

Article

Integrated Archaeological Research: Archival Resources, Surveys, Geophysical Prospection and Excavation Approach at an Execution and Burial Site: The German Nazi Labour Camp in Treblinka

Sebastian Różycki ^{1,*}^(D), Rafał Zapłata ², Jerzy Karczewski ³^(D), Andrzej Ossowski ⁴ and Jacek Tomczyk ⁵^(D)

- ¹ Faculty of Geodesy and Cartography, Warsaw University of Technology, 1 Sq. Politechniki, 00-661 Warsaw, Poland
- ² Faculty of Mathematics and Natural Sciences, School of Exact Sciences, Cardinal Stefan Wyszynski University in Warsaw, ul. Wóycickiego 1/3, 01-938 Warsaw, Poland; r.zaplata@uksw.edu.pl
- ³ AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, al. Mickiewicza 30, 30-059 Kraków, Poland; karcz@agh.edu.pl
- ⁴ Faculty of Medicine, Pomeranian Medical University in Szczecin, ul. Rybacka 1, 70-204 Szczecin, Poland; andoss@wp.pl
- ⁵ Institute of Biological Sciences, Cardinal Stefan Wyszynski University in Warsaw, ul. Woycickiego 1/3, 01-938 Warsaw, Poland; j.tomczyk@uksw.edu.pl
- * Correspondence: sebastian.rozycki@pw.edu.pl; Tel.: +48-22-234-5358

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Abstract: This article presents the results of multidisciplinary research undertaken in 2016–2019 at the German Nazi Treblinka I Forced Labour Camp. Housing 20,000 prisoners, Treblinka I was established in 1941 as a part of a network of objects such as forced labour camps, resettlement camps and prison camps that were established in the territory of occupied Poland from September 1939. This paper describes archaeological research conducted in particular on the execution site and burial site-the area where the "death pits" have been found-in the so-called Las Maliszewski (Maliszewa Forest). In this area (poorly documented) exhumation work was conducted only until 1947, so the location of these graves is only approximately known. The research was resumed at the beginning of the 21st century using, e.g., non-invasive methods and remote-sensing data. The leading aim of this article is to describe the comprehensive research strategy, with a particular stress on non-invasive geophysical surveys. The integrated archaeological research presented in this paper includes an analysis of archive materials (aerial photos, witness accounts, maps, plans, and sketches), contemporary data resources (orthophotomaps, airborne laser scanning-ALS data), field work (verification of potential objects, ground penetrating radar-GPR surveys, excavations), and the integration, analysis and interpretation of all these datasets using a GIS platform. The results of the presented study included the identification of the burial zone within the Maliszewa Forest area, including six previously unknown graves, creation of a new database, and expansion of the Historical-GIS-Treblinka. Obtained results indicate that the integration and analyses within the GIS environment of various types of remote-sensing data and geophysical measurements significantly contribute to archaeological research and increase the chances to discover previously unknown "graves" from the time when the labour camp Treblinka I functioned.

Keywords: non–destructive methods; geophysical prospections; GPR; German Nazi Treblinka I labour camp; palimpsest; Historical-GIS; Maliszewa forest; archaeology in forested areas; COST Action SAGA (CA17131)



1. Introduction

Research into the relics of mass murder and traces of martyrdom during World War II in Treblinka is an element of a global research tendency to shape an interdisciplinary perspective in order to identify, protect, and commemorate past events.

The described initiative fits into an examination of the history of the 20th century, the history of World War II, and consequently into the research referred to as archaeologies of the contemporary past (archaeology of recent past) [1–4], forensic archaeology [5,6], conflict archaeology (modern conflict archaeology [7–9], painful heritage (difficult heritage) [10,11], historical archaeology [12–15], in addition to the fields known as the archaeology of totalitarianism [16], Holocaust archaeology [17,18] or criminal archaeology [19,20]. Contemporary archaeological research is clearly a contributor to the collection of new data about the history of concentration camps, and includes non-destructive methods such as remote sensing or geophysical surveys. In recent years, the use of the aforementioned research instruments has contributed to opening a new chapter in revealing the fate of often nameless victims, their identification, and numerous events from World War II, in addition to the period of the communist regime. Restoring victims' dignity and memory after decades of non-existence is a focus for discussion [21] and for practical implementation of interdisciplinary research in Poland, Europe, and globally [22,23]. The situation concerning the former forced labour and extermination camp, and execution site, at Treblinka appears similar [24,25]. On the basis of the established concept—comprehensive research into the past of the camp and its surroundings (which is a concept supported by the category of a palimpsest in examining and comprehending past events) [26,27]—various activities have been undertaken which have yielded new data on the past and relics of the camp.

An interdisciplinary approach was directed towards archive resources, geomatic techniques, specialist analyses, and field research, in particular, a geophysical survey. New research methods presented here are connected to historical-geographic information systems (GIS), remote sensing, geomatics, and geophysics. These methods become more significant in disciplines such as history or archaeology when dealing with mass murder and the past of totalitarian regimes. A special role in these initiatives is reserved for non-destructive research, among which the aforementioned geophysical examination played a significant part in the presented initiative.

Research on the German Nazi labour camp, the execution site, and the places (often previously unknown) where victims' bodies were deposited in Treblinka is another example of studies trying to derive a research methodology to implement non-destructive methods, while outlining an interdisciplinary path-together with the other initiatives mentioned above-for research on the victims of totalitarian systems. At a micro scale focusing on the history of the Treblinka I camp, with a particular emphasis on the execution site and the victims' burial sites, the conducted work is a specific continuation of research studies carried out by historians, previous archaeological projects, or the work of committees investigating Nazi crimes. Particular attention should be devoted to the areas, in addition to the camp itself, identified as the execution and burial sites (the "death pits") in the so-called Maliszewa Forest [28], which were analysed in detail in the course of the presented research. The locations of numerous pits—mass and individual graves in which corpses of shot victims or those who had died at the camp were buried—have become an integral element of the camp's past that is permanently linked to the history of the region, and were also subjected to exhumation work during the post-war period. The research pertains to a specific area, connected to the site of multiple executions and burials—both of victims who were meticulously executed, as well as those who died in the camp due to illness or ill-treatment. At this point in time, the space is not yet completely delineated or defined. It is unknown exactly how many victims are buried there for example, nor where exactly the remains are located or how they are spread out (fragmented interment, chaotic layout etc.). There are two types of burial site: (1) graves that were created in an intentional burial ceremony, including all the activities and elements necessary (e.g., burial in a coffin, clearly defined grave shape etc.) and (2) "graves" that are the outcome of burial (individual or mass burials) and unintentional disposal of

bodies or their fragments, called "burial sites", "mass graves", or "death pits". Taking into account the post-war activities found in subject literature, i.e., the looting of graves and burial sites [29,30], the specific character of the researched area has to also be taken into account—it should be understood as a mass burial site, which at this point in the research could be described as, generally speaking, an area where multiple bodies and human remains can be found. In subject literature there exist the following division: individual, collective, and mass burial sites, with the last term defined in broad terms as a grave containing the remains of more than one person, deposited at a certain time or at roughly the same time (in contrast to a mass grave, where the remains of the dead are subsequently deposited in a longer time period) [31–36]. Therefore, the area of the Maliszewa forest (Las Maliszewa) is a place where one encounters both individual graves, as well as mass graves (created at a fixed point in time due to a similar set of actions and circumstances). The article uses the terms "death pits" (in order to provide a descriptive name of the specific areas where murder and burial of the dead was conducted—understood as graves from a legal-formal perspective), as well as the terms "mass-" or "individual burial sites". The description of the aforementioned areas is not exhaustive when it comes to the issue of categorization and definition of such areas, but such a topic exceeds the scope of this text.

Since 1947, the camps at Treblinka I and Treblinka II have undergone treatment intended to preserve and commemorate relics. However, in order to fully preserve and commemorate all the camps' features, further action is necessary. In recent years, further research has been consistently carried out using technologies and remote-sensing data. This research has helped expand the knowledge of these features of the camps, including their history, location, and the state of preservation of their relics, in addition to the sites where remains of mass murder victims were deposited. So-called "sensitive sites" [37,38] include old (and forgotten) cemeteries, graves, and other places where human remains were deposited (these latter locations are frequently referred to as graves or burial sites, even though they are not relics of burials performed in accordance with specific rituals or ceremonies of a given religion). Using technologies and geospatial data, these sites have become elements visible to contemporary geomatic systems, and thus to the users of these tools, thereby helping to contribute to and fit in with the contemporary narrative of the past. A manifestation of such a narrative is the newly created Historical-GIS (HGIS)-Treblinka, a system fed by the data from, for example, geophysical surveys. The first research campaign was carried out in 2016–2018 and included extended spatial data analysis, geophysical measurements, and excavation work. The results from the first campaign were used to select new research areas and conduct geophysical and excavation surveys in 2019 and those planned for the coming years. The aim of this study was to use multi-source spatial data and geophysical measurements as a preliminary mapping tool to guide archaeological excavation.

2. Study Area

The labour camp Treblinka I was established in the late summer of 1941, in the vicinity of a gravel quarry located between the villages of Treblinka and Wołka Okraglik. It was the area of the Warsaw District of the General Governorship including a section of the territory of the II Polish Republic occupied by the Germans. The camp commander, throughout the entire period of its operation, was Theo van Eupen [39]. During the first period of the camp's operation, the buildings (in the proper camp itself) were used, which were built by the Fabritz-Betonwerke Company, and then purchased for the labour camp [40]. Officially, the German authorities stated that solely "criminal elements" were sent to the camp. However, civilians were also sent to the camp, to be punished in revenge for armed attacks of the Polish underground, for ignoring the curfew, or for signs of resistance against representatives of occupational forces. Initially, mostly Poles were sent to the camp; later the number of Jewish prisoners (mainly from Poland) increased. The history of the camp, including the execution site in the Maliszewa Forest (Figure 1), involves victims of other nationalities, including the mass-murdered Romani and Sinti. Prisoners worked mainly in the gravel quarry adjoining the camp. A total of 20,000 prisoners passed through the camp, an estimated 10,000 of whom either died or were shot dead in the so-called Forest in Maliszewa village [41]. This was the site where the bodies of victims of hard labour

were buried, and where the wounded, emaciated, and those sentenced to death for various offences were shot. From April 1942, Polish Jews from the Warsaw Ghetto were executed here, and in the years 1942–1943 Romani and Sinti were shot here. Ukrainian guards who died of typhus were also buried within this area [40–42]. In the late fall of 1944, when the Eastern Front was approaching, the camp

was abandoned and destroyed.



Figure 1. (**A**) Geographical location and (**B**) aerial view of the area of former Treblinka I and Treblinka II camps. The investigated area with geophysical surveys and archaeological excavations is highlighted with red rectangles. The yellow polygon shows the border of the Museum in Treblinka. The blue polygon shows the border of the former Treblinka Labour Camp reconstructed using a 1944 aerial photo. The green polygon shows the actual commemorated border of Treblinka II extermination camp. The cyan rectangle marks the probable area of execution and burials. (**C**) Magnification of the area in which geophysical surveys and archaeological excavations were conducted. Coordinate grid: Polish Coordinate System 1992 (EPSG: 2180). Copyright: Head Office of Geodesy and Cartography in Poland.

To date, the execution site in the Maliszewa Forest has been commemorated with a monument in 1964, in addition to specifically planned informative elements and land development of the area (e.g., commemorative plaques, partial clearing of the area, and creating a network of roads and pathways). Currently, in addition to parallel crosses placed on the main site of mass executions and burial of the murdered, a number of death pit graves have also been marked by individual crosses in the area (Figure 2A). This memorialisation resulted from previous site research [17,18,23–25] and identification of the places where a portion of the bodies of the murdered had been deposited. These partial discoveries encourage further research to locate additional sites where human remains were buried, in addition to marking them in situ.

The area of the aforementioned Maliszewa Forest, and particularly sites that had been singled out as potential death pits, were the subject of detailed research within the presented article. Currently, the entire study area is overgrown by 50-year-old pine woods and is located within the limits of the Treblinka Museum. The site was previously partially cleared, and currently it covers an area of 15.5 hectares within the Treblinka Museum area. The entire area of the museum covers 138 hectares, the majority of which is forested, without a clearly documented subsurface and contains relics that are still preserved.

Multiple instances of burial sites and human remains can be located within the Maliszewa forest—they have been documented and marked in the field. Furthermore, they can be classified as either: (1) mass graves or (2) individual graves (Figure 2B). Until 2016, 16 points of interest were located within the analyzed area that can be connected to the places of last rest of those murdered and expired—"death pits" of various sizes and shapes (one of them commemorated with a group of systematically set up crosses (Figure 2A). The aforementioned points of interest were never geophysically analyzed before, and these areas themselves were never systematically analyzed using the aforementioned methods. Therefore, the conduct of such activities would allow for the creation of a data set—a geophysical representation of the execution and burial site of terror victims.

During preliminary research, a proper analysis of the surrounding environment materials (i.a. geology, soils properties) is a well established requirements for a success investigation [43]. Understanding the influence of different environmental settings on various geophysical techniques is essential to fully exploit the potential of these non-invasive approaches [44]. The consideration of environmental settings and in particular of soils and sediments during archaeo-geophysical prospection is a one of the main aim of COST Action SAGA: The Soil Science and Archaeo-Geophysics Alliance-CA17131 (www.saga-cost.eu), supported by COST (European Cooperation in Science and Technology). The Maliszewa Forest is located in the north-eastern part of the Wołomin Plain [45]. Its area is composed of three main landforms: outwash plain covered by Late Pleistocene–Early Holocene aeolian sands in the central and the north-western part, stagnant ice plateau on the east, and flat moraine plateau on the south [46]. These landforms formed during the late stage of the Odranian (Saalian) glaciation period [46]. The studied area is located in the "outwash plain" part of the Maliszewa Forest. The geological background of the area is composed of gravel and sand of various fractions, which also contain numerous pebbles and boulders of Scandinavian rocks [46]. The adjacent areas to the studied area are covered by aeolian sands, locally forming dunes. The soils in this area belong to the Albic Podzols type according to FAO-WRB classification.



Figure 2. (**A**) Crosses on the execution site and mass graves; the so-called Maliszewa Forest (2016); photo: R. Zapłata. (**B**) Board with information about the research conducted by the authors in 2017, mounted at the site of the conducted archaeological survey; photo: S. Różycki.

3. History of Research

The archaeological research concerning the Treblinka I or Treblinka II camps, in addition to the execution site in the Maliszewa Forest, has a short but intensive history: forensic archaeology has been conducted since 2010, and was preceded by exhumation work and archival research.

The latter were related to the interference and invasive work carried out soon after the end of World War II, which led to the remains being removed from the place where they had been deposited, based on the site inspection or accounts of witnesses and camp prisoners. Commissions for the prosecution of German Nazi crimes carried out inspections of the site and exhumations in selected places several times between September 1944 and November 1945 [29,30]. The documentation from that on-site

inspection is scant and does not allow the sites of field research carried out by the commission to be precisely identified. The results of these studies did not end with commemorations in the field; it is likely that a number of mass graves were not marked in the field and have been forgotten.

The first archaeological field research in the labour camp area and the execution sites was carried out by the staff from the Centre of Archaeology from Staffordshire in 2010 (preliminary surveys preceding the aforementioned research, interviews, and on-site inspections were carried out from 2007). These works allowed the character of the area and traces remaining at the camp to be described, and archaeological prospections to be carried out. A range of complementary data, including remote sensing, cartographic, airborne laser scanning (ALS), and other methods (GIS analysis, geophysical prospection, and archaeology excavation) were used to locate, record, and interpret the physical evidence at the labour camp and execution sites in Treblinka I [23,41]. Complementary examinations of the materials and relics of the camp and human remains is currently underway using the entire range of non-destructive methods and remote sensing data. Initiated in the first decade of the 21st century (and carried out parallel to the discussed project in recent years), the research supervised by Caroline Sturdy-Colls is an example of an application of remote sensing and forensic archaeology (i.e., Holocaust archaeology) [17]. The research allowed new places where human remains were detected to be identified, for instance, at the so-called execution site, thus contributing to building an updated map of post-camp features and their surroundings (part of the results of the research is under preparation) [18,23–25,41].

Since 2015, complex research in this area has been carried out by a team from the Warsaw University of Technology, with an interdisciplinary team of experts from diverse institutions and scientific-research units [42]. This research set an independent direction by also using remote sensing, which minimizes disturbance of the soil and sensitive sites by prioritising non-destructive prospection. It is a perspective in which German Nazi camps (with their context) are researched as a specific form of palimpsest [26,47], i.e., cultural texts superimposed on the landscape of Treblinka and its surroundings, before, during, and after the camp ceased to function, thus constituting a central axis of the research. Using the geomatic and remote-sensing tools and data, while analysing the context of the place and processes (e.g., natural processes) that led to blurring the traces of the camps' operations, it was attempted to (1) recreate past events, (2) locate and compile particular elements of the extermination camp, and (3) follow the processes which have taken place in this area until the present. The project refers to research that concerns the analysis and inventory of the military infrastructure [48], so also includes elements outside the camp. The history of land use and development of the site and its surroundings also plays a significant role in determining the methodology for researching such places. The camp and its surroundings are perceived as a cultural space where, for instance, elements of past events were erased (e.g., deliberate destruction of camp structures) while, at the same time, the landscape was filled in with new elements (e.g., as a result of various land development processes in the former camp and its surroundings, including the afforestation process [49]). Therefore, the research was carried out on the assumption that learning about these phenomena is an inherent element both in understanding past events and analysing the current state of the relics of the labour camp tragedy.

4. Materials and Methods

During the years of research, the work was completed according to a definite (and constantly updated) research pattern (Figure 3). The approved research procedure borrowed from various methods bordering on forensic archaeology [50–54] or Historical-GIS [55–58], and adopted guidelines and good practices [59–61]. It also included elements created to meet the requirements of the research conducted on the site of the German Nazi labour camp Treblinka I and its associated structures. The results of these procedures include newly identified and partially discerned structures and data that were continuously added to the Historical-GIS Treblinka platform, thus constituting an element of further work to examine, protect, and commemorate the camps in Treblinka. The interdisciplinary team attempted to analyse changes that occurred in the area since the time when the camp was

established, as well as to identify and inventory elements discernible under the surface, in particular using geophysical methods.



Figure 3. Sequence and elements of the research procedure implemented during the Historical-Geographic Information System (HGIS)-Treblinka project.

4.1. Archival Queries and Data Processing in Geographic Information System (GIS) Laboratory

Archive resources obtained as a result of preliminary queries concern witness accounts and testimonies, but also broadly relate to data describing the space of the camp itself and its vicinity. Regarding witness statements, original accounts and testimonies were considered during the research. A substantial part of these were previously popularized in the literature of the subject, yet in many cases original documents were not enclosed or cited. An analysis of original records in Polish, German, and Yiddish allowed additional information describing the operation of the camp itself and the execution site located in the Maliszewa forest to be acquired.

The subsequent stages of work focused on scientific queries that aimed to obtain the largest possible amount of spatial data in the form of archive aerial photographs, topographic maps, plans and sketches, and archive satellite photographs of the CORONA system. Archive aerial photographs were found to be of key importance for the research. As a result of a query (in the National Archives at College Park (NARA), Maryland, MD, USA), an aerial photograph at the scale 1:18,000 taken on 15 May 1944 was acquired. The photo from that flight encompassed the entire Forced Labour Camp Treblinka I and the places where executions were carried out. The choice of the photo was determined by its interpretative value, i.e., the appropriate scale and radiometric quality, and the date when it was taken. The aerial photography taken in May 1944 represents the camp at the peak of its operations, and numerous soil disturbances are visible at execution sites. At the data processing stage, the aerial photography underwent a process of orthorectification using the Geomatica OrthoEngine (PCI Geomatica OrthoEngine, Markham, ON, Canada) software. To determine potential sites (i.e., pits in execution areas) a visual analysis of archive material was applied, generating a vector layer and, subsequently, correlating information with the remaining data. Interpretations of archive photos were based on a comparison of locations and measurements of known pits with the visible characteristic (i.e., outstanding) features in the photographs. Then, similar features were identified, thus determining a set of potential sites for further research. Previous research has shown that archive resources are enhanced by analysing and correlating aerial photos with ground photos, which allows changes in the land at locations where mass graves are found to be analysed [48].

The next group of archive materials includes maps, plans, and sketches. In geoinformation systems, because of their correlation with other materials, these resources have acquired new analytical potential. Such was the case of the execution site in the Maliszewa Forest, where the changes in the land surface were analysed. The researchers used sketches and plans made by witnesses and held in the Jewish Historical Institute (Poland) and the Institute of National Remembrance Department in Koszalin (Poland), and topographic maps.

In a sense, the collection of data using ALS, which was collected within the Nation Protection ystem project [62] in recent years, is already archive material. The ALS data were collected in

IT System project [62] in recent years, is already archive material. The ALS data were collected in the period 2007–2013, with an average point density above 4 pts/m². The horizontal accuracy was 0.20 m and the vertical accuracy was 0.15 m. Recognition of potential historical objects was based on layers generated from a digital elevation model (DTM). These products were produced using the Relief Visualization Toolbox (RVT v. 2.2.1, Research Centre of the Slovenian Academy of Sciences and Arts, Ljubljana, Slovenia). The following results of ALS-based DTM processing were used in the interpretation:

- DTM relief hillshade for eight azimuth positions: 0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°, and the horizon of 20° (the hillshade is a 3D or 2.5D representation of the surface, with the sun's relative position taken into account for shading the image) [63].
- Local relief model—a map presenting the relation between analysed points and their neighbouring values [64].
- Slope exposure map—a map presenting the azimuth of ground (stocks) exposition [65].
- Aspect—a map presenting the degree of slope [66].
- Sky-view factor—a map presenting the proportion of the sky visible from a given point, allowing determination of the percentage of terrestrial visibility [67].

An analysis of ALS data processing constituted an integral part of the conducted research, contributing to generating a height difference map of the site while supporting the integrated interpretation. This interpretation was based on data obtained at various periods and from diverse sources. In the analytical studies, two main forms of processing with the largest potential for the conducted research were applied: a hillshade relief model and a local relief model, based on a digital elevation model (DEM) with a 0.5 m raster [68].

Collecting, processing, and analysing data, and then preparing derived products, was based on several GIS tools, and the software ArcGIS (ArcGIS v.10.6, ESRI, Inc., Redlands, CA, USA) and QGIS (v. 2.18.4 and 3.4.9, open-source software) was used to build the Historical GIS-Treblinka platform.

4.2. Ground-Penetrating Radar (GPR) Survey

Geophysical surveys constitute yet another group of field work of key importance for the realised research. This kind of field investigation was used because of numerous indications of the high potential of the above-mentioned methods in recognising such areas, and because the area in question had not previously been extensively examined using these methods. The geophysical method most frequently applied for locating burial places is the use of GPR [69,70]. The GPR method belongs to the group of electromagnetic methods [71]. The measuring equipment consists of two antennae: one transmitting and one receiving. The transmitting antenna emits an electromagnetic impulse into the rock mass, which is then reflected, refracted, and attenuated in the medium [72]. From the perspective of the GPR method, the most important phenomenon is reflecting the wave on the boundary of two media with different permittivity. The contrast in permittivity between the target feature and the surrounding medium is an important parameter. The larger the contrast, the larger the amplitude of the reflected wave. The reflected wave is recorded by the receiving antenna. Because of considerable attenuation of the electromagnetic wave in a geological and pedological medium, and the limited power of the transmitting antenna, the range of the GPR method does not exceed several dozen meters [73,74]. The depth range of the GPR method also depends on geological conditions and the humidity of the examined medium [75]. Taking measurements involves moving the antenna along a marked profile; the image obtained is a reflection of the structure of the geological medium. During GPR measurements, an antenna at a frequency between 10 MHz and around 3 GHz can be used [74]. The higher the frequency, the smaller the depth range, but the better the resolution. Because of the depth range and geometry of the survey targets, antennae at a frequency between 250 and 800 MHz are optimal in the search for burial sites. Depending on geological and soil conditions, an antenna with a frequency of 250 MHz has

a average depth penetration range of up to 10 m, and an 800 MHz antenna up to 3 m [74]. A 500 MHz antenna seems to be a reasonable compromise between depth penetration and resolution. The GPR method has a number of advantages: high resolution (when using high frequency antennas), speed of data acquisition in the field (under favourable environmental conditions), and preliminary in situ interpretation. GPR methods have been used in the search for victims from World War II [76–78] and those of the civil war in Spain 1936–1939 [79].

For the GPR research, two sets of measuring equipment and measuring parameters (see Table 1) were used consisting of devices, acquisition software, and software for processing registered data. During the two measurement campaigns, very similar parameters were used (time window), and the frequencies of the antennas were comparable to each other (500 and 400 MHz).

Area	GPR Equipment	Antennae	Year of Acquisition	No of Profiles	Length of Profiles (m)	Distance Between Profiles (m)	Time Window (ns)
GPR1	X3M	500 MHz shielded	2018	4	13.5	1	70
GPR2	X3M	500 MHz shielded	2018	4	12	1	70
GPR3	SIR 3000	400 MHz shielded	2019	11	10	0.5	50
GPR4	SIR 3000	400 MHz shielded	2019	3	4.2	0.5	50

Table 1. Technical data of ground-penetrating radar (GPR) surveys.

While taking measurements with the X3M radar, the antenna was moved directly on the ground (Figure 4), and while using the georadar SIR 3000, the antenna was mounted on a special cart with a precise system for calculating distances. Two measuring campaigns (one day each) were conducted (August 2018 and September 2019) to: (a) obtain new data and information (after interpretation of archival aerial photos and spatial data such as that from ALS) needed for carrying out later excavations (areas labelled GPR 1 and GPR 2) and (b) verifying new and previously examined objects (GPR 3 and GPR 4). Locations of those areas are presented in Figure 5. Areas GPR 1, GPR2, and GPR 4 are depressions visible in the ground, which coincide with soil disturbances (close to a circle with a radius of 2 m for GPR 1 and 2; rectangle 3×2 m for GPR 4) noticeable in the aerial photograph from 1944. It is worth mentioning here that the area GPR 2 is a land depression marked by two crosses. It is not known when the commemorative crosses were placed there, or whether exhumations were carried out on this site after World War II. GPR 3 is the area of the current parking lot, where cars and buses with visitors usually stop. The X3M georadar was used in the areas GPR1 and GPR2, and the SIR 3000 radar was used in the GPR3 and GPR4 areas. In the GPR1 and GPR2 areas, a 1 m grid was made of parallel profiles. In our case single echograms (B-Scans) were analyzed. The distance of 1m between the profiles for the 500 MHz antenna, taking into account the footprint of the antenna, seems sufficient, especially if we are looking for graves.



Figure 4. GPR measurements in the GPR1 area; photo: S. Różycki.

In measurements using the Mala GeoScience X3M device, the distance between traces was set to 0.03 m and the number of stacks to 16. While measurements were being taken, a measuring wheel (i.e., a device to measure distances) was attached to the georadar. These parameters ensured a useful signal from a depth of about 3 m below the surface was registered. Using Global Positioning System (GPS) technology, the team was able to establish a start and end of each profile to the nearest 5 cm horizontally. The entire measurement material was processed using the Reflex software of the Sandmeier company. Processing was aimed to improve the correlation of useful reflexes, improve the S/N ratio, and isolate anomalous zones in GPR reflection profiles. For the time-depth conversion, it was assumed that the velocity of the electromagnetic wave in the medium was equal to v = 0.1 m/ns. This value was based on the type of soil (sandy soils) in the test area. WARR profiling was not carried out in field.



Figure 5. The location of ground-penetrating radar survey profiles (GPR). Coordinate grid: Polish Coordinate System 1992 (EPSG: 2180). Copyright: Head Office of Geodesy and Cartography in Poland.

In GPR3 and GPR4 areas, where georadar SIR 3000 was used, the following measurement parameters were selected: electrical permittivity (dielectric constant) was set at 9.0 (which is equal to the velocity of v = 0.1 m/ns); 50 traces/sec. Measurement data were processed using the Quick3D and RADAN 6.5 software (both: Geophysical Survey Systems, Inc., Nashua, NH, USA). The raw GPR

data files were filtered by applying: range gain, horizontal and vertical low pass filters (RADAN), and background removal, AGC—Automatic Gain Control (Quick3D).

It should be recalled that in order to locate a burial site, the profile has to be made directly above the former grave. For this reason, best results are obtained when a grid of parallel profiles is applied (or possibly cross-cut with perpendicular profiles). The distance between the profiles should not be bigger than 1 m. Then it is possible to recreate a complete image of the medium beneath the examined surface. When taking measurements, a tracing tachymeter can be used (the prism is installed on the georadar antenna) or a GNSS precision device [80]. To locate on the actual site the anomalies visible in GPR reflection profiles registered without the use of geodetic equipment is very difficult and can be inaccurate. This is particularly true of measurements taken in forested areas or other difficult sites. During GPR measurements (with a 500 MHz antenna), it is possible to locate the boundaries of the trench, possibly large bone clusters, or large subsurface heterogeneity. Locating single bones is practically impossible [81]. In the GPR reflection profile one can see a disturbance in the continuity of subsurface layers. Unfortunately, this applies to a much lesser extent when locating graves from several decades ago.

4.3. Surveys, Drillings, and Archaeological Excavations

Surface prospection that accompanies geophysical research allows for the character of particular sites to be visually determined. Comparing known information with the vegetation occurring in a given area is a significant element of the examination, and can contribute to identifying so-called plant markers, i.e., places where once-disturbed soil can have an impact on the growth and development of specific types of low and medium plants (Figure 6) [82]. An on-site inspection also allows subsurface layers in the soil to be identified, e.g., in hollows made by wind-fallen trees.



Figure 6. (**A**) Example of diverse vegetation; low and medium greenery in the vicinity of one of the pits, test dig 1. Area cleared of low vegetation; photo: R. Zapłata; (**B**) visualisation of airborne laser scanning (ALS) data (local relief model, radius: 10 pix.) with indicated cluster of known death pits (larger red ellipse) and an indicated site where archaeological excavation was conducted (smaller red ellipse).

In the first archaeological campaign (2016–2018), potential pits were verified using spot drilling, which allowed stratification differences in places to be identified, ultimately contributing to the elimination of those features which were not of natural origin but manifested as anomalies in geophysical prospection. Test digs were crucial to the research, including geophysical prospections.

They were conducted to confirm the occurrence of geophysical anomalies i.e., anthropogenic features. Because there was a possibility of finding human skeletal remains, it was decided that interference would be minimal, reduced to surveying and digging small test pits. Large-scale archaeological excavations were by definition not appropriate. The work was carried out based on survey trenches, which in many places cut across features, with the possibility of surveying the whole area. Exploration was carried out until human remains were encountered. The level at which remains were deposited indicated (during exploration) the maximum depth of the trenches, which represented the "end level" of the excavation work. Skeletal remains were carefully documented, without removing them from their resting place. After documentation was completed, the test pit was filled in, with the stratification layers deposited in the original order. The first archaeological campaign was conducted by the Warsaw University of Technology with a team of specialists. The research adopted a standard exploration technique used in archaeology (especially in legal archaeology [83]) which employs stratigraphic exploration and descriptive documentation, as well as measurement, creation of drawings and photographic documentation. The research was conducted as a manual exploration process based on sifting through stratification entities, in order to, to the extent that it is possible, fully identify the contents of burial pits. The exploration of those same pits was based, i.e., on the analysis of the stratification entities—the fillings of the pits—taking into consideration the granulation, color, and cohesion of the aforementioned points of interest.

The research carried out in the years 2016–2018 contributed to obtaining data and results which were used (while becoming a platform for further research) in the second campaign conducted in 2019 by the Prosecution of the Institute of National Remembrance in cooperation with the Pomeranian Medical University in Szczecin. The mission of the Institute of National Remembrance—Commission for the Prosecution of Crimes against the Polish Nation is to research and popularize the modern history of Poland and to investigate crimes committed from 8 November 1917, throughout the Second World War and the communist period, to 31 July 1990. The second campaign was a separate activity with its own purpose whose form was determined by prosecutor's proceedings with particular measures and methods [84]. The campaign in 2019 included an extended archaeological survey and was supervised by the Rabbinical Commission for Jewish Cemeteries in Poland.

5. Results

5.1. Results of Archival Query and Data Processing in GIS Laboratory

The work commenced with an analysis of documents and accounts, which allowed the places where victims' remains could be found to be initially determined to carry out geophysical prospection at specified sites. Descriptions of execution sites were looked for as they could support interpretation stages of cartographic materials and on-site inspections, with particular consideration of characteristic in-field features. The majority of witness accounts describe executions on the edge of or in the woods by the village of Maliszewa:

"We were all laid face down on the ground. Then groups consisting of 10 to 20 people were led into the forest. In the forest three huge pits had been dug, three meters deep, and of varying length, next to which people were shot in fives" [85].

"Then guards pushed him with their machine guns to the group and on the edge of the forest in the previously dug out pits everybody was shot dead" [86].

Execution sites are also described in detail in the investigation records (9 August and March 1946) prepared by the coroner Zdzisław Łukaszkiewicz. During its inspection of the site, the commission also found traces of damage on tree bark caused by firearm rounds [87]. Unfortunately, information concerning tree damage cannot be used in the field research because now the area is covered with a 50-year-old wood.

The collected accounts were compared to the spatial data obtained. First, coordinates of the grave pits currently commemorated with crosses were obtained on the basis of visits to the site and geodetic measurements (GPS, Total Station). After uploading the coordinates into the ArcGIS software and correlating with archive data, they were observed to coincide with changes in the land (features in the shape resembling circles and a light hue; Figure 7B) visible in aerial photographs from 1944 (Figure 7A).



Figure 7. (**A**) Digital orthophotomap from an aerial photo from 1944 (© NARA); (**B**) orthophotomap from 1944 with superimposed grave pits commemorated by crosses on the site (© NARA); (**C**) orthophotomap from 1944 with superimposed grave pits commemorated by crosses on the site and test digs (© NARA); (**D**) orthophotomap from 1944 with grave pits commemorated by crosses on the site and GPR measurement profiles (© NARA); (**E**) compilation of vector features presented on drawings 7B–7D on the base of the orthophotomap from 2017 (© Head Office of Geodesy and Cartography in Poland). The location of ground-penetrating radar survey profiles (GPR). Coordinate grid: Polish Coordinate System 1992 (EPSG: 2180).

It was assumed that similar areas with changes in the ground, visible in the photograph from 1944, might indicate more execution or burial sites. The site located along the road which, in 1940, used to be the north boundary of the Maliszewa woods, was selected as the research area. In the presented aerial photo, it can be clearly seen that in May 1944 the Maliszewa Forest was about 120 m from the road. Therefore, the area selected for the research is not covered by vegetation or forest because of continuous logging of trees. Clearing the forest which, on the topographic maps from 1940, bordered the road, commenced when the Forced Labour Camp Treblinka I began to operate [42,48]. Thus, the selected research area was considered a potential burial place of victims from the first stage of the camp's operations. Forest clearing allowed filled-in grave pits on archive aerial photographs to be recorded. These grave sites were further confirmed by the analyses conducted upon witness accounts, which revealed that executions were carried out on the edge of the forest or in the pits in the forest. Witnesses saw both fresh and filled-in pits.

The selected research area was characterised by soil disturbances (light or light grey hue) visible on the photograph from 1944, and not previously commemorated, nor were there any archaeological excavations or other research conducted there since the post-war commissions. The selected disturbances did not resemble the circle-shaped disturbances; their outlines were less regular. However, at that stage it could be surmised that the visible light hues on the aerial photograph from 1944 might indicate the occurrence of potential burial sites. Before the two camps were established, the execution site had been a forest that gradually cleared towards the south, which can also be seen on archive aerial photos, in the form of small light-hued spots on the ground, directly beside the road along the west to east (W–E) line of Maliszewa Forest.

As a result of the analysis of archive resources, six areas within the Maliszewa Forest were chosen for field work, and thus for geophysical research (Figure 7C,D).

5.2. GPR Results

Areas GPR1 and GPR2 are characterised by relatively low attenuation of electromagnetic waves (considerable depth range). The registered image is badly distorted (significant diffraction and badly distorted layout of subsurface layers). After processing all of the profiles made on the parallel grid, it was attempted to correlate anomalies in adjoining profiles. Anomalies (similar values of samples on adjacent traces) located close to the surface (within the bracket 0.3–2.0 m below ground) were particularly sought. In GPR reflection profile no 1 in the GPR 1 area (Figure 8A), two anomalies can be found: 3.40–4.20 m, 0.3 m deep, and 10.00–12.00 m, 0.5 m deep. One can also see an outline of a grave pit between 2 and 12 m in profile (marked with a line in the GPR reflection profile).

The outlines of grave pits are also visible in parallel profiles 2 (Figure 8B) and 3 (Figure 8C) in the GPR 1 area. One could attempt to identify anomalies located within the outline of the grave pit with bodily remains. Results obtained predisposed this area to be verified in the course of excavation work by a survey dig.



Figure 8. GPR reflection profile from GPR 1 area, X3M device with shielded antenna 500 MHz. Yellow rectangle marks anomalous zones: (**A**) profile 1; (**B**) profile 2; (**C**) profile 3.

In the GPR reflection profile from profiles 4 and 5 (not included with this article) the boundaries of the grave pit are no longer visible. It is probable that the discovered burial pit breaks off, which does not mean the end of the burial zone. More anomalous zones at 1–2 m, 2.5–3.2 m, 3.5–4.5 m, 9.5–10 m, and 10–11 m, can be located in GPR reflection profile 2, recorded in the GPR 2 area (Figure 9). The depths of these anomalous zones vary. All of the zones are marked with yellow rectangles.

In the GPR 2 area, the edges of the grave pit are not as clearly visible as that in the GPR 1 area. It can be assumed that in this case, we may be dealing with a burial pit that has been either exhumed or its filling is homogeneous with the surrounding medium. No excavation work has been carried out in the GPR2 area.



Figure 9. GPR reflection profile from GPR 2 area, profile 2, X3M device with shielded antenna 500 MHz. Yellow rectangle marks anomalous zones.

In the parking lot (the GPR 3 area) numerous irregular anomalies were located. Their depth and size provided a basis for digging test pits. The two most prospective anomalies were marked in yellow (Figure 10).



Figure 10. Time slice at a depth of 0.75 m for GPR3 area (parking lot), SIR-3000 device. Profiles made every 0.5 m on the *X* and *Y* axes. Yellow color marks irregular anomalies.

The research carried out in the GPR4 area showed anomalies typical for regular individual burials (Figure 11). The enclosed GPR reflection profile shows two anomalies typical for burials: 0.5–1.0 m and 2.0–2.8 m. The sources of the anomalies are very close to the surface (0.5 m).



Figure 11. GPR reflection profile from profile 2; GPR 4 area; SIR-3000 device. Yellow rectangle marks anomalous zones.

5.3. Archaeological Data from New Trenches

During the first season in 2016, the research area was overgrown with trees, and low and dense vegetation on the forest floor. To carry out an archaeological exploration, museum employees cleared low vegetation from the selected areas. According to the implemented procedure, the clearing process did not involve removing plant roots. The process was repeated during subsequent research seasons. Depressions identical to the soil disturbances visible in the aerial photo from May 1944 were observed in the area. After preparing the area, archaeological excavations commenced with the digging of test pits combined primarily with specialist analyses and the anthropological examination of human skeletal remains.

The area of Trench 1 was selected after analysing the results of GPR measurements taken using the X3M device (see the GPR 1 area). Localisation of this trench superimposed on GPR profiles is visualized on Figure 12A. The work in the test dig started by removing forest litter, and then a layer of humus beneath which a cultural layer was found which constituted the infill of a grave pit. At the depth of 0.8 m, fragments of skeletal human remains (proximal epiphysis of the right humerus) were identified and documented. The head of the bone is not joined to its body, which indicates that it belonged to a young person who did not reach the age of 20–22 years [88]. The arrangement of the layers and the direction of the depression towards the west (beyond the research area) indicate that the remaining (larger) part of the grave pit is situated on the site lying to the west of the marked boundary of the area of research. An analysis of the situation suggests that the grave pit is partially located beneath the contemporary forest track. The research identified the edge of the pit of the original dig, which in combination with archive data, e.g., aerial photographs or ALS data, allowed a hypothetical outline of the pit where human skeletal remains are buried to be marked. Thus, research surveys confirmed the indications of the geophysical prospection, while also providing data for a re-interpretation of geophysical data.



Figure 12. Photos of stratigraphic surveys: (**A**) left: no. 1 trench excavation; photo: R. Zapłata; right: GPR1 profiles superimposed on trench 1 area and orthophotomap from 2017 (© Head Office of Geodesy and Cartography in Poland). (**B**) no. 2 trench excavation; photo: S. Różycki; (**C**) no. 3 trench excavation; photo: S. Różycki.

Trench 2 cut across one of the depressions. After removing the humus layer an outline of a pit 1.6 m wide was discovered. Within and outside the feature, cartridge cases for a Mauser 7.92×57 mm and TT 7.62×25 mm were found. Outside the pit they were only found lying close to the soil surface, and inside along the entire thickness of the pit. At the depth of 1.4 m from the soil surface human bones were discovered: a left femur and a proximal epiphysis of the left tibia (Figure 12B). Both visible epiphyses were well joined, which suggests that they belonged to an adult over 20–22 years old. The femur shows a poorly developed linea aspera, which might indirectly suggest a female skeleton [88].

In the third test dig (Trench 3), after removing the humus layer an outline of a pit 0.9 m wide was discovered in the central part of the trench. During the excavation at the depth of 0.6 m from the surface, a braincase (Lat. neurocranium) was found (Figure 12C). All of the cranial sutures were fully obliterated, which indicated an adult person. The preserved section of the right temporal bone shows a poorly developed mastoid bone (Lat. procesus mastoideus), indicates that it was a female [88].

Trench 4 was located farthest towards the north-west and encompassed one of the elongated depressions in the ground. After the outer layer of humus was removed, at the depth of approx. 0.1 m, an outline of a pit was revealed. A decorative iron wreath with wrought leaves of oak and other plants was found at the depth of approx. 0.8 m, by the western edge of the pit. The wreath was covered with rust, yet plant motifs were recognisable. At the level of approximately 1.60 m from the surface an outline of a coffin was revealed, in the form of a thin layer of rotten wood, in addition to human

bones. When they were cleaned, it was found that they were parts of a probably complete skeleton lying in the standard anatomical position. Among the grave goods there was a copper ring and a comb (Figure 13A). In the Trench 4 area the research continued in 2019. First, the georadar SIR 3000 was used (GPR 4). The profiles were located crosswise to the identified grave. The conducted excavation revealed another six regular burials situated in a straight line parallel to the road. These test surveys also positively verified the indications from geophysical prospection.



Figure 13. Photos of stratigraphic surveys: (**A**) no. 4 trench excavation; photo: S. Różycki; (**B**) no. 5 trench excavation; photo: S. Różycki; (**C**) aerial view of no. 6 trench excavation area; photo: A. Ossowski.

Trench 5 encompassed one of the elongated depressions in the ground, and measured 2.5 m (east–west) by 1.5 m (north–south). After removing humus, at the depth of approx. 0.2 m, the outline of the pit became clearer. At the level of approx. 0.5 m from the surface, a metal cartridge case for a Mauser 7.92×57 mm was discovered. The excavation continued to the depth of approx. 1.5 m, at which level human remains were found. These were a skull, a pelvis, and a thigh bone, loosely scattered within the pit (Figure 13B).

In the parking lot area (Trench 6) the GPR measurements indicated irregular anomalies which offered a basis for digging test trenches. Excavation work revealed that anomalies were clusters of gravel and stones (Figure 13C).

Excavation work led to the recognition of new graves: five locations of skeletal remains. Due to the adopted research procedure (i.e., conducting excavation research until the first skeletal remains were recognized and leaving them in situ), we can claim a probable diagnosis of a mass grave in the form of a death pit in relation to Trench 1 (similar to the shapes of the grave cavities found in other cases), while in relation to Trench 2–5, it is likely to be in the form of individual graves.

The excavation research, which frequently restricted exploration to a specific area and encompassed an outer fragment (i.e., an edge of a pit with a shape outline (e.g., a circle-trench 1)), combined with

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results of geophysical surveys, provided a basis for determining the boundary and range of the entire pit. This was done in combination with archive aerial photographs and processed ALS data, and did not require the excavation of the whole feature. Despite its approximate character, such identification allows an approximate protection zone around the site to be marked where remains of murdered victims might be buried, e.g., Trench 1. Alternatively, these zones may provide the basis for further research in order to more fully explore the burial site. In the revealed grave pits, the skeletal remains found belonged to victims associated with the operation of the camp, or people transported there and murdered. In two cases, the victims were people under the age of 20–22, which also confirms that adolescents were sent to the Forced Labour Camp Treblinka I. In the subsequent two cases, female remains were discovered. Coffin burials were yet another important discovery. At the present stage of the research it can be confirmed that the examined site was a camp cemetery for lower-rank personnel of non-German nationality. To conclude, it should be stated that test digs confirmed the indications from geophysical research in relation to two areas (Trenches 1 and 4), contributing to the identification and documentation of more sites where remains of murdered victims were buried in the Maliszewa Forest. The correlation of the results of geophysical and excavation surveys indicates a diverse structure of the subsurface layers, which cannot always be captured by geophysical methods.

A new data resource of a progressively completed geophysical map of land reconnaissance (supported with partial excavation verification), particularly of the Maliszewa Forest, was created within the continuously expanded HGIS-Treblinka platform.

6. Discussion

Discussion should be focused on the future research protection strategy for the area which, as can be seen, has not been fully examined as far as execution sites or places where human remains may be buried are concerned. In reference to the south-east boundary of the museum area, it is supposed that it does not encompass all execution sites. This provides a prompt for renewed analysis and discussion of the boundary of the museum grounds versus the real boundary within which human remains can be found, which has also been suggested by other research [18].

An analysis of the results of georadar profiling indicates that the use of the GPR method allows boundaries of grave pits correlating with adjacent profiles to be discovered; this was particularly noticeable in the GPR 1 area. It should be emphasised that almost 80 years have passed since the bodies were buried. Grave pits were filled with material previously dug from the same site. On GPR reflection profiles, boundaries of grave pits can be unclear. The measurement resolution that can be achieved using the GPR method is also important, and we can distinguish between horizontal and vertical resolution. Generally, resolution depends on the frequency of the wave travelling in the medium; additionally, horizontal resolution also depends on the depth at which targeted features are deposited [74]. For a 500 MHz antenna, vertical resolution equals 0.05 m and horizontal resolution equals 0.2–0.3 m. Thus, it can be seen that with the use of a georadar fitted with such an antenna, larger bone deposits can be found. Finding individual bones (e.g., femur or tibia, as in Trench 2) can be difficult. Anomalies located in both measurement areas could be caused by such larger bone deposits. Thus, precisely determining the origins of anomalies in a heterogeneous geological medium with significant diffraction can be very difficult. It should be added that tree and shrub roots, and large stones, are significant sources of diffraction in GPR reflection profile. However, diffraction is much stronger during measurements taken with the use of higher frequency antennae (e.g., 800 MHz), which results in a shorter electromagnetic wave travelling in the medium.

The analysis of archival data, the activities carried out so far, and the literature on the subject indicate that the area of the Maliszewa Forest is a specific space where human remains may occur in locations other than those discussed here, at various depths, and in the form of chaotically deposited bone fragments. Geophysical prospection may help to identify numerous locations, but due to the nature and form of the debris, other research is necessary to identify objects beyond the geophysical reconnaissance. It also seems crucial to reformulate the understanding of the place where bodies or

remains are buried (deposited). Therefore, it seems reasonable to go beyond the process of searching and documenting individual burial pits in order to identify, document, and read (i.e., mark in the field) a larger area in which loosely scattered human remains, combined with the fillings of the original burial pits, may lie.

Partial recognition of sub-surface relics of former camps, particularly using geophysical methods, encourages further similar work to non-destructively identify and fully document the preserved relics of mass murder. Because of partial effectiveness of non-destructive methods in identifying some post-camp features, it appears justified and necessary to verify them by excavations in which the ground is disturbed to the least extent possible. Such a solution would result in less disturbance of sensitive sites. Selecting areas for further geophysical penetration remains debatable without the possibility of conducting such prospection over the entire area. Therefore, further work requires taking into consideration results of analyses of other data, the current results of all research, and determining optimal solutions for a thorough examination of the area of Maliszewa Forest. At present, we can distinguish at least three categories for recognising and documenting the so-called death pits: (1) those known from previous work and researched using geophysical methods; (2) those that are newly identified and researched using geophysical and other methods; and (3) those remaining beyond geophysical prospection.

7. Conclusions

The results of the research carried out in the years 2015–2019 contributed to finding new sites at which human remains had been deposited within the area known as the Maliszewa Forest, based on the use of remote-sensing data and GPR. These finds were displayed and commemorated by information boards. The work yielded a large amount of data that are now an integral element of the Historical-GIS-Treblinka platform, thus constituting a geodatabase for (1) further research and inventory work, (2) a potential tool for protecting and managing camp relics for the Museum in Treblinka or heritage protection services in Poland, and (3) resources that might be used to popularize knowledge about Nazi camps.

Surveys carried out on the execution and burial sites indicate that not all such features have been discovered yet, and some are not reflected either in archive aerial photographs or ALS data. An analysis of diverse and integrated data from various time periods has shown that these data have varying potential for the identification of camp traces, thus encouraging further searches and analyses with the use of more remote-sensing resources. Thus far, the geophysical survey using GPR in the Maliszewa Forest have covered four sites (one grave and six regular burials were identified) within the research discussed in the current article and two sites by the research team from the Centre of Archaeology from Staffordshire University [89]. Thus, geophysical exploration has covered a small part of the Maliszewa Forest, comprising about a few percent of this area.

An analysis of archive resources with considerable informative potential can also show the change on the landscape of the former labour camp area. The fields that used to surround the camp grounds during the 1940s are now almost entirely overgrown with woods. Therefore, the present day reception of this site does not compare to that from the previous period.

Among research demands there are a few that should be mentioned: (1) continuation of the research work, including field work, of varying characters and ranges, to identify the still unknown places where human remains are buried; (2) obtaining new remote-sensing data; (3) continuation of geophysical research, among which the GPR method appears to be the best because of its high resolution (antennae at the frequency of 400–1000 MHz), with the magnetometry and electrical resistivity tomography (ERT) methods; (4) better description of the relationship between the properties of the soil and geophysical measurements [83]; (5) continuation of work to further expand the HGIS-Treblinka platform; (6) integration of research, especially the results of various science and inventory initiatives; and (7) integration of all activities with the strategy of the Museum in Treblinka to optimally use the

scientific and research potential for the protection, management, and commemoration of the suffering experienced by the victims of the German totalitarian system in Treblinka.

As mentioned in Section 2 local environmental conditions, including matrix composition of soil, depth and size of features, soil saturation, and geology (research demand no 4), affect the results of geophysical surveys [90]. The fully interpret data and information available from environmental datasets maximizes the ability to detect buried features and draw meaningful conclusions about them [44].

Specialist analyses, studies, and research conducted in the Labour Camp Treblinka I and the extermination camp Treblinka II are currently underway by interdisciplinary teams and various scientific research initiatives. Participants in the research, in cooperation with the Museum in Treblinka, include a multi-disciplinary team consisting of experts from the Warsaw University of Technology University of Science and Technology in Krakow, Cardinal Stefan Wyszyński University in Warsaw, University of Silesia, Warsaw University and the Rabbinical Committee for the Preservation of Cemeteries. This activity is conducted in consultation with Institute of National Remembrance.

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