Handheld Mobile LiDAR: Investigating its Viability as a Mapping Tool for Improving the Archaeological Mapping Process

by

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Abstract

Archaeological maps are central to the archaeological process; however, issues regarding their perception and representation are undertheorized and have direct effects on the archaeological outcomes. Mapping technologies such as Handheld Mobile LiDAR (HML) (portable mobile mapping systems) are a viable technology for improving maps, but their use brings new ethical challenges. This research paper focuses on HML applications in archaeology and is guided by two research questions: (1) How can we understand archaeological maps with the goal of making the process, and therefore the outcomes, better?; and (2) Is HML viable and practical for widespread archaeological site mapping? This research project uses a case study into the events surrounding Grace Islet, British Columbia to contextualize the mapping problem. I discuss methods for understanding and improving the archaeological mapping process, following a model of production, circulation, and consumption from Lister and Wells (2004), and embedding ethics as outlined by Meskell and Pels (2005). This research then takes an Action Research approach conducting a case study into the production process of HML maps to investigate its viability as an archaeological mapping tool. I discuss where researchers should practice extra care and hold ethical considerations, and make a case for how this technology can be practiced in the field in a manner that thinks “ethics first,” not “answers first.” This research contributes to the wider conversation of archaeological mapping with its identified approaches and study on the application of HML to foster an approach to archaeological mapping that promotes representation and objectivity, and embeds ethics in every stage.

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"If we are to minimize the sins of preconception and of selective observation, we must clearly consider our purposes and our methods. We must structure our research so that the facts will be self-evident, regardless of the researchers' personalities."

-Edward F. Heite 1971:19.

Introduction

1.1 Rationale for Research

Archaeological maps stand central to the initial observation of the archaeological record. As Lee (2018:149) defines, "archaeological maps attempt to objectively record surfaces or landscapes of the past as they *appear* in the present. For many archaeologists, they are *representations* of the past." Maps are an integral part in the field of archaeology as tools in the early observation stages and later decision-making processes around sites, such as decisions around excavation and the protection of cultural heritage. Maps are undebated in their importance to the archaeological process, yet their problematic nature is often overlooked. As Smith (2018:309) notes, "[o]ne tends to think of maps as 'unauthored' and anonymous, but the mapmaker's art/ifice is central to visual representation: a cartographer's portfolio can be as revelatory as an author's journal." Map consumers tend to overlook the active human lenses behind the creation of these authoritative images, establishing maps as seemingly transparent sources of authority. As Tomášková (2007:275) outlines "[t]he actual mapping of a site … is no less imbued with politics and subjectivity than locating a site in a country or region of the world. Every field project begins with maps, yet [site mapping is] undertheorized in terms of the impact such rudimentary activity has on an entire project from beginning to its interpretive conclusions."

By undertheorizing the impact of maps and hiding the subjectivity they contain when treated as "static, a-political, safe, authorised images or 'tracings' of sites and landscapes" (Lee 2018:149), their authoritative nature and objective status is enhanced while the ability of independent interpretation and the representative role of accurately presenting the people and cultures studied is reduced. In short, the overlooked subjectivity of archaeological maps is a significant problem that undermines the archaeological process.

1.2 Research Questions

A primary aim of this research project is to explore processes of archaeological mapping with the goal of making the process, and therefore the outcomes, better. Because archaeological maps influence an archaeological project from its "beginning to its interpretive conclusions" (Tomášková 2007:275), understanding how archaeological maps continue to influence the archaeological process after their creation can reveal ways in which we can improve the archaeological mapping process. This paper contextualizes the problematic perception of maps by discussing their objective power yet subjective nature. I conduct a case study of the events surrounding the site of Grace Islet to demonstrate that archaeological mapping processes can, and should be improved to create a higher standard in archaeology to prevent similar outcomes from occurring. This case study underscores that maps need to be understood as a process rather than a static image relaying objective information before the archaeological process can be improved. I argue that visual anthropological methods can help us to understand and evaluate the archaeological mapping process and identify where it can be improved using a model of production, circulation, and consumption (PCC) as described by Lister and Wells (2011). My research then identifies the call to embed ethics into anthropological research (Meskell and Pels 2005) as a way in which the archaeological mapping process can be improved. Following this, my research aims to expand and address the research problem beyond the theoretical and analytical framework by taking an Action Research (AR) approach to conduct a case study investigating handheld mobile LiDAR (HML; also known as portable mobile mapping systems or PMMS) as a technology that could improve the archaeological mapping process.

My research aims to evaluate if HML is viable and practical for widespread archaeological site mapping. This is evaluated by using a HML point cloud scan to move through the processes involved in producing a variety of archaeological maps in order to assess if this technology improves archaeological mapping. I take an AR approach to evaluate the application of HML within archaeology because, as will become clear in section 4 and 5, this technology will undoubtedly become readily used in the archaeological field in the near future. By examining and paying attention to not only the questions of whether this technology can be viably deployed, but also if it can be deployed in a manner that embeds ethics and therefore makes the archaeological process and its outcomes better, this research is intended to spark a value-oriented conversation about mapping technology.

The goal of this research, then, is to identify not only where and how the archaeological mapping process can be improved, but also where researchers should practice extra care and hold ethical considerations to ensure that improved archaeological maps actually result in better outcomes by using them in the field in a manner that thinks "ethics first," not "answers first."

Theoretical Framework

2.1 The Objective Power yet Subjective Nature of Maps

As outlined in section 1.1, archaeological maps play a significant role in representing the archaeological record. As visual resources, they help to relay the story of the past and are important tools in archaeological interpretation and decision-making. However, their overlooked subjectivity is a significant problem that undermines the archaeological process and this deserves our attention. The observation made by Tomášková (2007:275) that maps are powerful objects imbued with politics and subjectivity is not something exclusive to the field of anthropology. Geography has already grappled with this problem. Discussing a well-known and familiar example from geography—the Mercator projection—will aid in contextualizing the problem of objective map perception and help place the archaeological problem in a wider lens. The Mercator projection (MP) has had a long history of discussion within the academia (Battersby et al. 2014:85). Its world map projection (Figure 1) will be familiar to many because of its widespread use. The MP, created by Gerardus Mercator in 1569, is the most frequently used map in atlases and classrooms, showing where countries are, what they look like, and their place in the world (Anderson and Leinhardt 2002:290).

Figure 1. *The Mercator Projection Map*. Showing the Mercator projection. (Image by Nielkraye n.d.; adapted from Routley 2018).

The discussion on its "inappropriateness for general-purpose mapping, particularly at the global scale … seems to have … virtually phased out [the MP] for general-purpose global-scale print maps" (Battersby et al. 2014:85). However, as Battersby et al. (2014:87) note, "it has seen a resurgence in popularity in Web Mercator form" (Web Mercator being the online adaption of the MP). They observe that "[o]nline interactive maps have become a popular means of communicating with spatial data. In most online mapping systems, Web Mercator has become the dominant projection" (Battersby et al. 2014:87). Large online services such as Google Maps and other online navigation services continue to deploy the Web Mercator (Battersby et al. p.87).

The continued widespread use of the MP is considered problematic because it presents a distorted representation of continental scale, inaccurate to that of the physical world, "contributing to students' misconceptions about the size and relative location of land masses" (see Figure 2; Anderson and Leinhardt 2002:315). In fact, the MP is considered "the source of distorted mental maps of the world (Greenhood, 1964; Gunn, 1988; Muehrcke, 1974; Rice, 1990; Robinson, 1986; Tyner, 1987)" (Anderson and Leinhardt 2002:315). Others have argued that the MP represents a Eurocentric, power-oriented worldview that undermined the representation of the developing world such as the continent of Africa and the Near East (Harley 2009:136). Overall the effects of the MP on its consumers has been coined by Tyner (1987; cited by Anderson and Leinhardt 2002:315) as "Mercator mentality," "to describe the distorted perceptions people get from looking at a Mercator map" (See Figure 2).

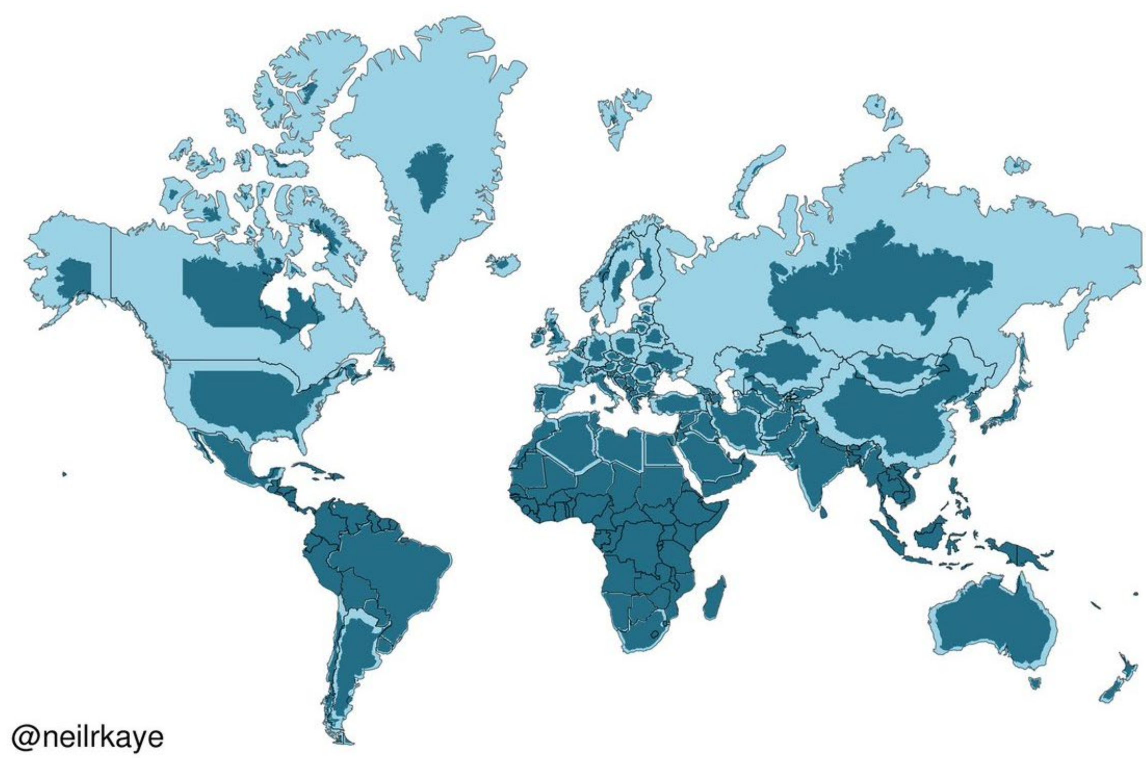

Figure 2. *Wold Mercator Projection Versus True Size.* (Image by Nielkraye n.d.; adapted from Routley 2018).

The Mercator Map portrays a distorted representation because of the decisions made during its production. A common problem cartographers are met with when trying to project a three-dimensional sphere onto a two-dimensional medium is that it requires some distortion. The goal of the MP (the reason for its production), was to allow oceanic travellers to follow a line of constant bearing, which was a major navigation problem for sea travellers prior to the creation of the MP (Anderson and Leinhardt 2002:290). The MP's widespread circulation and consumption as a general-purpose map is thus not what it was produced for. As Anderson and Leinhardt (2002:290) explain, "the Mercator projection was never intended as an instructional map and has acquired a poor reputation because of its significant size distortions of land masses near the poles. The Mercator map provides a good example of how projections, chosen by cartographers to serve one purpose, become problematic when used for other purposes."

The academic discussion around the use of the MP has proved fruitful in reducing its circulation, and its growing awareness will enable consumers to adapt their worldview. It has also prompted the production and identification of more representational two-dimensional maps such as the AuthaGraph in 2016 (Figure 3).

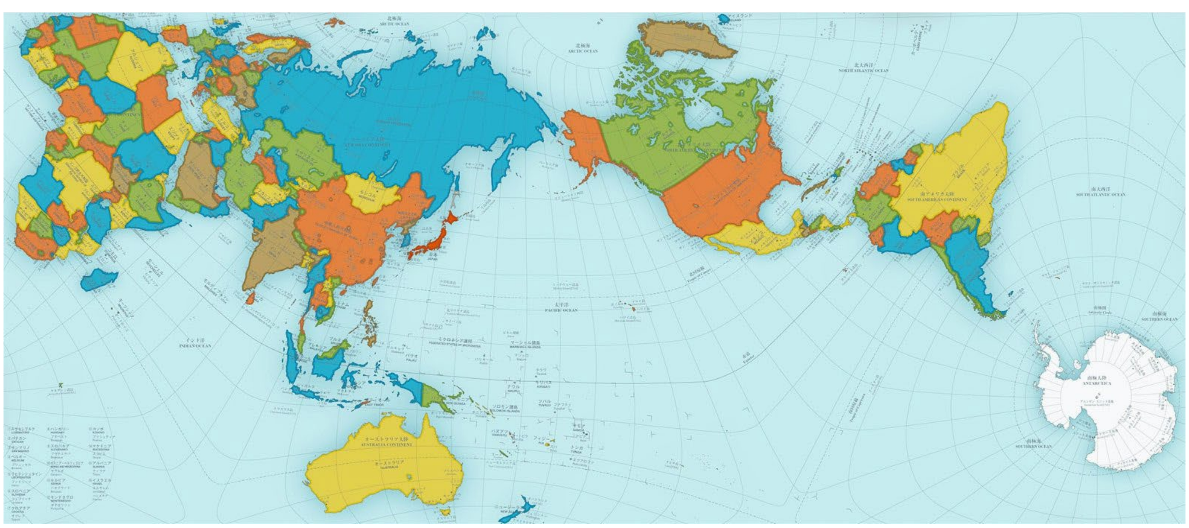

Figure 3. AuthaGraph World Map Projection. (Image by Narukawa 1999; adapted from Stinson 2016).

Different forms of circulation, for example through a digital medium, also provide opportunities for improved representation. The interactive world portrayed as a globe found in Google Earth comes to mind here. The digital platform provides us with the means to represent aspects in a manner that cannot be achieved when reverting to more 'traditional' two-dimensional platforms, but use of digital media reveals other considerations that must be taken into account, as will be discussed in section 4. Changing how maps are produced, circulated, and consumed provides us with ways to reduce the effects of a map's subjective nature.

What this discussion on the use and effects of the MP outlines is that maps as visual resources hold a certain power over their consumers. The reason a map is produced, the way it is circulated and the manner in which it is consumed each influence how the image affects reality. An image's reason for production does not necessarily decide its process of consumption or the interpretations that follow. The use of the MP as general-purpose map (an educational tool for depicting the world) gives it power through its authoritative and objective perception by the map consumers. This continues to shape and influence the worldviews of the consumers who carry and portray its subjective lenses outside of its margins.

The MP contextualizes the problem of objective map perception and helps place the archaeological problem in a wider lens. The example of the MP also showed that after critical assessment, solutions were sought and identified, reducing the problem and promoting better outcomes. A map's role and influence does not stop at the margins of its image but rather should be perceived and understood as a continued process, as will be shown in the next section regarding Grace Islet.

2.2 A Case Study of Grace Islet to Understand Maps as Processes

The events surrounding an effort to "develop" Grace Islet provides a case study of ineffective mapping to demonstrate that archaeological mapping processes can, and should be improved to create a higher standard in archaeology that can benefit the outcomes of archaeological projects. As Tomášková (2007:275) outlined, maps have impact on the "entire project from beginning to its interpretive conclusions." This case study also aims to demonstrate that maps need to be understood as processes rather than static images based on objective information before the archaeological process can be improved. The discussion of maps used in this case study suggest where and how archaeological mapping can be improved.

To summarize the relevant events, Grace Islet is located in the traditional territories of the Coast Salish First Nations a short distance off Ganges Harbour on Saltspring Island, British Columbia (BC). The islet has been privately owned since at least 1990 (McLeod 2016). In 2006-2007 under the BC Heritage Conservation Act (HCA), the owner was required to have an archaeological impact assessment (AIA) conducted on the land when plans were submitted for the construction of a residence (McLeod 2016). In the AIA, archaeologists recorded a total of 15 "rock features," two areas containing human remains, one newly identified burial location (possibly an above-ground platform burial location) and one previously identified burial cairn on the island (Simonsen and Somogyi 2010:3, 14). The archaeologists recommended that disturbance to the "rock features" affected by the development plans, could be avoided by "incorporating selected rock features into the design of planned structures, decks, walkways and associated landscaping" (Simonsen and Somogyi 2010:17). The AIA concluded: "In our opinion, the findings of this assessment do not preclude the possibility of constructing a well sited and sensitively designed dwelling, dock and related infrastructure on Grace Islet without causing damage to the 15 identified rock features" (Simonsen and Somogyi 2010:18). In October 2011, following the findings and recommendations in the AIA, the BC Archaeology Branch (hereafter the Branch) issued a site alteration permit, allowing the construction of the residence on Grace Islet. In July 2012, it was found that unmonitored ground disturbing activity had taken place, breaching both the alteration permit and the HCA (McLeod 2016). In order to "protect" the rock features and in adherence to the recommendations of the AIA report, the features were boxed in with plywood, with some boxes being covered with concrete, fully incorporating them into the foundation of the residence as seen in Figure 4 below (McLeod 2016). This not only made them inaccessible to any future archaeological study, but also desecrated burials that hold important cultural value for the Coast Salish people. After continued legal back-and-forth, an agreement was reached between the land owner and the BC Government for the purchase of the island by the BC Government for 5.45 million dollars in order to suspend construction and protect the site (McLeod 2016).

Figure 4. Grace Islet Cairns Incorporated in the Dwelling Foundation. (Images by @graceislet on Facebook found in qmackie.com 2014).

The initial AIA report and the accompanying maps did not accurately depict the reality and sensitivity of the site, resulting in shaky ground throughout the archaeological process.

Examining the initial AIA report reveals its shortcomings and aids in an understanding of flaws in the archaeological process in the case of Grace Islet. Although the archaeologists acknowledge that the presence of the identified burial cairn and human remains on the island "strongly suggests that the islet was used as a burial site by local First Nations people at some time in the past," they continue to suggest that all rock features they identified "may, in fact, be natural piles of stone" and not burial cairns, even though it is well-established that clusters of rocks are often associated with burials in Coast Salish territories (Simonsen and Somogyi 2010:3, 15; Mathews 2006). Instead, the authors choose to say that the rock features identified on the island "*may* represent intentionally constructed cairns" (emphasis added; Simonsen and Somogyi 2010:12).

The language used in the report to describe the situation of Grace Islet was problematic. Wording such as "rock cairn structures," "rock features," "cairns," and "burial cairns" is used almost interchangeably throughout the report in reference to the identified features (Simonsen and Somogyi 2010). Each term conveys different cultural value, making their sporadic use problematic. The count of the rock features is also troubling, as they first refer to 15 rock features and one burial cairn. Later the report refers to 14 rock features (Simonsen and Somogyi 2010:3, 14). Overall, the problematic use of language throughout the report disrupts the ability for readers to fully understand the significance and cultural situation of the site. Their non-specific description of the landscape makes it hard for an outside researcher to understand and grasp the situation of the island, clouding the understanding that all rock features are in fact most likely cairns and burial cairns, undermining the cultural significance of the island.

The map provided with the report could have reduced this distortion and provided valuable insight and understanding of the situation for Grace Islet, but this is regrettably not the case. Their archaeological site map (see Figure 5) is plotted on an already existing legal survey plan of the island, making for an initially confusing "reading" of the map.

Plan 1: Plan of Grace Islet (Based in Legal Survey Plan) Showing Locations of Rock Features (R#), Burial Locations and Shovel Test Units.

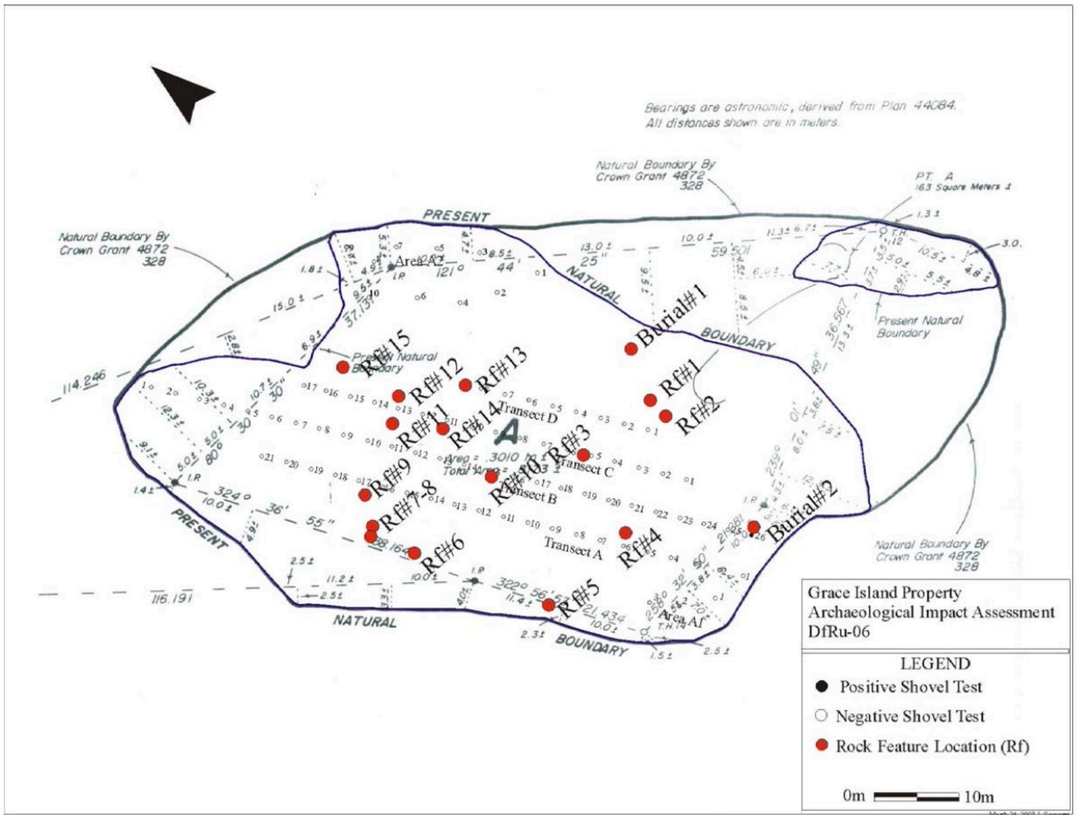

Figure 5. 2010 AIA Map for Grace Islet. (Simonsen and Somogyi 2010:16)

Some archaeologists have suggested that this represents the site as already disturbed or showing it as being colonized cartographically due to the irrelevant survey notes present on the map (Quentin Mackie, personal communication 2021). Content-wise, all the map really displays is the location of the 60 shovel tests that took place, as well as the locations of identified rock features and burials, which are denoted by red circles. As I argue later in this paper, (section 4), it will become clear that AIA mapping can expand far beyond this limited representation. Their notation of the features using a single colour and symbol makes it hard to grasp just how many cairn/rock features were present on the island, as well as whether or not Burial #2 has a rock feature associated with its location. In the report, Burial #2 is noted as the location of an above-ground burial, not mentioning any features in the vicinity (Simonsen and Somogyi 2010:14). However, upon later investigation after the island was bought by the BC government, there did seem to be a cairn associated with its location, changing the interpretation of the location from an above-ground burial to a definite burial cairn (Quentin Mackie, personal communication 2021).

The map shows the locations of 60 systematically conducted and evenly spread out shovel tests. The locations of these tests, as well as their description of the process, suggests that the consulting archaeologists did not purposely target the rock features for sub soil investigation (Simonsen and Somogyi 2010:12-13). Their decision to conduct shovel tests systematically and randomly is not explained in the report, and the locations of the shovel tests on the map suggest that many of the rock features did not have any shovel tests conducted in their vicinity. When looking at the map, the legal survey notes make it hard to locate and distinguish the shovel test notations. Specifically, Rf#1,2,5,6,7,8 & 15 have no shovel tests within their vicinity. Many of the other rock features possibly do not have shovel tests conducted close by, but this is hard to establish due to the questionable accuracy of the size and locations of the features and the shovel tests on the map.

The problematic and misrepresentational issues identified in the site map carry over into their impact map that contains the locations of the features in association to the proposed residence floorplans (displayed in Figure 6).

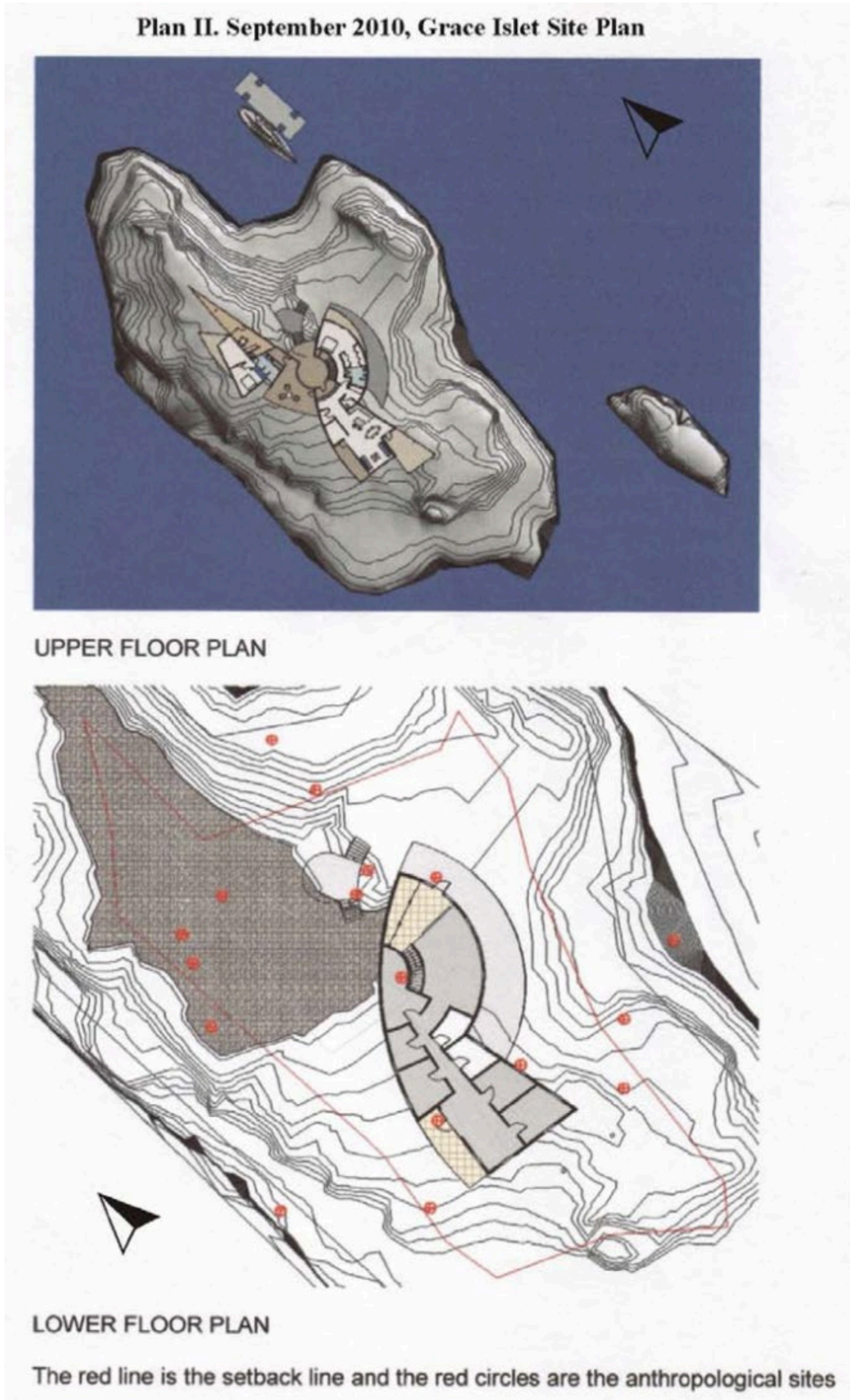

Figure 6. 2010 Impact Map for Grace Islet. (Simonsen and Somogyi 2010:19).

This map contains the overlay of the proposed residence on top of the cairns. With reference to this map in their report, the archaeologists suggest that “3-4 of the Rock Features may require some form of protection” (Simonsen and Somogyi 2010:18). They conclude that, of the 15 rock features recorded,

> “[s]even fall outside of the currently proposed development plan impact zone. Four are situated on or near the proposed locations of decks or walkways and can easily be avoided as these construction modes will be built on above ground concrete piles with little or no ground disturbance. The remaining four are situated on or near the locations of proposed structures and may require some form of development re-design in order to avoid disturbance.” (Simonsen and Somogyi 2010:18)

Comparing their description to their impact map, it becomes evident that, in fact, 11 features fall within the development setback line (indicated by the archaeologists with a red line in Figure 6), and six features seem to be in direct contact with the structure in some form. Their impact map also does not provide a clear picture of the extent to which the entire structure would affect the site, as their feature overlay is done on the lower floor plan which does not display the upper stories and the decks (see the top image in Figure 6 for an idea of the total impact by the residence). Even when neglecting this, avoiding disturbance in any way seems nearly impossible, yet their recommendation that “a well sited and sensitively designed dwelling, dock and related infrastructure on Grace Islet” can be constructed “without causing damage to the 15 identified rock features” was forwarded (Simonsen and Somogyi 2010:18). A better representation of the features in relation to the proposed dwelling would have more accurately portrayed the impact of the structure and the level to which it would have affected the features. An accurate 3D site rendering, like that possible with HML, could have achieved this.

Comparing the locations of the features on the site map to the impact map reveals that many of the feature locations do not add up between the two maps. In fact, a number of the features' real locations were apparently recorded as much as five meters out of place on the site map, a discrepancy which made it difficult for later surveys to relocate the features within the heavily altered landscape (Quentin Mackie, personal communication 2021). The inaccuracy of the site map resulted in one of the plywood boxes built to "protect" a feature to be misplaced by over two meters, leaving the actual feature exposed during the construction of the dwelling, which could have resulted in its accidental destruction (Quentin Mackie, personal communication 2021). This potentially devastating mistake can be attributed to the fact that the construction workers likely took the site map as providing them with an accurate representation of the island and its features, again, signifying that archaeological maps can be problematic due to their perceived authority and objectivity, as well as the earlier point made in section 2.1 that maps produced for one purpose, when circulated and consumed in another context, have consequences. The archaeological mapping process should be improved to promote better outcomes and prevent situations like this from happening.

Although both of the maps initially seem rather objective, the decision to depict the site and its features in a schematic manner opposed to a more detailed depiction not only reduces their individuality and cultural significance, but also takes away from their representation and removes any ability of independent verification. This is a problem because, as Smith (2018:308) outlines "the cartographer must decide how to render qualitative phenomena into quantitative icons: the difference between a "small pit" and a "large posthole" might be only a few centimeters, but the implied interpretations of those two phenomena are considerably different." The labels "rock feature" and "burial cairn" have carry different but important implications, with the latter being far more significant in terms of its cultural implications than a pile of rocks that might have been naturally deposited. The manner in which the features are depicted as simple dots on a map signals how static archaeological mapping can be, especially when contrasting them to the residence blueprints in their impact map. Considering the cultural significance of cairns and burial cairns, one can understand how misrepresentative this is. Notation in the form of simple and uniform dots on a map reduces the individuality and cultural significance of the cairns, and downplays the fact that they are, or even "might be," as the report's authors suggest, significant cultural objects considered sacred to the Coast Salish People. The inaccuracy with which the features' locations were recorded resulted in real and devastating impacts to the actual site that risked the preservation of the cairns.

Overall, the outcomes of the events surrounding Grace Islet was negative for all parties involved and resulted in detrimental cultural damage. Surveys of the island after its purchase by the BC government recorded 10 definite and 8 probable cairn features, painting a stark contrast to the initial AIA report (Quentin Mackie, personal communication 2021). What the maps and the resulting events suggest is that archaeological maps need to be understood and studied as processes rather than being viewed static images relaying objective information. A map's role and influence does not stop at its image; its presence is felt throughout the entire project. Maps are active agents in the archaeological process, and before the process can be improved, their effects must be realized and studied.

In 2015, the Branch published AIA mapping and shapefile requirements for all archaeological projects submitted to the Branch (British Columbia Archaeology Branch 2015).

These requirements are a step in the right direction and will undoubtedly reduce confusion in reading AIA maps such as those for Grace Islet. But more can be done to prevent the mistakes of Grace Islet in terms of mapping accuracy, site and feature representation, and the level of detail and information relayed on site maps, as this research paper will show.

What Grace Islet has showed is that archaeological maps can be highly problematic. The subjective choices made by the mappers can result in the misinterpretation of the site, and by extension the misrepresentation of cultural heritage. Maps like those from the report are hard to follow for outside researchers and result in little opportunity for independent verification and a broader understanding of the researchers' work. Archaeological maps have the opportunity to validate and confirm a researcher's findings. When they are not adequately used and poorly made, their influence diminishes and can result in negative effects. An image says a thousand words and a map does the same. But if these words are helpful or harmful is decided by the lenses through which the image is captured and interpreted. The effects of the maps from Grace Islet upon later stages of development and decision-making could have changed the outcomes had their map more accurately portrayed the landscape. Studying maps and the decisions made around their processes of production, their circulation, and their consumption can help better understand their effects and identify possible areas where the archaeological mapping process can be improved. This can result in better maps, better outcomes and a more holistic understanding of maps by not reducing them to their simple, static form. This broadened understanding of a map's effects can also aid researchers in identifying ethical dilemmas that might arise down the road following the production of a map, which can then be mitigated and prevented.

Analytical Framework

3.1 Visual Anthropology as a Tool for Analysis

Visual Anthropology provides methods of analysis that can aid in understanding a map and the way in which it influences the processes in which it is involved. Identifying and analysing the processes in which maps influence us and continue to influence us after their initial creation can aid in identifying and understanding how the archaeological mapping processes can be improved. The idea of looking at and understanding an image by looking at its processes is a method of visual image analysis found in areas such as Cultural Studies and Visual Anthropology. This next section of my research establishes that methods used in Visual Anthropology and Cultural Studies prove successful in providing an analytical framework that enables researchers to analyse a map and understand its effects by identifying and looking at its processes of production, circulation and consumption.

In a review of "recent approaches to the interpretation of visual images in anthropology, cultural studies and cultural geography," Pink (2006:31) outlines a move away from strongly critiqued "positivist 'truth-seeking' and objectifying approaches" toward methods of image analysis that grasp a complete understanding of "the relationship among people, discourses and objects." She identifies four key areas for the interpretation of visual images: (1) the context in which the image was produced; (2) the content of the image; (3) the contexts in and subjectivities through which images are viewed; and (4) the materiality and agency of images (Pink 2006:31).

Pink particularly embraces Lister and Wells' (2004) methods of visual image analysis, which she summarizes as follows:

> "Lister and Wells' visual cultural studies approach focuses on 'an image's social life and history'; 'the cycle of production, circulation and consumption through which [images'] meanings are accumulated and transformed'; the material properties of images and how their materiality is linked to social and historical processes of 'looking'; an understanding of images both as representation through which meanings might be conveyed and as objects in which humans have a pleasure-seeking interest; and the idea that 'looking' is embodied–'undertaken by someone with an identity'–and that visual meanings are thus both personal and framed by the wider contexts and processes outlined above." (Pink 2006:31)

Lister and Wells thus fully include, yet also expand upon, the four areas of analysis that Pink identified. Where Lister and Wells' approach becomes especially valuable for analyzing maps, however, is that their approach clearly identifies the stages in which an images' meanings are "accumulated and transformed." These can be used to analyse an image beyond what it displays, to understand how this display interacts and affects the people who see it (Lister and Wells 2004:64) This is identified by them as the cycle of production, circulation and consumption (Lister and Wells 2004:64, 90). This cycle, as discussed below, provides a useful model of analysis when applied to maps and more specifically archaeological maps to understand their processes.

3.2 The Model of Production, Circulation, and Consumption

In the *Handbook for Visual Image Analysis* (2004), Lister and Wells state that the primary purpose of their chapter "is to demonstrate and critically discuss the validity and usefulness of a range of methodologies which have been brought into play for analysing photographic images which have been a major element of visual culture in modern industrial societies" (Lister and Wells 2004:63). They list that the main features of their analysis can be summarized as follows:

1 We are interested in an image's social life and its history.
2 We look at images within the cycle of production, circulation and consumption through which their meanings are accumulated and transformed.
3 We pay attention to an image's specific material properties (its 'artifactualness'), and to the 'medium' and the technologies through which it is realized (here, as photographs).
4 While recognizing the material properties of images, we see these as intertwined with the active social process of 'looking' and the historically specific forms of 'visuality' in which this takes place.
5 We understand images as representations, the outcomes of the process of attaching ideas to and giving meaning to our experience of the world. With care and qualification, much can be gained by thinking of this process as a language-like activity – conventional systems which, in the manner of codes, convey meaning within a sign using community.
6 We temper point 5 with the recognition that our interest in images and other visual experiences (and, indeed, lived and material cultural forms) cannot be reduced to the question of 'meaning' and the intellectual processes involved in coding and decoding. As human beings, and as the members of a culture, we also have a sensuous, pleasure-seeking interest in looking at and feeling 'the world' including the media that we have put in it.

7 We recognize that 'looking' is always embodied and undertaken by someone with an identity. In this sense, there is no neutral looking. An image's or thing's significance is finally its significance for some-body and some-one. However, as points 1 to 6 indicate, this cannot be any old significance, a matter of complete relativism. (Lister and Wells 2004:64-65)

Lister and Wells (2004:64) believe that images should be analysed "without separating them from social processes." They state that they "work hard not to see pictures as rigid and fixed things - beginning and ending at their frames" (Lister and Wells 2004:64). Listing their methodology, Lister and Wells explain that this can be achieved by

> "approach[ing] … images as part of what has been described as 'the circuit of culture' (du Gay, 1997). Each one can be thought of as passing through a number of 'moments' and its passage through each moment contributes to the meanings – plural, not singular – which it has and may have. In short, they are socially produced, distributed and consumed; within this cycle there are processes of transformation taking place and also of struggle and contest over what they mean and how they are used" (Lister and Wells 2004:64)

The circuit of culture as described by Lister and Wells (2004) has been a widely evolving framework from cultural studies for examining cultural phenomena. Many authors within cultural studies have theorized and built upon this model (see Johnson 1986; du Gay et al. 1997). The content of this circuit, i.e. the stages it contains, depend on the phenomenon that is analysed.

In terms of du Gay et al.'s (1997) analysis of the Sony Walkman, their circuit contained five aspects. For Lister and Wells (2004), (as well as Johnson [1986]) their stages are three-fold (see Figure 7). du Gay et al. (1997:3) state that "any analysis must pass [through these stages] if it is to be adequately studied."

Figure 7. The Production Circulation and Consumption Model Stages. (Figure adapted by the author based on Lister and Wells 2004).

Approaching and understanding maps as a process can be achieved using the model outlined by Lister and Wells (2004). Their model allows the researcher to examine how the different stages affect each other and what the effects are. Their approach ensures that researchers do not remove themselves from their work. In other words, they are aware and acknowledge that their own lenses and worldviews affect how they see and perceive their data. This automatically includes a sort of ethical safeguard to the research approach/analysis here, and this can be effectively expanded upon to grasp more areas in which the archaeological mapping process can be improved.

Thus, examining maps and examining a different medium in which mapping can be conducted (as this paper takes up in section 4) is well guided by the points outlined by Lister and Wells (2004). Using production, circulation and consumption as the main model to understand maps beyond their tangible dimension encourages efforts to identify, understand, and acknowledge the effects and shortcomings of maps, enabling us to improve the process and therefore the outcomes.

3.3 Embedding Ethics to Improve the Process

Studying the effects of maps through Lister and Wells' (2004) PCC model not only reveals how and where in the circuit processes can be improved; it also acknowledges and reveals where questions of ethics might arise in the process. This extra awareness gives an opportunity for a conversation on ethics to be embedded in the production stage of the mapping process and continue to be held in the later stages of circulation and consumption. This is consistent with efforts to embed ethics as part of archaeological and anthropological research over recent decades.

Ethics is an arena of relatively recent concern within anthropology and archaeology. In an effort to address concerns about a lack of attention to ethical issues, professional associations like the American Anthropological Association developed standardized ethical codes. But this standardization has become problematic (Meskell and Pels 2005). Meskell and Pels (2005) argue that by treating ethics as a distant task, researchers lose sight of what it is actually there for. They observe that archaeologists perceive their "primary responsibility [as] to serve as caretakers of and advocates for the archaeological record, ensure its long- term conservation, and promote its use for the benefit of all people." Instead they argue that they should "redefine their goal as a search not for a transcendent truth opposed to local or particular interests but for significant truths about materials and sites in an open-ended negotiation. This redefinition allows for the recognition of (aesthetic, sentimental, or commercial) values other than the archaeological pursuit of evidence" (Meskell and Pels (2005:6-7).

With archaeology becoming a blended science, borrowing from other fields of anthropology that study living people such as ethnography, ethics should be playing an active role in the archaeological process. Not addressing ethics throughout the process can result in negative effects on the descendant communities whose ancestral past we study and interpret. Embedding ethics allows researchers to treat ethics as an open-ended task. Incorporating this conversation actively into the processes of archaeological mapping in both this research as well as archaeological mapping in general will result in better outcomes.

The discussion of Grace Islet (section 2.2) provides us with an unfortunate example of the results that can follow from treating ethics as a distant task, as Meskell and Pels (2004) warn. With Grace Islet, the developers outlined that they did everything according to the regulations set (McLeod 2016), yet many recognized that the process was inherently wrong and the outcome was negative for the parties involved. Grace Islet gives us a prime example of the issues that arise when ethics are treated as a separable process based on standardized requirements that just need to be met rather than thoroughly evaluated.

By embedding ethics, and including it as an open dialogue rather than as a separate body, participants will not be surprised if outcomes are not positive. Instead, their efforts throughout the process can help mitigate and change these outcomes. Embedding ethics into the archaeological process can prevent outcomes like that of Grace Islet by promoting reassessment at every stage, which is beneficial to the entire process and will result in better outcomes. For mapping, this process is the same, embedding ethics from the start ensures that the maps produced will be circulated in an appropriate manner and consumed in the way they are intended with their context included. The processes behind the incorrect consumption of the MP, which was discussed in section 2.1 showed that this an issue with ramifying consequences.

3.4 Action Research Approach

I turn now to an Action Research (AR) approach focused on HML as a method for improving the archaeological mapping process. O'Brien (2001:3) defines action research as "'learning by doing' - a group of people identify a problem, do something to resolve it, see how successful their efforts were, and if not satisfied, try again." Gilmore et al. (1986) give a more refined definition of AR which relays why it fits well with Meskell and Pels' (2005) call for embedding ethics:

> "[a]ction research...aims to contribute both to the practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously. Thus, there is a dual commitment in action research to study a system and concurrently to collaborate with members of the system in changing it in what is together regarded as a desirable direction. Accomplishing this twin goal requires the active collaboration of researcher and client, and thus it stresses the importance of co-learning as a primary aspect of the research process." (Gilmore et al. 1986:161).

In short, AR merges both problem and solution into its approach. Its call on active collaboration to reach a desirable outcome aligns with the calls made by Meskell and Pels as discussed in section 3.3.

By conducting an investigation into the viability of HML technology as a method for improving the archaeological process and promoting better outcomes, my research conforms to the AR approach to produce well- rounded and useful research.

Case Study

4.1 Focus

Viewing archaeological maps as a process using Lister and Wells' stages of production, circulation and consumption, and understanding how these stages influence each other and the final outcomes, I begin by focusing on the production stage, as decisions here ripple down through to the other two stages. The production stage is where the visual image of the archaeological map is created through data collection and site observation. Improvements in terms of representation, accuracy, detail, and opportunity for independent verification are aspects identified in section 2.2 on Grace Islet for how the archaeological mapping process can improve. Improving these aspects in the production stage will have a direct impact on the processes and decisions that occur in the later stages.

Digital applications are transforming the production of maps. As touched on in section 2.1, Google Earth is an example of how representational issues in mapping can be addressed by using digital space. It promotes a higher standard of representation by enabling mappers to reduce the difficult choices they have to make to fit their detailed landscape onto a limiting medium. Capturing data directly from the landscape (like Google Earth does with satellite imaging) rather than through the observations and interpretations of the mapper, also promotes accuracy of representation.

Light Detection and Ranging (LiDAR) technology encompasses both the digital medium as well as direct data capture. Archaeology has long benefited from LiDAR in improving both the accuracy and efficiency of archaeological mapping, which dramatically changed parts of the archaeological process. To understand how this technology directly affected archaeologists and their archaeological processes, and to gain a personal perspective, Nicole Kilburn offers us an understanding of how LiDAR brought a big change to the field. Her fieldwork in Belize; mapping features in tropical forest settings, which previously took painstaking effort and months of time to get through a few square kilometers suddenly took only a few days using aerial LiDAR as it is able to penetrate through the tree canopy, easily mapping the landscape below (Nicole Kilburn, personal communication 2021). For LiDAR application in archaeology in a more general sense however, LiDAR has until recently only remained viable for large archaeological projects backed by substantial funds (Corns and Shaw 2009). In addition to cost, aerial and terrestrial LiDAR (the most common types deployed in archaeology), involve substantial time allocation and planning. These considerations have made widespread use of LiDAR for archaeological mapping process out of reach for individual site recording such as Grace Islet. HML poses as an opportunity to break down many of these barriers.

HML is a form of LiDAR that allows the user to actively create a map of their three-dimensional spatial environment in a manner that still requires the researcher to be present on site. Although it is not reserved strictly for handheld operation (it can be attached to drones, backpacks, and vehicles) this distinction is made to differentiate it from other mobile LiDAR mapping technologies such as tripod LiDAR, and van-based LiDAR scanners. HML offers far greater versatility and deployability due to its size and mobility over these other forms of mobile LiDAR. But its viability and practicality for archaeological site mapping need to be evaluated with respect to its potentials and limitations.

4.2 Ethics in Archaeological LiDAR

In order to improve the archaeological mapping process by embedding ethics (section 3.3), my study into HML will not be limited to technological performance. To formulate a holistic understanding of the efficacy and implications that might come from the widespread application of HML for archaeological mapping, its ethical dilemmas must be fully considered. To launch this conversation and to provide structure and means of comparison between HML and traditional LiDAR, I draw on research by Cohen et al. (2020) who discuss the ethical implications of aerial LiDAR as applied in archaeology over the past 20 years. Cohen et al. (2020) review ethical concerns in archaeological LiDAR and make recommendations on how these issues can be approached. Their findings and recommendations "may be extended to other applications of RST [remote sensing technologies] in archaeological research" (Cohen et al. 2020:79), which is my aim in this case study.

Cohen et al. (2020:76) identify three main areas of ethical concern that archaeological LiDAR projects must address: data management and access; the role of stakeholders; and public education. Their research calls for the establishment of specific ethical guidelines to ensure that LiDAR research is "robust, reliable, ethical, and reproducible" (Cohen et al. 2020:77). With respect to data management and access, they outline that LiDAR data can be ethically problematic in terms of data ownership, storage, preservation, access, sharing, and protecting sensitive data (Cohen et al. 2020). They also argue for the democratization of archaeological science to increase the involvement and accessibility for stakeholders. They suggest that data should be widely accessible and only limited when risks for specific areas are carefully assessed. This suggestion raises a concern in terms of the protection of sensitive data, the potential for the destruction of cultural heritage, and an increase in looting. Yet Cohen and colleagues (2020) argue that, rather than increase risk of looting and cultural heritage destruction, an increase in open data will be more beneficial in identifying and preserving cultural heritage and enabling stakeholders to be more involved. For HML, their considerations will have to be addressed and revaluated because of the highly detailed 'micro-level' data produced by HML compared to the macrolevel of aerial LiDAR data on which they have based these findings.

Regarding stakeholders, Cohen et al. (2020) acknowledge that results and benefits of LiDAR may be spread unevenly for the parties involved, and the voice of descendant communities in the mapping process might be problematically suppressed by more dominant stakeholders such as governments. The researchers outline that "our archaeological understanding of techniques like lidar as being 'non- destructive' and 'non-invasive' is deeply problematic … [and] … must be taken into account as we develop programs of archaeological lidar (or, indeed, decline to do so)" (Cohen et al. 2020:84). In terms of HML, how descendant communities might be affected by the circulation of detailed site data will have to be considered.

Regarding public education, Cohen et al. note that media can problematically misrepresent data and promote pseudo-scientific claims. They outline that "careful consideration should be given to how research teams want the research portrayed, and the role of various stakeholders in this portrayal" (Cohen et al. 2020:85). With the powerful visuality of the maps that HML can produce, as will be demonstrated in section 4.4, the misinterpretation and inaccurate portrayal of archaeological sites and descendant communities poses a serious problem that will need to be addressed.

Cohen et al. (2020) argue that the areas of ethical concern identified in their paper are best addressed prior to data collection and should be part of a broader and more open conversation. Embedding ethics into the production stage of archaeological mapping will prove beneficial for the process and outcomes overall. They conclude that archaeologists who want to work with LiDAR data should "engage in a reflexive, holistic process of preparation that weighs the opportunities and challenges of integrating such kinds of data" (Cohen et al. 2020:86).

Due to the shared nature of the type of data generated by HML and aerial LiDAR, the extensive overview provided by Cohen et al. (2020) can be understood as effectively portraying the ethical concerns that arise throughout the stages of production, circulation and consumption of HML mapping data. Although some differences might exist in terms of the effects and severity of some of the ethical concerns outlined, all directly apply to the archaeological HML mapping process and should be considered in assessing the technology's viability, which I take up in section 4.6.

4.3 Literature Review

Cost is a key issue in evaluating the viability of HML. Because the technology is commercially available and already used in a wide array of applications, it can be argued that it is already more viable than traditional LiDAR and will likely come down in price as its user-base grows. The GeoSLAM Zeb Horizon system that collected the scan used in this case study costs between CDN $40,000-50,000, with more affordable models also offered by GeoSLAM (Matt Teppler, personal communication 2020). While this high cost likely excludes a large part of the field from considering this technology, it can also be bought second-hand or rented from a third party. Even brand-new, obtaining this technology for post-secondary institutions is not unfounded, especially when considering its cross-disciplinary applications (e.g., geography, engineering, earth and ocean sciences, and anthropology). For private archaeological consultant companies, such as those conducting AIAs, this system is also feasible in light of the increase in quality, speed and efficiency with which fieldwork can be conducted and processed (section 4.4, below). Reduced time spent mapping in the field reduces the overall cost of the AIA process and leaves more time for other fieldwork activities such as probing or shovel-testing.

Nocerino et al. (2017) tested the performance of two different HML systems: the GeoSLAM ZEB-REVO and the Leica Pegasus:Backpack. The researchers tested the systems' performance for typical indoor and outdoor scenarios and compared their values against those of a terrestrial laser scanner (TLS) (Leica HDS7000) and a van-based mobile mapping scanner (RIEGL VMX-450) for the same environments to assess the level of error in the HML systems. The researchers compared the two HML systems in their measurement errors, noise evaluation, and a statistical analysis that compared the two systems through a standard Gaussian assessment (kurtosis, skewness, sample mean, standard deviation) and a robust assessment (median, NMAD, sqrt (BWMV), interpercentile range 50%, 0,025 percentile, 0,975 percentile, and interpercentile range 95%). The researchers concluded that both HML systems fall well within the acceptable range of error, signaling their effectiveness in accurate data collection. The researchers also found that the GeoSLAM ZEB-REVO generally outperformed the Leica Pegasus:Backpack in accuracy for the parameters tested. The findings from this research suggest that the accuracy and performance of HML systems is viable for use in the field and their accuracy is within the parameters of the non-handheld scanners from this study.

To investigate the performance of mobile LiDAR systems compared to more traditional stationary LiDAR systems already widely deployed in the field of archaeology, Rodríguez-Gonzálvez et al. (2017) applied mobile LiDAR technology to the field of Cultural Heritage to evaluate its performance for documenting, divulgating, and developing architectural analysis of cultural heritage sites. The researchers compared their mobile LiDAR data (recorded by an

Optech LYNX Mobile Mapper mounted to a van) to the terrestrial laser scanner (TLS) (Trimble GX) (the most commonly employed active sensors for large cultural heritage sites according to the paper). The researchers directly compared the resulting 3D point clouds from both systems to assess the systems' time for data collection, data accuracy, and resolution. The researchers concluded that the mobile LiDAR system was the optimal approach for recording large Cultural Heritage sites due to its high-speed data acquisition and adequate accuracy. The researchers found that to record 250,000m^2, the mobile LiDAR system took 1 hour, compared to 159 hours for the terrestrial laser scanner. Although the terrestrial laser scanner surpassed the mobile LiDAR system in terms of point cloud density (15mm compared to 60mm) this was still well within acceptable range. Rodríguez-Gonzálvez et al. (2017) conclude by saying that "[e]ven if [the] Mobile LiDAR System provides a less dense point cloud, it is conclusive that it has enough spatial resolution and quality to provide the reconstruction of the most relevant architectural details in large Cultural Heritage sites" (2017:14). These studies demonstrate that Mobile LiDAR provides a notable advantage in the time of data recording compared to traditional LiDAR systems, while sacrificing minimal accuracy that is still well within acceptable range.

4.4 Process and Results

GeoSLAM is a leading company globally that offers HML technology for commercial application. Nocerino et al. (2017) suggest that their product has adequate ability to be applied in the field. Reaching out about my study to their Canadian office, Regional Channel Manager Matt Teppler was open and helpful during my entire study process. Mr. Teppler identified a scan in their database that, while not collected for archaeological purposes, contained features that represent an archaeological site. While understandably not being able to provide me with a scanner to collect my own point cloud data, Mr. Teppler gave a detailed description of the entire data collection process, enabling me to evaluate the viability of this stage for archaeological site mapping (Matt Teppler, personal communication 2021). I note that GeoSLAM did not set any limitations or requirements for my study in return for their insight and scan used in this case study.

The scan provided contains a cultural heritage site located in Walnut Canyon National Monument in Arizona, USA (see Figure 8). The site represented in this scan contains two archaeological dwelling features of different sizes. The smaller feature located towards the southeast corner of the scan is covered by a canopy. The site also contains fencing, a walking path, two signs and a bench.

Figure 8.
Walnut Canyon National Monument Site.
Top: terrestrial view;
Bottom: aerial view.
(Coordinates 35°10'22.3"N 111°30'30.5"W, Captured on Google Maps March 10, 2021).

The scan used in this analysis exists out of two datasets: a .las file containing with the site point cloud existing out of 28.7 million points; and a .laz file containing the scanning path (the route taken by the scanner during site recording). The .las file contains the colour of the site added by their photogrammetric camera color capture feature. While aiding in the representation of the archaeological site, I chose to omit this feature from the analysis to more accurately represent the experience using the base GeoSLAM Zeb Horizon scanner used to capture the site. Using the scanner requires no real training or expertise (Matt Teppler, personal communication 2021). The site was recorded in under 10 minutes in handheld operation at a walking pace. Because the scan was recorded without archaeological analysis in mind, the operator did not stray far off of the walking path, creating some gaps in the point cloud around the edges of the study area (see Figure 12 later on for the scanner route taken). Archaeological site recordings will undoubtedly be more thorough and therefore not encounter this issue. After data collection, the scanner can plug into a laptop and the data file is imported into GeoSLAM's Hub software. Here, the data can be viewed to verify that all areas intended for capture were captured. From Hub, the data can be exported into a wide range of point cloud filetypes that can then be imported into any compatible point cloud software (Matt Teppler, personal communication 2021).

From this point onward, I describe my own experience with the process of producing visual images from the HML data. The scan was processed using the opensource software CloudCompare (version 2.11.1 (Anoia) [MacOS 64-bit]) on my 2015 Macbook Pro. CloudCompare is a free 3D point cloud and mesh processing software that can be used for a wide array of 3D applications. CloudCompare was used in this study to ensure results and findings offer a more general and more widely applicable analysis of the HML mapping process.

Data was processed and maps were created without any prior knowledge of the software or point cloud data. This signals that HML data can be recorded and processed and maps can be created by anyone without any training or expertise in point cloud data capture and processing. Overall data processing in CloudCompare was straightforward and relatively easy. I found that there are lots of resources and tutorials available online (i.e. the CloudCompare forum and YouTube). The time it took me to make all of these maps is around six hours. As a first-time user of the program and this type of data it took me around five hours the day prior to making the maps to discover and test all of the features and capabilities. My estimation is that if one was to only create an AIA map like the mock AIA map I created (see Figure 9), it should take around two hours for someone who has some experience with the data and software. The software can be used without an internet connection once downloaded to your computer. This makes the program usable during remote field work and enables data processing to happen on site if needed as the transfer of data from the scanner also does not require an internet connection.

The goal of this case study was to investigate if the process of HML data recording and processing is practical for archaeological projects, and if it allows for the production of valuable and insightful archaeological site maps. The main strategy used in this case study to gauge if the HML process is in fact effective and viable for widespread archaeological use was through the creation of a mock site map as found and required in archaeological reports such as AIAs. A wide array of other maps were also created to investigate the capabilities and features HML data provides over traditional mapping platforms. (Note that this is not at all an extensive list of the maps CloudCompare is able to produce, these were simply features I came across during my use of the program without asking any specific questions or identifying any specific needs that I was trying to achieve for the maps. The extensiveness of CloudCompare as a data processing tool suggests that there are many more features and capabilities available and possible, I simply did not identify them or come across them in this research). The mock AIA map created in this case study can be seen in Figure 9 below.

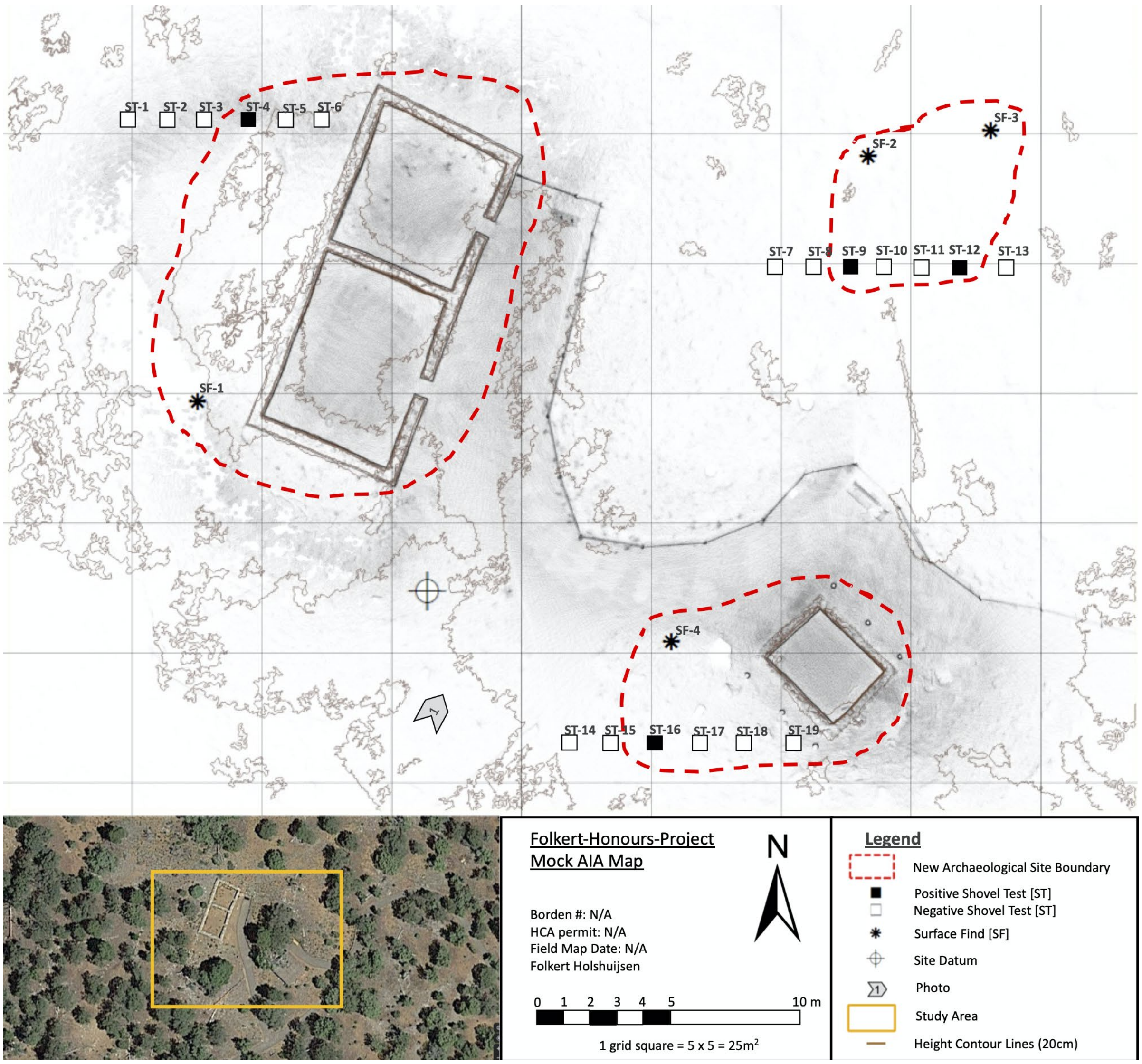

Figure 9. Mock AIA Map. (Image created by the author for this study).

The symbols overlaid on the map do not represent actual archaeological observations or finds (i.e. the site boundary markings, shovel tests, surface finds, site datum, and photo locations), but are purely there to demonstrate its capability and practicality for AIA mapping, and its adherence to the guidelines set by the Branch (British Columbia Archaeology Branch 2015). As can be seen in the legend, the green lines displayed throughout the map are height contour lines at 20cm intervals. Trees and shrubbery have been completely removed from the scan in CloudCompare to depict and best represent features that might otherwise be obstructed or hidden from the landscape. This is a notable benefit of LiDAR data over photogrammetry and other mapping techniques. The canopy that covered the smaller dwelling feature in the southeast corner of the site has also been removed to better represent the feature in the archaeological landscape. Other notable features of CloudCompare and HML data are of its ability to automatically generate contour maps (see Figure 10) and the relative ease of removing or including vegetation using features such as the Cloth Simulation Filter (CSF) augmented by some manual cleanup.

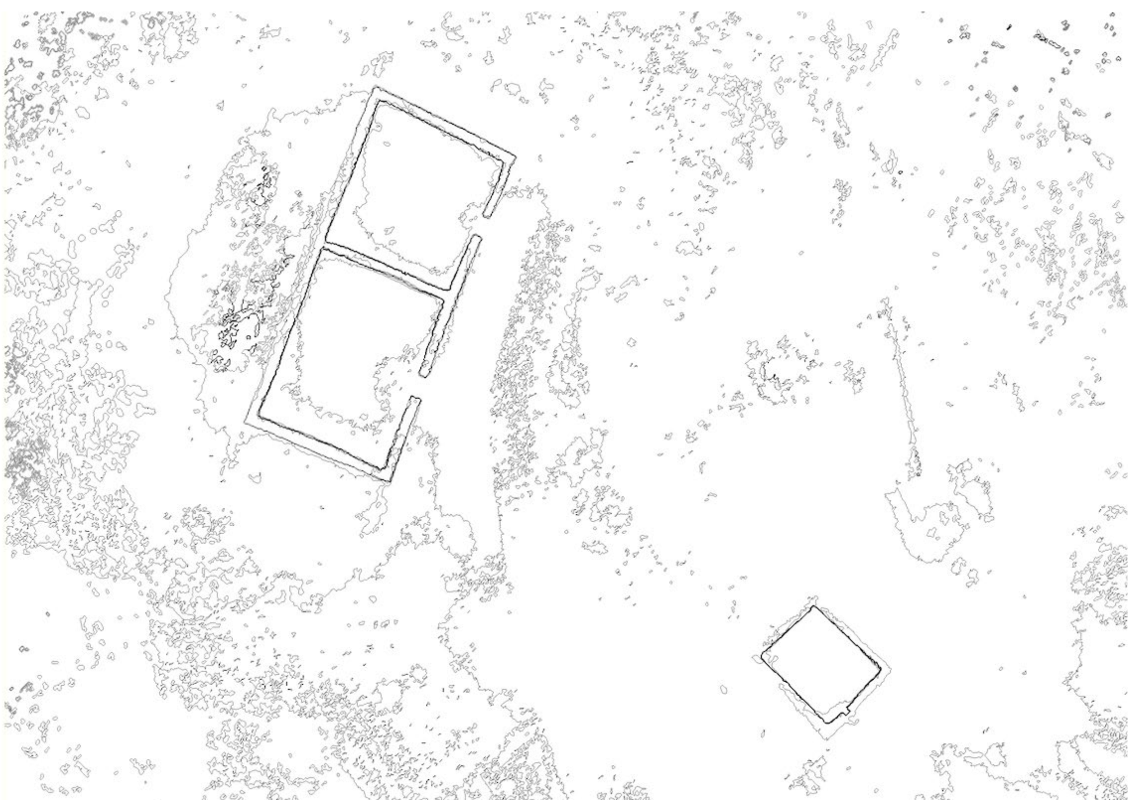

Figure 10. Contour Line Map. Contour lines are generated for every 10cm. (Image created by the author for this study).

Another strong feature is that maps are not limited to top-view maps. The capability to make and capture maps at a wide range of angles and zoom levels augments site representation and understanding for map consumers (see Figure 11). Height colour maps are also a strong feature to provide more visual understanding of the dimensionality of the site outside of contour maps, which can be hard to read. I observed that a combination of some of these features with an angled representation creates some very powerful images. (see Figure 11 for a combination of height colour with an angled view to grasp this observation)

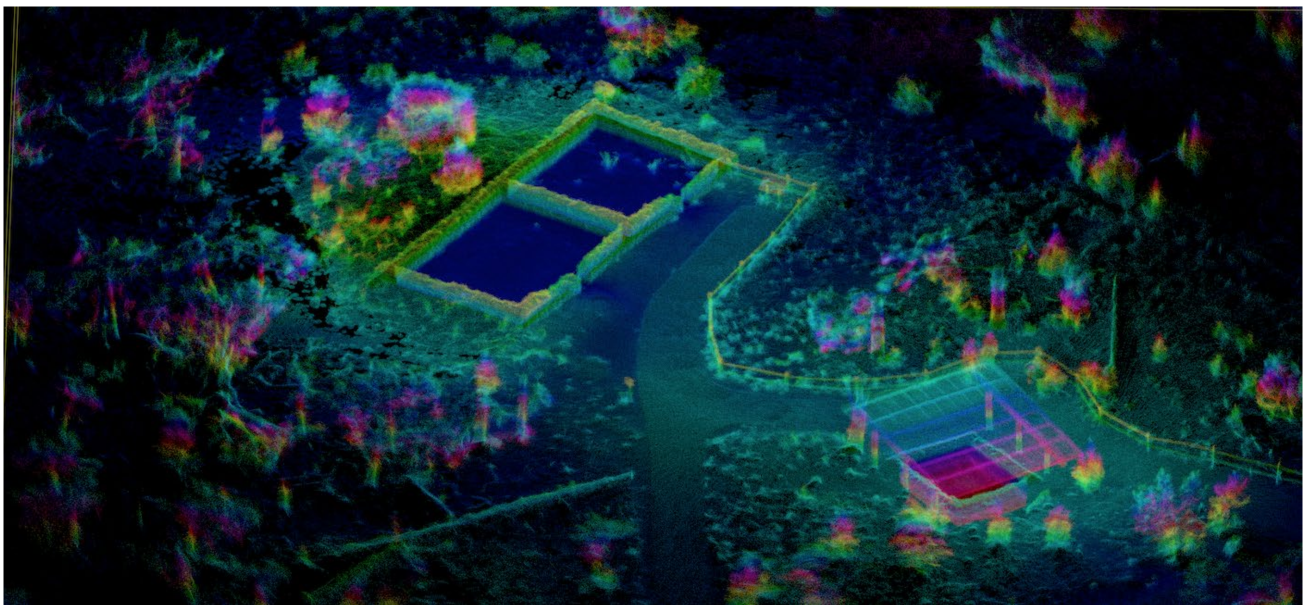

Figure 11. Height Colour Map with an Angled Viewpoint. (Image created by the author for this study).

Another main feature and strength of HML data, which can be overlaid onto any map here, is the accompanied .laz file containing the scanning path. This feature strengthens the presence of the mapper on the site and can give map consumers a better idea of the representation of the subjective human process involved. The scan path also strengthens the ability for maps and the mapping process to be more reproduceable. (see Figure 12 for the scan path overlay).

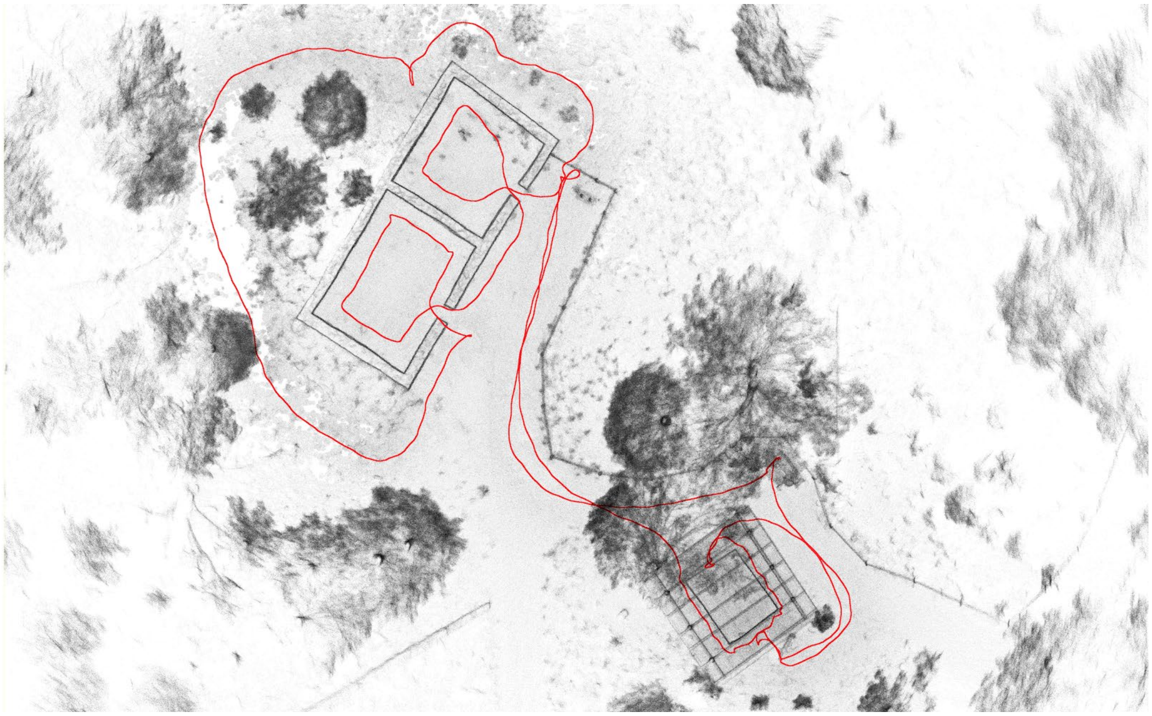

Figure 12. Scan Path Overlay Map. Path taken by the scanner is indicated in red on top of the top view of the site without any vegetation removal. (Image created by the author for this study).

The hillshade feature in CloudCompare produced another useful type of map (see Figure 13). This feature enables you to highlight and visualize depth and protruding ground features that might otherwise be overlooked during normal field survey.

Figure 13. Hillshade Map. The smooth triangular shapes present in this scan are caused by the interpolate function for some of the areas where insufficient data points were collected during the scanning of the site. (Image created by the author for this study).

Exporting the data from CloudCompare was straight forward. The actual data can be exported into a wide array of other point cloud filetypes. (.las .laz .e57 .bin .txt .asc .neu .xyz .pts .csv .sbf .ply .vtk .dxf .shp .pov .pn .pv). The captures, in this case the maps, are exported as a .bpm file. This file is rather large (around 700MB for my initial captures). This can be problematic in terms of both data storage and file circulation. I found that this can be easily mitigated by compressing the files, which will retain the original once unpacked, or by converting and downsizing the files into more common digital image formats such as .jpeg or .jpg etc.

4.6 Reflection

Returning to the wider scope of this case study, the observations made suggest that HML is a viable mapping technology for a large portion of the archaeological field. In addition to the ease and accuracy the technology afforded in making the mock AIA map, I found that the map created using the hillshade feature was quite revealing in terms of landscape attributes that might otherwise be hidden to the naked eye. This feature seems similar in the information it reveals as that of a hachure map. A hachure map identifies certain land protruding features, but the observational skill required to create these kinds of maps limits their use and creation to experts (Fradley 2018). HML seems to remove some of these analytical barriers. The extensive analytical features that become available to the archaeological site mapping process by using HML data suggest that more opportunity for analysis, beyond that which is normally possible. The broader collection of data by HML allows for insight into aspects of the site that might previously not be paid attention to or recorded unless specific questions were asked. This helps in broadening the understanding of a site and allows for different questions to be asked and potentially answered without having to return to the site to collect new data, promoting future research and deepening the overall archaeological analysis that would normally take place.

The mock AIA map created for this case study seems to be highly effective in relaying the features of the site in an accurate and clear manner. The map already vastly surpasses the map seen in the AIA report for Grace Islet both in accuracy and representation of the features present by maintaining a features' true dimensions and attributes. The height contour lines included in the map offer increased detail in understanding the dimensions of the site, as this is often difficult to relay on traditional mapping platforms. The overlaid five-meter grid increased awareness of the site's size, spatial relations of the observed features, and the mock shovel test locations. Overall, this site map seems to carefully and accurately relay the observed site and the archaeological processes that were conducted on it, opening opportunity for outside researchers to make independent observations of the site and allowing independent validation of the processes that were conducted. The detail and clarity of the map provides the opportunity of the data and process to be reproduced if need be.

In creating such a representational map in an efficient manner, and ensuring that its properties adhere to, and even surpass the guidelines set by the Branch, the argument can be made that HML data recording and processing is practical and beneficial for archaeological projects, and allows for the production of better, more insightful, more standardized, and more reproducible archaeological site maps that are helpful in improving the archaeological process and its outcomes. However, when considering the theoretical framework outlined in this essay; viewing maps as subjective processes, these results cannot stand on their own without considering the potential ramifications in the later stages of circulation and consumption. With embedding ethics at the centre of improving the archaeological process, using the PCC model from section 3.2 with the findings from Cohen et al. (2020) in section 4.2 it is possible to grasp a better, more holistic understanding of the true ramifications of HML in the archaeological mapping process.

As discussed above (section 4.2), the findings by Cohen et al. (2020) regarding ethical dilemmas associated with using LiDAR data are applicable to HML, but some more specific dilemmas arise. The high detail and accuracy of the data captured and the clearness with which this data is relayed onto a map can cause concerns in terms of site protection and the release of sensitive data that can result in problems in the later stages of circulation and consumption. Cohen et al. (2020) suggested that an increase in open data will be more beneficial in identifying and preserving cultural heritage than the risk of promoting looting (see section 4.2). This observation seems problematic for HML as the higher detail of the data compared to aerial LiDAR would only promote looting if sensitive data was released to the public. The benefit of identifying cultural heritage is far less of a factor here as HML is aimed at recording potential, or already identified, archaeological sites as is the case with AIAs, rather than recording large areas in the hopes of identifying new sites as is the case with aerial LiDAR. In terms of Grace Islet, however, the argument can be made that an increase in accuracy and detail of the locations and attributes of identified features might have resulted in better protection in terms of both the initial recommendations against construction, as well as the accurate identification, protection, and location of the features present. Still, this could be achieved when data is only shared with the relevant parties involved. For HML applications in archaeology it seems that limiting access to data to only the parties involved seems to be the best approach. In being able to share detailed site data with the relevant stakeholders, such as Indigenous descendant communities, their involvement and voice in the project can be effectively increased.

Data management and access, as discussed by Cohen et al. (2020) poses a number of ethical concerns due to the digital nature of this data. The digital format of HML poses a risk for unauthorized circulation and even study of the site if the raw scan files are shared, which can result in ethical dilemmas down the road. The concerns raised by Cohen et al. (2020) in terms of data ownership, data storage, data preservation, access to data, data sharing, and protecting sensitive data are fully shared with my observations using HML in this case study. It can be understood that any digital data is at higher risk of unauthorized distribution.

From the maps created with HML, their visuality makes them powerful images. In the consumption stage, this can be problematic as Cohen et al. (2020) also outlined. Having powerful images that are easily circulated without any context can result in misrepresentation. I would argue that this poses a bigger problem for HML than for aerial LiDAR due to the detail of the images which suggest that they can be interpreted by anyone. Context needs to accompany them to ensure that misinterpretation and misrepresentation is limited.

With HML being able to create an AIA map whose properties adhere to and even surpass the guidelines set by the branch, the argument can be made that HML data recording and processing is practical and beneficial for archaeological projects, and allows for the production of better, more standardized and more reproducible and insightful archaeological site maps that are helpful in improving the archaeological process and its outcomes. However, the effects that could follow from using HML in archaeology are not only positive, as the attributes of the technology pose a high risk in instigating ethical dilemmas harmful to the archaeological process, its stakeholders, and its outcomes. If these ethical concerns are properly thought out and addressed at every (PCC) stage prior to the use of the technology, and continue to be addressed during the entire process, then, HML can be successfully deployed within the archaeological field.

Discussion and Conclusion

The theoretical framework of this paper (Section 2) outlined that the subjectivity of archaeological maps is overlooked and undertheorized, which is problematic for the overall archaeological process. The power of maps through the objectivity and authority with which they are consumed and used as tools within the archaeological process is problematic when their subjective nature is not considered. The ramifications that can follow from this problematic perception have direct and negative outcomes, as was the case with Grace Islet. Grace islet showed us that archaeological maps have consequences as they circulate and are consumed, it showed us that map production can be flawed, and that there is ample room for improvement. What the theoretical framework relayed was that the archaeological mapping process should be studied and improved to promote better outcomes for the overall process.

The analytical framework laid out in section 3 identified that visual anthropology, through the production, circulation and consumption model, aids in understanding and analyzing archaeological maps as a process rather than an inert object. What this revealed, and what was demonstrated at Grace Islet, is that ethics should be at the forefront of the conversation at each of these stages if we want to improve the archaeological process and outcomes. By embedding ethics and treating it as an open conversation, as was outlined by Meskell and Pels (2005), the archaeological process can be improved. But when looking back at Grace Islet, ethics alone would not prevent the mistakes that occurred there. The production process, resulting in the physical map they produced, was insufficient in creating an archaeological map that could be relied on in terms of its clarity, accuracy, detail, and overall representation. Through the Active Research approach, focusing on the production stage, handheld mobile LiDAR seems to be a viable technology that improves the archaeological mapping production stage of the process. Its current attributes and abilities suggest that this technology will undoubtedly be used in archaeology in the near future. This paper is therefore not necessarily arguing for the implementation of this technology to improve the archaeological process, as much as it is arguing for awareness of the ethical ramifications and dilemmas that could come from its implementation if its effects are undertheorized. As the PCC model helps reveal, implementing this technology in the production stage reinvents the other stages in terms of the changes and effects that are carried throughout the process. Without addressing the ethical concerns beforehand, and reevaluating them at every stage by embedding ethics into the process, the widespread implementation of HML as a tool for archaeological site mapping will be ethically problematic and unsuccessful in improving the archaeological outcomes in a far-reaching and meaningful way.

To conclude, handheld mobile LiDAR is a versatile and viable tool for improving archaeological site maps, but in order for it to make the archaeological process and outcomes better, it needs to be implemented in a way that embeds ethics at every stage of the process. Addressing the ethical concerns now, before HML becomes widely used in the field will result in better outcomes. A model of production, circulation, and consumption which draws on visual anthropology enables us to study archaeological maps in a meaningful way that reveals how, and in what ways, maps influence the archaeological process, which in turn influences the outcomes. By improving both the ways in which maps are produced, circulated, and consumed, as well as by embedding ethics into the process, better outcomes will be achieved.

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