it would only be natural to use any excavations extant at the 1762 building.

There is one element that tends to obscure the dating of this sequence. That is the presence of a child's shoe beneath the present floor boards. The prevailing opinion among those dealing with early Americana, relative to shoe manufacture, is that an early shoe constructed with hand-cut wooden pegs, is more modern than an early shoe using iron nails. One source claims wooden pegs were invented in 1811.[46] Another, that Samuel Preston's machine, invented in 1838, drove pegs into soles, thus eliminating the need for hand insertion.[47] Yet the same authority states that in 1810, M. I. Brunel created a machine that used short nails to fasten uppers to soles, thus replacing hand sewing or wooden pegging.[48]

In accordance with the majority opinion, the child's wooden-pegged shoe would be dated at post-1800, demanding a replaced wheel pit floor built over it, some time between 1811 and 1832. Aside from any loss in the charm of the tiny footgear, because of its more recent 19th century vintage, an important historic fact is revealed. The fact has relevancy above its historicity relative to any reconstruction plans.

---

[46] The Chronicle of Early American Industries, Vol. I, #15, January, 1936, p. 5.

[47] John W. Oliver, History of American Technology (New York: Ronald Press Company, 1956), p. 166.

[48] Ibid., p. 134.

Using the dates above, which are maxima, the expected life of a wheel pit floor would be 21 years at the outside. If the shoe technological information is accurate, it is unlikely that a Moravian child would have been able to avail himself of a new development in the year of its invention. Consequently, the anticipated wheel pit floor life would have to be proportionally decreased.

Recommendations

This section is included with the report in compliance with a request of the administrative director of Historic Bethlehem, Incorporated. Many of the points have been mentioned orally to this gentleman, to members of the Board of Directors and to the institution's recently created Committee on Historical Research, in answer to inquiries.

The writer's requested professional suggestions relative to an executive director job description and qualifications, apparently have already become part of the prevailing opinion, and will not be reviewed here.

The present cause célèbre with the powers that be in Bethlehem seems to pivot on the desirability of archival research versus archaeological investigations. From recent local newspaper articles, the success of the former over the latter appears to be fait accompli. Unfortunately, the two phases of the question are considered an either/or proposition. The polarity or separation of the two principal elements of research is unscientific.

As stated in the text, the lack of the promised research for the 1964 archaeological project may have lessened the project's present effectiveness; it has not, and it could not, detract from the work's potential effectiveness. Much more deleterious to the time/discovery

ratio was the lack of promised labor.

The facts and evidence that could be recovered have been recovered. In the areas studied archaeologically, no amount of archival research could have made more information discoverable. It is admitted that documentary research may shed more meaningful light on what was uncovered, but this light is not dimmed because the library work follows the excavations. To proceed from this concept reveals a lack of understanding both of archaeology from the earth and history from the archives.

Neither discipline is a panacea for the other. Furthermore, a most comprehensive study of the archival material will not alleviate the necessity of further and repetitive research on the same subject following archaeological investigations. This realistic statement is based on the unavoidable truth that in the main, archival research is performed by history-oriented individuals. Therefore, much of the culture-historical information the archaeologist deals with will be overlooked in the initial research.

The above is one of the reasons why Historic Bethlehem is extremely fortunate in having the resources of the professionals that compose its Committee on Research. Some of these gentlemen, I am sure, will testify to the unavoidable truth of the above exposition. At least one member of the Committee has done some limited archaeological research and yet is in the main, professionally oriented towards history. I would expect complete substantiation from this quarter.

It was pleasing to read that others thought, as I did, that this Committee should be made a permanent arm of Historic Bethlehem, Incorporated. The writer would carry the case further and suggest that this Committee be made the authority on carrying out the aims of Historic Bethlehem, Incorporated, with the institution's Executive Director as liaison between the Committee and the Board of Directors.

This arrangement would take the following form. The Committee would present the Board with a realistic professionally considered set of alternatives as to the ultimate fate of those physical features under the Corporation's control. Is a particular historical structure to be returned to its 18th century character, grade and operation, or is it to be simply studied, its features reburied and shown by model?

Once the Board has been presented with the true picture of what is involved in each alternative, including costs, it would have to make a definitive statement of aim, policy and direction. Only this way can the professional investigators know how to proceed.

From this point on, the Committee would have the responsibility for deciding priorities, and the authority to implement the policy of the Board. To allow the Committee to operate, they should be given a yearly statement as to the funds available for that year. The Committee would then decide what works would best forward the aims of the institution, vis-a-vis funds, in that year. Periodically the Executive Director, being a member of the Committee, would advise the Board as to progress, followed by a detailed year-end report of the

whole. The Committee would thus form a "brain trust to evaluate and interpolate professional technics and nuances according to the formally established will of the Board, and be answerable only to proving how their efforts and expenditures fostered that will.

Prior to forming a definitive statement of policy and direction, it is strongly recommended that evaluation of the Monocacy Creek level problem be entertained. The problem has been presented and discussed in some detail in the Conclusion section of this report. From the writer's study, the problem is a major one, vis-a-vis the present "Master Plan" aims. If the industrial area is to be returned to its 18th century level, with early trade features made operational, the Creek will probably have to be dredged. If additional study vindicates this stand, it is recommended that United States Army Corps of Engineers aid be sought. Such assistance may be available, gratis, under a number of provisions, such as the Corps' Flood Control Program. I am sure the U. S. Department of Health, Education and Welfare in conjuction with Urban Renewal Programs could be presented with a persuasive case.

Illustrative of the problem and need for an empowered Committee for coordination, is the recent Bethlehem purchase of expensive fill to raise the surface of the Monocacy banks below the industrial area. This is a compelling example of lack of proper cooperation.

Should the Creek level truly be a problem to Historic Bethlehem, the filling of the lower flood plane will only aggravate the situation.

Should the Creek level not be a serious question, would not the post-18th century overburden covering the industrial area be a much cheaper "fill" for the planned downstream project; the removal of which would serve both interests at equal or less cost?

The following archaeological priority recommendations are based on several criteria. The point of departure proceeds from what is presently stated as the institution's aims in the Master Plan. For these priorities, the Creek level problem will be treated as if steps would be taken to modify its present configuration by dredging, damming, or a combination of both.

1. The Old Oil Mill versus the Hilltop (Old Pottery Area):

The hilltop along Main Street, where the lone old pottery wall now stands, is considered by many to be an eyesore. As such, much popular feeling exists for its removal, or final disposition. Two factors affect its priority placement. First, the amount of debris from the recently razed buildings could be removed archaeologically, but it would be extremely uneconomical to do so. Furthermore, contrary to some current opinion, I would not expect to find the main 18th century pottery kiln in that area. Secondly, the region has such a complex history that very detailed initial archival research is warranted.

As to the old oil mill, I have held that enough archival research already exists to allow excavations there. This opinion has already been overruled by the recent Committee decision, but the

site still should remain as first archaeological priority.

There are several reasons in addition to the archival question. Primarily, each year about this time Historic Bethlehem, Incorporated is faced with its fund-raising campaign. Contributors are definitely more generous when they see their organization producing visible results. Any scientific investigations at the oil mill is bound to produce more evidence relative to the water works. With both areas archaeologically studied, the southern extent of the industrial area would not have to be re-excavated, and releveling, grassing and/or reconstruction could begin, providing unique and impressive fund-raising materials.

Much public interest and surprise was expressed during the water works excavations. To let this impression lay fallow by too long a hiatus between excavations would sacrifice an important advantage.

Continuing to leave the Creek level question in abeyance, there is another major obstacle to regrading this area. This is the 54" sanitary sewer that underlies Water Street between the two sites. Apparently everybody involved with the intricacies of the Master Plan's implementation is aware of the sewer problem, but nothing has yet been done.

As the Committee has decided to give the year to archival studies, this free field time could be very profitably used in seeing that the impediment is removed. When archivally prepared to re-initiate

excavations, much time and expense would be saved.

Considering the general interest of the present Mayor and heads of the Parks and Water Department, which we feel the 1964 project was in part responsible for bolstering, cooperation is there for the asking. All cities have the realistic problem of idle men and machinery during the late fall and snow-free winter seasons. These resources can, if properly used, be a boon to Historic Bethlehem, and literally save thousands of dollars. This potential resource plays an important role in all of the suggested priorities.

It is recommended that the remainder of 1965 and the spring of 1966 be devoted to the removal of the intrusive sanitary sewer under Water Street, the marking of any unmovable water mains, and the location and disabling of any nonusable branch lines.

The quantity of archival materials relative to the oil mill should have been exhausted by the late spring of 1966, and that area should be the archaeological target for that season. Before or during the season, library research could be initiated on the old pottery and adjacent building area. During the fall and winter seasons of 1966 City cooperation could be employed in removal of the rubble. This would not take long for machinery, and there would be abundant time remaining during the same year for City work in the initial regrading and seeding of the water works and oil mill area.

The 1967 field season could be used on the hilltop to expose all features there.

At this juncture, an important ancillary problem to funds-available and ultimate aims should be reviewed. The point is now raised because the lack of resolution prior to the 1964 season had serious results. Some $5,000 was expended in 1964, revealing significant early organic and masonry remains. Yet once these features were exposed, the executive secretary did not know what was to be done with them. Exposure to air and water is most deleterious to such remains. The writer offered several weeks of his services gratis for the proper removal and preservation of the organic remains. The cost to Historic Bethlehem, Incorporated would have been less than $100 in materials. But continued exposure and indecision caused appreciable damage to these features, only being arrested by the Board calling the archaeologist back to Bethlehem for proper artifact reinterment. From mid-season, as old walls were uncovered, the writer strongly advised the elementary archaeological need of a mason's services for stabilization. This, too, was put off, and eventually disregarded as unnecessary, to the detriment of the structures. The results are now objectively and photographically recorded. Stabilization and preservation funds and facilities are as basic to sound archaeology as is the trowel and notebook.

2. Tannery and Adjacent Structures:

The country's one-of-a-kind tanning operation building still remains as a sound structure. Several modifications have been made, i. e. concrete paving, wall removals, and ceiling and roof alterations.

There is an average of 4" - 6" of Portland cement over most of the ground floor. The historical tanning vats, baths and accoutrements, if still extant, will be underneath this covering. The removal of this modern material can best be accomplished by pneumatic hammers and drills; a perfect occupation for idle City equipment during the fall of 1967. Again, appropriate archival research could be progressing concurrently.

To the south and west of the building, would be the Creek "bath yards" of the tanning trade and the historically adjacent slaughtering operations. Those several industries could be handled as a single archaeological unit during the 1968 season. Like the hillside, however, the area is covered by building rubble which needs prior removal. This could be accomplished with the proper City equipment in half a day. The ruins of the butcher's dwelling abutting the north side of the tannery should be left as is for the archaeologist. There is rubble here, too, but untrained removal would cause feature damage.

3. Gristmill, Spring House, Tawry, Milch Haus, Races, etc.

The remainder of the industrial area has been lumped, because there are various opinions concerning the disposition of the gristmill. A separate executive decision will probably be needed in its regard, primarily based on architectural considerations. Whatever the decision, a full field season study or more will have to be devoted to it and its raceways.

The area between the gristmill and the oil mill/water works

complex historically contained several buildings. The writer believes that the area may reveal some undocumented structures as well.

The general location of the spring house is known traditionally and we have located, electronically, two probably-associated walls. The complex of minor structures should be handled as a unit, and at the same time the location of old Creek banks, walks, roads, etc. should be sought.

By this timetable, barring serious complications such as the Monocacy, and assuming adequate funds and coordination, the archaeological investigations should be completed by the end of the 1970 field season. Depending upon the decided approach, the field work may take longer, but it is unlikely, discounting year-round work and inexhaustible labor supply, that such investigations could be completed sooner.

The professionally-oriented reader will realize that, although the major archaeological problems facing Historic Bethlehem, Incorporated have been discussed, each point has many facets and subtopics that demand more detailed consideration.

Archaeology is obviously as significant to the aims of Historic Bethlehem as any amount of historic or other research. It seems compelling, therefore, that any interpretive or policy-making organ of the institution include such a professionally trained individual among its members. Only an archaeologist can properly evaluate, criticize and elaborate on the recommended priorities. The constitution of the pre-

sent Committee more than adequately represents professional historians and archivists. Short of actual reconstruction, however, to expose the possible features of the Monocacy industrial quarter, archaeology will absorb the largest single expenditure of time and funds. A properly-qualified individual, at the continual call of the organization will prevent many pitfalls.

A very good example of the danger of omitting pertinently-trained advice occurred in the 1964 season. As already mentioned, the archaeologist's advice relative to stabilizing exposed old masonry walls was ignored. To justify this rejection of the writer's evaluation, the opinion of a visiting architect was sought. Reportedly the architect concurred with the decision to leave the walls unprotected. Damage resulted. Within two weeks after the discussion, the writer was employed by long-distance telephone to come to an exposed historic site in southern Pennsylvania, and in part advise what could be done to save exposed walls that were caving in everywhere. The individual on the other end of the phone was the same architect who had visited the water works excavations, and had given his advice two weeks earlier.

Bethlehem has a unique site with unique possibilities. It has more tangible historic reality than Williamsburg and Jamestown combined. It could easily have a future as the historical show-place of the eastern United States, if that is what is desired.

It is obvious that the members of the Board of Directors of Historic Bethlehem, Incorporated are unusually enlightened, and public-

spirited; otherwise, the organization would not exist. But just as the Board must turn its legal affairs over to a member lawyer, so it should turn the implementation of its desires over to professional investigators. It would seem to the writer that this is the first step. Both of the historic sites mentioned above are well-known publicly; but also they are well-known professionally as leaving much to be desired.

Praise should go to the Board for the incipipient organization of a committee that can avoid the pitfalls of those other sites, and one day make them envious of Bethlehem, Pennsylvania.

Illustration Descriptions

Unless otherwise noted, all photographs and photographic reproductions are by the author.

Plate I:

A) Reproduction of an early plan in the files of Historic Bethlehem, Incorporated.

B) Pipeline plan of "The Water Works of Bethlehem, Pa., 1786. Traced from original map."

C) Early plan with property boundaries.

D) Reproduction and clarification of "C."

Plate II:

A) Reproduction of a late 19th or early 20th century photograph of southwest portion of the old water works. Notice the accumulation of debris along the south face, making the original entryway unusable. (See Plates III, A & B; XIII, A, B & D; and XIV, A & D.) Note also the presence of "garage" doors on west face.

B) A painted copy of an earlier original, Garrison (?). Note the enlarged (or distorted) size of the "pottery" building on the hill, and the changes (or artistic omissions) in the number of window openings in the north face, ground floor of the old water works.

C) A pre-1889 photograph of the south and west faces of the old water works. Note apparently still-used south entrance and original west door configuration.

D) Early Garrison (?) painting from north of the stone bridge across the Monocacy. The old tannery is the large building on the left.

Plate III:

A) Cerca 1930 photograph of the old water works building, showing western and southern faces with all "modern" changes in evidence. "Garage" type doors on west, obliterated entrance on the south with transom windows incorporated into the present configuration. Abutted on the left side of the building is seen a garage, no longer extant. Two of its foundation walls can be seen in the upper portion of Plate XI, A.

B) Photo of south face prior to excavations.

C) West and north faces after some clearing of vegetation cover.

D) North face of building after vegetative denuding, and the commencement of excavations. Note newly exposed old "boundary wall" at left center. Test Pit #I in right foreground.

Plate IV:

A) Hillside to northeast of old water works, after defoliation

and the commencement of fill removal. For comparison, note pre-excavational contour. (Reproduction of photo by Barbara Liggett.)

B & C) Hillside north of old water works after some growth clearing. (Courtesy of the Call-Chronicle Newspaper.)

Plate V:

A) Excavations well under way on hillside, with 10N/180W to 4.5', left foreground, and 27.7S/180W (headrace area) on the right. (Courtesy of the Call-Chronicle.)

B) Reproduction of a 35 m.m. color slide showing hillside after excavations were terminated. Notice full extent of earlier "boundary" wall exposed, with its original "gateway" at center-left. The larger wall in the background is a modern retaining wall.

C) Close-up of the jumper terminus and the beginnings of the new pipe route to the oil mill. Looking southwest.

D) Close-up of the discontinued pipe to the old water works. Note the plug rammed into the opening beneath the metal collar, and the generally excellent preservation of the wood. Looking northeast.

Plate VII:

Sketch of the artifact features encountered in 10N/180W (Test Pit #1) after full exposure. The artist has drawn enlarged views of the jumpers and plug. (Richard Ellis was one of the student-workers on

the project.)

Plate VIII:

A) "Taking a break." Two student workers relaxing on the northeast wall of the wheel pit inside the old water works, after about 7 feet of fill had already been removed; looking northeast. Note the mud and muck that had to be endured in every excavation that passed the 4-foot level. Also note that even during a break, detailed measurements and notations had to be made. (Courtesy of the Call-Chronicle.)

B) Similar view of wheel pit as in "A" with much of the cribbing wood already exposed. (Courtesy of the Call-Chronicle.)

C) The cribbing portion of the woodwork preparation of the wheel pit fully excavated. This apparatus confined and directed the full force and volume of water from the headrace into the water wheel's buckets. Looking north.

D) Wheel pit cribbing. In background the partially-excavated headrace arch can be seen; looking northwest. Note the niche built into the wheel pit's west wall (designated by the two horizontal talley pins), above and left of center. It is an interesting feature whose exact purpose is as yet unknown (see Conclusions and Hypotheses section).

The wall bordering the wheel pit on the right is the same point on which the two workers are relaxing in

photo "A." The actual starting point of excavations with the old water works was some four feet above it. The edge of the crib in the lower portion of photo "C" is 9.9' below the original starting point.

Plate IX:

A) This illustration shows the excavated tailrace arch and the inferior portion of the present window sill on the west corner of the building's southern face. See Plate II, A & B for a comparison with the present exterior ground level.

This photograph was taken when the writer made a 180^{o} turn after the illustration in Plate VIII, C. Looking south.

B) The pipe pit, or that area of the old water works through which the fresh water pipe traversed on its way from the spring to the reservoir pit. Looking northeast. Note relationship of worker's stance to the starting point at the window sill above his head. (See Plate XII, A and Figure I.)

C) South half of wheel pit floor from same position, and "panned" directly down fromphotograph "A." Note that the only area of badly-preserved wood lies between the south edge of the crib ramp and the extent shown in this photograph. This region of poor preservation is most certainly not attributable to peculiar "fill" characteristics -- rather, it was the portion of the water wheel complex which received

the greatest punishment from the thrashing of the turning wheel and water's friction.

D) Following the principle "an excavation is not complete until the soil is definitely sterile," part of the broken portions of the wheel pit floor were removed. Immediately under this floor was a trapped child's shoe. A half a foot below that were the remains of an earlier wooden structure. (See Summary of Field Activities.)

Plate X:

Drawing of complex cribbing in the north third of the wheel pit based on detailed measurements. The scale is "one inch equals one foot" in the original drawing. Heavy dots with accompanying numbers refer to points of depth from the datum. (See appropriate discussion section.)

Plate XI:

A) North face of the old water works building, looking west. The three major areas of excavation along this line can be seen. The shallow foundation walls of the early 20th century garage addition can be seen.

It is in this area that much trouble with pot-hunter disturbance was encountered. (Original photography by Barbara Liggett.)

B) Bird's eye view of headrace along building from a second story opening. Note the fresh water pipes and joint in the right foreground, and the apparently intentionally-subterranean

headrace structure making a sharp angle to the left -- towards the Monocacy Creek.

C) Similar to "B" but taken at present ground level looking east. More details of pipe and raceway construction can be seen, both wood and masonry work.

Plate XII:

A) Soil stratigraphy over "pipe pit." With the exception of a layer of 4-1/2" cobble paving, already removed, the surface at top background was the excavational starting point within the old water works. Note the "window" sill at ground level in the upper left hand corner. This is the middle of the three ground-level openings along the north side of the building. Note also the wall running fore to aft in the right half of the photograph. This is the separation between "pipe" and "reservoir" pits. Compare with Plate III, D and IX, B.

For stratigraphic levels, use with Figure I.

B) Soil stratigraphy of part of the north wall of 10N/180W (Test Pit #1). For clarity use with Figure II. (Original photograph courtesy of A. R. Miller.)

Plate XIII:

A) Close-up of altered entrance on south face of the old water works building. Looking northeast. (Original photograph by Barbara Liggett.)

B) Excavations in the area of the original entryway, with the old stoop stone visible in the wall between the two workers. Looking northeast. (Courtesy of the Call-Chronicle.)

C) The octagonal fresh water pipe in the pipe pit. Looking north-northwest. Note the wooden wedges used to keep the pipe in place and prevent rupture when passing under masonry walls.

D) South face of old water works building. Excavations for information about original entrance and tailrace. Note intrusive plumbing complex. Looking east-northeast.

Plate XIV:

A) Southeast corner of main interior portion of old water works. "Floor" and reservoir pit stairway partially excavated; original entrance visible at upper right, and the partial re-opening of the main arch at upper left. (Courtesy of the Call-Chronicle.)

B) Similar to "A." Cleaning up after re-opening the old arch to the east section. (Courtesy of the Call-Chronicle.)

C) After excavations were completed. Looking east and showing the pipe arch (left over the reservoir pit, and the re-opened access arch to the right.

D) Re-opened access arch and, on the right, the exposed extent of the original entryway to the building from the south.

Plate XI:

A) Reservoir, looking northeast.

B) Reservoir, looking west, from pipe arch. The wall, upper center, separates the reservoir pit from the wheel pit. (See Plan I & II.) Note the overflow opening built into this wall. The wall to the right in the photograph separates the area from the pipe pit. Note, about mid-picture, the octagonal fresh water pipe emerging from under this wall and entering the reservoir. This portion of the image is slightly blurred because of the water covering it. Further note short section of the earlier round pipe entering the pit just above the octagonal one.

C) View of stairway to reservoir from the "service floor," looking southeast. Note the notches built into the stairs and containing the remains of the wooden beams that once lay there.

D) Lower portion of stairway, with notches on right, and edge of reservoir at lower left.

Plate XVI:

A) Northern portion of the east section of the old water works. Looking north. The wall to the left separates this section from the main apparatus area. The visible portion was the only area paved in brick. (Courtesy of the Call-Chronicle.)

B) Completed east section, looking south. The stairway was constructed after the excavations were completed here, to provide indoor access to the rest of the building.

C) Over the pipe arch in the east section, the original masons provided extra buttressing, probably to give support for a stove or fireplace on the upper floors. Looking southwest.

D) East section, pipe arch, lower portion, looking southwest. The stain on the walls reveals the soil level prior to excavations.

Plate XVII:

(Plates XVII through XX are reproduced from The Proceedings of the Lehigh County Historical Society, Vol. 19, 1952.) The three sections of an historical wood pipe hand pump. Note octagonal pipes.

Plate XVIII:

5) Inferior end of a pump top section with band to prevent splitting. Octagonal shape.

6) Tapered male end for jointing.

Plate XIX:

9) Lower end of pump bottom section.

10) Foot valve. The valve flap, or clapper, was of leather affixed to the top of the unit on one side only. To add weight and aid in the closing of this leather valve, a block of wood is attached. The waist of the valve body is grooved to allow for flax and tallow packing.

Plate XX:

11) A variation on Plate XIX, #10.

12) An incomplete "rod" valve, illustration of another type of pump barrel packing. Here layers of slit leather provide the insulation between pump piston and barrel.

Plate XXI:

A & B) Three portions of one complete shoe, found in south half of the wheel pit, in the muck immediately overlying the floor. It is of special interest because of the fact that all the sole pieces are held to the shoe body by small hand-cut wooden pegs, while the heel is attached with metal brads or tacks.

C) Nails A through D are all hand-wrought; C through G are cut nails.

A) From the exterior headrace excavation, 5.5' - 6.0' level.

B) Test Pit #1 (10N/180W), 8.5' - 9.0' level.

C) Reservoir pit. This specimen fell from the woodwork of the reservoir during the excavation of the 8.0' - 8.5' level.

D) Headrace excavation, 5.5' - 6.0' level.

E) Reservoir pit. From inside reservoir woodwork at the 8.5' - 9.0' level.

F) Headrace excavation, 4.5' - 5.0' level.

G) Test Pit #1 (10N/180W), 9.0' - 9.5' level.

D) Shoesoles:

A) Headrace excavation, 4.0' - 4.5' level.

B) Headrace excavation, 6.5' - 7.0' level.

C) 27.9S/160W excavation, 6.0' - 6.5' level.

Plate XXII:

A & B) From the 4.5' - 5.0' level of the tailrace excavation comes this unique specimen. It is less than 1/2" long at its widest point; made of bone or ceramic. Its size has not allowed for final determination of its substance material, because any tempering with its surface (which is needed to determine composition) will mar the delicate artifact. "A" shows the obverse, which has incised decorations -- a sun dial in the center, the sun and burst superimposed, grass and/or steps in the foreground, with the words "COM SOLEL" in signet or reverse fashion around the top. "B" shows the reverse side. Both have been reproduced here in "negative" fashion; that is, the dark portions in the photograph are the light portions on the real artifact. It was felt that this method would best illustrate the inscriptions.

C) Knives from various site areas:

a) Wooden handled - 27.9S/160W, 1.5' - 2.0' level.

b) Checkered "bone" handle - the only non-pocketknife in the group - 27.9S/160W, 0.0' - 0.5' level.

c) Checkered wooden handle - wheel pit excavations, 8.0' - 8.5' level.

d) Handle covering missing - over the wall separating the reservoir pit from the pipe pit, 40S/160W, 4.0' - 5.0' level.

e) Wooden handle - Test Pit #1 (10N/180W), 5.0' - 5.5' level.

D) Brass belt buckle, recovered at 9.3', directly under the tailrace arch. It has the letters "R" and "K" on the corners, and smaller letters, "M" and "S" flanking the compass between the two lions. On the outside of the "M" and "S" are four punched marks in the shape of a cross.

Figure I:

A measured stratigraphic profile drawing of the soil structure overlying the pipe pit within the old water works building. This figure may be used in conjunction with Plate XII, A for pictographic comparison.

Figure II:

A measured stratigraphic profile drawing of the soil structure overlying the features in Test Pit #1 (10N/180W). This figure may be used in conjunction with Plate XII, B for pictographic comparison.

Figure III:

Graphic representation of artifact percentages according to their various categories.

Maps & Plans

The following are all scale drawings of maps and plans which accompany this report in a separate map roll.

Map I:

A detailed, surveyed map of the area in which the 1964 Old Water Works Project took place. The water works building is shown and designated by the digit "1."

The surveyed and staked datum line is placed on the plan for easy relocation of features and to provide an established starting point for future archaeology.

The map encompasses the area from the Brethren's House building line on the south, to Ohio Road on the north, and from Main Street on the east to the far side of the Monocacy Creek on the west.

Map II:

Basically the same as Map I, Map II has the added feature of contour lines. The divisions are in two-foot intervals. There have been some changes in present contours from those that appear, as a result of excavations. See the text for pertinent changes. Please note the small "X's" which cover the entire hillside and water works area. These represent surveyed stakes placed in position before any earth was turned. These carry elevations and numbers that agree with the master grid system shown. There are in addition, some stakes driven during our survey which do not fall within the limits of these maps, especially on the north side of Ohio Road, and in the old spring area.

Plan I:

A scale drawing of excavated old water works floor plan. Specific areas are designated alphabetically, i. e.:

A - Wheel pit

B - Pipe pit

D - Reservoir pit

C - East section

The plan also has two profile lines superimposed for use with Plan II.

Plan II:

Feature profiles of the old water works to scale and covering all pertinent areas shown in Plan I. (See text for details.)

Plan III:

Hypothetical reconstruction of the working apparatus of the old water works.

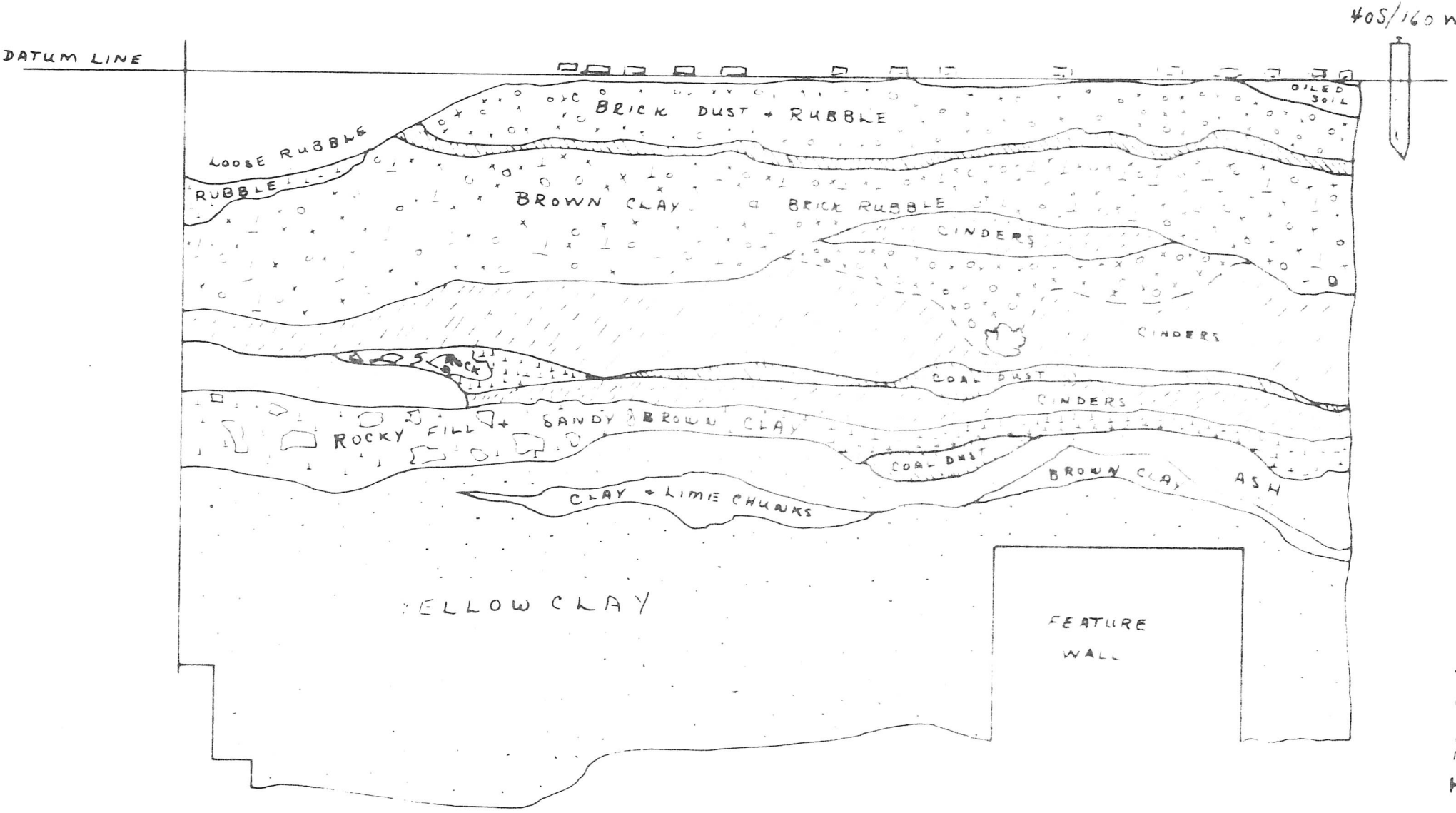
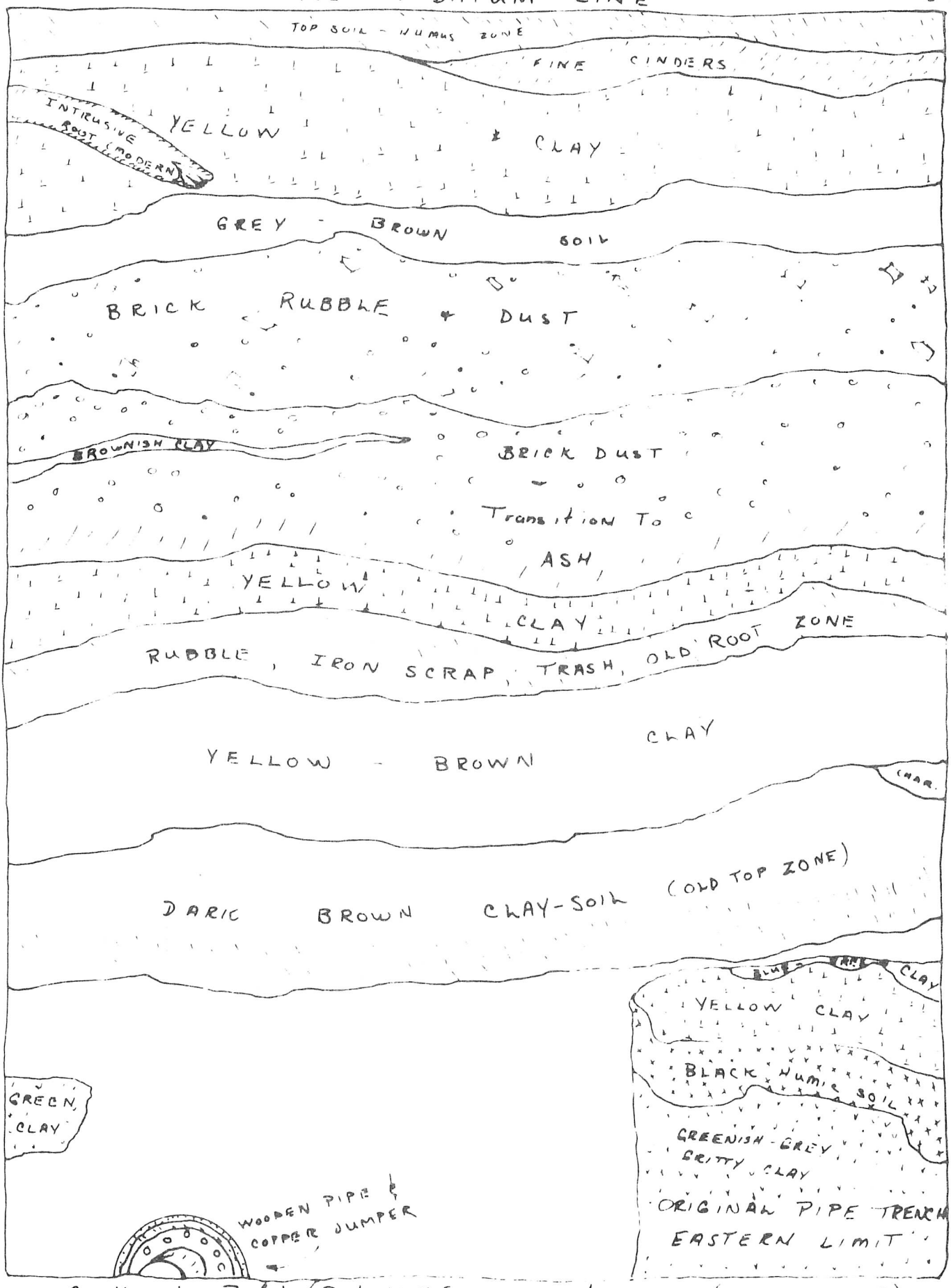


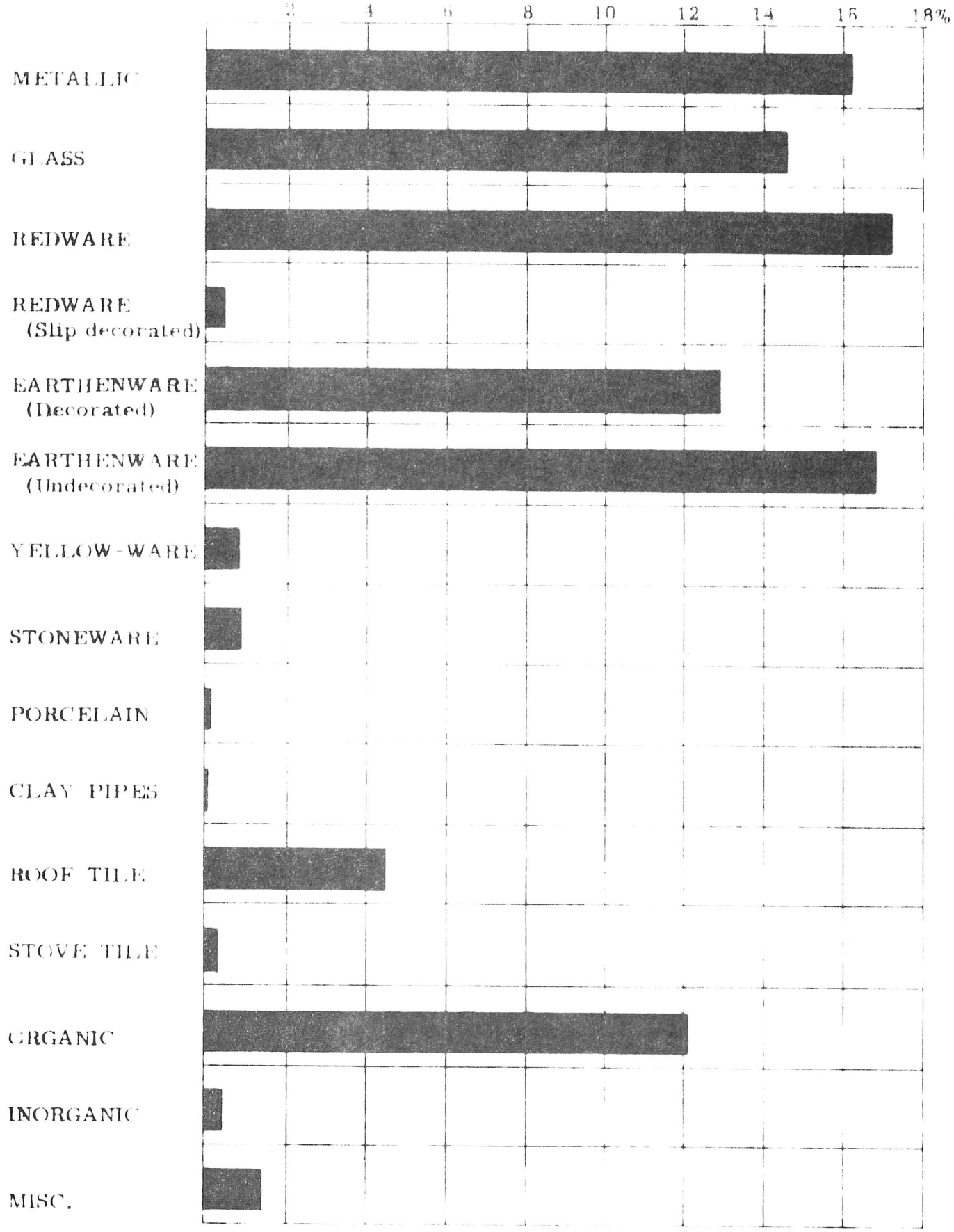
FIGURE I

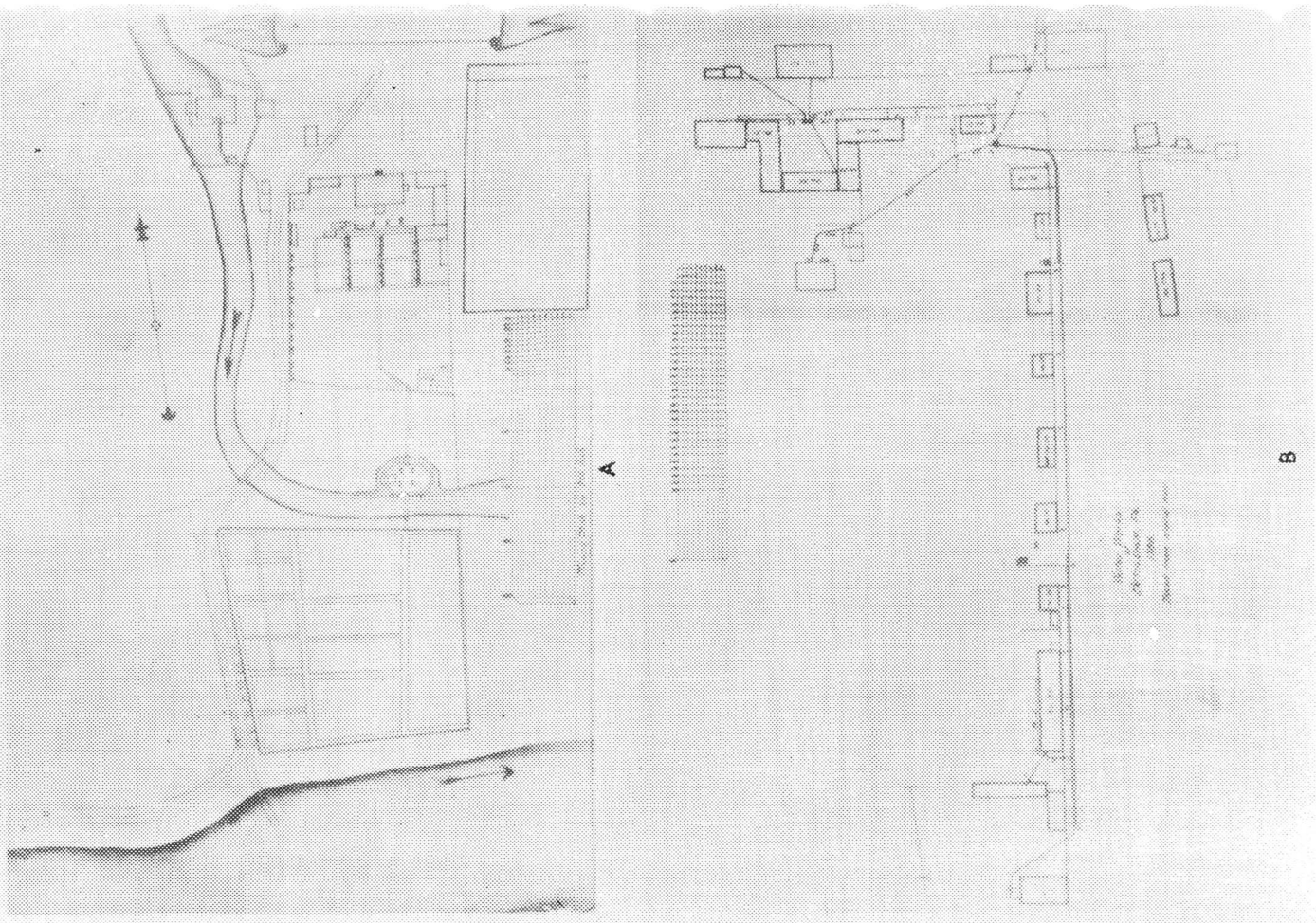
Stratigraphic Profile - E. Section - 40S/160W (SEE PLATE XII-A)



Stratigraphic Profile (Partial) N SECTION, 10N/180W (SEE PLATE X 1 B)

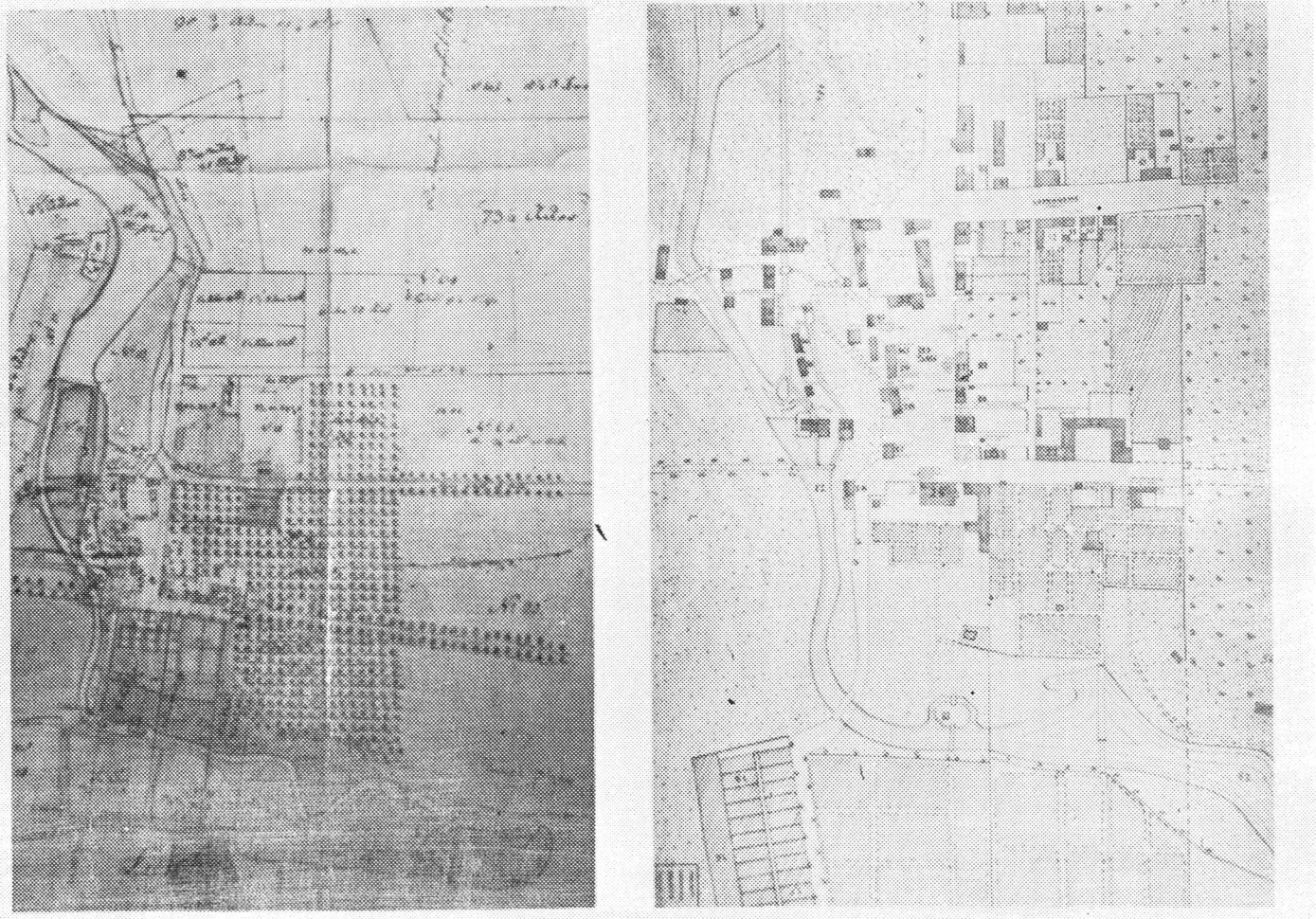
FIGURE III


2
4
6
8
10
12
14
16
18%
METALLIC
GLASS
REDWARE
REDWARE (Slip decorated)
EARTHENWARE (Decorated)
EARTHENWARE (Undecorated)
YELLOW-WARE
STONEWARE
PORCELAIN
CLAY PIPES
ROOF TILE
STOVE TILE
ORGANIC
INORGANIC
MISC.



A

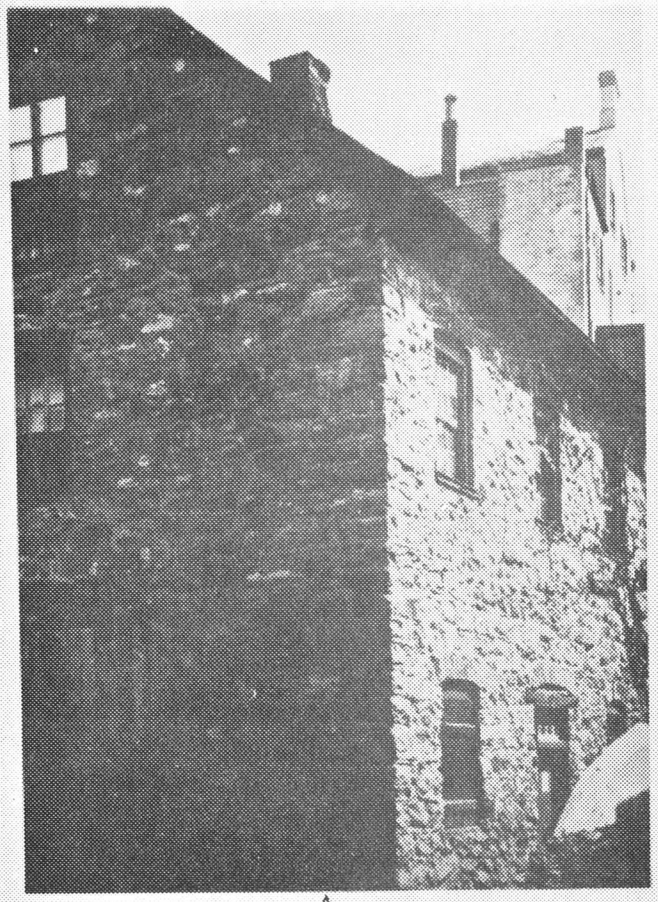
B



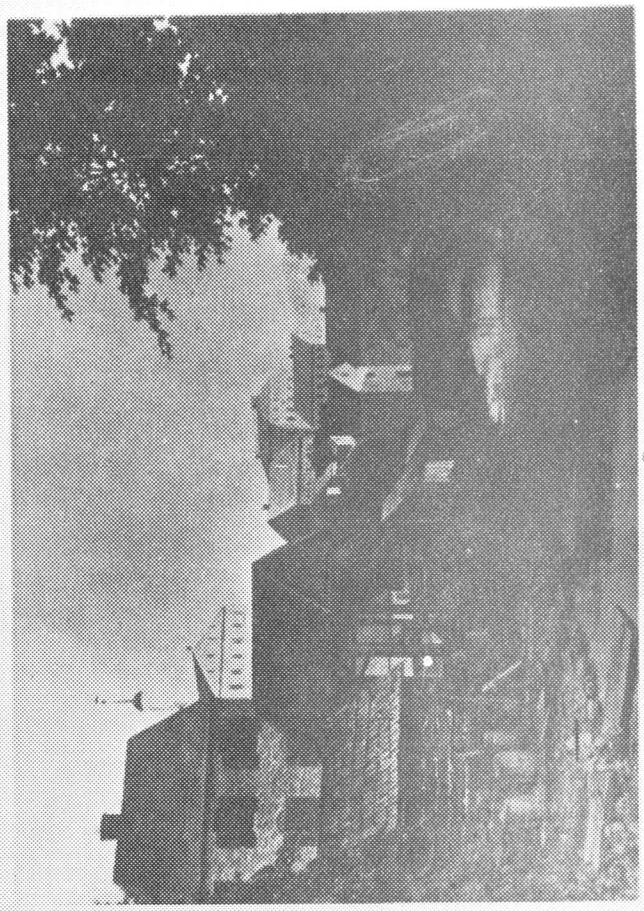
C

D

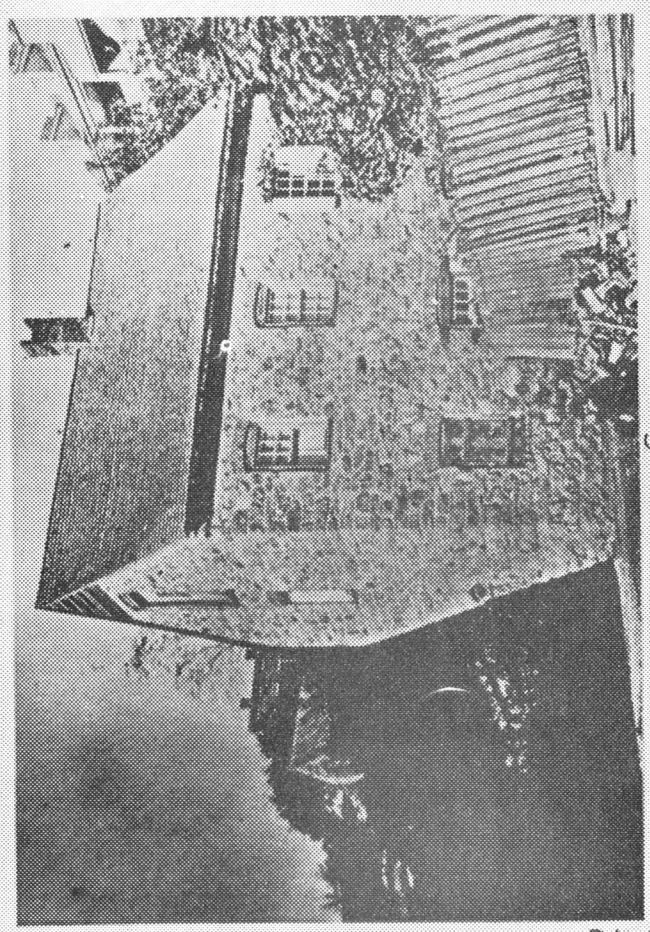
PLATE I



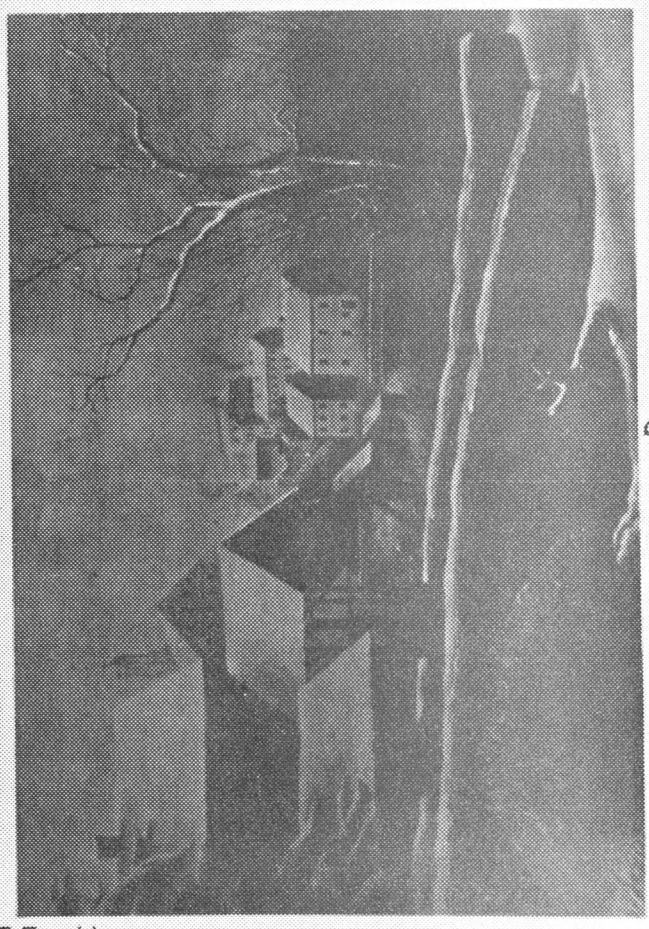
A



B

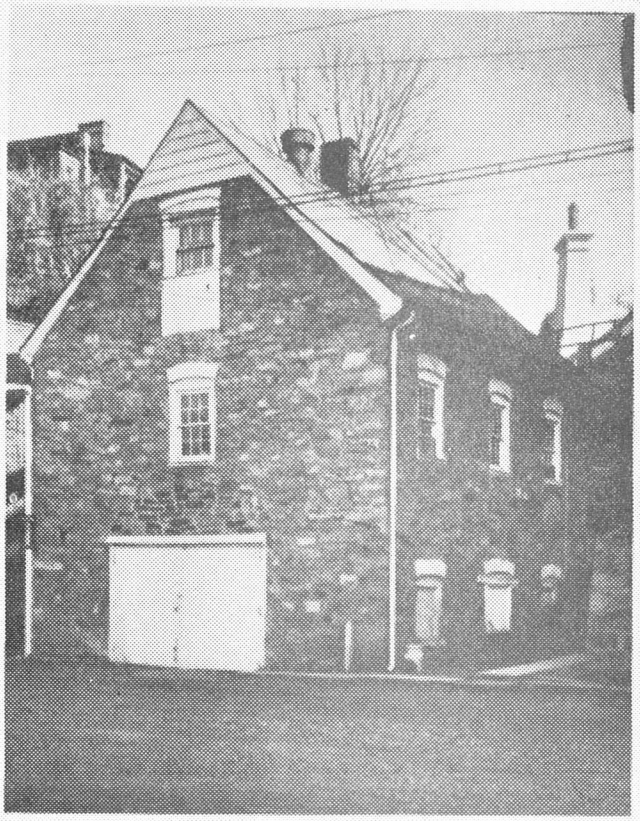


C

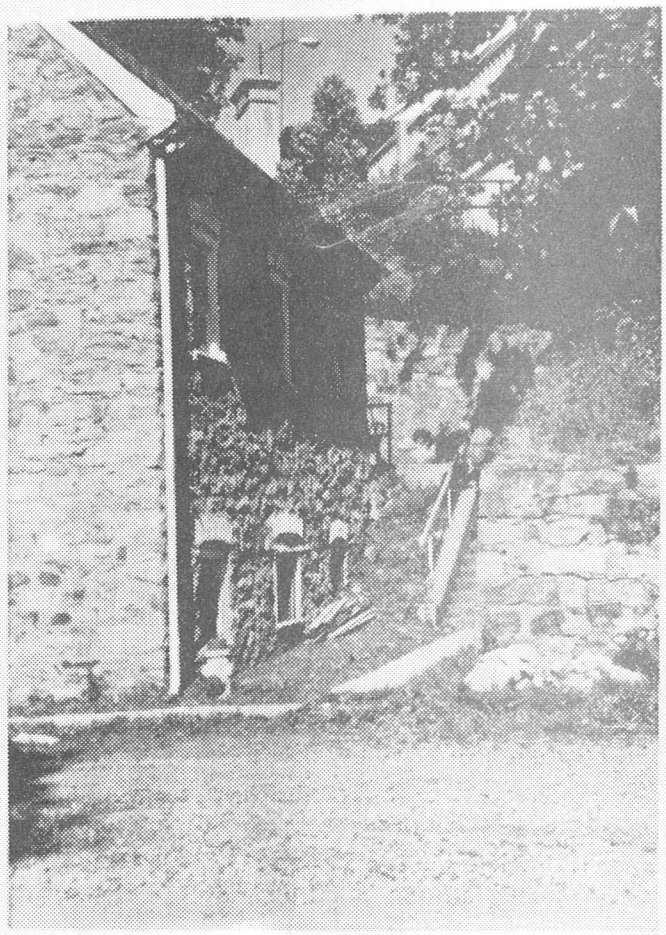


D

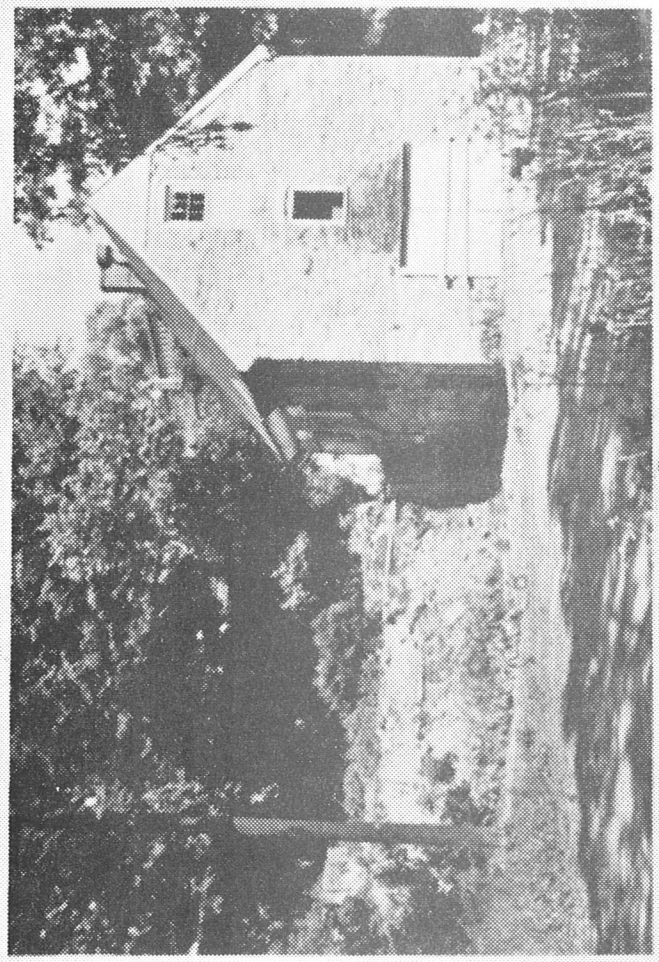
PLATE II



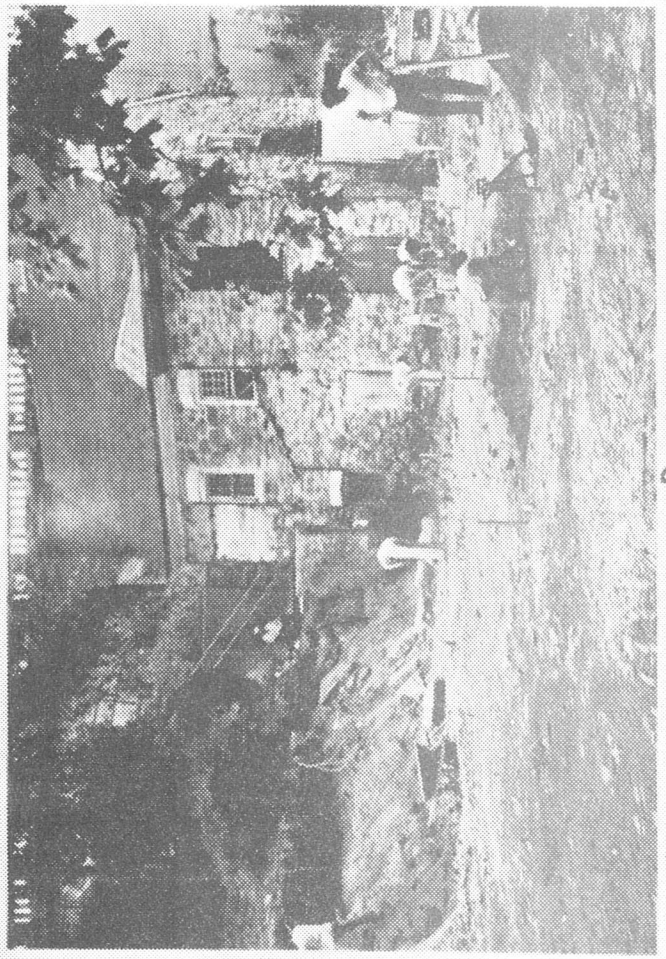
A



B



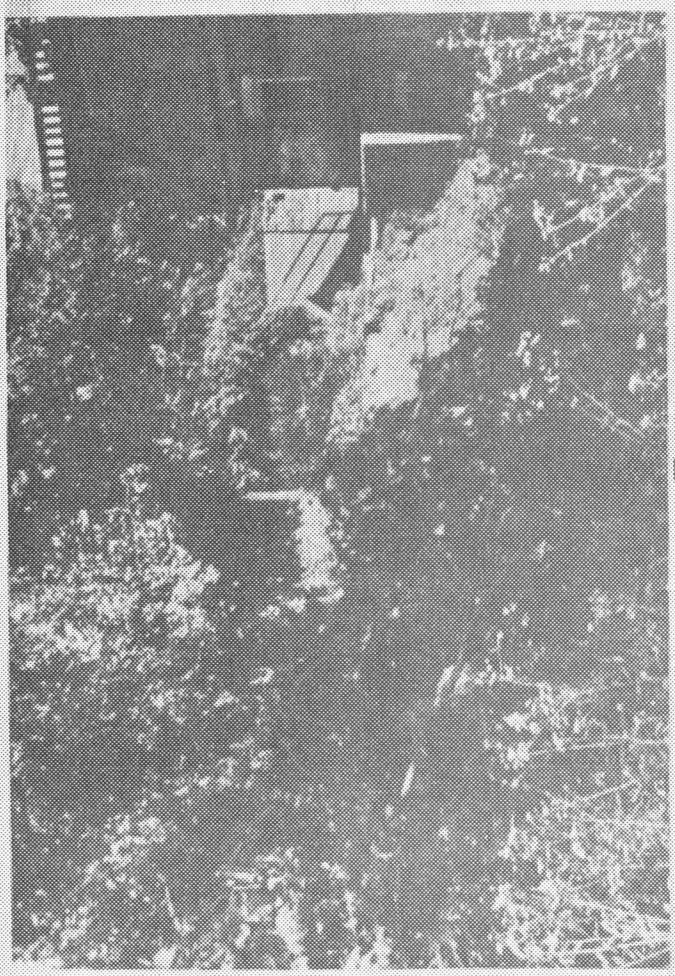
C



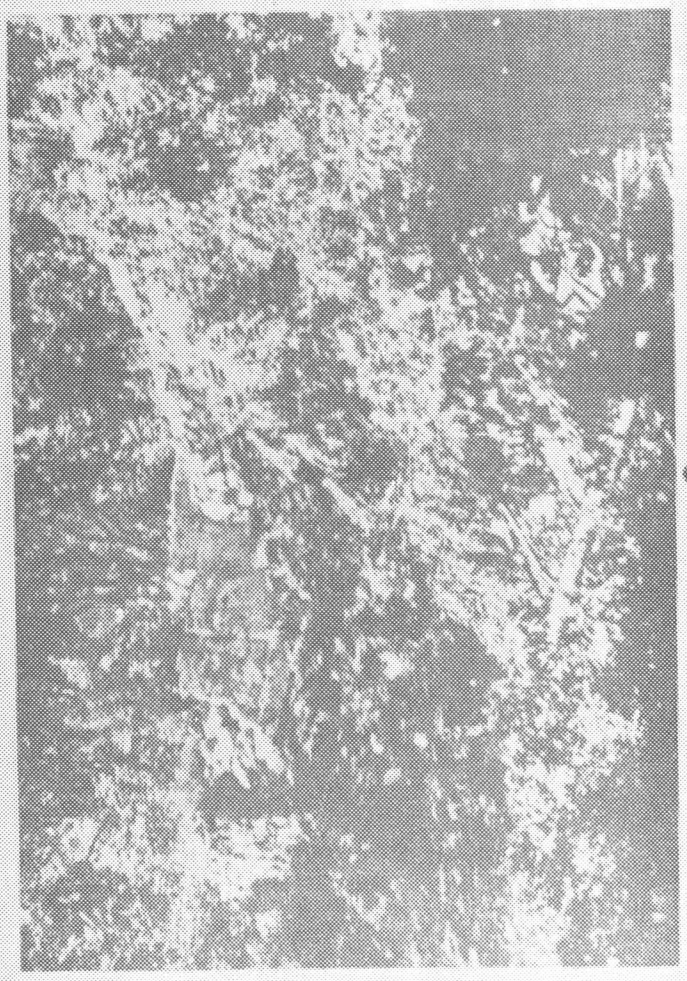
D

PLATE III

A

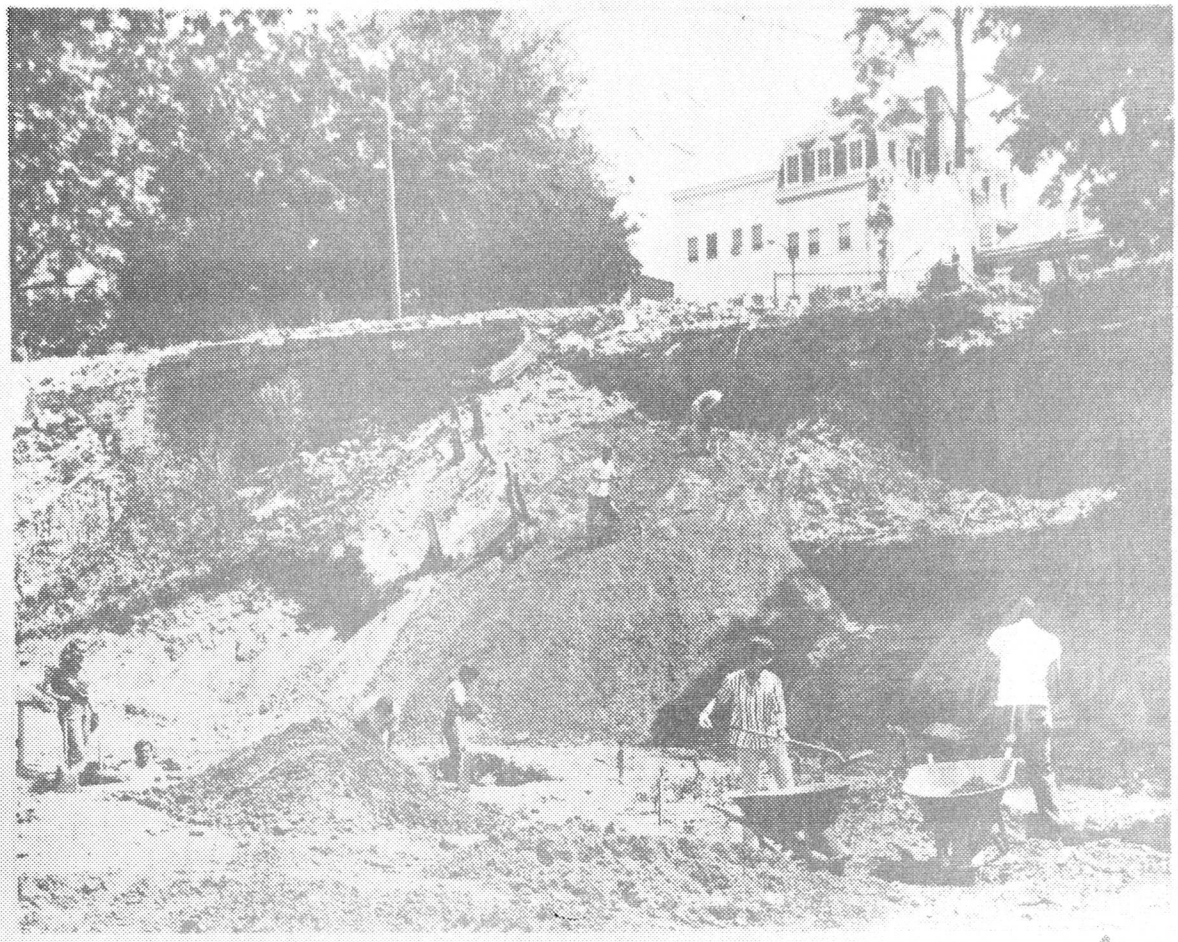


B

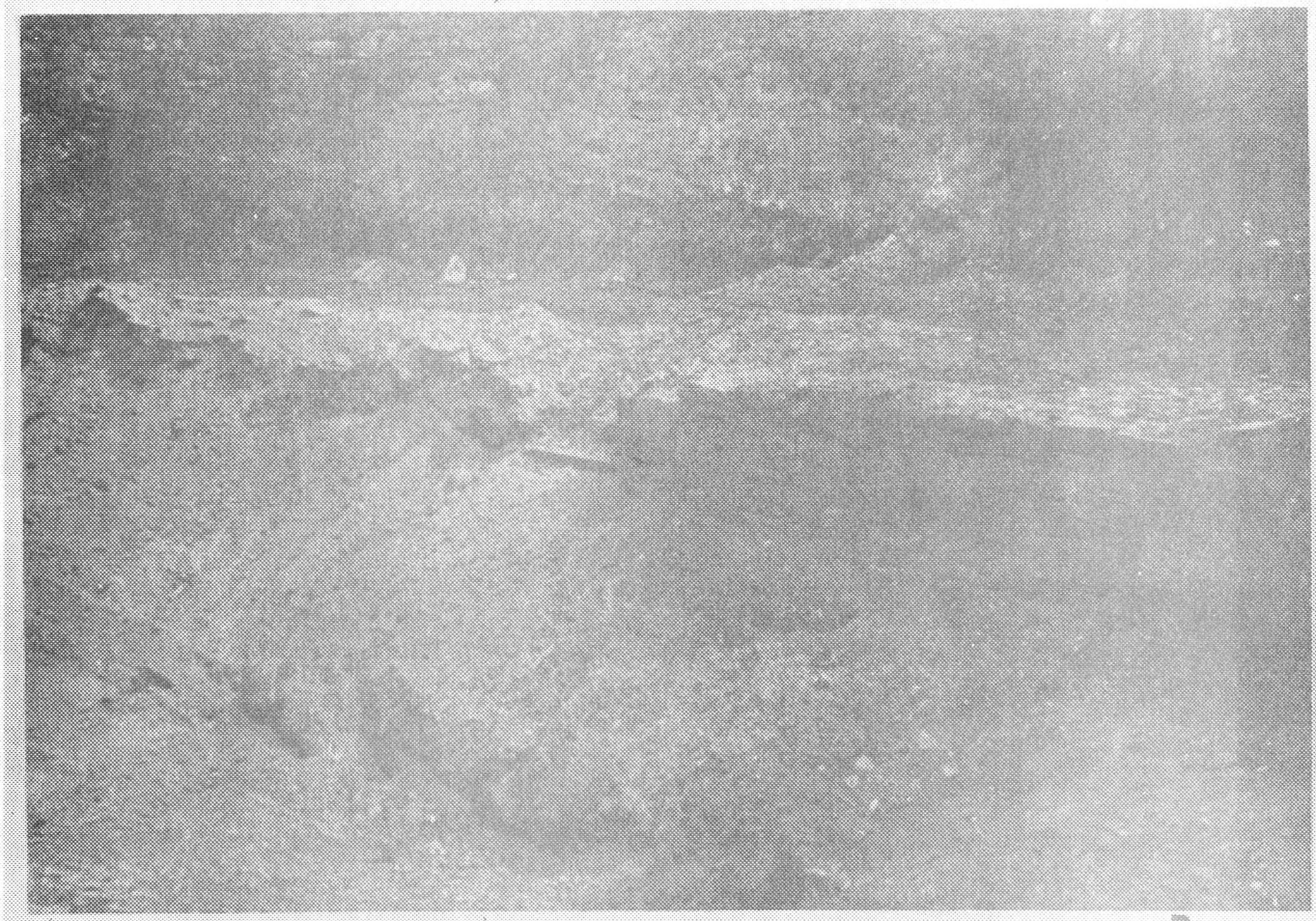


C

PLATE IV



A

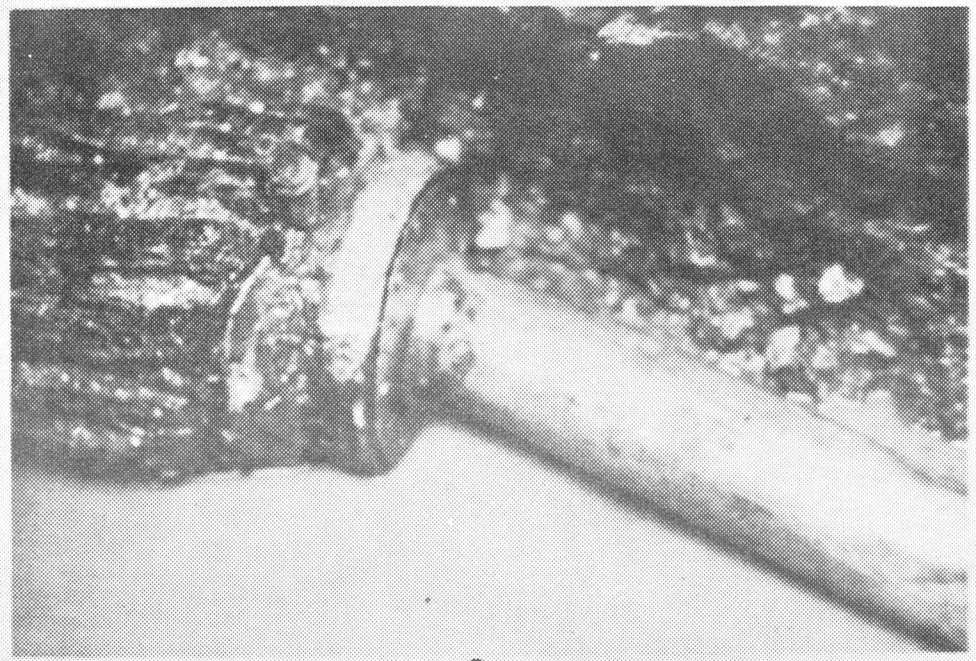


B

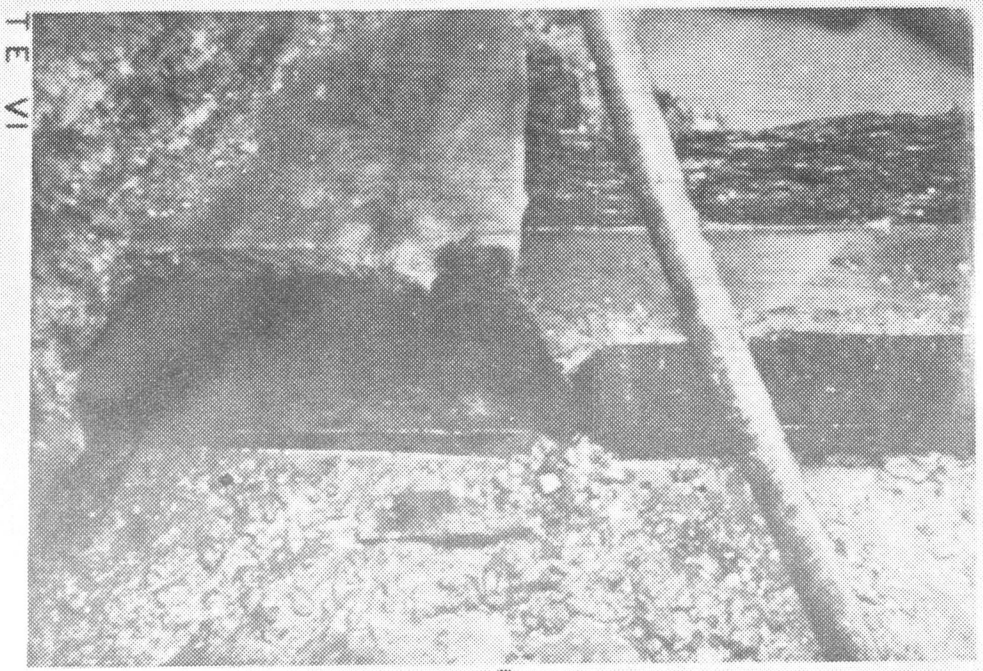
PLATE V

PLATE VI

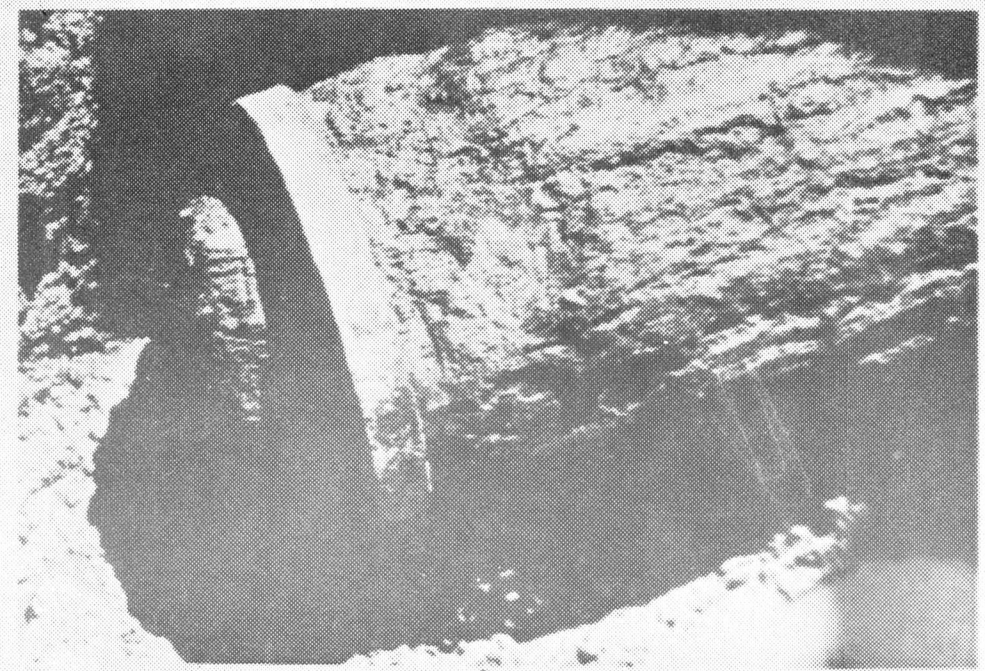
A



C



B

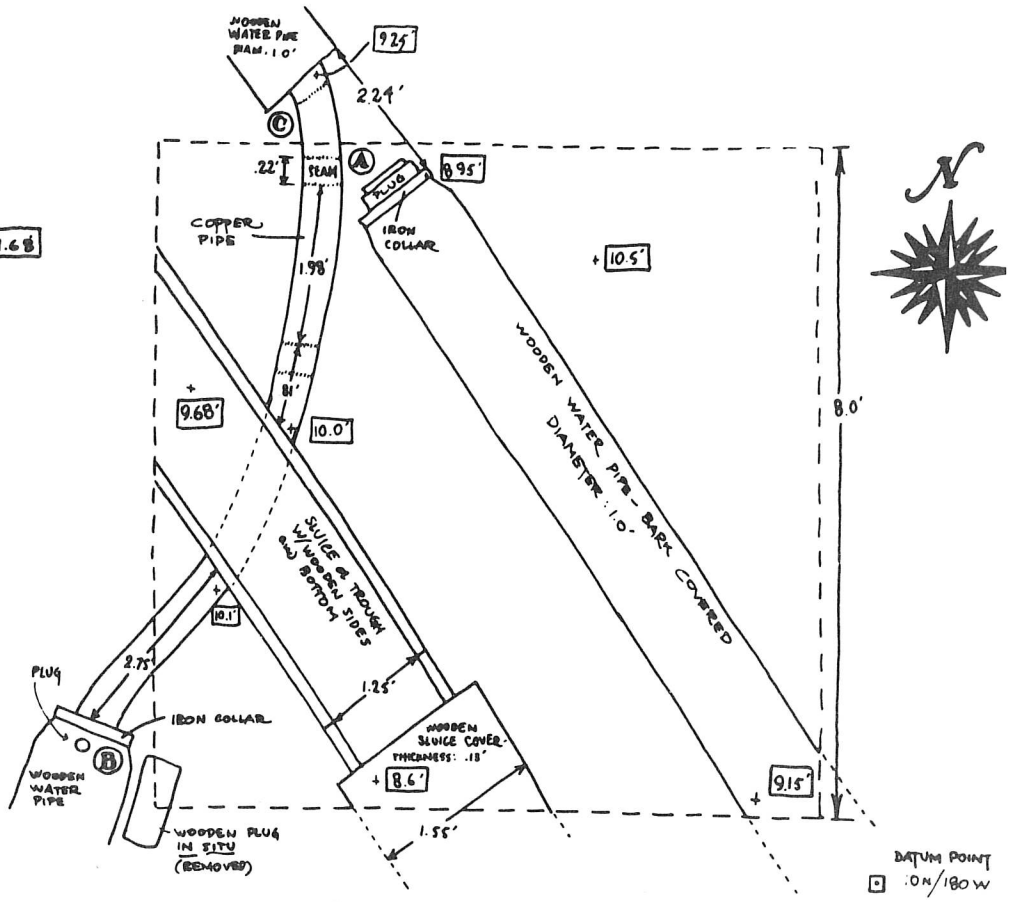


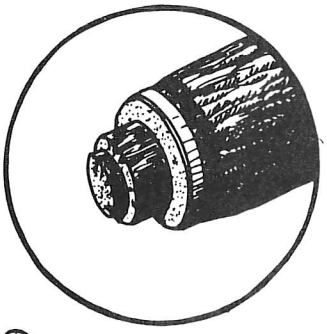
D

BETHLEHEM PROJECT
TEST PIT 1 10N/180W
MAXIMUM DEPTH: 10.5'
Depths from datum point are shown thus. +9.68

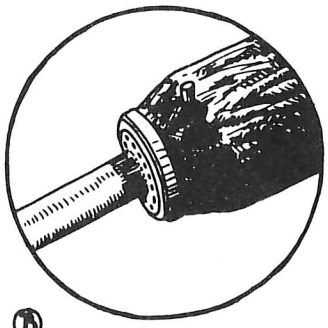
Drawn by Richard Ellis
7 August 1969

NOT DRAWN TO SCALE

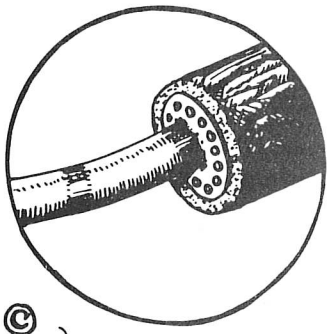




(A) Wooden pipe with iron collar and double plug arrangement to close it off. Adzed to fit collar.



(B) Wooden water pipe with iron collar and small plug. Copper jumper attached to copper flange with 14 studs. Wooden pipe is adzed to fit collar. This pipe is about 4-5" larger in diameter than (A) or (C).

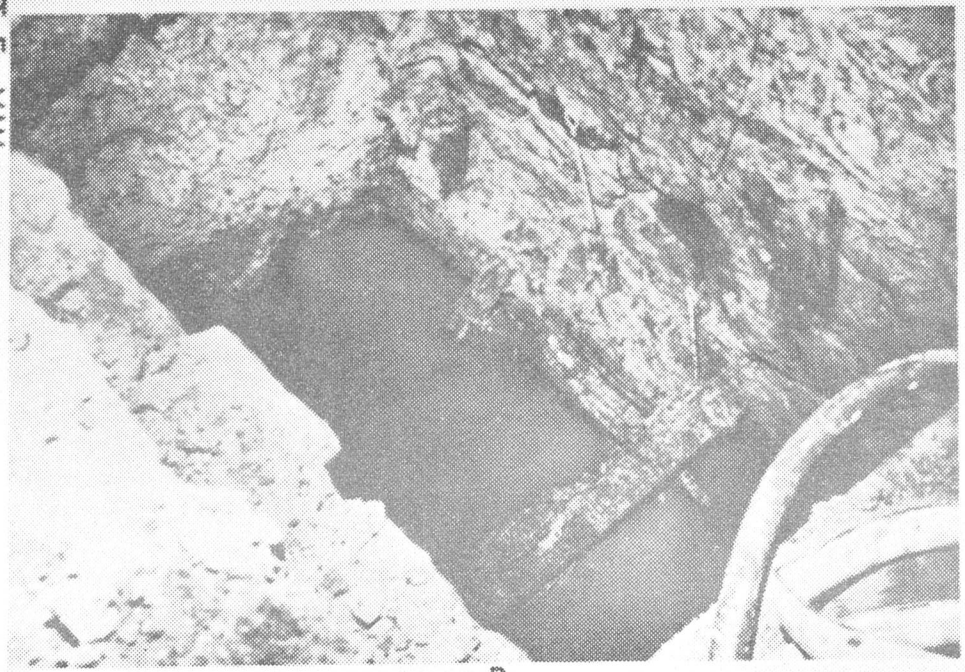


(C) Wooden water pipe with no collar. Copper pipe used as jumper to (B). Wooden pipe is not adzed down.

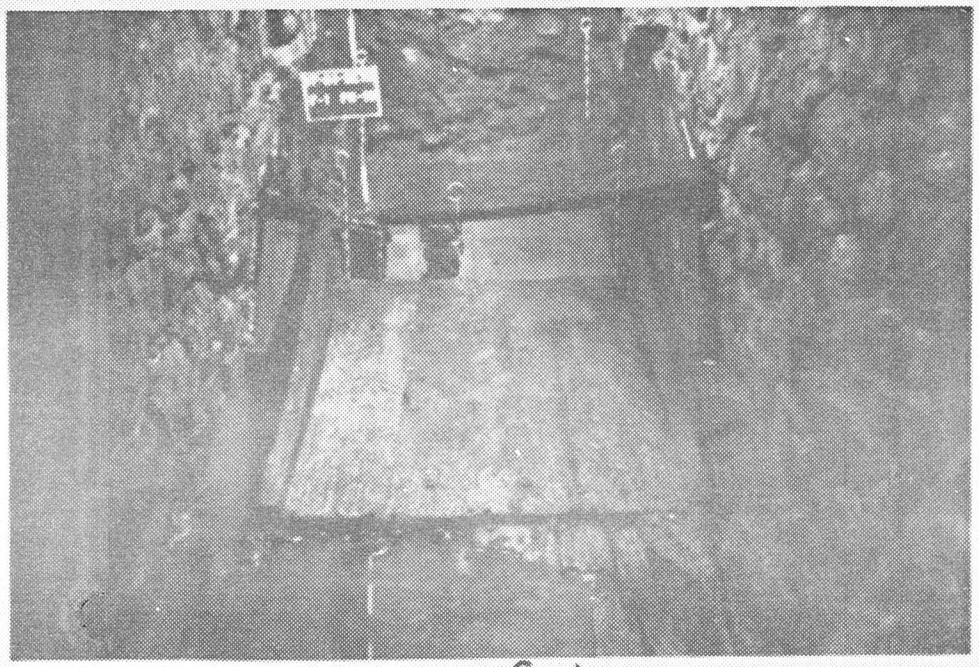
PLATE VII

PLATE VIII

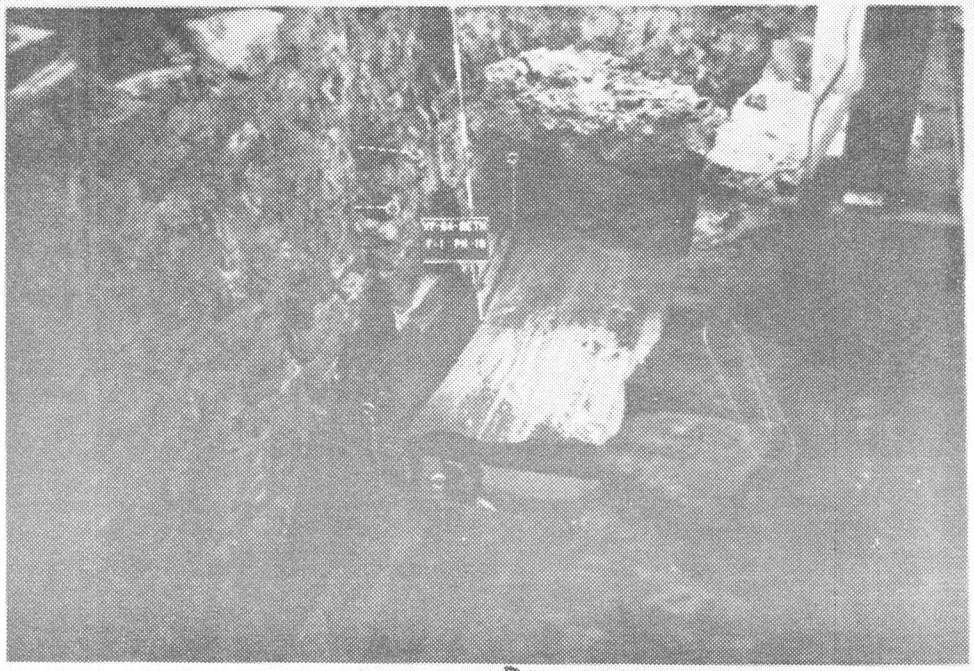
A



B

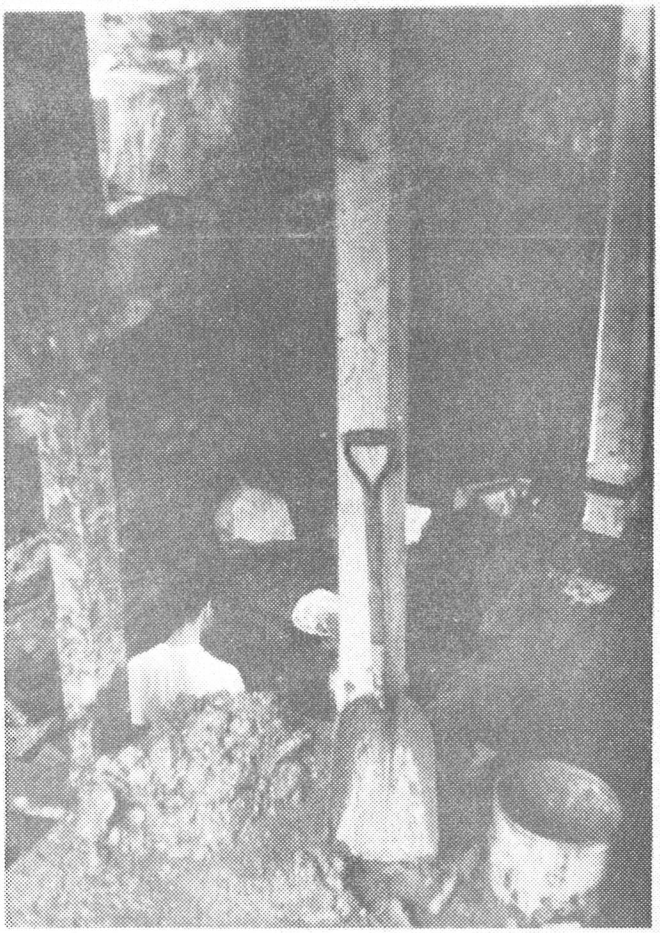


C

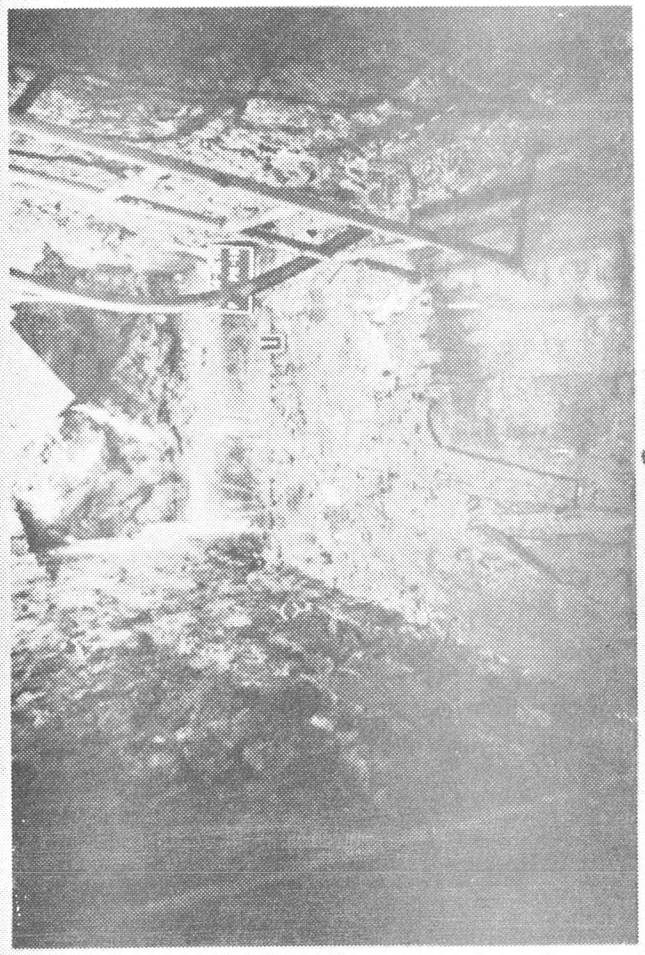


D

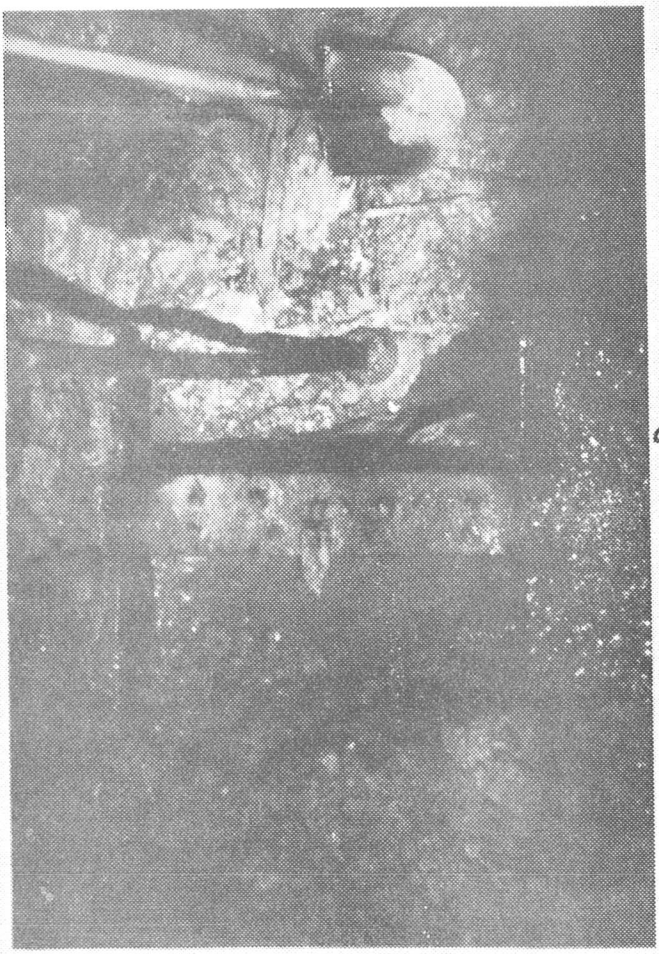
A



B

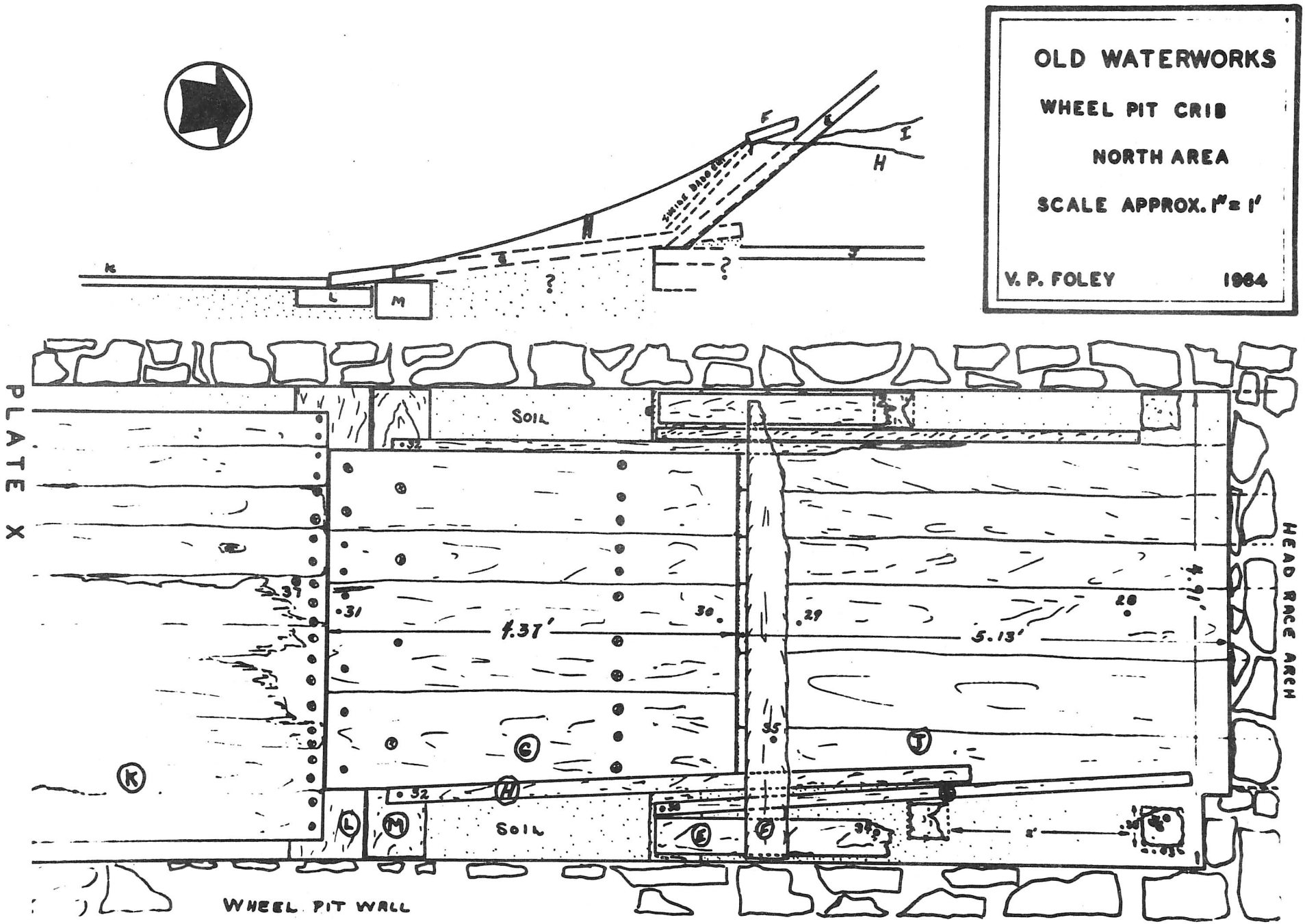


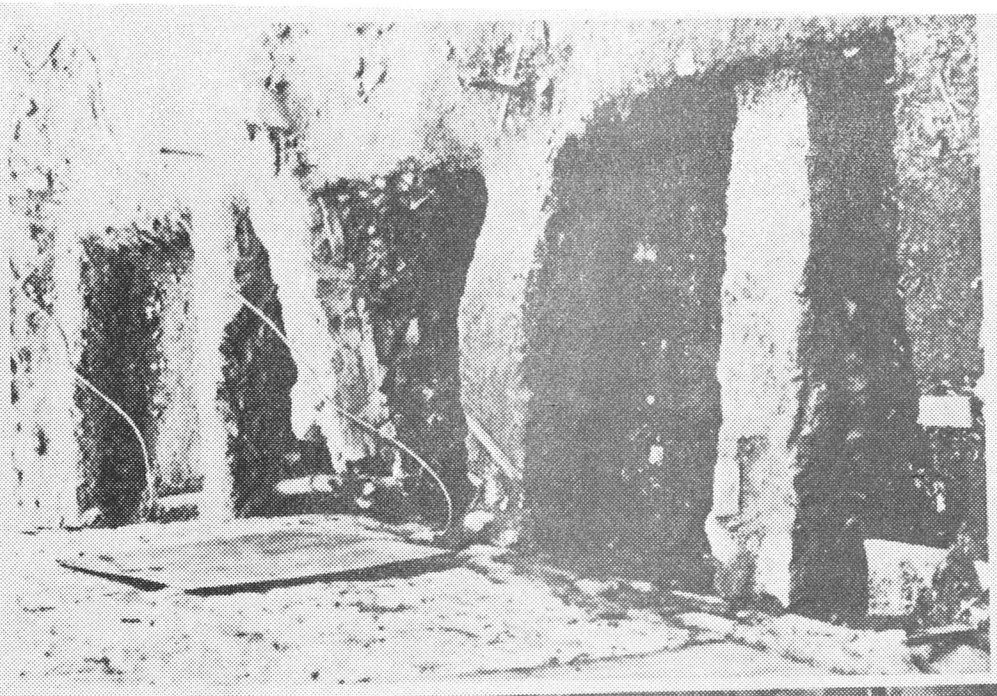
C



D

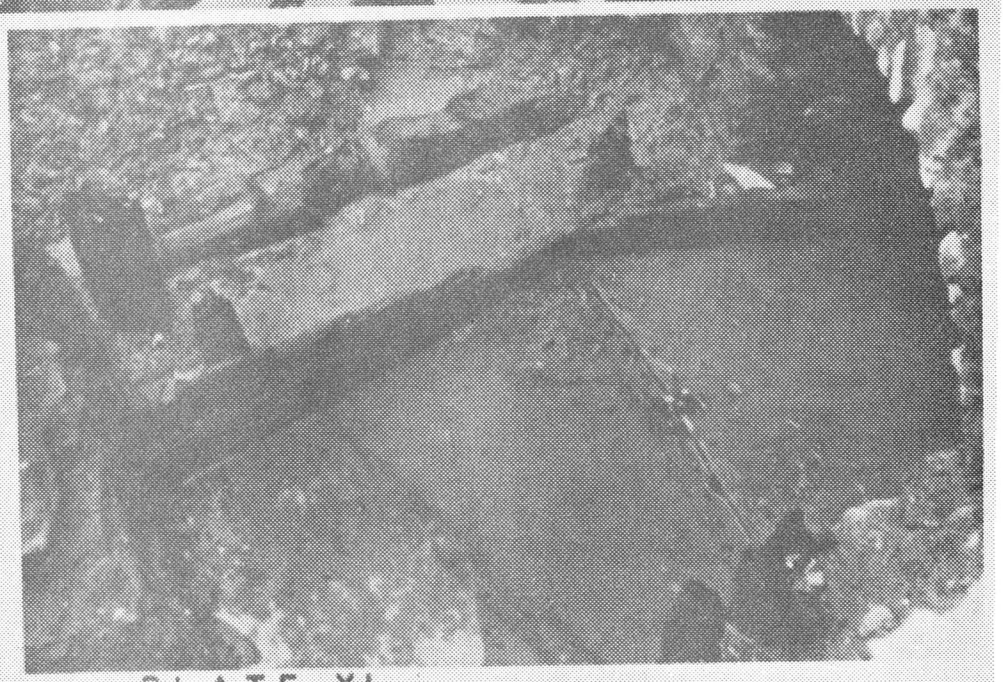
PLATE IX


OLD WATERWORKS
WHEEL PIT CRIB
NORTH AREA
SCALE APPROX. 1" = 1'
V. P. FOLEY 1964
PLATE X
HEAD RACE ARCH
WHEEL PIT WALL
SOIL
SOIL
4.37'
5.13'
4.91'
K
L
M
H
G
T
F
E
I



A

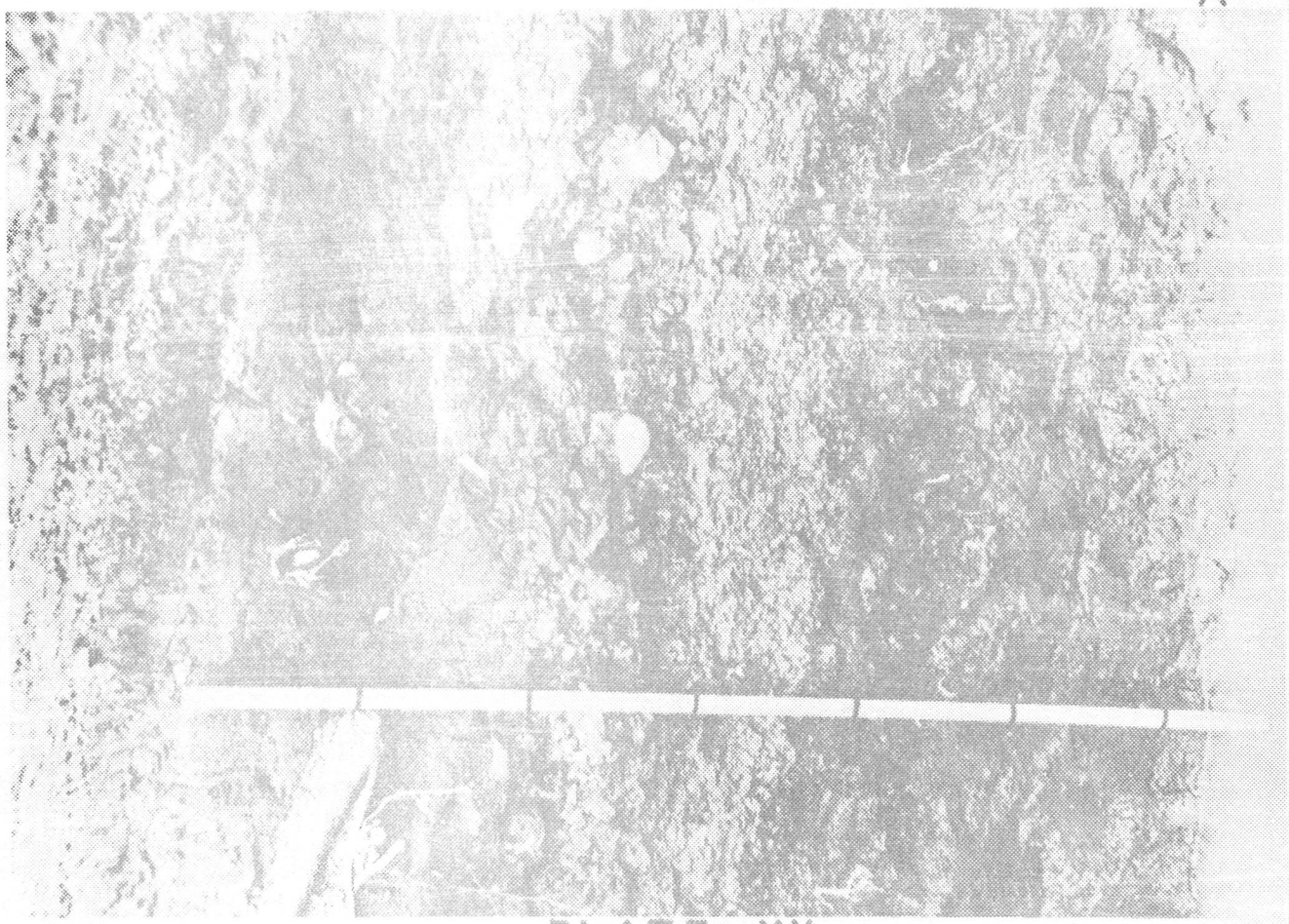
B



C

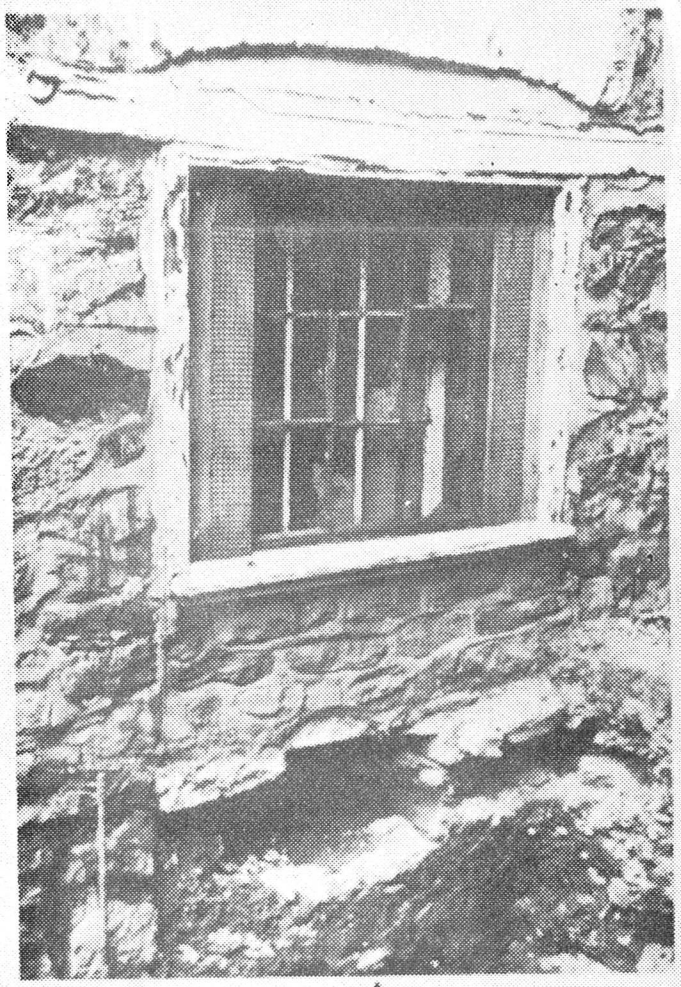
PLATE XI

A

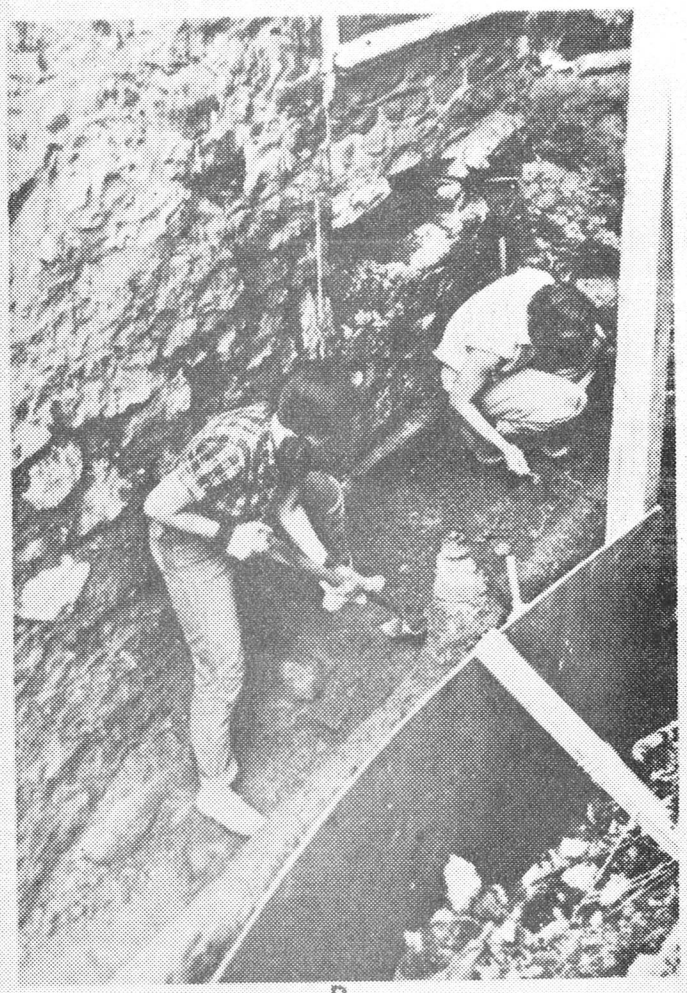


B

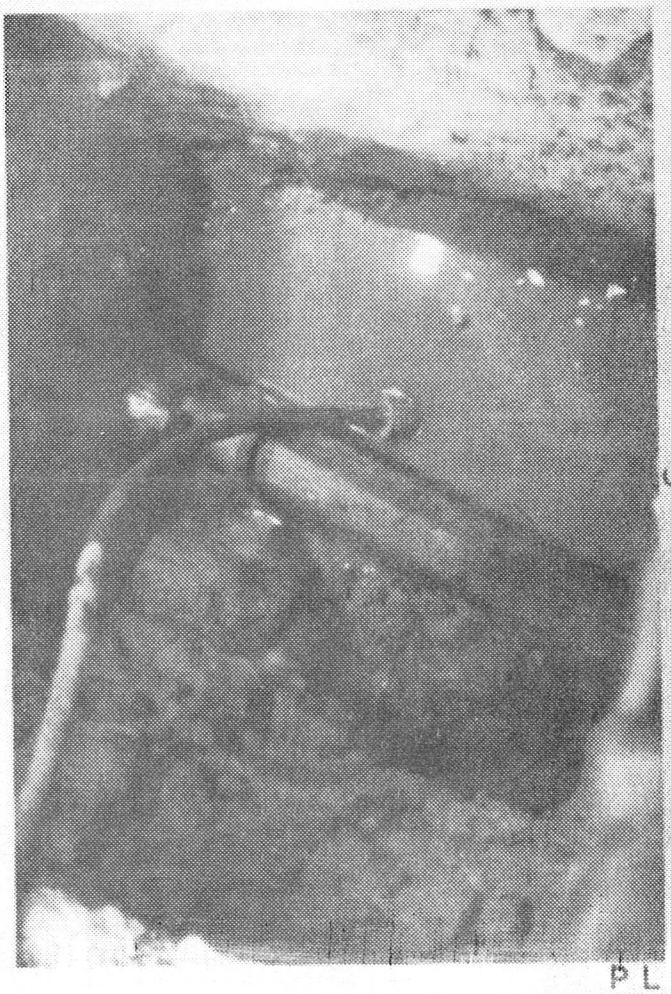
PLATE XII



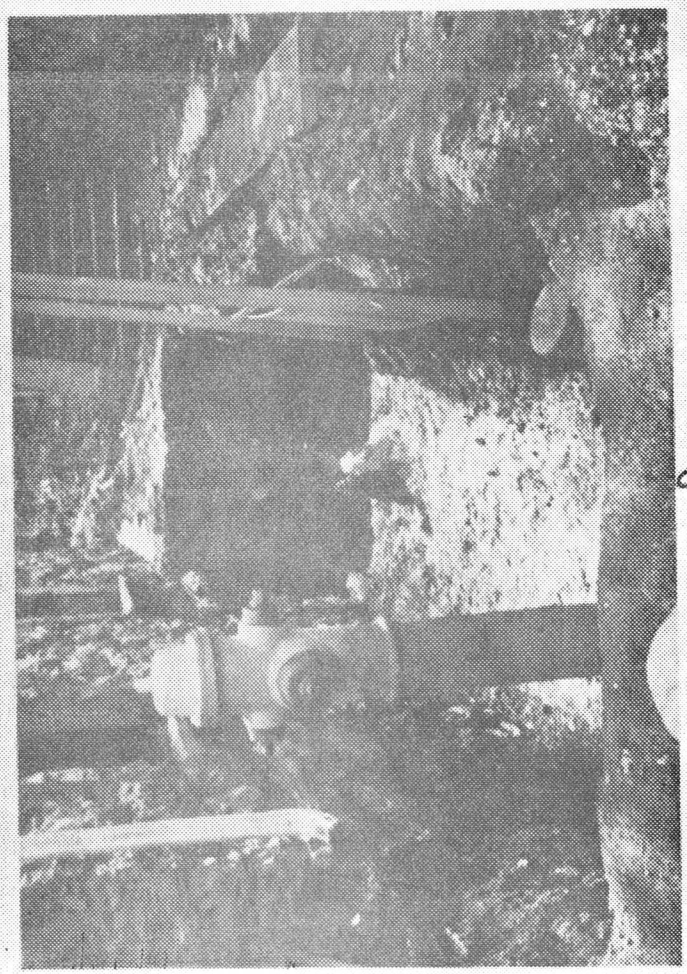
A



B

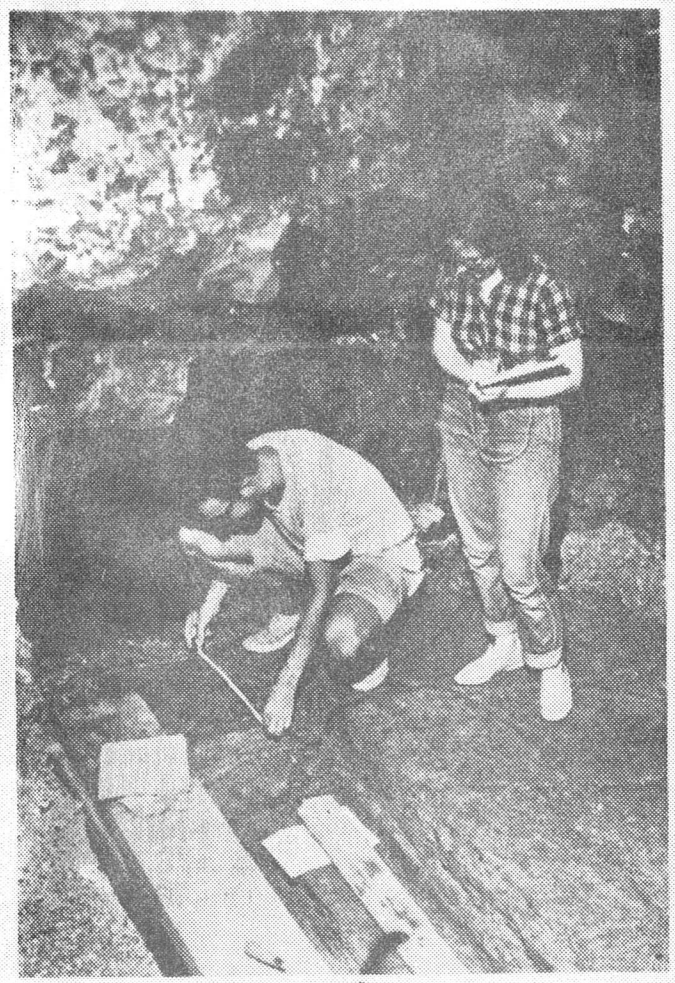


C



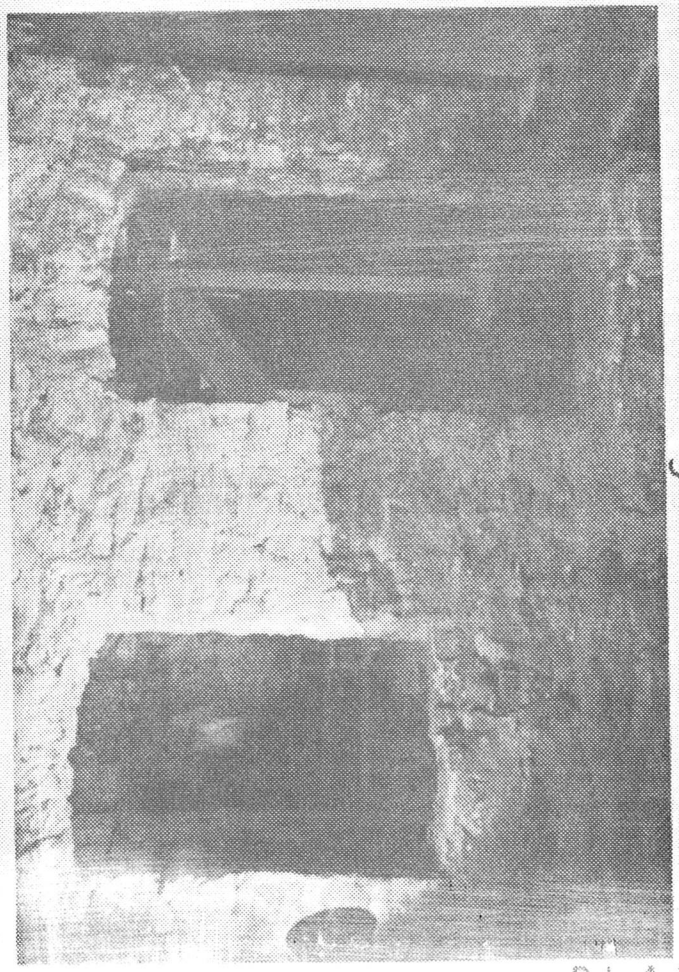
D

PLATE XIII

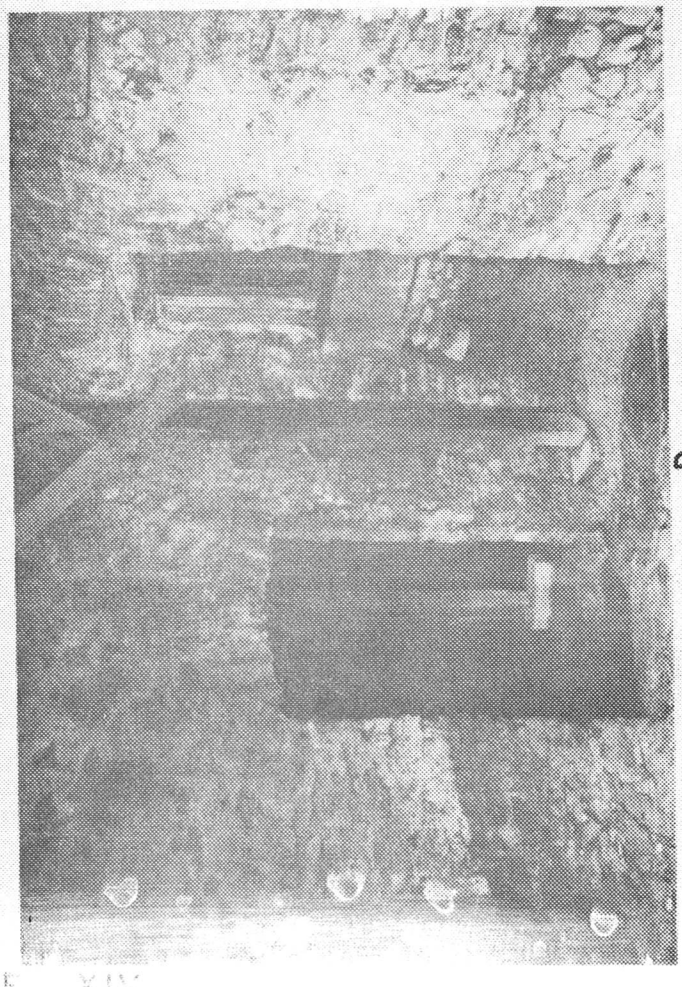


A

B

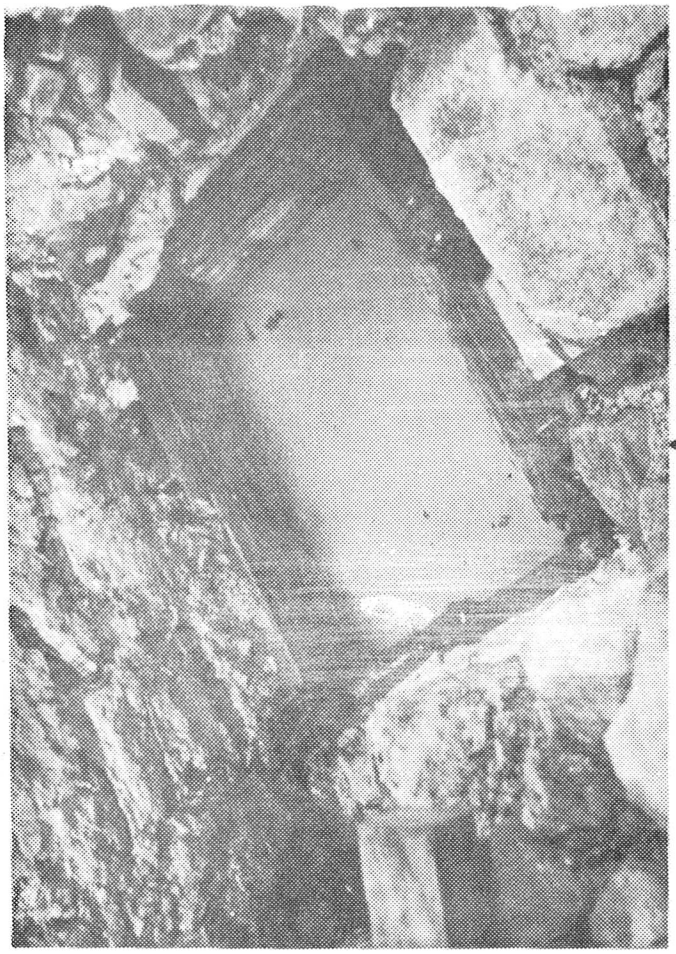


C



D

PLATE XIV



A

B

C

D

PLATE XV

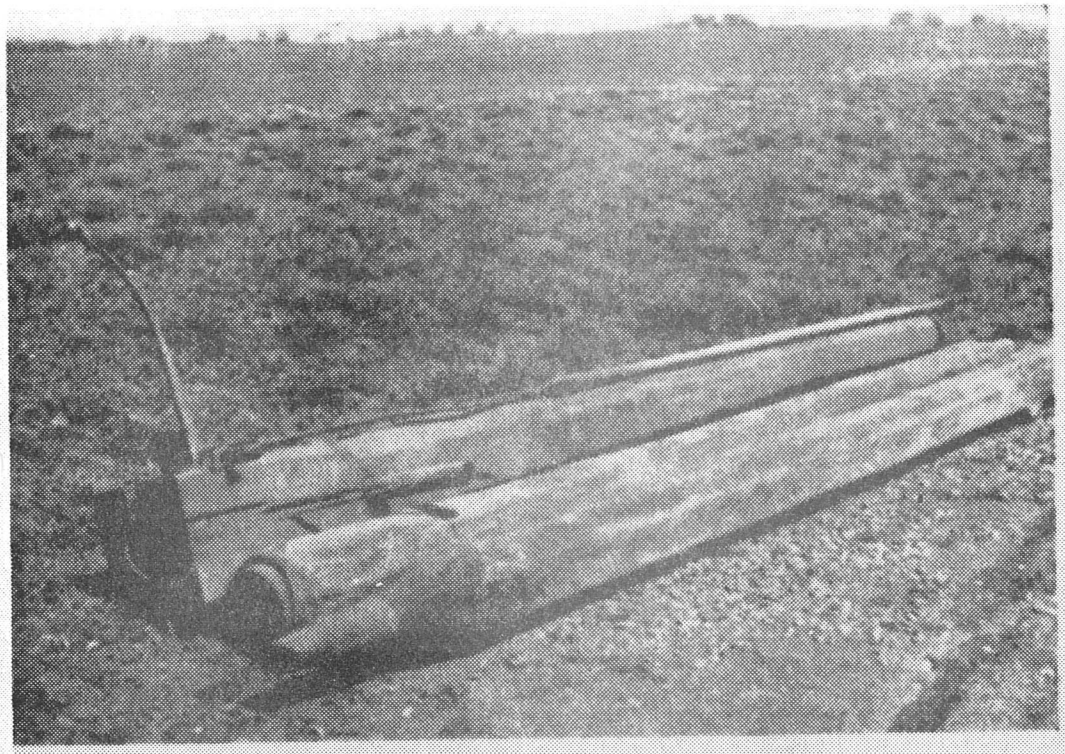
A

B

C

D

PLATE XVI



3

4

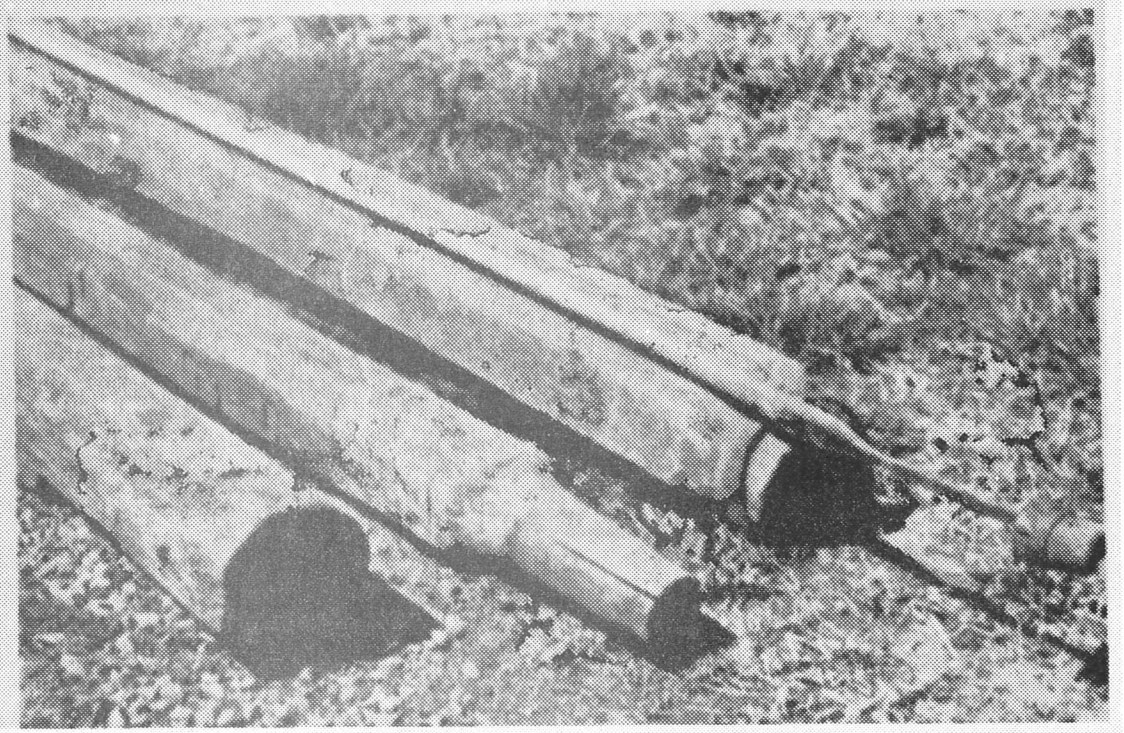
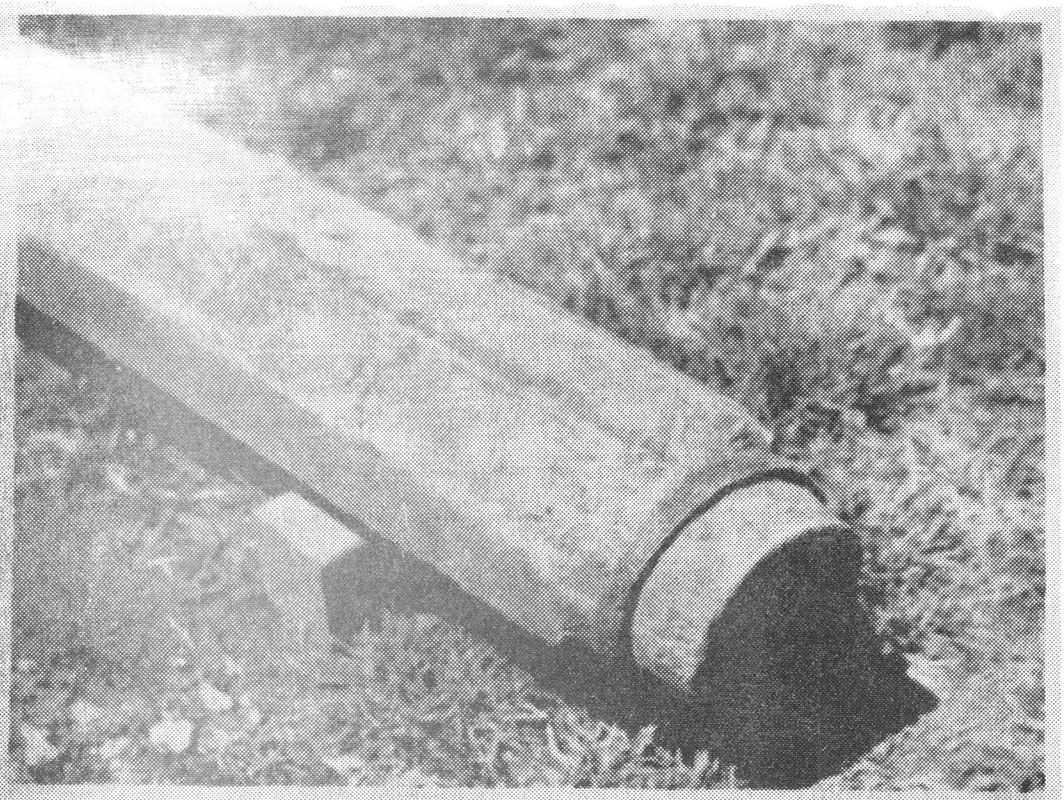
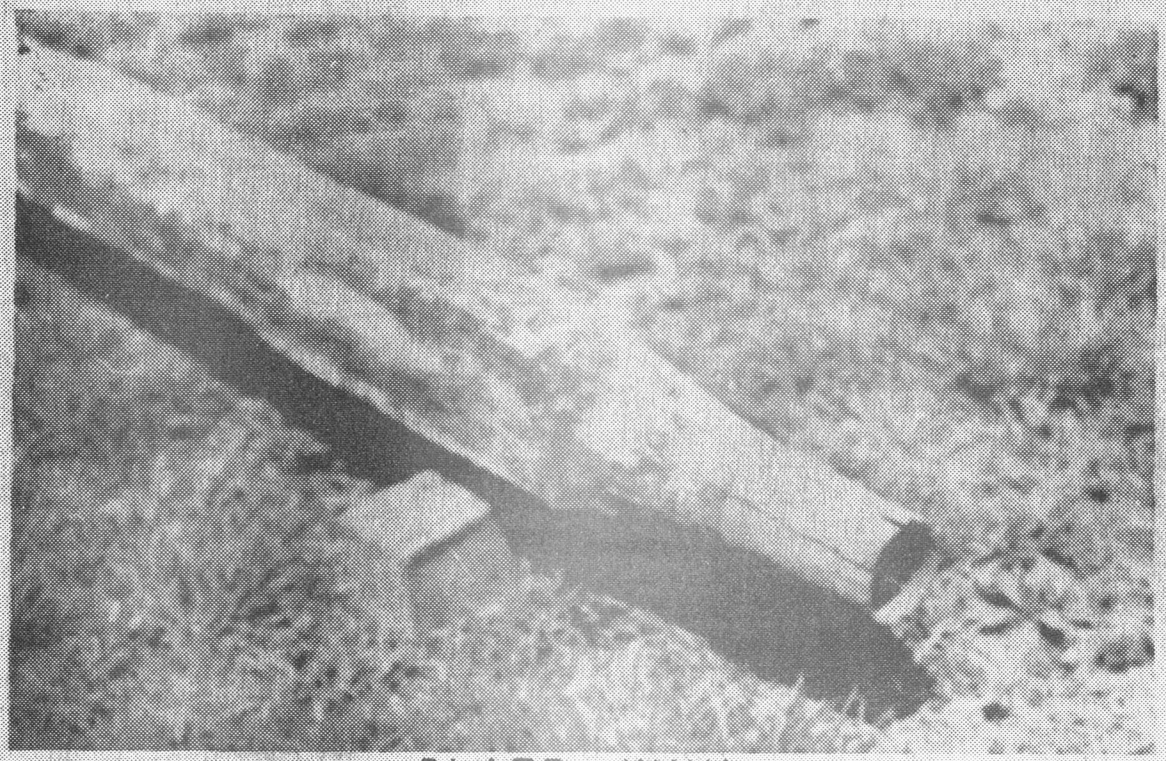


PLATE XVII

5

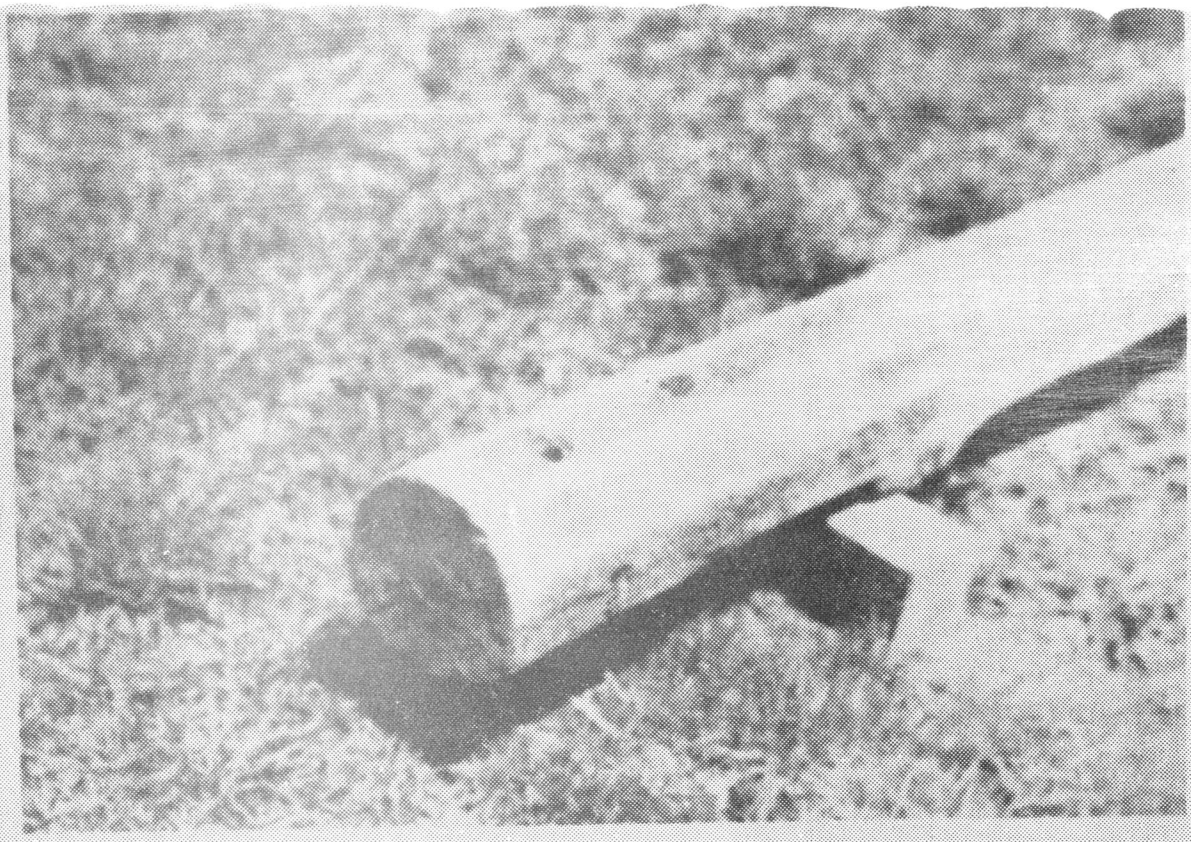


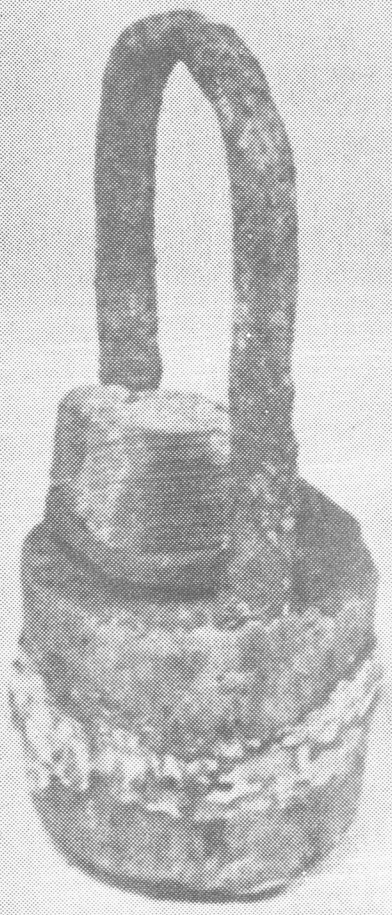


6

PLATE XVIII

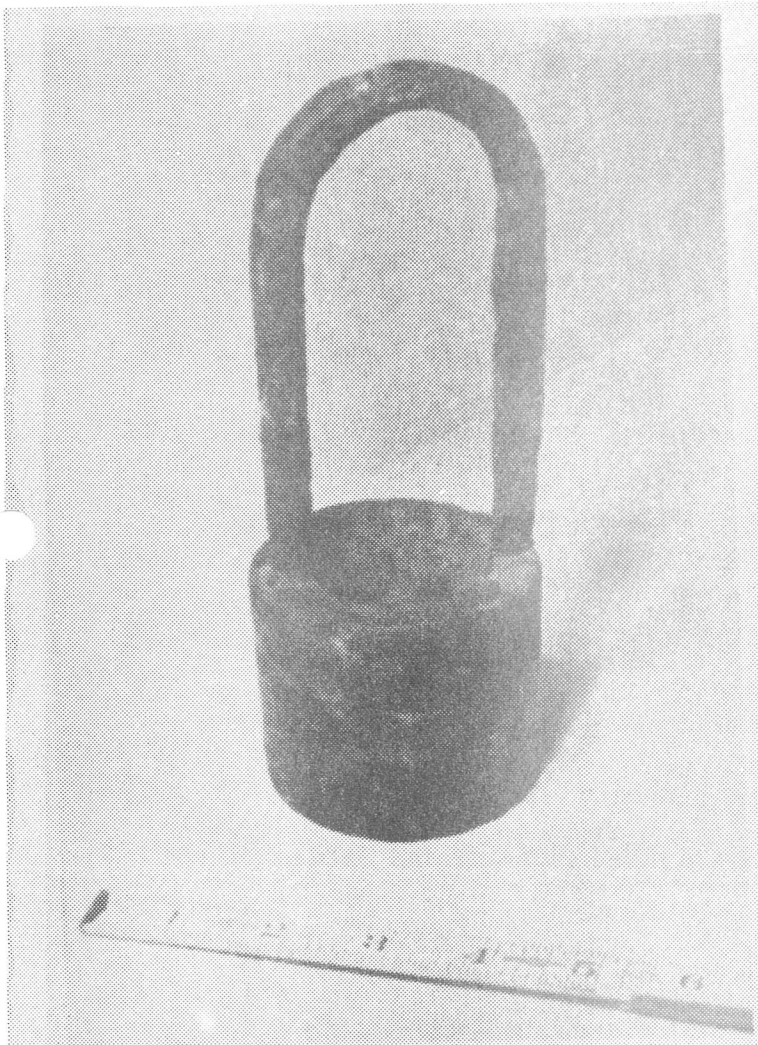
9



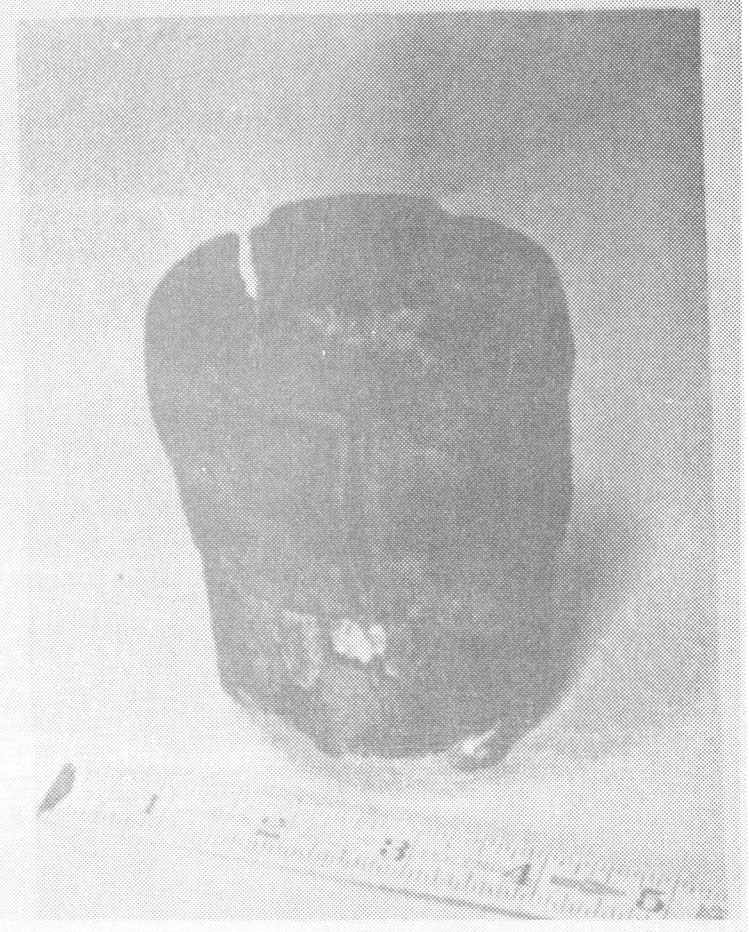


10

PLATE XIX

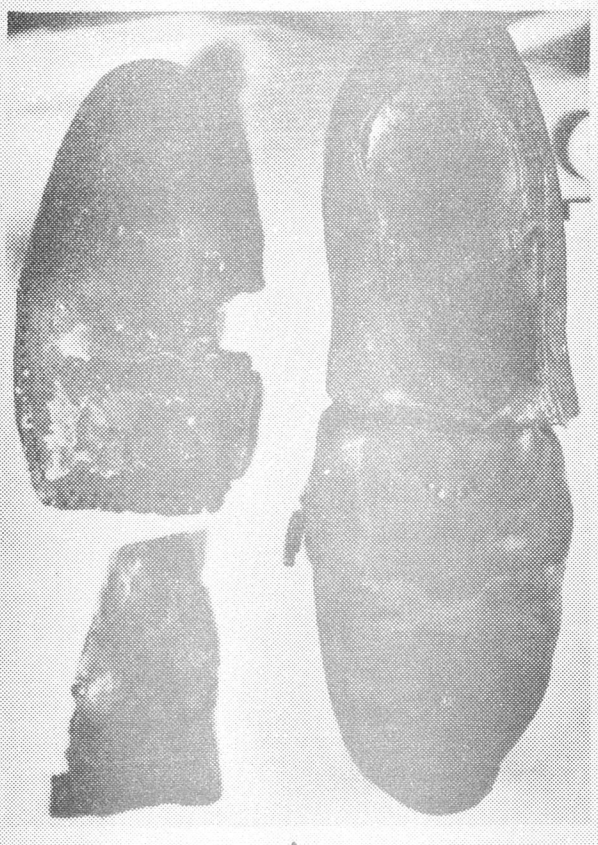


11

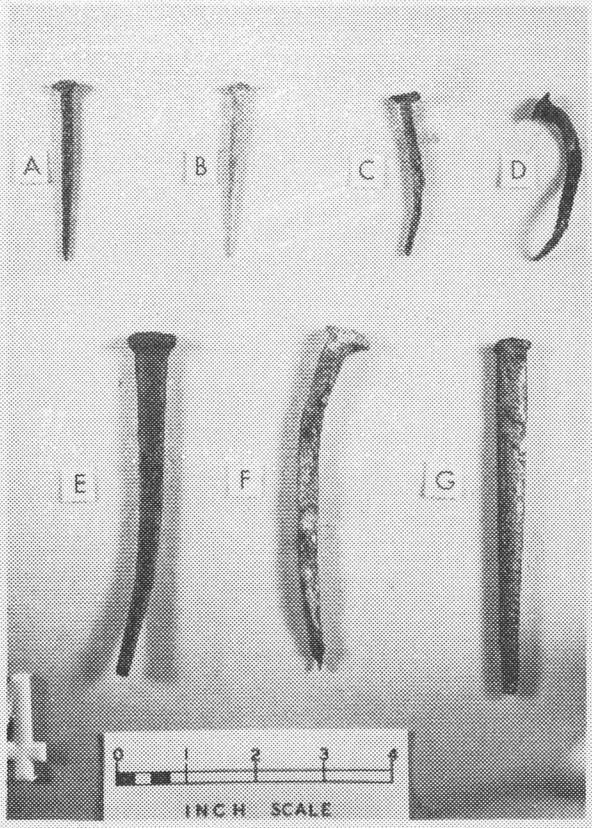


12

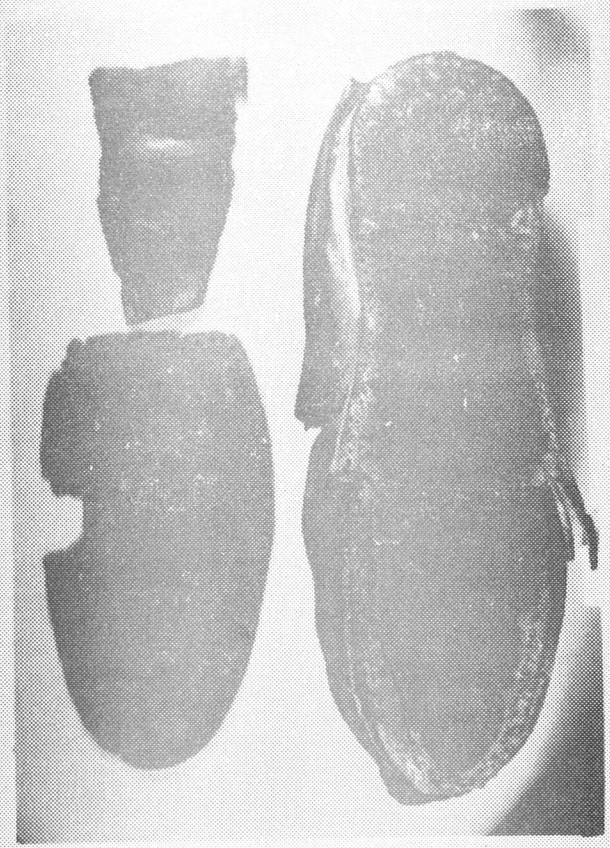
PLATE XX



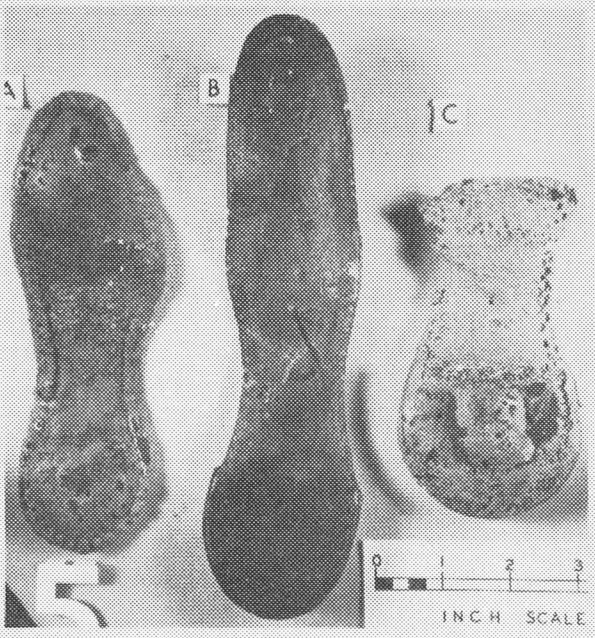
A



C

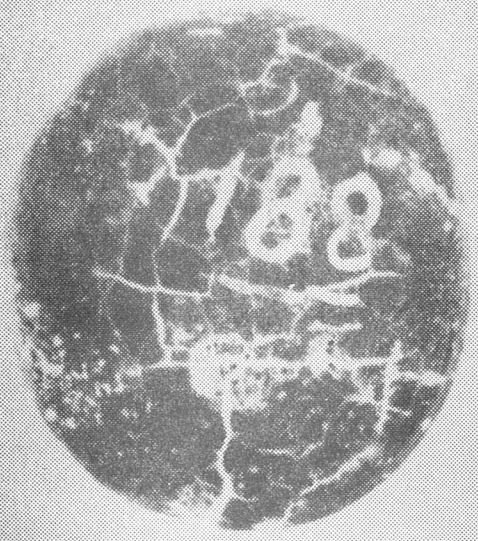


B

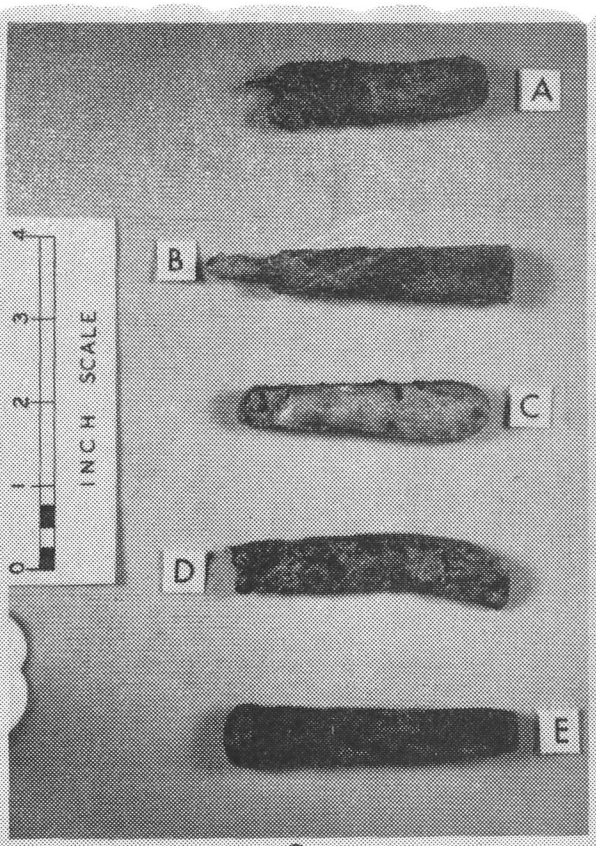


D

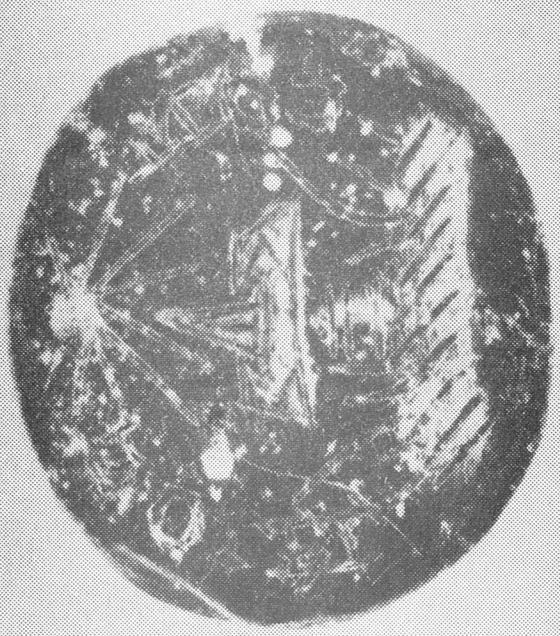
PLATE XXI



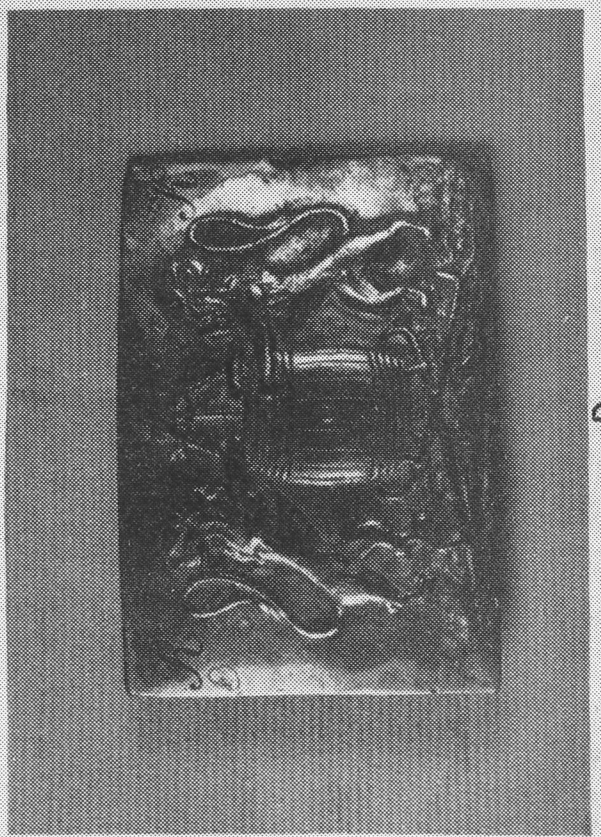
B



C



A



D

PLATE XXII

Bibliography

Barber, Edwin Atlee. 1893 *The Pottery and Porcelain of the United States.* New York: G. P. Putnam's Sons.

Bayne-Powell, Rosamond. 1956 *Housekeeping in the Eighteenth Century.* London: John Murray.

Belidor, Bernard Forest de. 1737 *Architecture Hydraulique.* Paris: Chez Charles-Antoine Jombert.

Bernern, Johann Matthias. 1735 *Theatrum Machinarum Molarium.* Leipzin & Redelstadt: Wolffgang Deer.

Bocklerum, Georgium Andreum. 1662 *Theatrum Machinarum Novum.* R. D. Henrici Schmitz, Marco-Svvelmensis.

Bridenbaugh, Carl. 1964 *The Colonial Craftsman.* Chicago: University of Chicago Press.

Buffet, Edward P. 1909 "An Early American Engineer - Robert Erskine" in *Power and the Engineer*, Vol. XXX. New York: Hill Publishing Company.

Chaffers, William. n. d. *Marks and Monograms on European and Oriental Pottery and Porcelain.* Los Angeles: Borden Publishing Company, 14th edition.

Chastellux, Marquis de. 1963 *Travels in North America in the Years 1780, 1781 and 1782.* Chapel Hill: University of North Carolina Press.

Coronelli, Frater Vincenzo. 1717 *Effetti delle acque.* Venice (?)

Derry, T. K. and Williams, Trevor I. 1961 *A Short History of Technology.* New York & Oxford: Oxford University Press.

Desaguliers, J. T. 1745 *A Course of Experimental Philosophy.* London: W. Innys.

Diderot, Denis. 1757 Encyclopedie, ou Dictionnaire Raisonne de Sciences, des Arts et des Metiers. Volumes VII & VII; Volume IV of the Planches. Paris: Braisson; David; Le Breton; Durant.

Du Bois, L. 1931 L'Enginieur Hydraulicien au XVII^me Siecle. Lausanne: La Concorde.

Dudley, Arthur W. 1916 "Experience with Wood Pipes in New Hampshire," in Journal of the New England Water Works Association, Vol. XXX, pp. 318-23.

Earle, Alice Morse. 1899 Child Life in Colonial Days. New York: The Macmillan Company.

_____. 1935 Home Life in Colonial Days. 2nd edition. New York: The Macmillan Company.

Erbe, Hellmuth. 1929 Bethlehem, Pa. - A Communistic Herrnhut Colony of the 18th Century. Stuttgart: German Foreign Institute.

Fagre. 1783 Les Machines Hydrauliques. Paris: Chez Alex. Jombert Jeune.

Fritts, Peter, et al. 1877 History of Northhampton County, Pennsylvania. Philadelphia and Reading.

Gillispie, Charles Coulston, ed. 1959 A Diderot Pictorial Encyclopedia of Trades and Industry. New York: Dover Publications, Inc.

Goodman, W. L. 1964 The History of Woodworking Tools. London: G. Bell & Sons, Ltd.

Graham, Frank D. 1960 Pumps, Hydraulics, Air Compressors. New York: Theo. Audel & Company.

Hagerup, H. 1949 Hagerups Illustrede Konversations Leksikon. Copenhagen: H. Hagerup.

Hudson, Kenneth. 1963 Industrial Archaeology. London: John Baker Publishers, Ltd.

Hume, Ivor Noel. 1963 Here Lies Virginia. New York: Alfred A. Knopf.

Journal of the New England Water Works Association. Vol. XVIII.
1904 Boston: New England Water Works Association.

Kovel, Ralph M & Terry H. Dictionary of Marks - Pottery and Porcelain.
1962 New York: Crown Publishers, Inc.

Larousse, Pierre. Grand Dictionnaire Universal. Paris: Pierre
1890 Larousse.

Leibert, Augustus H. A Chronicle of the First Century of Bethlehem, Pa.
1921 1741 - 1841. Bethlehem: No publisher given.

Leupold, Jacob. Theatri Machinarum - Hydraulicarum. Leipzig:
1774 Aug. Kosten Bernhard Christoph Breitkopfs und Sohn.

Levering, Joseph Mortimer. A History of Bethlehem, Pennsylvania,
1903 1741 - 1892. Bethlehem: Times Publishing Company.

Martin, John Hill. Historical Sketch of Bethlehem in Pennsylvania.
1872 Philadelphia: Orrin Rogers.

Maximillian, Prince of New Wied. Travels in the Interior of North
1843 America. Translated from the German by H. Evans Lloyd. London: Ackerman & Co.

Mercer, Henry C. Ancient Carpenters' Tools. Doylestown: Bucks
1960 County Historical Society.

Miller, Benjamin LeRoy. Northhampton County Pennsylvania Geology
1939 and Geography. Harrisburg: Pennsylvania Geological Survey, 4th Series, Bulletin C 48.

_____, et al. Lehigh County, Pennsylvania. Harrisburg:
1941 Pennsylvania Geological Survey, 4th Series, Bulletin C 39.

Morrison, Hugh. Early American Architecture. New York: Oxford
1952 University Press.

Mumford, Lewis. Technics and Civilization. New York: Harcourt
1934 Brace and Company.

Oliver, John W. History of American Technology. New York: Ronald
1956 Press Company.

Prony, Baron (?) de. 1790 Nouvelle Architecture Hydraulique. Paris: Chez Firmin Didot.

Public Works. 1922 Vol. LIII, July - December. New York: Public Works Journal Corporation.

Raccolta D'Autori Che Trattano del Moto Dell' Acque. 1765 Florence.

Ramilli, Capt. Agostino. 1588 Le Diverse Et Artificiose Machine. Aparigi in casa del autore.

Ramsey, John. 1939 American Potters and Pottery. No city given: Hale, Cushman & Flint.

Rau, Robert. 1877 "Historical Sketch of the Bethlehem Water Works, Bethlehem, Pa." Bethlehem: Compiled at the request of the Borough Council.

Spargo, John. 1948 Early American Pottery and China. Garden City: Garden City Publishing Company.

Suckling, George. 1780 An Historical Account of the Virgin Islands in the West Indies. London: Horace's Head.

Switzer, Stephen. 1729 An Introduction to a General System of Hydrostaticks and Hydraulicks, Philosophical and Practical. London: the Rose; the Angel & Homer's Head.

Tatum, George B. 1961 Penn's Great Town - 250 Years of Philadelphia Architecture Illustrated in Prints & Drawings. Philadelphia: American Institute of Architects, University of Pennsylvania Press.

Thorn, C. Jordan. 1962 Handbook of Old Pottery and Porcelain Marks. New York: Tudor Publishing Company.

Turner, William, ed. 1904 William Adams An Old English Potter. London: Chapman & Hall, Ltd.

Westergaard, Waldemar. 1917 The Danish West Indies Under Colonial Rule. New York: The Macmillan Company

Williams, David G. 1952 "A Wooden Water Pump Used in the Lower Jordan Valley" in Proceedings of the Lehigh County Historical Society, Vol. 19. Allentown: Lehigh County Historical Society.

Wolf, A. 1961 A History of Science, Technology & Philosophy in the 18th Century. New York: Harper & Brothers.

Wolf, Thomas F. 1934 Service Records of Existing Cast Iron Mains Laid in the 17th, 18th and 19th Centuries. Chicago: Cast Iron Research Association

Zedler, Johann Heinrich. 1747 Grosses vollstandiges universal Lexicon mit Supplements. Vol. 53. Leipzig & Halle.

Magazines, Newspapers & Pamphlets

Chronicle of Early American Industries. Vol. I, No. 15, January, 1936 Early American Industries Association, Inc.

_____. Vol. II, No. 3, January, 1938.

_____. Vol. III, No. 23, June, 1950.

City of Philadelphia, Department of Public Works, Bureau of Water. Description of the Filtration Works and Pumping Stations, also Brief Historical Review of the Water Supply 1789 - 1900. Booklet #3, 1909.

Myers, Elizabeth Lehman. "Nature, History & Other Lore." Vol. I Bethlehem Globe Times, 1926-1927.

_____. "Nature, History & Other Lore." Vol. II Bethlehem Globe Times, 1927.

Unpublished Material

"Bethlehemisches Diarium," English version in files of Historic Bethlehem, Inc. from original MS in Moravian Archives, Bethlehem. Translator unknown.

"General Diacony Waterworks Debit Records" July 28, 1762 through Sept. 23, 1766. Translated by Anthony N. B. Garvan. MS in Moravian Archives, Bethlehem, Pa.

Kane, Thomas J. "Master Plan for Historic Bethlehem." In files of Historic Bethlehem, Inc., Nov., 1963. (Multilithed.)

Murtagh, William J. "Moravian Architecture and City Planning: A Study of Eighteenth Century Moravian Settlements in the American Colonies with Particular Emphasis on Bethlehem, Pennsylvania." 1963, MS, doctoral thesis, Faculty of Arts & Sciences, University of Pennsylvania, Philadelphia. (Typewritten, bound.)

Nelson, Lee H. "Nail Chronology as an Aid to Dating Old Buildings." Presented at the Historic Structures Training Conference, Eastern Office, Design & Construction, National Park Service, U. S. Department of the Interior, Philadelphia. Rev. 10 Aug., 1962. (Mimeographed; 300 copies.)

Other Sources

Unless otherwise noted, all correspondence is in the files of the author.

Danish Embassy, Washington, D. C. Personal letter from Carlo Christensen, Cultural Counselor, Jan. 29, 1965.

Det Kongelige Bibliotek, København. Personal letter from Gerda Møller, Feb. 2, 1965.

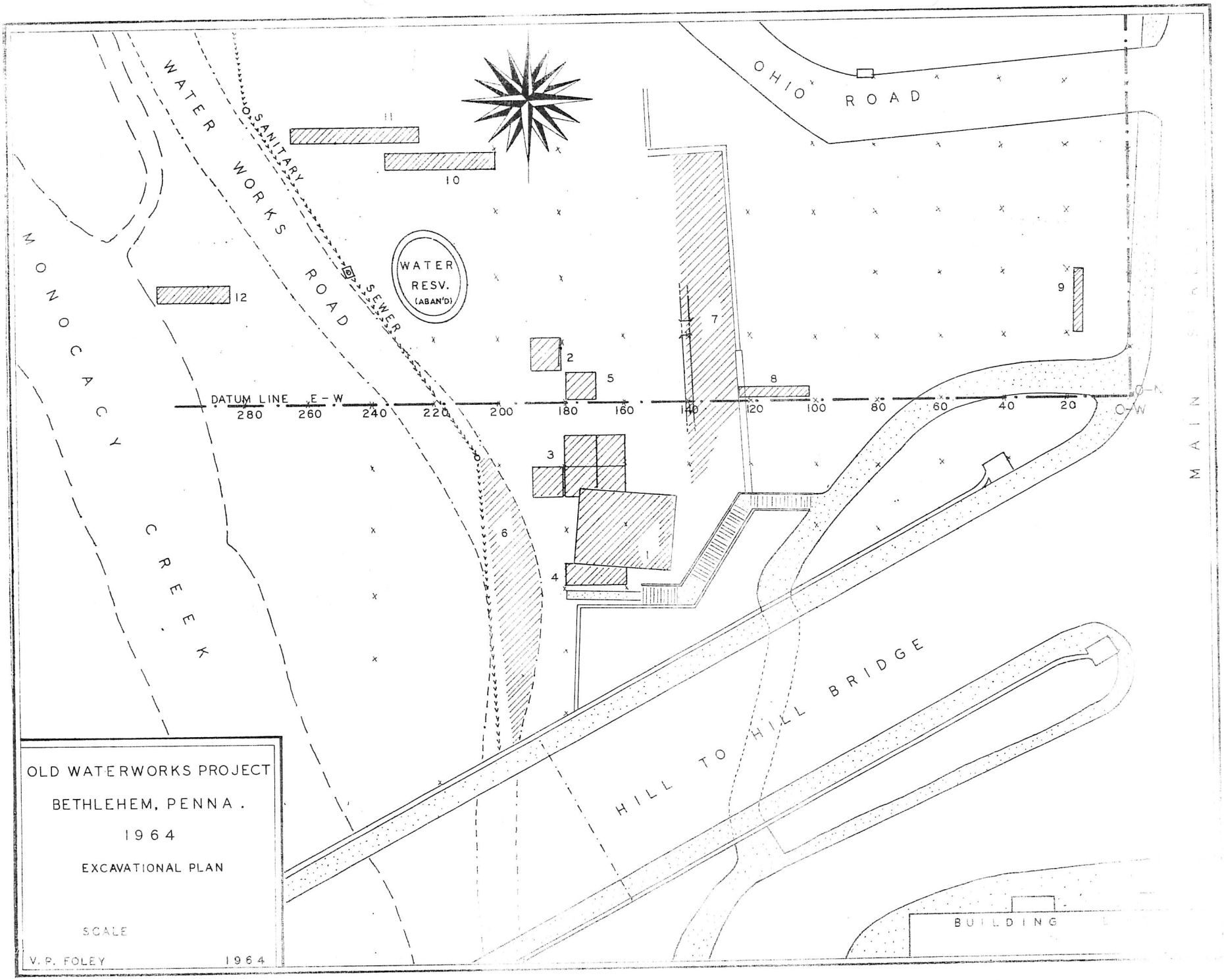
Government of the Virgin Islands of the U. S., St. Thomas, personal letter from June A. V. Lindqvist, Photostat & Microfilm Supervisor, March 1, 1965.

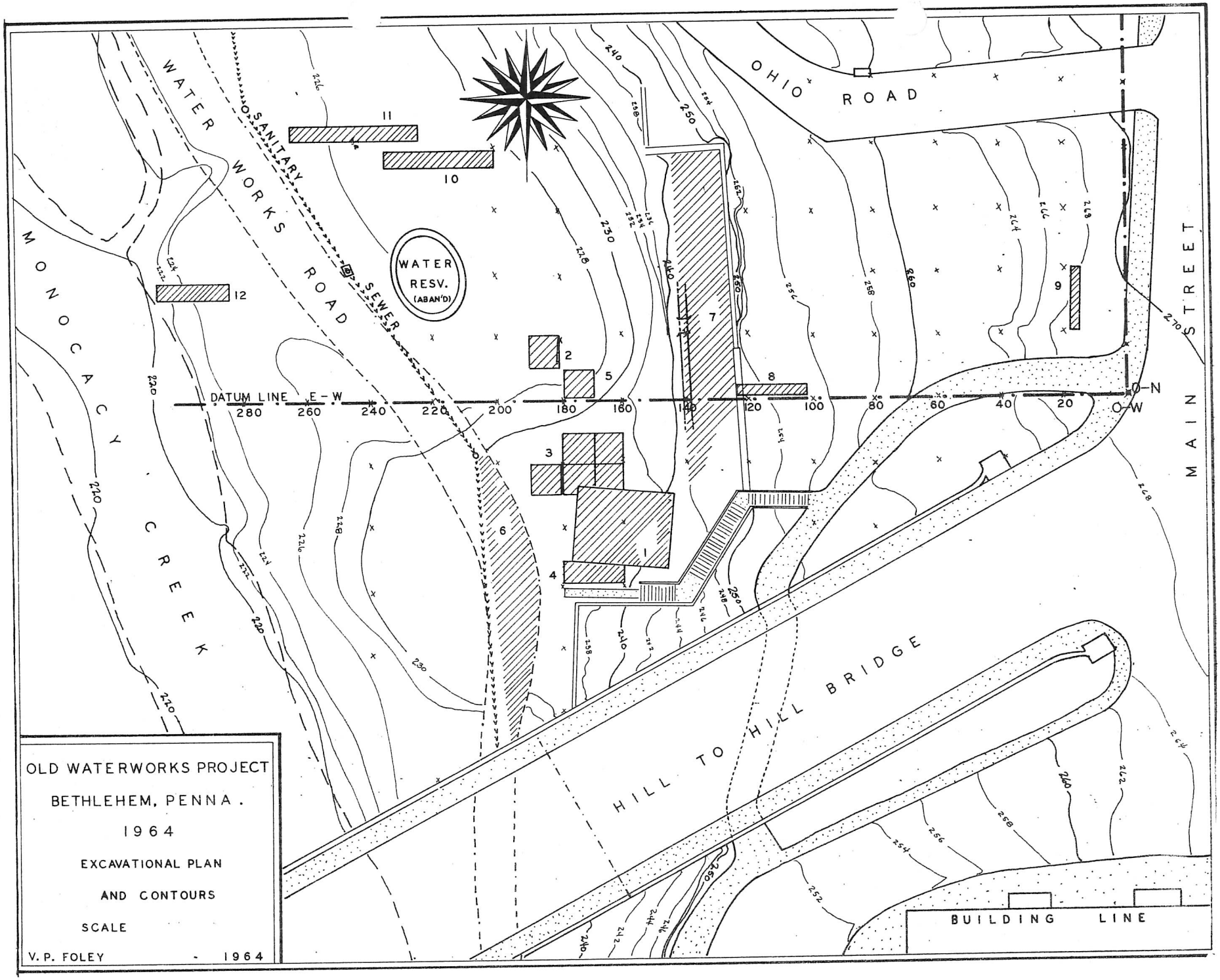
Government of the Virgin Islands of the U. S., Office of the Governor, St. Thomas. Personal letter from Lillian R. Greaux, Private Secretary to the Governor, Jan. 21, 1965.

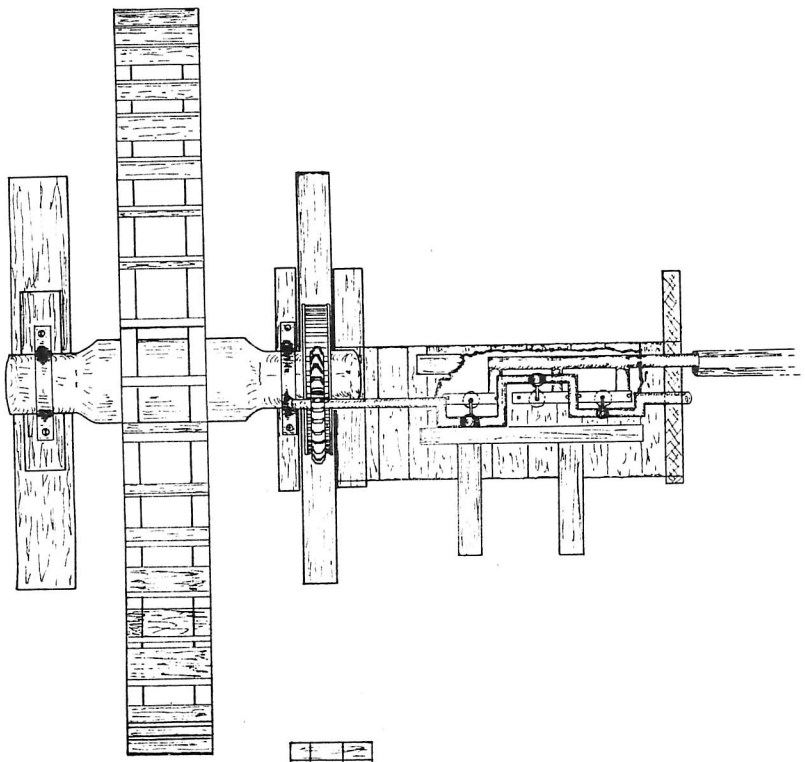
Pomona College. Personal letter from William V. Shannon, Executor of the Estate of Waldemar Westergaard, Jan. 21, 1965.

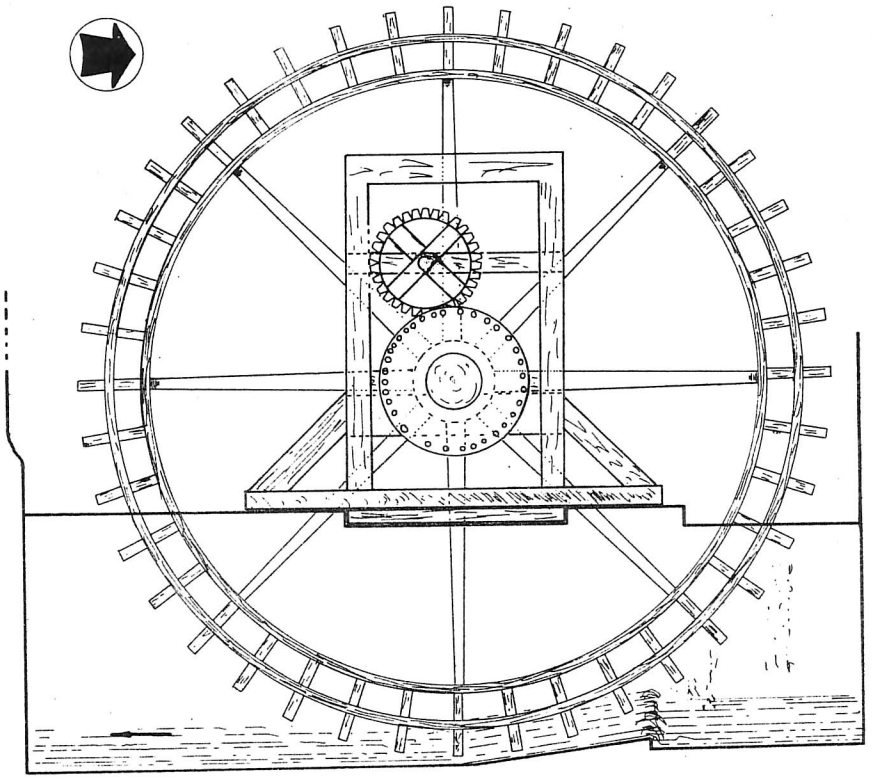
Rigsarkivet, København. Personal letter from Johan Hvidtfeldt, Feb. 25, 1965.

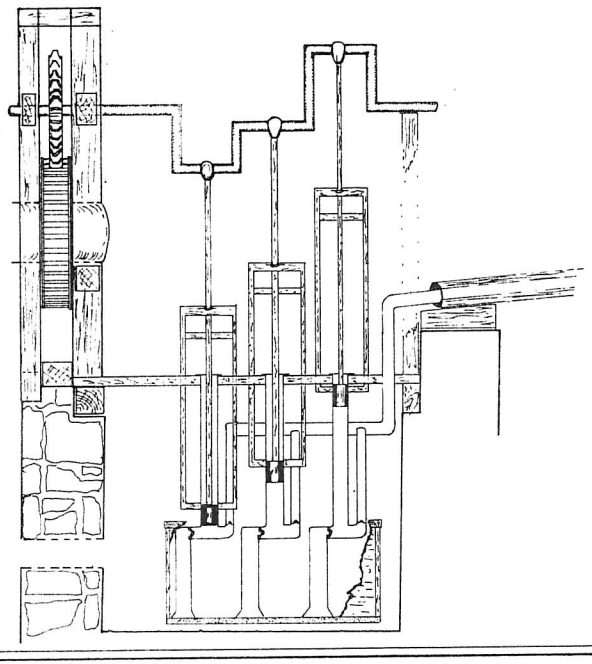
United States Department of Agriculture, Forest Service. Personal letter from B. Francis Kukachka, Chief Wood Identification Research Division, Aug. 19, 1964.


OHIO ROAD
WATER WORKS ROAD
SANITARY SEWER
WATER RESV. (ABAN'D)
MONOCACY CREEK
DATUM LINE E-W
280
260
240
220
200
180
160
140
120
100
80
60
40
20
O-W
O-N
HILL TO HILL BRIDGE
BUILDING
MAIN
1
2
3
4
5
6
7
8
9
10
11
12
OLD WATERWORKS PROJECT
BETHLEHEM, PENNA.
1964
EXCAVATIONAL PLAN
SCALE
V. P. FOLEY
1964


OHIO ROAD
WATER WORKS ROAD
SANITARY SEWER
WATER RESV. (ABAN'D)
MONOCACY CREEK
MAIN STREET
HILL TO HILL BRIDGE
BUILDING LINE
DATUM LINE E-W
O-N
O-W
OLD WATERWORKS PROJECT
BETHLEHEM, PENNA.
1964
EXCAVATIONAL PLAN
AND CONTOURS
SCALE
V. P. FOLEY - 1964







OLD WATERWORKS

BETHLEHEM, PA.

WATERWORKS APPARATUS

HYPOTHETICAL RECONSTRUCTION

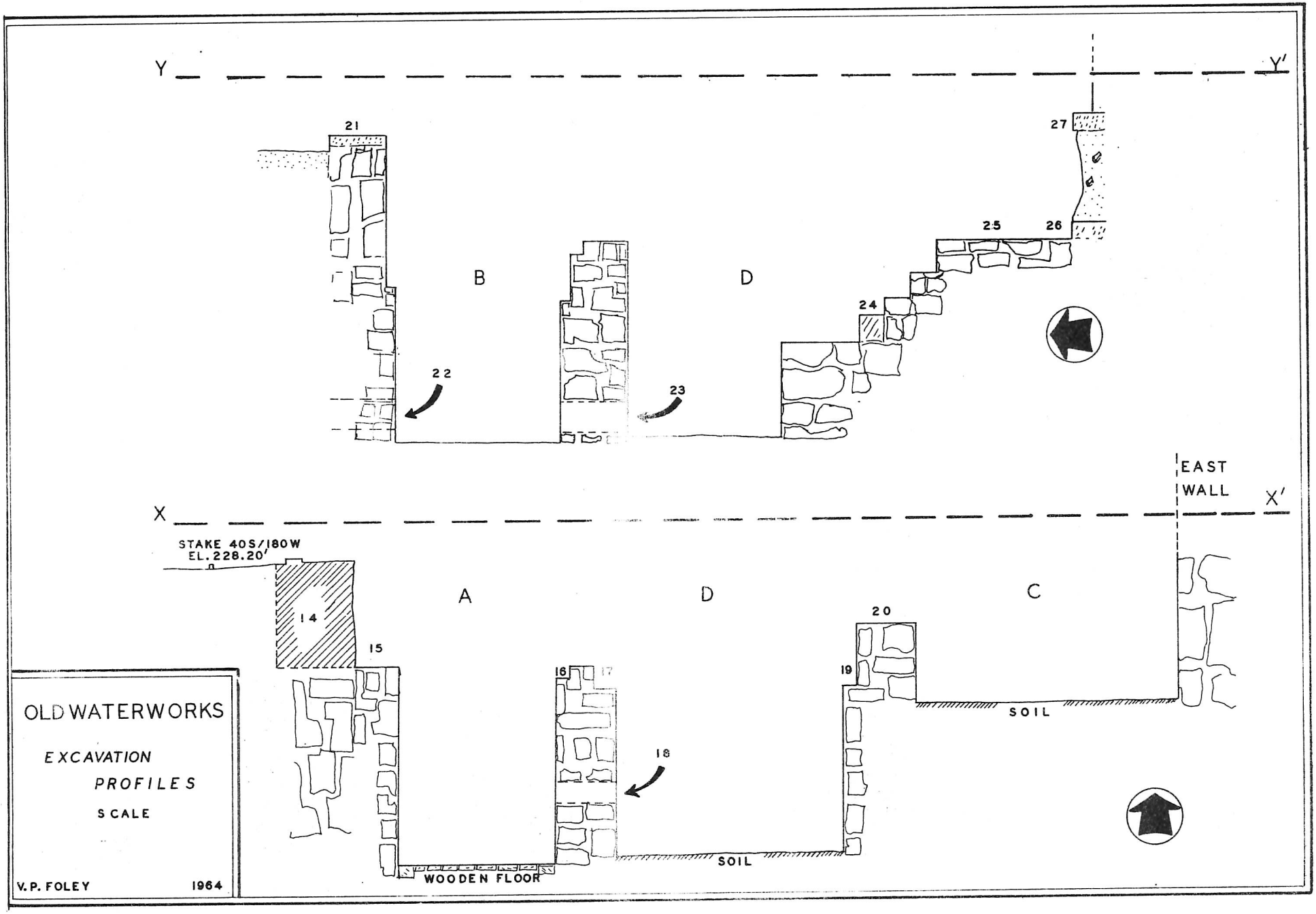
BASED ON

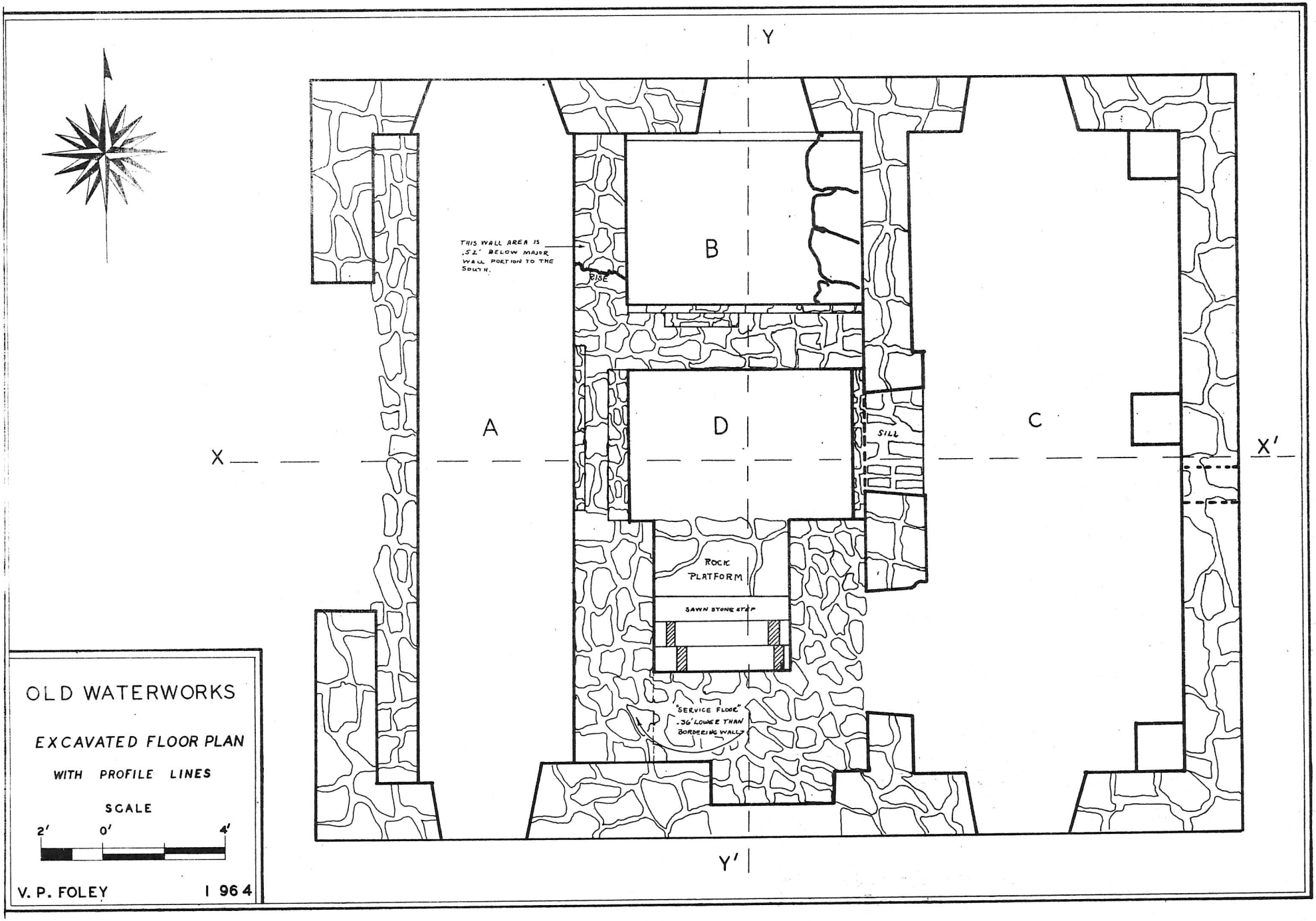
ARCHAEOLOGICAL & DOCUMENTARY

EVIDENCE & COMPARATIVE RESEARCH

SCALE APPROX.

V. P. FOLEY 1965


Y
Y'
21
27
25
26
24
B
D
22
23
X
X'
EAST
WALL
STAKE 40S/180W
EL. 228.20'
14
A
D
C
20
15
16
17
19
18
SOIL
SOIL
WOODEN FLOOR
OLD WATERWORKS
EXCAVATION
PROFILES
SCALE
V. P. FOLEY
1964



OLD WATERWORKS

EXCAVATED FLOOR PLAN

WITH PROFILE LINES

SCALE

2' 0' 4'

V. P. FOLEY 1964