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Memorandum

TO: Riaan Anthony
Interim Director
Charlottesville Parks and Recreation

FROM: Daniel C. Hyer
Line and Grade Civil Engineering

DATE: December 5, 2023

RE: Oakwood Cemetery Forensic Investigation

PART 1: INTRODUCTION

Oakwood Cemetery is a public burying ground located in the City of Charlottesville, Virginia. The cemetery occupies approximately 14 acres south of downtown Charlottesville and is adjacent to Elliott Avenue and 1st Street South, refer to Figure 1. *(Please note, all Figures shown within the body of this document are also included as full-size images at the end of this document.)* City of Charlottesville staff, including cemetery caretakers and landscape crews, have observed that a portion of the cemetery has become increasingly difficult to maintain as a result of persistently saturated ground, shown in Figure 2 and Figure 3. In due course of our investigation our team of professionals observed that wetland grasses have begun to establish within this saturated and wet area, which is to suggest that this is not just a simple maintenance challenge to the cemetery caretakers and grounds crews but, rather, indicative that there may be larger, more systemic factors to consider and understand.

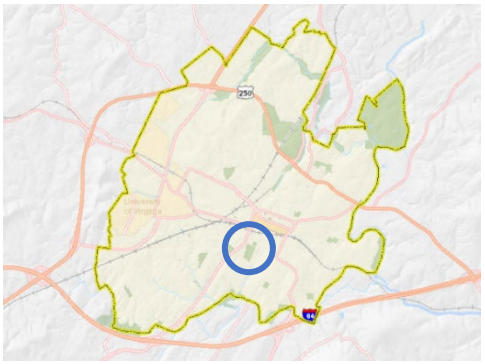

Figure 1 – Vicinity map showing Oakwood Cemetery (blue circle) within the City of Charlottesville limits.

Figure 2 – Aerial image showing saturated condition of Oakwood Cemetery near the intersection of Elliott Avenue and 1st Street South.

Figure 3 – Showing the area of saturated ground within Oakwood Cemetery.

In order to begin to understand what these contributing factors may be, our team has identified three specific areas of focus for our forensic investigation. These areas of focus have many overlapping and interrelated considerations that we will expound upon and discuss in detail. The three aspects of the investigation are: Historic and Cultural Resources, Hydrology, and Utilities. Each of these factors will be discussed in turn within the body of this report, but it is important to introduce them and explain their significance in an introductory manner.

Historic and Cultural Resources:

A brief review of the historic context of Oakwood Cemetery and general site development history can provide insight into various factors which may have contributed to the saturated ground phenomenon. Furthermore, because these saturated conditions are in the direct vicinity of burial sites (in fact several burial sites are within the saturated area), specific historic and cultural contexts of those who were laid to rest in the cemetery will be of specific importance for how the conditions can be improved or what physical constraints may be imposed on the opportunities for improvement.

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Hydrology:

Hydrology is the science and study of the movement of water, specifically related to how water moves across and below the land surface. Integral with hydrology are the topographic features of the land surface. Of specific interest to this evaluation are how the topography of Oakwood Cemetery and the movement of water through the cemetery may have contributed to the saturated ground phenomenon.

Utilities:

The presence of below grade utilities within the vicinity of the saturated ground is important to consider; specifically, we must consider if the existing utilities are capable to provide adequate service of their intended function or whether utilities may have contributed to the saturated ground phenomenon. Furthermore, the presence of utilities in and around the vicinity of the saturated ground and burial sites will require careful consideration for how to improve the saturated ground while not encroaching or disturbing the burial sites.

PART 2: HISTORIC AND CULTURAL RESOURCES

Understanding Oakwood Cemetery as a historic and cultural resource and taking into account the implications of the cemetery's physical history and historic context will provide a basis of understanding for this forensic study. The history of Oakwood Cemetery and how that history has intertwined with *Hydrology* and *Utilities* will be of specific importance in terms of what steps can be taken to remedy the deficiencies and what procedural steps and stakeholder involvement may be warranted in the process of restoring this area.

This portion of the study is informed by an archaeological and cultural resources review performed by Rivanna Archaeological Services. A full copy of their findings can be found in Appendix A.

2.1 Research and Findings

2.1.1 Development History

Oakwood Cemetery was established in 1863 in order to provide additional public burying sites since the City's first cemetery, Maplewood Cemetery, was growing full and it primarily provided internment for prominent white citizens. Furthermore, casualties from the Civil War had begun to arrive in Charlottesville and many of the wounded soldiers died in town and needed a place to be buried.

The City of Charlottesville purchased Oakwood's original 7.33-acre boundary in May of 1863 with burials likely beginning soon thereafter. After purchase, the City moved to segregate the new public burying ground. In October of 1875, a dividing line officially designating both 'white' and 'colored' sections was established, Figure 4 and Figure 5 (next page). It has been documented that

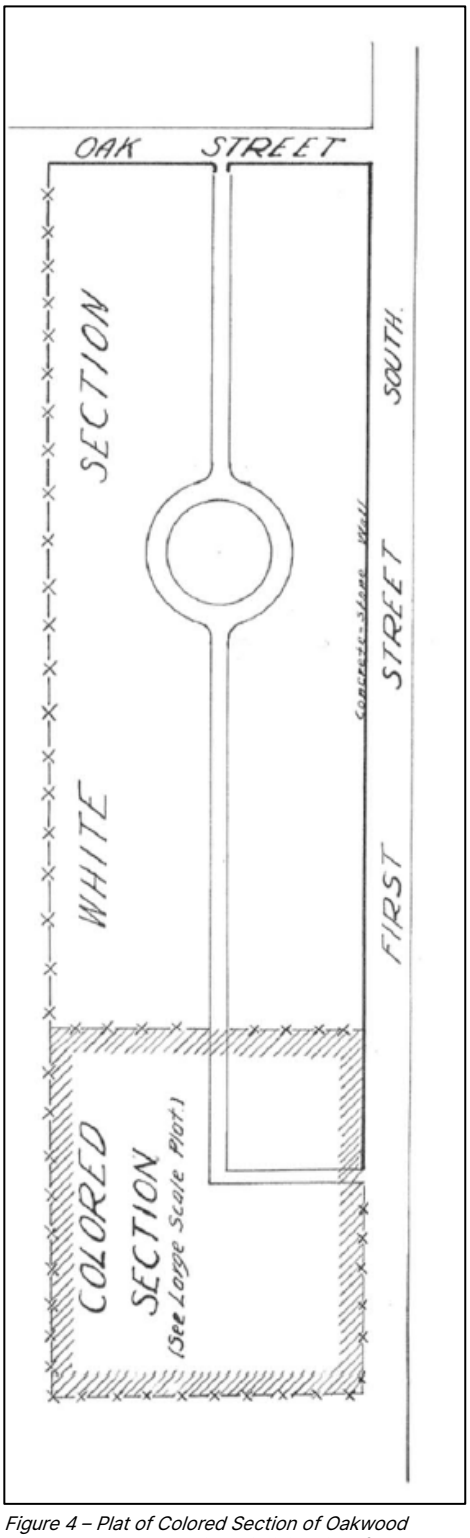

Figure 4 – Plat of Colored Section of Oakwood Cemetery, Charlottesville, Virginia. City of Charlottesville Bureau of Engineering, August 1, 1928.

Note that the future Elliott Avenue would be directly adjacent to the 'colored section' at the bottom of the figure.

the dividing line would be placed between cemetery sections VI and V (as denoted in Figure 6), thus providing a nearly equal division of the parcel. However, in reality the dividing line was placed further south, thus providing African-Americans with the extreme southern one third of the new cemetery (nearest the corner of Elliott Avenue and 1st Street South, though these roads were not constructed at that time).

In 1938, the City of Charlottesville purchased an additional 7.0 acres, expanding Oakwood cemetery to the west. The new 7-acre section mirrored the original section in general size and orientation. Later in the same year, the City of Charlottesville purchased an additional 0.5 acre parcel of land, located adjacent to and immediately south of the original denoted colored section. (It is noteworthy to point out that this final purchase of 0.5 acres is the same area exhibiting the saturated ground phenomena today.)

Figure 6 shows the expanded Oakwood Cemetery, to include the additional 7-acre purchase of land to the west and the 0.5-acre parcel to the south. This figure also shows the designations of the cemetery in terms of "Divisions." The African-American sections of Oakwood Cemetery were Divisions C, D, E, F and G.

By 1939, but possibly before, a road was constructed linking Oak Street (to the north) and the precursor to Elliott Avenue, west of 1st Street South, on the south end of the cemetery. The new north-south oriented cemetery road appeared to follow the course of an unnamed drainage tributary which led to Pollocks Branch (Refer to Hydrology section, below).

By the late 1950's, the City was making plans to extend Cherry Avenue from Ridge Street to Ware Street – what would become the Elliott Avenue of today. The improved road would firmly demarcate the southern boundary of Oakwood Cemetery. Based on available records and archived maps, it can be estimated that Elliott Avenue was constructed sometime between 1957 and 1966.

2.1.2 Human Internments Adjacent to Elliott Avenue

From the time that the City of Charlottesville has managed Oakwood Cemetery as a public burial ground, it has kept records of burials. These records document the name of the individual, the owner of the plot, the date of burial, the funeral home involved (if any), and the location of the burial according to division, block, section, row, and grave.

As previously mentioned, the area that is the focus of this study, the area of saturated ground, was denoted as Division G and was acquired by the City in 1938. Division G was exclusively an African-American portion of the Cemetery. City records indicate that burials occurred within 10 blocks of Division G, and a total of 122 individuals are recorded as being buried within Division G.

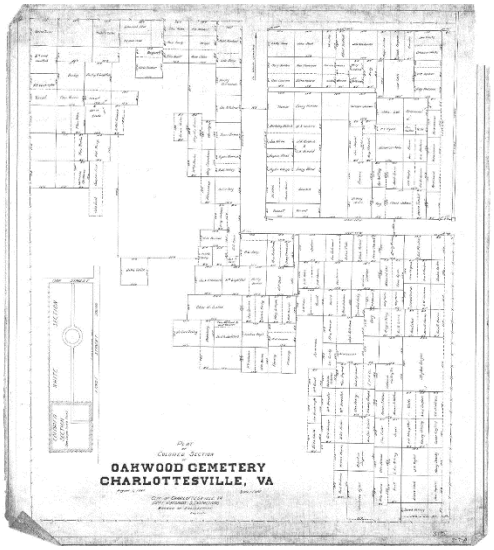

Figure 5 – Plat of Colored Section of Oakwood Cemetery, Charlottesville, Virginia. City of Charlottesville, Bureau of Engineering, August 1, 1928.

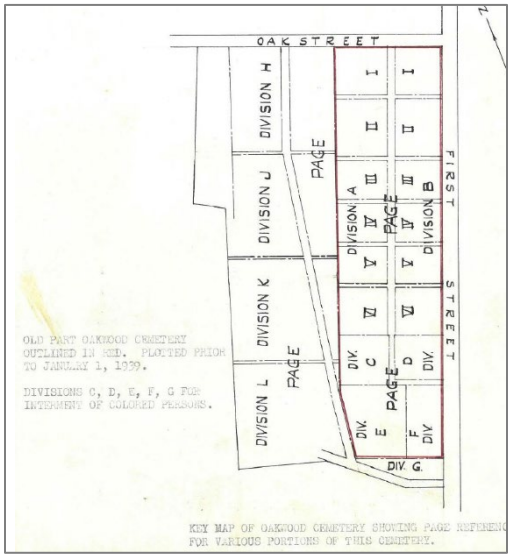

Figure 6 – Oakwood Cemetery showing the ca. 1863 red-outlined 'old' section at right and the new 1938 western addition at left. Note the small strip of land designated 'Division G' below and south of the old section of Oakwood Cemetery.

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In 2017, The City of Charlottesville hired NAEVA Geophysics, Inc. to conduct a ground penetrating radar (GPR) survey of the area adjacent to and north of Elliott Avenue in advance of proposed plans to construct a sidewalk in this location. Figure 7 shows the findings of this GPR Survey. The findings of the NAEVA GPR scan suggest that there are burial sites within Division G that are unmarked, which is to say, there are individuals who have been buried but there is not a corresponding surface demarcation such as a gravestone. What the study does not say, and what cannot be explicitly stated, is if the unmarked graves correspond with City records, or not. The NAEVA study can be found in Appendix B.

As a part of the fieldwork associated with this forensic investigation, our team performed additional GPR scans within the project vicinity. The primary goals of this additional GPR work were as follows:

1. Establish a baseline of GPR data from known, marked, burial sites adjacent to the project to confirm the grave sites could be imaged effectively,
2. Scan for unmarked burials within the study area, and
3. Evaluate the effectiveness of GPR within the saturated ground areas.

Our team collected GPR data along several burial rows and the graphic imaging positively correlated burial sites with geophysical imagery from the GPR device (Figure 8). Having performed this baseline diagnostic scan, our team attempted to scan for unmarked burials within the study area. In areas where the soils were dry it could be determined that no unmarked grave sites were present. These areas where the soil was dry and scanning could be performed in a satisfactory manner were located on the west side of the north-south cemetery road (Figure 9). On the east side of the north-south road, where the soils were saturated, the GPR scan was ineffective. Wet soils create geophysical anomalies within the scanning imagery, thus the presence of unmarked graves within the study, where the soils were saturated, could not be confirmed.

The full findings and data from the GPR scanning can be found in Appendix C. This document contains additional information and explanation related to the limitations of GPR scanning and the implications of such limitations for this project.

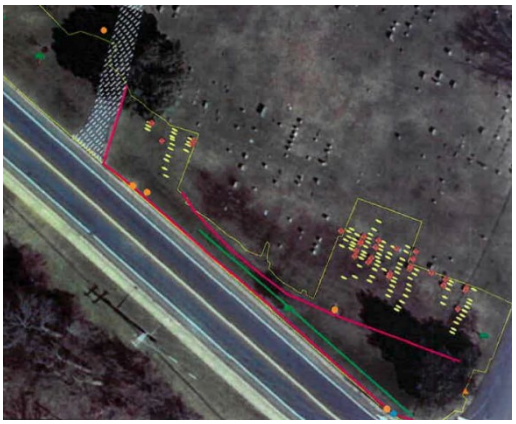

Figure 7 – Plan showing location of buried utilities (red and green lines), and grave like anomalies (yellow) and grave markers (red). The thin yellow outline represents the study area. NAEVA Geophysics, Inc., 2017.

Note the shading of the ground in relation to the study area and the area known to be saturated.

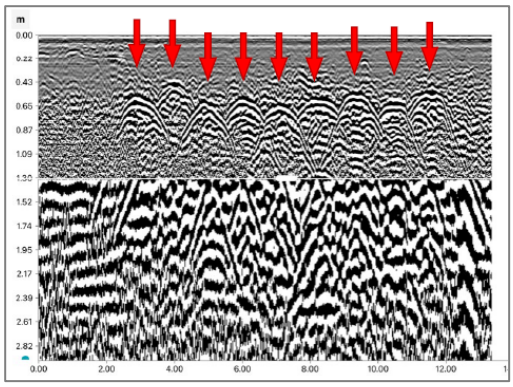

Figure 8 - Successful GPR Scan. Red arrows identify grave like anomalies corresponding with marked graves. Please note, this image was from

Figure 9 – 2023 GPR Scanning associated with this study. Orange shade is successful scanning area. Red shade is unsuccessful scanning area due to soil saturation.

2.2 Noteworthy Findings and Observations (Historic and Cultural Resources)

What follows are specific noteworthy observations informed by the Research and Findings which are relevant to the saturated ground phenomenon.

- The purchase of Oakwood Cemetery in 1863 did not include the area that is subject to this study, the low-lying saturated area. It is possible that this area contained natural drainage features.
- The southernmost section of the eastern portion of Oakwood Cemetery, Divisions C, D, E and F were designated the 'colored' burying ground in 1875.
- When the City finally purchased the lowest-lying portion of the land, denoted as Division G (0.5-acre parcel) this area was added to the 'colored section' burial grounds.
- When the cemetery was expanded, a road was constructed within the cemetery, running north-south and effectively bisecting the cemetery. It was placed in the general location of an existing drainage divide. (Refer to *Hydrology* section, below.)
- The construction of the north-south road, in 1939, also included the installation of drainage utilities along the north-south cemetery road.
- Elliott Avenue was constructed along the southern boundary of Oakwood Cemetery around 1960. (Based on CCTV utility scans we believe the date of construction to be 1960 and newspaper articles.)
- A 2017 GPR survey acquired by the City of Charlottesville confirmed the presence of burial sites directly adjacent to Elliott Avenue with no demarcation at the surface, which is to say they are unmarked graves. The data output from this scan appeared to be limited to areas within Division G which were not comprised of saturated soils.
- The GPR survey performed by the Line and Grade team could not confirm the presence of unmarked graves within areas of saturated soils. However, we confirmed that within areas of dry soil the GPR scan did not identify any unmarked grave sites.
- When NAEVA performed a GPR scan in 2017 there was enough "dry" soil to delineate some number of burial sites. Whereas, the GPR scanning performed by our team in 2023 experienced difficulty to scan some of these same areas due to the saturated condition. However, it is noteworthy that NAEVA also had some areas which must have been wet when their scanning was performed – given the strange shape of their scanning limits.

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PART 3: HYDROLOGY

The interrelated nature of the Historic and Cultural Resources (Part 2) and the site hydrology is already evident. How water moves across the land and how the land changes are inextricably linked; development affects hydrology, and hydrology affects development. Having a cursory understanding of the hydrology surrounding and enveloping Oakwood Cemetery will provide a basis of understanding related to the saturated ground within the area of focus.

This portion of the study is informed by historic archival research, review of USGS topographic maps as well as other supporting documents. Supporting documentation can be found in Appendix A.

3.1 Research and Findings

Before Oakwood Cemetery was established, the land was part of the Oak Hill estate, owned by Alexander Garret, and was comprised of 117 acres located south of Downtown Charlottesville. Following Garrett's death, the land was parceled and sold to settle his debts. As the land changed hands one of the parcels was dedicated to what would become Oakwood Cemetery.

A late nineteenth-century map of the vicinity indicates the landscape contained tributaries and ponds as the watershed flowed toward Pollocks Branch, refer to Figure 10. Locating this map relative to Oakwood Cemetery places this pond very near the location where the saturated ground is currently manifest.

Evidence that the land contained these tributaries is further supported by other archived maps, including an early twentieth-century map which also shows an unnamed tributary west of Pollocks Branch, lying directly west of what would become Oakwood Cemetery, refer to Figure 11.

It might be overly simplistic to suggest that this area simply contained a tributary or hydrologic feature. The hydrologic cycle and the interaction of water moving across the earth's surface needs to be understood within a time scale relative to geologic time; that is, these features manifested as a result of water movement over very long periods of time; they did not just "appear."

What these two initial maps (Figures 10 and 11) do not portray is the topographic data. It can be assumed that these tributaries were associated with low-lying areas in the landscape. However, in 1935, a USGS topographic map of the Charlottesville vicinity documents the topography of this area, see Figure 12. This map provides the link between the unnamed tributaries adjacent to Oakwood Cemetery and the topography which indicates low-lying stream-bed type features.

Figure 10 – Map of property owned or controlled by the Charlottesville Land Co., Charlottesville, VA, showing the ca. 1863 red-outlined 'old' section of Oakwood Cemetery, and the blue circle around a pond which flowed toward Pollocks Branch.

Figure 11 – Map showing the approximate, red-outlined location of the ca. 1863 'old' section of Oakwood Cemetery and its adjacent southern and western tributary drainage features.

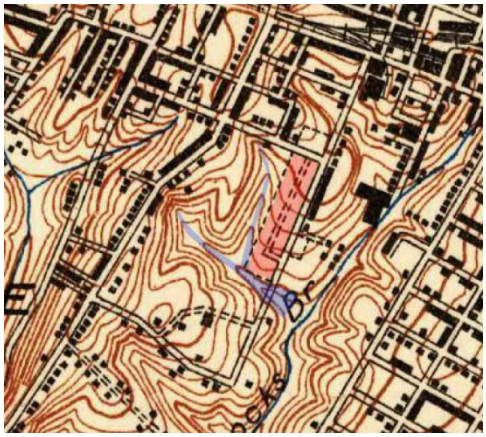

Figure 12 - Charlottesville and Vicinity, showing the red-shaded (ca. 1863) 'old' section of Oakwood

Cemetery and the blue-shaded drainages west and south of it following the topographic relief. Notice how the southern drainage broadens into a floodplain south of Oakwood Cemetery at its intersection with Pollock's Branch. U.S.G.S., 1935.

It is interesting to note that stream tributaries are not only providing flow of water that reaches the stream from overland flow, but streams are also hydrologically connected to groundwater flow. "Streams interact with ground water in all types of landscapes. The interaction takes place in three basic ways: streams gain water from inflow of ground water through the streambed, they lose water to ground water by outflow through the streambed, or they do both, gaining in some reaches and losing in other reaches."[1] This insight is to suggest that there is a layer of complexity to how the natural hydrology interacts with the land.

The first aerial photographs of Oakwood Cemetery and its vicinity were taken in 1937. In Figure 13, the extent of the original Oakwood Cemetery can be observed. Additionally, natural drainage tributaries corresponding with the original historic maps and the USGS map can be seen in actual form.

Subsequently, an aerial photo from 1957 (Figure 14) indicates the expanded cemetery and the installation of the north-south cemetery road. This road occupies nearly the same location as the original tributary. Going on, the Oakwood Cemetery plat shows this road and a "15 inch Storm Sewer In Place," refer to Figure 15.

In 1960, the City constructed the Cherry Avenue extension. This roadway reinforced a physical boundary to the cemetery as well as a hydrologic boundary. In Figure 16, (following page) an aerial image from 1966, shows the completed roadway corridor flanking the southern boundary of Oakwood Cemetery.

Furthermore, a topographic map from 1970 from the vicinity of Oakwood Cemetery shows the impact of construction of Elliott Avenue on the unnamed drainage tributaries. The topographic map, Figure 17 (following page), suggests that the construction of Cherry Avenue extended disrupted the natural flow of this tributary.

Figure 13 - Aerial photograph from 1937 showing the approximate location of the red-shaded ca. 1863 'old' section of Oakwood Cemetery. Note the presence of the darker colored vegetation, the northern leg of the unnamed drainage of Pollock Branch, to the west of the old section of Oakwood Cemetery.

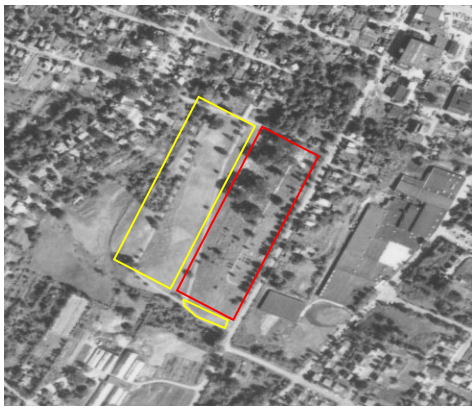

Figure 14 - Aerial photograph from 1957 showing the red-outlined ca. 1863 'old' section of Oakwood Cemetery and the new yellow-outlined western and southern additions. Note the presence of a new southern road, the precursor to Elliott Avenue south of Oakwood, and a spur road connecting Oakmont on the north with 1st Street South on the east.

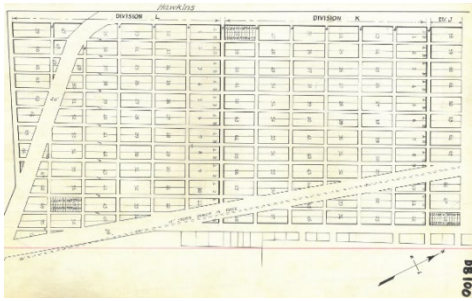

Figure 15 - Plat of the southern end of the western half of Oakwood Cemetery showing the road and a storm drain line paralleling its eastern side. North is to the right. No date [post-1938].

[1] Natural Processes of Ground-Water and Surface-Water Interaction; https://pubs.usgs.gov/circ/circ1139/htdocs/natural_processes_of_ground.htm

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Figure 16 – An aerial photograph from 1966 showing the boundary of Oakwood Cemetery (in red) and a new western extension of Elliott Avenue extending to the west to meet Ridge Street. Note the small remnant of the original tributary to the south of Elliott Avenue (in blue).

Figure 17 – A topographic map showing the vicinity of Oakwood Cemetery and the location of what remains of the natural tributary low-lying areas (blue shade). Also note the low-lying formed to the north of Elliott Avenue and they are specifically demarcated by a different line-type in the survey (green shade).

3.2 Noteworthy Findings and Observations (Hydrology)

What follows are specific noteworthy observations informed by the Research and Findings which are relevant to the site hydrology.

- Prior to becoming a cemetery, the land was a part of a larger landholding, which was subsequently divided and parceled. The natural landscape exhibited prominent hydrologic features which had been recorded in some of the earliest map records for the vicinity including two unnamed tributaries, one oriented north-south within the cemetery, and one oriented east-west along the southern boundary of the cemetery.
- From 1863, when the cemetery was first established, and for the following 100 years there is documented evidence of the continuous interaction between the built (developed) environment and the natural environment and that this interaction made an impact on the natural hydrologic cycles of the land.
- In 1938 the City acquired an additional 7-acres adjacent to the original cemetery and subsequently built a north-south road within the cemetery. This vehicular corridor was placed upon an existing unnamed tributary. In lieu of this natural feature the "improvements" to the land provided a "15 inch Storm Sewer in Place." This 15-inch storm sewer was intended to convey the water which had been using the tributary.
- It is noteworthy to express that just because a stream is relocated to a pipe that the natural hydrology may not recognize this pipe inasmuch as there is a complex and dynamic interaction between streams and groundwater. Despite the development of a road and a storm sewer pipe, the ground maintains a memory of this hydrologic feature.
- It is also noteworthy to express that the pipe material is not indicated in the record drawings.
- The tributary, which had bisected the cemetery property on the north-south axis, but was relocated into a pipe, flowed downstream and into another tributary, visually identified on all the reference maps included herein, which ran along the southern boundary of Oakwood Cemetery. This unnamed tributary flowed into Pollocks Branch.
- This subsequent tributary, along the southern boundary of Oakwood Cemetery, was eventually impacted by the development of the Elliott Avenue extension project. Portions of this tributary were eventually relocated into a stormwater pipe that flows below Elliott Avenue.
- The development of Elliott Avenue created a solid physical and hydrologic barrier along Oakwood Cemetery's southern boundary.
- In terms of a hydrologic barrier, the construction of a roadway requires substantial compaction of earthen materials which are intended to provide an adequate base material capable of supporting a vehicular corridor. However, in doing so, the natural flow of groundwater is blocked.
- Aerial Imagery from 1980 shows the first indications that the ground surface in the vicinity of Division G, the portions of the Cemetery directly adjacent to Elliott Avenue, were "darkening" or, perhaps the ground cover was changing or subject to a condition that was distinct from the rest of the cemetery.
- As of the writing of this Memo, the original construction documents from Elliott Avenue have not been located.

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PART 4: UTILITIES

Up to this point this document has reviewed the Historic and Cultural Resources related to the physical history as well as the Hydrology in the vicinity of the cemetery both prior to the cemetery and as the cemetery and surrounding land developed over time. This final portion of the study looks into the condition of the utilities in the vicinity of the cemetery, specifically the stormwater utilities.

This portion of the study is informed by a CCTV scan of the utilities as performed by IMEG as well as water chemistry testing performed by HydroGeo Environmental. IMEG's report can be found in Appendix D, and HydroGeo's full report can be found in Appendix C.

4.1 Research and Findings

As previously identified, there were two tributaries in the vicinity of Oakwood Cemetery, and both tributaries have been augmented to flow within man-made closed conduit pipe networks which were built in association with various improvement and development projects. For the purposes of this study the limits of CCTV scanning and associated utility investigation work are shown in Figure 18 which includes a portion of the storm sewer along the cemetery road and portion of the storm sewer within Elliott Avenue

In addition to the pipes, a visual investigation was performed at each manhole structure or junction.

4.1.1 Pipe Inspection

Upon mobilization to the site, it was the intention of the field crew to scan the 4 pipes shown in Figure 18.

However, in due course of performing the investigation additional pipes were found in the vicinity. These pipes are shown in blue in Figure 19 and appeared to be a French drain type installation.

Beyond the discovery of additional stormwater infrastructure, the CCTV scan revealed that a pipe directly adjacent to the intersection of the cemetery road and Elliott Avenue had been crushed, refer to Figures 20 and 21. The pipe had been crushed to the point where the CCTV pipe rover module could not pass through the pipe. On the upstream side of the crushed pipe a volume of standing water was observed. The crushed pipe appeared to be of a polymer-based material.

Subsequent conversations with City staff revealed that the pipe had been lined in 2016 and that the City was aware that a portion of the pipe was "sagging." This suggests that in 2016 the line was exhibiting evidence of distress, but that the distress had not yet reached the level of disrepair observed in our recent CCTV survey.

Video evidence from this area where the pipe has been crushed revealed that water leaking was into the pipe from the top. The leak appeared as a constant drip. It

Figure 18 – Map showing four known storm sewer pipes (red lines) in within the study area.

Figure 19 – Map showing additional storm pipes (blue lines) discovered within the study area.

Figure 20 – CCTV image upstream of a crushed pipe along the cemetery road adjacent to Elliott Avenue. Note the volume of water in the pipe.

Figure 21 - CCTV image downstream of a crushed pipe along the cemetery road adjacent to Elliott Avenue.

cannot be conclusively determined if this leak is groundwater flowing into the pipe or if it is condensation within the pipe. It is possible that the polymer-based lining had flexed under the crushing forces and that cracks may also be present. If indeed cracked, and based on the visual evidence of water dripping into the pipe, it can be proposed as a hypothesis that there are cracks on the bottom of the pipe as well and that these cracks allow water to seep into the soil surrounding the pipe. At this point it is important to recall that this pipe carries water which was at one point a tributary, and there is likely a base flow of water constantly flowing through this pipe. Under the present conditions it is likely this water is also constantly leaking out of the pipe as well. The video footage also suggested an abrupt change in the pipe material slope, which corroborates City staff's insight that the pipe had sagged or otherwise deflected under the crushing forces.

The pipe which runs parallel to Elliott Avenue, a 36" reinforced concrete pipe, which presumably carries the flow of the original unnamed east-west oriented tributary, exhibited water intrusion along most of the pipe joints, refer to Figure 22. In some cases the flow into the pipe was substantial. There was also a stamp within the pipe that had the pipe manufactured date of 1960, which would suggest the pipe joint materials are 63 years old and likely not functioning as originally intended due to age and natural material breakdown.

The pipes which were discovered in due course of the CCTV scan revealed a blind pipe connection adjacent to Division G of the cemetery, Figure 23. Further exploration revealed an earthen structure within the cemetery which received French drains from within the cemetery. Visual evidence suggests the system is clogged with mud, (Figure 24), but to state the degree to which this has caused the system to operate at a capacity less than intended would be conjecture. Clear/clean water was observed flowing into the 36" RCP along Elliott Avenue from this French drain system. It can be concluded the system provides some capacity to relieve hydrostatic pressure within the soil from within the cemetery.

4.1.2 Manhole Inspection

The manholes along the pipe network were also visually inspected. The two structures within the cemetery, directly adjacent to the cemetery road, are brick structures. Water could be observed weeping through the brick walls. No other noteworthy deficiencies were observed.

4.1.3 Water Chemistry

Water could be observed leaking into manhole structures and into pipes, but the source of the water was unknown. Our team collected four subsurface water samples. All four samples appeared to be influenced from naturally-occurring runoff due to the chloride levels falling above the City's 2023 water quality report and the fluoride levels falling well below the City's' reported levels.

Figure 22 – CCTV Image within the 36-inch RCP pipe along Elliott Avenue. Note the wet seams along every pipe joint.

Figure 23- CCTV Image within the 36-inch RCP pipe along Elliott Avenue. The blind pipe connection leading to the French drains within the Cemetery can be seen within the center of the frame.

Figure 24 – An earthen manhole type structure connecting the French drains within the cemetery to a pipe which will connect with the 36-inch RCP in Elliott Avenue shown in Figure 21.

4.2 Noteworthy Findings and Observations

What follows are specific noteworthy observations informed by the Research and Findings which are relevant to the utilities.

- The closed conduit stormwater conveyance systems were installed to convey the water originally carried by the unnamed tributaries within and adjacent to Oakwood Cemetery.
- The stormwater system within the cemetery has a history of deficient conditions, and in 2016 the City lined the system and noted that it was sagging at that time.
- Between 2016 and 2023 the lined pipe has crushed. This crushed pipe has created a volume of standing water upstream of the crushed area. The crushed pipe may have also cracked, as evidenced by water dripping in through the top of the pipe. It is likely water is also leaking out of the pipe as well.
- Water was observed to be leaking through every joint of the 36-inch RCP pipe under Elliott Avenue.
- A blind pipe connection had been made to the 36-inch RCP pipe providing for water from within a French drain system to flow into the Elliott Avenue system.
- Water was observed to be leaking through the brick manhole structures within Oakwood Cemetery.
- The geochemical fingerprint of the water samples suggests the water source leaking into the stormwater infrastructure is naturally occurring and not from a municipal water source.

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PART 5: IMPLICATIONS OF FINDINGS – CONNECTING THE DOTS

Thus far this Forensic Investigation has traced the Historic and Cultural resource contexts of Oakwood Cemetery, traced the development history related to the hydrology and topography of the cemetery, and has reviewed site specific CCTV footage from within the stormwater pipe networks adjacent to the area of focus.

At this point it remains to overlay the noteworthy findings and observations from each area of study and identify conclusions or correlations which are relevant to the observed saturated ground phenomenon

1. Oakwood Cemetery is comprised of 14 acres and was developed within a landscape that originally contained two unnamed tributaries. These tributaries were identified in the earliest records of the area.
2. In 1875 Oakwood Cemetery was designated to have 'white' and 'colored' sections and these sections were to be nearly equal.
3. A plat of the original Oakwood Cemetery reveals that the 'colored' section of the cemetery was closer to one third or perhaps or one quarter of the cemetery when it had been intended to be approximately half of the (original) cemetery.
4. The colored section of the cemetery occupied the lowest-lying land within the cemetery, adjacent to what is now the corner of Elliott Avenue and 1st Street South. Early plats suggest that the colored section of the cemetery left large portions of the cemetery unused, perhaps because of wet ground conditions.
5. When the Cemetery was expanded a natural drainage tributary was covered over by a north-south oriented road, and the water flow of the tributary was placed within a 15 inch pipe.
6. Based on the way groundwater and surface water are complexly integrated near surface water features, the relocation of a tributary into a pipe does not remove the memory of the land that this area is a stream and that the groundwater within the vicinity still "thinks" this is a stream bed.
7. Similarly, when Elliott Avenue was constructed and the unnamed tributary, which had run along the southern border of Oakwood Cemetery, was placed into a closed conduit stormwater system (circa 1960) the ground retained a memory that this was a stream valley.
8. The construction of Elliott Avenue created a hydrologic boundary to the flow of groundwater due to the compaction and import of foreign soil materials which had the intended purpose of bearing the load of a vehicular corridor but not conveying natural groundwater flows.
9. The natural hydrologic cycle remains intact and groundwater continues to flow through the vicinity as evidenced by water dripping or leaking into:
    a. RCP pipes where the joint materials have ceased to perform as intended,
    b. Brick manholes where the porous material properties of brick allow water to pass from the surrounding earth into the brick manhole box
    c. Through cracks in polymer based pipe lining materials where pipe materials have crushed and deflected.
10. That the source of the water bears the geochemical fingerprint of a natural water source and not a municipal water source.
11. The stormwater pipe deficiency is not a new problem. In 2016 the City lined the pipe and was aware of pipe sagging.
12. Between 2016 and 2023 the recently lined stormwater pipe adjacent to the Cemetery entrance along Elliott Avenue deflected and crushed.
13. This crushed pipe carries a base-flow of water from the original tributary it replaced. With the pipe condition currently crushed and broken, and most likely leaking, this base flow of water is weeping into the ground adjacent to the place where the pipe is crushed. The permanent pool of water just upstream of the crushed pipe suggests that the water is effectively dammed up to a certain volume and this sitting water has the chance to leak out of the pipe.
14. Aerial imagery of the subject area, when geolocated in relationship to the broken pipe, suggests a correlation between the broken pipe and the saturated ground in Division G, refer to Figure 25, below.
15. However, it is not likely that the saturated ground is only associated with the broken pipe but rather that the broken pipe, which carries the flow from the original tributary, has likely exacerbated what was likely going to be a condition that was subject to wet soil and soggy conditions based on groundwater flow and the historic evidence that this has always been a low-lying area.

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Figure 25 - Note the Location of the broken pipe, and the variation of the ground cover color between the broken pipe and the grounds adjacent to the pipe.

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PART 6: RECOMMENDATIONS AND NEXT STEPS

Having connected the dots between the noteworthy observations associated with each aspect of this forensic evaluation, the task is now to determine prudent next steps. It should be succinctly stated that the findings of this study suggest there are several factors contributing to the saturated ground condition. The natural groundwater hydrology and the development patterns of the cemetery and adjacent land has led to a constrained and less than ideal scenario for the natural flow of groundwater. The crushed and broken pipe has led to the condition becoming increasingly acute in recent years. As this study has also confirmed, Ground Penetrating Radar (GPR) scans can only effectively work in dry soils. As such, there is additional work to do prior to making any repairs or improvements to this area. The work in this area is delicate and nuanced. What follows are a series of next steps for the City to take.

6.1 Stakeholder Engagement

Given the presence of African-American burials within and adjacent to the project study area, as well as the organized efforts to rehabilitate and preserve the Daughters of Zion cemetery beginning in 2015, there is a need to engage relevant stakeholder groups prior to any physical undertaking at Oakwood.

A first step may be for the City and/or their project consultant to reach out to the current leaders of the Preservers of the Daughters of Zion organization to present the findings of this memo and obtain their thoughts on how to proceed with community outreach.

The appropriate stakeholders should be notified reasonably soon after the City reviews the memo, and certainly before approving any mitigation methods or future work.

6.2 Non-Destructive Testing

6.2.1 – Water-Table Mapping

Given the factors contributing to this ground saturation condition, additional data should be gathered, and it should be gathered as soon as reasonable. While the City is coordinating with relevant stakeholders a series of Piezometers should be installed adjacent to Elliott Avenue in the low-lying ground where there is confidence that no grave sites exist. These piezometers should be installed under the supervision of a Licensed Professional Engineer, Geologist, and Archaeologist. The piezometers should be monitored at regular intervals to begin a data set that represents the water table elevations in the project vicinity.

6.2.2 – Mechanical Dewatering

Following stakeholder engagement and collaboration, and after the piezometers have been installed and an initial data set of the groundwater table has been logged, the area should be dewatered with mechanical dewatering devices. Similar to the piezometer installation, this should be performed under the direct supervision of a Licensed Professional Engineer, Geologist, and Archaeologist. As the mechanical dewatering is able to draw down the groundwater elevations the piezometers should be continually monitored.

6.2.3 – Additional GPR Scanning

When the groundwater elevations have been sufficiently lowered, and the ground in the vicinity of Division G has been deemed “dry,” the entire vicinity should be re-scanned with a GPR device. Neither the NAEVA Geophysics, Inc. GPR scanning nor the scans performed for this forensic evaluation could conclusively map all the grave sites in the vicinity due to the saturated ground conditions. The ability to revisit the area and scan under ideally dry conditions will provide the degree of confidence required to perform necessary repairs to the stormwater Infrastructure.

6.3 Repairs to Stormwater Infrastructure

6.3.1 – Archaeological Work

Due to the documented presence of burials within Division G of Oakwood Cemetery, and the potential for undocumented burials within Division G, it is recommended that no ground disturbance take place adjacent to and north of Elliott Avenue without archaeological work clearing the proposed area of impact.

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6.3.2 – Stormwater Network Repairs

Based on the condition of the infrastructure in the vicinity of Division G at Oakwood Cemetery, the limits of the repairs are subject to discussions and coordination with the City. At the very least, the reach of pipe which is crushed needs to be replaced. However, there is a record as early as 2016 that this pipe was sagging, and as such it should be further evaluated whether there are additional factors which are causing this pipe to deflect and break. This can be determined during the archaeological work defined in 6.3.1.

It may also behoove the City to increase the scope of repairs to include the area drains on both sides of the cemetery road and the pipes in between.

The full scope of repairs should be discussed between the authors of this report and the City representatives to come to a consensus on what needs to be included when.

6.3.3 – Continued Groundwater Monitoring

While not explicitly a repair item: the piezometers installed as recommended in 6.2.1 should be maintained and monitored for no less than 12 months after repairs are completed. As previously discussed, the broken pipe is only part of the challenge in this area and with continued monitoring of the piezometers, additional ways to alleviate the saturated ground can be determined and adequately implemented.

PART 7: CONCLUSION

I would like to thank you again for the opportunity to provide our services. Given the broad sweeping and unique findings of this forensic study we would like to set up a meeting to discuss what has been presented herein with City staff members. This meeting will be scheduled upon submission of this report.

If you have any questions or require additional information, please do not hesitate to contact our office.

Sincerely,

Daniel C. Hyer, PE

List of Attachments:

Appendix A: Oakwood Cemetery Historic Context Summary by Rivanna Archaeological Services, LLC
Appendix B: NAVEA Geophysics, Inc. Study
Appendix C: Oakwood Cemetery GPR and Water Sampling by HydroGeo Environmental
Appendix D: Visual Evidence Log from CCTV Scans of Stormwater Utility Pipes by IMEG.
Appendix E: City of Charlottesville Department of Utilities Records

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Large Format Figures

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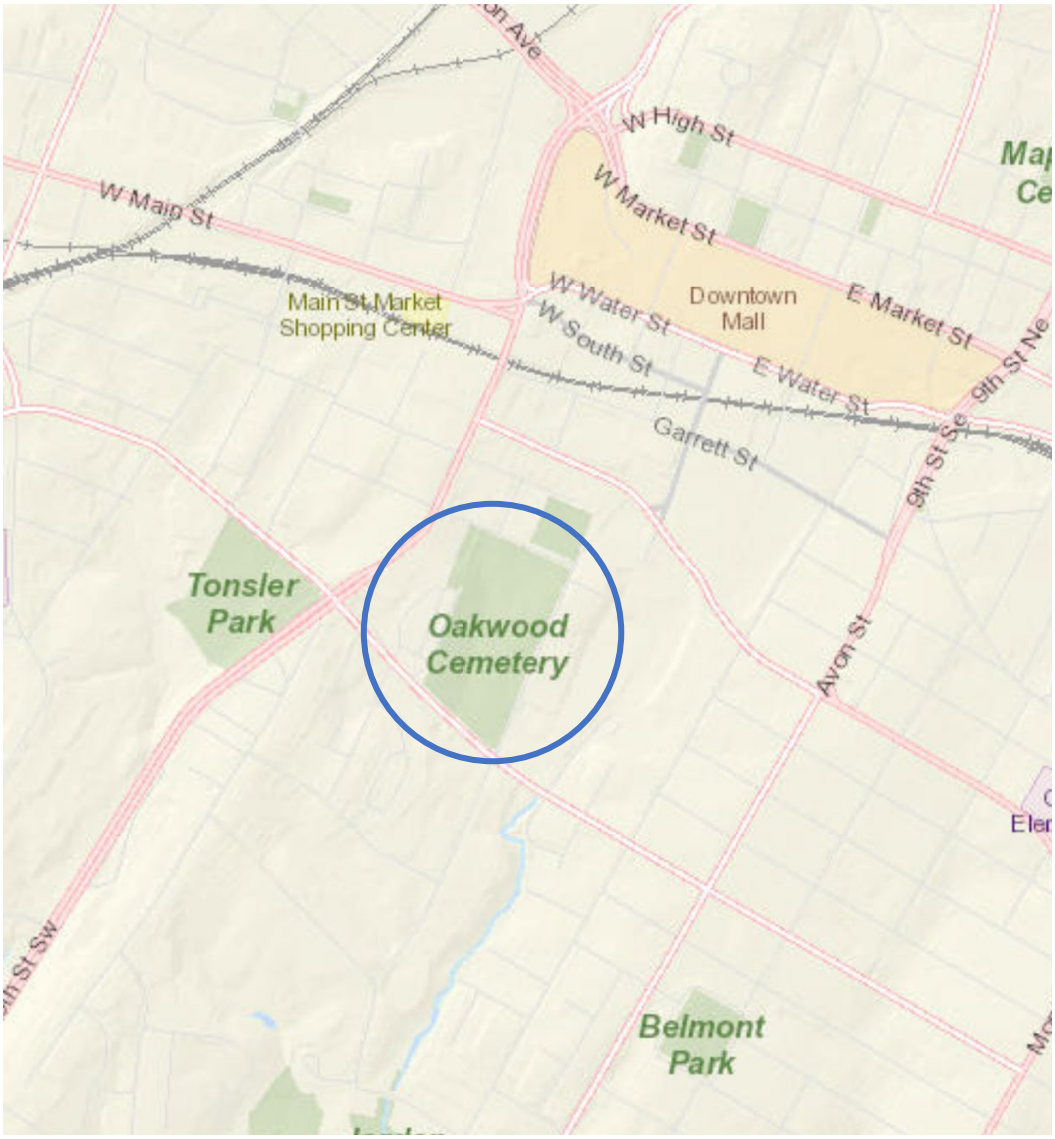

Figure 1 - Vicinity map showing Oakwood Cemetery (blue circle) within the City of Charlottesville limits.

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Figure 2 - Aerial image showing saturated condition of Oakwood Cemetery near the intersection of Elliott Avenue and 1st Street South.

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Figure 3 - Showing the area of saturated ground within Oakwood Cemetery.

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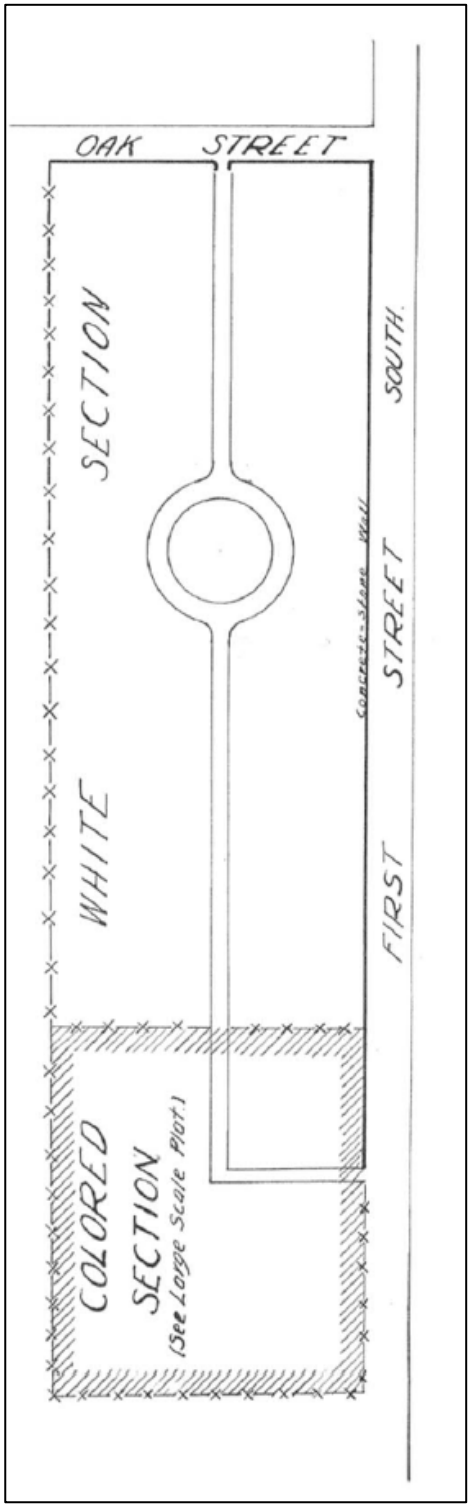

Figure 4 – Plat of Colored Section of Oakwood Cemetery, Charlottesville, Virginia. City of Charlottesville Bureau of Engineering, August 1, 1928.

Note that the future Elliott Avenue would be directly adjacent to the 'colored section' at the bottom of the figure.

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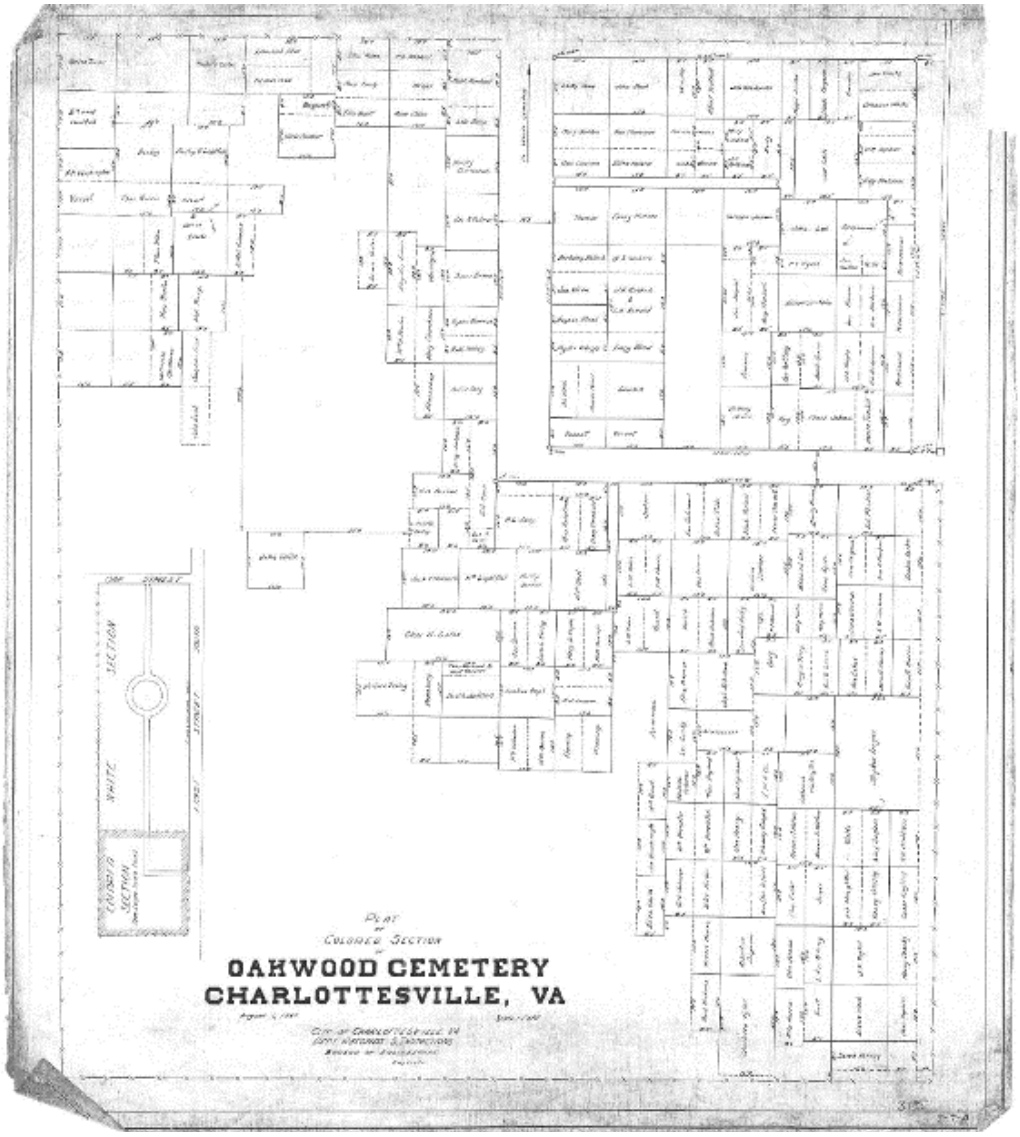

Figure 5 – Plat of Colored Section of Oakwood Cemetery, Charlottesville, Virginia. City of Charlottesville, Bureau of Engineering, August 1, 1928.

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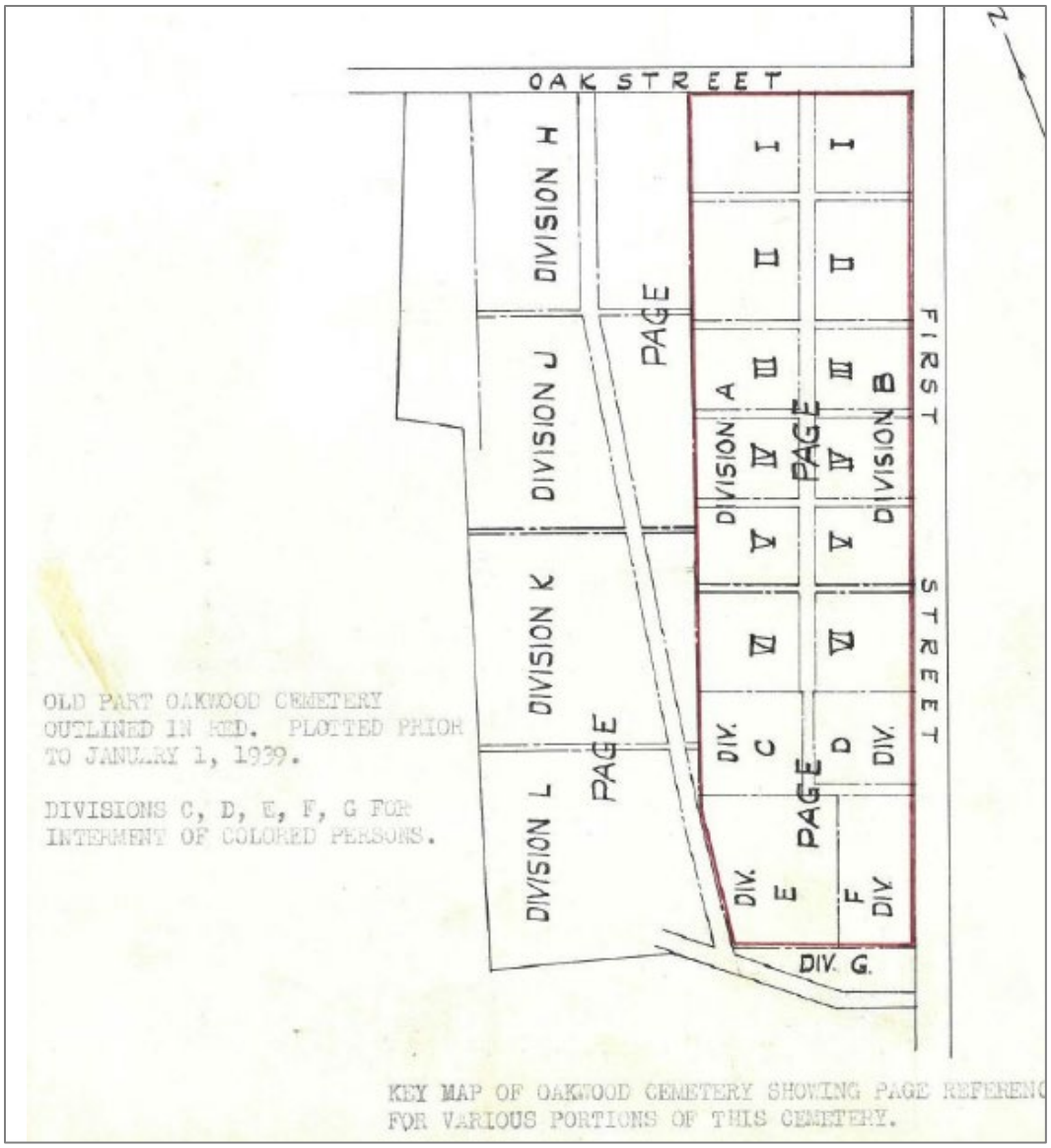

Figure 6 – Oakwood Cemetery showing the ca. 1863 red-outlined 'old' section at right and the new 1938 western addition at left. Note the small strip of land designated 'Division G' below and south of the old section of Oakwood Cemetery.

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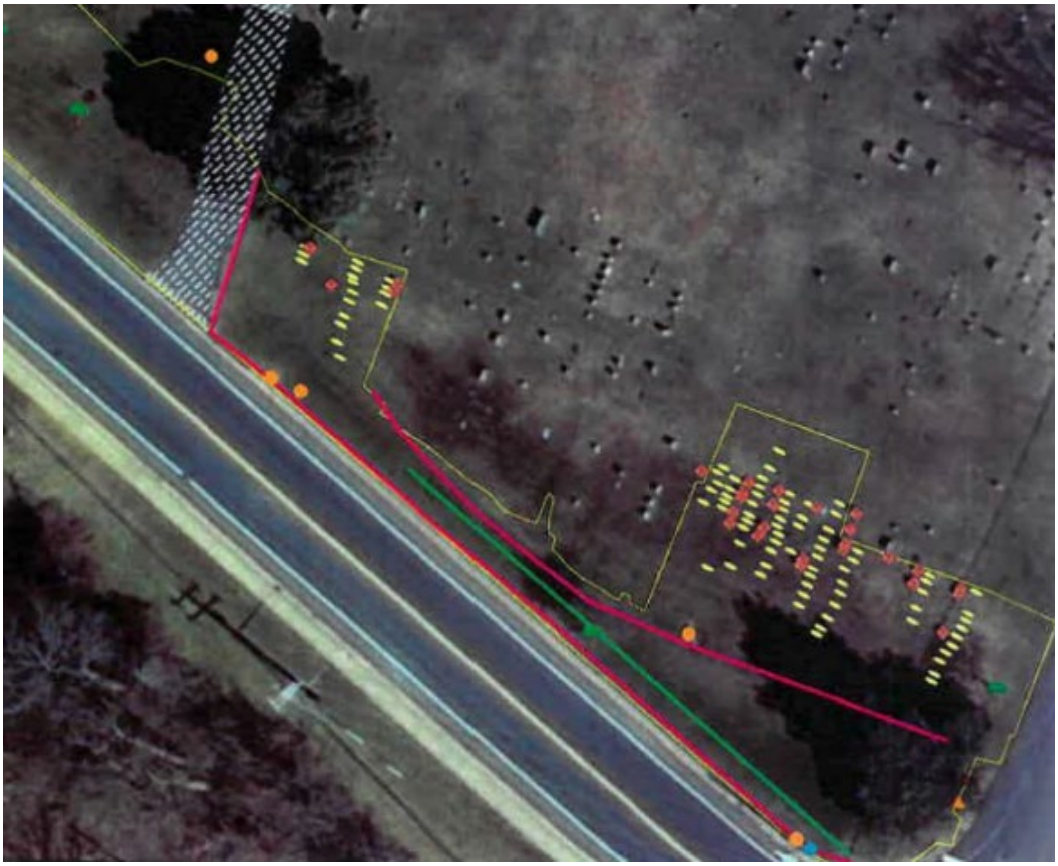

Figure 7 – Plan showing location of buried utilities (red and green lines), and grave like anomalies (yellow) and grave markers (red). The thin yellow outline represents the study area. NAEVA Geophysics, Inc., 2017.

Note the shading of the ground in relation to the study area and the area known to be saturated.

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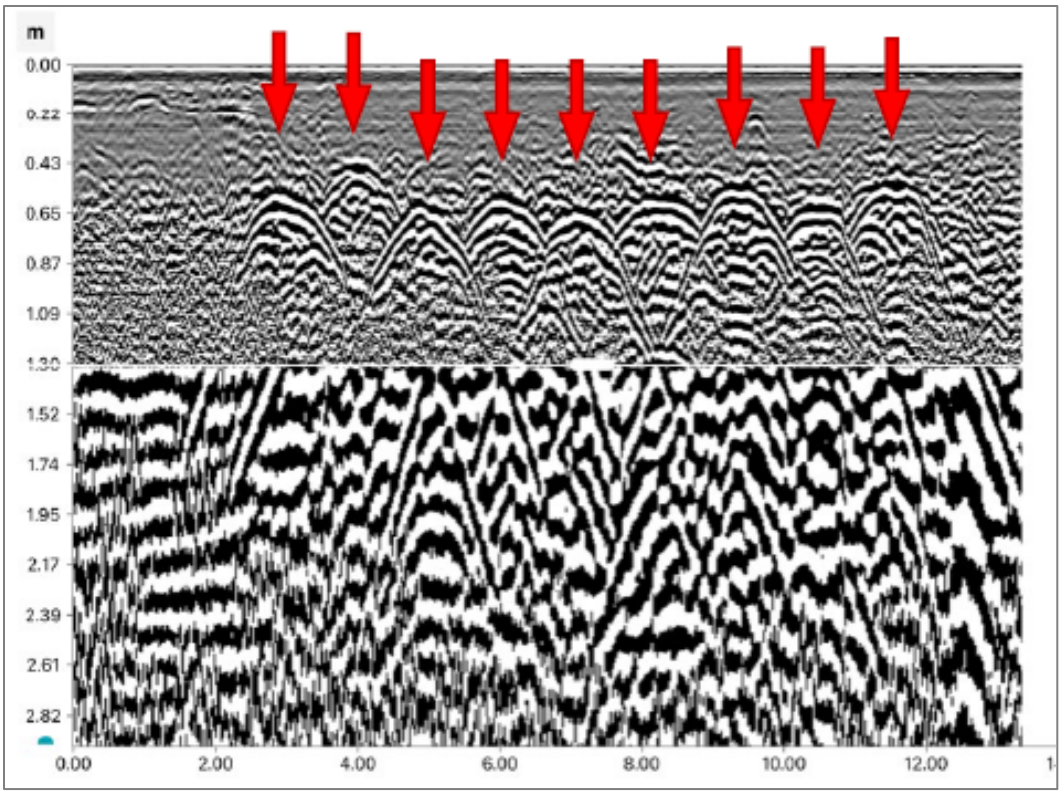

Figure 8 - Successful GPR Scan. Red arrows identify grave like anomalies corresponding with marked graves. Please note, this image was from

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Figure 9 – 2023 GPR Scanning associated with this study. Orange shade is successful scanning area. Red shade is unsuccessful scanning area due to soil saturation.

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Figure 10 – Map of property owned or controlled by the Charlottesville Land Co., Charlottesville, VA, showing the ca. 1863 red-outlined 'old' section of Oakwood Cemetery, and the blue circle around a pond which flowed toward Pollocks Branch.

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Figure 11 – Map showing the approximate, red-outlined location of the ca. 1863 'old' section of Oakwood Cemetery and its adjacent southern and western tributary drainage features.

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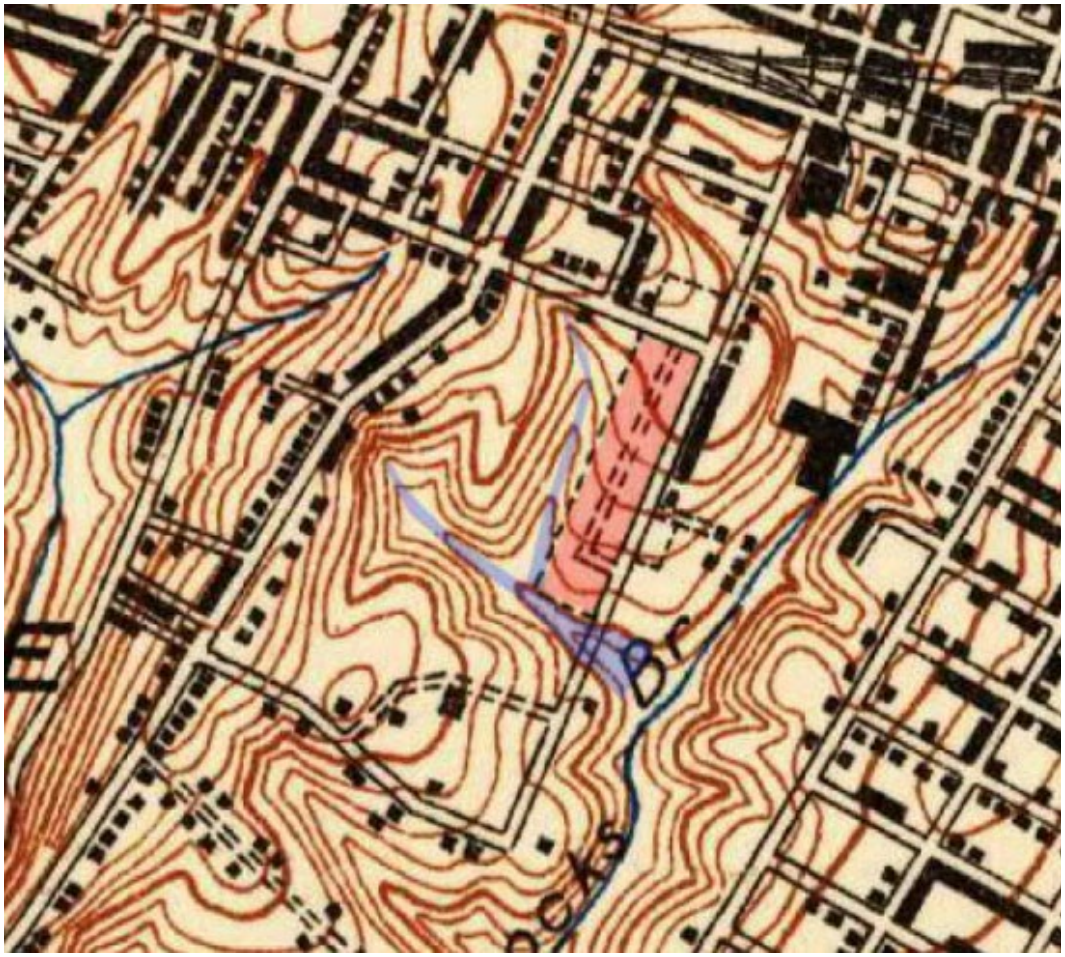

Figure 12 - Charlottesville and Vicinity, showing the red-shaded (ca. 1863) 'old' section of Oakwood

Cemetery and the blue-shaded drainages west and south of it following the topographic relief. Notice how the southern drainage broadens into a floodplain south of Oakwood Cemetery at its intersection with Pollock's Branch. U.S.G.S., 1935.

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Figure 13 - Aerial photograph from 1937 showing the approximate location of the red-shaded ca. 1863 'old' section of Oakwood Cemetery. Note the presence of the darker colored vegetation, the northern leg of the unnamed drainage of Pollock Branch, to the west of the old section of Oakwood Cemetery.

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Figure 14 - Aerial photograph from 1957 showing the red-outlined ca. 1863 'old' section of Oakwood Cemetery and the new yellow-outlined western and southern additions. Note the presence of a new southern road, the precursor to Elliott Avenue south of Oakwood, and a spur road connecting Oakmont on the north with 1st Street South on the east.

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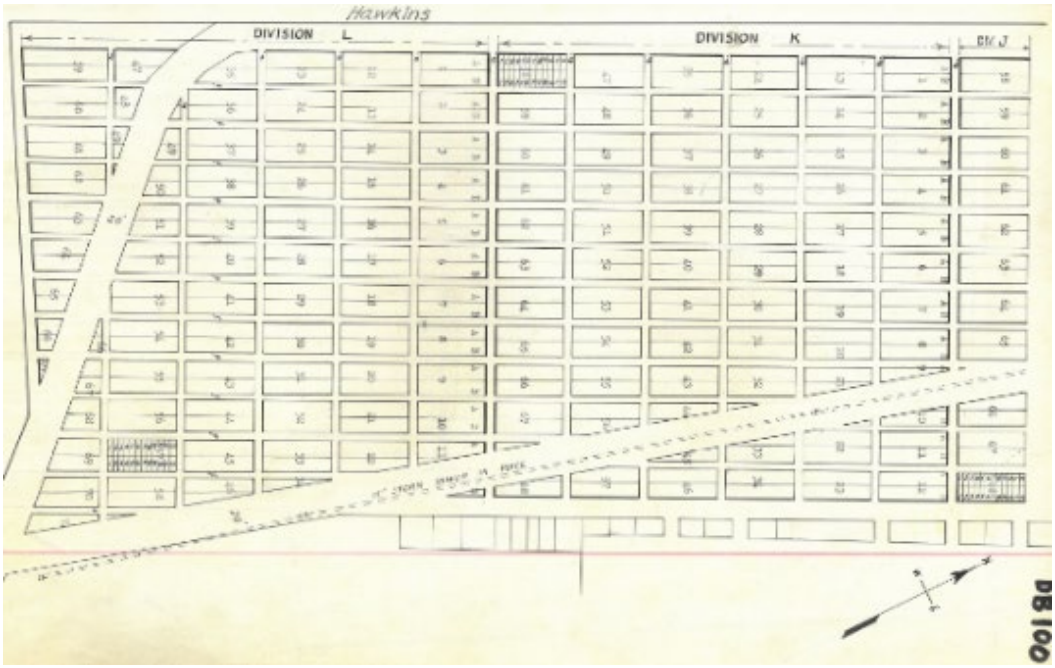

Figure 15 - Plat of the southern end of the western half of Oakwood Cemetery showing the road and a storm drain line paralleling its eastern side. North is to the right. No date [post-1938].

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Figure 16 – An aerial photograph from 1966 showing the boundary of Oakwood Cemetery (in red) and a new western extension of Elliott Avenue extending to the west to meet Ridge Street. Note the small remnant of the original tributary to the south of Elliott Avenue (in blue).

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Figure 17 – A topographic map showing the vicinity of Oakwood Cemetery and the location of what remains of the natural tributary low-lying areas (blue shade). Also note the low-lying formed to the north of Elliott Avenue and they are specifically demarcated by a different line-type in the survey (green shade).

Figure 18 – Map showing four known storm sewer pipes (red lines) in within the study area.

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Figure 19 – Map showing additional storm pipes (blue lines) discovered within the study area.

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Figure 20 - CCTV image upstream of a crushed pipe along the cemetery road adjacent to Elliott Avenue. Note the volume of water in the pipe.

Figure 21 - CCTV image downstream of a crushed pipe along the cemetery road adjacent to Elliott Avenue.

Figure 22 – CCTV Image within the 36-inch RCP pipe along Elliott Avenue. Note the wet seams along every pipe joint.

Figure 23 - CCTV Image within the 36-inch RCP pipe along Elliott Avenue. The blind pipe connection leading to the French drains within the Cemetery can be seen within the center of the frame.

Figure 24 - An earthen manhole type structure connecting the French drains within the cemetery to a pipe which will connect with the 36-inch RCP in Elliott Avenue shown in Figure 21.

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Figure 25 - Note the Location of the broken pipe, and the variation of the ground cover color between the broken pipe and the grounds adjacent to the pipe.