A REVIEW OF INTRUSIVE SEARCH METHODS AND EXCAVATION TECHNIQUES
FOR CLANDESTINE GRAVE SITE RECOVERY IN FORENSIC ARCHAEOLOGY

By

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Declaration

I declare that this thesis does not contain any material submitted previously for the award of any other degree or diploma at any university or other tertiary institution. Furthermore, to the best of my knowledge, it does not contain any material previously published or written by another individual, except where due reference has been made in the text. Finally, I declare that all reported experimentations performed in this research were carried out by myself, except that any contribution by others, with whom I have worked is explicitly acknowledged.

Signed: Danielle Colledge

Date: 28 June 2020
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I would like to thank my supervisor, Brendan Chapman, for providing continuous support throughout my studies. This semester has been very challenging with all the changes that occurred, and I could not have completed this thesis without your guidance.

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Part One

Literature Review

A review of intrusive search methods and excavation techniques for clandestine grave site recovery in forensic archaeology
Abstract

Archaeological intrusive search and excavation methods have been widely used in the recovery of human remains and associated evidence from clandestine graves. This is due to the realisation that employing archaeological methods has increased evidence recovery rates and reduced the risk of damaging evidence. It is imperative to the forensic investigation that appropriate archaeological methods are employed as maximum evidence recovery with minimal damage is required. Despite the critical role adequate search and excavation techniques play, there is limited literature available which analyses and compares the effectiveness and suitability of common intrusive search methods and excavation techniques in forensic archaeology. Probe searches, shovel testing, and utilising heavy equipment are types of intrusive search methods used to locate potential clandestine graves. Arbitrary Level Excavation (ALE), Stratigraphic Excavation (SE), and a combined ALE/SE excavation approach are excavation methods advocated by numerous authors to recover buried remains. This dissertation aims to review current literature regarding these intrusive search methods and excavation techniques used in the recovery of remains from clandestine grave sites. This review found that probe searches have proven to be successful to locate a potential grave site and to outline the perimeter of the grave. In terms of excavation techniques, it appears that SE has higher evidence recovery rates when compared to ALE, but no such comparisons can be made for the combined approach due a to lack of scientific research. It is clear throughout this review that there is a lack of standardisation and scientific research regarding the practicality and utility of intrusive search methods and excavation techniques. Therefore, several recommendations for future research are proposed to address these gaps identified in the literature.
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List of Abbreviations

ALE – Arbitrary Level Excavation
EM – Electromagnetic
GPR – Ground-Penetrating Radar
MAGs – Magnetometers
NSW – New South Wales
SE – Stratigraphic Excavation
US – United States
WA – Western Australia
XUs – Excavation units
INTRODUCTION

A grave can be defined as an excavation in the earth for the reception of a corpse, with clandestine meaning secret and concealed (1). Therefore, a clandestine grave is referred to as a secret burial, often associated with homicide. In Australia, the homicide victimisation rate is relatively low, at only 375 victims in 2018 (2). The number of those cases that result in the remains being buried in clandestine graves is considered to be relatively small. However, in America, the estimated number of murders is high at 16,214 (5.0 murders per 100,000 people) in 2018 (3), with significantly more bodies being buried in graves as a method of disposal compared to Australia. Examples of where archaeological methodologies may have been used to locate and recover remains from clandestine graves include the search of the Belangelo State Forrest, New South Wales (NSW), regarding the Ivan Milat “backpacker murders” in 1992; the investigation into the 2007 murder of Corryn Rayney in Kings Park, Western Australia (WA); the search for the victims of serial killer Bruce McArthur in Toronto, Canada from 2010-2017, and; the investigation into the murder of Mary Brosley in Palmer, Massachusetts in 1970.

Forensic archaeology is defined as the application and adaptation of traditional archaeological methodologies to assist and provide evidence to forensic investigations (4-8). It is a sub-discipline of traditional archaeology (4, 5, 7, 9) that provides critical information in regards to the location, recovery, documentation, and analysis of buried remains in forensic death investigations (4, 7, 9). It wasn’t until the 1930s and 1940s that archaeological techniques began to be utilised in forensic investigations (5, 6). In the mid-to-late 1970s, numerous scientific literature was published (10, 11), emphasising the importance of utilising
forensic archaeology (5) in forensic death investigations. In the last 50 years, forensic archaeology has rapidly expanded (5, 6, 9). Today, archaeological search and excavation techniques are routinely used in medico-legal investigations for the recovery of human remains from clandestine grave sites (4, 5, 12). The widespread credibility and increased demand for forensic archaeologists at crime scenes is due to the realisation that employing archaeological methods to forensic investigations has increased evidence recovery rates (5-7, 13) and minimised subsequent damage to the remains (8). When proper archaeological techniques are not employed during the search and excavation of remains, it often results in the destruction of the crime scene context (12, 14) and associated evidence (14, 15), which may have significant downstream implications on the investigation.

A primary aspect of any forensic homicide investigation is locating the site of deposition (16), in this case, the clandestine grave(s). The type of search method utilised depends on a variety of factors including; the size of the area to be searched, type of terrain, soil type, logistics (money, time, resources), climate, time since burial, and burial depth (17-21). It is important to note that, generally, non-intrusive search methods are employed first as they are non-destructive towards the remains and evidence and work by observing or detecting surface changes consistent with a clandestine grave (16, 18). There is extensive literature that analyses several common non-intrusive search methods, including visual searches (16, 22-27), cadaver dogs (16, 24, 26) and geophysical methods such as ground penetrating radar (GPR) (19, 20, 24, 25, 28-33), electromagnetic (EM) induction meters (24, 28, 31, 34, 35), electrical resistivity meters (20, 24, 30-33, 35, 36), magnetometers (MAGs) (33, 35), magnetic susceptibility (20, 37) and metal detectors (31, 38). Although non-intrusive search methods are routinely used and are imperative search techniques when locating clandestine grave in
forensic investigations, these search methods are beyond the scope of this review, which will focus exclusively on intrusive search methods. Intrusive search methods are destructive (16, 26) and can potentially damage the remains and evidence. They are commonly used as a follow-up when non-intrusive methods have been exhausted or failed to locate a potential grave. Despite the potentially destructive nature of these methods, they are routinely employed in forensic burial investigations. In addition, there is a lack of scientific research that explores the effectiveness and practicality of utilising intrusive methods as a search technique.

Numerous scientific literature has been published highlighting the importance of utilising adequate forensic archaeological excavation techniques when recovering buried remains (5, 6, 12). During the investigation of domestic murder cases, Spennemann and Franke (39) and Haglund (12) used archaeological techniques to recover remains and associated evidence from clandestine graves. The authors’ contribution towards the careful removal of remains and evidence from within the grave fill was essential towards the forensic investigation and resultant court case. However, there is no standard excavation method in forensic archaeology and numerous authors advocate for different methodologies. In addition, there is a lack of substantial empirical testing in regards to archaeological excavation methods (40) and their evidence recovery rates. Therefore, a significant portion of the excavation undertaken does not meet the admissibility regulations and legal requirements of the international court system (41), as the methods utilised must be able to demonstrate that they adhere to a widely accepted and tested archaeological investigatory process (41-43).
CHAPTER TWO – EXPERIMENTAL DESIGN

2.1 Review of Existing Literature

This dissertation was conducted in order to systematically review the currently available literature regarding intrusive search methods and excavation techniques used in forensic archaeology for clandestine grave site recovery. The structured approach of the systematic review ensures that relevant research is included in this review and selected appropriately. Relevant literature was searched that includes, but is not limited to, the following databases: Scopus, Web of Science Core Collection, Science Direct, JSTOR, ProQuest, SAGE Journals, Wiley Online Library, and Google Scholar.

Keyword searches were utilised to find potential literature for inclusion in this review. To review intrusive search methods, search terms included intrusive AND search, probe AND search, probing, probe, “T-bar probe”, “penetrometer probe”, “soil-cor* probe”, “soilcor* probe, “shovel test”, shovel AND search, “heavy equipment”, “heavy machin*”, bobcat AND search, backhoe. Results were refined to the category of archaeology. To review excavation techniques, search terms included “arbitrary excavation”, “arbitrary level excavation”, “pedestal excavation”, “stratigraphic excavation”, “forensic archaeolog*” AND excavation, “excavation* methods”, “grave recovery”, “grave* recovery*”, “grave site recovery” and “gravesite recovery”. The first 50 search results were sorted to determine relevance. Search results were limited to English unless an English translation was available. There were no restrictions on the date of publication. Textbooks, peer-reviewed journal articles, and published theses/dissertations were included in this review. Literature was included in this review if they contain one or more of the following:
• A description of intrusive search methods used to locate grave sites.

• Analysis and comparison of intrusive search methods used to locate graves sites.

• A description of archaeological excavation techniques used to recover evidence and remains from grave sites.

• Analysis and comparison of archaeological excavation techniques used to recover evidence and remains from grave sites.

The articles obtained from the keyword searches were initially judged to be relevant based on the title of the article and the abstract. Literature included based on the title and abstract were read in its entirety and critically evaluated to further determine relevance. Literature deemed relevant based on this was then incorporated into this review. Additional searches were conducted based on the relevant literature obtained from these keyword searches. The table of contents for textbooks and published thesis/dissertations were examined to identify potentially relevant chapters. The chapters were briefly skimmed to further determine relevance. If judged to be relevant, the associated section was read in its entirety and critically evaluated to be incorporated into this review. References cited in the literature deemed relevant and used in this review were sought and analysed based on the same criteria.

2.2 Research Aims and Objectives

This dissertation aims to review current literature regarding intrusive search methods and excavation techniques used in the recovery of remains from clandestine grave sites. This will be achieved by:

1. Researching the current intrusive search methods used to locate clandestine grave sites.
2. Researching the current excavation techniques used in forensic archaeology to recover remains from clandestine grave sites.
Aforementioned, intrusive search methods are destructive (16, 26) and can potentially damage the remains and evidence. Therefore, it is recommended that they are used as a follow-up after non-intrusive search methods have been exhausted (16, 17). However, there is a lack of empirical testing of intrusive search methods within the literature and additional studies are required. This chapter will examine three intrusive search methods: probing, shovel testing, and utilising heavy equipment.

3.1 Probing

Arguably the most common intrusive search method utilised to locate both a clandestine grave and its perimeter is a probe search (16). Literature by Imaizumi (44), Owsley (17), Ruffell (45), and Murdo (26) discuss the effectiveness of using probes to locate graves. A probe is a metal or fiberglass rod which has a crossbar handle at the top and a rounded or slightly pointed tip. It is typically around ½ inch in diameter and 4 feet in length (16, 17), however, the length can be varied as required by attaching extensions (17). The probe is inserted into the soil and used to detect differences in soil compaction or soil stratigraphy. Probes are simple to use and less expensive compared to other search methods (17, 26), making them ideal for forensic investigations. They are designed to follow-up visual searches to narrow down the search area. Three types of probes can be utilised; a T-bar probe, a penetrometer probe, and a soil-coring probe.

The T-bar probe is the most common probe used (16) and works by detecting differences in soil compaction through resistance (16, 17, 26). The disturbed soil from the grave fill will be
less dense than the surrounding undisturbed soil. Therefore, a probe manually inserted into disturbed soil (the grave fill) will penetrate deeper and easier, when the same amount of pressure is applied, compared to undisturbed soil (16, 17). When a soft spot is detected it is marked, resulting in a pattern of markers that may show the approximate dimensions and shape of the grave. Similarly to the T-bar probe, the penetrometer probe measures differences in soil compaction, but uses a presser gauge (16) as opposed to subjective resistance. This provides a quantitative measurement of soil density to identify disturbed soil. A standard T-bar probe can be modified to record pressure measurements by attaching a pressure or weight gauge (45). The soil-coring probe is used to determine if soil layers have been disturbed by examining a vertical core of soil. The probe is generally 1 m in length and comprised of a hollow coring tube that is open on one side to allow for visualisation of the soil stratigraphy (16, 17). A reference soil core sample is extracted from the surrounding undisturbed soil and used to compare the cores from the disturbed soil. Disturbed soil will have a distinct ‘mottled’ appearance resulting from the mixing of different soil layers. Dupras et al. (16) state that, because the soil-coring probe is not pushed into the soil as far as the other two probes, there is a reduced risk of damaging the remains and associated evidence. Owsley (17) advocates for the utilisation of all three probe types when attempting to locate a possible clandestine grave to further verify the results. To reduce the potential damage to remains and evidence, the author states that the same holes created by the T-bar probe can subsequently be used for the penetrometer and soil-coring probes.

Owsley (17) states that probes are beneficial as they provide a variety of information in a short period, facilitate excavation, and can successfully detect a grave long after burial took place. The author briefly mentions that probing successfully located a burial that was 150
years old, but acknowledges that recent burials have significantly less resistance compared to older burials (17). However, no information regarding the context, environmental conditions, or soil type of the 150-year-old burial was provided. Therefore, the significance of these results can not be determined. The benefits of utilising probe searches, listed by Owsley (17), are that they are cheap, can be utilised in conjunction with other search methods, are readily available, require very minimal maintenance, and are rapid and effective.

The main problem associated with probe searches is that they are invasive and could potentially damage the remains and evidence within the grave fill. However, Owsley (17) argues that the proper use of the probe causes minimal damage. In addition, they can not be systematically applied over large search areas. Probing is a time-consuming method and should only be used when a potential grave location has been identified via non-intrusive search methods. Importantly, probing requires compact soil and therefore, may not work in soil composed of homogenous sands. The probe can easily be pushed into undisturbed homogenous sands making it difficult to determine differences in soil compaction (16) and therefore, make it difficult to identify potential graves.

Owsley (17) provides examples of forensic and archaeological cases in urban, rubbish-filled, and wooded locations where probes were successfully utilised to locate graves. However, detailed descriptions of the soil types, depth of burial, and time of burial were not provided, which is essential as these factors impact the effectiveness of the probe. Ruffell (45) added a weight gauge to a standard T-bar probe and was able to successfully identify a 3-year-old grave. The data obtained allowed for the geometry of the excavation to be determined. The author notes that further research is required to test the modified probe and the data derived
over various location types and against other methods. A study conducted by Murdo (26) found that probing, when used on areas flagged during the visual search, successfully identified both grave sites and the perimeter of the graves. The study was conducted in the same location for both burials, so no information regarding the impact of probe searches on different soil types was obtained. In addition, there was no mention of whether or not the probe searches damaged the remains within the grave.

Despite the probe being a simple, inexpensive means to locate grave sites, there is a lack of scientific articles that experimentally test and compare the effectiveness of probe searches to locate clandestine burials. Further research is required to determine the best probe method for various environments and soil types and to what extent, if any, probes damage remains and associated evidence.

3.2 Shovel Testing

Shovel testing is occasionally used when other search methods have been exhausted or as a follow-up to probe searches (16). When performing a shovel test, a small test hole is dug with a shovel (16, 26) to determine if there is a potential clandestine burial. Changes in soil stratigraphy are observed to determine if the soil has been altered (26), which may indicate the presence of a burial. As this method is highly destructive, it is not a recommended search method and should only be used as a last resort when all other search methods have failed. There is a significant lack of literature and experiments surrounding shovel testing and its ability to locate a potential grave site.
3.3 **Heavy Equipment**

Heavy equipment, such as a backhoe or grader, is the most intrusive and potentially destructive search method (16, 17, 24) that can be used to locate a clandestine grave. Due to the potentially extreme damage heavy equipment can inflict on the evidence and remains, they should only be used when all other search methods are exhausted (16, 24) or traditional methods are not possible (16). Heavy equipment can be used to remove a thin layer of topsoil (16, 17), leaving behind a relatively smooth surface. Any change of appearance in soil, such as colour changes or differences in soil stratigraphy, may indicate the presence of a burial. It is recommended to use a backhoe with a flat-blade bucket or an elevated scrapper (16) as it is less invasive and destructive. Once a smaller area of interest is identified, the bucket of the backhoe can be extended over the potential burial, leaving the weight from the machinery away from the grave to minimise damage. Owsley (17) states that “a small backhoe, such as found on a Bobcat, can be useful and is easy to manoeuvre in areas with trees or other obstacles” (p.3). Once a potential grave site has been identified, other search methods or careful excavation can take place.

The greatest advantage for utilising heavy machinery to locate a clandestine grave is its ability to search large areas (17) and remove a considerable amount of soil (16), compared to traditional search methods. It is also useful when there is a lack of information regarding the location of the grave site(s) (17), as large areas can be screened and searched in a relatively short period of time. However, it is expensive and could potentially do significant damage to the remains and associated evidence, which could impact the forensic investigation.
Dupras et al. (16) state that in landfills, heavily flooded areas and large areas where geophysical methods are not suitable, the only option to successfully search the area for a grave may involve utilising heavy equipment. The authors were asked to assist in the search for the remains of a missing male on an abandoned pig farm. The search area was $15 \times 25$ m and consisted of tall grass and brush, making a visual search extremely difficult. To successfully search the site, a large field mower was used to clear the area before a backhoe was brought in to systematically search the entire area in a timely manner. Due to the area being an abandoned pig farm, traditional search methods were unsuccessful. The backhoe was able to successfully identify the grave by dislodging a human tibia bone. The authors did not mention the damage, if any, the backhoe made on the tibia bone or the rest of the remains and the impact this may have had on subsequent analysis.

Heavy equipment has proven to be a useful search method in some cases where other techniques have been exhausted or been unsuccessful. However, extreme caution needs to be taken as this method can potentially be extremely destructive to remains, evidence, and the integrity of the grave.

### 3.4 Summary

Intrusive search methods, such as probing, shovel testing, and heavy equipment, are used as a follow-up after non-intrusive methods to locate clandestine graves. Arguably the most common intrusive search method is a probe search (16). Despite the common acceptance for the utility of a probe search (16, 17, 26, 44, 45), there is a lack of empirical data evaluating the effectiveness of probes in various soil types. In certain circumstances, shovel testing and utilising heavy equipment, such as a backhoe, may be required to identify a potential grave.
When using these methods, caution is required as both methods can potentially be extremely destructive to the grave and the evidence within. There are very few published scientific papers that investigate the practicality, utility, and effectiveness of these intrusive search methods. More comprehensive studies and experimentation is required to determine the effectiveness in various soil types and the extent of damage these methods have on remains and evidence.
Aforementioned, the incorporation of archaeological excavation techniques to forensic investigations involving clandestine grave site recovery is essential. Training and utilising archaeological methods has resulted in the dramatic increase in the recovery rate of evidence, the ability to interpret the burial context, and results in minimal damage to both the remains and the grave integrity (8). This chapter discusses the current archaeological excavation techniques.

4.1 Excavation Techniques

Forensic archaeologists utilise traditional archaeological excavation methods that are adapted, depending on the context of the scene. This accommodates the complex nature of burials associated with forensic investigations (4, 5, 46) and ensures a high rate of evidence recognition and recovery (46). Evis et al. (46) state that “this adaptation is largely characterised by processes to establish forensic relevance, limit contamination, record stratigraphy using spits and sections across the grave, as well as the retention of grave fills for subsequent detailed analysis” (p. 176). Despite common opinions regarding the usefulness of forensic archaeology to grave site recovery, the excavation methodology is divided, with forensic archaeologists advocating different excavation techniques for similar grave types (41, 46). This emphasises the lack of standardisation in forensic archaeological fieldwork. The lack of standardised archaeological excavation protocols has resulted in a large variety of excavation methods being applied to forensic excavations (47). Additionally, there is a lack of scientific literature comparing excavation techniques to determine the best method in terms of evidence recovery rates (15, 41, 46). The most common archaeological excavation methods
are Arbitrary Level Excavation (ALE) and Stratigraphic Excavation (SE) (46). However, in order to apply archaeological excavation techniques to forensic investigations, a combined ALE and SE approach is required.

**4.1.1 Soil Stratigraphy**

Stratigraphy is the analysis of the sequence of deposits of soil, which build up over time and form layers, also known as strata (16). These layers can be viewed and interpreted to provide information on the burial contexts (16, 48). Different layers are often described as soil horizons and have observably different characteristics (16) (Table 1, Figure 1). The SE method, described below in 4.1.3 *Stratigraphic Excavation*, utilises soil stratigraphy to determine the chronological order evidence was deposited into the grave.

**Table 1:** Observable characteristics for different soil horizons. From Dupras et al. (16) p.201.

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>O horizon (organic matter)</td>
<td>Litter layer of loose and partly decayed organic matter</td>
</tr>
<tr>
<td>A horizon (surface soil)</td>
<td>Layer of soil with the most organic matter accumulation and soil life</td>
</tr>
<tr>
<td>E horizon (subsurface area of leaching)</td>
<td>Lightly coloured zone of leaching from surface soil</td>
</tr>
<tr>
<td>B horizon (subsoil)</td>
<td>Layer of accumulated mineral and organic compounds from above</td>
</tr>
<tr>
<td>C horizon (parent rock)</td>
<td>Layer of large partially altered or unaltered rocks</td>
</tr>
</tbody>
</table>
4.1.2 Arbitrary Level Excavation

Literature by Spennemann and Franke (39), Stover and Ryan (49), and Oakley (50) argue that graves should be excavated using the ALE method. ALE, also referred to as the Pedestal method (15), is the standard method routinely used during forensic death investigations for the recovery of individual buried remains (15, 46). It is a common method used in traditional archaeological assessments that has been widely adopted in forensic investigations (46).

During excavation, soil is removed in predetermined layers, known as spits (Figure 2; obtained from Hanson (48)). As evidence within the grave is identified, the soil surrounding the evidence is carefully removed, leaving the evidence in situ on a ‘pedestal’. As depicted in Figure 2c-d the grave walls are removed during excavation. The evidence is documented in situ within the grave and is only removed if deemed to be hindering the excavation process. Trenches are often dug around the grave, slightly below the remains, to allow for easy access to the body (15, 46).

**Figure 1:** Common soil horizons encountered in archaeological excavations. From Dupras et al. (16) p.202.
Figure 2: Arbitrary level excavation methodology. a) section across grave and natural stratigraphy; b) removal of O horizon leaf litter, exposing the grave in plan; c) removal of arbitrary levels (1-11), cutting through stratigraphic sequence, mixing soil (fill) types and removing the grave wall; d) evidence/remains and immediate soil left intact and surrounded by an access trench, resulting in the ‘pedestalling’ of evidence (48).

One of the benefits of utilising the ALE method is how easy it is. Because spits can be easily and accurately measured to predetermined depths, less archaeological experience is required (46). This allows forensic investigators who have significantly less archaeological expertise to successfully excavate clandestine grave sites. Spennemann and Franke (39) found that ALE allowed for spatial and depth control for both soil removal and artefact recovery when exhuming six caskets. Additional benefits to the ALE method proposed by Tuller and Duric (15) include: easier access and viewing of remains and evidence; ability to take dynamic photographs for a strong visual impression of the remains and evidence; reduces the amount
of time spent standing on top of the remains during excavation (47), which may damage the
remains or evidence (46); and the use of trenches assists with potential water drainage issues
that can damage the remains and evidence (46, 47). When excavating mass graves, Tuller and
Duric (15) and Haglund et al. (47) discovered that trenches did allow for water and
decomposition fluids to drain away from the remains. However, this drainage lead to the
erosion of the grave and resulted in moving evidence out of situ and further disarticulated
skeletal remains (15).

A major limitation of this excavation method is the destruction of the grave walls, resulting in
the loss of tool marks and potential trace evidence. The grave walls and associated tool marks
can only be recorded in diagrams at the interface of each arbitrary level, if distinguishable
from the natural soil strata. This reduces the accuracy of recording potential tool marks (15,
46). Dupras et al. (16) and Tuller and Duric (15) advocate against the removal of the grave
walls as tool marks and trace evidence present may provide vital evidence when interpreting
how the grave was created. In addition, tool marks may provide essential links between the
crime scene and the perpetrator(s) (15, 16), which is vital in forensic investigations. Other
problems associated with the ALE method involve soil stratigraphy. Evis et al. (46) found that
the ALE method results in the mixing and potential contamination of natural strata with the
grave fill and evidence. This can lead to incorporating irrelevant soil and ‘evidence’ that may
pre or post-date the grave, potentially impacting the conclusions made regarding the grave
context. Evidence removed from the grave can also have no known stratigraphic origin (46,
48) due to the introduction of artificial divisions of deposits during the excavation process
(46, 48). Hanson (48) states that finding evidence in the position it was deposited and filled in
(in situ) is critical in an investigation as it has significant evidentiary value. In addition, Hanson
argues that excavating trenches without utilising machinery does not save time, effort, or space, which is a common belief. Trenches are destructive to the grave integrity and, despite being the common procedure during excavations (48), are rarely necessary. Finally, it is argued that this method destroys and ignores stratigraphic information within the grave (46, 48). However, Spennemann and Franke (39) were able to successfully interpret soil stratigraphy using the ALE method.

In 1995, Spennemann and Franke (39) successfully applied ALE to six exhumations on Mejatto Island, Republic of the Marshall Island. It was critical to a United States (US) Congress investigation that the exhumations were conducted to a standard of high accuracy and accountability, hence the use of forensic archaeological techniques. Due to the nature of the burials, it was not required to maintain the integrity of the grave walls, hence the use of the ALE method. The exhumations were conducted in four arbitrary levels. Spit 1 was at 0.6 m, spit 2 at 1.0 to 1.2 m, spit 3 was where the casket perimeter was visible, and spit 4 was the exposed casket. Because the graves were dug in arbitrary levels and properly documented at each spit, a description and interpretation of soil stratigraphy was possible (Table 2 and Figure 3). This allowed for the interpretation of the events that occurred during burial, an important aspect of forensic investigations (12, 39). Based on the soil stratigraphy for Exhumation Number 1, the authors concluded that unless a single person was constantly moving from one side of the grave to the other, taking a shovel load from different soil types, then two or more people were involved. They further concluded that this vital information would have been missed if archaeological techniques were not utilised, highlighting the importance of proper excavation techniques to maximise evidence recovery in forensic investigations (39). This example highlights the benefits and potential the ALE method has to forensic clandestine
grave site recovery when the context of the investigation does not require the integrity of the grave wall to be maintained.

Table 2: Characteristics of the soil types in Mejatto (39).

<table>
<thead>
<tr>
<th>Soil no.</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Subangular coarse, very loose sand of very pale brown to pinkish white/pinkish grey colour (Munsell 7.5-10YR 7.8/2-3) [13]; single grain, non-sticky and non-plastic; this soil has no humus content and no root matter</td>
</tr>
<tr>
<td>2</td>
<td>Subangular medium to coarse, very loose sand of light brownish grey colour (Munsell 2.5Y6/2); single grain, non-sticky and non-plastic; this soil has some root matter</td>
</tr>
<tr>
<td>3</td>
<td>Subangular mainly medium, partially coarse, sand of dark grey to dark greyish brown colour (Munsell 2.5Y 4/1-2); single grain, friable, non-sticky and non-plastic; this soil has a very small humus content and a higher content of root matter than soils no. 1 or no. 2</td>
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<tr>
<td>4</td>
<td>Subangular mainly medium, partially coarse, sand of grey to greyish brown colour (Munsell 2.5Y 6/1-2); single grain, friable, non-sticky and non-plastic; this soil has a very small humus content and a higher content of root matter than soils no. 1 or no. 2</td>
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Figure 3: Soil stratigraphy from Exhumation Number 1, excavated in a series of four spits. Left: Cross-section of a profile (profile drawing); Right: Interpretation of the soil stratigraphy (39).
Despite its limitations, ALE continues to be regarded as the standard method utilised to excavate single clandestine grave site burials in forensic investigations (15, 46). One possible suggestion for this was proposed by Evis et al. (46). The authors argue that the majority of forensic graves lack complex stratigraphy and are often comprised of only one soil type. Therefore, the interpretation of stratigraphy is simple and justifies the utilisation of the ALE method (46). Literature by Haglund et al. (47) argues that, when excavating mass graves, the contents of the grave are more important than maintaining the grave wall integrity and reconstructing how the grave was created. In order to efficiently remove evidence from mass graves, it is easier and quicker to destroy the grave wall and remove evidence from the side (47), hence excavating using the ALE method. When a grave is narrow, access to the remains is difficult, and/or the surrounding soil is unstable (48), it may be necessary to remove the grave wall and use the ALE method. In forensic investigations, it is required that graves can be re-interpreted from the documentation made during the excavation to provide details on how the grave was created (46, 48). This includes interpreting tool marks found on the grave walls to potentially indicate the method and tools used to dig the graves. The best way to achieve this is by utilising the SE method (48), as the grave wall integrity is maintained.

4.1.3 Stratigraphic Excavation

In contrast, literature by Connor and Scott (6), Hunter et al. (21), Skinner et al. (51), Blau (52), Blau and Skinner (53), Jessee and Skinner (54), Skinner and Sterenberg (55), Evis et al. (46), Tuller and Duric (15), Hanson (48), Ward et al. (56) and Schultz and Dupras (5) argue that graves should be excavated using the SE method. The SE method identifies and excavates separate stratigraphic contexts (46), allowing for sequence analysis (Figure 4). Each stratigraphic context is removed and documented from the latest deposit to the earliest, in a
sequence that is the reverse order of deposition (15, 46, 48). This method views the entire grave as an archaeological feature, including the grave walls and floor. The grave walls are exposed and maintained throughout the excavation process (15, 46, 48). This allows for the retention and accurate documentation of tool marks and other trace evidence present on the grave wall surfaces and grave floor, as depicted in Figure 4d.

![Stratigraphic excavation methodology](image)

**Figure 4**: Stratigraphic excavation methodology. a) removal of O horizon leaf litter, exposing the grave in plan; b) careful and controlled removal of grave fill without destroying stratigraphic boundaries and damaging the grave surface; c) complete removal of grave fill, exposing the remains, evidence and grave walls for analysis; d) stratigraphic excavation exposes a variety of trace and other evidence on the grave walls and floor (48).

The main benefit of utilising the SE method is the ability to interpret events through reconstruction of the depositional sequence of soil types and evidence (46, 48). Three-dimensional documentation of each stratigraphic context (46) allows for the soil and
associated evidence to be interpreted within the grave site (48). Reconstructing the sequence of events during the burial is crucial to forensic investigations. Aforementioned, Spennemann and Franke (39) were able to interpret the events that occurred during burial due to information gathered surrounding the stratigraphic context of the grave fill. Additional benefits proposed by Evis et al. (46) include: revealing interfaces between each deposit; spatial and depth control for both evidence recovery and removal of soil; prevention of contamination between different soil stratigraphy due to the excavation of separate stratigraphic contexts; chronological recovery of evidence which allows for the interpretation of the events that occurred at, or around, the time of burial; and the ability to take dynamic photographs of the remains and evidence which reflect the order of deposition. Tuller and Duric (15) also found that SE is better at maintaining the grave contents in situ, there is greater control over the excavation process, and the grave formation process can be better understood, all factors that are vital in forensic investigations.

Despite all the benefits mentioned above, there are some limitations to this method. Unlike the ALE method, trenches are not dug around the grave. Therefore, without tents and other suitable precautions, water can collect in the grave (15, 46) and may alter or damage the grave integrity and evidence both within and outside the grave. In addition, Evis et al. (46) state that it can be difficult to recognise individual stratigraphic contexts, particularly interfaces. Over time, extensive bioturbation by earthworms, plant root growth, ploughing, and other animal and insect activity (48), causes the different soil layers to mix. This makes it difficult to recognise and document each stratigraphic layer. The authors also note that SE is a more complex method to perform (46) compared to the ALE method and requires a more in-depth knowledge of archaeological techniques. This method is also perceived to slow down
excavation (46) as it is more complex and appears more time consuming compared to ALE. The two main problems associated with the SE method proposed by Tuller and Duric (15) are: limited access to the remains, particularly in confined and deep graves; and the remains are stood on during excavation, potentially damaging the remains. However, Hanson (48) states that the soil content from the grave fill weighs more than the excavator and, therefore, standing on the remains should not damage it. Most graves can be successfully excavated from the surface at depths of 0.7-0.8 m (48) and therefore, do not require the excavator to stand on the remains if the grave is shallower than this.

Given the benefits proposed above for the SE method, in particular the ability to determine the sequence of events that occurred and recovering tool marks and trace evidence from the grave wall, it is obvious why the majority of literature advocates for this method to be utilised in forensic investigations. Misinterpretation, destruction, and/or loss of evidence has potentially devastating consequences for forensic investigations and prosecutions (46, 48), hence the need to utilise the archaeological methodology with the greatest information and evidence recovery. Because the findings from forensic excavations are subject to legal implications, such as prosecutions, information regarding the excavation methods suitability, error rates, and potential impacts on interpretations is required (41, 46).

4.1.4 Recovery of Evidence, Tool Marks and Stratigraphic Contexts

Two key journal articles aim to experimentally compare ALE and SE to determine which method is better in terms of evidence recovery (15, 46). Evis et al. (46) conducted a blind experiment to compare the ALE and the SE methods in regards to evidence recovery rates, recovery of stratigraphic contexts, recovery of tool marks, and the time taken to excavate.
Each grave measured 1.20 m long, 0.75 m wide and 0.85 m deep and were designed to be as identical as possible regarding the location and properties, to allow for an objective comparison of the two techniques. All evidence was placed in identical, predetermined locations within each grave fill, making all eight graves a replica. Four archaeologists with various levels of expertise (Archaeologist 1: 7 days of archaeological experience; Archaeologist 2: 3 months of archaeological experience; Archaeologist 3: 2.5 years of archaeological experience; and Archaeologist 4: 6 years of archaeological experience) individually excavated two grave sites using both the ALE method and the SE method. Because each archaeologist excavated two replica graves using two different methods, the ALE and SE graves for each archaeologist were 180° mirror images to reduce bias. The authors note that no archaeologist realised that the graves were identical (46). Overall, the results of this study demonstrated higher total evidence recovery rates for the SE method when compared to the ALE method. The total evidence recovery rates expressed as a percentage of the sum of the evidence recovered, stratigraphic contexts, and tool marks recovered, were 71% and 56% for the SE and ALE methods, respectively (46). However, statistical analysis was not conducted on the results obtained, and therefore, statistical significance could not be determined. Neither method conducted in this study successfully recovered all the evidence, highlighting the importance of continued research regarding the reliability and suitability of both ALE and SE and the development of novel techniques with higher evidence recovery rates.

The average evidence recovered, both in situ and out of situ, was higher for the SE method when compared to the ALE method, at 72% and 64%, respectively. Between the four archaeologists, the rate of evidence retrieval varied between 55-77% and 59-82% for the ALE and SE methods, respectively. The ALE methodology had a higher average of evidence found
out of situ of 37.5% (range of 18-54%) compared to the SE method which had an average of 29% (range of 0-46%) (46). Evidence identified out of situ was recovered via subsequent sieving of the removed soil, highlighting the importance of adequate screening of the soil removed. The authors attribute the higher average of evidence found out of situ for the ALE method to the application of the method and subsequent removal of the grave wall. Removing the edge of the grave fill resulted in some evidence being dislodged from its original position and recovered during sieving. The authors did not attempt to explain the reason behind the SE method producing similar results. In addition, the ALE method, on average, recovered a higher amount (33%) of extraneous evidence compared to the SE method (8%) (46). Extraneous evidence is the inclusion of unrelated evidence present outside the grave boundary, in the undisturbed strata. When utilising the SE method, only one archaeologist (out of four), recovered an extraneous artefact. The authors note, however, that this is due to the archaeologist incorrectly identifying the boundaries of the grave throughout the excavation. When utilising the ALE method, two archaeologists (out of four) were unable to differentiate between the grave fill and undisturbed strata and subsequently recovered extraneous artefacts. This is attributed to the removal of the grave wall boundaries during ALE. Although not explained by the authors, Hunter and Cox (57) and Hanson (48) state that by arbitrarily stripping the grave, evidence from the within the grave fill and the surrounding undisturbed strata become co-mingled and lose their original contexts. This results in an increased risk of recovering extraneous evidence (46, 48), which potentially has significant downstream implications on the forensic investigation.

In addition to comparing the recovery rates of evidence, Evis et al. (46) compared the recovery of stratigraphic contexts between the ALE and SE methods. The authors recorded an average
of 51%, with a variance rate of 4%, of stratigraphic contexts correctly identified when excavating using the ALE method. An average of 71% of the stratigraphic contexts were correctly identified whilst utilising the SE method, with a variance rate of 38% (46). The authors attribute the low recovery rate when using the ALE method to the method itself, rather than the application. As the grave structure is destroyed during the removal of the arbitrary levels, interfaces within the grave structure are also destroyed, making it difficult for the archaeologist to identify and define the stratigraphic contexts of the grave. Overall, when utilising the ALE methodology, the authors noted that the archaeologists were unable to define the chronology of activity during the creation of the grave. Determining the chronology of activity is essential during forensic investigations (48) and the excavation technique employed should be able to achieve this. In comparison, the authors attribute the results obtained for the SE method to additional factors, such as excavation experience and the skills of the archaeologist, rather than the method itself. The archaeologists with the least experience, Archaeologists 1 and 2, only recovered 62% and 52% of the stratigraphic contexts, respectively. The ones with the greater experience, Archaeologists 3 and 4, successfully recovered 81% and 90% of stratigraphic contexts, respectively (46). The level of experience had no impact on the results obtained for the ALE method. Therefore, the results indicate that individual experience plays a vital role in the recovery of stratigraphic contexts when utilising the SE method. The authors did not explain how the percentage result was determined.

The recovery of tool marks present on the grave walls, created by a machine bucket tool, was also recorded. Only one archaeologist (out of four) successfully identified the presence of tool marks within the grave when using the ALE method, resulting in an average recovery of only
12.5% for this method (46). However, the authors note that the reason the archaeologist was able to identify the tool marks was due to the final spit coinciding with the grave floor where the marks were maintained and subsequently observed. Because three archaeologists could not identify tool marks, they were unable to determine how the grave was constructed. Again, these results were attributed to the method itself, as destroying the grave wall during the ALE method destroys the associated tools marks. When using the SE method, all four archaeologists were able to identify tool marks, resulting in an average recovery of 63.5% for this method (46). All archaeologists successfully identified the presence of machine bucket tool marks when using the SE method and were, therefore, able to discern how the grave was created. The higher rate of recovery of tool marks for the SE method can be attributed to maintaining the integrity of the grave walls.

The second study was conducted by Tuller and Duric (15) and aimed to identify the most effective excavation method to recover skeletal remains from mass graves. Two mass graves, with similar properties, were excavated utilising the ALE and SE methods. Both graves were 10 m apart and had similar properties. Grave A was excavated by a team of forensic pathologists and anthropologists utilising the ALE method. Grave B was excavated by a team of archaeologists utilising the SE method. All members had experience excavating mass graves, however, the impact different disciplines had on the recovery of evidence is unknown. The authors note that the differences in the results obtained were too great to be caused solely by the use of different disciplines, but acknowledge that the same disciplines need to be used for more accurate results. The authors experienced similar results to the study above by Evis et al. (46) and advocates that SE is the best methodology. Unlike Evis et al. (46), chi-square goodness-of-fit and contingency tests were performed to statistically analyse the
resultant data. The results indicated that ‘small’ skeletal remains were recovered at a higher rate utilising the SE method (total of 89 bones) compared to the ALE method (total of 25 bones), which the authors attribute to better recovery techniques from the archaeological excavation team (15) as opposed to the different methodologies.

In addition, there was a significant difference in the recovery of unassociated remains. The grave excavated via the ALE methodology had significantly greater numbers of unassociated remains (total of 635 bones) when compared to the SE method (total of 239 bones) (15). Therefore, the SE method better maintained the provenience and articulation of remains within the grave. The authors concluded that this could be attributed to the SE method maintaining the grave wall integrity and keeping the remains in situ (15). They argue that removing the grave walls allows for the body mass to relax and slump, leading to further disarticulation and moving the remains out of situ around the perimeter of the grave (Figure 5) (15). Despite this study being conducted on skeletal remains from mass graves, it still has practical implications on the recovery of single remains from clandestine grave sites. It provides a statistical analysis comparing the ALE and SE methods in terms of evidence recovery. Additional studies are required to further compare the two methods.
Figure 5: Body mass slumping after excavation. A: Stratigraphic excavation method; B: Arbitrary level excavation method (15).

4.1.5 Utilising a Combined Excavation Approach

Journal articles by Ward et al. (56) and David and Weisler (58) and textbook publications by Dupras et al. (16), Byers (22), and Balme and Paterson (59) outline a combined ALE and SE method. This combined methodology is based on three basic principles obtained from the ALE and/or SE methods: utilising a grid for horizontal control (16, 22, 56); vertical control using excavation units (XUs) responsive to stratigraphic contexts (56, 58); and a final reconstruction of three-dimensional stratigraphy post-excavation (56). This was the beginning of the ‘combined excavation approach’ routinely used today in forensic investigations for clandestine grave site recovery (56). Essentially, this approach involves the removal of soil in arbitrary levels, whilst maintaining the integrity of the grave walls. When utilising the
combined approach, graves should be dug in defined arbitrary levels of 1 inch (22) or 2 inch spits (5, 16). The combined approach is designed to maximise evidence recovery (16, 56) and increase the interpretation ability of the associated evidence. Theoretically, the combined excavation approach allows for increased evidence recovery rates, recovery of tool marks and trace evidence from the grave walls and floor, and recovery and interpretation of stratigraphic contexts. In addition, this method can be applied by individuals, such as crime scene officers, that have limited knowledge in identifying soil stratigraphy (59), without losing vital stratigraphic evidence. Despite the theoretical benefits, there is no scientific literature that evaluates the practicality, suitability, or validity of utilising the combined ALE and SE approach.

4.2 Summary

It is clear that there is a lack of standardisation and scientific evidence regarding the appropriate archaeological excavation technique to apply to clandestine grave site recovery (46). ALE and SE continue to be the most common archaeological excavation techniques applied. Both methods are applied to forensic investigations and aim to maximise evidence recovery, with minimal damage. Additionally, a combined ALE and SE approach is routinely used in medico-legal investigations but lacks scientific validity. Utilising appropriate excavation techniques, depending on the context of the scene, is essential (5, 6, 12) to criminal investigations to ensure potential information is not damaged or overlooked. Although numerous authors agree that appropriate excavation techniques are required, there is very little literature that evaluates the effectiveness and subsequently compares the different methods. Further research is required to assess and compare the excavation
techniques in terms of evidence recovery rates, recovery of grave walls and associated tool marks and trace evidence, error rates, and interpretation of stratigraphic contexts.
CHAPTER FIVE – DISCUSSION AND CONCLUSIONS

Applying appropriate archaeological methods towards locating and recovering remains and evidence from clandestine graves is essential during forensic investigations to maximise evidence recovery rates (5-7, 13) and minimise damage (8). When archaeological methods are not utilised, it can potentially damage or exclude vital evidence and have significant downstream implications on the criminal investigation. Despite the common acceptance and application of these search methods and excavation techniques, there is minimal literature that scientifically validates their utility.

Research conducted by a few authors including Dupras et al. (16), Owlsley (17), Ruffell (45), and Murdo (26) attempt to investigate the use and practicality of intrusive search methods. Probe searches, shovel testing, and utilising heavy equipment are often used to locate potential clandestine burial sites after non-destructive methods have been exhausted. The literature published from these authors have provided a critical step towards empirically testing these search methods, but additional research is required. The findings from the research into intrusive search methods outlined in this review are relatively consistent. Probe searches have proven to be beneficial to not only locate a potential grave but to also outline the grave perimeter. All authors highlighted the potential damage and extreme caution that is required when using more destructive search methods, such as shovel testing and using heavy equipment. However, the effectiveness of intrusive searches is substantially impacted by environmental conditions, particularly soil type, and the methods may not apply to all environmental conditions.
It is evident from this review that numerous authors advocate for different excavation methods. Some authors, such as Spennemann and Franke (39) advocate for the ALE method, whereas others such as Connor and Scott (6) and Hunter et al. (21) advocate for the SE method. In addition, a relatively new method, the combined excavation approach, is being advocated by authors such as Ward et al. (56) and Balme and Paterson (59). This highlights the lack of standardisation regarding the appropriate archaeological excavation technique to apply to clandestine grave site recovery. Currently, there is a distinct lack of scientific research available that directly compares all three methods in terms of evidence recovery rates. It is possible to draw conclusions on the effectiveness of the ALE and SE methods based on the research conducted by Tuller and Duric (15) and Evis et al. (46), which indicates that SE is the best methodology. Additional research, in various environmental conditions, is required to determine which of the three methods is the most suitable for recovering remains for forensic investigations.

As stated throughout this review, archaeological search and excavation methods must be applied when location and recovering remains from clandestine graves. The significant research gaps identified in this review demands for the continued research into the practicality and suitability of intrusive search methods and archaeological excavation techniques. This will ensure that appropriate techniques are applied to reduce the risk of damaging remains and maximising evidence recovery rates.
Aforementioned, there is a distinct lack of scientific literature published in regard to the methodologies involved in intrusive searches and excavation techniques for the recovery of buried remains. For intrusive searches, future research is required to expand on the research conducted by Owsley (17) and Ruffell (45) into the effectiveness of probe searches. Alterations in the experimental parameters regarding the location, soil type, burial depth, and time since burial are required to determine what extent these factors have on the utility of probe searches to locate clandestine graves. This additional research will provide critical information into the strengths and limitations of probe searches, information which can help during forensic investigations to decide which type of probe, if any, is the most suitable in regard to the context of the scene.

Although numerous authors agree that appropriate excavation techniques are required, there is very little literature that experimentally tests the validity and suitability of the ALE, SE, and combined excavation methods. Forensic excavation techniques should consistently yield the highest evidence recovery rates, and have the ability to be adapted to fit the complex nature of forensic burials (15). Currently, this information is lacking as there is a significant gap in the literature in terms of experimentally and empirically testing these methods (46). Further research is required to assess and compare the excavation techniques in terms of evidence recovery rates, recovery of tool marks and trace evidence from the grave walls, error rates, and interpretation of stratigraphic contexts. Statistical analysis of each method, similar to the one proposed by Tuller and Duric (15), needs to be applied to the resultant data to determine the statistical significance of the results.
In some cases, traditional archaeological excavation methods can not be applied to forensic investigations. For example, deep holes, confined spaces, or potentially hazardous environments may have little to no access to the forensic archaeologist and require the use of a novel approach (4, 5, 8, 16, 60). Schultz and Dupras (5) applied such an approach, using an industrial vacuum excavator truck when searching for human remains in a sealed city septic-holding. Due to the potentially hazardous chemicals that may be present in the tank and the confined entrance, traditional archaeological techniques could not be applied. The use of an industrial vacuum excavator allowed the tank to be excavated and the contents searched. However, there is no published literature on the effectiveness or potential effect this method has on the remains and associated evidence. It is unknown if this method damages the remains and evidence, if it affects the integrity of the grave and what the evidence recovery rates are. Therefore, future analysis is required to test and evaluate the practicality of utilising industrial vacuum excavators for grave site recovery.
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Part Two

Manuscript

A review of intrusive search methods and excavation techniques

for clandestine grave site recovery in forensic archaeology
Abstract

Archaeological intrusive search and excavation methods have been widely used in the recovery of human remains from clandestine graves as they increase the evidence recovery rates. It is imperative to the forensic investigation that appropriate archaeological methods are employed as maximum evidence recovery with minimal damage is required. This review evaluates various intrusive search methods including probe searches, shovel testing, and heavy equipment and common excavation techniques including Arbitrary Level Excavation (ALE), Stratigraphic Excavation (SE), and a combined ALE/SE excavation approach for their potential use and effectiveness at locating clandestine grave sites. Despite the critical role adequate search and excavation techniques play, there is limited literature available which analyses and compares the effectiveness and suitability of common intrusive search methods and excavation techniques in forensic archaeology. This review found that probe searches have proven to be successful at locating a potential grave site. In terms of excavation techniques, it appears that SE has higher evidence recovery rates when compared to ALE, but no such comparisons can be made for the combined approach due to lack of scientific research. It is clear throughout this review that there is a lack of standardisation and scientific research regarding the practicality and utility of intrusive search methods and excavation techniques and the need for additional research.

Keywords: Forensic science, forensic investigation, probing, shovel testing, heavy equipment, arbitrary level excavation, stratigraphic excavation, combined excavation.
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List of Abbreviations

ALE – Arbitrary Level Excavation
SE – Stratigraphic Excavation
XUs – Excavation units
1. Introduction

A grave can be defined as an excavation in the earth for the reception of a corpse, with clandestine meaning secret and concealed (1). Therefore, a clandestine grave is referred to as a secret burial, often associated with homicide. In Australia, the homicide victimisation rate is relatively low, at only 375 victims in 2018 (2). The number of those cases that result in the remains being buried in clandestine graves is considered to be relatively small. However, in America, the estimated number of murders is high at 16,214 (5.0 murders per 100,000 people) in 2018 (3), with significantly more bodies being buried in graves as a method of disposal compared to Australia.

Forensic archaeology is defined as the application and adaptation of traditional archaeological methodologies to assist and provide evidence to forensic investigations (4-8). It is a sub-discipline of traditional archaeology (4, 5, 7, 9) that provides critical information in regards to the location, recovery, documentation, and analysis of buried remains in forensic death investigations (4, 7, 9). Today, archaeological search and excavation techniques are routinely used in medico-legal investigations for the recovery of human remains from clandestine grave sites (4, 5, 10). The widespread credibility and increased demand for forensic archaeologists at crime scenes is due to the realisation that employing archaeological methods to forensic investigations has increased evidence recovery rates (5-7, 11) and minimised subsequent damage to the remains (8). When proper archaeological techniques are not employed during the search and excavation of remains, it often results in the destruction of the crime scene context (10, 12) and associated evidence (12, 13), which may have significant downstream implications on the investigation.
A primary aspect of any forensic homicide investigation is locating the site of deposition (14), in this case, the clandestine grave(s). Current intrusive search methods used to locate a potential grave site include probe searches, shovel testing, and utilising heavy equipment. Once a potential grave site has been located, careful excavation using archaeological excavation techniques is required. There is no standard excavation method in forensic archaeology and numerous authors advocate for different methodologies including Arbitrary Level Excavation (ALE), Stratigraphic Excavation (SE), and a combined excavation approach. The following review summarises currently available literature regarding intrusive search methods and excavation techniques and evaluates their potential use and effectiveness in locating and recovering remains from clandestine graves.

2. Discussion

2.1 Intrusive Search Methods

Intrusive search methods are destructive (14, 15) and can potentially damage the remains and evidence. Therefore, it is recommended that they are used as a follow-up after non-intrusive search methods have been exhausted (14, 16). The type of search method utilised depends on a variety of factors including, the size of the area to be searched, type of terrain, soil type, logistics (money, time, resources), climate, time since burial, and burial depth (16-20). However, there is a lack of empirical testing of intrusive search methods within the literature and additional studies are required. Probing, shovel testing, and utilising heavy equipment are three intrusive search methods commonly used to locate a grave site.
2.1.1 Probing

Arguably the most common intrusive search method utilised to locate both a clandestine grave and its perimeter is a probe search (14). Literature by Imaizumi (21), Owsley (16), Ruffell (22), and Murdo (15) discuss the effectiveness of using probes to locate graves. The probe is inserted into the soil and used to detect differences in soil compaction or soil stratigraphy. Probes are simple to use and less expensive compared to other search methods (15, 16), making them ideal for forensic investigations. Three types of probes can be utilised; a T-bar probe, a penetrometer probe, and a soil-coring probe.

The T-bar probe is the most common probe used (14) and works by detecting differences in soil compaction through resistance (14-16). The disturbed soil from the grave fill will be less dense than the surrounding undisturbed soil. Therefore, a probe manually inserted into disturbed soil (the grave fill) will penetrate deeper and easier, when the same amount of pressure is applied, compared to undisturbed soil (14, 16). When a soft spot is detected it is marked, resulting in a pattern of markers that may show the approximate dimensions and shape of the grave. Similarly to the T-bar probe, the penetrometer probe measures differences in soil compaction, but uses a presser gauge (14) as opposed to subjective resistance. This provides a quantitative measurement of soil density to identify disturbed soil. A standard T-bar probe can be modified to record pressure measurements by attaching a pressure or weight gauge (22). The soil-coring probe is used to determine if soil layers have been disturbed by examining a vertical core of soil. The probe is generally 1 m in length and comprised of a hollow coring tube that is open on one side to allow for visualisation of the soil stratigraphy (14, 16). A reference soil core sample is extracted from the surrounding undisturbed soil and used to compare the cores from the disturbed soil. Disturbed soil will
have a distinct ‘mottled’ appearance resulting from the mixing of different soil layers. Dupras et al. (14) state that, because the soil-coring probe is not pushed into the soil as far as the other two probes, there is a reduced risk of damaging the remains and associated evidence. Owsley (16) advocates for the utilisation of all three probe types when attempting to locate a possible clandestine grave to further verify the results. To reduce the potential damage to remains and evidence, the author states that the same holes created by the T-bar probe can subsequently be used for the penetrometer and soil-coring probes.

Owsley (16) states that probes are beneficial as they provide a variety of information in a short period, facilitate excavation, and can successfully detect a grave long after burial took place. The author briefly mentions that probing successfully located a burial that was 150 years old, but acknowledges that recent burials have significantly less resistance compared to older burials (16). However, no information regarding the context, environmental conditions, or soil type of the 150-year-old burial was provided. Therefore, the significance of these results can not be determined. The benefits of utilising probe searches, listed by Owsley (16), are that they are cheap, can be utilised in conjunction with other search methods, are readily available, require very minimal maintenance, and are rapid and effective.

The main problem associated with probe searches is that they are invasive and could potentially damage the remains and evidence within the grave fill. However, Owsley (16) argues that the proper use of the probe causes minimal damage. In addition, they can not be systematically applied over large search areas. Probing is a time-consuming method and should only be used when a potential grave location has been identified via non-intrusive search methods. Importantly, probing requires compact soil and therefore, may not work in
soil composed of homogenous sands. The probe can easily be pushed into undisturbed homogenous sands making it difficult to determine differences in soil compaction (14) and therefore, make it difficult to identify potential graves.

Owsley (16) provides examples of forensic and archaeological cases in urban, rubbish-filled, and wooded locations where probes were successfully utilised to locate graves. However, detailed descriptions of the soil types, depth of burial, and time of burial were not provided, which is essential as these factors impact the effectiveness of the probe (16-20). Ruffell (22) added a weight gauge to a standard T-bar probe and was able to successfully identify a 3-year-old grave. The data obtained allowed for the geometry of the excavation to be determined. The author notes that further research is required to test the modified probe over various locations. A study conducted by Murdo (15) found that probing, when used on areas flagged during the visual search, successfully identified both grave sites and the perimeter of the graves. The study was conducted in the same location for both burials, so no information regarding the impact of probe searches on different soil types was obtained. In addition, there was no mention of whether or not the probe searches damaged the remains within the grave.

Despite the probe being a simple, inexpensive means to locate grave sites, there is a lack of scientific articles that experimentally test and compare the effectiveness of probe searches to locate clandestine burials. Based on the limited research available, probe searches appear to be an effective method at locating grave sites. Further research is required to determine the best probe method for various environments and soil types and to what extent, if any, probes damage remains and associated evidence.
2.1.2 Shovel Testing

Shovel testing is occasionally used when other search methods have been exhausted or as a follow-up to probe searches (14). When performing a shovel test, a small test hole is dug with a shovel (14, 15) to determine if there is a potential clandestine burial. Changes in soil stratigraphy are observed to determine if the soil has been altered (15), which may indicate the presence of a burial. As this method is highly destructive, it is not a recommended search method and should only be used as a last resort when all other search methods have failed. There is a significant lack of literature and experiments surrounding shovel testing and its ability to locate a potential grave site.

2.1.3 Heavy Equipment

Heavy equipment, such as a backhoe or grader, is the most intrusive and potentially destructive search method (14, 16, 23) that can be used to locate a clandestine grave. Due to the potentially extreme damage heavy equipment can inflict on the evidence and remains, they should only be used when all other search methods are exhausted (14, 23) or traditional methods are not possible (14). Heavy equipment can be used to remove a thin layer of topsoil (14, 16), leaving behind a relatively smooth surface. Any change of appearance in soil, such as colour changes or differences in soil stratigraphy, may indicate the presence of a burial. It is recommended to use a backhoe with a flat-blade bucket or an elevated scrapper (14) as it is less invasive and destructive. Once a smaller area of interest is identified, the bucket of the backhoe can be extended over the potential burial, leaving the weight from the machinery away from the grave to minimise damage. Owsley (16) states that “a small backhoe, such as found on a Bobcat, can be useful and is easy to manoeuvre in areas with trees or other
obstacles” (p.3). Once a potential grave site has been identified, other search methods or careful excavation can take place.

The greatest advantage for utilising heavy machinery to locate a clandestine grave is its ability to search large areas (16) and remove a considerable amount of soil (14), compared to traditional search methods. It is also useful when there is a lack of information regarding the location of the grave site(s) (16), as large areas can be screened and searched in a relatively short period of time. However, it is expensive and could potentially do significant damage to the remains and associated evidence, which could impact the forensic investigation.

In some cases such as landfills, heavily flooded areas, and large areas where geophysical methods are not suitable, the only option to successfully search the area for a grave may involve utilising heavy equipment (14). Dupras et al. (14) were asked to assist in the search for the remains of a missing male. Due to the environmental conditions and the area being an abandoned pig farm, traditional search method were extremely difficult or unsuccessful. A large field mower was used to clear the area before a backhoe was brought in to systematically search the entire area in a timely manner. The backhoe was able to successfully identify the grave by dislodging a human tibia bone. The authors did not mention the damage, if any, the backhoe made on the tibia bone or the rest of the remains and the impact this may have had on subsequent analysis.

Heavy equipment has proven to be a useful search method in some cases where other techniques have been exhausted or been unsuccessful. However, extreme caution needs to
be taken as this method can potentially be extremely destructive to remains, evidence, and the integrity of the grave.

The above studies have outlined the methodology and potential usefulness of intrusive search methods to locate a possible grave site. However, there are very few published scientific papers that investigate the practicality, utility, and effectiveness of these search methods. More comprehensive studies and experimentation is required to determine the effectiveness in various soil types and the extent of damage these methods have on remains and evidence. Once a clandestine grave site has been identified, the remains and associated evidence must be removed via archaeological excavation techniques.

2.2 Excavation Techniques

Forensic archaeologists utilise traditional archaeological excavation methods that are adapted, depending on the context of the scene. This accommodates the complex nature of burials associated with forensic investigations (4, 5, 24) and ensures a high rate of evidence recognition and recovery (24). Evis et al. (24) state that “this adaptation is largely characterised by processes to establish forensic relevance, limit contamination, record stratigraphy using spits and sections across the grave, as well as the retention of grave fills for subsequent detailed analysis” (p. 176). Despite common opinions regarding the usefulness of forensic archaeology to grave site recovery, the excavation methodology is divided, with forensic archaeologists advocating different excavation techniques for similar grave types (24, 25). This emphasises the lack of standardisation in forensic archaeological fieldwork which has resulted in a large variety of excavation methods being applied to forensic excavations (26). Additionally, there is a lack of substantial empirical testing in regards to archaeological
excavation methods (27) and their evidence recovery rates. Therefore, a significant portion of the excavation undertaken does not meet the admissibility regulations and legal requirements of the international court system (25), as the methods utilised must be able to demonstrate that they adhere to a widely accepted and tested archaeological investigatory process (25, 28, 29). The most common archaeological excavation methods are Arbitrary Level Excavation (ALE) and Stratigraphic Excavation (SE) (24). However, in order to apply archaeological excavation techniques to forensic investigations, a combined ALE/SE approach is required.

2.2.1 Arbitrary Level Excavation and Stratigraphic Excavation

Literature by Spennemann and Franke (30), Stover and Ryan (31), and Oakley (32) argue that graves should be excavated using the ALE method. ALE, also referred to as the Pedestal method (13), is the standard method routinely used during forensic death investigations for the recovery of individual buried remains (13, 24). It is a common method used in traditional archaeological assessments that has been widely adopted in forensic investigations (24). During excavation, soil is removed in predetermined layers, known as spits (Figure 1; obtained from Hanson (33)). As evidence within the grave is identified, the soil surrounding the evidence is carefully removed, leaving the evidence in situ on a ‘pedestal’. As depicted in Figure 1c-d the grave walls are removed during excavation. The evidence is documented in situ within the grave and is only removed if deemed to be hindering the excavation process. Trenches are often dug around the grave, slightly below the remains, to allow for easy access to the body (13, 24). Table 1 details the advantages and disadvantages proposed for the ALE method.
Figure 1: Arbitrary level excavation methodology. a) section across grave and natural stratigraphy; b) removal of O horizon leaf litter, exposing the grave in plan; c) removal of arbitrary levels (1-11), cutting through stratigraphic sequence, mixing soil (fill) types and removing the grave wall; d) evidence/remains and immediate soil left intact and surrounded by an access trench, resulting in the ‘pedestalling’ of evidence (33).
Table 1: The proposed advantages and disadvantages of the ALE method (13, 14, 24, 26, 30, 33).

<table>
<thead>
<tr>
<th>Excavation Technique</th>
<th>Advantages</th>
<th>Disadvantages</th>
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</thead>
<tbody>
<tr>
<td>ALE</td>
<td>Easy</td>
<td>Destruction of the grave walls (loss of tool marks and potential trace evidence)</td>
</tr>
<tr>
<td></td>
<td>Requires less archaeological experience</td>
<td>Difficult to distinguish interfaces</td>
</tr>
<tr>
<td></td>
<td>Allows for spatial and depth control</td>
<td>Mixing and potential contamination of soil stratigraphy</td>
</tr>
<tr>
<td></td>
<td>Easier access and viewing of remains and evidence</td>
<td>Destroys and ignores stratigraphic information</td>
</tr>
<tr>
<td></td>
<td>Ability to take dynamic photographs for a strong visual impression</td>
<td>Evidence may have no known stratigraphic origin</td>
</tr>
<tr>
<td></td>
<td>Less time spent standing on the grave fill</td>
<td>Does not save time, effort or space</td>
</tr>
<tr>
<td></td>
<td>Trenches assist with water drainage issues</td>
<td>Trenches may erode grave and move evidence out of situ</td>
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Despite the argument that this method destroys and ignores stratigraphic information (24, 33), Spennemann and Franke (30) were able to successfully interpret soil stratigraphy using the ALE method on six exhumations on Mejatto Island, Republic of the Marshall Island. Due to the nature of the burials, it was not required to maintain the integrity of the grave walls, hence the use of the ALE method. Because the graves were dug in four arbitrary levels and properly documented at each spit, a description and interpretation of soil stratigraphy was possible (Table 2 and Figure 2). This allowed for the interpretation of the events that occurred during burial, an important aspect of forensic investigations (10, 30). The authors concluded
that this vital information would have been missed if archaeological techniques were not utilised, highlighting the importance of proper excavation techniques to maximise evidence recovery in forensic investigations (30). This example highlights the benefits and potential the ALE method has to forensic clandestine grave site recovery when the context of the investigation does not require the integrity of the grave wall to be maintained.

Table 2: Characteristics of the soil types in Mejatto (30).

<table>
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<tr>
<th>Soil Number</th>
<th>Brief Description</th>
<th>Colour</th>
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<tbody>
<tr>
<td>1</td>
<td>Subangular coarse, very loose sand; single grain, non-sticky and non-plastic; no humus content and no root matter</td>
<td>Very pale brown to pinkish white/pinkish grey</td>
</tr>
<tr>
<td>2</td>
<td>Subangular medium to coarse, very loose sand; single grain, non-sticky and non-plastic; has some root matter</td>
<td>Light brownish grey</td>
</tr>
<tr>
<td>3</td>
<td>Subangular mainly medium, partially coarse sand; single grain, friable, non-sticky and non-plastic; very small humus content and a higher content of root matter than soils number 1 or number 2</td>
<td>Dark grey to dark greyish brown</td>
</tr>
<tr>
<td>4</td>
<td>Subangular mainly medium, partially coarse sand; single grain, friable, non-sticky and non-plastic; very small humus content and a higher content of root matter than soils number 1 or number 2</td>
<td>Grey to greyish brown</td>
</tr>
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</table>
Figure 2: Soil stratigraphy from Exhumation Number 1, excavated in a series of four spits. Left: Cross-section of a profile (profile drawing); Right: Interpretation of the soil stratigraphy (30).

Despite its limitations, ALE continues to be regarded as the standard method utilised to excavate single clandestine grave site burials in forensic investigations (13, 24). One possible suggestion for this was proposed by Evis et al. (24). The authors argue that the majority of forensic graves lack complex stratigraphy and are often comprised of only one soil type. Therefore, the interpretation of stratigraphy is simple and justifies the utilisation of the ALE method (24). Literature by Haglund et al. (26) argues that, when excavating mass graves, the contents of the grave are more important than maintaining the grave wall integrity and reconstructing how the grave was created. In order to efficiently remove evidence from mass graves, it is easier and quicker to destroy the grave wall and remove evidence from the side (26), hence excavating using the ALE method. When a grave is narrow, access to the remains is difficult, and/or the surrounding soil is unstable (33), it may be necessary to remove the
grave wall and use the ALE method. In forensic investigations, it is required that graves can be re-interpreted from the documentation made during the excavation to provide details on how the grave was created (24, 33). This includes interpreting tool marks found on the grave walls to potentially indicate the method and tools used to dig the graves. The best way to achieve this is by utilising the SE method (33), as the grave wall integrity is maintained.

In contrast, literature by Connor and Scott (6), Hunter et al. (20), Skinner et al. (34), Blau (35), Blau and Skinner (36), Jessee and Skinner (37), Skinner and Sterenberg (38), Evis et al. (24), Tuller and Duric (13), Hanson (33), Ward et al. (39) and Schultz and Dupras (5) argue that graves should be excavated using the SE method. The SE method identifies and excavates separate stratigraphic contexts (24), allowing for sequence analysis (Figure 3). Each stratigraphic context is removed and documented from the latest deposit to the earliest, in a sequence that is the reverse order of deposition (13, 24, 33). This method views the entire grave as an archaeological feature, including the grave walls and floor. The grave walls are exposed and maintained throughout the excavation process (13, 24, 33). This allows for the retention and accurate documentation of tool marks and other trace evidence present on the grave wall surfaces and grave floor, as depicted in Figure 3d. Table 3 details the advantages and disadvantages proposed for the SE method.
Figure 3: Stratigraphic excavation methodology. a) removal of O horizon leaf litter, exposing the grave in plan; b) careful and controlled removal of grave fill without destroying stratigraphic boundaries and damaging the grave surface; c) complete removal of grave fill, exposing the remains, evidence and grave walls for analysis; d) stratigraphic excavation exposes a variety of trace and other evidence on the grave walls and floor (33).
<table>
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<tr>
<th>Excavation Technique</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>Ability to interpret events by reconstructing the depositional sequence</td>
<td>Water can collect in the grave fill</td>
</tr>
<tr>
<td></td>
<td>Three-dimensional documentation of each stratigraphic context</td>
<td>Can be difficult to recognise individual stratigraphic contexts</td>
</tr>
<tr>
<td></td>
<td>Reveals interfaces between each deposit</td>
<td>More complex method to perform</td>
</tr>
<tr>
<td></td>
<td>Spatial and depth control</td>
<td>Requires more in-depth knowledge of archaeological techniques and stratigraphy</td>
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<tr>
<td></td>
<td>Prevention of contamination between different soil stratigraphy</td>
<td>Perceived to slow down excavation (more time consuming)</td>
</tr>
<tr>
<td></td>
<td>The ability to take dynamic photographs of the remains and evidence which reflect the order of deposition</td>
<td>Limited access to remains</td>
</tr>
<tr>
<td></td>
<td>Better at maintaining the grave contents in situ</td>
<td>Remains are stood on during excavation (depths greater than 0.7-0.8 m)</td>
</tr>
<tr>
<td></td>
<td>Greater control over the excavation process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Grave formation process can be better understood</td>
<td></td>
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</table>

Given the benefits proposed above for the SE method, in particular the ability to determine the sequence of events that occurred and recovering tool marks and trace evidence from the grave wall, it is obvious why the majority of literature advocates for this method to be utilised in forensic investigations. Misinterpretation, destruction, and/or loss of evidence has potentially devastating consequences for forensic investigations and prosecutions (24, 33),
hence the need to utilise the archaeological methodology with the greatest information and evidence recovery. Because the findings from forensic excavations are subject to legal implications, such as prosecutions, information regarding the excavation methods suitability, error rates, and potential impacts on interpretations is required (24, 25).

2.2.2 Recovery of Evidence, Tool Marks and Stratigraphic Contexts

Two key journal articles aim to experimentally compare ALE and SE to determine which method is better in terms of evidence recovery (13, 24). Evis et al. (24) conducted a blind experiment to compare the ALE and the SE methods in regard to evidence recovery rates, recovery of stratigraphic contexts, recovery of tool marks, and the time taken to excavate. Each grave was designed to be replicas regarding the location and properties, to allow for an objective comparison of the two techniques. Four archaeologists with various levels of expertise (Archaeologist 1: 7 days of archaeological experience; Archaeologist 2: 3 months of archaeological experience; Archaeologist 3: 2.5 years of archaeological experience; and Archaeologist 4: 6 years of archaeological experience) individually excavated two grave sites using both the ALE method and the SE method. Because each archaeologist excavated two replica graves using two different methods, the ALE and SE graves for each archaeologist were 180° mirror images to reduce bias. The authors note that no archaeologist realised that the graves were identical (24). Overall, the results of this study demonstrated higher total evidence recovery rates for the SE method when compared to the ALE method. The total evidence recovery rates were 71% and 56% for the SE and ALE methods, respectively (24). However, statistical analysis was not conducted on the results obtained, and therefore, statistical significance could not be determined. Neither method conducted in this study successfully recovered all the evidence, highlighting the importance of continued research.
regarding the reliability and suitability of both ALE and SE and the development of novel techniques with higher evidence recovery rates.

The average evidence recovered, both in situ and out of situ, was higher for the SE method when compared to the ALE method, at 72% and 64%, respectively. Between the four archaeologists, the rate of evidence retrieval varied between 55-77% and 59-82% for the ALE and SE methods, respectively. The ALE methodology had a higher average of evidence found out of situ of 37.5% (range of 18-54%) compared to the SE method which had an average of 29% (range of 0-46%) (24). The authors attribute the higher average of evidence found out of situ for the ALE method to the application of the method and subsequent removal of the grave wall. Removing the edge of the grave fill resulted in some evidence being dislodged from its original position and recovered during sieving. The authors did not attempt to explain the reason behind the SE method producing similar results. In addition, the ALE method, on average, recovered a higher amount (33%) of extraneous evidence compared to the SE method (8%) (24). Extraneous evidence is the inclusion of unrelated evidence present outside the grave boundary, in the undisturbed strata. When utilising the SE method, only one archaeologist (out of four), recovered an extraneous artefact. The authors note, however, that this is due to the archaeologist incorrectly identifying the boundaries of the grave throughout the excavation. When utilising the ALE method, two archaeologists (out of four) were unable to differentiate between the grave fill and undisturbed strata and subsequently recovered extraneous artefacts. This is attributed to the removal of the grave wall boundaries during ALE. Although not explained by the authors, Hunter and Cox (40) and Hanson (33) state that by arbitrarily stripping the grave, evidence from the within the grave fill and the surrounding undisturbed strata become co-mingled and lose their original contexts. This
results in an increased risk of recovering extraneous evidence (24, 33), which potentially has significant downstream implications on the forensic investigation.

In addition to comparing the recovery rates of evidence, Evis et al. (24) compared the recovery of stratigraphic contexts between the ALE and SE methods. The authors recorded an average of 51%, with a variance rate of 4%, of stratigraphic contexts correctly identified when excavating using the ALE method. An average of 71% of the stratigraphic contexts were correctly identified whilst utilising the SE method, with a variance rate of 38% (24). The authors attribute the low recovery rate when using the ALE method to the method itself, rather than the application. As the grave structure is destroyed during the removal of the arbitrary levels, interfaces within the grave structure are also destroyed, making it difficult for the archaeologist to identify and define the stratigraphic contexts of the grave. Overall, when utilising the ALE methodology, the authors noted that the archaeologists were unable to define the chronology of activity during the creation of the grave. Determining the chronology of activity is essential during forensic investigations (33) and the excavation technique employed should be able to achieve this. In comparison, the authors attribute the results obtained for the SE method to additional factors, such as excavation experience and the skills of the archaeologist, rather than the method itself. The archaeologists with the least experience, Archaeologists 1 and 2, only recovered 62% and 52% of the stratigraphic contexts, respectively. The ones with the greater experience, Archaeologists 3 and 4, successfully recovered 81% and 90% of stratigraphic contexts, respectively (24). The level of experience had no impact on the results obtained for the ALE method. Therefore, the results indicate that individual experience plays a vital role in the recovery of stratigraphic contexts when
utilising the SE method. The authors did not explain how the percentage result was determined.

The recovery of tool marks present on the grave walls, created by a machine bucket tool, was also recorded. The justification for using a mechanical digger is that they are commonly used to dig graves (24, 40), however, recovery rates of tool marks will differ when other methods, such as a shovel, are utilised to create the grave. Only one archaeologist (out of four) successfully identified the presence of tool marks within the grave when using the ALE method, resulting in an average recovery of only 12.5% for this method (24). However, the authors note that the reason the archaeologist was able to identify the tool marks was due to the final spit coinciding with the grave floor where the marks were maintained and subsequently observed. Because three archaeologists could not identify tool marks, they were unable to determine how the grave was constructed. Again, these results were attributed to the method itself, as destroying the grave wall during the ALE method destroys the associated tools marks. When using the SE method, all four archaeologists were able to identify tool marks, resulting in an average recovery of 63.5% for this method (24). All archaeologists successfully identified the presence of machine bucket tool marks when using the SE method and were, therefore, able to discern how the grave was created. The higher rate of recovery of tool marks for the SE method can be attributed to maintaining the integrity of the grave walls.

The second study was conducted by Tuller and Duric (13) and aimed to identify the most effective excavation method to recover skeletal remains from mass graves. Two mass graves, with similar properties, were excavated utilising the ALE and SE methods. Grave A was
excavated by a team of forensic pathologists and anthropologists utilising the ALE method whereas Grave B was excavated by a team of archaeologists utilising the SE method. The authors note that the differences in the results obtained were too great to be caused solely by the use of different disciplines but acknowledge that the same disciplines need to be used for more accurate results. The authors experienced similar results to the study above by Evis et al. (24) and advocates that SE is the best methodology. Unlike Evis et al. (24), chi-square goodness-of-fit and contingency tests were performed to statistically analyse the resultant data. The results indicated that ‘small’ skeletal remains were recovered at a higher rate utilising the SE method (total of 89 bones) compared to the ALE method (total of 25 bones), which the authors attribute to better recovery techniques from the archaeological excavation team (13) as opposed to the different methodologies.

In addition, there was a significant difference in the recovery of unassociated remains. The grave excavated via the ALE methodology had significantly greater numbers of unassociated remains (total of 635 bones) when compared to the SE method (total of 239 bones) (13). Therefore, the SE method better maintained the provenience and articulation of remains within the grave. The authors concluded that this could be attributed to the SE method maintaining the grave wall integrity and keeping the remains in situ (13). They argue that removing the grave walls allows for the body mass to relax and slump, leading to further disarticulation and moving the remains out of situ around the perimeter of the grave (Figure 4) (13). Despite this study being conducted on skeletal remains from mass graves, it still has practical implications on the recovery of single remains from clandestine grave sites. It provides a statistical analysis comparing the ALE and SE methods in terms of evidence recovery. Based on the two studies outlined above, SE appears to be the most beneficial
method compared to ALE in terms of evidence recovery rates, recovery of tool marks, and recovery of stratigraphic contexts. However, in order to accurately determine the most effective method to recover remains, additional studies are required.

![Diagram of body mass slumping after excavation. A: Stratigraphic excavation method; B: Arbitrary level excavation method.](image)

**Figure 4**: Body mass slumping after excavation. A: Stratigraphic excavation method; B: Arbitrary level excavation method (13).

### 2.2.3 Utilising a Combined Excavation Approach

Journal articles by Ward et al. (39) and David and Weisler (41) and textbook publications by Dupras et al. (14), Byers (42), and Balme and Paterson (43) outline a combined ALE and SE method. This combined methodology is based on three basic principles obtained from the ALE and/or SE methods: utilising a grid for horizontal control (14, 39, 42); vertical control using excavation units (XUs) responsive to stratigraphic contexts (39, 41); and a final reconstruction of three-dimensional stratigraphy post-excavation (39). This was the beginning of the
‘combined excavation approach’ routinely used today in forensic investigations for clandestine grave site recovery (39). Essentially, this approach involves the removal of soil in arbitrary levels, whilst maintaining the integrity of the grave walls. When utilising the combined approach, graves should be dug in defined arbitrary levels of 1 inch (42) or 2 inch spits (5, 14). The combined approach is designed to maximise evidence recovery (14, 39) and increase the interpretation ability of the associated evidence. Theoretically, the combined excavation approach allows for increased evidence recovery rates, recovery of tool marks and trace evidence from the grave walls and floor, and recovery and interpretation of stratigraphic contexts. In addition, this method can be applied by individuals, such as crime scene officers, that have limited knowledge in identifying soil stratigraphy (43), without losing vital stratigraphic evidence. Despite the theoretical benefits, there is no scientific literature that evaluates the practicality, suitability, or validity of utilising the combined ALE/SE approach. Therefore, no conclusions can be made regarding its effectiveness in recovering remains from clandestine graves and further research is required.

3. Conclusions

Applying appropriate archaeological methods towards locating and recovering remains and evidence from clandestine graves is essential during forensic investigations to maximise evidence recovery rates (5-7, 11) and minimise damage (8). When archaeological methods are not utilised, it can potentially damage or exclude vital evidence and have significant downstream implications on the criminal investigation. Despite the common acceptance and application of these search methods and excavation techniques, there is minimal literature that scientifically validates their utility.
Research has attempted to investigate the use and practicality of intrusive search methods to locate clandestine grave sites. The literature published from several authors pertained in this review has provided a critical step towards empirically testing these search methods, but additional research is required. The findings from the research into intrusive search methods outlined in this review are relatively consistent. Probe searches have proven to be beneficial at locating a potential grave site. All authors highlighted the potential damage and extreme caution that is required when using more destructive search methods, such as shovel testing and using heavy equipment. However, the effectiveness of intrusive searches is substantially impacted by environmental conditions, particularly soil type, and the methods may not apply to all environmental conditions.

In addition, there is a clear lack of standardisation regarding the appropriate archaeological excavation technique to apply to clandestine grave site recovery. Several approaches including ALE, SE, and a combined ALE/SE method are advocated by numerous authors. Currently, there is a distinct lack of scientific research available that directly compares all three methods in terms of evidence recovery rates. This manuscript evaluated several archaeological excavation techniques for their potential use and effectiveness at recovering remains and evidence from clandestine graves. Despite the significant lack of research, conclusions can be drawn using the few studies that have been conducted and the proposed advantages and disadvantages of the ALE and SE methods outlined in this review. These studies indicate that SE is the better methodology when compared to ALE. No conclusions can be made regarding the combined approach due to a lack of research.
Continued research, in various environmental conditions, is required to determine the most suitable intrusive search and excavation technique for recovering remains for forensic investigations. This will ensure that appropriate techniques are applied based on the context of the scene and may lead to developing a standardised approach within forensic archaeological fieldwork. Further research and empirical testing into excavation techniques are essential to meet the admissibility regulations and legal standards of the international court system required in forensic investigations.
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2FYxFaqXShNdz_Pw9P4x-93ue_fTjHHYa5g5gO882clj3v7ooqPKJuEcXGA.

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