Technical Report on the Tuam Site

Stage 2: Options and Appropriate Courses of Action available to Government at the site of the former Mother and Baby Home, Tuam, Co. Galway

Delivered to Minister Katherine Zappone, Department of Children and Youth Affairs

By the

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Finalised 19th October 2017

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In March 2017, the Mother and Baby Home Commission of Investigation released a press statement conveying the discovery of juvenile human remains, in significant quantities, in subsurface chambers on the site of historic sewage system at the former Mother and Baby Home, Tuam, Co. Galway. On the 1st of June, Minister Katherine Zappone commissioned an Expert Technical Group to outline to government what options are available to provide a technical response to this situation in the context of internationally accepted best practise in such cases. The group acknowledges that decisive action is required so as not to further delay the dignity of those interred here but also for reasons of preservation/conservation. This report is a detailed presentation of those options that have been identified and what is physically and technically possible at the site.

The situation in Tuam is an unprecedented one for the agencies that usually deal with medico-legal death investigations in Ireland. The group has not identified any directly comparable cases, either nationally or internationally, that involve the complexities of commingled juvenile human remains, in significant quantities and in such a restricted physical location.

There are a number of factors that make this situation unique:

- The forensic requirement of the site;
- The 'significant' quantities of juvenile remains;
- The commingled or intermixed state of the remains;
- The position of the remains within subsurface chambers, with limited access.

These factors each need to be considered in terms of what is feasible at this site, as well as what outcomes can be reasonably expected. Such complexities cannot be understated and the outcomes may be more limited than expected.

It is the understanding of the ETG that the site is currently in the ownership of Galway County Council and that human remains interred here are in the jurisdiction of the Coroner for North Galway.

The ETG has identified five options available to deal with the human remains at the site:

i) Memorialisation – an option that may be adopted in its own right but also as a result of any further option or action undertaken on site.

ii) Exhumation of known human remains – whereby human remains are exhumed to an alternative location with no further investigation or analysis.

iii) Forensic excavation and recovery of known human remains – a full forensic control and methodology to recover the remains identified to date by previous excavations. Engineering

and Health and Safety consultations indicate that excavation here would be possible but will require a considered approach and significant ground preparations. Full analysis of the remains could be conducted at a post excavation stage.

iv) Forensic excavation and recovery of known human remains with further evaluation/excavation of other areas of interest – the geophysical survey conducted over the entire site illustrates that there are further subsurface anomalies outside of the memorial garden. This would include the recovery of remains identified in the memorial garden and any further human remains identified at other locations.

v) Forensic Excavation of Total Available Area – the most intrusive excavation covering 100% of the available site. All known human remains would be recovered and all other anomalies would be investigated. This is the most exhaustive approach with potential to expose archaeological features.

In instances such as this that involve of commingling of human remains it would be preferred that as much of the remains as possible are recovered and identified. This sorting of mixed remains into individual remains is a particular requirement of mass graves. The sorting of human remains in these contexts involves a variety of specialised techniques; these include osteological and anthropological techniques, and molecular techniques such as DNA.

The issue of DNA and potential identification is highly complex and comes with high expectations. In reality, individual identification of remains here is unlikely without further significant investigation. The commingled state of individuals makes it particularly challenging to isolate the skeletal remains of a single individual. The risk of destruction to human remains themselves, in the pursuit of DNA, also poses a range of ethical questions. In a collective interment scenario, a collective identity is potentially all that is possible.

The site here cannot be considered a mass grave in terms of what is typically associated with violence or conflict; however, any further physical investigation here would necessitate the use of the skillset designed to forensically investigate mass graves. The excavation and analysis of this site-type requires a specialised and distinct set of skills in terms of initial organising and set-up, on-site recovery and post recovery analysis. Archaeological excavation is destructive process; information is lost if not recorded promptly accurately and comprehensively in a standardised approach. The approach must satisfy judicial requirements, irrespective of whether for judicial or humanitarian reasons.

In the context of international best practise considerations, forensic science has been increasingly used in complex cases such as this during the last 30 years. More recently, this type of work is termed Humanitarian Forensic Action (ICRC), aiming to capture the use of forensic science in mass death contexts that are not necessarily criminal contexts. This approach provides a structure that protects the dignity of the dead through proper recovery, management, and where possible, identification.

In light of research conducted for the purposes of this report the ETG has identified number of factors in the consideration of implementing what could be considered best practice and Humanitarian Forensic Action. These factors identified for consideration are:

- The formation of a Multi-Disciplinary Body to implement strategy
- Undertake further archival research and collection of witness testimony
- Undertake further targeted survey and testing/evaluation of specific areas
- Implement a full forensic excavation of all known human remains
- Implement a full forensic anthropological analysis
- Assessment of application of DNA technologies
- Memorialisation and conservation of the site

Communication with family groups and all relevant stakeholders must be managed effectively. Expectations of outcomes of any future work must be set at realistic levels and these outcomes must be agreed prior to the commencement of any action on site.

It must be stated that it is possible that what is desired to be known about those interred here, may never be fully realised.

The ETG acknowledges that there are legal and ethical considerations that are outside the scope of its work and that have implications for the decision-making process of Government and that have not been considered in the production of this report.

Acknowledgements

The Expert Technical Group would like to acknowledge the following individuals for their generosity of time, information and experience shared. Their inclusion does not imply nor should it be taken as an endorsement of the findings presented.

An Garda Síochána – D. Inspector M Coppinger, Insp. D Flanagan, D. Sgt. S Birmingham, D. Gda J Hennessey, Sgt. P. Hastings

Coroner for North Galway – Dr V. Costello

Department of Children and Youth Affairs – F. Lynch, M. Shannon, J. Gibbs and M. Johnson

Forensic Science Ireland – Dr G. O'Donnell, Dr D. Ramsbottom

Health & Safety Authority – B. Higgisson

National Monuments Service – M. McDonagh, M. Keane and S. Kirwan

Office of the State Pathologist - Prof Dir. M. Cassidy and Dr. L. Mulligan

Ordnance Survey Ireland – D. Cronin

Tusla, The Child and Family Agency – S. Mugan

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Professor Dame S. Black, Centre for Anatomy and Human Identification, University of Dundee, Scotland.

Dr S. Blau, Senior Forensic Anthropology, Victorian Institute of Forensic Medicine, Australia.

Professor D. Bradley, Principle Investigator, Molecular Population Genetics, Smurfit Institute of Genetics, Trinity College Dublin, Ireland.

Professor T. Brown, Manchester Institute of Biotechnology, School of Earth and Environmental Sciences University of Manchester, Manchester, UK.

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Dr M. Tidball-Binz, M.D., Head of Forensic Project, International Committee of the Red Cross (ICRC), Geneva, Switzerland.

Professor G. Shannon, Special Rapporteur on Child Protection, Department of Children and Youth Affairs, Ireland.

Shorcontrol Safety Ltd. – J. Kelly, R. McSherry and F. Spillane.

Professor P. Smith, Joel Wilbush Emeritus Professor, Faculties of Medicine and Dental Medicine, Director of the Laboratory of Bioanthropology and aDNA, Hebrew University Jerusalem, Israel.

Dr C. Speller, Lecturer in Bioarchaeology, BioArch, Department of Archaeology, University of York, UK.

E. Carrick Utsi, EMC Radar Consulting, Cambridgeshire, UK.

D. Walker, Senior Human Osteologist, Museum of London Archaeology, UK.

Dr D. Wolf-Steadman, Director, Forensic Anthropology Facility, University of Tennessee, Knoxville, Tennessee, USA.

The ETG wishes to acknowledge the support and co-operation it received from the Department of Children and Youth Affairs, the Coroner for North Galway, the Gardaí in Tuam and specifically the residents of the Dublin Road Housing Estate for their patience in the course of fieldwork for this report.

Terms of Reference

APPOINTMENT OF AN EXPERT GROUP TO PROVIDE TECHNICAL ASSISTANCE TO GOVERNMENT IN RELATION TO THE SITE OF THE FORMER MOTHER AND BABY HOME IN TUAM, CO. GALWAY

1. BACKGROUND:

The Commission of Investigation (Mother and Baby Homes and certain related Matters) was established in 2015 to examine the experiences of women and children in Mother and Baby Homes over the period 1922-1998.

An early focus of the Commission's work was to examine the question of burials on the site of the former Bon Secours Mother and Baby Home in Tuam, Co. Galway. Following a series of surveys and test excavations, the Commission confirmed the presence of human remains interred on the site.

The Commission's statement on 3 March 2017 is attached as Appendix 1 for ease of reference.

The discovery has generated a demand for clarity on a series of complex questions which arise in relation to the interred remains and the future of this site more generally. The deaths of 796 children were recorded during the 36 years in which the Home was in operation although it is unknown how many of these children's remains may be interred on the site. Public reaction to the discovery has at its core a focus on respecting the dignity and memory of the children who lived their short lives in this Home.

Those persons with personal and family connections to these issues, and the wider local community, will be consulted by the relevant authorities as part of an inclusive process of responding to their concerns.

2. THE NEED FOR EXPERT TECHNICAL ADVICES:

The Government is committed to responding to these issues as effectively and as sensitively as possible. The Minister for Children and Youth Affairs wants to ensure that the approach to be adopted is informed by technical input that accords with international best practice in this specialised area. For this reason the Minister for Children and Youth Affairs is proceeding to appoint a team of technical experts to provide the necessary advices as soon as possible.

The team should be comprised of independent experts with appropriate qualifications and relevant national and international experience. Several areas of expertise including forensic archaeology, juvenile osteoarchaeology, forensic anthropology and DNA analysis will be required. The appointed team may consult with additional experts as it considers appropriate. The expert technical team will

be tasked with producing a *Technical Report on the Tuam Site* which can assist and inform Government deliberations on the appropriate course of action.

The technical advices will be provided in a stage process. Stage 1 will form the basis for the extensive enquiries that will be required to deliver a final report in Stage 2. Stage 1 will be to investigate and produce a preliminary report on the options available in relation to dealing with the human remains at the site of the Children's Burial Ground at Tuam. This report shall be delivered to the Minister by the 30th of June. Stage 2 will investigate each option in a substantive manner, consult with relevant experts and conduct scientific testing as required. This will inform the Minister on the the feasibilty of each option and the relevant outcome for each option that has been outlined in the preliminary Stage 1. The final *Technical Report on the Tuam Site* shall be delivered to the Minister by the end of September 2017.

The Final Technical Report should address:

1. The relevant factors in the management and conservation of the Tuam site, including the range of options for further survey or physical analysis of the site;
2. The possible options and best international practice in the event of a decision to proceed with full or further partial excavation with a view to the exhumation of human remains;
3. The potential to identify the remains of children buried on the site, and the logistical and technical challenges that would be involved in the event of undertaking such work;
4. The potential viability of various options and the potential to achieve specified outcomes; and
5. The measures necessary to protect the human remains interred on the site during any works which may be undertaken

In drafting its Report the expert team is required to:

6. Liaise as appropriate with the Minister and Department of Children and Youth Affairs;
7. Ensure the report is accessible to a non-technical audience and have regard to the potential of the report to inform public debate on these issues;
8. Take account of any information made available by the Commission on Mother and Baby Homes in relation to the site and the chamber structures already identified;
9. Arrange for the completion of a geophysical survey to further clarify the extent of potential burials on the extended site which remains in the ownership of Galway County Council;
10. Have regard to the history of the site, the geology of the local landscape and any relevant environmental factors;

11. Specify the steps which are necessary to comply with the legislative and administrative arrangements which generally apply to such activities in Ireland; and
12. Provide an initial estimate of the potential timeframe and approximate cost involved with each option outlined.

The expert technical team will be required to submit its Report to the Minister for Children and Youth Affairs by the end of September 2017.

It is recognised that the specific circumstances of this discovery gives rise to a number of potential legal and ethical questions which may require clarification in the context of the Government's deliberations on the future of this site. The Government will arrange for these matters to be examined in parallel with the work of the expert technical team.

Department of Children and Youth Affairs

1 June 2017

1 Introduction

The basis for this report is the discovery of juvenile human remains at the site of the former Mother and Baby Home in Tuam, Co. Galway. Inquiries into how to proceed from this on behalf of Minister for Children Katherine Zappone reveal a highly complex situation with many stakeholders involved, including former residents, their families, state institutions and agencies, and the wider public at a local, national and international level. Dealing with this site from a technical perspective, as is the remit of the group, is equally complex.

This report was delivered to the Department of Children and Youth Affairs as swiftly as possible in order to progress the matter so that the individuals interred here in Tuam are afforded the dignity and respect that is afforded to the deceased in our communities. The accessibility of the report was a key issue in its preparation and this has been the primary objective throughout. However, the realities of this site are multifaceted and these cannot be and are not circumvented or simplified in the presentation of the report.

The purpose of this section is to set out the background to the discovery of juvenile human remains at the Tuam site, outline the setting up by the Minister of the Expert Technical Group, show how it gathered information about the site and what this information tells us. Finally, it draws attention to the unique and complex features of the site and their implications for the outcomes of future interventions at the site.

1.1 Background

The possibility of unrecorded burials at the site of the former Mother and Baby Home in Tuam, Co. Galway was first brought to public attention in 2014. The Commission of Investigation (Mother and Baby Homes and certain related Matters) was established in 2015 (hereafter referred to as MBHCOI). An investigation of the potential for burials at the site in Tuam was included in its extensive remit.

Field investigations by the MBHCOI began in 2015 by investigating the site of the memorial garden, using a non-invasive geophysical survey. This was followed by a series of test excavations in 2016 and 2017 to ground truth anomalies that had been identified by remote sensing. On the 3rd of March 2017, the Commission released a press statement detailing the fact that in the course of these test excavations 'significant quantities' of juvenile human remains were located in 'underground chambers' that were associated with a structure potentially relating to the historic treatment of sewage waste. Radiocarbon dating of a sample of the remains discovered suggest the remains date from 'the timeframe relevant to the operation of the Mother and Baby Home…from 1925-1961'. As a result of this discovery the Commission 'asked that the relevant State authorities take responsibility for the appropriate treatment of the remains'.

Setting up the Expert Technical Group

On 1st June 2017 Minster Katherine Zappone established a group to provide expert technical advice on how the government should proceed in dealing with the site and with the human remains therein. As per the Terms of Reference for this Expert Technical Group this process was divided into

two distinct stages. Stage 1 of the process, delivered in June 2017, set out the options that had been initially identified by the group. Stage 2 is represented here by this report in which each of the options identified are explored in greater and more substantive detail. These options are presented from a technical perspective in the scope of requirements, feasibility, estimated timelines and costs.

The six person group represents a multidisciplinary approach to the technical issues at the site; three of the team members had previously worked on the excavations for the MBHCOI. Each team member brings different expertise to bear on this report; forensic archaeology, forensic anthropology, Osteoarchaeology, excavation, remote sensing, DNA Analysis and the Irish medico legal perspective.

1.2 Baseline Information

The site of the memorial garden at Tuam is currently being reported on by the MBHCOI and, as such, the work of the ETG must run parallel with their process. The MBHCOI was established under the Commissions of Investigation Act 2004. This act does not allow for information gathered under their remit to be disclosed or published at this time (Section 11(iii)). Their investigations are currently ongoing and the work of the ETG must not interfere with the due process of their work. As such the information gathered by the MBCHOI during test excavations could not be shared with the ETG at this time. The MBCHOI is due to report to Government in 2018 and their work must be separate to and independent of the reporting of the ETG.

In the interest of timeliness, the group sought onsite observations from the Coroner and the Office of the State Pathologist, to form baseline data for the research of the ETG. These included details of statistics such as the size and nature of the chambers, the potential quantity of individuals contained within, and where on the site these chambers were located.

Additional logistical information was gathered in the form of a geophysical survey of the entire available space that would have been occupied by the site of the Mother and Baby Home. This is discussed in section 2.3. This information formed the basis for the consideration of options available at the site. Historic mapping data and information was also sought to aid the identification of subsurface features that may be highlighted by geophysics results.

Historical information was sought from the Coroner and his agents in relation to the possible number of individuals that may be located on the site of Tuam. In addition, demographic information such as ages-at–death, as well as cause of death, were also requested. These are all factors that would assist with determining what the feasibility of identifying particular individuals might be. At the time of writing this information could not be provided. The estimate for the numbers of individuals who died at the Mother and Baby Home in Tuam, is derived from the Report of the Inter-Departmental Group on Mother and Baby Homes, presented in July 2014. This report identified the number of deaths from the General Registers Office of 796 children during the years 1925-1961.

The information relating to the site that the ETG has gathered may be summarised as follows:

A structure of significance was observed within the boundaries of what is currently referred to as the memorial garden. It is an elongated structure, comprising 20 chambers, with juvenile human remains identified in 17 of those chambers. Information relating to the chambers state that all are

deep and narrow, and are broadly equivalent in size. The human remains within appear to be those of infants with no evidence of formal burial. The dating of these remains by the MBHCOI place the time of death of these juveniles within the modern context, up to 1961. It is the understanding of the ETG that this places the remains within the jurisdiction of the coroner whose district the remains lie in. In this case the Coroner for North Galway.

Unique and Complex Situation

It was clear from the outset of these inquiries that the situation at Tuam was both unique and complex. Initial observations allowed the identification of a number of factors that, together, have no national or international comparisons that the group is aware of. These factors are identified as:

1) The need to observe the potential forensic integrity of the site;
2) The 'significant' quantities of juvenile remains;
3) These human remains lying in a commingled state;
4) The remains are in a subsurface chamber, with limited access, and possibly also affected by the water table.

These factors each need to be considered in terms of what is feasible at this site, as well as what outcomes can be reasonably expected from any decision that might be made in relation to future actions at the site. The complexities cannot be understated and the outcomes may be more limited than expected.

1.3 The History of the Site

The former Mother and Baby Home at Tuam occupied a parcel of land within the northern portion of the townland of Toberjarlath. The northern, western and eastern boundaries of the former site are reflected in the townland boundaries here. The neighbouring townland to the west, Farrannabox, is the only point at which part of the former site of the Mother and Baby Home extends beyond the bounds of Toberjarlath. This is now the area of the memorial garden. The townland name, Toberjarlath, comes from the Irish *Tobar Iarlath* meaning 'Jarlath's Well' (loganim.ie). These townlands are within the Civil Parish of Tuam and in the Barony of Clare, Co. Galway.

It is important to place the site of the former Mother and Baby Home within a historic context to fully consider what archaeology might yet be encountered at the site. The historical and archaeological setting of the site has therefore been traced through all the relevant documentary and cartographic sources that are publicly available and additional information provided by the agents of the Coroner. Below is a brief review of that historical and archaeological evidence with further details given in Appendix E.

1.3.1 Archaeological Background

There is only one recorded prehistoric archaeological site within a 2 kilometre radius surrounding the site. This is a burial mound in which an urn was reputedly found more than a century ago (SMR GA029-203----). However, the name Tuam, or *Tuaim* in Irish, derives from tumulus or burial mound and it is unclear whether this was the site associated with the name. The tumulus of legend was

referred to as *Tuaim Dá Ghualann*, the mound of the two shoulders. This latter mound is likely to have been Bronze Age in origin but no trace of it remains today. The paucity of prehistoric archaeological remains should not be taken as evidence of an absence of early activity but as an indicator that prehistoric archaeology is unlikely to be found at the site concerned.

In contrast, medieval archaeological monuments (from 400 – 1600 AD) are frequent occurrences in the immediate area (see Appendix D). The core medieval town of Tuam lies over 700m northwest of the site of the former Mother and Baby Home (See Figure 1 – Appendix C). A more detailed evolution of the town is given in Appendix E, but it is worth noting that the urban area did not extend to encompass the site of the former Mother and Baby Home in medieval times.

1.3.2 The Nineteenth Century

The Ordnance Survey 1st edition six-inch map series was conducted between 1829 and 1842. This is the first accurate mapping of the area[1] and shows the area of interest as unmarked farmland. At the point at which the later site extends into Farrannabox townland (i.e. the now memorial garden) there is a small quarry depicted (See Figure 2 – Appendix C). The existence of a quarry is noteworthy as it indicates that stone or gravel was prevalent here, and perhaps suggests that drainage was also quite good, thus promoting this location for the position of the subsequent sewage tank. This map is also helpful as it confirms that no structures were upstanding within this part of the townland of Toberjarlath in 1838, and therefore, a reduced potential for earlier archaeology to be found on-site.

The form and layout of the Union Workhouse at Tuam is important in any subsequent assessment of the former Mother and Baby Home. The Irish Poor Law Act was enacted in 1838 and established 130 Poor Law Unions across the country (Lynch 2014, 190). This was largely in response to the famine which swept Ireland in 1822 and each Union was to construct a workhouse. These were designed to accommodate about 1% of the population and all the initial 123 workhouses were built from three standardised layout designs by George Wilkinson. Smaller workhouses were designed to accommodate 200 – 300 people, medium-sized workhouses had 400 – 600 inmates, while the large workhouses were designed for 1,000 people (O'Connor 1995, 80).

The Tuam Poor Law Union established a workhouse at the site in 1840-1. This had to serve a population of over 70,000, and while technically opened in 1842, it did not receive admissions until the 4th May 1846 due to difficulties in collecting funds (O'Connor 1995, 123). The Tuam Workhouse was designed to accommodate 800 inmates and so was at the larger end of the scale of workhouse design.

The great Famine of 1845-1852 placed an immediate pressure on these institutions. In the case of Tuam Workhouse, even though it was built to house 800 people, the Tuam Herald in February 1848 reported that 'at least 2,000 unfortunates were waiting in front of the Workhouse at Dublin Road on a Monday hoping to gain admission' (Delaney *et al.* 2014, 6). By 1853, the Medical Officers of Tuam Dispensary District notified the Board of Guardians of the Workhouse that the 'burying ground in the Town of Tuam is in such a state as to be injurious to the health of the occupiers of premises in… the entire Town' (GCCAS/GPL5/6).

[1] The Down Survey maps (1655-56) for most of Co. Galway were destroyed in 1711.

A standardised layout drawing of a Workhouse is given in Figure 3 (Appendix C). It is at least possible that there was variation in design when one considers the difficulty the Board of Guardians had in collecting the poor law rates. However, the plan of Tuam Workhouse at the Irish Architectural Archive appears accurate, as opposed to aspirational and the date on the plans is 1846. This layout plan conforms to the standardised layout (Figure 4 Appendix C). It includes cesspools at either side servicing the 'Baths' and 'Privies' in the front building. A central cess pool is marked in each of the four large yards, though it is not clear how these connected to the system, if at all. There were also cess pools beneath the privies at the end of each 'Idiot Ward' and the 'Dead House' at the rear. These cess pools directly connected with privies appear to have been approximately 3m x 3m in size and over 2m in depth (Figure 5 Appendix C).

Further ancillary alterations to the building were made at different times. The minutes books of the Board are missing for the period of the famine but it has been suggested that sheds were erected to accommodate a further 100 inmates. There were sheds and auxiliary premises made available, which were closed again in 1851, but these seem not to have been located at the site of the Tuam Workhouse (GCCAS/GPL5/ x).

In 1892, this area was again surveyed to produce the 25-inch Ordnance Survey maps (Figure 6 – Appendix C). The Union Workhouse is depicted as is a rectangular structure extending beyond the townland boundary at the southern corner. The site of the now memorial garden is not annotated but is marked as an unroofed rectangle over the location of the previous quarry. This is the feature that is later marked as a sewage tank. Other notable aspects of this map are the lines of possible walls, dividing a strip of ground along the southwest against the rear wall and a triangular area just northeast of the sewage tank area. The layout of the building itself is quite typical, as shown in Figure 7 (Appendix C). This comprised a frontal probationary block with baths, either side of which is a yard for girls and boys. Behind this is a large block with school rooms, nursery, work room and dormitories for girls, boys, aged men and women. A central chapel and dining hall extends from the latter, separating the women's yard from the men's yard. The rear block is largely used as an infirmary with psychiatric/'idiot' wards either end. Four open yards are delineated at the rear of the standardised plan, but a fifth is marked on the Tuam layout. The mortuary (or 'Dead House') is at the rear. Along the north-western side of the Tuam Workhouse there are additional buildings. The function of these is not known and they do not appear on the original layout drawings. It was recorded that a new wing was constructed in 1891, most likely one of the latter buildings. There is also a Fever Hospital at the eastern limit of the site. By 1892, a 'pump' is marked in the centre of the Women's yard. This location was marked 'cess pool' on the architectural drawing of 1846. The small circle to the northeast of the pump on the 1892 Ordnance Survey map may be an alternative opening to the earlier cess-pool.

1.3.3 The Twentieth Century

The Union Workhouse continued in use through the early years of the 20th century. Amongst the relevant information in the minute books of the Board of Guardians in this period are references to the sewage system. In 1912, '*The Clerk laid before the Board, the amended plan, specification and estimate, £400, for improving the sewage from the Workhouse cesspool as prepared by Mr Michael Newell*...' (GCCAS/GPL5/101, 660) and later that year the Poor Law Inspector stated that '*The Infirmary is very clean, but the body of the house swarms with fleas...Proper lavatory*

accommodation is much needed in the main building' (*ibid*. 101, p333). It is further mentioned that Donnelly & Moore Engineers also submitted plans for the sewage system (*ibid*. xv). The first reference here clearly states a 'cesspool' in the singular and may refer to the later sewage tank at the south. Between August 1912 and July 1914, it was noted that '*The Workhouse sewerage is a bad state and flows out on the public road, this was called attention to at last inspection but nothing done*' (*ibid*. 101, 999). Still nothing appeared to have been done by January 1916 when the Poor Law Inspector noted 'The water supply is most unsatisfactory and... The sanitary condition of the workhouse is most unsatisfactory owing to the lack of a sufficient water supply...' (*ibid*. 101, 226). By 1920, the issue had still not been resolved, when in September the Local Government Board wrote '...in connection with the sewerage scheme proposed some years ago for the Workhouse, and stating that they are advised that any claim for the work in question is barred by Section 51(7) of the Local Government (Ireland) Act 1898 and that the time cannot now be extended' (*ibid*. 106, 477). These references suggest that little or nothing was done in this period to alleviate the sewage system issues.

The six-inch Ordnance Survey map was revised in 1914 (Figure 6 Appendix C). However, no additional information is presented on this map.

The use of the Workhouse gradually but systematically ended when it began to be garrisoned by British forces in late 1920. The Workhouse had been partially occupied on previous occasions, as the military had been stationed here between 1870 – 1872 and again for soldiers on-leave in the winter of 1918. An interim report on local government by Dáil Éireann, from August 1920, noted that the Workhouse at Tuam was still operating normally at that time (BMH.WS1413 Annexes, 82 and 85). However, the minute books of the Tuam Board of Guardians note the incremental occupation of the Workhouse by the military, until June 1921, when the military informed the Clerk that they would be taking over the remaining portion of the building (GCCAS/GPL5/, xvi). There are several accounts of the regular British Army occupying the former Workhouse during 1921 (BMH.WS1489, 22; BMH.WS673, 11).

After the Anglo-Irish Treaty was signed in December 1921 (enacted in 1922), the Workhouse was vacated by the British military force and re-occupied by Free State soldiers. In April 1923, six Anti-Treaty men were arrested and executed at Tuam (i.e. the Workhouse). These became known as the Tuam Martyrs and a commemorative plaque remains on the only section of preserved upstanding wall of the Workhouse/Mother and Baby Home (Figure 9 – Appendix C). This section was the east wall of the Chapel and dining hall. It measures 6m in length and 0.62m in thickness. The commemorative plaque is fitted into a former window opening. Just days after the end of the Civil War in May 1923, two more men, also from the Anti-Treaty side, were executed. It has been suggested that all those executed were buried within the grounds of the former Workhouse and subsequently moved to the Republican plot at Donapatrick.

It was decided that the destitute and orphaned children at Glenamaddy Workhouse under the Bon Secours Sisters would move to this site at Tuam in October 1925 (Corless 2013, 5). There was some delay as the Free State army still occupied the former Workhouse. Although overgrown with weeds with some damaged floor boards, the building was generally in good condition (*ibid*, 6).

In 1927, the Ordnance Survey produced the 2nd edition of the 25" map. This showed the location of the now Mother and Baby Home in some detail (Figure 10 – Appendix C). The area extending into Farrannabox townland, at the south, is marked '*Sewage Tank'* and subtle additions feature along the

northern side of the 'tank'. The whole site is marked 'Children's Home' and there is a small additional building adjacent to the rear mortuary building.

In 1937, the *Irish Independent* advertised a tender for a new drainage scheme at the Children's Home, however, it was also around this time that a new sewage/drainage scheme was brought to the Tuam area and the Mother and Baby Home likely availed of this (Corless 2013, 16-17). Another noteworthy reference is made in the Tuam Herald in 1940 where The Co. Galway Homes and Home Assistance Committee 'decided to prepare a tunnel at the Children's Home for use [as]an air shelter for the occupants of the Home' (*ibid*. 16). It is unclear whether or not such a tunnel was ever constructed. Other structural alterations are recorded to have been made in 1939, 1946 and 1959 (Dictionary of Irish Architects; www.dia.ie).

It was decided in early 1961 that the Mother and Baby Home, having become dilapidated and needing repair, should close and by the summer all occupants had been removed to other institutions (Corless 2013, 15). The site appears to have remained unoccupied until the former Mother and Baby Home was demolished ahead of the construction of residential housing. An aerial photograph from *circa*. 1977 shows the final phase of houses having been constructed (Figure 11 Appendix C). An area at south, including what would become the memorial garden, remained as an overgrown area. Following the apparent completion of the construction, a planning map was created in 1978, in which this overgrown area is marked as a Burial Ground (Figure 12 Appendix C). No differentiation is apparent on this mapping between the area of the memorial garden and that of the now road access area immediately to the northwest.

The memorial garden at the site had been registered in 2016 as an archaeological monument, i.e. a Children's Burial ground (SMR GA043-141----), but subsequent to the excavations carried out by the Mother and Baby Home Commission of Investigation, the classification was made "a redundant record" (see section 1.3.1).

1.3.4 Previous Excavations

There have been 47 licensed archaeological excavations in the Tuam area since the 1970s (www.excavations.ie). Most of these have no bearing on the archaeological potential at the site of the former Mother and Baby Home. However, during the development of the Tuam Town Water Supply Scheme in 2012, a series of burials were found at the western entrance to the Dublin Road Housing Estate (Archaeological Licence No. 10E0117). This was at a location that would have been within the boundary walls, to the west, of the Workhouse/Mother and Baby Home. The excavations revealed a total of 48 individuals buried within 18 grave pits (Delaney *et al*. 2014). Unusually, these grave pits were aligned north-south and all contained between two and four individuals (*ibid*.). The graves contained both males and females, young and old. These were dated by association to the period of the Great Famine and the Workhouse, and interestingly, all burials had been coffined, evidenced by coffin nails (*ibid*.). These burials were clearly within the walls of the Workhouse and complaints about this practice were made in 1847 by the Poor Law Commissioners. They disapproved strongly of burials taking place within 90 feet of the fever sheds. Tenders were put out for burial grounds outside of the Workhouse in 1848 and so it would seem possible that these burials relate to the period 1846-1848 (*ibid*, 44). It is not certain however, that the fever sheds referred to by the Poor Law Commissioners were located at the western side of the Workhouse –

these burials are approximately 90 feet from the main Workhouse buildings – and so there are potentially other locations in which burials took place during these years of the Great Famine.

The evolution of the buildings on site, from a Union Workhouse, to a Military Barracks, to a Mother and Baby Home can be well-understood. The many alternations that may have been made to buildings is less well-understood and may have an impact on what is recognised within geophysical surveys *etc*. The difficulties encountered with the sanitary system are important and the re-design of this may have left redundant subsurface structures/conduits.

2 Status, Environment and Survey of the Site

2.1 Site Ownership

The term 'site' refers to the area to the rear of the houses in the Dublin Road Housing estate. It incorporates the playground, the access roads, the memorial garden and the car park. It is the understanding of the ETG that the site is currently in the ownership of Galway County Council.

2.2 Aspects of the Environment at Tuam

There are several factors that must be considered in any appraisal of the site of the former Mother and Baby Home at Tuam. These include geographical and environmental issues that may be considered unique to this site.

The specific geology of the site at Tuam remains largely unknown. The bedrock geology is 'Visean limestone & calcareous shale' (GSI data at map.geohive.ie). The near surface natural subsoil at the site can be extrapolated from the 2012 excavation at the western corner of the Tuam site. Here, it has been described as a 'yellow-grey silty gritty layer' (Delaney et al. 2014, 31). Together with the presence of quarries in the area, it might be assumed that bands of gravels or limestone/shale bedrock underlie this upper subsoil. The limestone aspect of the bedrock geology may also suggest a degree of porosity and the bedrock groundwater is noted as karstified (GSI data at map.geohive.ie). The water-table depth and variability is unknown at present but likely fluctuates seasonally.

The bounded area of the Union Workhouse and subsequent Mother and Baby Home is 2.8 hectares. Today 2.4 hectares are covered by houses, roads and gardens (85% of the total area). This accessible space (the remaining 0.4 hectares) includes the known location of interments at the memorial garden, in addition to the access roadways at the rear of properties and the playground area. These areas have been constructed over the southern corner of the former Mother and Baby Home (Figure 13 Appendix C).

The access road was, until recently, not divided from the memorial garden. Anecdotal information suggests that this was a burial plot for both nuns and those executed here during the Civil War. It has also been suggested that these graves were exhumed in the 1960s. It seems that this area of the site was converted to access the rear of the adjoining properties in the 1980s.

The original boundary wall of the Workhouse/Children's Home remains along the south-eastern edge of the site. This varies from 1.8m – 3.6m in height along the length that remains and is constructed of limestone. The wall now bounding the south-western and northern parts of the memorial garden appears to be of much more recent construction but is still mostly over 1.8m in height. The precise nature of the foundations of these boundary walls in not known. Furthermore, in many instances local residents have constructed garden sheds against the opposite side of these walls.

Access into the available area is limited to two laneways, defined during the residential construction phase in the 1970s (Figure 13 Appendix C). These are located between properties at the northwest and northeast of the playground and measure 22m and 27m in length, and 3m and 3.3m in width

respectively. As the only access points, these laneways may restrict the size of machinery into the site in any future works.

Almost all of the surrounding residential properties at west, north and east, have gateways leading to the available area. As will be shown in section 2.3, there are also probable utilities servicing the rear of these properties. Furthermore, these two-storey properties have a clear view over the playground area. The visibility and inconvenience of any future work must necessarily be a consideration, as must consultation with such relevant stake-holders.

In terms of burial locations, it is known that some 19th century burials were located at the western corner, now beneath the public road. It has been suggested that these graves may extend both to the south and east from the point of discovery (Delaney *et al*. 2014, 29). The view that all subsequent burial practices moved beyond the walls of the Workhouse, as requested by the Poor Law Commissioners, cannot be held with any certainty. From the original plans of the Workhouse, there could have been as many as nine separate cess-pools built beneath the complex, excluding the external sewage tank at the south. Of these, the locations of just three remain within the accessible space at present. Such subterranean chambers could be considered areas of interest with the potential for interment to have taken place after their disuse.

A triangular area, adjacent to the southern boundary wall is also of potential interest. This was first outlined on the 1892 Ordnance Survey map, repeated on the 1914 map but absent from mapping thereafter (Figure 6 Appendix C). This may have had a domestic use or potentially demarcated a burial plot.

2.3 Geophysical Survey – Summary and Results

Apart from one portion of the wall of the Chapel/Dining Hall of the former Home and a portion of the southern boundary wall, there are no structural elements from the Workhouse/Mother and Baby Home evident above ground. A Geophysical survey was used to check for subsurface remains across the available area of the site. The detailed findings of this geophysical survey are given in Appendix F and this section will highlight some of the findings of the survey.

As a non-destructive method of investigation, geophysical survey is a collective term for a set of techniques commonly used in the initial stages of forensic investigations. Geophysical techniques have been in used in archaeological research since the 1930s with a proven ability to detect buried structural features and objects (Cheetham 2005, 64). In Ireland, this has been exemplified by the work of the Discovery Programme and numerous development-led projects (Newman 1997; Bonsall and Russell 2014). Within the field of forensic archaeology, these techniques have been shown to successfully locate individual graves and mass-graves (Kimmerle 2013; Cheetham *et al.* 2008).

This survey was designed to identify areas of interest (i.e. potential burial locations) both at and outside of the memorial garden. It further sought to find where ground was unstable, confirm the layout of the former Home derived from maps/plans, and provide general measurements of features known to be of significance.

The techniques that were applied in this survey were Ground Penetrating Radar and Magnetometry. In simple terms, Ground Penetrating Radar (GPR) relies on reflected radar/microwave signals to distinguish between parts of the ground that have different electrical conductivity (Cheetham 2005,

86). Where the conductivity is high, as in wet soils, the depth that can be surveyed can be limited. Magnetometry measures the disturbance of magnetic fields, which can happen through the disturbance of soils, fire, metallic objects *etc*. (*ibid*., 76).

The magnetometry survey of the memorial garden broadly outlined the edges of the former sewage tank, a feature that measures approximately 12m by 8m (points 1-3, Figure 59 Appendix F Report 1). Two further anomalies appear to indicate the line of the former southern boundary wall of the Workhouse (points 5 and 6 Figure 59 Appendix F Report 1). There is single area of disturbed ground against the eastern wall for which there is no clear explanation. The GPR survey of the same area was hampered by wet weather which likely impacted the results, particularly with regards to the estimated depth at which anomalies occur. The uppermost layers identified by GPR show only variances in the backfill of previously excavated trenches and the covering of gravel overlying these. At 0.65m below ground level, an anomaly is seen along the southern side of the area. We can say that this is the structure of chambered tanks previously uncovered by the Mother and Baby Home Commission of Investigation. This measures approximately 12m in length by 2m in width (Figure 51 Appendix F Report 1). Across the majority of the area at approximate depth of 0.93m, there is demolition or backfill material, presumably infilling the area of the sewage tank. At 1.2m below ground level, it was noted that there is a regular rectangular feature occurring near the eastern boundary wall and this is approximately 12m in length and about 2m wide. It looks to be formed of structural material and air gaps (Figure 54 Appendix F Report 1). This anomaly seems to be comparable to the known chambered tanks along the south and even though it is only evident in this 'time-slice', it must be considered as potentially significant.

Elsewhere, the geophysical survey identified the foundations of the main Mother and Baby Home building. The foundations of the Chapel/Dining Hall were evident along the roadway at the north of the playground and extend beneath the car-parking area (Figures 27-32 Appendix F Report 1 and Figures 40 – 44 Appendix F Report 1). The southern wing of the 'Idiot's Ward' extends across the centre of the current playground defining the women's yard to the north (Figures 9-12 Appendix F Report 2).

The 'pump' shown within the Women's Yard on the Ordnance Survey maps of 1892 and 1914 is identified within the GPR survey. Located at the northeast side of the playground at a depth of 0.65m below ground level, the structure measures roughly 4.3m x 2.1m (Figure 8 Appendix F Report 2). Further proof that this is the footprint of the pump structure id that at a depth of 0.94m, a pipe can be seen extending from it towards the northwest (Figure 9 Appendix F Report 2). That this feature is a near surface water system is demonstrated by the fact that at 1.34m below ground level there is no trace of the pump structure or associated pipe.

The mortuary building at the rear is obscured by a modern shed, but the geophysical readings near it do suggest a deep feature at the southeast side (Figure 21 Appendix F Report 1), while at just 0.27m below ground level a rectangular anomaly is evident to the north-east, approximately 5-6m in width (Figure 16 Appendix F Report 1). This mirrors the estimated width of the rear mortuary and potentially the cess-pool beneath.

The evidence for underground chambers is conclusive. Of the nine cess-pools from the original drawing, just three would have fallen within the area of the survey. That beneath the mortuary has been mentioned but there may also have been one at the end of the building wing that extends beneath the playground. The results of the GPR over this area suggest that there has been

disturbance to a deep of at least 2.2m (Figure 13 Appendix F Report 2). While the walls of the cess-pool should have been highlighted they may be masked by the backfill which surrounds them. The third cess-pool would have been centrally located within the Women's yard. This is now the car-park at north and here GPR found that there was substantial amounts of backfilled rubble to a depth of up to 2m below ground level. However, at approximately 1.42m below ground level, two linear pipes or channels extend from north (Figure 44 Appendix F Report 1) and these are shown clearly at a depth of 1.69m (see 'A' Figure 46 Appendix F Report 1). There are also features of block construction material ('B') at this depth and these were evident from as shallow as 0.92m (Figure 43 Appendix F Report 1). These are approximately 2m x 2m in extent and are positioned adjacent to the lines of possible pipes/culverts. These may have been structural pillars of a cess-pool vault. Extending into the playground area at a depth of 1.54m below ground level, is a probably pipe or culvert leading to the south (Figure 13 Appendix F Report 1). This linear appears as though it may join with another linear extending towards the memorial garden.

A small square anomaly is found within the playground area just outside of the memorial garden – at 1.54m below ground level (Figure 12 Appendix F Report 2). Where the access road meets the memorial garden, there is also a square structure at 1.78m below ground level. This second possible structural feature manifests as an almost square area, approximately 5m x 5m, at the northeast of that area. Areas of moisture are noted in conjunction with this feature (see 'B' Figure 11 and '10' Figure 56, Appendix F Report 1). These could possibly be related to underground culverts.

The internal enclosing walls of the Workhouse yards and buildings were identified at the rear and the southeast. The boundary demarcating the triangular area at south is not noted by either of the geophysical surveys. No formal burial grounds were indicated but discrete features were noted at several points including a row of five features in the magnetometry at the northeast of the playground and a further eleven features spread across the southwestern part of the playground area (points 10-14 and 58-69 Figure 14 Appendix F Report 2).

At the area of the access roadway adjacent to the memorial garden, GPR survey indicated that there is a significant amount of backfilling (to about 0.75m below ground level), but this activity is primarily focused at two/three areas. These hollow areas (approximately 8m x 4m in size), aligned roughly east-west. Magnetometry also recorded these relatively shallow disturbances and suggests that they may have been due to the removal of trees (points 5-9 Figure 56 Appendix F Report 1).

Utilities or modern services (i.e. pipes) were noted in several areas, particularly along the northern access road and extending into the playground from north (Figures 24-25 Appendix F Report 1 and Figure 15 Appendix F Report 2).

In summary, the locations of three original cess-pools may still exist. There are also two small square structures at the south of the playground area. Pipe or culvert channels appear to connect some of these subterranean features. There are large areas obscured by what is probably demolition debris but also discrete anomalies that could potentially be graves/pits. The features noted at the eastern edge of the memorial garden are also worthy of further consideration. No formal burial ground was evident.

3 Best Practice, Nationally and Internationally, in Humanitarian Forensic Action

3.1 Introduction

Section 3 will set out the framework for what is considered to be international best practice and provide the technical backdrop for any option that is to be considered at the site in Tuam. This section looks in detail at national and international comparisons for this unique site, looking at the issues of mass grave excavation, juvenile human remains, commingling, identification, communication, and somewhat briefly, legislative considerations.

3.2 National Comparisons

There is no precedent in the history of the Irish State for dealing with a situation such as is found in Tuam; a mass grave of unidentified commingled juvenile human remains of a potential forensic interest. The ETG is aware of one situation that could be considered broadly comparable in relation to exhumation and treatment of identified and unidentified remains. This case is summarised here to highlight the potential complexities that result if a situation is not suitably dealt with from the outset.

3.2.1 High Park Exhumations

In 1993 exhumations occurred at a former convent in High Park, Drumcondra Dublin. The circumstances of these exhumations became controversial and were re-examined by a Committee set up to establish the facts of State involvement with the Magdalen Laundries. A report into this formed a section of an extensive report by the Committee that was published in 2013.

A graveyard associated with High Park Convent and Magdalen Laundry, operated by the Order of Our Lady of Charity, was subject to an application for licence for exhumation in 1992. The site had been used as a burial ground from 1889 to 1976 for the interment of consecrates of the Convent and Magdalen Laundry. This application, by the Order, requested the exhumation of 133 individuals from the Department of Environment, Community and Local Government.

The Department responded to this by requesting death certificates for each individual buried here. A further application, on behalf of the Order, listed 133 named women, of these 75 had death certificates, a further 24 were referred to by their religious names and not their birth name, and 34 had ‘no trace’ forms. The Department requested again that death certificates be provided for the final 58 individuals. It was reported back to the Department in subsequent communication that the Order was unable to produce burial records from the period 1942-1968 (Department of Justice and Equality, 2013) and additional death certificates could not be found.

A licence to exhume and reinter the 133 individuals was granted on the 25th May 1993 by the Department of Environment, Community and Local Government. A number of conditions were placed on this licence; firstly, that each exhumation must be carried out within 12 months of the license and secondly, that the remains are either reinterred or cremated within 48 hours of exhumation (Department of Justice and Equality, 2013).

Exhumation of remains, as per the licence, commenced on the 23rd August 1993. Within a few days of on-site works it was observed that there were "remains interred in the burial ground which had not been included in the license" (*ibid*. 806). A further licence was granted to the Order on the 31st August 1993 to exhume all deceased persons interred in the burial ground (Department of Justice and Equality, 2013). An additional 22 unidentified individuals were located. All 155 sets of remains found, and with one exception, all were cremated and reinterred in Glasnevin Cemetery.

In 2003, 2010, and 2012 further investigations were made into the circumstances of these exhumations and re-interments. It was determined that it was not possible to identify the additional 22 individuals due to a lack of archive or catalogues relating to death and burial records. Further research by the Congregation identified and matched the names and dates of death to all of the 155 individuals whom had been finally exhumed and reinterred. This was accepted by the Committee. However, they noted the concern and distress that this situation had caused for those that had been admitted to the Magdalen Laundries, their families, and the general public (*ibid*. 811).

In this case, additional enquiries by An Garda Síochána in 2012 concluded that "without any suggestion of criminal action or wrongdoing and, on the basis of those records, no further action on the matter was deemed necessary by the Gardaí" (*ibid.* 813).

In light of an examination of international best practice (see Section 3.4), by current standards the course of action taken in relation to High Park would not presently be acceptable in relation to the discovery of unidentified human remains. While the ETG acknowledges the context is not directly comparable, the discovery of unidentified human remains at the site in Tuam requires a more considered approach than has previously been exhibited in Ireland.

3.3 International Comparisons

The combination of an institutional boarding home and commingled interments of juvenile remains in a sewage treatment system is a unique situation, with no directly comparable domestic or international cases. However, when divided into separate elements, there are a number of contexts worldwide which bear similarities to aspects of the Tuam site. When looking internationally, it is possible to identify two main comparable elements of this case. These can be separated into cases involving (i) boarding home burials of children, and (ii) commingled mass graves. These will be examined separately below.

3.3.1 Boarding Home Burials

There is no shortage of examples involving unmarked, un-registered, and forgotten graves and cemeteries at boarding homes. The term "boarding home" is used broadly here to cover the range of institutions to include, but not limited to, orphanages, residential schools for poor and/or minority children, reform institutions for juvenile delinquents, and boarding houses for pregnant women.

Such institutions were prevalent in the 19th and 20th century and often these institutions were sponsored by the State or religious institutions. However, many are privately run, either for-profit or out of philanthropic motivations. In many cases, as with the Mother and Baby Homes in Ireland, combinations of sponsors may support these institutions.

Chapin (1915) pointed out in an article from the early 20th century that infants are extremely vulnerable to their surrounding environments and that individual care is of great importance, rather than the institutionalised care they regularly receive in boarding homes. One repeated theme is that the children in these boarding homes are often the most vulnerable within a population.

Incomplete records of deaths and burials are another similarity shared by many former boarding houses. Burial practices often reflect cultural attitudes towards the dead, underscoring their perceived status in society (Spennemann 2007). While physical records may have been misplaced or destroyed over time.

Examples of child burials (and possible mass graves) at boarding homes are plentiful. Most recently, attention has been drawn to the Smyllum Park boarding home in Lanark, Scotland, which operated from 1864 to 1981, having looked after approximately 11,000 children during the course of its operation. An unmarked burial plot in nearby St Mary's cemetery containing the bodies of an unknown number of children is present on the grounds with little record. Past residents claim physical abuse at the hands of the administrators, and calculated death rates have been reported as three times higher than regular Scottish society in the same time period (Bowcott 2017). Scotland is now setting up an enquiry into the allegations, examining the boarding home system within the country, with results to begin being made public in November, and making this enquiry perhaps the most similar to the Mother and Baby Home context. However, many other cases do exist to include, but are not limited to, investigations of the former Haut de la Garenne boarding home on Jersey, the former Ballarat Orphanage in Australia, and the Duplessis Orphans in Canada, which included a Quebec-wide institutional system that allegedly falsely certified orphaned children as mentally ill and confined them to psychiatric institutions in order to provide state/church care for them.

Canada is currently engaged in a transitional justice process investigating the effects of their past boarding school program aimed at "Christianisation" of First Nation children (Canadian native Indian population) (Maass 2016). The Indian Residential School Truth and Reconciliation Commission (TRC) of Canada is investigating the system of 139 residential schools set up that housed and schooled children removed from their families in an effort to better integrate them into the larger Canadian society (Jung 2009). The United States had similar programs that either targeted specific tribes, or were limited to state programs rather than a single federal system. In Canada, approximately 150,000 children went through the residential system during the course of a century. Many children died or went missing during this time. The dead were buried usually within the school grounds or in a nearby cemetery, often without notification to the family. Many of these cemeteries, and the records of burials, have been lost over time. The TRC was created in order to establish what happened at these schools and where the missing/dead children are, among other issues related to the former residents. The Truth Commission has found numerous abandoned cemeteries which have since been registered and restored along with memorialisation of the names of the deceased, if known.

Truth Commissions or other forms of Transitional Justice have operated to expose past injustices, which standard judicial systems are incapable of handling (United Nations 2010). As systems of

investigation outside of the normal domestic judicial systems, transitional justice processes can explore past events without formalising accusations against specific individuals or mandating prosecutions if it is not desired. These processes can be formal, government-sanctioned processes, locally created community boards of inquiry, or something in between. This flexibility allows them to be formulated to specific contexts, casting as detailed or as broad a net as desired. Transitional Justice has been widely used in investigations of past conflicts or in cases where governments have targeted portions of their own population.

3.3.2 Commingled mass graves

Numerous investigations of mass graves containing commingled remains have been conducted throughout the world. A body of scholarly works within the field of forensic science documents these cases and details methods and techniques that are used to investigate them (Adams and Byrd 2008, Congram and Sternberg 2009, Congram, *et a*l. 2016, Komar 2003, Stover *et al*. 2003). Commingling of remains can occur due to decomposition and natural techonomic processes when a number of bodies are placed on top of one another. Skeletal elements will mix overtime as the soft tissues degrade and the soil surrounding them settles. Natural processes of this settling can move sediment and bones over time, displacing them from their original articulating positions. Commingling will also occur when human activity, either intentional or accidental, disturbs a number of burials or a mass burial. Disturbances by human activity are well documented in the archaeological literature. However, there are examples in contemporary forensic cases of commingled mass graves as the result of human activities.

Perhaps the best-known case is that of Srebrenica in eastern Bosnia and Herzegovina, where thousands of executed Bosnian Muslims were killed in Europe's worst episode of ethnic cleansing since WWII. Here bodies were buried in a series of mass graves in order to hide the atrocities. Shortly afterwards the United Nations announced that it would undertake investigations of mass graves in Bosnia. The Serb perpetrators then decided to hide their crimes by digging up the mass graves with construction machines, which caused massive trauma and disarticulation to the bodies, and hide the evidence in more remote, secreted mass graves. Not only did this activity mix bodies from a single mass grave, the perpetrators removed truckloads of remains from one grave and dumped them in two to three other mass graves, further commingling them in an effort to confound investigators should the graves be located. This effort on the part of the perpetrators created more than 15 secondary mass graves out of a minimum of seven original (primary) ones. The subsequent United Nations' International Criminal Tribunal for the former Yugoslavia (ICTY) investigations employed forensic scientific methods and techniques to locate, excavate, and examine the remains from these graves. The resulting forensic investigations generated a number of methods, many of them adapted from standard archaeology, to help sort out commingling problems to include the use of DNA to both identify remains and re-associate disarticulated remains back to their bodies (Byrd and LeGarde 2014, Hanson et al. 2000, Tuller et al 2014, Wright et al. 2005). A subsequent result of the ICTY Srebrenica investigations was an increase in knowledge on how to conduct investigations and identification of remains from commingled mass graves, and expanded the practical experience of an international body of forensic experts to sort these complex cases (Tuller 2012).

While the ICTY investigations were focused on extracting evidence for court, other efforts were made to identify human remains. In Bosnia and Herzegovina, the International Commission on

Missing Persons (ICMP) developed a DNA lead identification processes that allowed for rapid, accurate, and economical use of DNA analysis (Wagner 2008). Processes at ICMP were also developed in DNA analysis to re-associate remains that had been disarticulated from the bodies. The use of DNA in the identification of large amounts of remains has since been replicated in a number of contexts, and will likely remain a main tool for investigators for years to come.

While the term mass grave usually conjures images of a large pit in which multiple bodies have been placed, there are other types of commingled grave contexts. Natural features and human-made structures have been used as *ad hoc* depositories of human remains. Forensic investigations have discovered commingled graves and surface scatters of human remains in caves, sink-holes, the bottom of cliffs, natural depressions, wells, building foundations, drainage ditches, and collapsed buildings.

It must also be understood that many mass graves are not created in an attempt to hide bodies, but developed within the context of cultural norms utilizing features available at the time. For example, the Iroquois Indians in Canada and the United States traditionally created buried ossuaries where remains of people who died over a time frame of several years were collected together, then intentionally mixed up as part of the burial ritual symbolizing the relationship of all who died as one people. In southern Louisiana in the United States, where the water table precludes most below-ground burials and cemetery space is sparse, above-ground crypts are reused by family members. When a family member dies, the remains from the previous internment, now skeletonised, are removed from the burial platform within the crypt to the bottom of the tomb where they mix with past generations. The idea of mixing with ones' 'people' in death is viewed positively in these cases.

Schmitt (2001) indicates that excavation of infant remains is more difficult than adults, even for practiced archaeologists. Forensic practitioners, who regularly excavate graves containing adult remains, are not as familiar with infant skeletal remains and may not recognize them as readily as adult elements. That is, it is unusual to find mass graves of infants, and even individual infant burials when buried with an adult (a mother, for example), may at first be overlooked due to the small size and fragile condition of remains in comparison to the adult. Cases with similarities to the Tuam Mother and Baby Home include work conducted by the Argentine Forensic Anthropology Team (EAAF) in El Mozote and surrounding area in El Salvador and Las Dos Erres ("The Two Rs" in Spanish) in Guatemala, and investigation of the Arthur G. Dozier School for Boys at Marianna, Florida in the United States by the Florida Institute for Forensic Anthropology and Applied Sciences, University of South Florida. In contrast, some archaeological practitioners, may have considerable experience in the excavation of infant and juvenile skeletal remains. In an Irish context, this relates particularly to the excavation of archaeological sites known as *cillíní* or so-called 'children's burial grounds', which frequently contain the almost exclusive remains of infants and young children.

There are some sites, containing multiple remains of juveniles, which are more recent in origin. In 1981, during El Salvador's civil war, the Salvadoran Army killed more than 200 individuals in the village of El Mozote, including at least 152 children. A 1992 United Nations-sanctioned Commission on the Truth for El Salvador launched a forensic investigation into the massacre. This investigation was conducted by the EAFF who found that over 200 civilians, the majority children under the age of 12 years (United Nations 1993). Remains were found in a convent in the village where the victims had been first held and later killed. The resulting massacre created a commingled mass grave within the building foundations of the fallen structure. It was estimated that 85% of the dead within this

structure were children, the mean age being six years old. There is uncertainty as to the number of dead recovered within the convent due to the combination of the fire damage to the remains, extensive perimortem skeletal injuries, and the post-mortem damage that occurred prior to analysis. This uncertainty was compounded because of the fragile nature of infant remains, some of which may have been totally consumed by the fire or because of the extensive fragmentation of body parts. The El Mozote example illustrates how difficult it may be to produce an accurate account of infant and children remains in some cases.

The Dos Erres massacre in Guatemala occurred in 1982 when Government commandos attacked the village during their "scorched earth" policy against civilians suspected of supporting rebels. A total of 222 civilians were reported to have gone missing as a result of this attack, including 105 children under the age of 12 years. The perpetrators discarded most of their victim's bodies by throwing them down a dry well in the village. In 1994 and 1995, the EAAF recovered a total of 156 skeletons from the well and six more outside within the village. This left a discrepancy of 58 missing people when comparing the list of missing provided by survivors and the number of skeletons collected. Of the 58 victims still missing, 38 were children. This discrepancy was partially explained by the severely deteriorated condition of the children's skeletonized remains, meaning that the younger children and infant remains may not have survived, or that a number of missing children were buried or abandoned elsewhere and not found during the investigations (Olmo 2006). This case likewise highlights the difficulty that forensic practitioners sometimes have when trying to account for the missing, and underscores how records (in the Dos Erres case, the list of the dead provided by surviving villagers) may not add up to the actual number of skeletons recovered.

The final example illustrates a case with broad technical similarities to the Tuam Mother and Baby Home is the investigation and excavation at the Arthur G. Dozier School for Boys at Marianna, Florida. The Dozier School was a reform institution for juvenile delinquents that operated 1900 until 1973 and allegedly abused their charges. Approximately 100 children died while at the boarding home during its operation, with many of them being buried on the grounds in a plot of land. A Government investigation was conducted to understand what took place at the school, and what became of the boys who died. This investigation involved a multi-disciplinary approach to include archival research, witness interviews, and forensic archaeological, anthropological and DNA techniques to assess suspected burials and to recover and analyse human remains. From the plot of land on the former boarding home grounds used as a cemetery, known as "Boot Hill" by former residents, over 50 sets of remains have been recovered of which approximately 20 have been identified and returned to their families (Kimmerle, *et al*. 2016). Work continues on this case, demonstrating the complexity of a full forensic investigation that aims at identifying remains. Without family reference samples for DNA and accurate (and complete) records of the missing, a full identification process, while having some success, will not be able to identify all remains. If such a course is charted, then considerations for long-term storage and an end-plan needs to be considered.

3.4 International Standards of Best Practice

There are no set international standards when it comes to investigation of mass graves or for forensic science as a whole. The institutions that could house such standards, such as the International Criminal Court or perhaps the United Nations, do not maintain specific protocols or

standard operating procedures that would cover the excavation of mass graves and/or detailed laboratory processing and identification of remains. The reason for this is that the various fields of forensic science (e.g., pathology, toxicology, biological anthropology, genetics, *etcetera*) have not organised themselves on a worldwide scale in a manner to agree upon a universal set of practices. There are two main reasons for this: first, the manner in which forensic science is practiced varies from region to region and country to country. Each place differs in the way the subject is taught to students. For example, the fields of forensic archaeology and forensic anthropology are taught as separate disciplines in the United Kingdom and Ireland, while in the United States these subjects are taught as a subfield under anthropology. Education systems and their requirements for degrees/certificates differ between countries and will ultimately affect the how the practitioner applies the subject. Secondly, each area of the world will have its own medico-legal system where reliance on forensic evidence is weighed differently. There is combination of the use of strict guidance for the use of forensic science and others will use more general guidelines. However, regions of the world, such as the European Union, have created standards that are applied within their areas of influence, and practitioners and institutions continually interact with one another in efforts to improve forensic science.

While international forensic science standards do not exist per se, there are several best practice guidelines that set out to explore minimal investigative requirements. These guidelines have been created to provide nations and first responders with direction in the absence of local operating procedures or where the context of their investigation is not covered by their regular protocols, such as investigating after political violence which resulted in thousands of disappearances and deaths. The most relevant of these guidelines is the *United Nations Manual on the Effective Prevention and Investigation of Extra-Legal, Arbitrary and Summary Executions* (U.N. Doc. E/ST/CSDHA/.12[1991]), also known as the Minnesota Protocols. While this manual focuses on violations of International Humanitarian Law and Human Rights Law such as those enshrined in the Universal Declaration of Human Rights, the International Covenant on Civil and Political Rights, the European Convention for the Protection of Human Rights and Fundamental Freedoms, certain articles of the Geneva Conventions, and other such treaties and international case law, they include sections related to crime scene processing, collection and analysis of evidence, testimonial procedures, qualifications of experts, autopsy, and other relevant processes. However, the actual guidelines of the Minnesota Protocols are very basic. For example, it advises the investigator to take photos and notes at crime scenes, to treat witnesses with respect, and to write a report of findings after autopsy, but does not give specific procedures on how to do this. While these procedures may seem obvious to an investigation, some countries have demonstrated a lack of such standards. The Minnesota Protocols were created specifically to list the minimal procedures required to conduct investigations in order to assist countries in their non-standard investigations.

Most nations, including Ireland, already have standard operating procedures (SOPs) and investigation protocols that far exceed the minimal processing standards set in the Minnesota Protocols. Forensic Science Ireland and An Garda Síochána are established institutions with quality crime scene and forensic scientific procedures. In addition, archaeological practices in Ireland also have specific sets of procedures and regulations that regulate site processing to high standards. These institutions and organisations coordinate with their peers in the European Union and other parts of the world to maintain high quality standards and have a vast amount of experience. Many practitioners (forensic and archaeology) also belong to professional associations designed to

improve both member ability, encourage research, and advance scientific practice within their particular field.

The largest forensic association is the American Academy of Forensic Science (AAFS), which, includes a large number of non-U.S. members. The AAFS has been instrumental in organizing Scientific Working Groups (SWGs) in order to provide both minimal required standards, determine best practices, and develop consensus standards among its various forensic scientific sections. Recently these working groups have evolved into the Organization of Scientific Area Committees (OSAC) administered by the National Institute of Standards and Technology (NIST), which work to create and promote forensic scientific standards for 25 forensic disciplines to include forensic anthropology, DNA, disaster victim identification, and crime scene investigation (NIST 2016). Member organizations and institutions include government agencies, academic institutions, and private sector organizations. In Europe, the European Network of Forensic Science Institutes (ENFSI) has 68-member laboratories from 36 countries, to include Ireland. The ENFSI seeks to improve forensic science through mutual exchange of information on competence management, research and development, and education/training by sponsoring 17 EWGs, to include trace evidence, DNA, and scene of crime sections (ENFSI 2017). The ENFSI also has two standing committees on Quality and Competence and Research and Development that aims to develop policies regarding the use of forensic science, provide advice to members, and create development strategies.

Forensic laboratories have been moving towards formal accreditation in recent years. Accreditation may be a legal requirement in some cases, while other laboratories pursue it as part of best practice procedures and encouraged by their membership in one of the forensic organizations. In regard to anthropology/archaeology and DVI, one of the prime accrediting organizations is the International Organization for Standards (ISO) in Geneva, Switzerland. The Defense POW/MIA Accounting Agency in the United States, a US government organization charged with the search, recovery, and identification of Americans who have gone missing in past wars, has currently the only accredited anthropology/archaeology laboratory. This accreditation is thorough the American Society of Crime Laboratories Director's Laboratory Accreditation Board (ASCLAD-LAB) under ISO 17025 criteria. Several other laboratories are also seeking accreditation under the ISO 17025 criteria at this time. While accreditation does not mean that all such laboratories will operate in the same manner, it does help a laboratory strengthen operations by providing independent, impartial, and objective criteria, and acknowledges that laboratory operations meet agreed upon standards.

Although no set formal international forensic science standard exists, one can view the connection of protocols, operating procedures, professional organizational committees/working group documents, and accrediting boards as analogous with case law, each building upon one another and contributing to a collective knowledge of methods and procedures. In this sense, there is general agreement on minimal standards and best practices available in forensic science. Of course, the case of the Tuam Mother and Baby Home is different from the normal criminal case or archaeological site, as it involves relatively recent commingled remains of children in a potentially non-criminal case, and many standards derived from domestic criminal justice or forensic institution operating procedures may not be applicable. However, the field of forensic science has evolved from expertise dedicated to working in domestic settings in support of a criminal justice system, to a discipline capable of dealing with large-scale, complex situations in unfamiliar contexts, and during this time practitioners and organizations have developed certain methods and techniques that have been found to be applicable in many contexts.

Over the past thirty years, forensic science, particularly the fields of archaeology, biological anthropology, pathology, and genetics, has increasingly been used in contexts of mass death which include, but are not limited to, armed conflict, interethnic violence, state-sponsored disappearances, and natural or human-made disasters. Recently, this type of work has been called Humanitarian Forensic Action, a term favoured by the International Committee of the Red Cross (ICRC) to capture the use of forensic science in mass death contexts that are not necessarily criminal cases, and seek to provide assistance by protecting the dignity of the dead through proper recovery, management, and if possible identification (Cordner and Tidball-Binz 2017). If forensic investigation are to take place at the Tuam Mother and Baby Home, it would likely fit within this definition of work. A key aspect of Humanitarian Forensic Action is a multi-disciplinary approach that regularly combines multiple forensic fields with other sciences not regularly associated with forensic investigations that can include ethnologists, historians, geographers, archaeologists, geologists, and other disciplines. Furthermore, this form of investigation regularly incorporates robust public outreach projects to both inform and engage the public. Indeed, the public, rather than a criminal justice system, is the prime stakeholder in such cases and cannot be discounted.

There are not many Humanitarian Forensic Action cases analogous to the Tuam Mother and Baby Home cemetery. Perhaps the closest case are the investigations at the Arthur G. Dozier School for Boys at Marianna, Florida in the United States, a reform school for delinquent boys that allegedly suffered abuse while housed at the institution. Forensic scientific methods and techniques were used to investigate the alleged disappearance of over 100 recorded children from this school (Kimmerle, *et al*. 2016). Fifty sets of remains were recovered, 8 were positively identified with DNA, 14 were presumptive identifications. The investigators focussed on different types of identification. At conclusion, there were just 12 cases where DNA profiles were not possible (Kimmerle, pers. comm. 2017). A multi-disciplinary approach was used in this investigation. It included archival research and witness interviews, as well as recognized standard archaeological, anthropological, and DNA techniques to assess suspected burials and to recover and analyse human remains. Most importantly, stakeholders were involved in the planning process and all activity was conducted in a transparent environment.

3.4.1 Forensic and Archaeological Excavation

The importance of standards in archaeology has long been recognised. There are several reasons for this, the most important of which is that archaeological excavation is a destructive process whereby information is lost if not recorded promptly, accurately and comprehensively. Furthermore, standardised information is comparable between different features, as well as different sites and standardised data can be both understood and critiqued by other archaeological professionals at a remove from the excavation.

The accepted standard of archaeological excavation in Ireland is known as single-context recording. This means that each event within the soil (deposits, layers, cuts etc.) is identified as a 'context' which in turn is described, drawn to scale and photographed. The number attributed to a context is then used to cross-reference this 'event' with information pertaining to location (in three-dimensions), artefacts, samples, drawings (at appropriate scales) and photographs, as well as the position of the context within an overall stratigraphic matrix. The standards that are applied to within single-context recording are set out within the MoLAS Archaeological Site Manual, originally

published in 1980 (Museum of London Archaeological Service, 1994). The Institute of Archaeologists of Ireland has also produced codes of conduct for excavations and the treatment of human remains (IAI 2006; Buckley et al. 2004) while the National Museum has produced advice for excavators with a view to archaeological objects (National Museum of Ireland, 2010).

There are no defined international standards for archaeological excavation and, as mentioned previously (section 3.4), there are no universal international standards for forensic science or for forensic archaeology. The standards used in archaeological excavation are transferrable and acceptable in forensic excavation. However, forensic excavation is usually conducted with a view to greater scrutiny of the results (i.e. within the judicial system) and therefore, the methodologies used are necessarily more robust. Guidance and standards that do exist for forensic archaeology emphasise '*that features are investigated and excavated using the archaeological technique most suited to the specific circumstances of the case*' and further that stratigraphic integrity be maintained, recovery of evidence maximized and the details of the scene reproducible from the contemporaneous records of the excavation (Powers and Sibun, 2014, 12). The approach will satisfy current judicial requirements, irrespective of whether that work is for judicial or humanitarian reasons (Andersen *et al.* 2008, 39).

The accepted practices in forensic excavation of individual graves and mass graves is that, firstly, the archaeologists excavating the graves should have extensive excavation and recording experience, have anthropological knowledge and know about evidentiary requirements and protocols (Hunter and Cox, 2005; Wright *et al*. 2005; Andersen *et al.* 2008). Secondly, the location of the grave (or feature) must be plotted accurately and all items/contexts be recorded, enabling them to be re-modelled in three dimensions (Hunter and Cox, 2005). Disturbing any aspect of the 'scene' prior to a record being made is a loss of integrity. Plans and section drawings need to be made in addition to any digital records, and these are usually at a scale of 1:10 in forensic recoveries (Hunter and Cox, 2005). The photographic record is also necessary (Powers and Sibun, 2014, 12). Particular attention needs to be paid to the position of the body, or skeleton, and this needs to be tied into the grid system and its rotation and direction of limbs *etc*. recorded in full (Wright *et al*. 2005). With comingled remains, this means every individual bone is mapped. Thirdly, soils need to be removed in stratigraphic sequence where possible using principles that do not destroy the stratigraphic interfaces (Andersen *et al.* 2008). Fourthly, the rationale and approach taken (and changes to that approach), the process and results must be maintained as contemporaneous notes. Any attempt to alter this action log may be treated as an attempt to pervert the course of justice (Hunter and Cox, 2005; Wright *et al*. 2005). One important observation when dealing with mass graves has been the physical and psychological well-being of the staff (Wright *et al*. 2005). Some such physical and psychological issues are related to the counter-contamination measures which must be enforced on site.

In addition to assessment of deposits, features and human remains, tool-marks, trace evidence, artefacts, biological and chemical evidence, and entomology are issues which need to be addressed throughout the forensic excavation. A comprehensive but practical sampling strategy needs to be applied at every stage of the forensic excavation. Finally, all of these procedures of the forensic excavation must be conducted at all times with an awareness of contamination, using agreed measures of access and protective clothing (Powers and Sibun, 2014, 12).

3.5 Analysis of Human Remains from Commingled Contexts, with Specific Reference to Juvenile Remains and Tuam

The excavation and analysis of mass graves require specialised and distinct skill sets, in terms of initial organising, on-site recovery, and post-recovery analysis. It is imperative that systems are put in place, prior to the commencement of any fieldwork, so that all eventualities may be addressed. Crucial is the ability to recover, record, and analysis remains based on strategic goals, which may be linked with criminal and/or Coronial investigations. The identification of individuals is typically one of the primary goals of mass grave investigations and this may be further complicated by issues such as commingling (mixing) and/or fragmentation of remains. The apparent juvenile nature of the remains in Tuam adds further significant complications.

Commingled juvenile remains have been encountered in archaeological contexts. For example, the remains of almost 100 perinates were excavated from a Roman-era sewer under a bathhouse in Ashkelon in Israel (Smith and Kahila, 1992), 449 foetuses and infants were identified from deposits excavated from a well in the Athenian Agora in Greece (Liston and Rotroff, 2013), and 262 foetuses and infants were recovered in a well in Ancient Messene, also in Greece (Bourbou and Themelis, 2010), all representing some degree of commingling. However, in those sites, as may be expected with archaeological material, the emphasis was on contextual information and establishing the numbers of individuals present rather than on actual individualisation. The largest cemetery of infants in the world, with burials spanning from 750 BC to AD 100, is currently being excavated at Kylindra on the island of Astypalaia in Greece (Clement et al., 2009). The numbers of individuals identified to date is in excess of 3,400 (Astypalaia Bioarchaeology Programme, 2017). All but one of these burials were contained within individual pots, and while some pots may contain the remains of two individuals, perhaps twins, there appears to be little commingling. In instances where the remains of multiple juveniles have been recovered in forensic circumstances, such as the Dozier school in Florida (Kimmerle et al., 2016), the remains were recovered as individual burials, with limited commingling.

3.5.1 Anthropological Analysis of Commingled Remains

The establishment of the Minimum Number of Individuals (MNI) is a vital undertaking in any commingled assemblage (see Byrd and Adams, 2016, Konigsberg and Adams, 2014). In its simplest expression, each bone, tooth, and fragment are catalogued and the portion with the highest representation may be taken as indicating the MNI. For example, a commingled adult assemblage with five left femora (‘thigh bones’), three right humeri (‘arm bone’), and six left tibiae (‘shin bone’), would have an MNI of six individuals (after White, 1953). This may be further amended if, for example, all the tibiae were from male individuals and three of the femora were from females, the MNI would then change to nine. If different ages-at-death were present then the numbers may again change. This technique has been substantially refined in osteoarchaeological studies through the zonation method (Knüsel and Outram, 2004) and, more recently, the landmark method (Mack et al., 2016). Similar landmark methods may be used in detailed forensic assessments, particularly on highly fragmented human remains, where GIS ‘placing’ of fragments may alternatively be used (Herrmann et al., 2014).

A recent study highlighted that the disparity that can occur in using osteological methods of assessment in calculating numbers of individuals could be substantial (Lambacher et al., 2016). Disparities have also been noted in different techniques used in forensic cases (Herrmann et al., 2014), though not as extreme as the former study. Interesting, in both aforementioned osteoarchaeological and forensic studies, the landmark method was deemed one of the most reliable. Unfortunately, it cannot yet be determined which method is the most reliable as each would need to be tested on a commingled assemblage where the original number of individuals is actually known: however, the landmark method may be the more reliable in fragmented remains spread across multiple contexts (ibid., 678). However, there are no known published records of these methods being applied to exclusively juvenile remains.

Morphological methods of determining the ethnicity, age-at-death, sex, stature, and other anthropologically assessed factors from adult commingled remains have been outlined in detail in numerous relevant publications (see for example Adams and Byrd 2014, Blau and Ubelaker 2016, Cox et al 2008). With juveniles, determining the age-at-death may include a variety of methods, including growth and development of enamel and teeth, and osteometric assessment of long bones and other skeletal elements (see Schaefer et al., 2009, Scheuer and Black, 2000, Scheuer et al., 1980), while the sex of juveniles may only be reliably determined through DNA analysis. With any juvenile individuals from Tuam, there may be problems in the use of long bones to determine age-at-death, as it is known that stresses may impact negatively on bone growth (Smith and Avishai, 2005). Given that some of the juveniles in Tuam may have suffered from malnutrition and/or undernutrition, as well as some diseases, it is possible their growth may have been negatively impacted. Therefore, caution should be exercised (see also Gowland and Chamberlain, 2002). Dental development and eruption remain as acknowledged reliable indicators of age-at-death. However, with Tuam, the assemblage may primarily comprise commingled remains and there is likely to be a high level of loose teeth, disassociated from the original maxillae (‘upper jaw’) and mandibles (‘lower jaw’). There are other methods of estimating age-at-death. The measurement of tooth crown height and examination of the neonatal line in sectioned teeth may provide more precise age-at-death estimates (Smith and Avishai, 2005). Indeed, virtual histology, through non-destructive X-ray microtomography, can pinpoint age-at-death, at least of foetuses and young infants, quite precisely (Nava et al., 2017).

Other anthropological analyses of any skeletal remains may involve the recording of any pathological lesions of evidence of disease and trauma, *etcetera*. While this evidence may be morphological, other technologies may be used to further examine the evidence. For example, X-rays may detect old healed fractures. A number of interesting avenues of research may be available for young juveniles and infants in particular. More detailed analysis may include isotopic analysis. Shifts in stable carbon and nitrogen isotopes have been used to identify breast-fed infants and even the length of time a child was breastfed (Ventresca Miller et al., 2017), while high stable nitrogen isotope signatures in foetal/perinate individuals has been tentatively linked with *in utero* stress related to chronic maternal ill-health (Kinaston et al., 2009). Recent research indicates that other non-destructive methods, such as X-ray microtomography (Micro-CT), may also be used to identify still-births and short-lived infants by examining the level of microbial bioerosion in the bones, which is typically least in such individuals (Booth et al., 2016). Three episodes of *in utero* stress were also identified using the same process on the teeth of an Upper Palaeolithic pre-term foetus from Ostuni in Italy (Nava et al., 2017). Interestingly, the absence of the neonatal line (in teeth), may also be used

as indicator of still-births and has been used in both archaeological and forensic studies to confirm infanticide (Smith and Avishai, 2005, Lewis, 2007, 160). A recent study has also indicated that the width of the line is inversely proportional to the duration of the delivery, that is, the longer the delivery the thinner the neonatal line (Hurnanen et al., 2017).

3.5.2 Individualisation of Commingled Remains

In instances of commingling and/or fragmentation, it would be preferred that as much of the remains, as possible, of each individual, are identified and returned to the family. This sorting of mixed remains into individual remains is a particular requirement in mass graves and other MFIs (see, for example, Adams and Byrd, 2014, and Cox et al., 2008). Commingled and/or fragmentary remains includes fragmented limbs and/or individual bones, as well as the possible dispersal of the remains of one individual across a number of sites. The sorting of such remains involves a variety of techniques which may include gross, metric, and molecular analyses (as detailed in Adams and Byrd, 2014, Byrd and Adams, 2016, Cox et al., 2008, 307-308).

The context of commingling is crucial to the individualisation of remains. The terms ‘open’ and ‘closed’ may be applied in these instances (similar to being applied to whether there is a known list of deceased or not, see above). A ‘closed context of commingling’ represents the disturbance of a primary grave, where no secondary elements may have been introduced. In comparison, an ‘open context of commingling’ represents the commingling of remains from several primary graves (Puerto et al., 2014, 311), or perhaps the introduction/presence of material into a commingled deposit which may have nothing to do with the other forensic remains (Garrido Varas and Intriago Leiva, 2012).

The process starts in the field upon excavation and recording. As with all aspects of the investigation of mass graves, it is imperative that strict recording procedures are in place from the beginning and that they are adhered to. If detailed records are not already in place before a bone or body part is removed from its point of deposition, then those records cannot be formed in retrospect, particularly in a forensic investigation. Gross sorting of commingled remains include biological profiles, visual pair-matching, articulation, process of elimination, robusticity, and taphonomy. Metric sorting involves osteometric analyses, while molecular sorting involves the application of DNA technologies (Byrd and Adams, 2016, 228). Technologies continue to advance: X-ray fluorescence (XRF), which detects elemental concentrations in bones, has been used to assist in sorting commingled remains, although with caution (Perrone et al., 2014, Byrnes and Bush, 2016).

The application of some of these technologies to the case in Tuam will be limited. For example, immature juvenile bones do not have the articular surfaces which may sometimes be used to provide matches in commingled adult assemblages. Similarly, the application of osteometric sorting would be limited. There will always be a certain degree of asymmetry in an individual, which can make reassociation/individualisation difficult. However, this issue has been somewhat addressed with regards to the skeletal remains of adults (Lynch et al., 2017). There does not appear to be comparable work on juvenile remains. XRF, as mentioned earlier, does not appear to previously have been specifically tested on juvenile, and particularly infant, individuals and, in any case, diagenetic effects can significant impact the bone chemistry (pers. comm. Dr Jennifer F. Byrnes and Dr Guinevere Granite). The timing sequence of epiphyseal fusion is a technique which has been used in

commingled assemblages containing juveniles, specifically looking at the remains of 256 male individuals aged between 14 and 30 years, who were killed during in the fall of Srebrenica during the Bosnian war in 1995 (Schaefer, 2014, Schaefer and Black, 2007), which appear to be considerably older than the possible age-at-death profile of those in Tuam. However, it may be possible to adapt those methods to the specific case in Tuam. For example, the sequence of fusion of elements of the spine could be sequenced (see Schaefer et al., 2009, Scheuer and Black, 2000).

Deoxyribonucleic acid, or DNA (Section 3.5.3.1), can be utilised in the individualisation of commingled and fragmentary remains. The individualisation process, using DNA, may sometimes also dramatically increase the minimum number of individuals (MNI) of commingled assemblages: the MNI, as established from physical sorting of bones, from a commingled assemblage from Río Medina in Argentina, was four, while genetic testing established that in fact 11 individuals were represented in the assemblage (Puerto et al., 2014, 320, Table 14-2).

Individualisation using DNA significantly extends the scope of the technology, which may typically be proposed initially for identification purposes. For instance, in a hypothetical situation, where five bodies have been buried in the same communal grave, excavation may reveal that the bodies have become fully skeletonised and the bones are commingled. To identify these five individuals, one could test the five right femora (thigh bones) in the assumption each femur represents one individual. However, individualisation or reunification of the remains would involve testing all of the recovered bones in order to assign them to the correct individual (the methods listed earlier cannot reunify every single bone in the human body). If hundreds of bones were exhumed, then all would need to be tested, expanding the testing programme concomitantly.

Forensic experience with commingled assemblages indicates that 'identification and sorting based on anthropological analysis must be considered as preliminary in most cases and necessarily followed up by DNA testing'. If there is substantial commingling of a large number of individuals, there may be a large list of potential candidates for remains, and the antemortem information is limited (Puerto et al., 2014, 307). DNA is one of the methods that can conclusively reunite isolated/commingled remains and it may identify almost every fragment of remains recovered from mass graves (Čakar et al., 2017, 1). DNA technology is still being used today to identify human fragments from the 2001 World Trade Centre terror attack in New York (Associated Press, 2017). It has also been extensively used in the individualisation (and identification) of the commingled skeletal remains of American military personnel killed in the Korean War (Jin et al., 2014).

However, extensive DNA testing of *all* human remains from MFIs, may not be an option in some investigations, due to, for example, financial implications and/or issues with the samples themselves. A forensic investigation into a secondary deposit of skeletal remains from a mass killing in Chile in 1973 was recently undertaken (Garrido Varas and Intriago Leiva, 2012). The remains of the victims were exhumed from their primary point of deposition, in the flues of mineral furnaces, for basic forensic analysis, in 1978 and then reburied in a concrete chamber in a village cemetery. Their remains were mixed with other individuals who had been deposited in the chamber before and after 1978. During the most recent forensic investigation of the remains in 2006, the mass of bones was divided into three groups: the first comprising remains conclusively identified as originating from the original mass killing victims, the second comprising remains of individuals who were definitively not victims of the mass killing, and thirdly, remains that could not be conclusively identified as belonging to either group (Garrido Varas and Intriago Leiva, 2012, e21). This, or variations of it, is a common

occurrence in commingled deposits (H. Tuller, pers. comm.). The application of DNA technology to individualisation in Tuam is addressed in section 5.

3.5.3 Identification of Commingled Remains, including DNA

Identification of individuals is typically one of the primary aims of any investigation of mass graves and/or commingled assemblages. DNA technology increasingly plays a vital role in this (Mundorff et al., 2014). Identification attempts to restore a level of humanity to both the deceased and to surviving families. However, each case will be fundamentally different, with varying challenges and outcomes. Some of the common methods of physical identification include facial recognition, fingerprinting, and dental analysis, and these may be used during MFIs in particular, where remains may be relatively intact. In some cases, particularly with skeletonised remains, identification using DNA may be the only possible option.

DNA Technology

The application of DNA profiling to human remains in commingled contexts can assist in both identification and individualization, see Section 3.5. DNA technology has advanced rapidly and has become an important tool in the investigations of mass fatalities – for example those that resulted from the 2001 attack on the World Trade Centre in New York and the Balkans War (1990s) (Puerto et al., 2014, 309). DNA technology continues to undergo rapid development and the field has seen the emergence of new, even more powerful, technologies, particularly in relation to Next Generation Sequencing (NGS). While there are established standards and guidelines for the more common DNA profiling which is currently undertaken on forensic samples, similar guidelines have yet to be established for NGS (Baker, 2016, 423). DNA samples collected from forensic investigations should 'only be analysed by an internationally accredited DNA laboratory, preferably accredited to ISO 9001:2000 and ideally ISO 17025:2000' (Hall et al., 2008, 482-3). However, the process of extracting DNA is destructive. It requires the powdering of a complete tooth or the immersion of *circa* 1g of bone in liquid nitrogen, with extended chemical processes to remove salts and other compounds. As such, testing skeletal remains is time-consuming and technically difficult as specialist DNA extraction techniques have to be applied.

Some of the incidents where DNA has been used to identify individuals include transportation accidents (air, land, and marine), terrorist acts (such as the London bombings in 2005), war crimes (for example, during the former Yugoslav wars in 1990s), fatal fires involving mass loss of life (such as at Grenfell Tower in 2017 and the 1993 Waco siege), natural disasters (the 2004 Indian Ocean earthquake and tsunami), criminal acts (such as the abduction and murder of selected individuals by paramilitary groups like the Irish Republican Army (IRA)), as well as in the investigations of historical burial sites (such as World War I war graves). Although these investigations may be carried out by a variety of authorities, there are a number of groups who have developed specific skill sets in dealing with such mass fatalities. These include, but are not limited to, the International Commission on Missing Persons (ICMP, see www.icmp.int/about-us/), the International Committee of the Red Cross (ICRC, see www.icrc.org), the Independent Commission for the Location of Victims Remains (ILCVR, see www.iclvr.ie), the Argentine Forensic Anthropology Team (EAAF, see www.eaaf.org), and the

Commonwealth War Graves Commission (www.cwgc.org). These organisations regularly locate, exhume, and identify the skeletal remains of multiple individuals at ground burial sites.

The methods used will depend on a number of crucial factors. Interestingly, appearance of a sample is no indicator as to the state of preservation of the DNA (Baker, 2016, 416). Of primary importance to the prospects of success is the condition of the remains. Upon death, the tissues in the body begin to putrefy and decompose. The soft tissues decompose first, leaving behind the skeletal structures such as bones and teeth. The soft tissues are a rich source of DNA. However, this DNA quickly degrades as the soft tissues decompose. There is DNA within the skeletal structures but this is in low quantities and technically more difficult to access.

Another important defining factor relates to the age of the remains. Simply put, the older the sample the more difficult it is to recover any DNA present. DNA begins to degrade from the point of death and the DNA molecule, which is a long chain, becomes increasingly fragmented and refractory to DNA analysis. Some of the DNA techniques are better able to cope with this fragmentation.

Environmental conditions also play an important role in what profiling methods may be applied, as local ground conditions may have a major impact on the condition of the remains. DNA is preserved best in neutral, or slightly alkaline, conditions, with the absence of microorganisms (Baker, 2016, 416). If ground conditions are wet, or there are compounds that promote decomposition, then the remains may be in very poor condition, which then may impact on the preservation of DNA. In fact, environmental conditions appear to have more influence on the degradation of DNA than time since deposition (Baker, 2016, 416).

One of the final defining factors, and which is specifically linked with what may be the strategy of any DNA profiling to begin with, is the availability of ante-mortem samples and the genetic relationship of those to the deceased.

Some investigations, specifically by the International Commission on Missing Persons (ICMP), through tests involving thousands of fatalities associated with recent conflicts in the Western Balkans, have established what skeletal structures have the greatest potential to yield DNA results (Hines et al., 2014). The structures which most consistently returned DNA results were the teeth (91%), followed by the talus (89%), the other tarsals (87%), the petrous portion (86%), and the femur and vertebrae (both 85%). The sites used in that study included remains from mass graves, as well as underwater sites and surface remains. In the case of the remains from mass graves contexts, the petrous portion proved the most reliable (100%), followed by teeth (95%), and the pelvis (88%). In remains from underwater sites, the talus (100%) most consistently provided DNA, followed by other tarsal bones and the metatarsal (both at 91%), and the tibia (90%) (Hines et al., 2014, 278-281). There are also recommendations for precisely where on each bone the sample should be taken (see Appendix 13-2 in Hines *et al.,* 2014). A study by EAAF (Argentine Forensic Anthropology Team) found that the tibia yielded better results that the femur (typically a strong robust bone that is often targeted for samples), while vertebrae and ribs also proved more reliable that samples from the arms (Puerto et al., 2014). Another study indicates that the bones from the extremities may provide better DNA yields than the more traditional dense bones such as the diaphysis of the femur (Mundorff and Davoren, 2014).

In reality, every site is different, depending on the factors already described above, amongst others. It is, therefore, crucial that a pilot study (Section 5.3) be initially undertaken, prior to any more

extensive investigation, to conduct DNA tests on a representative set of exhumed remains. The condition of the DNA recovered and the likelihood of success using the available techniques can then be assessed from a practical perspective, and the realities and outcomes of such analyses may be fully realised. This would then allow for a targeted programme of sampling to be undertaken, depending on the circumstances and the desired outcomes. Of course, if the initial pilot study is not entirely inclusive, it may need to be repeated: for example, preservation (and thus quality of DNA) may differ across a site, even if the site is quite small. It is essential also that all other examinations of the remains to be sampled are completed before they are tested for DNA. This would include a detailed inventory, including measurements, photographs, radiographs, and any other appropriate analyses (Hines et al., 2014, 283).

Identification using DNA Technology

There are several DNA profiling methods that can be applied to post-mortem samples. Two genomes are found in almost every cell in the human body: the nuclear genome (found in the nucleus of each cell of the body), which is inherited from both parents, and the mitochondrial genome (found in the energy producing mitochondria inside each cell), which is inherited from the mother only. In nuclear genomes, the most commonly-used form of forensic typing is using Short Tandem Repeat (STR) loci (positions on a chromosome). Autosomal STRs are inherited from both parents, and a DNA profile of 17 loci provides a unique identifier. STRs are good where there may be some degradation of the sample and it may also be good in skeletal remains (Baker, 2016, 416-419). STRs are 'nearly unique to the individual because they are inherited half from the mother and the other half from the father' (Jin et al., 2014, 412, 414). Y-chromosome DNA (Y-DNA) is only present in males, and is passed from father to son but it may be difficult to analyse in degraded samples. Mitochondrial DNA (mtDNA) can be useful for small amounts of degraded material. It is inherited only from the mother and can be used to indicate relatedness, but it is time-consuming and labour-intensive, and is only utilised in forensic cases when STR is not possible (Baker, 2016, 418-421). While both Y-DNA and mtDNA may indicate relatedness, STR is the method which can actually provide identification. MtDNA, in forensic cases, would only be considered if STR profiles fail due to degradation of the genetic material (Puerto et al., 2014, 316).

In order to identify the deceased, their DNA profile (post-mortem sample) needs to be compared with ante-mortem samples, if no other reliable methods are available. There are four general ways of obtaining a missing person's DNA profile: from a national DNA database record, from a medical archive sample (such as a neonatal blood card), from a personal effect (such as a toothbrush or hairbrush), or from blood relatives (e.g. the mother and father of the missing person). Certainly, in some incidents, the deceased's identity may be clarified from any of the first three examples. In other cases, comparing the DNA of the deceased with possible surviving relatives may be the only viable option in terms of identification. This is driven by the circumstances of the mass fatality incident. Mass graves, in forensic contexts, may be investigated as either 'open cases' or 'closed cases', depending on the availability, or not, of a list of victims (Puerto et al., 2014, 311).

DNA profiling cannot, in and of itself, provide absolute proof of identity. It will tend to lend support to a hypothesis of identity. But how much support, depends on the availability of ante-mortem samples from close genetic relatives. The end product of a familial DNA comparison is the calculation of a 'likelihood ratio' (LR). The LR is a statistical assessment of the level of support for the person of

interest being who we assert they are. This calculation involves creating alternative propositions for the evidence (Hypothesis 1 or H1 and Hypothesis 2 or H2), computing the probability of the evidence under each proposition and then taking the ratio between them. An LR of greater than one supports H1. The higher that LR (i.e. the bigger the number) then the greater the degree of support for H1 (see the **Table** below).

In a hypothetical case, one could consider the following alternative propositions for the DNA results:

Hypothesis 1 (H1) : X is the biological mother of the individual

Hypothesis 2 (H2) : An unknown female, who is unrelated to X, is the biological mother of the individual

The LR in this case is about Y. That is, the evidence is approximately Y times more likely if **H1** is true rather than **H2**. The magnitude of Y represents the degree of support and the strength of support is drawn from the seven-point verbal scale below:

Level of Support for H1	Likelihood Ratio
Neutral	1
Weak	>1 - 10
Moderate	>10 - 100
Moderately Strong	>100 - 1000
Strong	>1000 - 10,000
Very Strong	>10,000 - 1 million
Extremely Strong	Over 1 million

A final decision as to whether the available evidence (both non-genetic and genetic) is sufficiently persuasive to prove the identity of the deceased to some pre-determined threshold, such as beyond reasonable doubt or on the balance of probabilities, is not a scientific question. This judgment is normally deferred to a legal arbiter, such as a Coroner or a Judge, or to some other competent body or panel tasked with making the final determination/s. The end point of the identification process is the final determination of identity and is *not* just the provision of DNA evidence. The scientists themselves should not be the final arbiters and are not competent to make this judgment. It is therefore important that if an identification programme is to be employed, that there is a final body put in place to adjudicate each case which can consider, *inter alia*, the scientific evidence.

The possible application of DNA technologies to the remains in Tuam is outlined in Section 5.

3.6 Memorialisation and Transitional Justice

'Public memorials are just one of many mechanisms for dealing with the past, but they seek perhaps most directly to engage the broader public in this process. Combined with other initiatives, such as truth commissions and war crimes tribunals, public memorials are infused by their creators with an optimism that they can help create a better world' though redress of past wrongs and prevention of repeated behaviour (Bickford 2014). Memorialisation is a powerful tool that both effects and is in itself shaped by local and national memory, and thus influences how people perceive history. Be it a monument, museum, shrine, renamed building/street, community space, or other form of remembrance, memorials are a form of physical narration used to mark past events, justify actions, and "preserve" or "adjust" historic perceptions. As it helps create an historic narrative, the form in which memorialisation takes and the meaning it is to convey must be carefully considered. Because the designers of a memorial hold the power to influence the historic record, it is important to consider who those designers are.

When considering memorialisation, ways must be found to engage a wide range of stakeholders. Memorialisation that focuses exclusively on family members who have lost relatives may ultimately fail if the views of other stakeholders are ignored. Past studies of family-centred investigations found that such investigations eventually evolved into a right "belonging to society at large" to know what has happened in the country in the past (Rojas-Perez 2015, Wagner 2008). That is, interest in disappearances that involves the state, no matter how significant, will likely be viewed as a national importance not just a right involving immediate family members.

An example of incorporating larger social/national views is the work of the Defence POW/MAI Accounting Agency (DPAA), an agency within the United States Department of Defence that is charged with the search, recovery, and identification of U.S. personnel who have gone missing in past wars. The United States spends a great deal of time and resources in the efforts to recovery missing service personnel all the way back to the second world war. The premise behind the effort is twofold: (1) To return missing persons to their family; (2) and to "leave no man behind," which underscores the notion that the effort is important to American society and the nation. DPAA's work incorporates the needs of the family, but also transcending them by engaging American views of social obligations, patriotism, and image of itself as a nation (Swift 2003, Wagner 2013). A great deal of effort is put into ceremonies and memorials after a set of U.S. service members remains are identified. These often include both national and local government efforts as well as family member input. Inclusion of the larger public into how a memorial is to be enacted at the Tuam Mother and Baby Home will allow for a broader discussion of the past events, better dissemination of findings among the population, and a more transparent process. Such efforts will give any memorialisation a better chance of acceptance.

The disadvantage of engaging a large number of stakeholders is that broadly conflicting ideas may develop between various local and national considerations. Yet, this should not be avoided. Public remembrance has typically been associated with the idea of the nation and driven by state priorities, which selectively molds public perception (Ibreck 2013), however, local communities have rejected state narratives when it doesn't represent their views of history or politics (Stefatos and Kovras 2015). A successful memorialisation should strive to reflect a narrative that upholds an historic accounting that is accepted by all included stakeholders. Stakeholders can be very creative with preserving memory, and it is recommended that a transparent platform be provided so their ideas

may be heard. A process that has been increasingly used throughout the world that engages stakeholders and uses memorialisation as a core mechanism to address past wrongs has been Transitional Justice. This starts with the assumption that it is seeking to address widespread and systematic harms that are fundamentally irreparable (Gallen, *pers. comm*. 2017).

Transitional Justice processes such as truth commissions are mechanisms of social reconstruction outside of standard governmental systems that are used to restore a sense of justice, respect for human rights, promote reconciliation, offer reparations, and memorialisation (Duthie 2010, Fondebrider 2009, United Nations 2010). A key component of transitional justice is that it assists in reconfiguring narratives through investigation, truth telling, and commemoration (Anderlini et al. 2010, Drexler 2010). Originally envisioned to facilitate reconciliation in countries undergoing transitions from authoritarian rule to democracy, Transitional Justice is increasingly used in stable societies to cope with issues that regular governing institutions are ill-equipped to handle. While a government may not be in "transition," the act of addressing past wrongs can itself become a transitional process through investigation and memorialisation of truth that transforms the way society views the past (Jung 2009).

One recent example of the use of Transitional Justice in a non-transitional society is the Solomon Islands Truth and Reconciliation Commission (TRC) established in 2009 to investigate the causes of ethnic violence in order to bring about national unity, reconciliation, restore dignity of victims, retrieve memory of those who were killed past internal violence in their country from 1997 – 2003 (ICTJ 2011). The Solomon Islands was already an established democracy, and did not need a TRC processes to assist with transition; however, the government felt that the best way to address inter-ethnic violence within their communities was through open dialog and commitment to truth. Memorialisation of events that acknowledge wrongs is a part of these processes and viewed as a method to generate national healing and unity.

Perhaps, the most relevant Transitional Justice process in a non-transitioning society to the current Mother and Baby Home burials issue is the Indian Residential School Truth and Reconciliation Commission (TRC) of Canada (Jung 2009). The Canadian government created a series of 139 residential schools in cooperation with Catholic and Protestant churches to "civilize and Christianize" native First Nation children (Canadian Indians) (Maass 2016). They did this by removing the children from their family homes and culture and immersing them in what was considered a proper cultural environment by the state and church. Approximately 150,000 children went through this system over the course of a century. A large number of children went missing or died while in the school, and often their family was not notified. When children died, the schools often buried the dead somewhere within the school grounds. As these improvised cemeteries were not registered burial sites they had few legal protections and, as a result, often became "decommissioned" when the schools closed or moved. It was unknown as to who and how many died, what they died from, where they were buried, and who went missing. The TRC was created in order to answer these questions, among other issues related to the residential schools.

The Indian Residential School TRC investigated these questions and found that over 4,100 deaths were documented, but it is estimated that the real number is closer to 6,000 as many deaths are suspected of not being reported (Maass 2016). Numerous improvised cemeteries have been located, and searches are still ongoing for more. Many of these cemeteries have been overgrown. In other cases, land in which the cemeteries are has since been sold and repurposed by the new

owners. An important result of the Indian Residential School TRC here has been an effort at identifying, recommissioning, and restoration of these cemeteries (funded by the TRC, certain churches, and First Nation communities). Memorialisation at these newly restored cemetery sites record the history of the Indian Residential School program and the names and numbers of the children interned (if known).

In addition, a part of the Indian Residential Schools Settlement Agreement which established the TRC included acknowledgment and an apology by the government for what had taken place (IRSSA, 2007). Such formal acknowledgment of past wrong doings is a form of memorialisation. The signed document adjusts past historic narratives of "proper" cultural values and educates the reader on the truth involving the residential homes. Subsequent legal rulings based on the settlement agreement are thus based on this new narrative, underscoring the varied forms memorialisation can take.

As stated, memorialisation is often enacted as a way to acknowledge wrongs done in an effort to redress the issue as well as adjust historic narratives. Acknowledgment is particularly important when loss of life was unrecorded. Unrecorded burials are those that are purposefully hidden or burials considered unimportant at the time. Memorialisation acts to re-classify these deaths by restoring the dignity of the victim, transforming them from discarded bodies back into people (Hopwood 2011). In this manner, memorials can be viewed as a form of symbolic reparations where the process of public acknowledgment affords victims and family members recognition and respect (Hopwood 2011).

An example of this transformation process has occurred in Srebrenica. When it was learned that the United Nations would begin forensic investigations of in Bosnia and Herzegovina, the perpetrators dug up these initial mass graves with heavy machinery and reburied the now disarticulated remains in secondary locations in order to confound the investigators. Over the course of years, these secondary mass graves have been located, excavated, and many of the remains identified. The identified individuals are laid to rest at the cemetery adjacent to the Srebrenica-Potocari Memorial Centre. The memorial has an interpretive centre that explains how the massacre took place and the events that led up to it along with granite panels listing the names of those who went missing. The cemetery is carefully laid out with uniform graves and headstones. Annual memorial services take place at this location where surviving family members, community, national and world leaders, and the general public converge to commiserate, recount the events that took place, and offer condolences. According to Wagner and Kesetovic (2016:43), the memorial centre and cemetery represent "a kind of triumph – scientific, political, and social – over the wilful destruction of human life." The design of the memorial space has thus transformed the dead from simple numbers of missing to important members of a community with a history and families.

Modern public memorials are "physical representations of commemorative activities that concern events in the past and are located in public spaces. They are designed to evoke a specific reaction or set of reactions, including public acknowledgment of the event or people represented; personal reflection or mourning; pride, anger, or sadness about something that happened; or learning of curiosity about periods in the past" (Bickford 2014). To do so, memorials may draw upon better known monuments or works of art, such as the Vietnam Wall in Washington DC, to help evoke the emotion they aim to highlight. Current trends in memorialisation often highlight a painful/shameful past, rather than heroic/glorious one, and try to understand how the events came to be in an effort to educate the viewer and motivate society not to repeat the mistake. These works aim to educate

the public in order to prevent the same reoccurrence of the events. Modern memorialisation has been used to highlight the disenfranchised, and, if done right, can transform the discarded back into members of the community. Finally, where once memorials were the provenience of government decisions, trends now incorporate the larger society in creation of memorials where sometimes the only role a government has is granting permission for the memorial site. For the success of memorials, community involvement is a necessary component.

3.7 Communication

The production of this report involved broad and varied discussions with national and international organisations. It was highlighted in the early stages of research that any approach to the site at Tuam requires a dedicated communication strategy. From a technical perspective, the lack of effective communication leads to unrealistic expectations of what is possible on site, as well as in relation to human remains of this nature from this specific context.

3.8 Legal and Administrative Issues in relation to Human Remains

There are numerous legal issues that relate to the human remains at Tuam and what the roles of various State agencies play in the outcomes of this site. It is not for the ETG to provide specific advice on these matters. However, it is necessary to identify these parameters and the potential legal or arbitrary issues that may arise.

In summary, unidentified human remains have been located deposited in a setting that is not, to the knowledge of the ETG, registered either publicly or privately as a burial site. It is the understanding of the ETG that these remains may lie in a structure that was designed for the treatment of sewage waste. It is acknowledged here that there is currently insufficient information about these human remains to determine the causes or circumstances of the death of these individuals.

One of the singular and most relevant issues, from a legal and administrative perspective, that the ETG has identified, is the current absence of an active oversight body or responsible State agent, whom would be the central stakeholder in this case. Based upon the facts reported by the press release of the MBHCOI, it is the understanding of the ETG that the Coroner for North Galway maintains jurisdiction over these remains, and should be involved in any future decisions that relate to the recovery or otherwise of these remains. As the Coroner has taken jurisdiction he has the right to investigate and to make findings as to the circumstances in which some of the deaths occurred.

A number of legal pathways are identifiable at this point. However, their appropriateness should be examined. Exhumation for medico-legal death investigation, where violent or unnatural death is suspected, is covered under Section 47 of the Coroners Act 1962 (as amended). Exhumation for purposes other than medico-legal death investigation are covered by Section 46 of the Local Government (Sanitary Services) Act 1948, as amended by Section 4(2) and the Second Schedule of the Local Government Act 1994.

A license to exhume, other than under a medico-legal death investigation, is pursuant to a number of conditions. It was indicated by the Department of the Environment in 1989 that a death cert should accompany a licence to exhume (Department of Justice, 2013, 808). This process does not cover the specific situation of commingled remains, where it is not possible to identify named individuals in a mass grave. In Tuam it is not possible to recover these remains individually as named persons. Exhumation licences are also subject to certain conditions which include a requirement for next-of-kin consent. Further it is understood that, under current practice, a licence will not be granted where the remains lie unidentified in a common plot (e.g. the burial ground of a religious order).

Should any recovery of remains be pursued at Tuam, the process by which this is achieved must be clarified by the relevant State agencies. For the purposes of certain options, identified by the ETG, the assistance of the Coroner for Galway North will be required, as the coroner whose district the human remains lie and who has jurisdiction in relation to the same.

It was highlighted to the ETG that should the issue of DNA be pursued there is pre-existing legislation that may be of assistance in this regard. An Garda Síochána utilise the Criminal Justice (Forensic Evidence and DNA Database System) Act 2014 to deal with all matters DNA. There are provisions within the Act that could assist the Coroner if a decision regarding the recovery and examination of human remains was made. These provisions have been identified as:

- Section 48 – Taking of samples in relation to missing persons (Appendix 4).
- Section 50 – Taking of samples from bodies of unknown deceased persons (Appendix 5).
- Section 66 – Missing and unknown persons index (Appendix 6).

This legislation allows for the examination and retention of DNA separate from a criminal database. Should the option of DNA be considered this may be of assistance.

Any investigation proposed here may benefit from a consideration of the human rights norms prevailing at the relevant time. A number of additional socio-legal issues were identified, however they fall outside the Terms of Reference of the ETG. These include human rights issues around the right of an individual to a respectful and appropriate burial. There is also the possibility that there may be an obligation under international human rights law, including under the European Convention on Human Rights, arising from the right to respect for family life. This could arguably entitle living family members to know the fate of their relatives. There is an obligation on the State, pursuant to the Irish Constitution (*Bunreacht na hÉireann*) and under human rights law, to fully investigate the deaths so as to vindicate the right to life of those concerned. An implied right to death registration may also exist under the International Covenant on Economic, Social and Cultural Rights. Additionally, and more generally, it may be relevant to examine the applicable domestic law and international human rights law in place between the years 1920 to 1960 and how this might impact on the right to respect for family life, and/or the right to a respectful and appropriate burial.

3.8.1 Legal and Administrative Issues in relation to Archaeological Heritage

The excavation of 19th century burials and that the former Children's Home had originally been a Union Workhouse does mean that the site could be considered a zone of archaeological potential. Currently, eleven Union Workhouses across counties Cork, Kerry, Galway and Dublin are registered

on the Sites and Monuments (SMR) database, and are scheduled for inclusion in the next RMP (www.archaeology.ie).

The site of the former Mother and Baby Home is not included in the statutory Record of Monuments and Places (RMP) or otherwise protected as a monument under the National Monuments Acts 1930-2004. However, a Sites and Monuments Record (SMR no. GA043-141----) was created on foot of a report of a children's burial ground at the location of the sewage tank. Although scheduled for inclusion in the next revision of the RMP, the site has been re-classified as a 'redundant record' in light of the findings of the Mother and Baby Home Commission of Investigation work in 2016. This means that the site of these burials is understood to be modern in origin.

Consultation with the National Monuments Service confirmed that forensic investigations do not require a licence under section 26 of the National Monuments Act 1930 where the purpose of that work, and the remains that that work is directed at, are not archaeological in nature. If features or deposits which are archaeological in nature were uncovered then this could be dealt with by ceasing any investigatory work that could disturb archaeological remains. Anything that might reasonably be considered as archaeological remains or objects within the meaning of the National Monuments Acts legally require reports of finding of such objects to the National Museum of Ireland. Any disturbance of archaeological remains would require a licence to be issued from the National Monuments Service and the National Museum of Ireland.

This section has looked at international standards of best practice in the area. Though there are no definitive and universally agreed protocols here three principles stand out. These are appropriate management, appropriate recovery, and, where possible, identification. Transparency in all actions taken and the involvement of the relevant stake-holders must be included to appropriately manage the expectations of what is possible at the Tuam site. The methods that are relevant in the recovery and identification of human remains, an outline of what these involve, and the benefits and costs that each entail, were looked at. In the next section, we look at their relevance and applicability in the context of Tuam and the options available here.

4 Outline of Possible Options on Site from a Technical Perspective

The ETG was asked to outline the options that are available from a technical perspective to assist government deliberations in relation to the site at Tuam. These options are described here without bias and in the order of least site disturbance to most disruptive, for ease of presentation. The least intrusive method refers to negligible disturbance to the soils and structures at the site, while the more intrusive options necessitate various degrees of excavation and associated engineering and health and safety works.

To inform these options a geophysical survey was undertaken and DNA sampling, in the form of a pilot study, was proposed. DNA sampling did not occur in the time that was available to the ETG. DNA and identity should be a consideration in any option that involves forensic recovery of human remains at Tuam. It is not described here in section 4 as it is considered an additional level of investigation. The issue of identification is highly complex with no single answer and the ETG is aware that high, and potentially unrealistic, expectations exist among stakeholders. Thus, it is more appropriate that this option is considered separately and this is discussed in depth in Section 5.

It is necessary to note that the costs detailed in this section refer to time in the field only and the logistics of excavation, and not to subsidiary costs that would be incurred in post-excavation, such as making the site safe and/or reporting. The costs are presented as a guide or a starting point only. They are a broad indication of what the task or option outlined may cost.

Any option, or combination of options, that is considered by Government requires that a detailed project plan would be put in place in discussion with the relevant stakeholders. The expected, or desired, outcomes for any stakeholder will influence the final methodology for any course of action at this site.

4.1 Baseline Scenario

This option involves no further investigative work on site. The site would return to being managed as a site of memorial and the known human remains present to be conserved. This option necessitates engagement with relevant stakeholders. They may choose to include any approach, from a memorial plaque through to a complete redesign of the site and associated playground area. This scenario also requires a consideration of what would be necessary to make the site safe for public access.

It is important to note that any action that is undertaken at the site may have memorialisation as a final outcome. It may be returned to as a result of any option that Government chooses.

4.1.1 Requirements

- Identification of stakeholders;
- Transparent communication with stakeholders;
- Design of suitable memorial;
- Further investigation;
- Consideration of requirements to make site safe for public access.

This option requires that the issues of memorialisation are considered in the broader sense of what might be appropriate within the Transitional Justice Model, see section 3.6. One of the key issues for this option to be applied successfully would be the acquisition of further information about those whose deaths are recorded in the Mother and Baby Home. In order to memorialise, it is essential to know what and whom are being acknowledged. Further investigation on behalf of Government would be required in order to memorialise effectively.

Relevant stakeholders must be identified and organised to consider the form of memorialisation. In the case of the Tuam Mothers and Baby Home, obvious participants include surviving family members, select community and government leaders, and representatives of the appropriate government agencies involved in monument construction. However, care must be taken to also involve non-family community members as well as segments of the broader Irish population. Those living in the area will likely interact with the memorial more often, and so will have interest in its final shape. As this case has attracted national interest, portions of the population at large will likely also wish to have some input into how the past is represented at the former care home.

Finally, the site would need to be secured, so that there would be no further risk of injury to individuals or risk of damage to surrounding structures from the known subsurface features on the site.

4.1.2 Outcomes

If this option is selected alone the primary outcome will be that further knowledge about the site will be limited. Suitable memorial can transform those interred here back into members of the community as a form of symbolic reparation.

4.1.3 Estimate

Timeline is offered as a guide only and representative of the time from the point of decision. Cost is estimated based on reinstatement and making the site safe, together with a form of memorialisation. These estimates are offered as a guide only and are provided from a technical perspective.

Timeline: 6 months to 1 year.

Cost: €100,000-€500,000.

4.2 Exhumation of Known Human Remains

This option involves the recovery of human remains interred in the subsurface chambered structure, as identified by test excavations. This option involves exhumation without forensic excavation and without the additional information that can be garnered from a forensic approach. While the installation of engineering, and health and safety concerns, will both remain, the time on-site and post-excavation will be reduced in comparison to a forensic excavation approach.

While intrusive, this option is non-investigative, and allows for no further analysis of remains exhumed. It does allow for the remains to be exhumed to a more suitable context than where they currently lie. Stakeholders would need to be engaged with and communication channels kept open at all times.

4.2.1 Requirements

- On-site works to include Health and Safety;
- On-site works to include Engineering;
- Exhumations by archaeologists and anthropologists;
- Full-time security or Garda presence;
- Engagement and communication with stakeholders.

Human remains that are interred here currently lie in a chambered structure whose depth is estimated to be >2m below the surface. Each chamber is described as being narrow in width with limited access. Advice received by the ETG is that this space would be considered a confined space for personnel to access, see Appendices G and H, and, as such, needs to have a clear programme of works put in place.

In this scenario excavation would also be potentially required directly to the outside of the chambered structure in order to detect remains that may be present. This option would require a combination of engineering aspects, designed to allow the site to be safe for both manual and machine excavation. It would require a minimum of four experienced, and suitably qualified archaeologists, on-site and a minimum of two experienced, and suitably qualified, physical anthropologists on-site. The site would be treated as a construction site and, as such, all the necessary precautions and facilities would be required. Due to the nature of the site and what is being recovered, a full-time security or Garda presence would be advisable for the duration of site works.

This option would require engagement with stakeholders and a consideration of their concerns. Transparent communication with the stakeholders should be a priority.

4.2.2 Outcomes

Remains located in the chambered structure would be exhumed to a more suitable context, with no further investigation.

4.2.3 Estimate

Timeline is offered as a guide only and representative of the time from the point of decision. Cost is estimated based on excavation alone, as well as reinstatement and making the site safe. This does not include subsequent re-interment of remains that have been recovered or any memorial. These estimates are offered as a guide only and provided from a technical perspective.

Timeline: 3 month lead-in for engineering works and ground preparation, 8 weeks on-site excavations

Cost: €300,000 – €800,000

4.3 Forensic Excavation and Recovery of known Human Remains

This option would involve the complete forensic archaeological excavation, recovery, and analysis of human remains from the structure identified by the MBHCOI. From the reported evidence thus far, it seems that this structure is the only part of the memorial garden that contains human remains. However, in any forensic archaeological recovery of these remains, there would be a potential high risk of disturbance to the wider area of the memorial garden. This option allows for the complete excavation of the memorial garden with a full forensic control in place. This allows all evidence and contextual information to be protected and examined. In this option the methods and processes allow for every fragment of human remains to be recovered.

In this scenario, a higher degree of effort can be placed on the on-site processes which can then assist in the individualisation of commingled remains, as discussed in section 3.5.

As with all other options, stakeholders concerns would need to be considered and a communication strategy put in place.

4.3.1 Requirements

- Excavation methodology to include excavation and analysis to forensic standard
- Excavation and analysis to forensic standard;
- On-site works to include extensive Health and Safety;
- On-site works to include extensive Engineering;
- Experienced anthropologists/osteoarchaeologists, forensic archaeologists, administrative, and IT support staff;
- On-site forensic excavation requirements and off-site mortuary facilities;
- Full-time Garda presence, both on-site and off-site;
- Engagement and communication with stakeholders.

Due to the lack of knowledge about the site, and the remains interred within, a process known as ‘Humanitarian Forensic Action’ has been identified as the method best applied in this option. It would allow for work to take place under forensic controls, so that evidence would be treated correctly and preserved, should it be required in the future for judicial proceedings. This would require meticulous excavation and recording throughout the excavation and recovery of remains. It would therefore require increased resources throughout both the fieldwork and post-excavation stages.

Due to the extensive detail required in this task, the engineering design would remain the same as for option 2. However, it would be required to be more robust due to the extended period of time personnel would be on site. In terms of access, personnel would be in confined spaces for longer periods of duration to allow for the forensic recovery process. The Health and Safety Plan would need to allow for the higher risk this poses to personnel. This option would require excavation both

outside and inside the chambered structure, and the engineering design would need to reflect this. The site would be treated as a construction site and, as such, all the necessary precautions and facilities would be required. As with the previous option, due to the nature of the site and what is being recovered, full time Garda presence would be required for the duration of site works.

Post-excavation analysis would play a crucial role in this option and would require the time spent in the field to be reflected in a suitable laboratory or temporary mortuary close to the site. This would require full staff including IT and administration and full-time security or Garda presence.

For this option it is envisaged that personnel required would be 12 staff on site and 12 staff in the laboratory, 24 in total. This includes teams of suitably qualified and experienced anthropologists/osteoarchaeologists (with particular expertise in juvenile osteology), forensic archaeologists, administrative and IT support staff.

A project plan would be required to be put in place, designed in conjunction with both the stakeholders and the desired strategic outcomes of the investigation. This plan should include a detailed consideration of the Engineering design, the Health and Safety Plan, excavation methodology, and laboratory analysis. While stakeholders need to be engaged in the process, it is imperative that a clear communication strategy be established to manage the expectations of the stakeholders of the outcomes of such a forensic investigation of the site.

4.3.2 Outcomes

The site would be excavated under forensic control and human remains recovered in a forensic manner. All efforts would be made to individualise the commingled assemblage, using appropriate archaeological, osteological, and forensic methods. The possible use of DNA technology may be included in this option, with regards to both individualisation and identification. Further laboratory analyses may be considered, depending on the strategic outcomes as defined in any project plan.

4.3.3 Estimate

Timeline is offered as a guide only and representative of the time from the point of decision. Cost is estimated based on excavation, post-excavation, and reinstatement of the site safe. This does not include subsequent re-interment of remains that have been recovered and is exclusive of third-party costs such as DNA testing or memorial. These estimates are offered as a guide only and are provided from a technical perspective.

Timeline: 3 month lead-in for engineering works and ground preparation, 10 weeks excavation, and 10 weeks in laboratory processing, the latter to be run partially concurrently; total estimate 6 - 8 months.

Cost: €500,000 – €1,200,000

4.4 Forensic Excavation and Recovery of Known Human Remains with Further Evaluation/Excavation or other Areas of Potential Burial/Interest.

This option would require full consideration of results following an extensive programme of non-intrusive investigative work. The aim of this option would be the recovery of human remains from the site in a targeted manner, based on information that has been, or would, be acquired. A comprehensive appraisal of the resulting evidence from geophysical survey, assessment of witness statements, and historical records would be required. There would be possible duplication of efforts with the investigations of the MBCHOI and this should be addressed in the first instance.

This option would include the complete forensic excavation and recovery of all human remains from within the area of the memorial garden, as well as any potential human remains in other targeted areas that are identified. Any potentially relevant areas of interest are only to be considered as initial findings based upon the non-invasive survey conducted by the ETG in July 2017. However, there are subsurface structural anomalies that have been established as potentially being similar to that described by the MBHCOI.

4.4.1 Requirements

- Ground-truthing of existing geophysical surveys to determine other areas of interest, which would then be subject to test excavations under the necessary Engineering and Health and Safety requirements
- Excavation methodology with all excavation and analysis, to forensic standard
- Experienced anthropologists/osteoarchaeologists, forensic archaeologists, administrative, and IT support staff
- Off-site mortuary facilities
- Full-time Garda presence, both on-site and off-site
- Engagement and communication with stakeholders

This option would require access to the entire available site at the Dublin Road Housing Estate for the duration of the project. Other areas that are identified, as potentially being of interest, would be ground-truthed through archaeological excavation testing. This would involve placing narrow trenches over the features and excavating them in a systematic manner to determine the nature and potential scope of any possible features of interest. This testing could be used to determine if the areas of interest, are relevant and/or contain human remains. These areas would then potentially need to be secured by relevant engineering works based on a presumption of similar depths of between 2-3 metres. Each area must be dealt with sequentially prior to excavation of the memorial garden so as to minimise any impact within that area until it may be investigated.

As this option builds on the previous, it is therefore envisaged that personnel required would be similar, 12 staff on site and 12 staff in the laboratory, 24 in total. This includes teams of suitably qualified and experienced anthropologists/osteoarchaeologists with expertise in juvenile osteology, forensic archaeologists, administration and IT support staff. Due to the nature of the site, and what is being recovered, a full time Garda presence would be advisable for the duration of site works.

Post-excavation analysis would play a crucial role in this option and would require the time spent in the field to be reflected in a suitable laboratory or temporary mortuary close to the site. This would require full staff including IT and administration, and full-time security or Garda presence.

A project plan would be required to be put in place, designed in conjunction with stakeholders and the desired strategic outcomes. This plan should include a detailed consideration of the Engineering design, the Health and Safety Plan, excavation methodology, and laboratory analysis. An understanding of expected outcomes would need to be communicated with all stakeholders.

4.4.2 Outcomes

Each anomaly on site would be ground-truthed for the potential of further human remains from the timeperiod of the former Mother and Baby Home. Additionally, the subsurface chambers and the memorial garden would be excavated in their entirety to a forensic standard. Human remains recovered would be analysed and all efforts would be made to individualise the commingled assemblage, using appropriate archaeological, osteological, and forensic methods. The possible use of DNA technology may be included in this option, with regards to both individualisaton and identification. Further laboratory analyses may be considered, depending on the strategic outcomes as defined in any project plan. Known human remains would be recovered and the potential for further human remains to be located at the site would be established and concluded.

4.4.3 Estimates

Timeline is offered as a guide only and representative of the time from the point of decision. In this option timeline and cost are less precise due to the scope of the unknown factors. The outcome of ground-truthing and what is found on site will determine the amount of further excavation and laboratory analysis required. Cost is estimated based on excavation, post-excavation, and reinstatement of the site. This does not include subsequent re-interment of human remains that have been recovered and is exclusive of third-party costs such as DNA testing or memorial. These estimates are offered as a guide only and provided from a technical perspective.

Timeline: 6 - 12 months

Costs: €2,000,000-2,500,000 from fieldwork to laboratory, highly variable dependent on outcomes of ground truthing.

4.5 Forensic Excavation of Total Available Area

This option represents the most intrusive methodology that might be applied at this location. It involves the full forensic investigation and archaeological excavation of all available ground formerly occupied by the Mother and Baby Home at Tuam, in order to physically, and practically, exhaust all potential for further relevant, and preserved, human remains. Due to the high level of variables and unknowns, this option is the most intrusive, expensive, and disruptive to current residents. In a manner similar to previous options this would include an investigation of anomalies identified by

geophysical survey and a complete forensic excavation of the memorial garden and recovery of known human remains here.

The fact that the site had been a Union Workhouse, and later a military barracks, prior to functioning as a Mother and Baby Home is a foreseeable complication to this option. As a result of the site history there could be significant disturbance to historical burials and other archaeological features that do not relate to the Mother and Baby Home.

While extensive, the excavation of all available areas could not be considered conclusive. Just over 0.4 hectares of the property, which was once within the boundary of the Mother and Baby Home, is now open ground (that is, playground, memorial garden, car park and roadways). Since the closure and demolition of the home the remaining 2.3 hectares has had houses, private gardens, sheds and public roadways built upon it (approximately 85% of the original site).

4.5.1 Requirements

- Complete resolution of all extant available ground excavated to forensic standards
- The necessary Engineering and Health and Safety requirements
- Excavation methodology designed to excavate in sections to minimise impacts on ground yet to be excavated
- Forensic analysis of human remains
- Experienced anthropologists/osteoarchaeologists, forensic archaeologists, administrative, and IT support staff
- Off-site mortuary facilities
- Full-time Garda presence, both on-site and at off-site mortuary.
- Engagement and communication with stakeholders.

All other requirements, as identified in previous options, would be necessary here with the expansion of the ground to be excavated. A project plan would be required to be put in place that was designed in conjunction with stakeholders. This plan should include a detailed consideration of the Engineering design, the Health and Safety Plan, excavation methodology and subsequent laboratory analysis. An understanding of expected outcomes would need to be communicated with all stakeholders.

This option proposes that excavation begin in the north of the site and excavate all levels and stratigraphy to natural or sterile levels. The site can be dealt with in sections according to the results of geophysics strategic site management. This is an extensive project that would require extensive forward planning. As such the expected outcomes and desired lines of investigation would need to be established prior to the undertaking of this option. Due to the nature of the site when human remains are present and being recovered a full time Garda presence would be advisable.

4.5.2 Outcomes

All known human remains would be recovered, unknown anomalies, and the area of the former site of the Mother and Baby Home would be excavated in totality. Human remains recovered would be analysed and all efforts would be made to individualise the commingled assemblage, using appropriate archaeological, osteological, and forensic methods. The possible use of DNA technology

may be included in this option, with regards to both individualisaton and identification. Further laboratory analyses may be considered, depending on the strategic outcomes as defined in any project plan. Known human remains would be recovered and the potential for further human remains to be located at the site would be established and brought to conclusion.

4.5.3 Estimates

The estimate here is based upon the outside potentials. The number of deaths officially registered here is 796, see section 1, and this may be considered as the maximum possible recoveries in this scenario. However, due to the history of this site, it is a possibility that historic burials may be encountered. Cost is estimated based on excavation, post-excavation, and reinstatement of the site. This does not include subsequent re-interment of human remains that have been recovered and is exclusive of third-party costs such as DNA testing or memorial. These estimates are offered as a guide only and provided from a technical perspective.

Timeline: 12 – 24 months

Costs: €3,000,000-5,000,000 from fieldwork to laboratory, highly speculative and variable dependent on finding in real time on site.

5 Assessment of application of DNA technologies in Relation to Tuam

Any investigation involving the use of DNA, which investigates the molecular makeup of an individual, needs to be undertaken using a defined strategy with clear objectives. What is the specific purpose of the analysis? What are the outcomes? What purpose would identification serve? What skeletal elements are to be targeted? The information which may be gained may be unique to the deceased and the use of such information is highly sensitive. This also translates to any individuals who claim genetic relationships to the deceased. In addition, any actual bones/teeth submitted for testing may be completely destroyed in the process. How would such destruction serve the deceased and how may it impact on any relatives (who may have varying opinions of DNA testing), particularly if the test is unsuccessful? All of these are essential on a number of levels and will be further elaborated on below.

Ultimately also, as with any forensic investigation of multiple individuals involving commingling, a decision would need to be made to determine if DNA was to be used to identify every individual or every fragment, or indeed both (Conlon, 2014, 483).

5.1 DNA Technology in Identification

The potential for the use of DNA to positively identify individuals is highly complex and dependant on a variety of issues, particularly the potential for the survival of viable DNA within the bones themselves and also the availability of viable ante-mortem samples, see section 3.5. If the remains in Tuam are primarily from infants and young juveniles, who died within the years of the Mother and Baby Home, then it is probable that the options of identification through personal ante-mortem comparisons would be impossible. The probable only method of identification of any remains from Tuam may be from comparison of DNA from excavated remains with samples obtained from blood relatives. While DNA is the 'most expensive, most complex, and most lengthy identification modality' (Conlon, 2014, 486), it essentially remains the probable only possible method of identification with the human remains in Tuam. The existence of DNA technology should not be automatically assumed to be without issues with regards to the remains in Tuam and these are examined in detail below in section 5.4.

5.2 DNA Technology in Individualisation

It is essential to consider DNA technology in the individualisation of commingled remains (see Mundorff *et al.*, 2014, and Section 3.5), and this is no less the case with Tuam. A reunification programme however, is likely to significantly increase the cost of the DNA programme and would extend the time required to complete the project. It would not be an understatement to say that a 'full' reunification programme of the remains currently believed to be at the Tuam burial site could take years to complete and cost millions of euro.

Essentially, it is possible that, following excavation, significant quantities of skeletal remains from Tuam may remain as commingled remains and may not, with presently available technologies, be individualised. This would create a situation where some human remains, probably partial remains, may be identified to living relatives, some, probable partial remains, which will be unidentified, and lastly, a possible significant quantity of remains which cannot be individualised and cannot be identified. This impacts on whatever is envisaged for the human remains after all analyses are complete.

5.3 DNA Pilot Study in Relation to Tuam

Prior to any possible wide scale programme of DNA testing at Tuam, it would be essential that a pilot or feasibility study be undertaken. It is crucial that samples selected for DNA be 'driven by context, morphological analysis, and available resources' (Ubelaker, 2014, 4). A simple visual observation that bones may be well preserved, and thus will be suitable for DNA testing, is not sufficient (Baker, 2016, 416). A preliminary testing programme, on a representative sample, could be used to firstly, determine if DNA actually survives, secondly, which bones/teeth may be the most suitable in terms of DNA yields, and thirdly, the likelihood of success using the available techniques. Thus, any subsequent tests for the identification of individuals may utilise the bones/teeth which have been proven to provide the most DNA in this case, as well as highlighting if variations occur between areas of the site. It would be crucial to have such information before any larger programme of testing is even considered. Any DNA analysis would need to be undertaken in an internationally accredited laboratory with specialised experience in the extraction of DNA from commingled assemblages where preservation may be an issue.

5.4 Specific Issues Regarding DNA and the Juvenile Remains from Tuam

There are a number of issues which would need to be considered and addressed prior to any contemplation of a preliminary pilot DNA study as suggested above, as well as any subsequent, more extensive, programme of DNA testing on remains from Tuam which may follow.

Some of the primary considerations in terms of whether DNA extraction is even possible, have been described earlier, see section 3.5. These include the condition of the remains, the age of the remains, environmental conditions, and the availability of ante-mortem samples. The condition of the remains from Tuam may only be determined on excavation – the sample of bones recovered under the auspices of the MCHCOI may represent just a small percentage of the actual human remains that are on the site. Even if bones and teeth appear visually well preserved, that does not equate to the preservation of DNA. Current information indicates that the remains date to the period of use of the site as a Mother and Baby Home (1925-1961). As DNA starts to degenerate from the point of death it will be more difficult to extract quality DNA. However, certainly the date of the remains from Tuam do not preclude DNA extraction: DNA profiling has been successfully applied to bones from World War I soldiers and to the exhumed bodies of the Russian Royal family, the Romanov's, killed in 1917. In terms of environmental conditions, again, these cannot be conclusively commented on at present, without detailed excavation. However, the remains are apparently contained within a number of chambers that may, in some fashion, be related to the treatment/containment of sewage and/or waste water. This suggests at least some water-logging of

the site at some stage, which may have impacted on the remains and consequently the nature of any DNA.

All of these factors will impact on whether DNA may actually survive in any remains from this site and the type of DNA which may be extracted. However, another crucial factor in terms of the possible use of DNA at Tuam is the fact that, current information indicates that the remains may be all juvenile in origin. This may alter in the course of an investigative excavation. However, based on the current available information, this has an impact on the issue of DNA. With infants, and juveniles, obtaining DNA from skeletal structures is potentially much more difficult. Particularly with infants, teeth may be lost post-mortem (particularly given the commingled nature of the assemblage), they may not be fully formed (completely formed teeth, with intact roots, are required for DNA extraction: the first teeth to have a complete root are the deciduous incisors in the second year of life), and they may also be less resistant to post-mortem decay. Infant bones are soft and cartilaginous and, as such, may also be more prone to post-mortem decay. Thus, DNA profiling may be inherently difficult to begin with regarding the remains from Tuam.

As outlined extraction of DNA involves the destruction of actual samples. Current information indicates that DNA testing of juveniles/infant bones would concentrate on specific bones/teeth to being with (in the context of a pilot study), elements that would be considered to have the greatest potential for DNA survival and extraction. These include fully formed teeth (with the roots complete), the femur ('thigh bone'), and the petrous portion (from the temporal bone of the cranium). Certainly, in the first two, in the case of juveniles and infants, it is believed that the entire tooth and almost the entire bone would be destroyed, and the petrous portion would also be completely destroyed. By extrapolation, this suggests that, should other bones be tested, they too would be destroyed, and that the chance of actually obtaining DNA from those bones may be quite negligible. While the destruction of bones/teeth may be acceptable when attempting to identify an individual whose remains comprise multiple, and perhaps complete, skeletal remains, it defeats the purpose when one considers individualisation in young juveniles. This is due to the fact that the very process of trying to individualise the bones of the skeleton of a juvenile may result in practically the total destruction of those remains.

It is possible that, even if a detailed preliminary analysis is undertaken on assessing the potential for DNA and suitable bone/teeth types are identified, it does not follow that DNA extraction will subsequently be successful in every sample tested. One important factor, in terms of previous studies, is the percentage of tests which *fail* to produce DNA profiles (see, for example, Figures 13-3 to 13-5, in Hines et al., 2014). It is not always possible to obtain DNA profiles from every sample of bone or teeth (see, for example, Čakar et al., 2017). This is similar with archaeological studies, where DNA extraction has been undertaken on infant and juvenile remains. One of the earliest widespread applications of DNA was on the perinates recovered from the sewer of a Roman-era bathhouse in Ashkelon in Israel (Smith and Kahila, 1992). Forty-three femora were tested for DNA-based sex identification. However, this was only possible in 19 specimens (Faerman et al., 1998). Similarly, DNA sex-identification was achieved in just 13 of the 31 perinate samples tested in a study on infanticide in two Romano-British sites (Mays and Faerman, 2001). Admittedly, the date range of the aforementioned sites would have impacted on the type of analysis undertaken and techniques have continued to evolve also. However, despite these undoubted advances in techniques in recent years (see, for example, Associated Press, 2017) there are still no guarantees of success with examining samples for DNA. A recent DNA study examined the sex profile of 33 perinates which were

excavated from Yewden Roman villa in Hambledon in England. Extraction was only successful in 12 individuals (Mays and Eyers, 2011, Abu-Mandil Hassan et al., 2014). In another recent forensic investigation into child deaths at the Former Arthur G. Dozier School for Boys (*c.* 1900-1960) in Marianna, Florida. Of the 57 samples that were submitted for DNA testing, 33 produced mtDNA and 10 yielded mtDNA and YSTR DNA (Kimmerle et al., 2016, 91). Until a detailed testing programme is designed, with a clear research agenda, the situation regarding the Tuam remains is unclear.

A important issue also regards the types of DNA which may be extracted. Again, at present, this is an unknown factor. But the quality and nature of any DNA recovered from any excavated remains from Tuam may only be as useful as the comparative samples which may be provided by living relatives, as there is unlikely to be any other method of identification possible in this case (see Mundorff et al., 2014). Any identification of actual deceased in Tuam, assuming appropriate DNA may survive, can only be achieved if relatives provide samples. And that identification is based on the type of DNA extracted from bones/teeth of the deceased as well as the genetic distance of any surviving relatives. The cost implications may vary considerably, based on what DNA technologies may be possible or pursued. At present, it is not even known what types of DNA profiles may be possible, if DNA even survives. STR DNA, mtDNA, and Y-DNA, may or may not survive, and each has different levels of reliability in terms of potential identification. In addition, in theory, the more relatives, per deceased, that provide comparable DNA profiles, the higher the possibility of identification. However, questions must also be asked regarding DNA profiles that may be attained from deceased where there are no known relatives and/or where existing relatives do not want to be identified. The rights of the deceased as well as any living relatives must be a consideration.

Finally, it is imperative, if DNA was to be used in any form for any investigation at the site in Tuam, that public perceptions of the technology be considered. A common perception, possibly perpetuated by popular forensic film and TV productions, may be that DNA is a tool which can answer a plethora of questions and will almost always allow identification of individuals. The actual realities are very different and it is imperative that public expectations be addressed from the outset.

6 Factors for Consideration in the Implementation of Best Practice

In assessing the options outlined in Section 4, together with the internationally accepted standards and procedures provided in Section 3, several factors need further consideration should any actions be implemented at the Tuam site. Firstly, while the full forensic excavation of known human remains would address many concerns over the site, it could not be considered comprehensive and thus would pose challenges in the adoption of any Transitional Justice model. In contrast, the total excavation of the available space, while exhaustive in its approach, could lead to extended time-frames, escalated costs, and the potential unnecessary disturbance of 19th century Workhouse burials. It is the view of this Group that any action undertaken should be in line with best practice, employing an informed, phased approach, to the resolution of the site. This multi-facetted approach, in which the following stages may be appropriate courses of action, shall be considered in full:

- The formation of an Multi-Disciplinary Body to implement strategy;
- Undertake further Archival Research and collection of Witness Testimony;
- Undertake further targeted Survey and Testing/Evaluation of specific areas;
- Implement a full Forensic Excavation of all known Human Remains;
- Implement a full Forensic Anthropological Analysis;
- Assessment of application of DNA technologies;
- Memorialisation and Conservation of the site.

Certain actions would impact on the nature of subsequent actions, for example, the results of targeted survey/testing and full forensic excavation will influence what happens after that. Other stages could run concurrently, such as communication within a transitional justice strategy and archival research, and initial site preparations. These actions require further detailed explanation, specifically with regards to the former Mother and Baby Home at Tuam. These stages are presented here as an aid to Government deliberations.

6.1 The formation of an Multi-Disciplinary Body to implement strategy

As has been identified in section 3.8 there is a current lack of an active oversight body or State agent responsible for decision making in relation to the site and the human remains interred here. A decisive first step to any considered options, is the formation of such an oversight or directorial body, to manage the process necessary to implement a Humanitarian Forensic Action at the site at Tuam. Furthermore, if this process were to be implemented within a broader Transitional Justice

model it would allow for the consideration of all relevant stakeholders in the decision-making process.

The role of the coroner in such a body should be considered central in establishing clearly defined strategic goals and outcomes to any further work envisaged in relation to this site and human remains interred therein. These would include a defined communication strategy and a strategy to manage the requirements and expectations of all stakeholders with regard to a proposed investigative programme. While there is not currently a body, agency or department that could clearly fulfil this role, there are pre-existing structures that could be adapted for this purpose.

6.2 Undertake further Archival Research and collection of Witness Testimony

Additional investigative work needs to be applied in order to move to the stage of further excavation at the site. Such resources were not available to the ETG at the time and in the time-frame that was assigned. The consideration of further human remains at the site in Tuam would require dedicated examination into archive sources, for example the 'St Marys Home Register' of Admissions and Discharges held by the Child and Family Agency. This document could inform on the potential number of burials that may exist here and provide assistance in relation to identifying the scale of interments.

Prior to 1st January 1995, Stillbirths in Ireland were not required to be registered (www.irishstatutebook.ie/ eli/ 1994/ act/ 1/ enacted/ en/ print and www.irishhealth.com/ article.html?con=254). The Register of Death statistics that were derived from the GRO and made available to the ETG reflect only children whom had lived (DCYA, 2014). As such it could be reasonably envisaged that there may be more interments at this site than appear on the GRO register.

It has been widely reported in the press that there are a number of individuals who claim to have seen juvenile human remains in subsurface structures. It would be considered necessary to make enquiries of these witnesses to aid the investigation of the site.

6.3 Undertake further targeted Survey and Testing/Evaluation of specific areas

The results of geophysical survey, historical archives and witness testimony could be combined to form a picture of what the subsurface of the site might look like and where potential additional burials might be located. The geophysics in this report has identified at least eight additional features or anomalies that might be investigated further through 'ground-truthing'. Subsequent test/evaluation excavation of these areas could be applied should it be determined that a feature is of relevance. Any such test trenches could be completed using light machinery and hand-excavation by suitably qualified and experienced anthropologists/osteoarchaeologists, and forensic archaeologists.

6.4 Implement a full Forensic Excavation of all known human remains

It is likely that following the previous stage of targeted survey and evaluation, that other locations within the site might be found to contain relevant burials (section 2.3). These areas would need to be fully forensically excavated in sequence from those most accessible to those that are least accessible. It may be presumed that, in practical terms, this would mean that the memorial garden would be the final area to be excavated. However, should it be the case that there are numerous or expansive areas that contain relevant interments, then it may become more effective to completely excavate the entire area.

The general principles under which such forensic excavations would take place is outlined in sections 3.4 and 3.4.1. It is of utmost importance that the excavation work be carried out by experienced and competent professionals using the most informed methodologies. The forensic and archaeological protocols cannot be detailed here (when the location and nature of those potential excavations are unknown). However, with regard to the excavation of the chambered tanks within the memorial garden, where the tanks, together with the comingled/disarticulated remains, pose a particular challenge, some of the requirements can be predicted. For example, once access to the tanks is gained safely, a full record of the commingled skeletal remains should be made by scaled drawings and 3D photogrammetry and photographs. While notes would be made by the osteoarchaeologists present, the polar ends of each bone could also be recorded (using EDM/Total Station) and labelled accordingly. The position of all other material and debris (i.e. timber, plastics, rubble) would also be accurately mapped. The skeletal remains might then be retrieved as the deposit material is excavated and sampled. All spoil material from these deposits would subsequently be sieved for minute traces of evidence. All this must be done without causing cross-contamination of potential DNA samples.

The area of known human remains within the memorial garden is currently the only location for which the practicalities of forensic excavation methodology might be surmised. The restricted nature of the site and the depth at which any forensic archaeological excavation must reach poses considerable challenges. Engineering solutions have been provided in Appendix G. These solutions use a series of shoring measures to ensure the safe access to the full depth of the known sewage tank here. It becomes clear from an engineering viewpoint that the outer surfaces of the memorial garden would need to excavated first, followed by the interior of the sewage tank, before access could be gained into the 20 chambers. It also suggests the possibility of removing a portion of the boundary wall and adjoining sheds as an option to create a safe working environment. Even with these measures in place, the depth and size of the chambers mean that the workspace available would be considered a confined space. The duration and scale of any forensic excavation results in the site being categorised as a 'construction site' under the Safety, Health and Welfare at Work Act 2005 and SHWW Construction Regulations 2013. A health and safety report addressing numerous foreseen issues of excavation in this environment is given in Appendix H.

Excavation of the entire area of the former Mother and Baby Home should be avoided as it is the site of an earlier Union Workhouse, and where the potential for 19th century burials has been demonstrated, it is likely that archaeological remains would be uncovered. Burials from the famine period may not always be immediately differentiated from 20th century graves. This may require some archaeological/forensic excavation to decipher and thus an archaeological excavation licence. It would therefore be prudent for any future investigatory team to equip itself with an

archaeological excavation licence in advance so that any archaeological material inadvertently or incidentally uncovered during forensic investigations could be dealt with in the most expeditious manner possible. The National Monuments Service recommended that only the minimum amount of interference necessary take place with 19th century workhouse features or burials, to avoid forensic investigations becoming caught up with unrelated archaeological material and the resources involved in dealing with such material appropriately. The archaeological materials would necessarily be recorded to forensic standards, comparable to (and often surpassing) those standards used in traditional archaeological practice (see section 3.4.1).

6.5 Implement a full Forensic Anthropological Analysis

There does not appear to be any directly comparable site to the situation in Tuam, which appears to be a substantial assemblage of the commingled remains of young juveniles.

The degree of preservation will dictate the analyses which may be undertaken, while the nature of those analyses will depend on the strategic goals of the investigation. Preservation rates may vary across the site, and analyses applied on remains in one area may not be applicable elsewhere. It is noted that juvenile, and particularly younger infant bones, may be more susceptible to chemical and mechanical erosion due to the low mineralisation and high porosity of the bones (Booth *et al*., 2016, 131). At present, the condition of the remains is undetermined.

The establishment of a Minimum Number of Individuals is of crucial importance in any commingled assemblage. There are various techniques of establishing Minimum Number of Individuals (MNIs) in commingled assemblages (see section 3.5). In the case of Tuam, age-at-death may be particularly useful in calculating the number of individuals, and the fact that the tanks may be relatively self-contained (17/20 identified with human remains) may assist in the process. In addition, the landmark method could be adapted to specifically record infant and juvenile remains, and GIS could also be utilised. The use of DNA technology in relation to individualisation is specifically addressed in Section 5.

Following on from the establishment of MNI, age-at-death, and possibly sex, any further analyses would be based on the strategic goals of the investigation. Other analyses could be applied to specifically address issues regarding pathological lesions such as recording evidence of diseases, malnutrition or trauma. There are specific methods of analysis which may be of particular importance to the examination of the remains at Tuam, if established as part of a strategic goal, that is, in depth analysis of the evidence of health, and additionally ill-health, within these individuals.

In investigations of mass graves, remains may often be largely skeletonised, as appears to be the case in Tuam. This naturally limits the use of the some of the identification techniques mentioned in section 3.5. In the case of skeletonised remains, DNA profiling may be the only option in terms of identification.

Given the forensic aspect of the Tuam remains, individualisation may be an important goal if excavations proceed. All non-biomolecular techniques referred to earlier (section 3.5), may not all be directly applicable to much of the human remains in Tuam. However, the apparent context of the remains in Tuam, as well as the apparent age profiles, may inadvertently assist with any individualisation process. The commingled juvenile remains were identified in 17 of 20 tanks, which

may be partly self-contained. Essentially, each tank may be a sealed context, and there may be little mixing of remains *between* tanks. Should a tank be found to contain the remains of a full-term infant, a one-year-old, and a three-year-old, then most of the skeletal remains, if well preserved, may be individualised by an experienced anthropologist. If, however, individuals are found to be of very similar ages then individualisation may be difficult. DNA technologies in terms of individualisation, are examined in sections 3.5 and 5.

6.6 Assessment of application of DNA technologies

The possible application of DNA technology to the commingled juvenile remains from Tuam has been extensively examined in Section 5. The age of the remains and environmental conditions would significantly influence whether DNA survives and the quality of any such results. Identification would be complex, and would also be dependent on what comparable genetic samples would be available. The commingling of material will be a major complicating factor. Absolute identity may not be a possibility. It is unlikely that DNA may useful in this case for individualisation.

6.7 Memorialisation and conservation of the site

Once all site works are complete the site should be appropriately memorialised and conserved for remaining historic burials or features. As is discussed in section 3.6 memorialisation can be a powerful tool to aid the physical narration and the perception of past events. It is important for the memorialisation process that there is transparent communication and that the concerns of stakeholders are effectively addressed; their engagement is crucial to the commissioning of any on-site memorial.

The Transitional Justice model is one that uses memorialisation and the engagement of stakeholders as a core mechanism to address past wrongs. Memorialisation of events that are considered wrongs is a part of the Transitional Justice process and is viewed as a method to generate national healing and unity. Acknowledgement of the loss of life, including unintentional, restores the dignity of the victim and affords victims and family members recognition and respect (Hopwood, 2011). Memorial at Tuam will allow for broader discussion, better dissemination of findings, and a more transparent process.

The details outlined in this section have been identified by the ETG as necessary for any best practise implementation of Humanitarian Forensic Action at the former Mother and Baby Home at Tuam. In the consideration of these actions, the ETG acknowledges that there are legal and ethical considerations that are outside the scope of its work and that these additional issues have implications for the decision-making process of Government.

7 Conclusions

7.1 Findings of the ETG and this Report

The ETG was established to provide Minister Katherine Zappone with advices and options in relation to the site at Tuam and the human remains contained therein. It was not within the remit of this group to provide recommendations but to provide independent information to inform debate and assist the decision making on what the next step is at the site. Extensive research was conducted to this end, including consultations with individuals and organisations, nationally and internationally, to establish what would be considered best practice in regard to the options available on site.

The group also conducted research from a technical perspective to establish what were the options available to Government. In order to complete this task, the ETG aimed to acquire as much factual information about the site and about the human remains that had been discovered there. However due to legislative restrictions, information and evidence previously gathered by the MBHCOI in relation to this site could not be shared with the ETG at this time. The MBHCOI is conducting ongoing investigations that are due to be reported on in 2018. It would be erroneous and misdirected for the ETG to interfere with the due process of a Commission of Investigation. This consideration presented a particular challenge in fulfilling the task of the Group. In order to identify the scope of available options the ETG was required to establish the historical context for the site and to establish what further information could be attained about the context of the human remains. This information became the baseline from which options, timeframes and costs could be framed.

It was established that there are a number of issues that make the site and the recovery of human remains here complex and unique when compared nationally and internationally. These were issues were found to be:

1) The forensic requirement of the site
2) The 'significant' quantities of juvenile remains
3) These human remains lying in a commingled state
4) The remains being present in a subsurface chamber with limited accessibility and potentially also affected by the water table.

These unique challenges were addressed in the drawing up of this report. Technical excavation and recovery issues were addressed by Engineering and Health and Safety Design. The potential for further human remains to be present at the site was addressed by historical research and geophysical survey. It was found that while the recovery of human remains would be feasible, the degree in which this is done varies depending on the scale of the site. Research informed the group that a forensic approach is the most appropriate manner in which to approach the recovery of these remains and that the potential exists for further human remains to be located on the site.

A chief concern for the ETG was that this report be compiled and presented on time in order that the decision-making process in relation to the individuals interred in Tuam can progress.

A particular challenge to the ETG was the absence of an oversight body, party or state agency that was willing to lead the decision-making progress. Legislative issues over the jurisdiction of remains

previously recovered here have hampered the abilities of the ETG to pursue the DNA potential of human remains on site through a pilot study. This issue was not satisfactorily resolved. However, a pilot study would also have its limits in that it may only provide an indication rather than an absolute conclusion on issues of identification.

Minister Zappone and the Department of Children and Youth Affairs have taken a leading role in attempting to deal with the discovery of juvenile human remains in a sewage facility in Tuam. The government agencies that were consulted in the process of compiling this report facilitated the ETG wherever possible. However, no agency, Department or organisation acknowledged a role in coordinating any future work at the Tuam site. This poses clear problems; while the ETG acknowledges the lack of precedent for the situation and the site this issue, as a priority, should be resolved as effectively and timely as possible.

7.2 Summary

The varied nature of complexities at the site in Tuam limit what is forensically possible, it is highly unlikely that any action undertaken on this site will definitively answer the questions that the public and family members have. We are considering a group of collectively interred individuals so it may only ever be possible to provide collective answers. Forensic science has its limits and these limits change daily as new technologies and understandings emerge.

The potential to identify individuals interred in Tuam is one that poses many challenges as has been identified in this report. It is an issue that has the potential to cause upset and potential damage to relations between the public, the Church and the Government. The commingled state of individuals here makes it particularly challenging to realistically isolate individual remains. The risk of destruction to human remains themselves, in the pursuit of DNA, also poses a range of ethical questions.

Once again it is stressed that communications with family groups and all relevant stakeholders must be managed effectively to reduce potential stress and trauma. Expectations of outcomes of any future work must be set at realistic levels and these outcomes must be agreed prior to the commencement of any option identified.

A culture of transparency should be cultivated and it must be stated that it is possible that all that is expected or desired to be known in relation, to the infants and juveniles interred here, may never be fully realised. This is the most challenging fact that must be faced, and it may be unacceptable. Communications are critical to inform the realities of what is currently feasible. Forensic science has its limits and the site at Tuam tests the boundaries of forensic investigation in every regard.

8 Appendices

Appendix A – Glossary of Terms

ACRONYMS

AAFS	American Academy of Forensic Science
ASCLAD-LAB	American Society of Crime Laboratories Director's Laboratory Accreditation Board
CWGC	Commonwealth War Graves Commission
DCYA	Department of Children and Youth Affairs
DMORT	Disaster Mortuary Operational Response Team
DNA	Deoxyribonucleic acid
DVI	Disaster Victim Identification
EAAF	Equipo Argentino de Antropología Forense/Argentine Forensic Anthropology Team
ENFSI	European Network of Forensic Science Institutes
GIS	Geographic Information System
GRO	General Registers Office
ICMP	International Commission on Missing Persons
ICRC	International Committee of the Red Cross
ICTY	International Criminal Tribunal for the former Yugoslavia
ILCVR	Independent Commission for the Location of Victims Remains
INFORCE	International Forensic Centre of Excellence
INTERPOL	International Police Organisation
IRA	Irish Republican Army
ISO	International Organization for Standards
MBHCOI	Mother and Baby Home Commission of Investigation
MFI	Mass Fatality Incident

MNI	Minimum Number of Individuals
MtDNA	Mitochondrial DNA
NGS	Next Generation Sequencing
NIST	National Institute of Standards and Technology
OSAC	Organization of Scientific Area Committees
POW/MIA	Prisoners Of War/Missing In Action
STR	Short Tandem Repeat
SWGs	Scientific Working Groups
TRC	Truth and Reconciliation Commission
XRF	X-ray fluorescence
Y-DNA	Y chromosome DNA

GLOSSARY

anomaly	something that deviates from what is standard, normal, or expected
articulated	Where bones of the skeleton remain jointed or in anatomical position
commingled	where dis-articulated remains of two or more skeletons have mixed together
dis-articulated	Joints separated, where bones of the skeleton have become disjointed
exhumation	to dig something buried, especially a dead body, out of the earth
forensic	scientific methods and techniques to the investigation of crime.
geophysical survey	*Geophysical survey* is a cost-effective, non-intrusive and relatively quick way of detecting and assessing sub-surface features
ground Penetrating	a geophysical technique which records reflected signals from radar

Radar (GPR)	pulses directed into the ground and create an image of the subsurface structures/features beneath
infant	1< years of age
juvenile	17< years of age
magnetometry	a technique of measuring and mapping patterns of magnetism in the soil
memorial garden	the walled garden in the south of the site that has been regarded by local residents as the 'children's burial ground'.
memorialisation	process of honouring the memory of someone or something
osteometric	the measurement of bones
stakeholders	a person with an interest or concern in something
site	refers to all available ground to the interior or the Dublin Road Housing Estate
young juvenile	6< years age

Appendix B – References

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www.dia.ie Dictionary of Irish Architects

www.duchas.ie National Folklore Collection UCD Digitization Project

www.eaaf.org **Argentine Forensic Anthropology Team (Equipo Argentino de Antropología Forense, EAAF)**

www.excavations.ie Database of Irish Excavations Reports

www.geohive.ie Ordnance Survey Ireland

www.kettleontherange.com/2015/07/21/considering-the-burial-ground-tuam-babies

www.iclvr.ie Independent Commission for the Location of Victim's Remains

www.loganim.ie Irish placenames resource

www.icmp.int International Commission on Missing Persons

www.icrc.org International Committee of the Red Cross

www.irishhealth.com Independent Irish health website

www.irishstatutebook.ie electronic Irish Statute Book

Appendix C – Images and Mapping

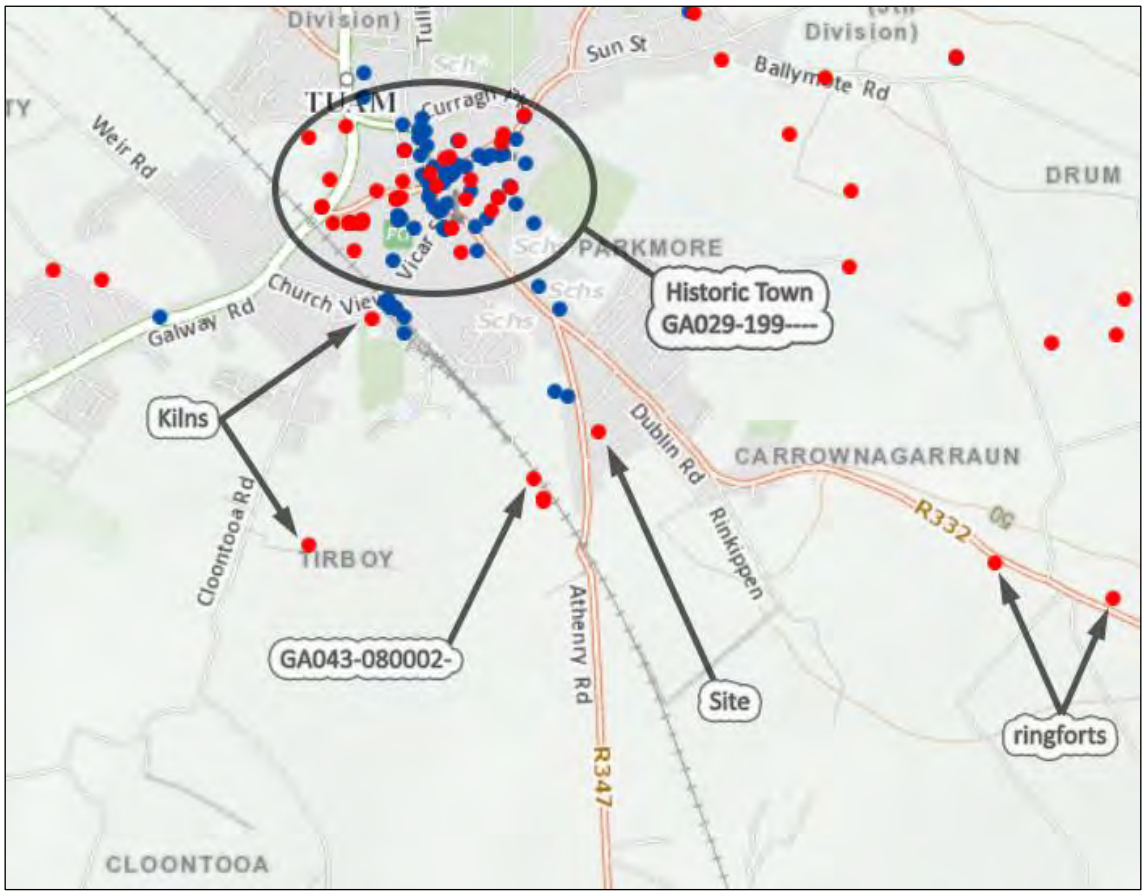

Figure 1: Sites marked on the Site and Monuments Record. SMRs marked in red; NIAH sites marked in blue (from www.archaeology.ie)

Figure 2: Extract from the 1st edition Ordnance Survey six-inch map (sheet GA043) 1838. © Government of Ireland, 2017 Unauthorised reproduction infringes state copyright. OSi permit number [OSi_NMA_030]

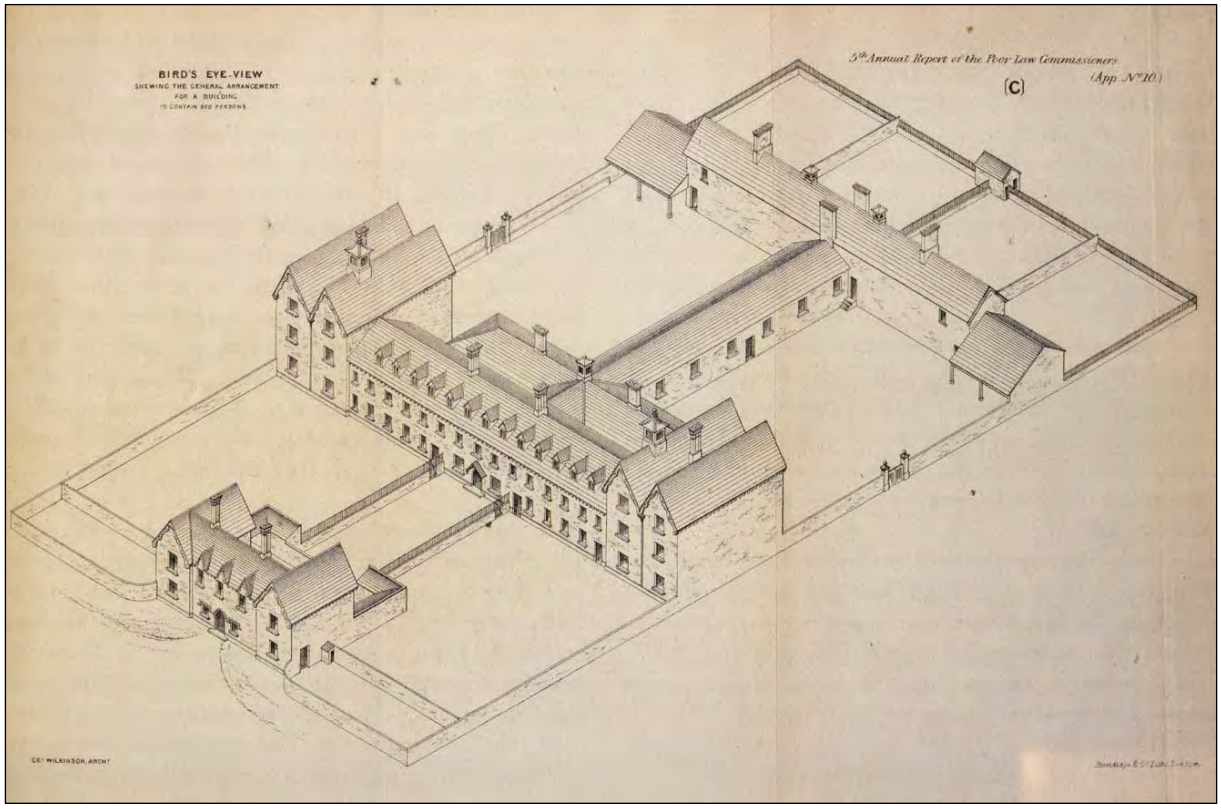

Figure 3: Standardised Workhouse plan by G. Wilkinson

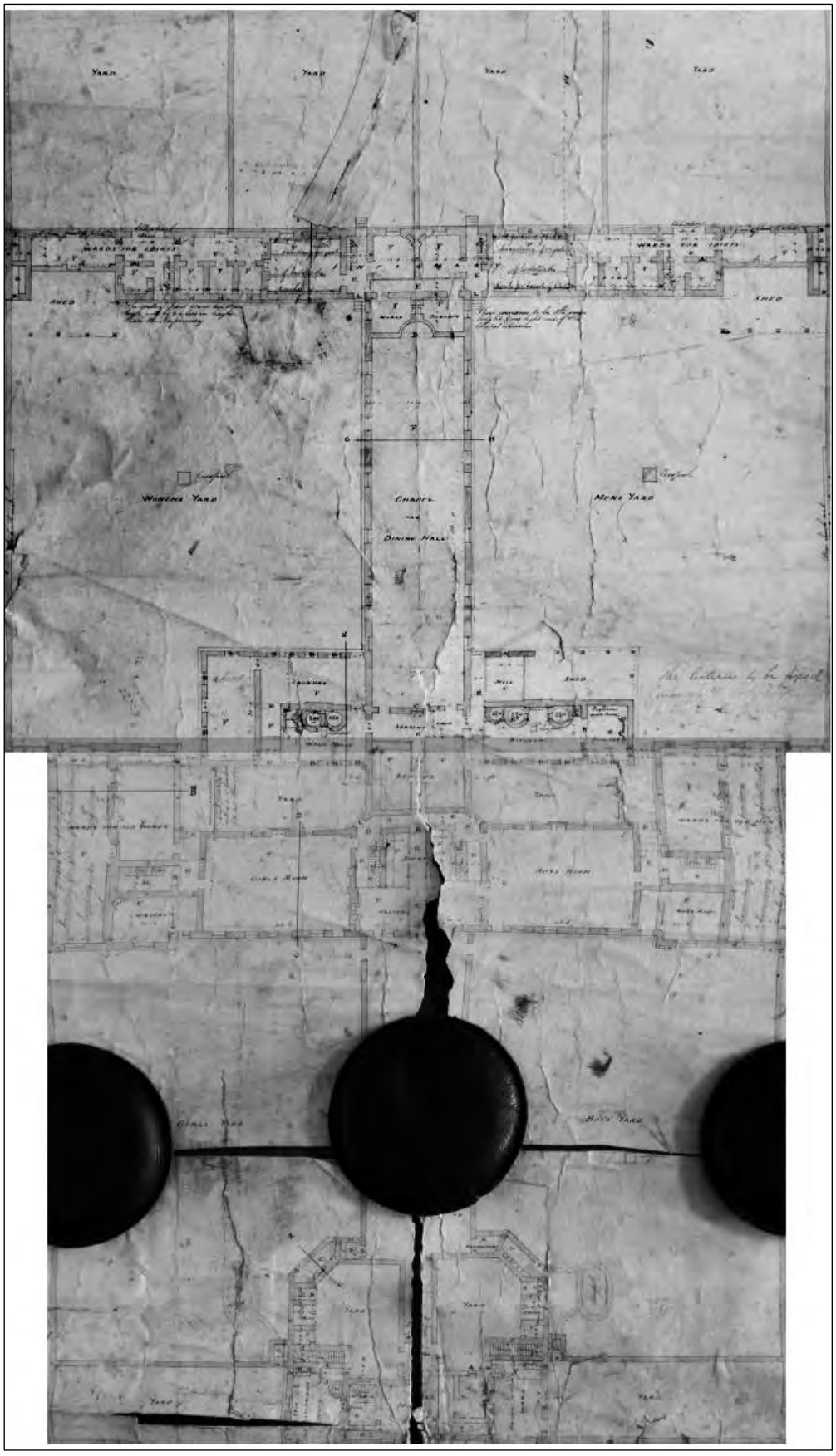

Figure 4: Layout of Tuam Workhouse from the Irish Architectural Archives

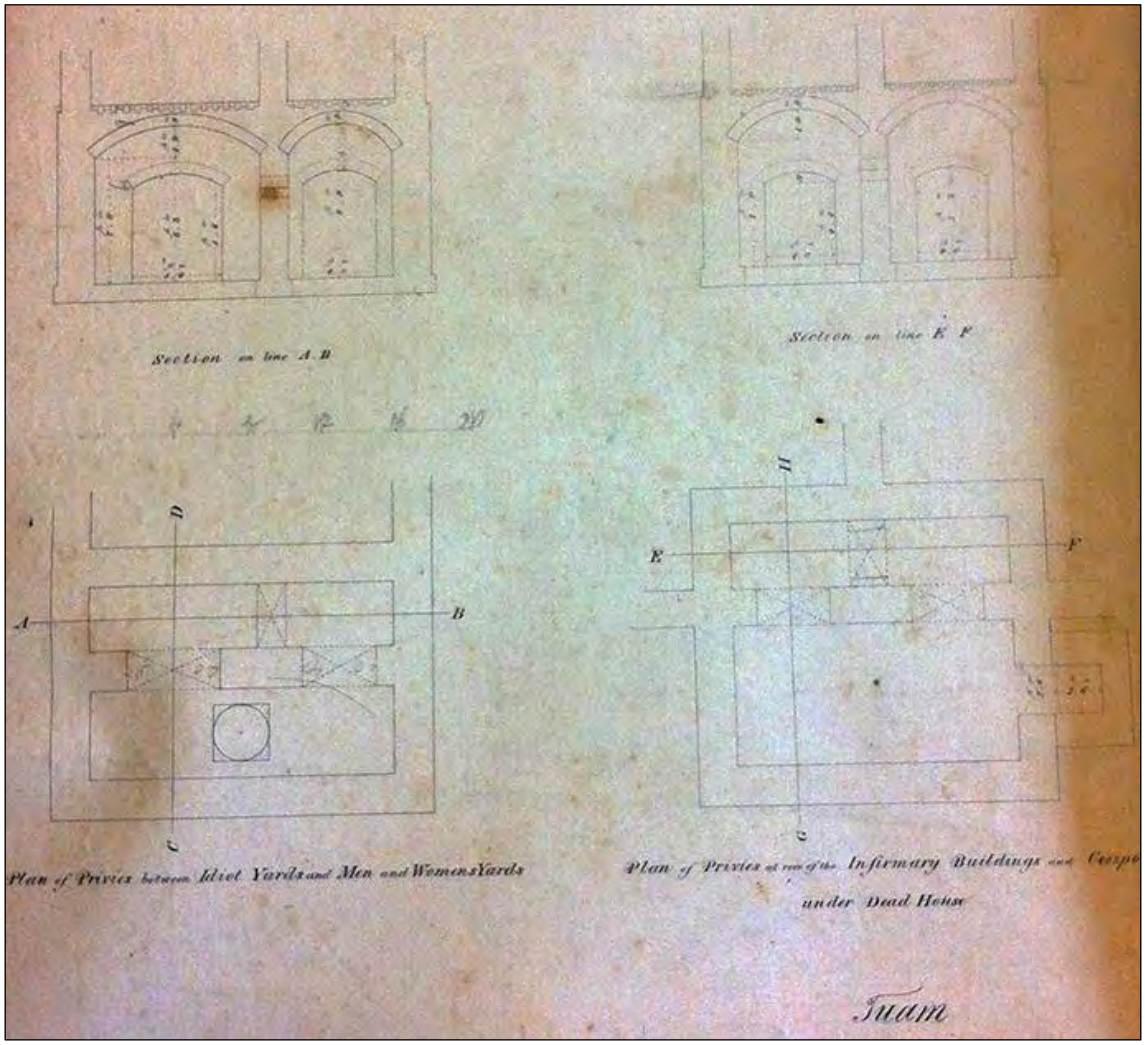

Figure 5: Schematic plans and sections of the cess-pools at Tuam Workhouse from the Irish Architectural Archives

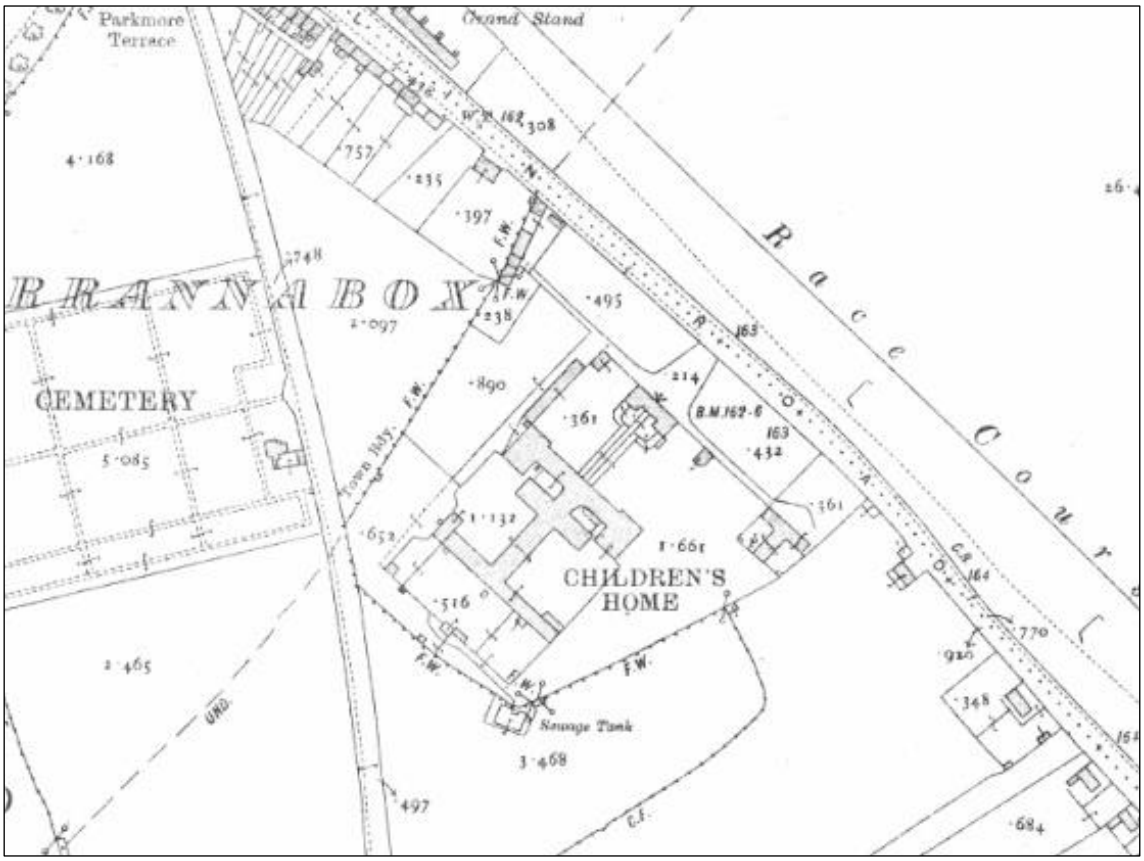

Figure 6: Extract from the 1st edition Ordnance Survey 25-inch map (sheet GA043) 1892. © Government of Ireland, 2017 Unauthorised reproduction infringes state copyright. OSi permit number [OSi_NMA_030]

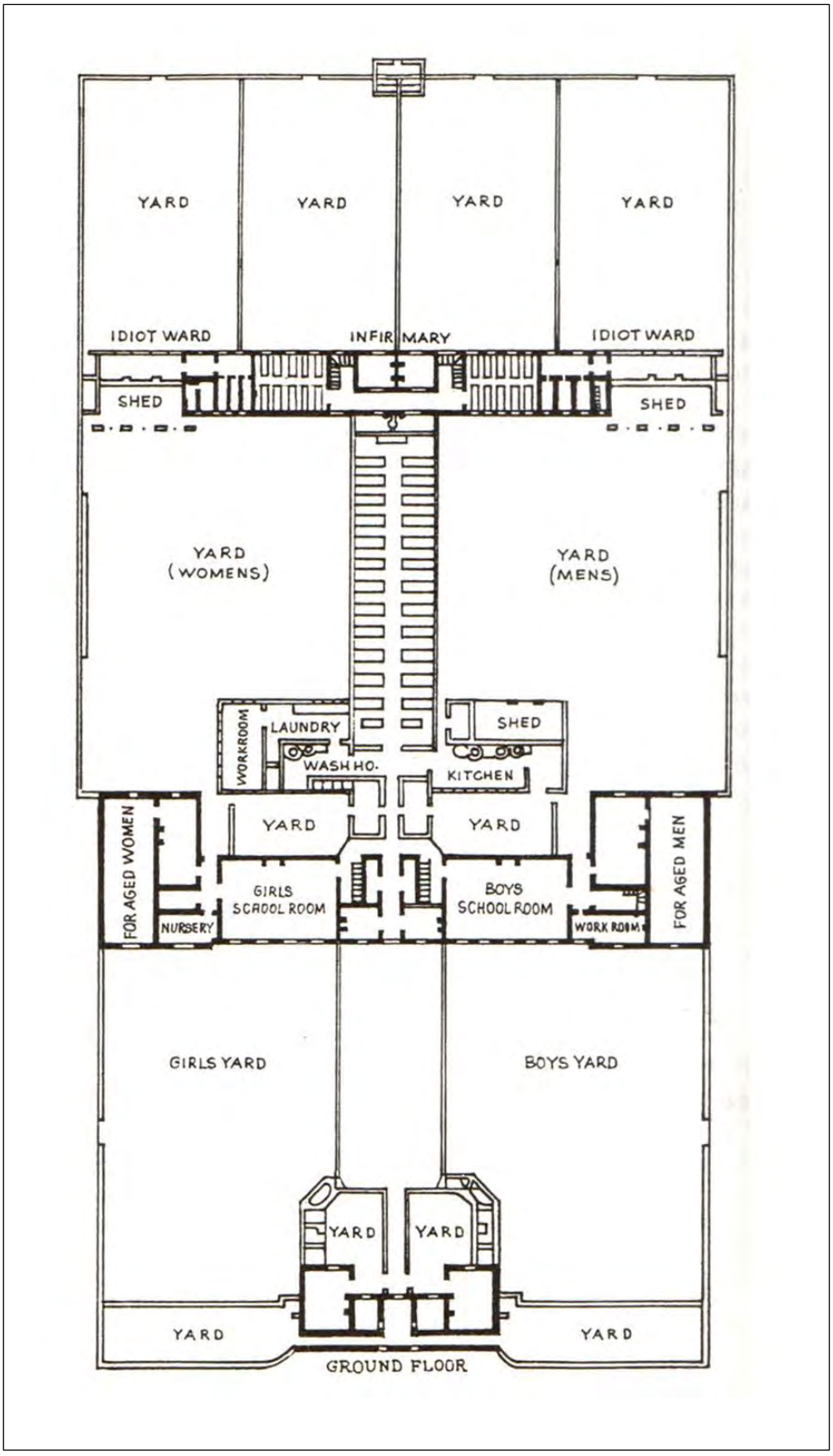

Figure 7: Standardised layout of a workhouse, from O'Connor 1995, pg86

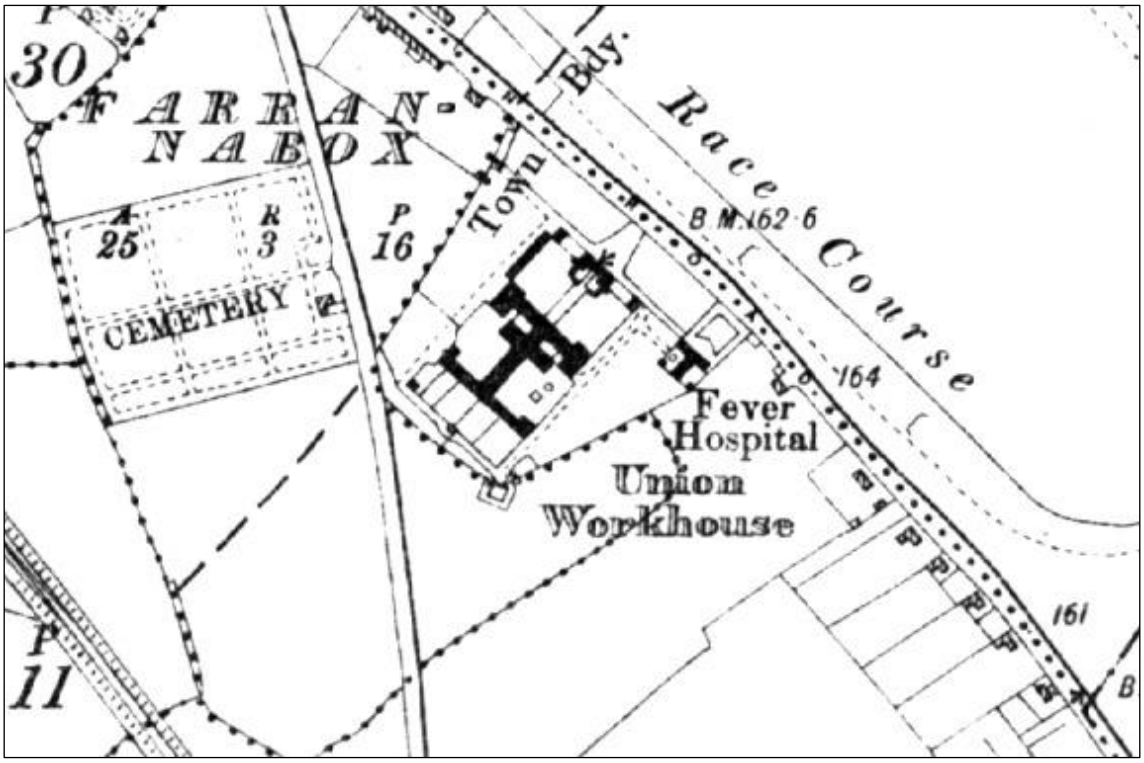

Figure 8: Extract from the 2nd edition Ordnance Survey six-inch map (sheet GA043) 1914. © Government of Ireland, 2017 Unauthorised reproduction infringes state copyright. OSi permit number [OSi_NMA_030]

Figure 9: Commemorative plaque set within surviving portion of Chapel/Dining Hall wall, from southeast

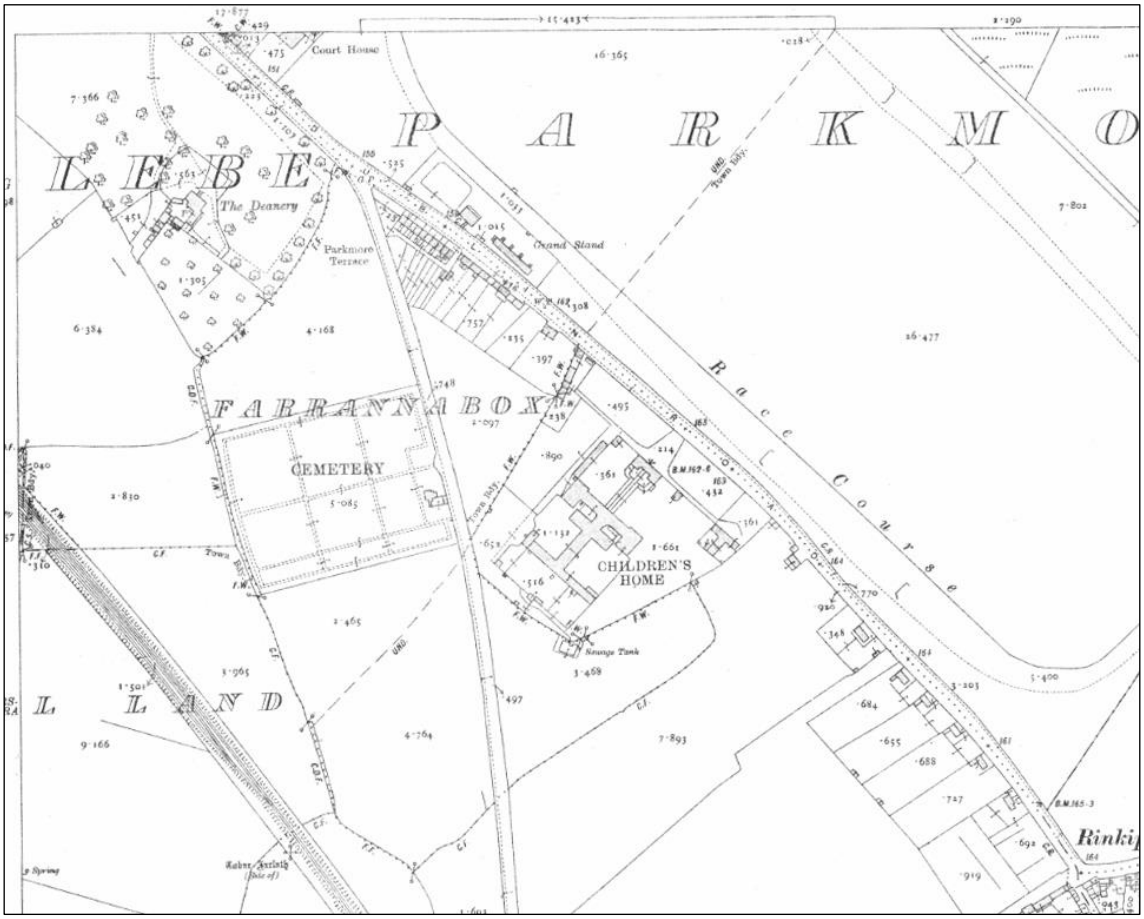

Figure 10: Extract from the 2nd edition Ordnance Survey 25-inch map (sheet GA043) 1927. © Government of Ireland, 2017 Unauthorised reproduction infringes state copyright. OSi permit number [OSi_NMA_030]

Figure 11: Aerial photograph of the site in the final stages of redevelopment in 1977 reproduced at kettleontherange.com

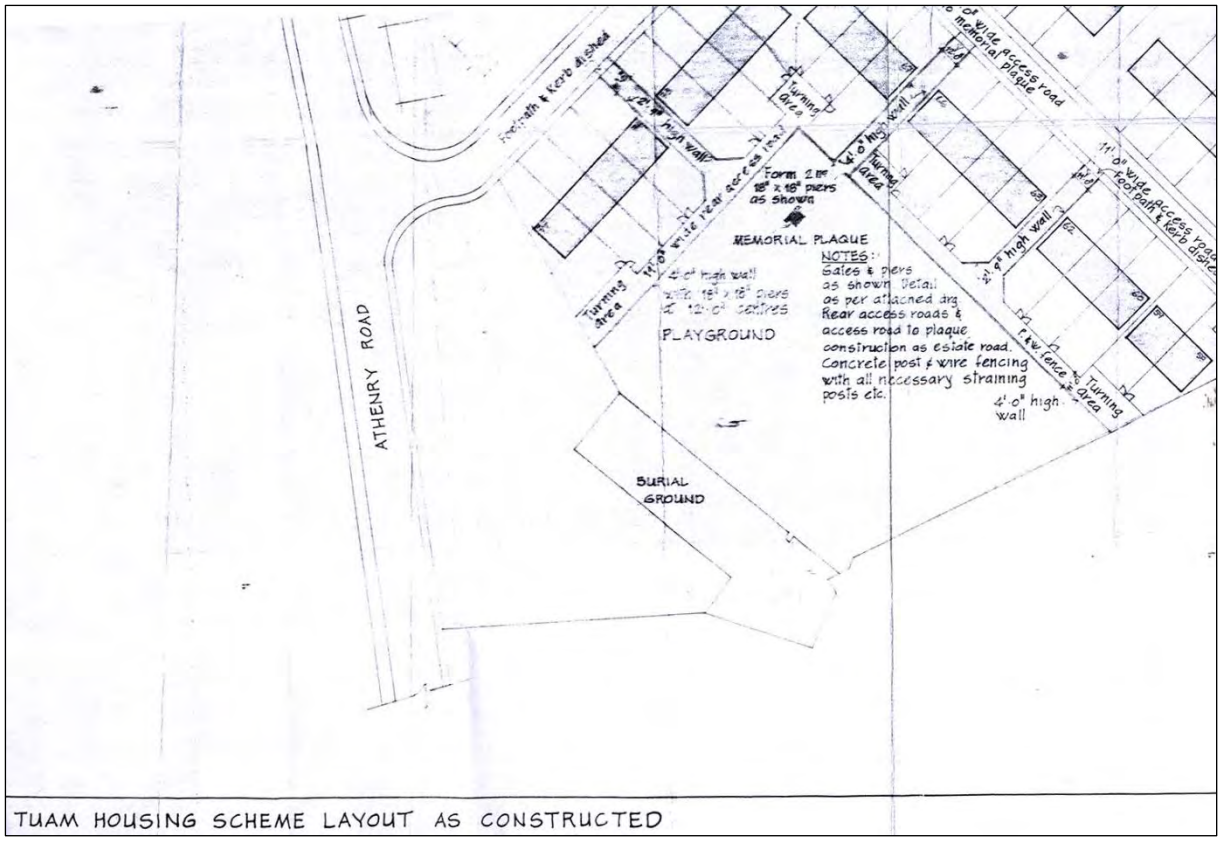

Figure 12: Galway County Council planning map of housing scheme in 1978

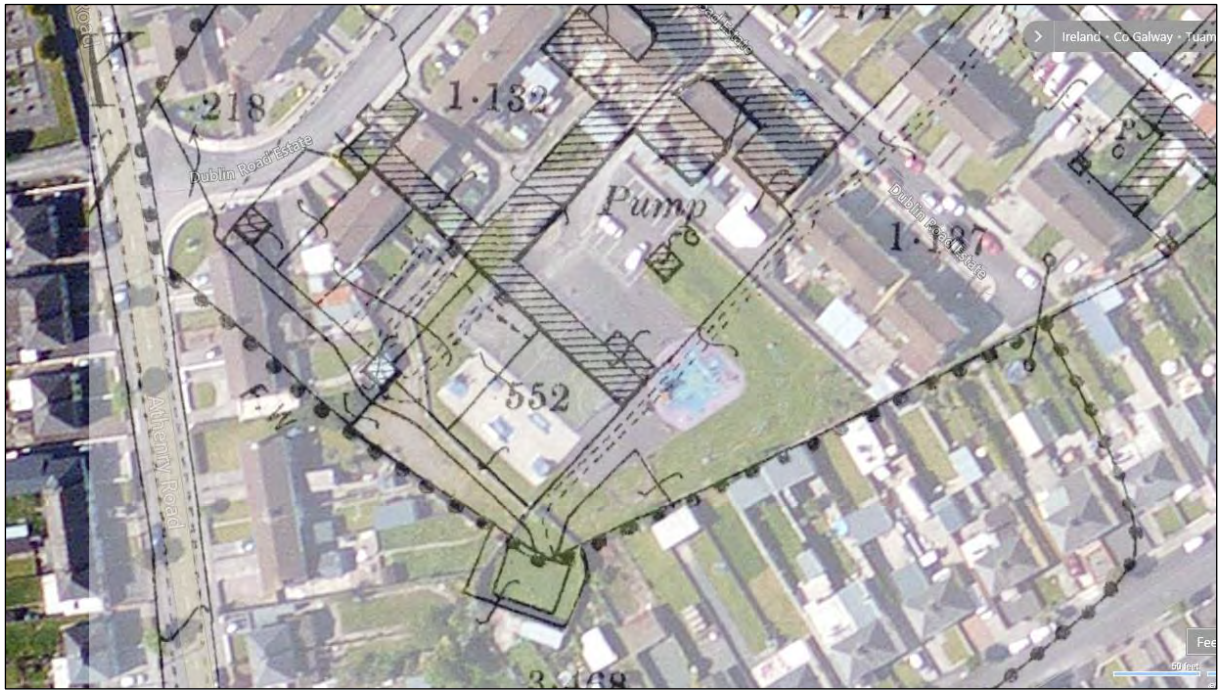

Figure 13: Overlay of 1927 map over current aerial image

Appendix D – List of Archaeological Sites within a 2m radius

This information is from the online Sites and Monuments Record (www.archaeology.ie).

SMR No.	Class	Townland
GA029-018----	Graveyard	BALLYMOAT
GA029-019----	Redundant record	BALLYMOAT
GA029-020----	Ringfort - rath	BALLYMOAT
GA029-021----	Water mill - unclassified	BALLYMOAT
GA029-066----	Kiln - lime	DEMESNE
GA029-067----	Ecclesiastical residence	DEMESNE
GA029-068001-	Ecclesiastical enclosure	DEMESNE,TOWNPARKS (4th Division - Tuam)
GA029-068002-	Church	TOWNPARKS (4th Division - Tuam)
GA029-069----	Windmill	DRUM (Tuam Rural ED)
GA029-107----	Kiln - pottery	KILLALOONTY
GA029-108----	Redundant record	KILLALOONTY
GA029-170----	Ringfort - rath	TOWNPARKS (1st Division - Tuam)
GA029-171----	Ringfort - rath	TOWNPARKS (1st Division - Tuam)
GA029-171001-	Children's burial ground	TOWNPARKS (1st Division - Tuam)
GA029-172----	Monumental structure	TOWNPARKS (1st Division - Tuam)
GA029-173----	Castle - unclassified	TOWNPARKS (1st Division - Tuam),TOWNPARKS (2nd Division - Tuam)
GA029-175----	Ritual site - holy well	TOWNPARKS (1st Division - Tuam)
GA029-176----	Well	TOWNPARKS (1st Division - Tuam)
GA029-177----	Ritual site - holy well	TOWNPARKS (2nd Division - Tuam)
GA029-178----	Religious house - Premonstratensian canons	TOWNPARKS (2nd Division - Tuam)
GA029-178001-	Burial	TOWNPARKS (2nd Division - Tuam)

GA029-179001-	Cathedral	TOWNPARKS (2nd Division - Tuam)
GA029-179002-	Cathedral	TOWNPARKS (2nd Division - Tuam)
GA029-179003-	Graveyard	TOWNPARKS (2nd Division - Tuam)
GA029-179004-	Cross - High cross	TOWNPARKS (2nd Division - Tuam)
GA029-179005-	Cross - High cross	TOWNPARKS (2nd Division - Tuam)
GA029-179006-	Cross - High cross (present location)	TOWNPARKS (2nd Division - Tuam)
GA029-179007-	Cross - High cross (present location)	TOWNPARKS (2nd Division - Tuam)
GA029-179008-	Cathedral	TOWNPARKS (2nd Division - Tuam)
GA029-179009-	Building	TOWNPARKS (2nd Division - Tuam)
GA029-179010-	Burial	TOWNPARKS (2nd Division - Tuam)
GA029-179011-	Ecclesiastical enclosure	TOWNPARKS (2nd Division - Tuam)
GA029-180001-	Church	TOWNPARKS (2nd Division - Tuam)
GA029-180002-	Graveyard	TOWNPARKS (2nd Division - Tuam)
GA029-180003-	Ecclesiastical enclosure	TOWNPARKS (2nd Division - Tuam)
GA029-180004-	Cross-slab	TOWNPARKS (2nd Division - Tuam)
GA029-181----	Church	TOWNPARKS (2nd Division - Tuam)
GA029-182----	Water mill - vertical-wheeled	TOWNPARKS (2nd Division - Tuam)
GA029-184001-	Religious house - Augustinian canons	TOWNPARKS (3rd Division - Tuam)
GA029-184002-	Cross - High cross	TOWNPARKS (3rd Division - Tuam)
GA029-185----	House - 18th/19th century	TOWNPARKS (3rd Division - Tuam)
GA029-186----	Designed landscape feature	TOWNPARKS (3rd Division - Tuam)
GA029-187----	Graveyard	TOWNPARKS (3rd Division - Tuam)

GA029-188----	Cathedral	TOWNPARKS (3rd Division - Tuam)
GA029-189----	Graveyard	TOWNPARKS (4th Division - Tuam)
GA029-190----	Religious house - unclassified	TOWNPARKS (4th Division - Tuam)
GA029-191----	Windmill	TOWNPARKS (5th Division - Tuam)
GA029-192----	Redundant record	TOWNPARKS (5th Division - Tuam)
GA029-199----	Historic town	CORRALEA WEST,TOWNPARKS (1st Division - Tuam),TOWNPARKS (2nd Division - Tuam),TOWNPARKS (4th Division - Tuam),TOWNPARKS (5th Division - Tuam),VICARSCHORAL LAND,TOWNPARKS (3rd Division - Tuam),GLEBE (Clare By.)
GA029-203----	Burial mound	TOWNPARKS (1st Division - Tuam)
GA029-209----	Memorial stone	DEMESNE,TOWNPARKS (5th Division - Tuam)
GA029-214----	Kiln - pottery	TOWNPARKS (2nd Division - Tuam)
GA043-010----	Earthwork	BALLYMOAT
GA043-011----	Children's burial ground	BALLYMOAT
GA043-013----	Earthwork	BALLYMOAT
GA043-014----	Earthwork	BALLYMOAT
GA043-027----	Redundant record	CARROWMONEEN
GA043-028----	Ringfort - rath	CARROWMONEEN
GA043-029----	Ringfort - rath	CARROWMONEEN
GA043-030----	Redundant record	CARROWMONEEN
GA043-080001-	Ecclesiastical enclosure	FARRANNABOX,TOBERJARLATH,VICARSCHORAL LAND
GA043-080002-	Ritual site - holy well	TOBERJARLATH
GA043-080003-	Church	TOBERJARLATH
GA043-126----	Kiln - corn-drying	TIRBOY

GA043-127----	Kiln - lime	TIRBOY
GA043-141----	Redundant record	TOBERJARLATH

Appendix E - Further Details on the Archaeological and Historical Setting of Tuam

The archaeological monuments that surround the site of the former Mother and Baby Home at Tuam indicate the extent to which this site may have been subject to activity pre-dating the nineteenth century.

The historic town of Tuam (SMR GA029-199----) was founded on the southern bank of the River Nanny. It owes its origins to St. Jarlath, *Iarlaithe mac Loga*, who founded a monastery here in the 6th century, where two ecclesiastical enclosures were at Templenascreen (SMR GA029-068001-) and another at Temple Jarlath (SMR GA029-180003-). The latter was probably the original monastic settlement and is preserved as a graveyard within the western part of the town. St. Jarlath became the first Bishop of Tuam and his successors are recorded in the Annals throughout the 8th, 10th and 11th centuries. Long after his death in AD 540, St. Jarlaths' bones were placed in a shrine kept at Templenascreen (Lewis 1837, 646). The O'Connors, Kings of Connaught, built a castle overlooking the river in 1161 (SMR GA029-173----) and a 12th century church was also centrally located but little of this survives (SMR GA029-179001-). From the 13th century the town expanded and was granted a licence for an annual fair (Lewis 1837, Vol. 2, 646). It was also at this time that religious orders, a daughter house of the Premonstratensian Canons and Augustinian Friars, founded abbeys at the east and south of the town (SMR GA029-178- and GA029-184001-). Further evidence of the high status of Tuam during this period is evident in the number of High Crosses, one of which is considered a National Monument (SMR GA029-179006-, GA029-179007, GA029-184002- and GA029-179004-).

The early ecclesiastical site of Toberjarlath consists of a holy well (SMR GA043-080002-) and a church site (SMR GA043-080003-) within an ecclesiastical enclosure (SMR GA043-080001), approximately 210m southwest of the site of the former Mother and Baby Home. There are no surviving remains of a church and the outline of the enclosure is only partially preserved in the modern field boundaries. The holy well, *Tobar Jarlath*, was noted during the first Ordnance Survey in 1839 (O'Flanagan 1927, 46) and is marked 'site of' on the 3rd edition six-inch O.S. map from 1930. The Schools' Manuscripts confirm that an annual pilgrimage had taken place here but that by the 1930s these rounds had ceased (Duchas.ie/ Tomás Ó Ruiseil, 287). A stone memorial erected in 1943 now marks the site. The significance of this early site is that it occupies a position that is bounded by three townlands – Toberjarlath, Farrannabox and Vicarschoral land – similar to the bounded position in which the former Mother and Baby Home was located.

The town of Tuam survived into the later medieval period largely due to its ecclesiastical prominence. It was destroyed by fire in 1244 and plundered by Charles Oge, son of William de Burgo in 1356 (Lewis 1837, 646). Nevertheless, it was retained under Catholic control until 1587-8, when the Cathedral building and revenues were transferred into Protestant control (Bradley & Dunne 1992, 167).

In 1613, Tuam was chartered as a parliamentary borough by James I (Lewis 1837, 646; Delaney *et al.* 2014, 5). As such the town was entitled to elect a member of parliament and 12 burgesses. The elected official was inaugurated in the Chair of Tuam (SMR GA029-203----), again revitalising the idea of *Tuaim Dá Ghualann,* which was situated within the remains of the 12th century castle. That the town prospered in this period is evidenced by a water-mill (SMR GA029-182----), an 18th century

pottery kiln (GA029-214----). The town was also reshaped during these centuries with the principle feature of the new layout being '*the triangular Market Square from which five streets radiated*' (Gosling 1995, 129). By the late 18th century, several significant buildings were constructed, including the Market House and bridge, and it was considered prosperous provincial town (Delaney *et al.* 2014, 6).

In light of the information above, it can be said that there is no definitive evidence of any occupation of the site prior to the establishment of the Workhouse in the 1840s. This location may have had minimal occupation for which there is no documentary evidence or have been used exclusively in agriculture in earlier centuries.

Appendix F – Geophysical Survey Reports

EMC Radar Consulting

atlas geophysical

Geophysical Surveys

of

The site of the former Mother and Baby Home in Tuam,

Co Galway, Ireland

For

Minister Katherine Zappone,

Department of Children and Youth Affairs,

Leinster House, Kildare Street, Dublin 2.

Report 1 of 2

Final: 14th September 2017
Originally issued: 29th August 2017
Revised: 6th September 2017

CONTENTS

SURVEY OBJECTIVE

In 2015, a geophysical survey of the memorial garden associated with the Mother and Baby Home in Tuam, Co. Galway, was commissioned by the Mother and Baby Home Commission of Investigation of Ireland, the purpose of the investigation being to locate the former cess pit and associated features. Witness testimony had given these structures as the burial location of a number of infants. The results of this survey were then investigated by trial excavation to confirm both the results of the survey and the original witness evidence. The excavation resulted in the discovery of human remains within one part of the foul water system.

The Department for Children and Youth Affairs, Ireland, has now decided to commission a further series of geophysical investigations to cover not only the memorial garden but also the remainder of the site of the former Mother and Baby Home for which there is public access. This site may be categorised as a playground, a car park, three sections of road and the memorial garden itself (Figure 1). The purpose of this series of investigations is to establish the location of any potential burials or underground features such as pipes or man-made drainage channels, in the process identifying the potential for further excavation and, where possible, to assess the subsurface for any Health and Safety issues should it be necessary to bring heavy machinery on to the site.

Figure 1: The Six Defined Survey Areas.

This report deals with the first five survey areas i.e. three road sections, the car park and the memorial garden. A second report will be issued on the area of the playground.

SURVEY STRATEGY

These investigations were carried out using Ground Penetrating (or Probing) Radar (GPR) and Magnetometry. Resistivity was trialled but not used, in part because it is

not normally considered to be an effective technique on concrete and other manmade surfaces.

These geophysical investigations cover an area which is characterised by a variety of man-made surfaces as well as grass and includes a large number of surface obstacles including walls, fences and play equipment. Although its deployment may be both time consuming and labour intensive when used for mapping, GPR is a suitable technique for detection of the targets below all of these surfaces. Close mapping was applied in order to optimise the detection capabilities of the radar.

Magnetometry and resistivity are both more suited to open ground. Both techniques were trialled and magnetometry was deployed successfully within the unsurfaced areas such as the memorial garden. Resistivity was less successful and was therefore not deployed across the site. Lastly, in order to test for buried utilities, electromagnetic location equipment ("CAT and genny") was used.

Use of Ground Penetrating Radar

GPR operates on the same principles as conventional radar except that it uses a wider frequency range, a shorter pulse, and a much shorter range of detection. The radar generates a short pulse which is transmitted into the ground via an antenna. The return signal is received by another antenna. The amplitude of the returning signal provides information about changing ground characteristics with depth. The use of the radar does not affect underlying deposits: it is non-destructive.

GPR cannot identify the nature of the material through which the electromagnetic pulses pass. The signals returned to the radar are the result of changes in the electromagnetic properties between two or more adjacent materials. The amplitude (strength) of the returned signals is a measure of the magnitude of the difference between these materials rather than being a characteristic of any one material.

An integral part of this investigation is the detection of graves and also of any buried pipes and potential voids. Identification of all three types of target is normally made on the basis of patterning in the horizontal data, supplemented in the case of voids by a high signal amplitude. It may be possible to detect potential graves and buried pipes on the basis of 2-dimensional, vertical data but it can be difficult to determine the full extent of either feature unless an area survey is completed. Identifying the horizontal boundaries of a potential grave is essential in order to distinguish between a grave and any other subsurface feature and it is the linear continuity of a buried pipe which identifies it as such.

Successful detection of graves depends upon the style of burial, the surviving contents of the grave including both the size of the buried person(s) and any accompanying grave goods, whether or not a coffin was used, the type of soil, its moisture content and the frequency of radar antenna used for the survey. It is possible for graves to remain undetected if the burial is old (so that sufficient time has elapsed for the bones to take on the electromagnetic characteristics of the surrounding soil), the deceased was wrapped in a simple shroud and the grave therefore retains no visible sign of air gaps and no accompanying possessions are buried alongside. If the material remaining within the grave is capable of retaining moisture, this may also aid

detection. The wavelength of the radar used is critical since any target must be greater in size than 10% of the wavelength.

It is important to appreciate that the radar can only detect the final state of any extant remains and not the process which has brought about this result. The separate identification of two or more objects requires these to be sited a distance of one wavelength apart from each other or they may be detected as a single object. For these reasons, where a site has been used and re-used over a long period it can be difficult to understand the structures represented in the data. Inter-cutting of graves is a good example of where this may be a difficulty.

As far as built structures such as the footings of walls are concerned, identification may be possible in the vertical plane if sufficient vertical extent exists. It is usually easier to identify wall foundations from their patterning in the horizontal plane by recognising the remains of a linear, rectangular or other non-randomly shaped feature.

As regards the identification of voids, this may be revealed by a high signal amplitude or by echo effects if the volume of the void has a direct relation to 0.5 of a wavelength or above. However both echo effects and strong signal amplitude may be caused by other materials such as metal.

It is a feature of GPR that the same signal patterning may be produced by different combinations of features &/or materials. It is also not possible to date remains except relatively where one set of remains overlies another.

Equipment

The equipment used for these surveys was a GroundVue 3_8 in single channel mode with a 400MHz antenna.
A 400MHz antenna has a wavelength of c. 25cm in dry soil. Where moisture is present, the wavelength will be shorter. This is sufficient for detection of pipes and services, and, provided that they are detectable, locating most graves.

Site Conditions

Although it was possible to survey with GPR across all areas of the site, the surface conditions were not ideal. It is important to maintain good contact between the antenna and the ground surface for efficient transmission of the radio waves into the subsurface. The car park had a sufficiently smooth surface but the road sections and the memorial garden were not as smooth due to the use of relatively large sized gravel and the length of grass on the verges. The area of the playground had a smoother surface but, as it contains a considerable amount of equipment, it was necessary to work around this and certain smaller areas have therefore had to be excluded.

Site Coverage

In order to optimise detection and maximise the information obtained by the GPR, survey lines for each of the six areas were completed at a transect spacing of 0.25m. This is half the spacing required by the widely accepted guidelines published by

Historic England (English Heritage, 2008). These guidelines were originally set as a compromise between the investment required to achieve the Nyquist requirement for full information and an acceptable level of information with a lesser use of resources. For this investigation, it is more appropriate to optimise the target definition because of the potential difficulties of interpretation given the sensitive nature of the investigation and the history of re-use of the site itself. The 0.25m spacing complies with current European guidance (Schmidt et al, 2015).

Survey Parameters

A sampling interval of along the line of travel of the radar was set for 27mm in all six area surveys and the probing depth set to 50ns (approximately equivalent to 2.5m in dry soil conditions, less where moisture is present).

Velocity Calibration (GPR)

GPR depths are measured in nanoseconds time because electromagnetic waves do not travel at a constant velocity. To translate this into depths measured in metres, it is necessary either to know the speed of transmission through the ground or to calibrate using either borehole information or curve fitting to hyperbolas (targets) in the data.

Curve fitting has been used to calibrate the transmission velocity of 0.1m/ns, indicating dry conditions in most of the subsurface in spite of the rainfall during the survey. There are areas, however, where the velocity varies between 0.07m/ns and 0.09m/ns indicating the presence of moisture. Although 0.1m/ns has been used in determining the depths of the GPR information for four out of the five survey areas, the actual depths in areas containing moisture will be overstated due to the slower transmission of the radio waves.

The main area affected is the memorial garden for which the calibrated velocity was 0.07m/ns so that this value was used to translate depths within this survey area.

The Use of Colour in GPR Data

It is important to realise that GPR uses electromagnetic pulses (radio waves) and is not an optical technique. The signal amplitude indicates a change of materials but it is a relative and not an absolute measure. As such, it does not and cannot usually be used as an indicator of the actual materials present. The stronger the signal, the more contrast is visible in the data. Similar colours (signal amplitudes) can originate from different combinations of materials. It is only legitimate to postulate continuity of a feature if that continuity is evident directly from the data and not solely on the basis of similarity of signal amplitude. For that reason, greyscale images have been used for analysis of the 2-dimensional data and no colour scale is therefore provided.

The 2-dimensional data is displayed in greyscale of black (strong positive) to white (strong negative). On this colour scheme, grey represents continuity rather than an absence of material. Black and white indicate anomalous material.

Colour has been used to illustrate the 3-dimensional data from which horizontal time slices have been extracted. On this colour scale black indicates a high signal amplitude (positive or negative). The darker the colour, the greater the difference between the feature and its surrounding environment. Light green denotes continuity with or similarity to the subsurface environment. A colour scale is included in the appendix to this report.

SURVEY RESULTS

AREA 1: ROAD 1 (See Figure 1)

Road 1 is the first section of the road, leading towards the memorial garden along the southern edge of the site. There is evidence to suggest that this part of the site may have been used as a burial ground. It was not possible to obtain information regarding burial practice for comparison with the geophysical data.

Fieldwork

This area was surveyed on Monday 17th July 2017 which was a warm day with no rainfall.

2-Dimensional Data

The 2-dimensional data is presented from West to East (left to right across the page). Marker 1 on the data indicates a position 8m from the memorial garden fence. Marker 2 is 22.3m to the West of this position.

The area is characterised by repeat layering in the first 75cm of the subsurface, as shown by the black and white horizontal banding visible in figures 2 and 3. The layering is not always continuous across the area which might potentially mean that a number of different features are present. Below this level there are a variety of signal returns, some of which may represent structures (cf Figures 2 and 3). It is not possible to interpret these features solely from the vertical perspective.

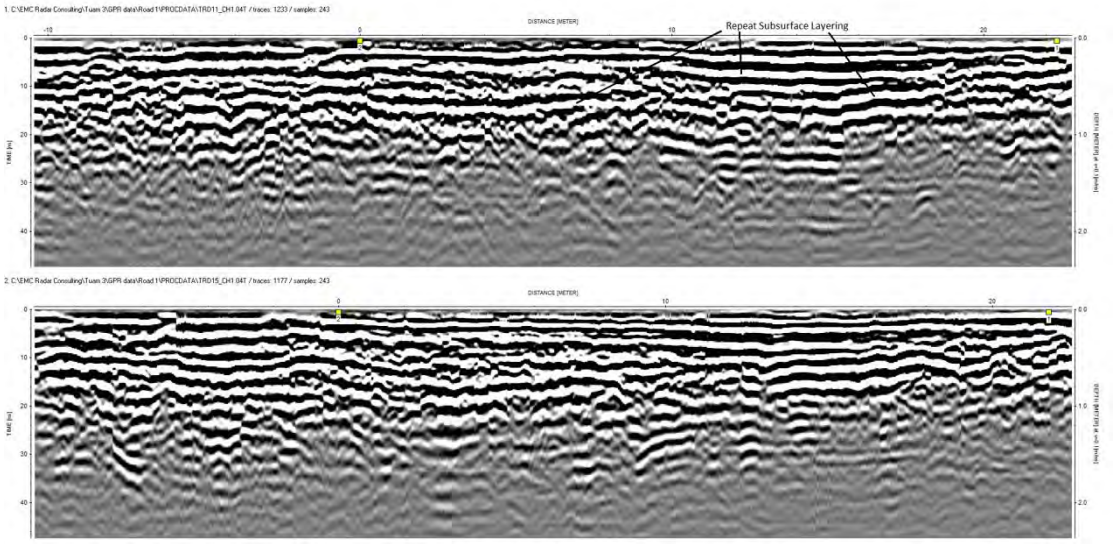

Figure 2: Sample 2-dimensional data from Road Section 1.

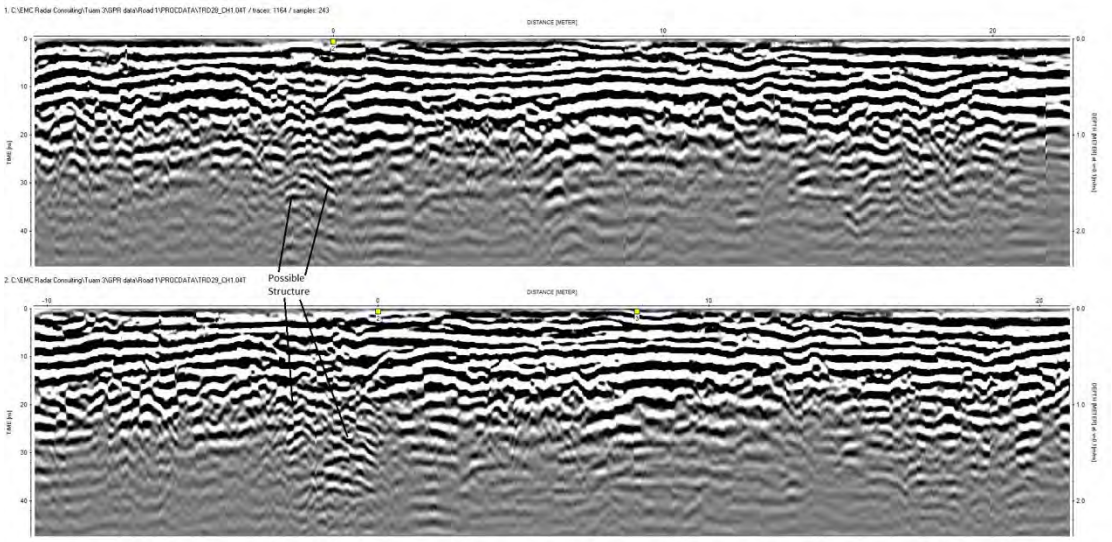

Figure 3: Sample 2-dimensional data from Road Section 1.

Time Slices extracted from the 3-Dimensional Data

The 2-dimensional survey lines have been incorporated into a 3-dimensional data block on the basis of their relative positions along survey line 2. Time slices, in essence horizontal plans, have been extracted from this data block on the basis of changing patterns visible in the data. Where air gaps exist or moisture is present the view will be quasi-horizontal i.e. apparently horizontal but not physically so due to the differing transmission velocities in different parts of the survey area. Time slices have been selected on the basis of the change in patterning visible.

All horizontal time slices extracted from 3-dimensional data are presented with North at the top of the page and West to the left hand side. The x=0 position marks the line of the 2nd survey reference line i.e. it corresponds to the position of marker 2 on the 2-dimensional data.

Time Slice at 3ns (c. 15cm)

Material which is anomalous (or different from its environment) shows in the time slices as black (greatest difference) or dark blue. Areas of light green represent continuity of material. The patterning at 15cm below the surface reflects the distribution of the secondary layers visible in the 2-dimensional data (Figure 4). Since the outlines of the dark areas are relatively fluid rather than sharply edged and interconnect to some extent, this appears to be some sort of systematic infill, raising the question of why there are holes in these locations. Unfortunately, there is not an easily understood outline or regular pattern to the dark areas although they could potentially form the southern portion of a dedicated area as the main signals form a truncated trapezium between 0m and 19m along the x axis.

It is not possible to interpret this definitively but one possibility is that it represents part of the construction of the unpaved access road. This does not, however, explain why the holes, at least one of which continues much deeper (cf Figure 2), required backfilling. It is not possible to provide an answer to this from the GPR data alone

but the data could potentially be consistent with the suggestion of former burials from which at least some of the deceased had been removed, particularly if this loosely defined area continues towards the North.

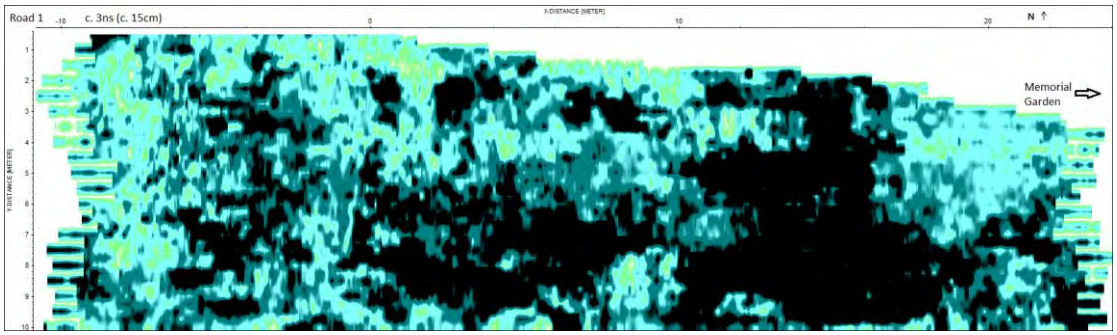

Figure 4: Time Slice of Road Section 1 extracted at c. 15cm

Time Slice at 7ns (c. 35cm)

Continuing down a further 20cm, the patterning resolves into one large rectangular shape in the eastern sector together with a more random dispersal to the West and a possible barrier running North/South in a curvilinear shape along the outside of the memorial garden (Figure 5). In all cases, the strong signals (dark areas) correspond to layering in the vertical section which again suggests a systematic infill. The rectangular outline suggests the backfill of an earlier manmade feature. It would be very unusual for this shape to be the random result of natural events. The approximate area of this feature is 4m by 8m.

In the NW corner, although the outlines appear incomplete, there appears to be the remains of another rectangular feature. As with the larger backfilled feature to the East of it, it is unlikely to be coincidence that the outer edges are rectilinear, this usually indicates human activity.

Along the eastern side, adjacent to the memorial garden, there appears to be a barrier of some description although, as the materials are dispersed, it is difficult to say whether this is, for example, an underground feature related to the cess pit within the garden and its associated features or the remains of footings of an above ground structure. In either case, the material appears to have been dispersed, presumably during the redevelopment of the site.

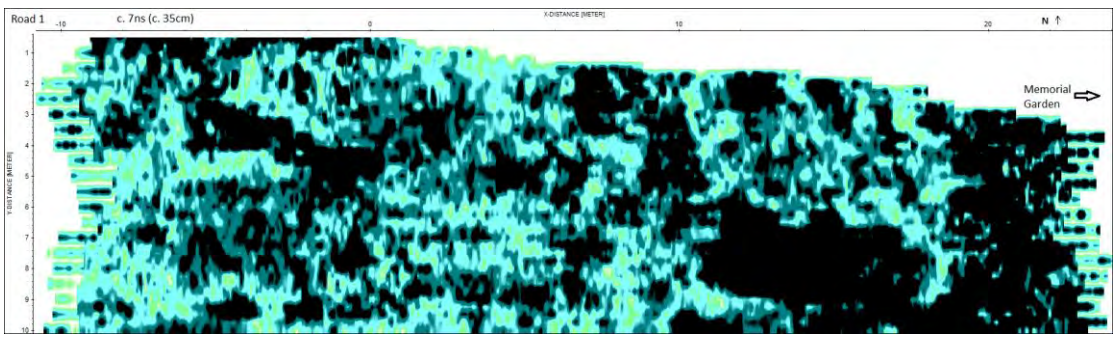

Figure 5: Time Slice of Road Section 1 extracted at c. 35cm.

Time Slice at 9ns (c. 44cm)

The pattern changes some 9cm lower down although each of the anomalous features is again a depiction of systematically backfilled areas (Figure 6). The overall outlines again follow straight lines and mostly right-angled corners, lying at a slight angle to the direction of the survey. Again, this suggests human activity. Unfortunately, it is not easy to determine what this represents without relevant additional external information (e.g. witness evidence or former plans of the area).

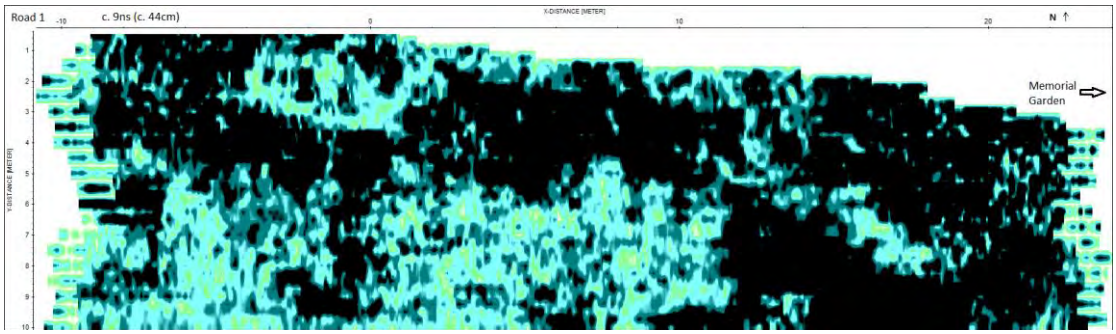

Figure 6: Time Slice of Road Section 1 extracted at c. 44cm.

Time Slice at 11ns (c. 57cm)

Surprisingly the patterning changes within the next 13cm of depth. The outer ring of strong signal returns forms a semi-circular shape with an apparent extension towards the SW corner and the outlines of the anomalous areas are much more dispersed (Figure 7).

Testing the time slice against the horizontal data confirms that the majority of these signals correspond to systematic layering, as before, although there is at least one area where there appears to be an object within the layering. As before, this is consistent with reworking of the site, possibly in advance of the road construction. The question remains as to why this amount (and more random pattern) of backfill was required.

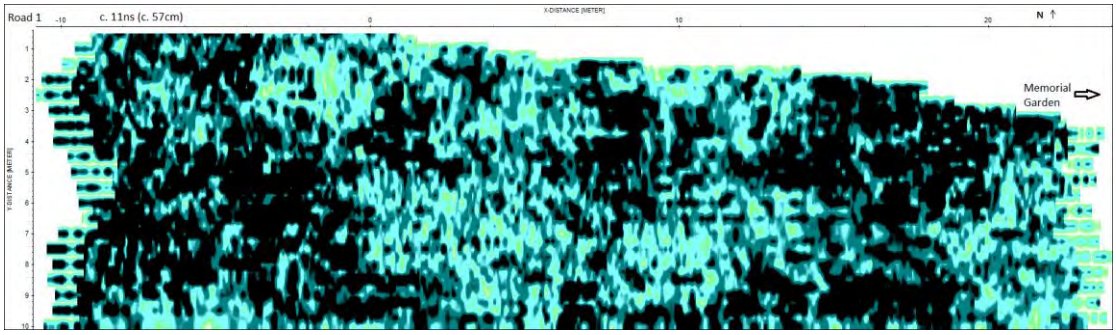

Figure 7: Time Slice of Road Section 1 extracted at c. 57cm.

Time Slice at 15ns (c. 75cm)

The deepest layer of systematic infill occurs around 75cm below the surface of the road. The remaining outline, such as it is, corresponds to the previous time slice (Figure 7). In Figure 8, "1" indicates the lowest reaches of the large rectangular

feature seen in the first two time slices (Figures 4, 5). The area marked as "2" is similarly a series of layers of material, presumably backfill. The other areas are a mixture of backfill and discrete objects.

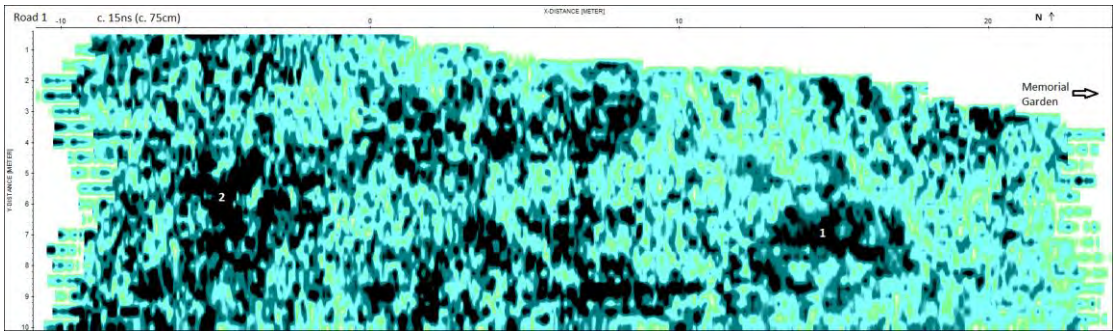

Figure 8: Time Slice of Road Section 1 extracted at c. 75cm.

Time Slice at 19ns (c.95cm)

Below the level of infilling, there is an irregular pattern of other anomalous material (Figure 9). Unlike the previous time slices, this corresponds mostly to individual objects, some of which may have been part of the same feature (cf the mid-section of the southern sector in Figure 8). None of the features remain intact and it appears that this represents a level of destruction prior to backfilling. For one location, towards the NW of the survey area, the evidence suggests the remains of a structure in situ although it is not clear exactly what this was. This is marked A in Figure 9 and is the same feature as indicated in the 2-dimensional data in Figure 3 above.

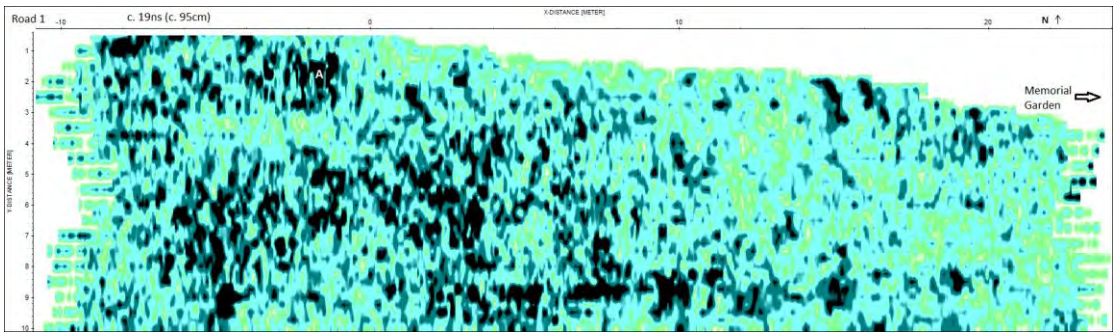

Figure 9: Time Slice of Road Section 1 extracted at c. 95cm.

Time Slice at c. 31ns (c.1.57m)

This same structure, A, is visible among the disparate elements considerably lower down. This is not an echo effect. As evidenced by the 2-dimensional data, it is a physical structure of some sort. From the depth, this is either a feature which extended into the ground below or the footings of a feature above ground.

Test checking of some of the other anomalous signals suggests that these relate to large blocks of material. Although there are a few areas where there is evidence of possible moisture content, this does not appear to be a pattern of moisture content and there is insufficient evidence of ringing (echo effects) to suggest the presence of either air or metal. It appears that the patterning visible in this time slice may show the

remains of building-type material in which case this would represent the remnants of various features post-destruction in advance of re-development.

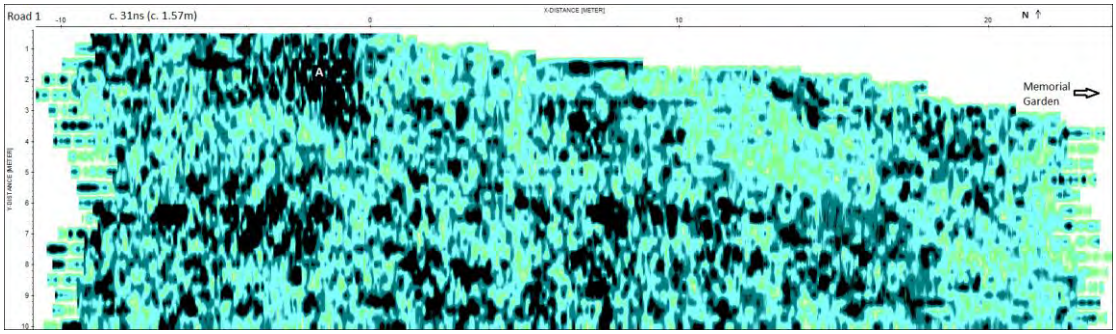

Figure 10: Time Slice of Road Section 1 extracted at c. 1.57m.

Time Slice at c. 36ns (c. 1.78m)

The outline of structure A becomes clearer by this depth (Figure 11). The remaining anomalous material also appears to be structural in nature although the patterning also suggests extensive destruction. It is possible that the square outline around B is the remains of the footings of an enclosure or perhaps a building, possibly with an internal division from the position of the larger anomalous (dark) signals. There is a small amount of evidence in the 2-dimensional data for damp spots at and below this level in the area of the NW section of line around B and also at and below the large reflector along the southern edge of the same feature at c. x = 5m.

The linear feature marked C in the time slice may be a utility, in which case the depth would suggest foul water drainage. As for the rest of the potentially structural material, it is no longer intact and the section which is visible no longer joins on to other similar features.

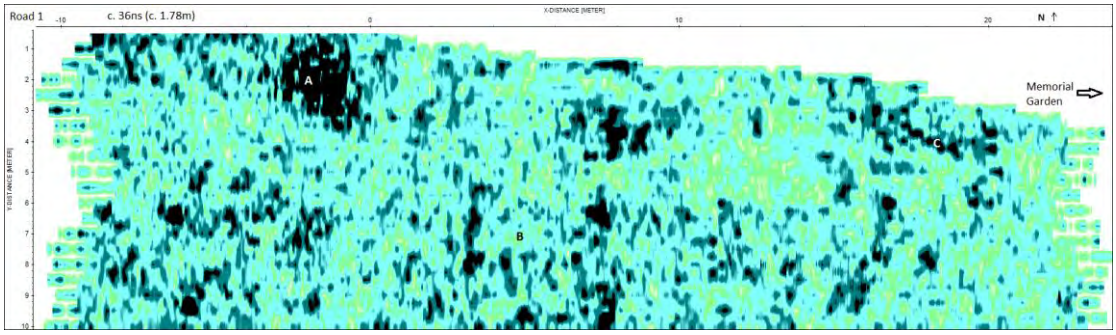

Figure 11: Time Slice of Road Section 1 extracted at c. 1.78m

Conclusions and Recommendations

There is a complex pattern of extant anomalous material below the level of Road 1 which suggests the demolition of existing features, both hollowed out and systematically backfilled and also potential remains of former construction. It is not easy to make sense of the patterning without external input, for example, witness testimony might be useful as would former plans of the area.

Road 1 contains a large number of backfilled hollows close to the existing road surface. These extend in depth from c. 15cm to c. 75cm which would be considered unusually shallow for a normal burial. The initial patterning, in particular the rectangular outlines, strongly suggests the backfill of man-made structures although it is not possible to define whether all of these would have been below or above ground initially. There is evidence for at least one area which appears to be a hollowed out feature below ground i.e. the 4m by 8m rectangular area visible in most of the time slices. Several of the other areas illustrated in Figures 6 to 10, while less substantial, appear similar.

The deeper material appears to be mostly structural in nature although it has been comprehensively destroyed prior to re-development. A few ephemeral outlines and one substantial part of a structure remain and it may be possible to identify these from earlier plans, photographs or witness statements. There are a few discrete points where the evidence for excess moisture exists in the GPR data.

Beyond one short section of possible pipe at a depth of c. 1.78m, there is no evidence visible of any utilities beneath this section of the road and no definite suggestion of any voiding although this does not imply any load bearing quality for those damaged structures which still exist.

It is recommended that the patterning be compared with witness' evidence and former plans of the area to see if it is possible to reconcile the outlines indicated by the GPR.

AREA 2: ROAD 2 (See Figure 1)

Road 2 is the angled section of the road leading from the southern edge of the playground towards the western edge of the playground.

Fieldwork

This area was surveyed on Monday 17th July 2017 which was a warm day with no rainfall.

2-Dimensional Data

The 2-dimensional data is displayed from NW to SE (left to right across the page). Markers 1 and 2 on the data indicate the positions of the survey reference lines, 2 being towards the NW end of the survey area and 1 to the SE.

As in the first southern section of the road, the area is characterised by a packed subsurface including repeat layering in the first 75cm of the subsurface, as shown by the black and white horizontal banding visible in figures 12 and 13. The layering is considerably less than in the first (southern) road section. Below this level there are a variety of signal returns, some of which may represent structures (cf Figures 12 and 13). It is not possible to interpret these features solely from the vertical perspective.

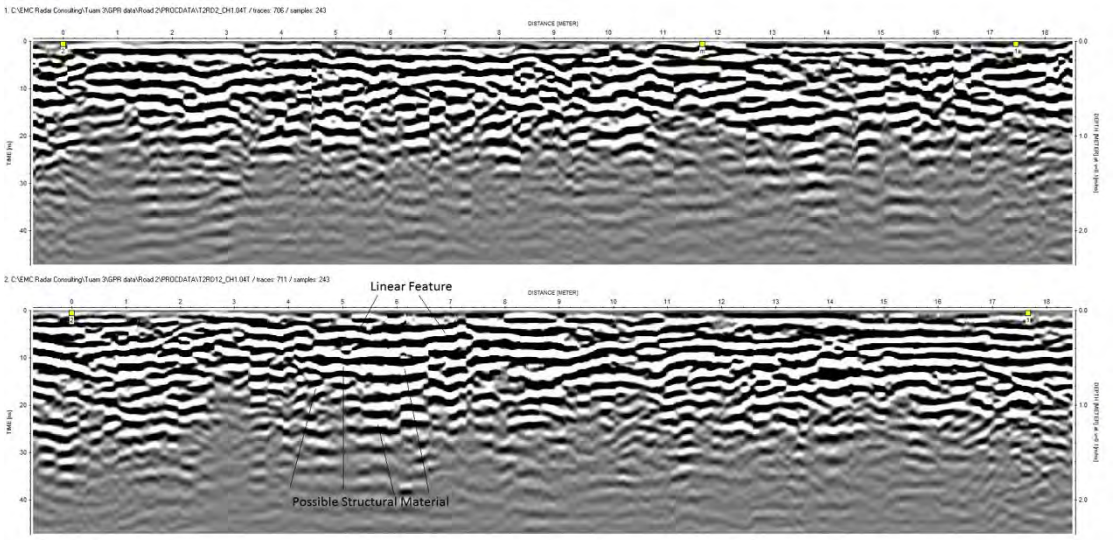

Figure 12: Sample 2-dimensional data from Road Section 2.

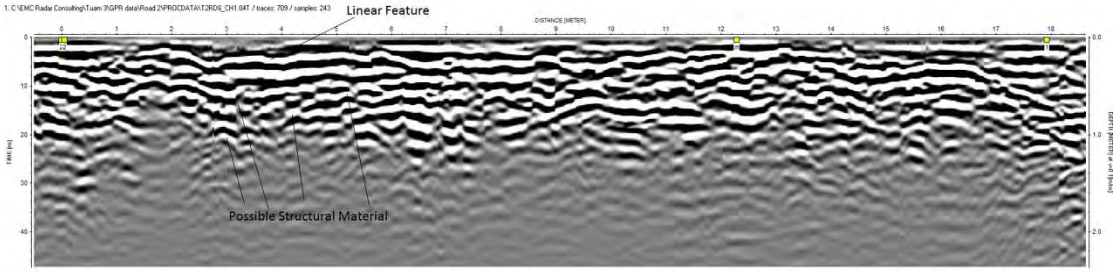

Figure 13: Sample 2-dimensional data from Road Section 2.

Time Slices extracted from the 3-Dimensional Data

The 2-dimensional survey lines have been incorporated into a 3-dimensional data block on the basis of their relative positions along survey line 2. Time slices, in essence horizontal plans, have been extracted from this data block on the basis of changing patterns visible in the data although given the relatively small size of the area, it is difficult to determine what may or may not be significant within the wider context of the site as a whole. Where air gaps exist or moisture is present the view will be quasi-horizontal i.e. apparently horizontal but not physically so due to the differing transmission velocities in different parts of the survey area. Time slices have been selected on the basis of the change in visible patterning for this data set and, because of the interconnection with Road section 1, at similar depths to the time slices from that area also. Exceptions to this are where the data does not appear to have any internal patterning at the relevant depth or where a previously selected time slice is of approximately the same depth and therefore shows similar features. The time slices not selected for illustration can be generated should it become evident in later investigations that they may have some significance.

All horizontal time slices extracted from 3-dimensional data are presented with NE at the top of the page and NW to the left hand side. The x=0 position marks the line of the 2nd survey reference line i.e. it corresponds to the position of marker 2 on the 2-dimensional data.

Time Slice at 1.95ns (c. 10cm)

Very close to the surface there are a number of linear outlines which suggest the existence of a pipe or pipes leading from/into the back of the adjacent houses (cf Figure 1). Since the NW end of this feature and also the area marked A in Figure 14 are visible on the surface, it is likely that this marks the infill above the pipe rather than the depth of the pipe itself. This would also explain the lack of continuity in these features.

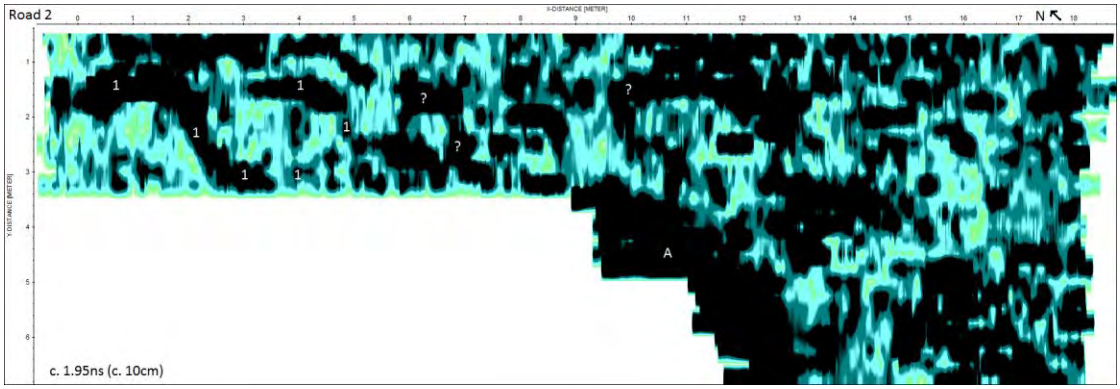

Figure 14: Time Slice of Road Section 2 extracted at c. 10cm.

Time Slice at 3.9ns (c. 20cm)

The possible pipe becomes clearer by c. 15cm depth with its best definition appearing at nearly 20cm depth where, potentially, it extends for the full length of this section of road (Figure 15). The definition still lacks complete continuity which suggests that it may no longer be in use. Alternatively, it may not be fully operational and is possibly blocked in places. Care should be taken in excavating around this feature since it is not known for certain what the nature of the utility is.

If the pipe is blocked, this could also explain the adjacent dark areas, one possibility being the leakage of water from a break.

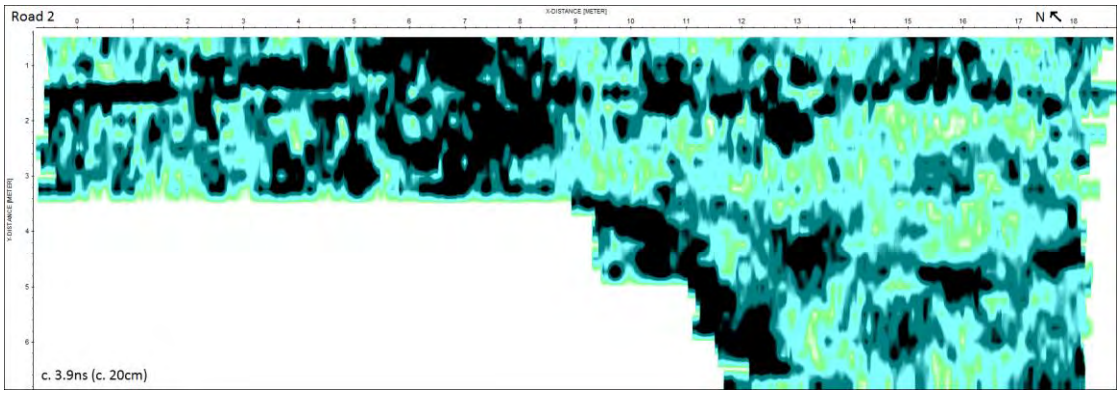

Figure 15: Time Slice of Road Section 2 extracted at c. 20cm.

Time Slice at 5.5ns (c. 27cm)

The same line of a possible pipe is visible some 7cm deeper where it also appears to be associated with a large rectangular anomalous area (Figure 16). Part of the top of this area is actually visible in the previous time slice. This rectangular structure can also be seen in lines 6 and 12 of the 2-dimensional data above where a linear feature (the black and white continuous line overlies a more complicated structure (Figures 12 and 13). What is not clear is whether this is some form of pipe laid over the top of the foundations of another structure or whether the two features are actually part of the same construction.

On survey line 6, the marker m has been used to mark the position of stonework in the road surface which is thought to be part of the former Mother and Baby home. This also has structural material below it and appears to be part of the same feature. The corresponding position for marker m has been marked on the time slice. Note that there is a small area of stone, not a single point.

This raises the possibility that this feature does not relate to the existing houses but to the former Mother and Baby Home. The patterning requires to be checked against existing plans of the former home and the possible pipe/drain checked against the alignment of the current houses.

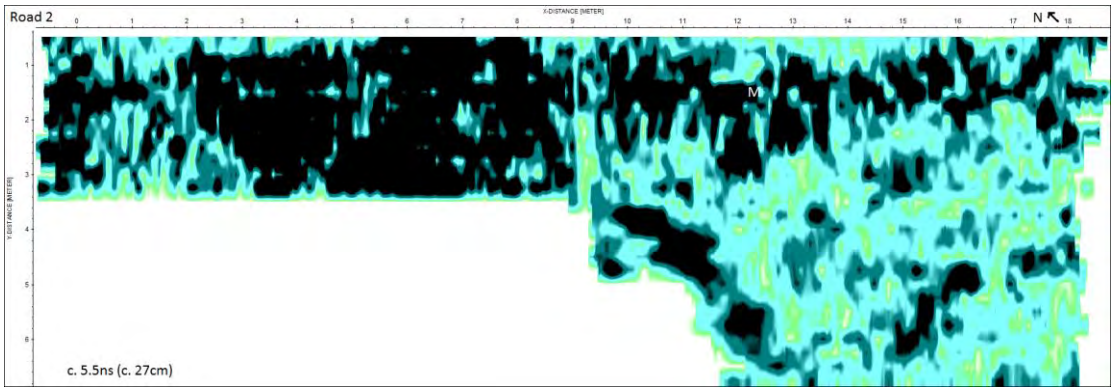

Figure 16: Time Slice of Road Section 2 extracted at c. 27cm.

Time Slice at 8ns (c. 41cm)

Another rectangular feature becomes visible at the slightly deeper level of 41cm below the current surface in the southern section of the road (Figure 17). The outline is either incomplete or more complicated than a single rectangular feature and the general patterning not materially different from Figure 6, the time slice at c.44cm depth in Road Section 1. All of the major dark outlines, including the potentially rectangular one, show as continuous linear features but with varying depths along the black and white lines which mark out the position of this material. Most of these lines are singles, some are double but they not repeated in the same way as the apparently backfilled spaces along section 1 of the road were. Although they could represent a relatively thin layer of backfill, it is also possible that this is a larger structural feature whose axis aligns approximately with the line of travel of the radar (i.e. left/right across the time slice). For this to be the case, the remains must be reasonably substantial in their horizontal extent.

Taken in association with the previous time slice, this material is likely to relate to the former Mother and Baby Home.

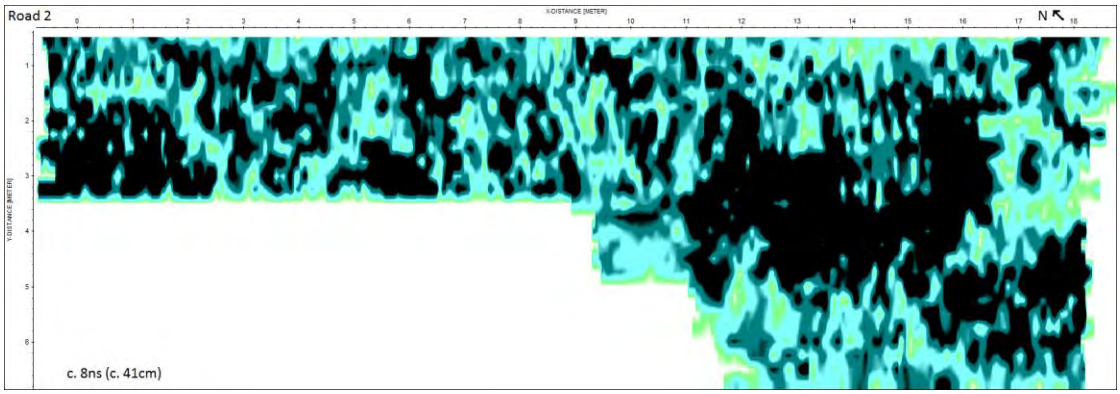

Figure 17: Time Slice of Road Section 2 extracted at c. 41cm.

Time Slice at 11.3ns (c. 57cm)

In overall appearance, the southern end of this time slice resembles the first road section. From the corner northwards, it does not (Figure 18). Some 16cm lower down, the anomalous areas in the SE corner are composed of repeated layers and it is likely that this area has been systematically backfilled at some point.

Although the area around the SW corner does not show up as anomalous at this depth unlike in the shallower time slices (cf Figures 14 to 16 above), this contains layering to a depth of over 1m and is likely to have been systematically backfilled.

There does not seem to be any systematic patterning for the length of the road to the North of the corner and the anomalous material here seems to be composed of individual objects rather than layers.

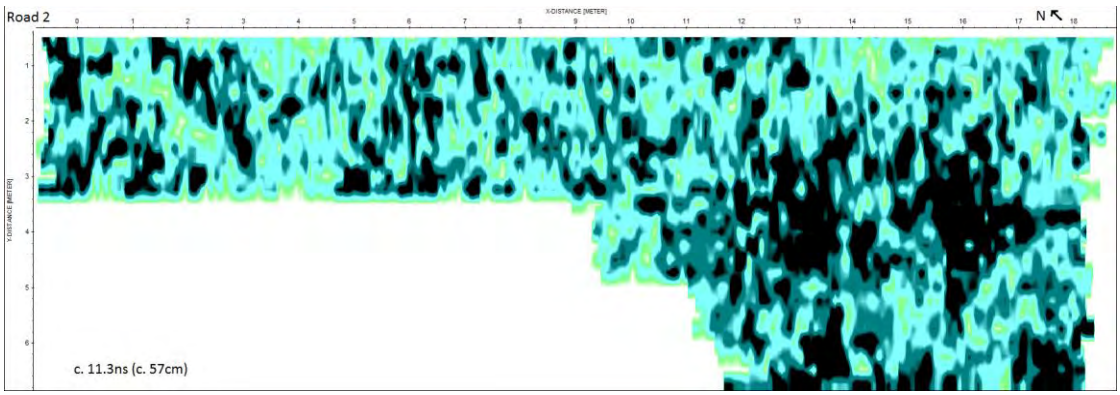

Figure 18: Time Slice of Road Section 2 extracted at c. 57cm.

Time Slice at 19.3ns (c. 97cm)

At this depth on the first section of the road, although the anomalous material formed a spread of material, presumably due to destruction, there were the beginnings of potentially man-made outlines presumably of material still in situ (Figure 9).

Accordingly, although there does not appear to be a coherent pattern at this depth in the second road section, the time slice is included in case the overall image for the full site may require it. The anomalous material visible, as for the first road section is large objects rather than systematically laid layers (Figure 19).

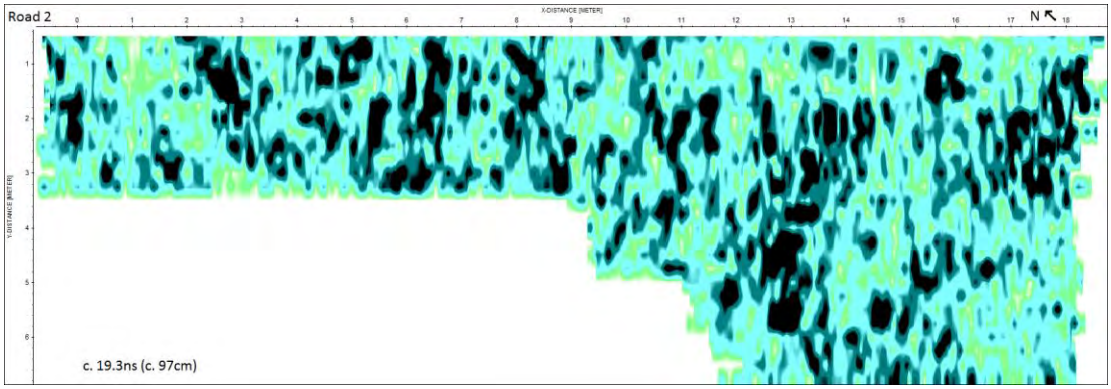

Figure 19: Time Slice of Road Section 2 extracted at c. 97cm.

Time Slice at 27.1ns (c. 1.36cm)

Since section 2 of the road is a relatively small area, it is difficult to derive an overall coherent picture. At a depth of 1.36m, at the northern end of the site, the material appears to form an outer ring, partially visible in Figure 20 with a narrow band nearly clear of material and other anomalous material inside. This may or may not be significant.

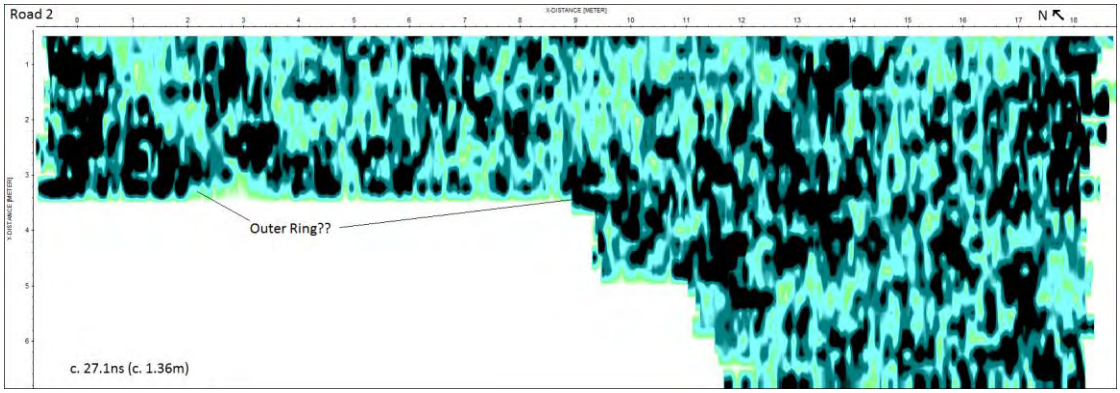

Figure 20: Time Slice of Road Section 2 extracted at c. 1.36m.

Time Slice at 31ns (c. 1.57m)

At this depth in the first section of the road, the otherwise scattered materials formed outlines which suggested previous construction (Figure 10). For the 2nd road section, although no overall pattern is discernible, the materials are different in the northern and southern sections (Figure 21). Towards the North end, there appear to be structural remains, apparently in situ. In the South, there is a single layer of anomalous material represented by the dark signals in the time slice.

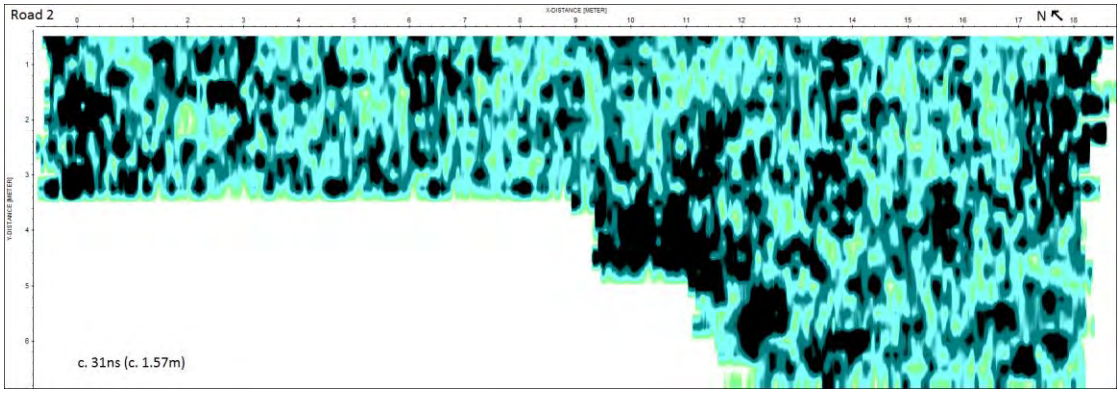

Figure 21: Time Slice of Road Section 2 extracted at c. 1.57m.

Time Slice at 35.5ns (c. 1.78m)

Although this time slice does not give an overall coherent picture, there is a difference in the material to the South and that to the North (Figure 22). The southern material appears to be structural. The dark area on the NE edge is definitely a deep construction, similar in appearance to feature A in the equivalent time slice for section 1. The dark areas in the SW corner appear to represent short layers of material and may therefore also be structural in origin.

The northern section of the road again suggests concentric remains but it is not possible to determine the nature of the material forming this pattern.

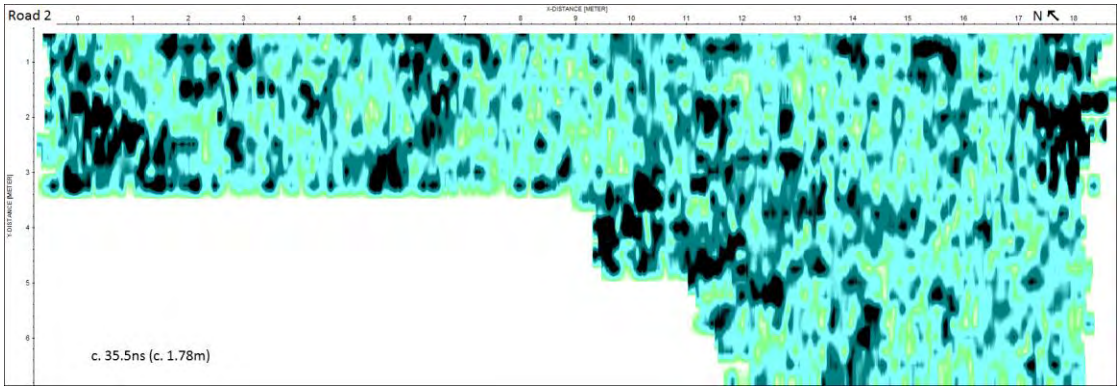

Figure 22: Time Slice of Road Section 3 extracted at c. 1.78m.

Conclusions and Recommendations

The patterning of the subsurface below the second section of the road is as complex as that in the first section. It falls into two different types, that to the South resembling the first section of road while the northern area does not contain the same depth of layering nor similar structures. The area of backfilled hollows is limited to the southern third of the survey area. In the vicinity of the SW corner, this extends in depth to over 1m. At the deepest level there is a structure similar to one in the first section. It is possible that these areas overlap each other, in which case this may be the same feature. This needs to be checked by plotting the 2 time slices on to a plan of the full survey area.

In the northern two thirds of the area there is a very shallow incomplete linear feature which may or may not be associated with a larger rectangular feature lying directly below it. This is the only potential utility within the area. Since it appears to be related to the underlying structure which, in turn, is related to the possible remnant of the former Mother and Baby Home visible at surface level, this may represent material related to the former Home.

It is recommended that such patterning as was uncovered in the southern part of Road section 2 be compared with witness' evidence and former plans of the area to see if it is possible to reconcile the outlines indicated by the GPR with this patterning in the GPR data.

It is also recommended that the position of the pipes apparently leading in the direction of the existing houses be checked to see if it is possible to verify their association either with these houses, or, if not, pre-existing buildings.

AREA 3: ROAD 3 (See Figure 1)

Road 3 is the northern section of the road which divides the houses from the playground that they surround. Only the road around the playground was surveyed, the access roads were not included. The Road 3 survey was carried out from the Road 2 section up to the car park entrance. It did not include the short lane backing the houses in the NW corner on one side and with a grass and flower bed on the other.

Fieldwork

This area was surveyed on Tuesday 18th July 2017 which was a mild, overcast day with little rainfall.

2-Dimensional Data

The 2-dimensional data are presented North to South across the page from left to right. Markers 1 and 2 on the data indicate the positions of the two survey reference lines used.

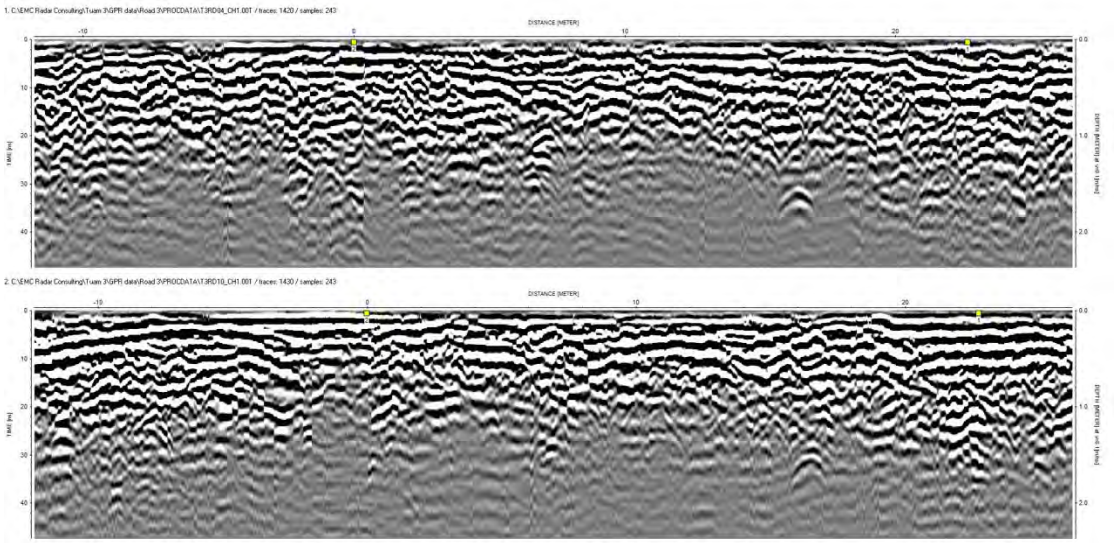

Figure 23: Typical 2-dimensional data from the Road Section 3.

As for the previous two sections of road, the data are characterised by a crowded subsurface. However, the outline of buried structures is very much clearer than in either of the previous road areas surveyed. This is evidenced by the broken and interconnecting signal segments and the occasional intact hyperbola, a contrast to the systematic layering in sections 1 and 2, but which are typical of the data from this area (see Figure 23).

Although it is not possible to interpret the data from the 2-dimensional data alone, it is evident that the area contains the footings of former buildings.

Time Slices extracted from the 3-Dimensional Data

The 2-dimensional survey lines have been incorporated into a 3-dimensional data block on the basis of their relative positions along survey line 2. Time slices, in essence horizontal plans, have been extracted from this data block on the basis of changing patterns. Where air gaps exist or moisture is present the view will be quasi-horizontal i.e. apparently horizontal but not physically so due to the differing transmission velocities in different parts of the survey area. The majority of the time slices selected on this basis correlate with those selected for Road sections 1 and 2, confirming that these levels in the subsurface are consistent across the site.

All horizontal time slices extracted from 3-dimensional data are presented with East at the top of the page and North to the left hand side. The x=0 position marks the line of the 2nd survey reference line i.e. it corresponds to the position of marker 2 on the 2-dimensional data.

Time Slice at 0.8ns (c. 4cm)

There are three areas of strong signal response very close to the surface of the road. Of these, the square area marked 1 in Figure 24 is almost certainly metal from the strength of the response and its continuing echo effect throughout the full depth of the data set. The adjacent area, marked 2 in Figure 24 does not appear to be of similar material and lacks the same strong response. There is no obvious cause for the dark area along the western edge further North.

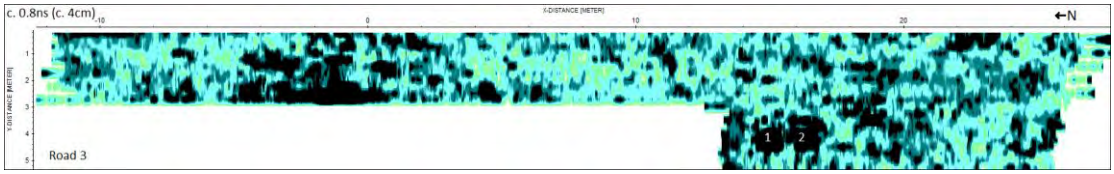

Figure 24: Time Slice from Road Section 3 extracted at c. 4cm

Time Slice at 2.3ns (c. 12cm)

Features 1 and 2 are still visible at 12cm below the surface. The northern feature has become a straight line, suggesting the existence of a possible utility along the western edge of this section of the road (Figure 25).

To the East of this linear feature there is a large near-rectangular area of strong signal response with another incomplete linear feature associated, running nearly parallel to its western neighbour. Although it is not clear from the time slice, there is a suggestion that this second linear feature turns the corner towards feature 1. This would imply that the utility is drainage and that the metallic feature 1 forms a drain.

There is similar partial utility evidence in section 2 of the road and it is possible that these linear features are part of the same system (Figures 14 and 15). This needs to be checked.

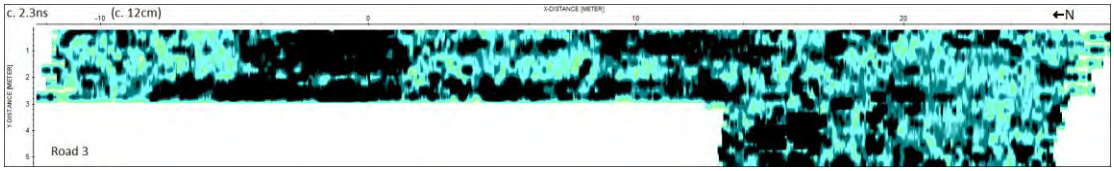

Figure 25: Time Slice from Road Section 3 extracted at c. 12cm.

Time Slice at 8.8ns (c. 44cm)

Although the anomalous material forms a scattered pattern, at this depth it appears to form two discrete areas. To the South, there is a curvilinear feature crossing East/West which may be the remains of a former road or path. In the remainder of the area, the material follows a series of interconnecting straight lines before turning around the SW corner. An echo effect from feature 1 is visible as part of the material around the SW corner.

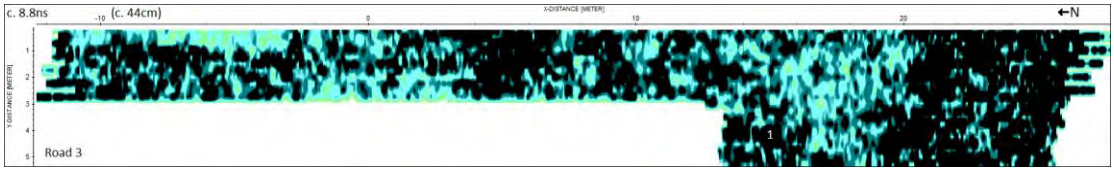

Figure 26: Time Slice from Road Section 3 extracted at c. 44cm.

Time Slice at 15.6ns (c. 78cm)

At this depth the pattern simplifies slightly, leaving what appears to be a partial building outline to the North and a possible extension of that structure towards the SW. In the South, the footings for the possible road/path are much reduced and the echo effects from feature 1 are still visible.

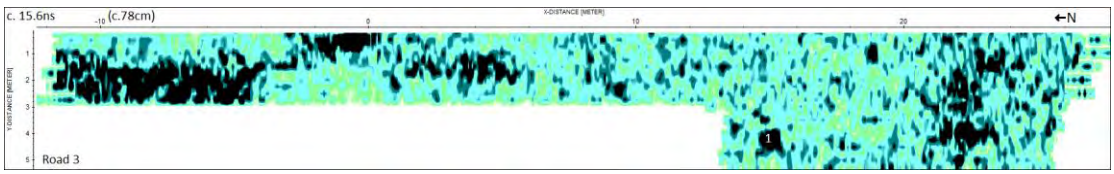

Figure 27: Time Slice from Road Section 3 extracted at c. 78cm.

Time Slice at 19ns (c. 94cm)

The basic pattern at this level is essentially unchanged i.e. the remains of building

foundations in the North, the possible remains of an extension immediately to the South and a scatter of material crossing the southernmost extent of the survey area.

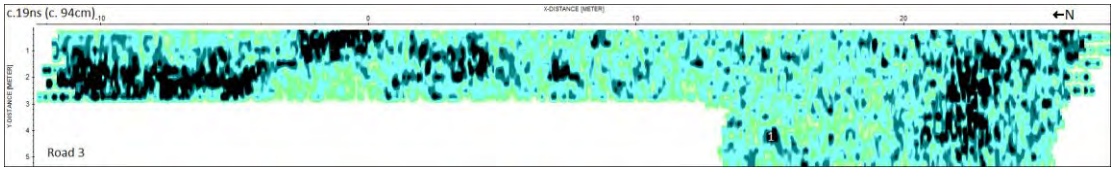

Figure 28: Time Slice from Road Section 3 extracted at c. 94cm.

Time Slice at 24ns (c. 1.2m)

Although the pattern remains essentially the same, the outline of the possible extension to the South of the main building foundations is more clearly defined at this level.

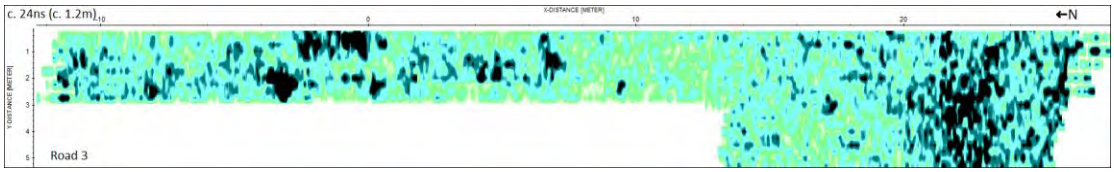

Figure 29: Time Slice from Road Section 3 extracted at c. 1.2m.

Time Slice at 28ns (c. 1.4m)

The overall pattern remains the same as in the previous time slices but the definition of the additional part of the building, to the South of the first set of foundations to be recognised is more clearly marked. The dark area marked feature 1 remains an echo effect from the near surface.

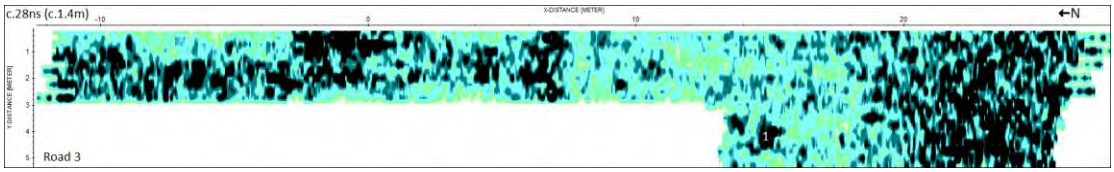

Figure 30: Time Slice from Road Section 3 extracted at c.1.4m

Time Slice at 32ns (c. 1.61m)

In addition to the previous patterning, which remains essentially unchanged, a broken line of dark patches has become visible to the South of feature 1 (Figure 31). These anomalous spots align exactly with each other and are mostly visible as a distinctive hyperbola, below the main depth of subsurface remains. The feature is visible in Figure 23 at x = c.16.5m in both of the survey lines illustrated.

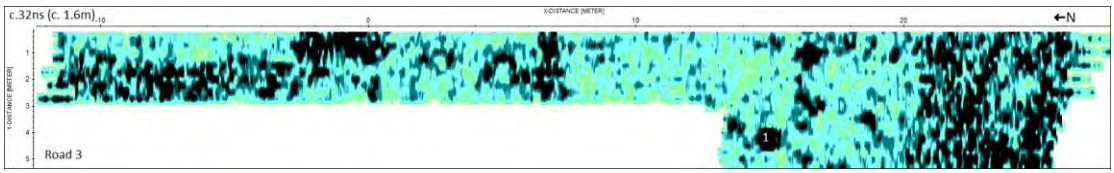

Figure 31: Time Slice from Road Section 3 extracted at c. 1.61m.

It is not possible to say definitively if this is the remains of a former utility or some other linear feature although the former is likely. Assuming that it does represent a former utility, it is clearly damaged.

Time Slice at 37.5ns (c. 1.88m)

Within the next 30cms of depth both the possible utility and the extension to the main footings have disappeared. This confirms the likely identification of the possible utility since, unlike the main foundations and as indicated in the 2-dimensional data, it does not continue for any great depth. Given the depth of this feature, it is likely to be for foul water drainage.

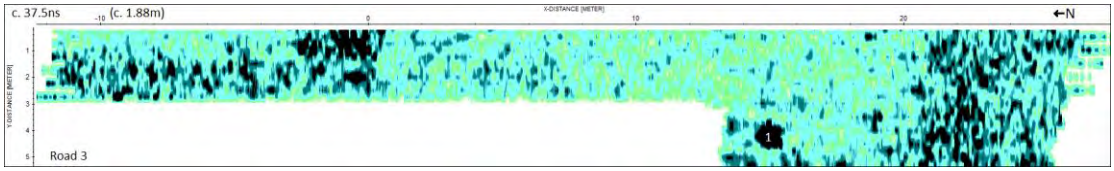

Figure 32: Time Slice from Road Section 3 extracted at c. 1.88m.

Time Slice at 41.8ns (c. 2.09m)

The final traces of the foundations are visible a little over 2m below the current ground surface (Figure 33).

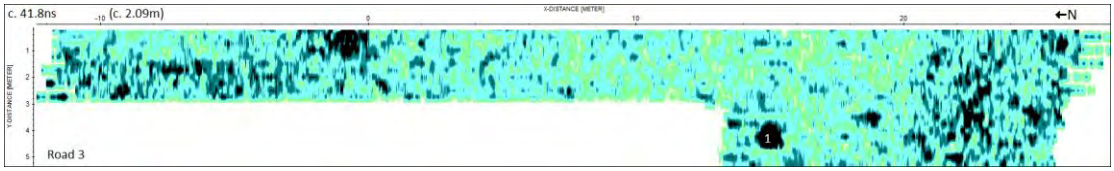

Figure 33: Time Slice from Road Section 3 extracted at c. 2.09m.

Conclusions and Recommendations

The data from the third road section represents the clearest and most straightforward set of plans from beneath the area of the road. The results should be compared to known plans of the former Mother and Baby Home to establish a correlation. The major features appear to be building footings with at least one possible associated utility.

For the near surface, there is a possible more modern utility, potentially associated with other features at a depth of c. 12cm which may align with the central linear feature observable in Road Section 2. Consideration needs also to be given as to whether this is a modern utility or associated with the former Mother and Baby Home.

AREA 4: CAR PARK (See Figure 1)

The car park lies to the East of Road Section 3, between the playground and the northern line of houses. The survey area includes the area immediately to the West of the car park to the limit of the adjacent flower bed and the eastern edge of the fenced off area around the memorial section of wall. It does not include the line of the third road section (see Figure 34).

Figure 34: The western limits of the survey of the car park area.

Fieldwork

This area was surveyed on Thursday, 20th July. The weather was not good with blustery wind and frequent showers.

2-Dimensional Data

The 2-dimensional data are presented West to East across the page from left to right. Markers 1 and 2 on the data indicate the positions of the two survey reference lines used.

It is immediately apparent from the 2-dimensional data in this area that the car park covers former buildings as there is a considerable quantity of structural material buried in the subsurface. There are also areas of layering which suggest systematic backfill. The relative proportion of backfill to other structural material increases towards the northern end of the car park but both appear to be present across the full survey area (Figures 35 and 36).

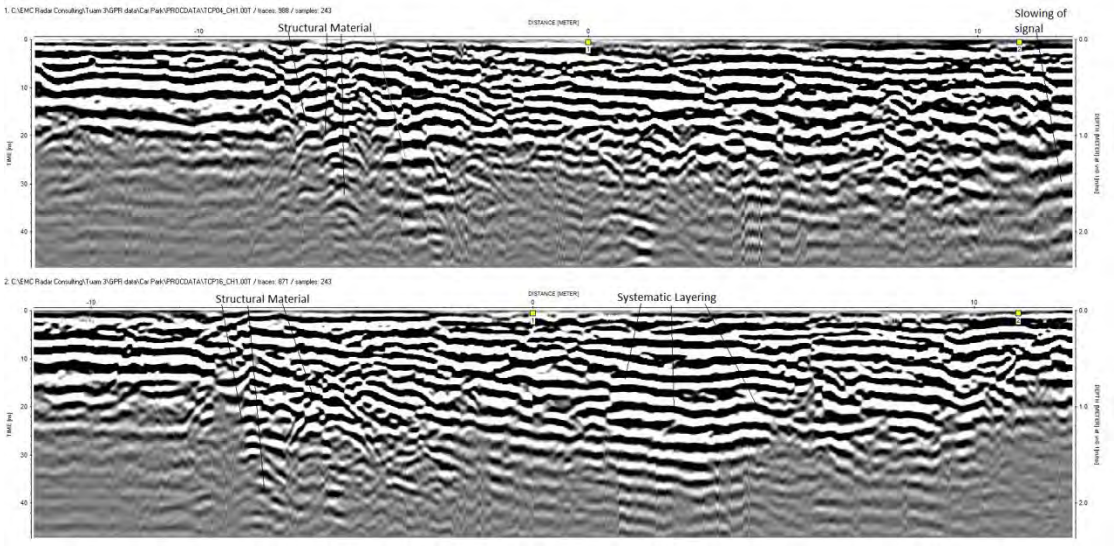

Figure 35: Typical GPR Data from the southern area of the Car Park.

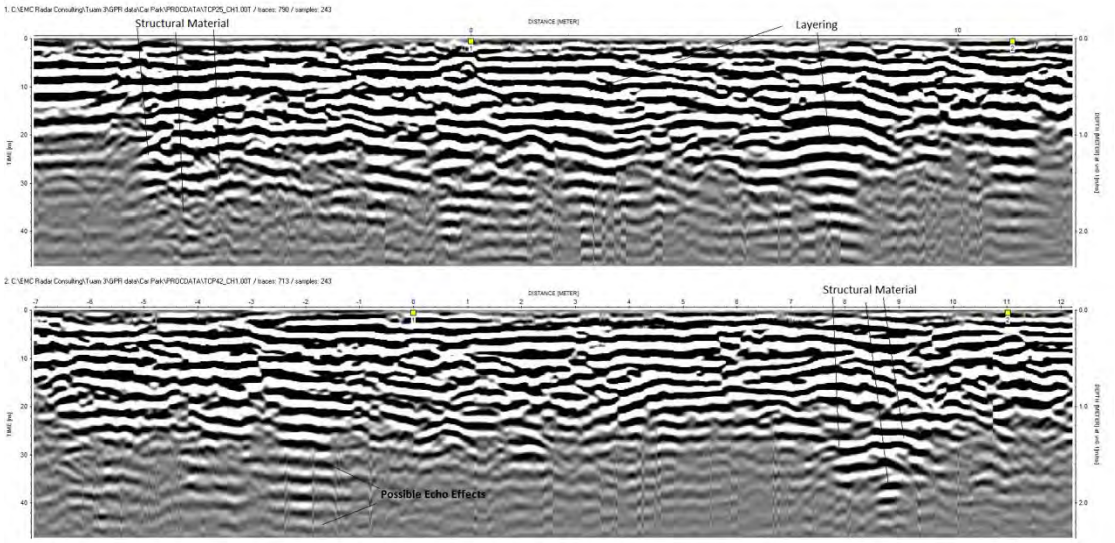

Figure 36: Typical GPR Data from the northern area of the Car Park.

Time Slices extracted from the 3-Dimensional Data

The 2-dimensional survey lines have been incorporated into a 3-dimensional data block on the basis of their relative positions along survey reference line 1. Time slices, in essence horizontal plans, have been extracted from this data block on the basis of changing patterns. Where air gaps exist or moisture is present the view will be quasi-horizontal i.e. apparently horizontal but not physically so due to the differing transmission velocities in different parts of the survey area. This area did not provide any substantial evidence of varying transmission velocity. It is noticeable that selection on the basis of the change in patterning has resulted in good correspondence with the depths of the time slices extracted in the other areas included in this report.

All horizontal time slices extracted from 3-dimensional data are presented with North at the top of the page and West to the left hand side. The x=0 position marks the line of the first survey reference line i.e. it corresponds to the position of marker 1 on the 2-dimensional data.

Time Slice at 2.7ns (c. 14cm)

There are a number of thin lines visible forming a series of rectangles. For the outermost this takes the form of an L-shape at the western end of the car park. The partial outline of an inner rectangle is formed by a West/East line parallel to the base of the L-shape along the line y = 4m. This line meets the original L shaped feature within an irregularly shaped dark area of anomalous material at c. x = -3m. It also meets another potential North/South line at x = 0m. Within the innermost rectangle there lies the remains of a potential square outline. There are other potential subdivisions. All of the lines meet each other at right angles. From this it is clear that this must be the outline of a former building. The patterning suggests an internal room layout within one structure although because many of the lines are incomplete, the interconnections cannot be traced entirely.

The 2-dimensional data is broadly supportive of this interpretation. Although many of the anomalous areas are indeterminate in the vertical plane, there is some evidence of wall type construction, particularly in the outer segment of the L-shape with an underlying similar but more substantial construction, albeit offset to the inside. This suggests that this level of the subsurface is a former surface and that the underlying construction is the foundations of the former building.

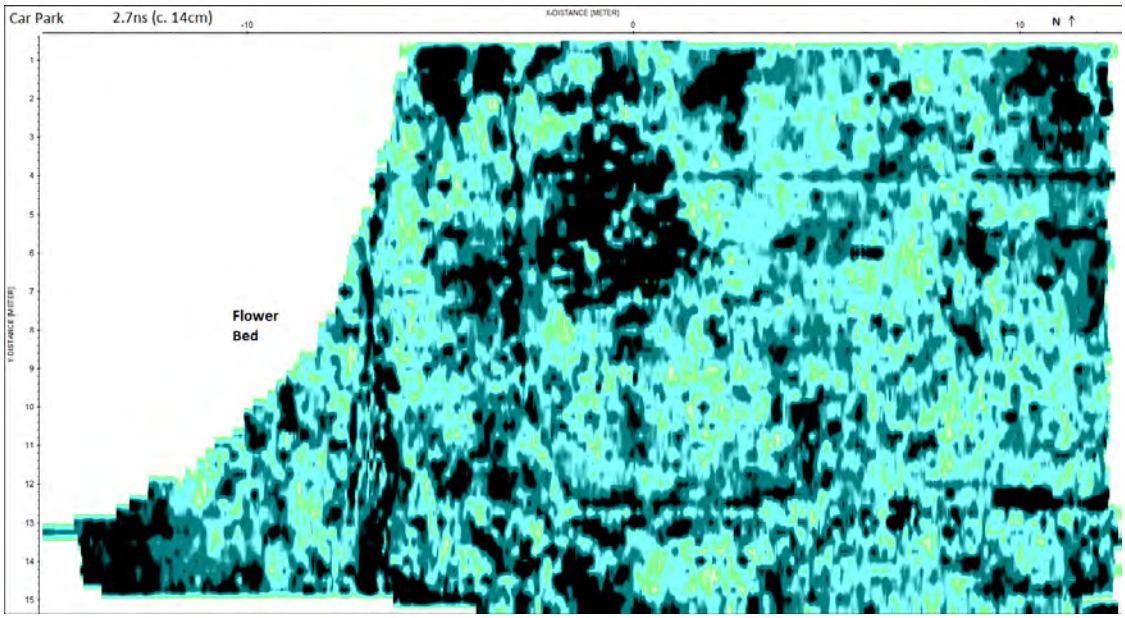

Figure 37: Time Slice of the Car Park extracted at c. 14cm.

Time Slice at 4.1ns (c. 21cm)

The patterning some 7cm deeper is similar. Some of the outlines are clearer and the adjacent areas of strongly anomalous material suggests the remains of former floors. It is not possible to confirm this in any absolute sense from the data alone and it is recommended that the patterning be compared with former building plans from the area.

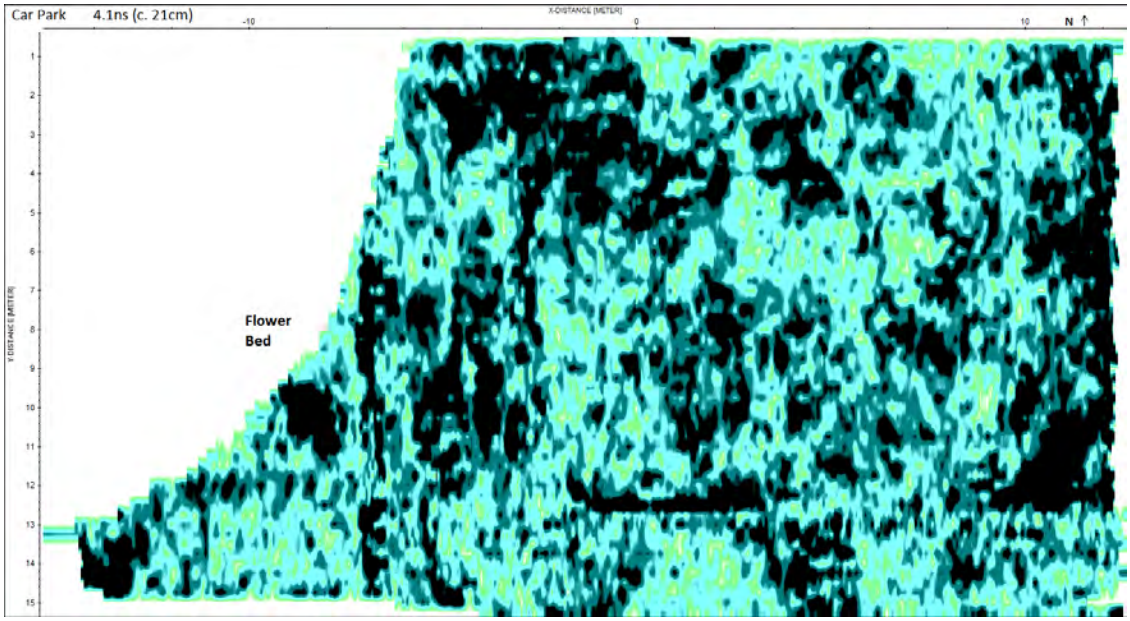

Figure 38: Time Slice of the Car Park extracted at c. 21cm.

Time Slice at 6.25ns (c. 31cm)

The spread of material across the site is much more extensive at this level (Figure 39). It is difficult to determine what this material represents. Viewed vertically, these are blocks of layered signal. However, unlike the areas of presumed backfill, the layering is neither even nor systematic. It is possible that they represent large slabs (for example) in which the signal in and the signal out are effectively conflated. Assuming that this is a correct interpretation, their relatively haphazard placement suggests at least partial destruction of the building of which they were originally a part.

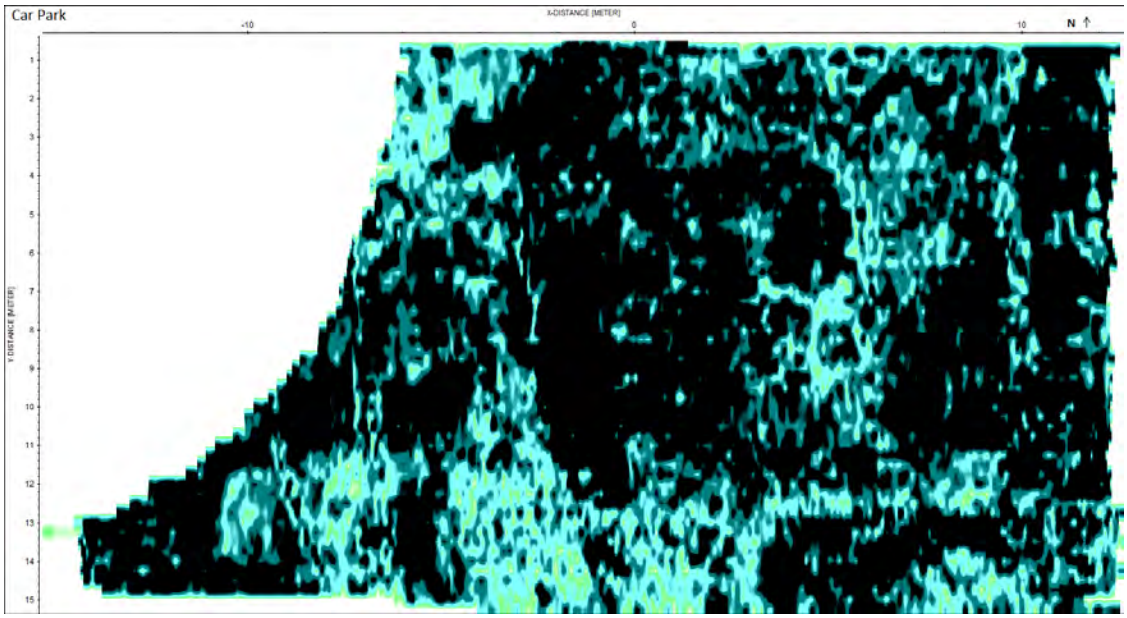

Figure 39: Time Slice of the Car Park extracted at c. 31cm.

Time Slice at 8.2ns (c. 41cm)

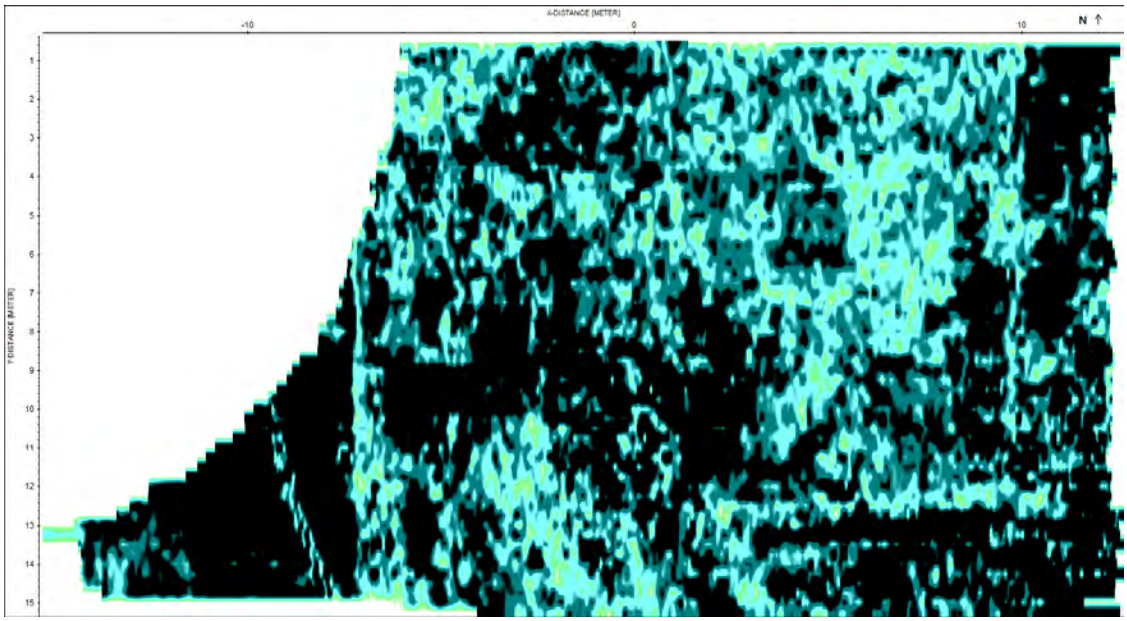

Figure 40: Time Slice of the Car Park extracted at c. 41cm.The next time slice, at 41cm, shows similar material but the placement of the material is different and the probable building outlines detected closer to the present day surface are more visible (Figure 40). Some of the material also lies directly above what appear to be foundations which confirms the likelihood of this being building remains.

The pale line running through the dark area towards the SW corner appears to represent where this surface has been cut through.

Time Slice at 10.7ns (c. 54cm)

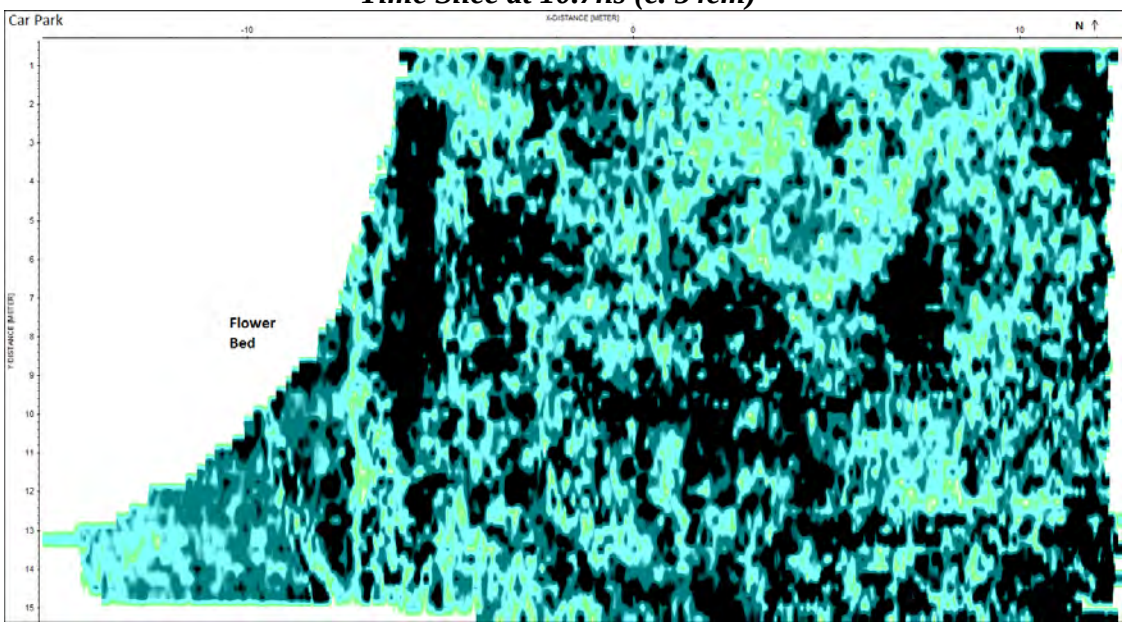

Figure 41: Time Slice of the Car Park extracted at c. 54cm.

The outlines of parts of the building are still visible at this depth (Figure 41). The SW corner no longer appears as anomalous but the channel cut through is still visible.

The dark linear feature running North/South lies directly above the level of the foundations and shows evidence of layering.

Time Slice at 13ns (c. 65cm)

Although the pattern set by the anomalous material is different some 11cm deeper, it appears to be formed by building material and delineates the same overall outline of the remains of a former building (Figure 42).

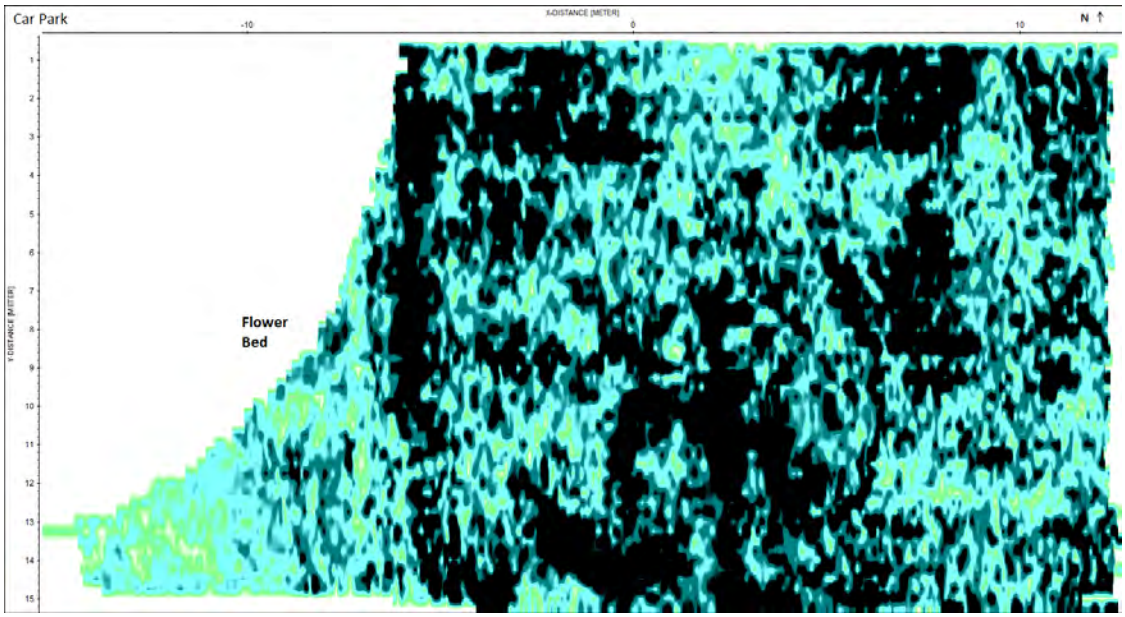

Figure 42: Time Slice of the Car Park extracted at c. 65cm.

Time Slice at 18.4ns (c. 92cm)

There are a large number of linear features crossing the area at this depth, in different orientations (Figure 43). Viewed vertically most of the signals are consistent with a possible pipe, in some cases quite large. Not all are at exactly the same depth. Since the signals are mostly continuous, this implies that these are features are unbroken. Looking at the vertical section also reveals that there are a number of very large hyperbolas located within some of the signals from building materials and which are therefore not able to be distinguished from their immediate environment in the horizontal section. An example in Figure 43 is located along x = 4.6m and at y = 13m as well as to either side of this point. This may be, as in two earlier time slices (Figures 40 and 41), a break in another type of feature but it might also be a pipe.

If an excavation is carried out in this area, care will have to be taken in the areas indicated in the time slice. Although it is unlikely that these services are still operating given that the building they relate to has been destroyed, there may still be contents and there remains a residual risk that they connect to current services. It is not possible to identify the type or types of utilities present on the basis of the GPR evidence alone. The outline of the building should be compared with previous plans since identifying the nature of the building might throw some light on this.

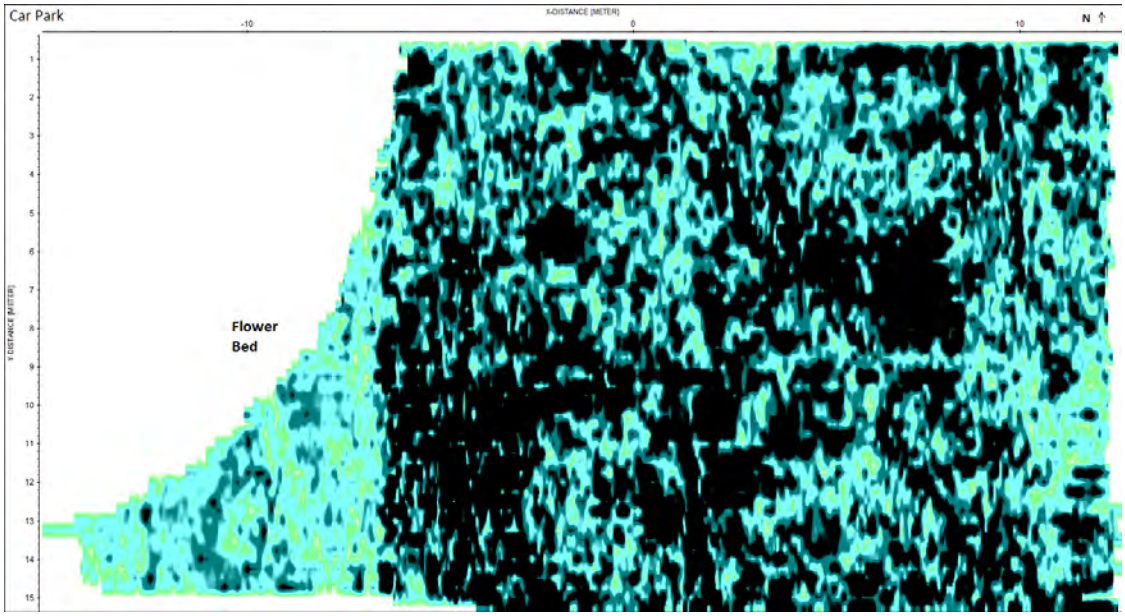

Figure 43: Time Slice of the Car Park extracted at c. 92cm.

Time Slice at 28.3ns (c. 1.42m)

The linear features visible at this depth lie beneath the floor of the former building (Figure 44). They are not all intact, some are represented by a series of broken dots. These appear to be a mixture of blocks of construction material (previously referred to as "foundations" and some substantial hyperbolic signals which might indicate either a structure still in situ or a large diameter pipe. The depth of these features suggests that if one or more pipes are represented, they are likely to be foul water drainage/sewers.

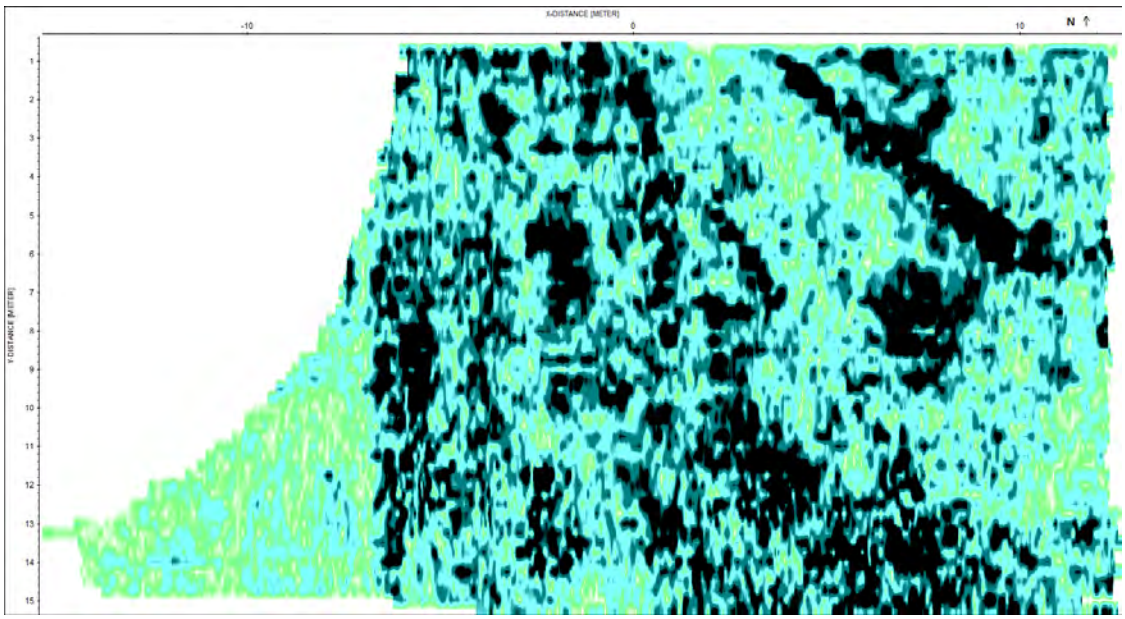

Figure 44: Time Slice of the Car Park extracted at c. 1.42m.

Time Slice at 30.9ns (c. 1.54m)

The majority of the strong (dark) signals in this time slice are consistent with the existence of foundation-type material i.e. construction material which lies beneath the potential base of the former building (Figure 45). Many of the same features from the previous time slice are present. Their apparent increase in breadth is probably a reflection of the width of the radar beam (which increases with depth) rather than a reflection of increasing width of the feature(s). The overall impression is consistent with that of a network of possible underground pipework.

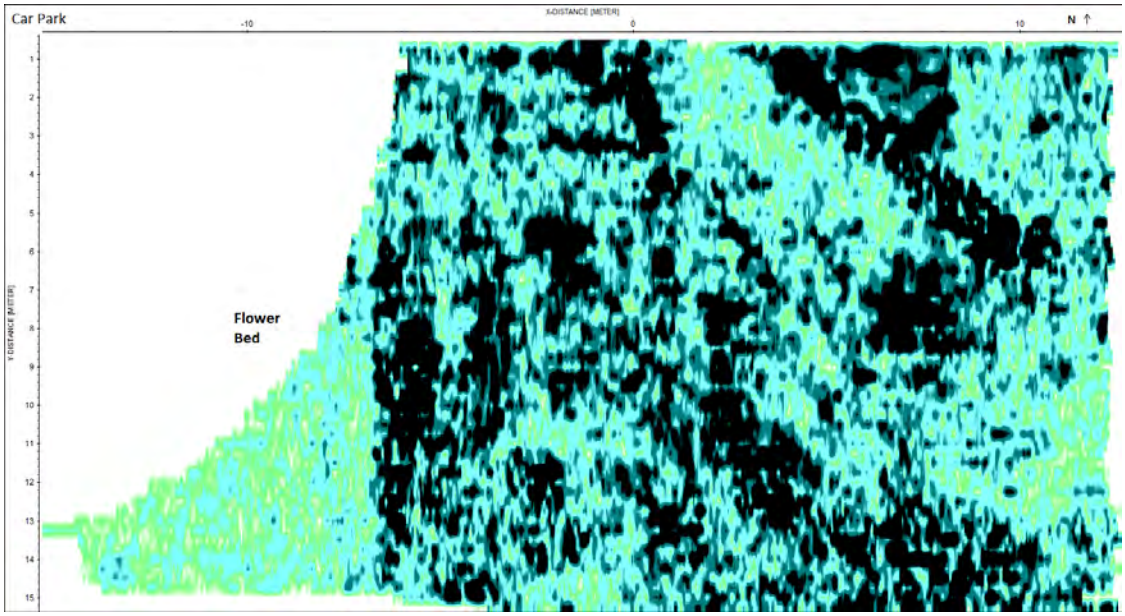

Figure 45: Time Slice of the Car Park extracted at c.1.54m.

Time Slice at 33.8ns (c. 1.69m)

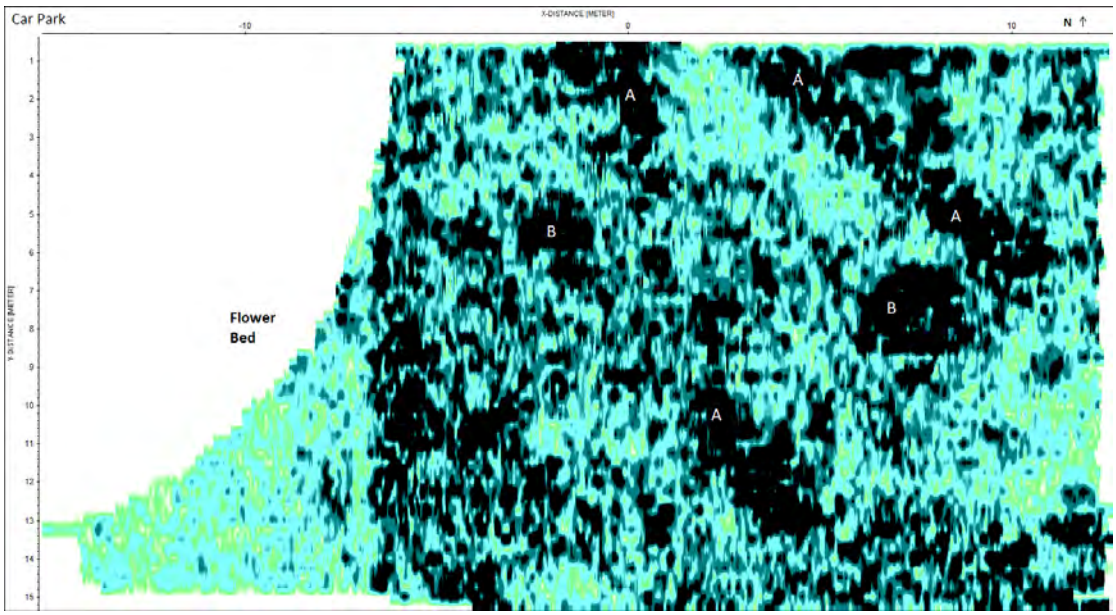

Figure 46: Time Slice of the Car Park extracted at 1.69m.

As with the previous two time slices, the material visible at this depth either forms a linear feature, possibly a large pipe or drain or it forms a block of construction material (Figure 46). The former are marked A and the latter B.

Time Slice at 42.4ns (c. 2.12m)

The majority of the anomalous material lies above this depth (Figure 47). Within the linear features marking the outside of the former building, there are a few real remains. Most of the apparent anomalous material is actually the result of echo effects from the subsurface material above this level.

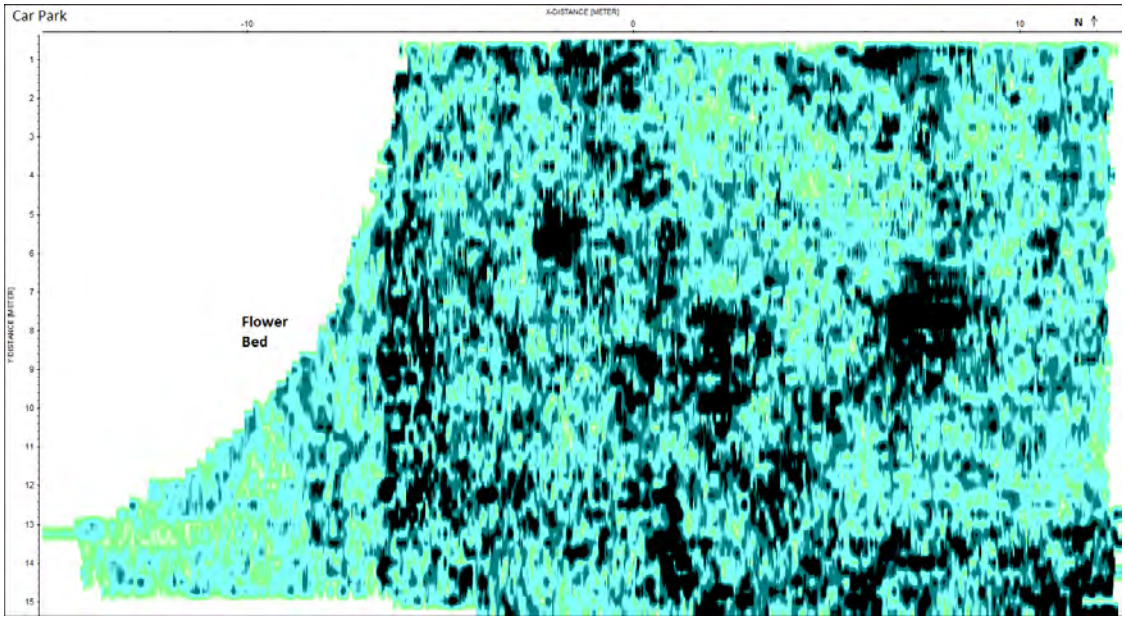

Figure 47: Time Slice of the Car Park extracted at c. 2.12m.

Conclusions and Recommendations

There are the remains of a substantial building and its associated features buried beneath the area of the car park. The associated features include several large linear features below the building which could be large diameter pipes and an area towards the SW immediately beyond the building which seems likely to have formed some sort of forecourt. Although the building has been destroyed, there are also some possible internal layouts visible in the shallow time slices. During the course of the survey mention was made of a pumping station in the vicinity. Although it is not possible to make a positive identification on the basis of the GPR data alone, the evidence in the time slices is potentially consistent with this identification.

We recommend that the outlines portrayed in the time slices are compared with historical plans of the area to see if it is possible to establish the nature of the former building.

AREA 5: MEMORIAL GARDEN (See Figure 1)

The former memorial garden was surveyed in 2015 and, based on the geophysical results, trial excavations of the area have been made. The area is currently enclosed

by a locked hoarding. It is known that the area covered by the garden was originally occupied by a sewage tank.

Fieldwork

The survey was carried out on the afternoon of the 19th July and the morning of the 20th July. There was heavy overnight rain on the 18th July and intermittent showers on both of the survey days. It was also very windy and the surface of the survey area remained wet in the areas where vegetation was growing.

The same is not true of the subsurface. In this area transmission velocity was calibrated to 0.07m/ns which indicates high water content of the soil. The difference is because of the lack of man-made cover (e.g. asphalt in the car park) which results in the rain having an immediate impact and the change in weather (cf the road sections). The result of the lower transmission speed is that the depth to which the radar probes is reduced.

2-Dimensional Data

The 2-dimensional data area are displayed North to South from left to right across the page. Markers 1 and 2 on the data indicate the positions of the two survey reference lines used.

The data indicate that this area is less crammed with material than the areas reported on above. There is a near continuous layer change at c. 18cm below the surface which presumably corresponds to the layer of concrete laid across the site before the area was made into a memorial garden. This is marked by a continuous series of black and white banding across the radar plot (Figure 48). The depth of this layer is not uniform, it dips in the centre of the garden relative to the sides.

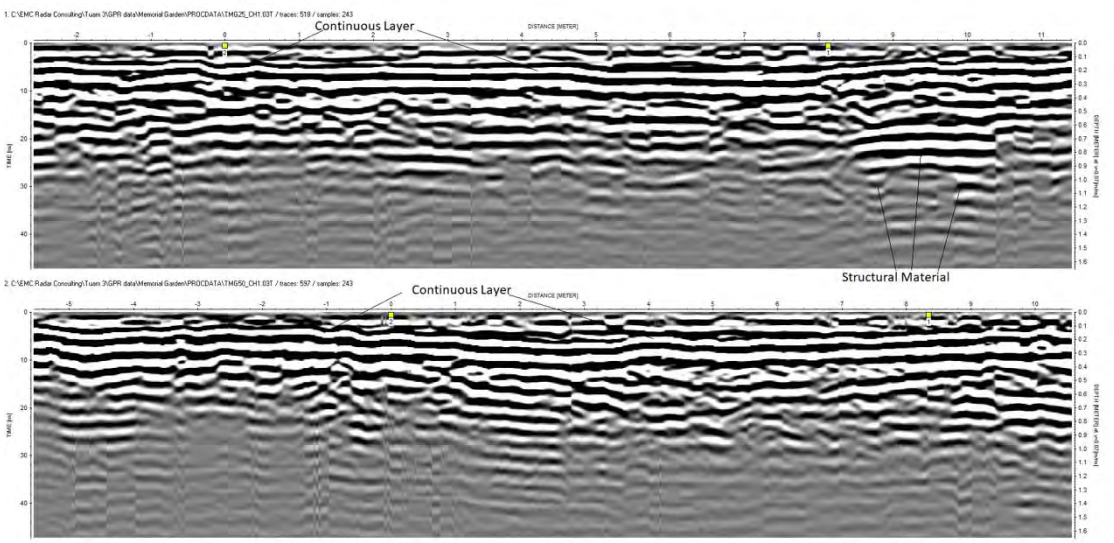

Figure 48: Sample 2-dimensional Data from the Memorial Garden.

At the South end, just beyond reference line (and marker) 1, there are a distinctive series of signals indicating structural material. This patterning, visible in the upper half of Figure 48, occurs in many of the survey lines. There are also large blocks of

signal at a depth of 20ns (c.0.7m) and below which suggest that there are other structures present. Although this has been labelled in Figure 48 as "structural material", this merely indicates that a man-made structure is thought to exist at this point. Large blocks of signal may not equate to large blocks of building material. This may be the signal response to voids or other types of material contained within a structure. Sizing depends not only on the object(s) but also on the wavelength with which they are measured.

Time Slices extracted from the 3-Dimensional Data

The 2-dimensional survey lines have been incorporated into a 3-dimensional data block on the basis of their relative positions along survey line 2. Time slices, in essence horizontal plans, have been extracted from this data block on the basis of changing patterns. Where air gaps exist or moisture is present the view will be quasi-horizontal i.e. apparently horizontal but not physically so due to the differing transmission velocities in different parts of the survey area.

All horizontal time slices extracted from 3-dimensional data are presented with East at the top of the page and North to the left hand side. The x=0 position marks the line of the 2nd survey reference line i.e. it corresponds to the position of marker 2 on the 2-dimensional data.

Time Slice at 4.5ns (c. 16cm)

The anomalous material within the initial few centimetres appears to be backfill. There is no particular pattern to this in the horizontal plane and in this it differs markedly from the systematic backfill in specific areas observed, for example, in the first road section, directly to the West of the garden. By 4.5ns (c. 16cm at 0.07m/ns), there are three distinct areas of anomalous material: along the southern boundary, in the NW corner and the NE corner, spilling over towards the centre (Figure 49).

At this depth, the dark signals across the South of the site form a coherent band suggesting that this is a substantial linear feature. Viewed in the vertical plane, this appears to be a covering which lies some depth above a linear feature lower down in the subsurface.

The material in the NW corner also appears to be layered backfill although in some places this may actually represent part of the concrete layer (e.g. along the y = 12.75m line from x = -5.5 to 0.4). The anomalous material towards the NE and the centre also is due to layered material. As there is no underlying coherent pattern, this is probably generalised backfill. It is not clear why these three areas differ from the remainder of the surface at this depth. One possibility for the areas around the outside is the increased presence of water, related to the position of adjacent vegetation.

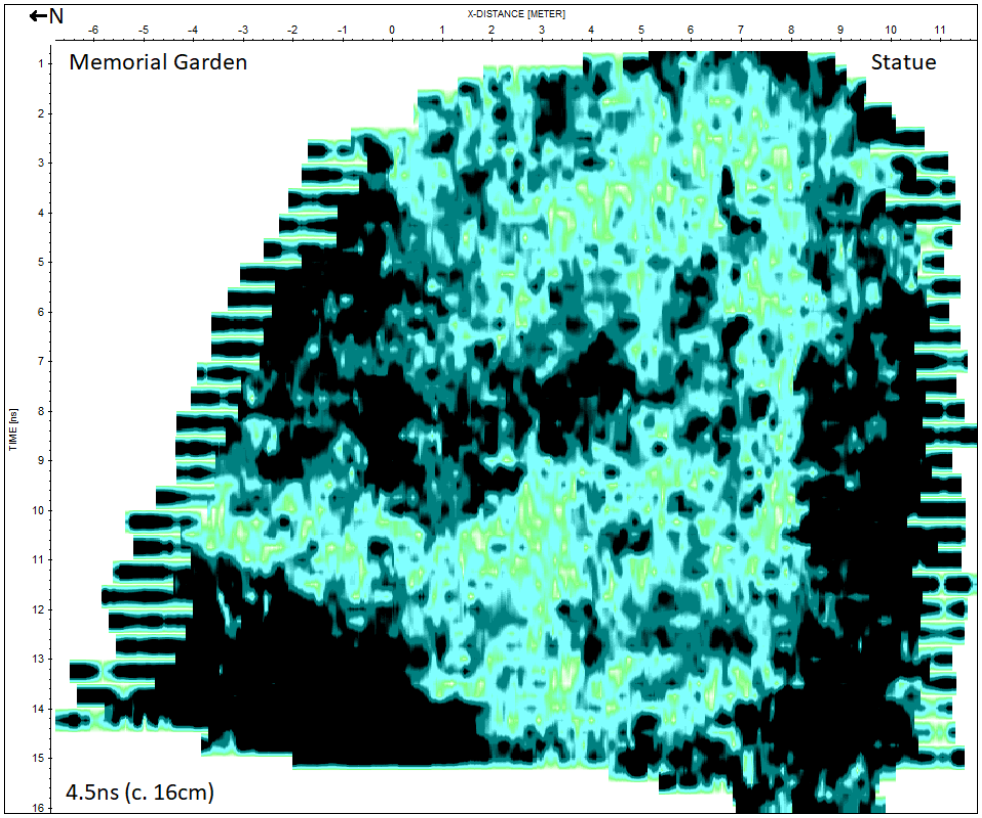

Figure 49: Time Slice from the Memorial Garden extracted at c. 16cm.

Time Slice at 11.9ns (c. 42cm)

The layered material has its maximum coverage over the site at c. 6.25ns or 22cm. This then clears to a more mixed pattern of materials which may be backfill or a combination of backfill and former structures. At a depth of 42cm, there is a single "hotspot" of anomalous material. The 2-dimensional data indicates this as a separate area of approximately 1.5m across, lying directly above (and possibly part of) another feature below which echo effects can be seen in at least one location. It is not clear what type of feature this represents. Echo effects are frequently the result of either gaps of a size related to the wavelength of the radar (for example 0.5λ) but may also be the result of metal being present since radio waves cannot penetrate metal. In this case, the amplitude (magnitude) of the echoes is not great and air is therefore more likely than metal.

There is a suggestion in this time slice of three sides of a potentially rectangular outline of a possible adjacent feature to the East of this hotspot from the scattering of other anomalous material. However, this may also relate to backfill and therefore not be of any significance.

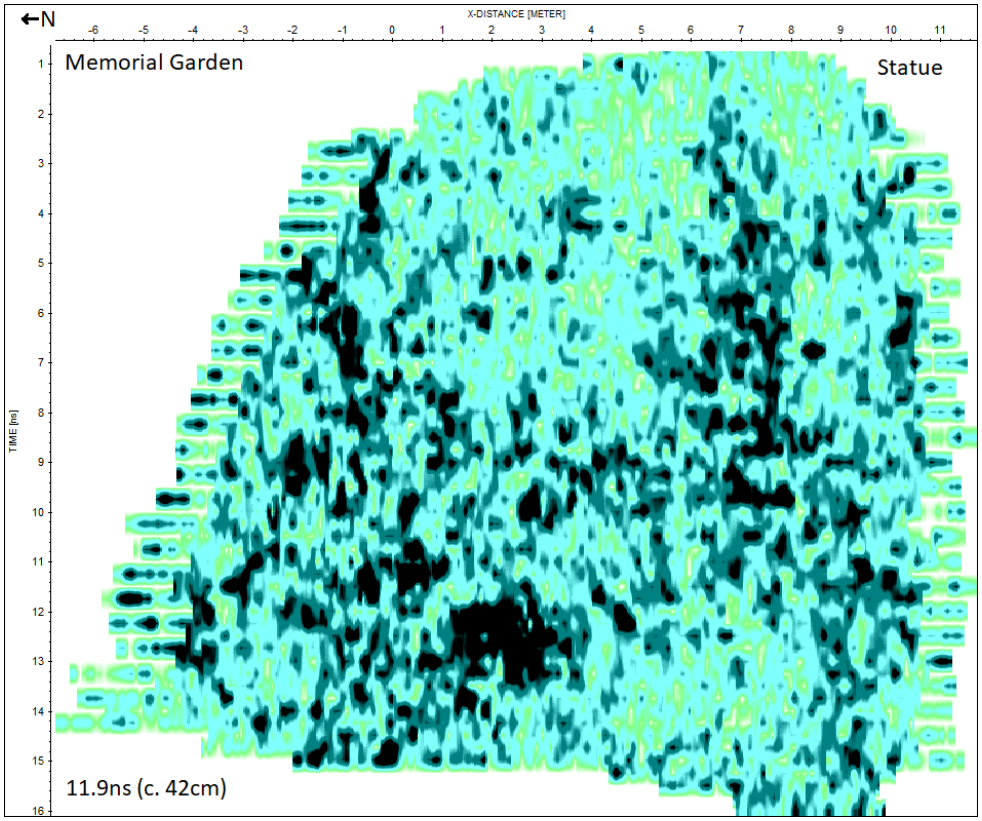

Figure 50: Time Slice from the Memorial Garden extracted at c. 42cm.

Time Slice at 18.5ns (c. 65cm)

There is a large clearly delineated linear feature along the South side of the survey area at this depth (Figure 51). This corresponds to the structural feature observable in the South side of almost all of the 2-dimensional data files including the two in Figure 48. Figure 51 shows a close up view of 2 cross sections of this feature.

It is evident that this feature must form part of the sewage system both from its size and the regularity of its shape. However, on viewing the cross section in close up, it becomes evident that there are discontinuities in the shallower layers above, implying that this is also an area which has been investigated by trial excavation (Figure 52). The discontinuity is marked on the upper radar trace and can be seen on the lower one at a short distance to the North of marker 1.

The structure is formed primarily of three sections, one above and two below. All three are very strong amplitude signals implying the presence of air, water or metal. Of these, air is the most likely since radio waves do not penetrate metal and there is

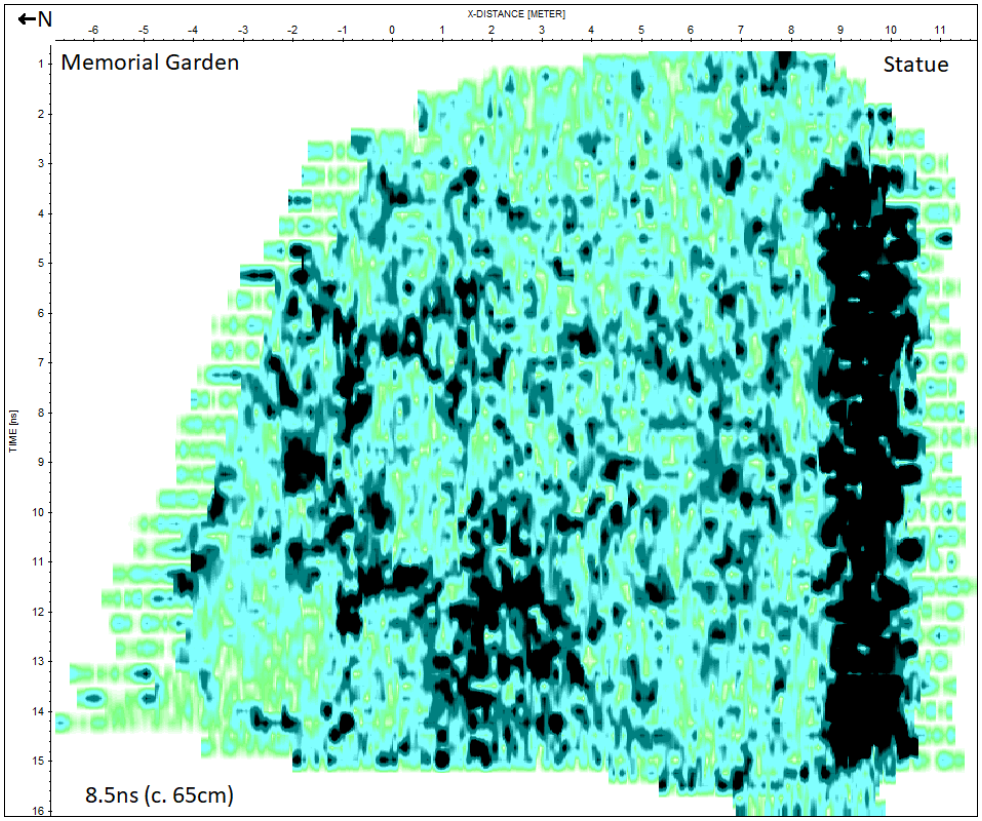

Figure 51: Time Slice from the Memorial Garden extracted at c. 65cm.

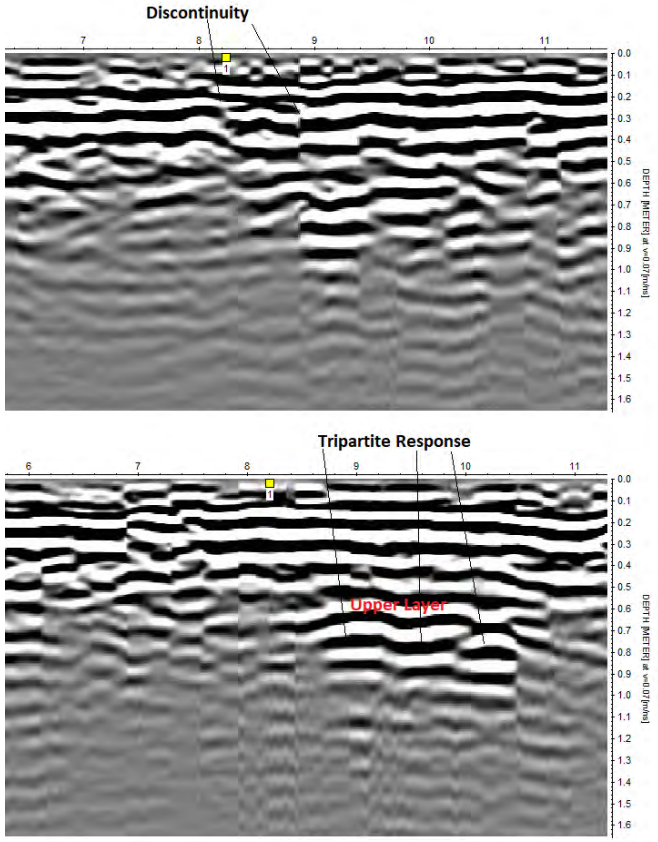

Figure 52: Cross Section of the Linear Feature illustrated in Figure 51.

no evidence of an accumulation of water in this vicinity. There is a baseline below the feature at a little over 1m in depth.

Time Slice at 26.6ns (c. 93cm)

The southern drain is still visible at this depth but there is also a wide distribution of other anomalous material (Figure 53). In many cases the shapes suggest man-made structures but these also appear incomplete or damaged. This could be either because they have been damaged or because they are structures still in situ surrounded by similar material. It is also possible that the radar is detecting gaps between materials.

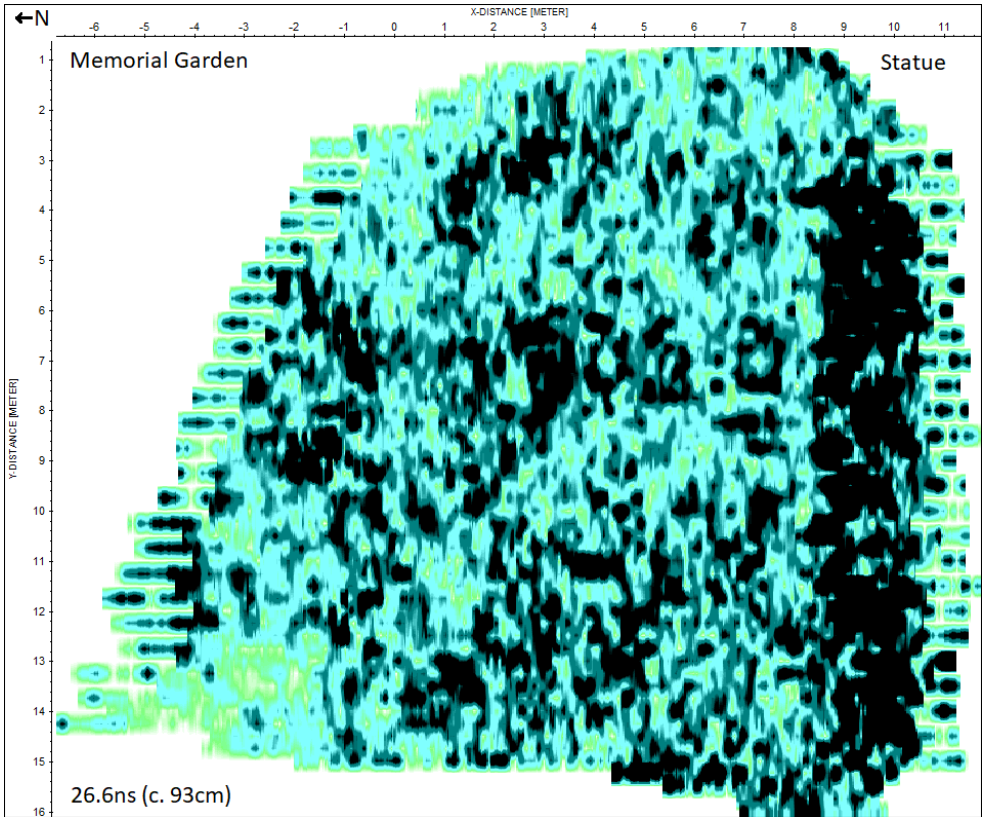

Figure 53: Time Slice from the Memorial Garden extracted at 26.6ns (c. 93cm)

Time Slice at 34.4ns (c. 1.2m)

This depth corresponds to the final depth of the southern drain (Figure 54). A similar structure appears along the eastern edge of the survey area. The red arrows in Figure 54 indicate the outer edge of this feature which can be traced through to x = 6.4m where it meets the x-axis. There is a parallel inner edge and what appears to be regular rectangular features crossing between the two edges. It is probable that these strong signals are a mixture of structural material and air gaps.

Viewed in vertical presentation, this appears to be structural material and potentially similar in nature to the southern drain. It is probably also part of the sewage handling system associated with the former cess pit.

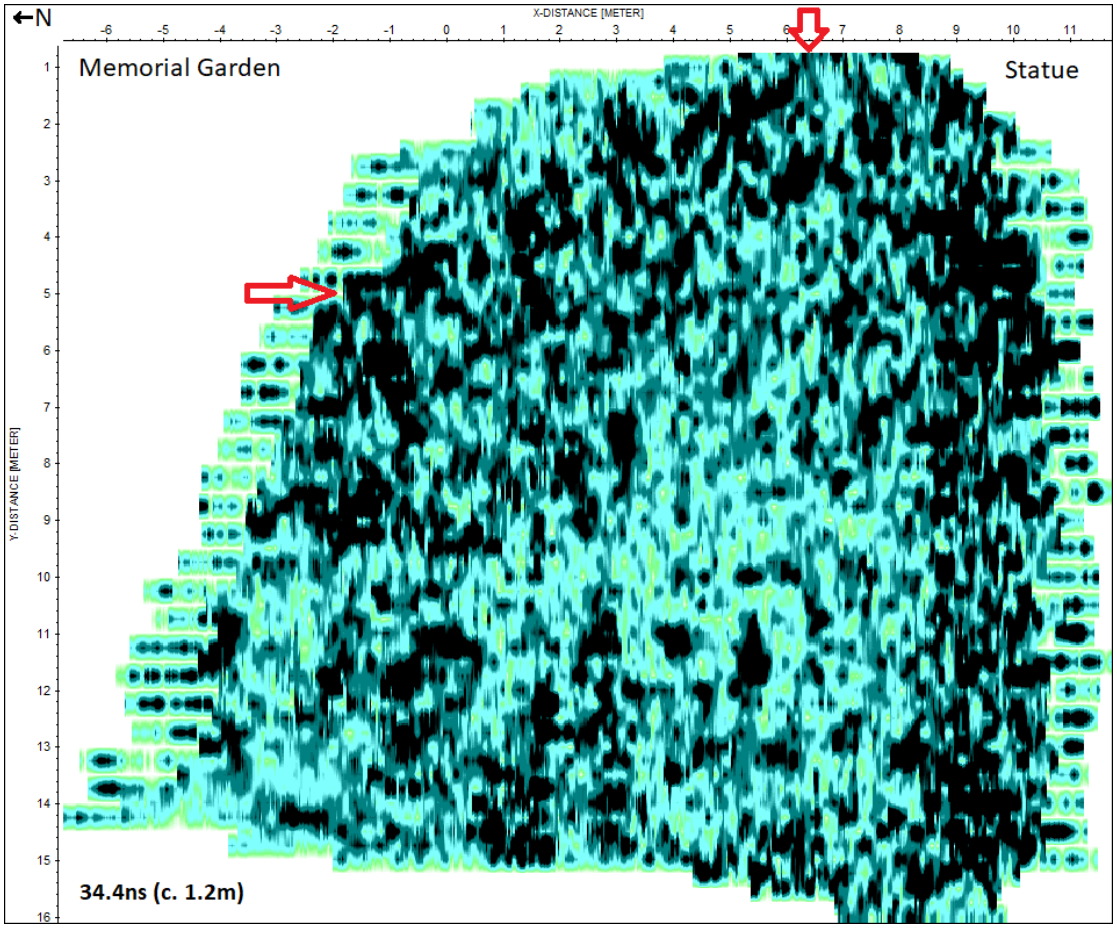

Figure 54: Time Slice from the Memorial Garden extracted at 34.4ns (c. 1.2m).

Time Slice at 61ns (c.2.05m)

This time slice is not archaeologically significant but it is relevant to the evidence above regarding the southern drain (Figure 55). The pattern showing along the southern edge of the survey area is primarily composed of echo effects indicating the existence of relatively large air gaps in the construction material above.

There is a scattering of similar signals associated with the eastern and northern edges of the survey area although these are many fewer than along the southern perimeter. The eastern part lacks the repeated columns of faint signal which indicate echoes. However, these signals could still be echo effects if the voids are partially filled in. There is a possibility of these signals representing the base of construction but that would be inconsistent with the rest of the survey area. In the northern part, the scatter of anomalous material is definitely echo effects emanating from voids within construction material above.

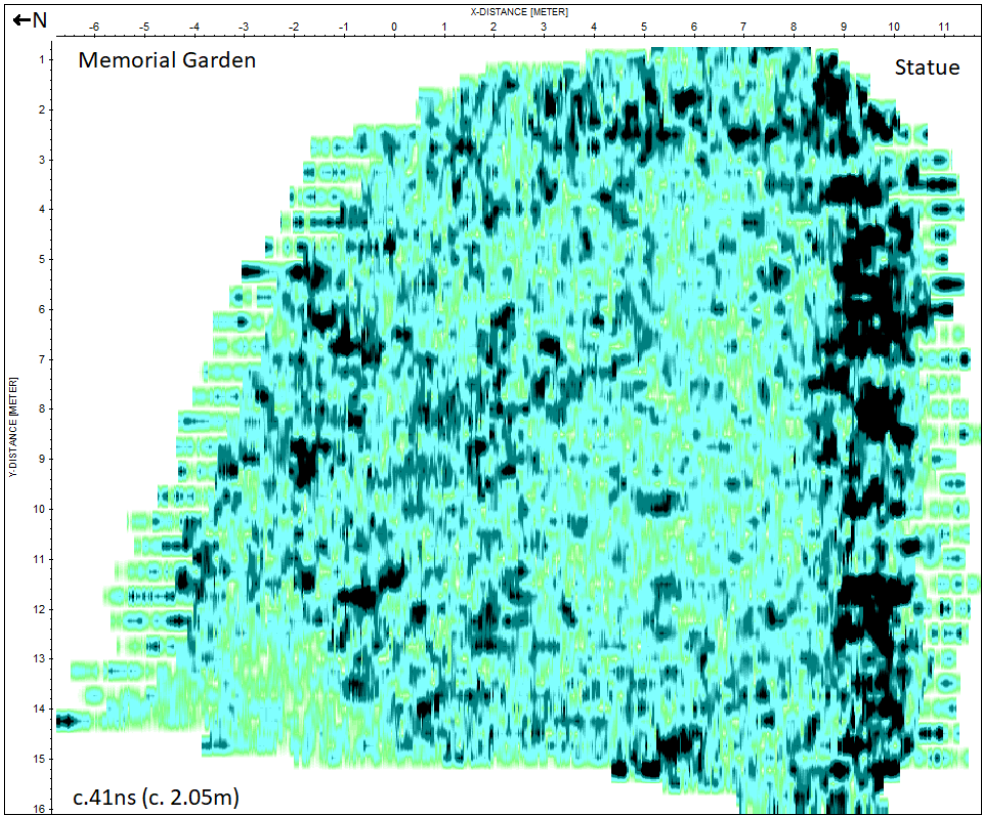

Figure 55: Time Slice from the Memorial Garden extracted at c. 2.05m.

Conclusions & Recommendations

This area is known to contain the remains of a sewage tank which served the former Mother and Baby Home. Part of the drainage system is visible along the southern edge of the survey area. There is evidence also that this feature formed the target of trial excavations carried out prior to this survey. There is another potential arm to the system along the eastern edge (see Figure 54).

Comparison of the time slices from the memorial garden and road section 1 indicate that if the drain continues towards the West, it passed beneath the gardens to the South of the road and not beneath the road itself.

Magnetometer Survey

The magnetometer used for the investigation was a Magneto MXPDA 5 channel system manufactured by Sensys (Germany) The system contains five fluxgate magnetometer probes spaced at 0.25m centres mounted to cart. Each probe has a range of ±10,000 nT is sensitive to 0.5V/μT.

The magnetometer uses a real-time kinematic global navigation satellite system (RTK-GNSS) to geo-reference each data point acquired. Spatial accuracy is typically ±10mm. Without this level of accuracy, the acquisition software will display a warning and prevent data capture.

Survey Strategy

The survey strategy essentially mimicked that of the GPR survey. The playground and access roads were broken down into individual sections and surveyed one after the other in the following order:

1. Road Section 1
2. Road Section 2
3. Road Section 3
4. Memorial Garden
5. Grass surrounding paved play area.

The results from Road sections 1, 2, 3 and the memorial garden are included in this report. The grass surrounding the paved play area will be reported in a subsequent report.

Use of Magnetometry

Magnetometry is a passive technique whereby the measurement probes are measuring the deviation in the planets magnetic field caused by subsurface anomalies. Such anomalies can be caused by the excavation and back-fill of a pit or grave, kiln fired material such as brick and buried ferrous objects.

Due to the sensitivity of the device, the anomalous magnetic response caused by hot-rolled asphaltic materials, as encountered on the paved play area, saturates any subtle responses from anomalies beneath. After a short trial, it was deemed inappropriate to use the magnetometer on the paved surfaces.

Magnetometer Results

Road Section 1.

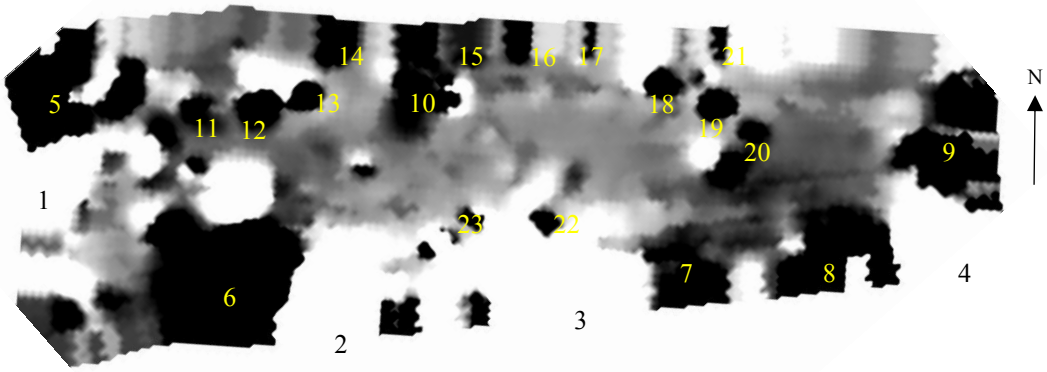

Figure 56: Magnetometer Results from Road Section 1.

The results from Road 1 were dominated by four magnetic anomalies (annotated 1 to 4 in Figure 56.). These were the effects of large steel gates at the rear of the houses on Dublin Road Estate and Athenry Road. These responses appear in the data as large white areas of negative magnetic response.

Anomalies 5, 6, 7, 8 and 9 appear to be irregular in shape and from calculations derived from the magnetic moment of the anomalies, appear relatively shallow (>1m below ground level). These responses could possibly be related to backfilled depressions from trees removed during the construction of the estate.

Anomalies 10 to 21 appear as discrete point features with an unusually high monopolar response typically associated with disturbed or back-filled ground.

Road Section 2

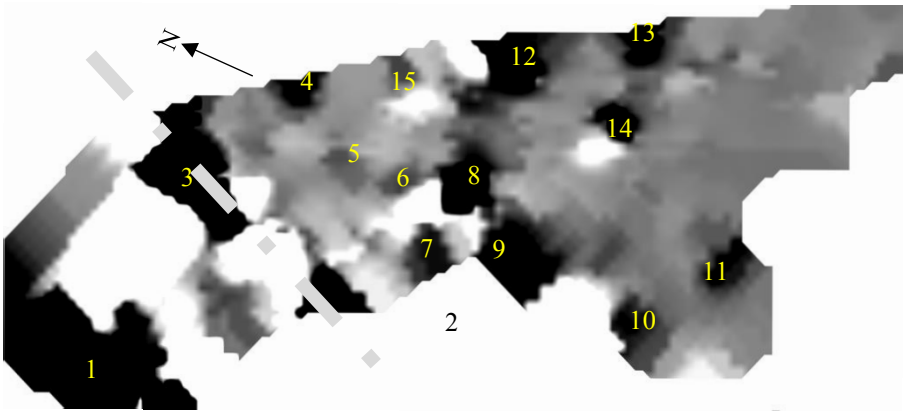

Figure 57: Magnetometer Results from Road Section 2

As previously identified in the results from Road section 1, the dominant response to the north of the survey area (annotation No.1) was caused by the steel gates and garage doors associated with the properties on the Dublin Road Estate. An area approximately 4m x 2m on the western edge of the area could not be surveyed due to a pile of garden waste (annotation No.2).

A linear anomaly (annotation No.3 with a dashed line indicating orientation) was identified cutting across the north end of the survey area. It is likely this is an old steel or cast-iron pipe.

Anomalies annotated 4 to 13 appear as discrete point features with an unusually high monopolar response typically associated with disturbed or back-filled ground.

Anomalies annotated 14 and 15 are bi-polar responses suggesting a ferrous content to the response.

Road Section 3

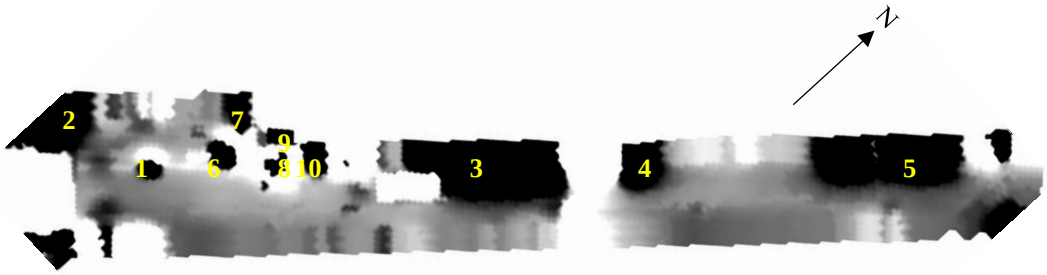

Figure 58: Magnetometer Results from Road Section 3

The results from Road section 3 show anomalies that are, for the most part, attributable to surface features. Anomaly 1. is the response from a cast iron gully cover. Anomalies 2, 3, 4 and 5 are caused by the metal gates and fences at the rear of the properties on Dublin Road Estate.

The cluster of anomalies annotated as 6, 7, 8, 9 and 10 appear as a mixture of mono-polar and bi-polar responses. These anomalies are possibly associated with the construction of the garage buildings.

Memorial Garden

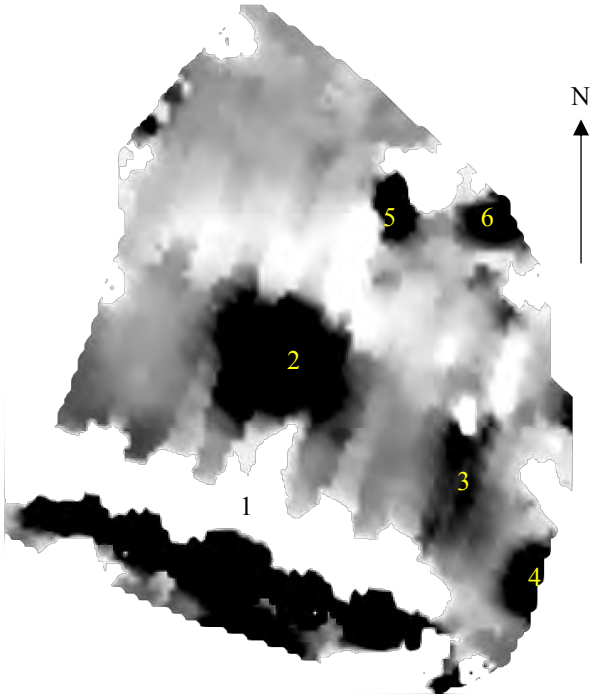

Figure 59: Magnetometer Results from the Memorial Garden

The results from the memorial garden show a significant rectilinear bi-polar anomaly along the southern edge of the survey area (annotated No.1). The anomaly appears to be oriented West North West/East South East and parallel with the southern wall of the garden.
This response of this magnitude is typically associated with large man-made structures containing a substantial quantity of ferrous material.

Anomalies 2, 3, 4, 5 appear as discrete features with an unusually high monopolar response which is typically associated with disturbed or back-filled ground.

Conclusions of the Magnetometer Survey

The magnetometer survey has identified numerous anomalies within the four survey areas outlined in this report. A representative sample of these anomalies should be targeted with direct exposure/excavation to determine their cause.

Electromagnetic Utility Locating (EML)

This method is primarily used to detect and trace sub-surface utilities comprising electrically conductive materials. The principal equipment used in this type of survey are known as a CAT (Cable Avoidance Tool) and Genny (signal generator).
A Radio Detection RD8100 CAT and Radio Detection Tx10 signal generator were used for this survey.

The equipment can be used in two modes; Passive mode and Active mode.
Passive mode comprises of "power" and "radio" settings that are used locate utilities already carrying an electrical current or are conducting the ground wave of a transmitted radio wave and therefore generating their own electro-magnetic field.
The primary limitation of this mode is that it is often not possible to identify the nature of a utility when in "radio" mode.

Active mode involves using the transmitter (Genny) to apply an artificially generated electro-magnetic field to a service either by a direct connection using a clamp or by induction from the surface.

Direct connection provides the most accurate and reliable results however require direct access to a particular cable or pipe through a manhole.

Induction does not require access to a manhole but can often produce misleading results as more than one cable or pipe can be inducted at any one time and therefore a utility maybe incorrectly identified.

After a sweep of the entire site in the passive mode, only two responses were identified. A current was induced to the utility in these locations and traced.

The nature of the utility located was unknown but, due to the ease at which it carried an induced current, is likely to be a redundant cast iron water or gas pipe.
The locations of these two utilities are shown in **Figure 60.**

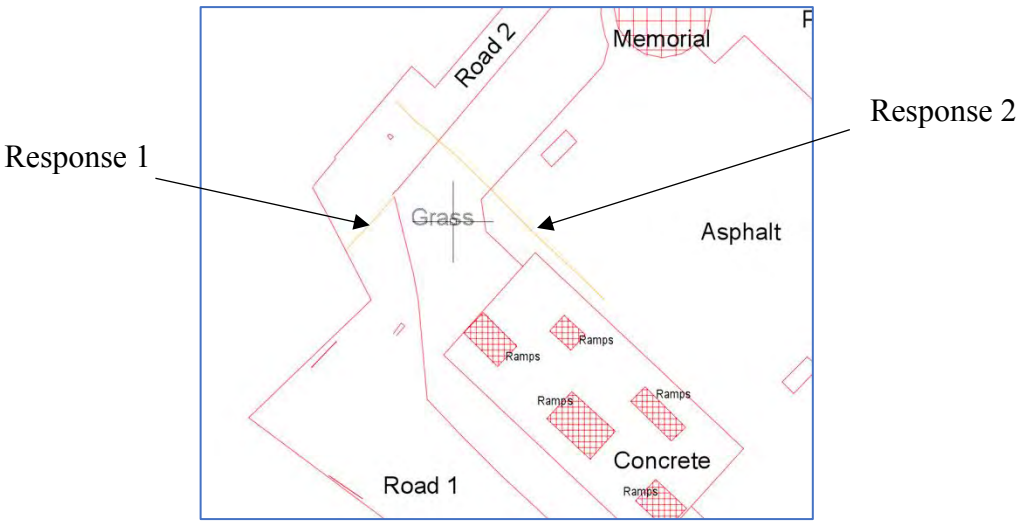

Figure 60: Location of EML responses

Overall Conclusions of the Geophysical Investigation

The geophysical investigations used GPR and magnetometry to map the public areas of the former Mother and Baby Home at Tuam, Galway, Ireland. The two techniques are complementary. All areas were suitable for investigation by GPR. The magnetometer was used where practical due to the interference posed by adjacent metal gates and since not all man-made surface materials allow accurate gathering of data. In addition, Electromagnetic Location (EML) techniques were used to check for the existence of utilities in the area. This report deals only with the five smaller discrete areas defined in Figure 1. The area of the playground will be the subject of a second volume in view of its size and complexity, especially as regards surface obstacles.

The magnetometry results and a selection of GPR time slices have been used to illustrate the location of geophysical data relative to the current physical layout of the site. The drawing TuamGeo_01 therefore forms a part of this report.

The GPR data shows evidence of disturbance in certain areas, notably along the two sections of road to the South of the site and revealed the outline of a number of former buildings, particularly in the northern section of the road and the area of the car park.

There is evidence of a number utilities, most notably beneath the car park where the number, size, depth and complexity of location would be consistent with a building connected with water flow, e.g. a pumping station (e.g. Figures 44 and 45). There is also evidence for potential utilities beneath the three road sections (Figures 11, 14 to 16 inclusive, 25), confirmed in one instance by the magnetometer (Figure 57). These do not appear to be functioning in all cases but there will have to be a check made on the positions relative to some of the current housing to the West of the main site. Both conductive utilities detected cross Road 2 (Figure 60)

Neither GPR nor magnetometry can define the load bearing properties of subsurface material, and it is not possible in all cases to distinguish voids from other strong signals such as those returned by water or metal. However, the main area affected by voids appears to be the memorial garden. Both GPR and the magnetometer identified the former excavation in the area of the southern drain associated with the former sewage tank. The GPR data suggests that there may be a similar feature adjacent and to the East. The magnetometer results identified not only the position of the sewage tank itself (No 2, Figure 59) but also a number of anomalous “hotspots” which may be significant.

Where possible an attempt has been made to identify the type of structure imaged in the geophysical data. This is not always possible and there are a considerable number of anomalous features which need to be checked against witness information, former plans and potentially (ultimately) by trial excavation.

Finally, it should be noted that, in spite of the good definition obtained in the data which is the subject of this report, there are inevitable constraints on using geophysical methods. This means that it is not necessarily possible to identify all subsurface material and potential hazards. For example, a radar can only separately

identify a target which lies at one wavelength from any other and is not obscured by other more strongly reflective material. It cannot identify targets which are less than 10% of the wavelength. For the GPR equipment used in this investigation, the primary energy is associated with a 25cm wavelength (measured in dry soil). Care must therefore be taken in excavating this site.

Acknowledgements

These surveys were carried out by EMC Radar Consulting working in partnership with Atlas Geophysical Ltd.

EMC Radar Consulting and Atlas Geophysical would like to thank Aidan Harte for his helpful practical support during the survey.

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Schmidt, A, Linford, P, Linford, N, David, A, Gaffney, C, Sarris, A and Fassbinder, J (2015). "EAC Guidelines for the use of Geophysics in Archaeology. Questions to Ask and Points to Consider" EAC Guidelines 2, Europae Archaeologia Consilium (EAC), Belgium. ISBN 978-963-9911-73-4.

Further Information

Given the dispersed nature of the remains detected in this series of surveys and the fact that the survey team did not have access to most of the detailed evidence concerning the use of the site, it may be necessary to check potential interpretations of the geophysical data.

Any queries arising from the content of this report or the GPR survey to which it refers should be addressed in the first instance to Mrs Erica Carrick Utsi, EMC Radar Consulting.

EMC Radar Consulting
13 West End
Haddenham
Ely
CB6 3TD
Tel: 01353 741033

Appendix

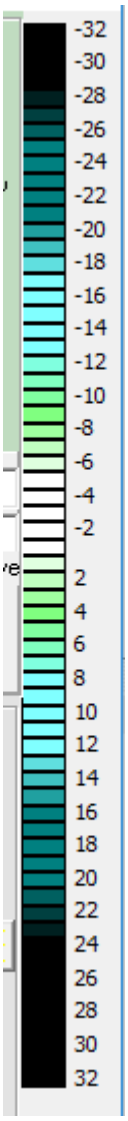

Figure 61: Colour Scale used to Depict Signal Amplitude in the GPR Time Slices

EMC Radar
Consulting

atlas
geophysical

Geophysical Surveys

of

The site of the former Mother and Baby Home in Tuam,

Co Galway, Ireland

For

Minister Katherine Zappone,

Department of Children and Youth Affairs,

Leinster House, Kildare Street, Dublin 2.

Report 2 of 2

Final: 14th September 2017.
Draft issued 5th September 2017

CONTENTS

SURVEY OBJECTIVE

In 2015, a geophysical survey of the memorial garden associated with the Mother and Baby Home in Tuam, Co. Galway, was commissioned by the Mother and Baby Home Commission of Investigation of Ireland, the purpose of the investigation being to locate the former cess pit and associated features. Witness testimony had given these structures as the burial location of a number of infants. The results of this survey were then investigated by trial excavation to confirm both the results of the survey and the original witness evidence. The excavation resulted in the discovery of human remains within one part of the foul water system.

The Department for Children and Youth Affairs, Ireland, has now decided to commission a further series of geophysical investigations to cover not only the memorial garden but also the remainder of the site of the former Mother and Baby Home for which there is public access. This site may be categorised as a playground, a car park, three sections of road and the memorial garden itself (Figure 1). The purpose of this series of investigations is to establish the location of any potential burials or underground features such as pipes or man-made drainage channels, in the process identifying the potential for further excavation and, where possible, to assess the subsurface for any Health and Safety issues should it be necessary to bring heavy machinery on to the site.

Figure 1: The Six Defined Survey Areas.

A report dealing with the first five survey areas i.e. three road sections, the car park and the memorial garden was finalised on 14th September 2017. This second report focusses on the area of the playground.

SURVEY STRATEGY

This area had not previously been surveyed. Ground Penetrating (or probing) Radar (GPR) was used to cover as much of the area as was feasible given the concentration

of above ground obstacles, primarily play equipment. The advantage of using GPR is that the technique has no difficulty in penetrating manufactured materials such as those used to cover the playground and can also be used on the grass surrounding the play area. Although close mapping takes considerable time to achieve, particularly over such a large area, the target detection is very much improved by using the radar in this manner.

Magnetometry and resistivity are both more suited to open ground. Magnetometry was also used in those areas suited to the technique. Resistivity was not used since trials of this technique proved ineffective in detecting the subsurface in this area.

Lastly, in order to test for buried utilities, electromagnetic location equipment ("CAT and genny") was used.

Use of Ground Penetrating Radar

GPR operates on the same principles as conventional radar except that it uses a wider frequency range, a shorter pulse, and a much shorter range of detection. The radar generates a short pulse which is transmitted into the ground via an antenna. The return signal is received by another antenna. The amplitude of the returning signal provides information about changing ground characteristics with depth. The use of the radar does not affect underlying deposits: it is non-destructive.

GPR cannot identify the nature of the material through which the electromagnetic pulses pass. The signals returned to the radar are the result of changes in the electromagnetic properties between two or more adjacent materials. The amplitude (strength) of the returned signals is a measure of the magnitude of the difference between these materials rather than being a characteristic of any one material.

The expected targets for this area were the remains of buildings and other associated features including buried pipes and potential voids. The overall brief includes the detection of potential graves and this cannot be excluded from the search. The constraints associated with the detection of these different targets were fully outlined in Report 1 of 2 and will therefore not be repeated here beyond noting that the detection of each type of target is subject to technical limitations associated with a) the wavelengths emitted by the radar and potential ambiguities in interpretation.

Equipment

The equipment used for these surveys was a GroundVue 3_8 in single channel mode with a 400MHz antenna.

A 400MHz antenna has a wavelength of c. 25cm in dry soil. Where moisture is present, the wavelength will be shorter. This is sufficient for detection of pipes and services, and, provided that they are detectable, locating most graves. It is also a suitable frequency for the detection of building remains (cf the section dealing with the Car Park in Report 1 of 2).

Site Conditions

Although it was possible to survey with GPR across the playground, the surface conditions were not ideal. It is important to maintain good contact between the antenna and the ground surface for efficient transmission of the radio waves into the subsurface. The actual surface of the playground was sufficiently smooth for good signal transmission but the play equipment, benches, tables and trees all formed surface obstacles which had to be worked around. As a result, there are gaps in the data (shown as white areas in the time slices, plain grey in the 2-dimensional data) where it was either not possible to survey or not practical to do so, taking into account the overall images required and the length of time necessary to carry out additional measurements for accurate compilation of images of the subsurface.

Should any of the data from the excluded areas be deemed essential, it will be necessary to remove all surface obstacles before any ancillary survey work can be carried out.

Site Coverage

In order to optimise detection and maximise the information obtained by the GPR, survey lines were completed at a transect spacing of 0.25m. This is half the spacing required by the widely accepted guidelines published by Historic England (English Heritage, 2008). These guidelines were originally set as a compromise between the investment required to achieve the Nyquist requirement for full information and an acceptable level of information with a lesser use of resources. For this investigation, it is more appropriate to optimise the target definition because of the potential difficulties of interpretation given the sensitive nature of the investigation coupled with the history of re-use of the site itself. The 0.25m spacing complies with current European guidance (Schmidt et al, 2015). This is the same coverage applied to the other five smaller areas of investigation (cf Report 1 of 2).

Survey Parameters

A sampling interval of 27mm along the line of travel of the radar was set and the probing depth set to 50ns (approximately equivalent to 2.5m in dry soil conditions, less where moisture is present). These are the same parameters used in the five smaller areas of investigation.

Velocity Calibration (GPR)

GPR depths are measured in nanoseconds time because electromagnetic waves do not travel at a constant velocity. To translate this into depths measured in metres, it is necessary either to know the speed of transmission through the ground or to calibrate using either borehole information or curve fitting to hyperbolas (targets) in the data.

Curve fitting has been used to calibrate the transmission velocity of 0.1m/ns, indicating dry conditions in most of the subsurface in spite of the rainfall during the survey. This is not unusual where manmade materials such as asphalt and concrete cover the ground surface. There are small discrete areas in the subsurface where wetter conditions are indicated but, with the exception of the grass, these are

relatively few. Although 0.1m/ns has been used in determining the depths of the GPR information, where moisture is present, the actual depths will be overstated due to the slower transmission of the radio waves. This applies primarily to the areas currently covered by grass.

The Use of Colour in GPR Data

It is important to realise that GPR uses electromagnetic pulses (radio waves) and is not an optical technique. The amplitude of signals returned from the subsurface indicates a change of materials but it is a relative and not an absolute measure. As such, it does not and cannot usually be used as an indicator of the actual materials present. The stronger the signal, the more contrast is visible in the data. Similar colours (signal amplitudes) can originate from different combinations of materials. It is only legitimate to postulate continuity of a feature if that continuity is evident directly from the data and not solely on the basis of similarity of signal amplitude. For that reason, greyscale images have been used for analysis of the 2-dimensional data and no colour scale is therefore provided for these.

The 2-dimensional data is displayed in greyscale of black (strong positive) to white (strong negative). On this colour scheme, grey represents continuity rather than an absence of material. Black and white indicate anomalous material.

Colour has been used to illustrate the 3-dimensional data from which horizontal time slices have been extracted. On this colour scale black indicates a high signal amplitude (positive or negative). The darker the colour, the greater the difference between the feature and its surrounding environment. Light green denotes continuity with or similarity to the subsurface environment. A colour scale is included in the appendix to this report.

SURVEY RESULTS

PLAYGROUND (See Figure 1)

The playground occupies the major proportion of the site under investigation. The surface is primarily composed of construction material but there are also surrounding grass areas.

Fieldwork

The southern part of the playground was surveyed on Tuesday 18th July 2017 and the northern part on Friday 21st July 2017. Weather conditions were mixed but included heavy rainfall and wind. The rain will have affected the areas below grass rather than those with an artificial covering.

2-Dimensional Data

The 2-dimensional data is presented from West to East (left to right across the page). Three parallel survey reference lines were used. The distance between line 1 (to the West) and line 2 is 16m and from line 2 to line 3 is a further 16m.

The area is characterised by a dense concentration of mixed materials. Some near surface layering is visible and there are clear indications of possible building remains. Although there does not appear to be much material, if any, below c. 2m, there is evidence of a large number of discrete objects in the deeper levels which may indicate the presence of drainage channels, for instance, although viewed in the vertical dimensions these could equally well be signals returned from stray individual stones or the remains of other structures. The coherence or not of these signals as linear features can only be verified from the horizontal format of the data and then only if they are not wholly or partially obscured by other similar material.

That the area had a variety of buildings and relatively open spaces is suggested by marked differences in the evidence from the different areas of the subsurface. A good example of this is the comparison of line 11 from the northern half of the playground and line 12 from the southern half of the survey area (Figure 2). Line 11, the lower image, is packed with a high density of anomalous material, the overall outline of the distribution suggesting the possible existence of a very large pit. Along the base of this possible pit there are several large discrete hyperbolas which might indicate drains or foundations.

Although line 12 contains some similar signals, there is a pit outline which is much more clearly defined. This contains are far fewer anomalies and the data is primarily dominated by near surface layering (as evidenced by broad black and white banding). Line 11 lies along y = 27.5m and line 12 along y = 54m in the time slices.

Lines 14 (y = 26.75m) and 52 (y = 17.75m) from the northern half of the playground illustrate the variety of potential building material in the subsurface, including signals which might be reflections from drains (Figure 3). These latter are large structures. These lines also illustrate that it may not be possible to trace all utilities across the site due to the amount of similar material in the immediate environment. To be certain of distinguishing one object from another, the two targets require to be one wavelength (c.25cm in this instance) apart. If this separation is not present, both objects are likely to be represented by a single hyperbola.

Almost all of the radargrams suggest the presence of a wide shallow ditch or pit running across the site in an approximate North/South direction. This can be seen in Figures 1, 2 and 3. Where there are clear boundaries, these start a few metres to the West of marker 1 and continue past marker 2, sometimes as far as marker 3. In other places, it is the outline of the material contained within the ditch or pit which defines its extent. For these latter cases, the depth is usually greater (cf Figure 1). Figure 3 illustrates that parts of this ditch or pit have been backfilled with repeat layers of material. It is not possible to tell the nature of the material from the GPR data alone but the smoothness of the line across might indicate that a manmade material such as concrete or tarmac has been laid across the area (cf the evidence from the time slices below). It is possible that this might represent building material provided that the construction is intact at this depth. The lines would not be consistent with backfill from material from a former building as this would give a much more mixed effect. If concrete is present, there is no reinforcement as there is no evidence of rebars. The lower line of data shows evidence of ringing (or echo effects) which, from the strength of the signal could indicate metal in the bottom of the pit or ditch. Line 46 lies along y = 46m and line 81 along y = 37.25m.

There is a small area in the NE of the playground containing a grass mound. This has not been contoured within the data since it affects a very small proportion of the overall area. As a result, the data from this area shows what appears to be a subsurface depression. This is actually a reflection of the difference in height between the mound and the surrounding ground surface.

Beyond a general description, it is not possible to interpret these features solely from the vertical perspective.

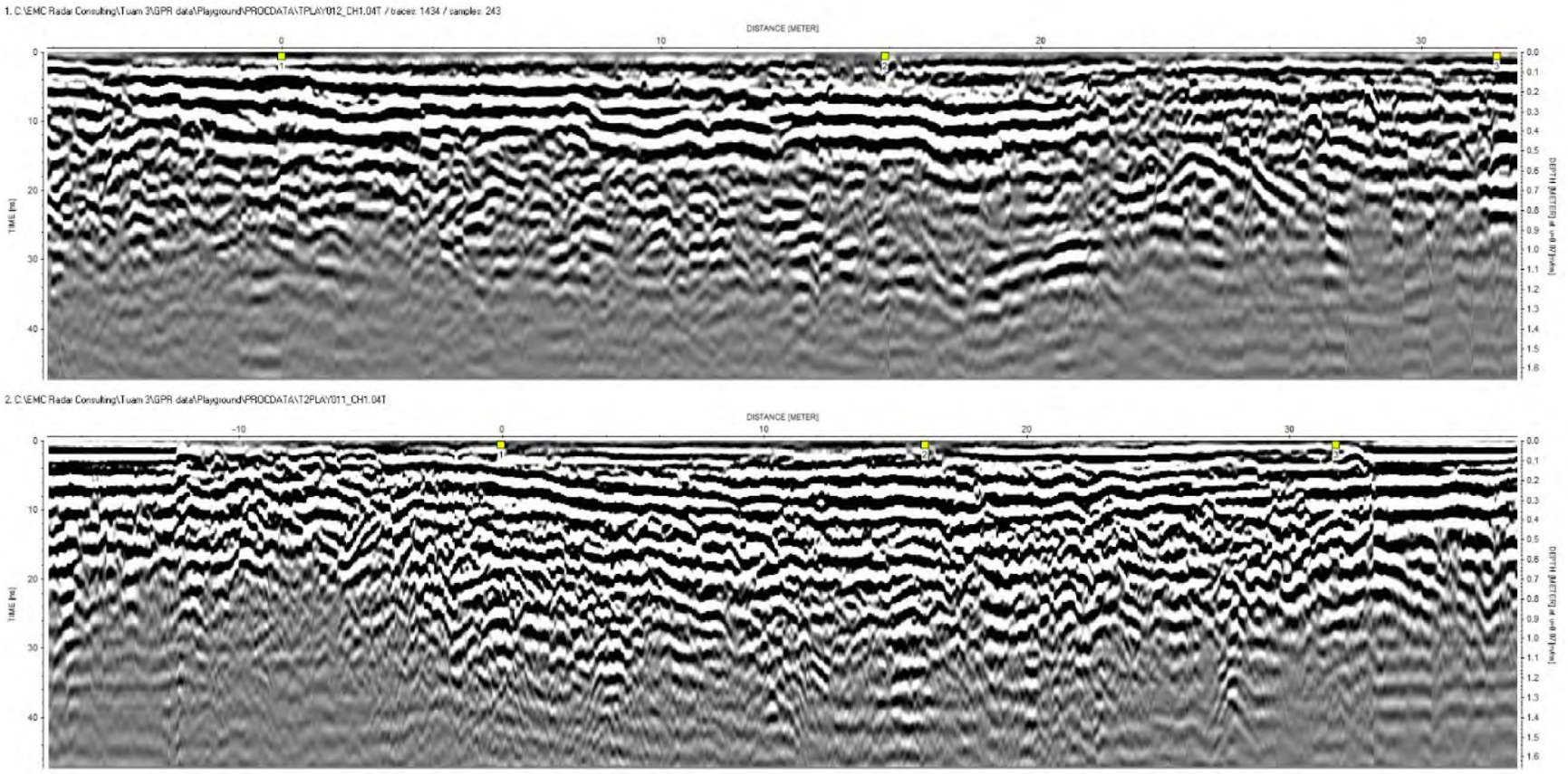

Figure 2: Survey data from lines 11 (North) and 12 (South) showing the variety of types of subsurface.

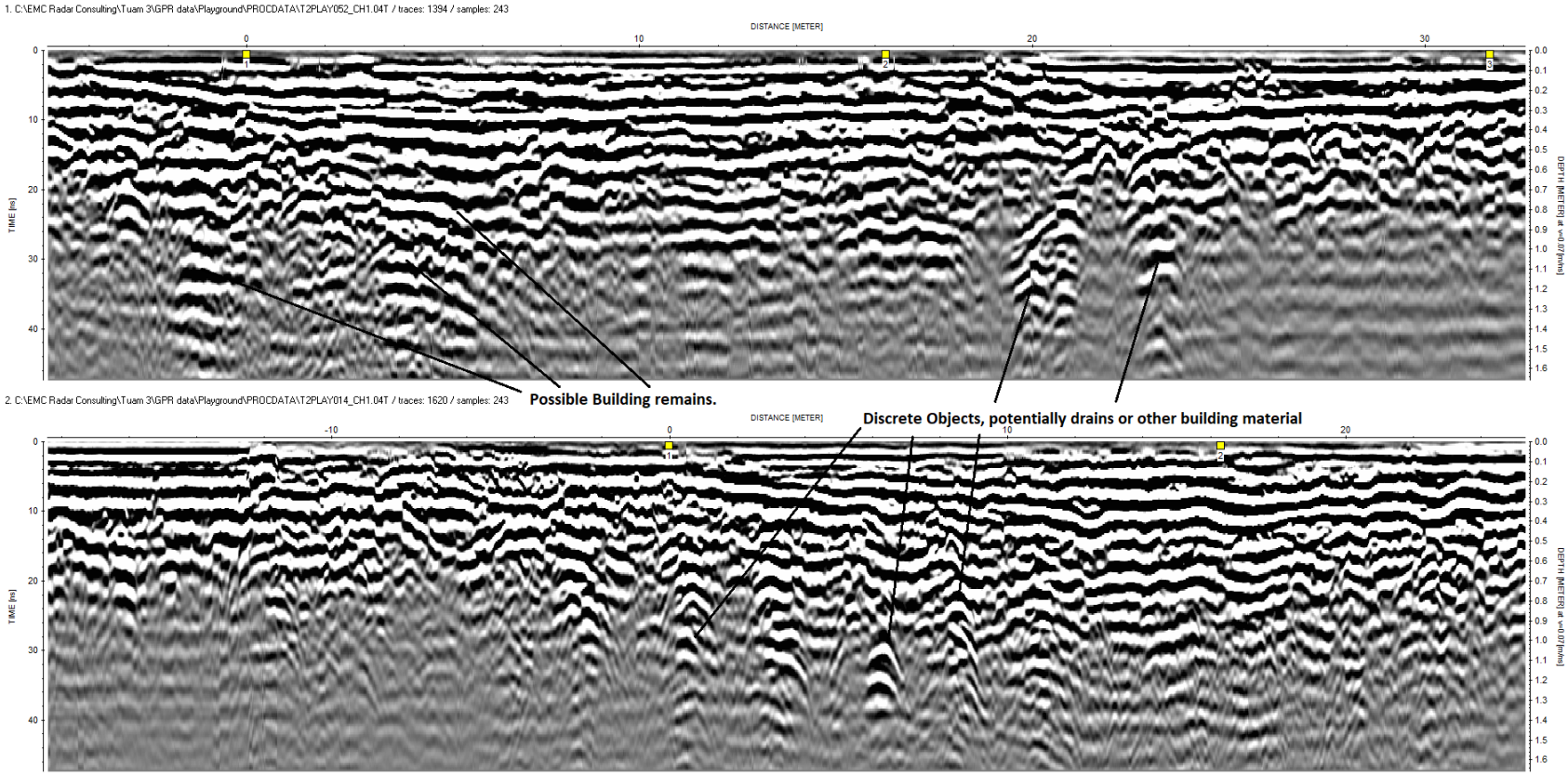

Figure 3: Data from survey lines recorded in the northern part of the playground.

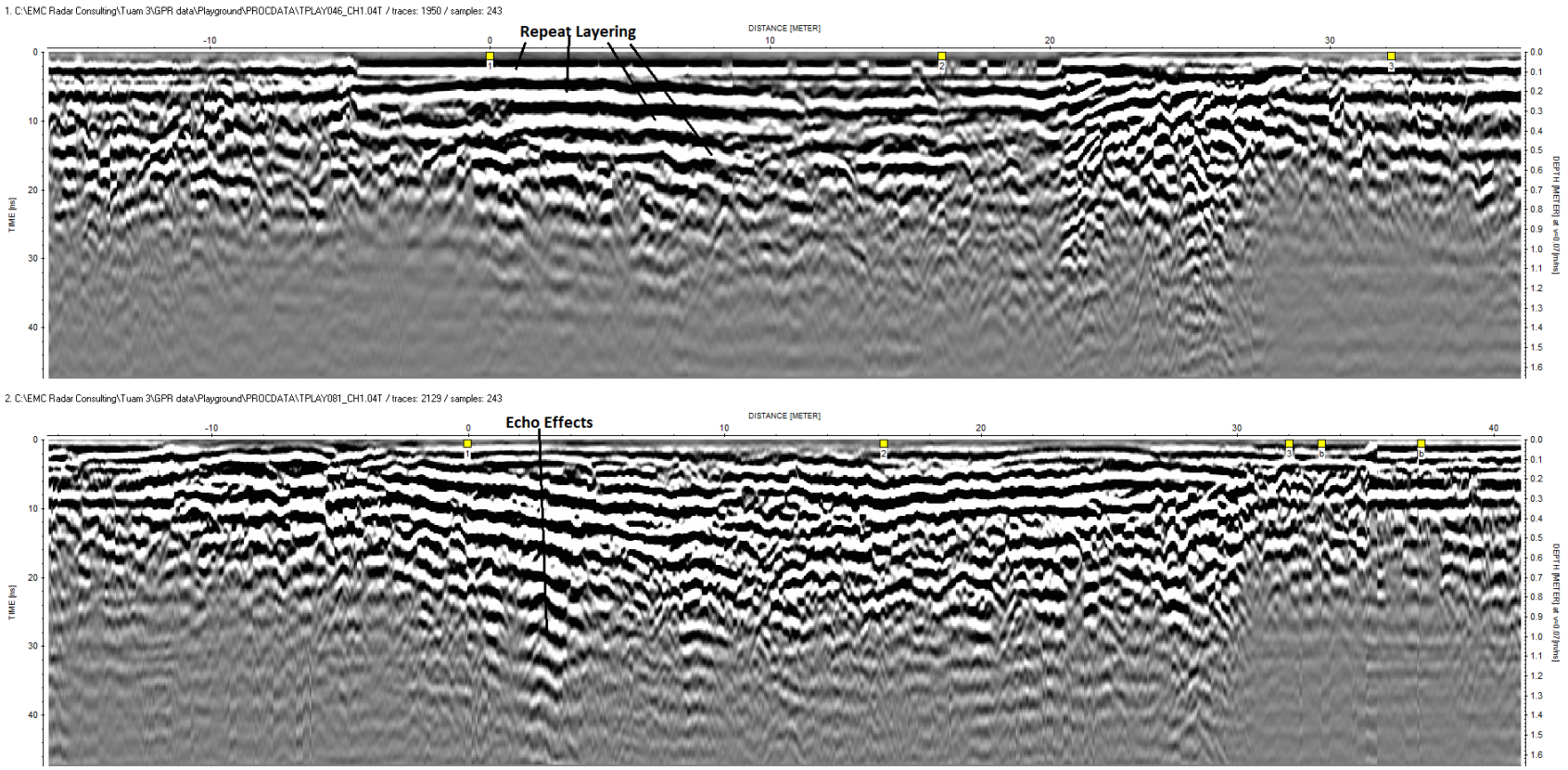

Figure 4: Data from survey lines recorded in the southern section showing repeat layering and echo effects.

Time Slices extracted from the 3-Dimensional Data

The 2-dimensional survey lines have been incorporated into a 3-dimensional data block on the basis of their relative positions along survey line 1. Time slices, in essence horizontal plans, have been extracted from this data block on the basis of changing patterns visible in the data. Where air gaps exist or moisture is present the view will be quasi-horizontal i.e. apparently horizontal but not physically so due to the differing transmission velocities in different parts of the survey area. Time slices have been selected on the basis of the change in patterning visible.

All horizontal time slices extracted from 3-dimensional data are presented with North at the top of the page and West to the left hand side. The x = 0 position marks the line of the 1st survey reference line i.e. it corresponds to the position of marker 1 on the 2-dimensional data.

Time Slice at 1ns (c. 5cm)

This depth is so shallow that any features showing in it are more likely to reflect the most recent construction rather than the former buildings on the site: see for example, the partial circle delineating the area of the swings on the NE side (Figure 5). However, there is evidence of a shallow drain at the South end of the area, indicated by red arrows in Figure 5. This turns through 90 degrees and crosses into the area of the memorial garden.

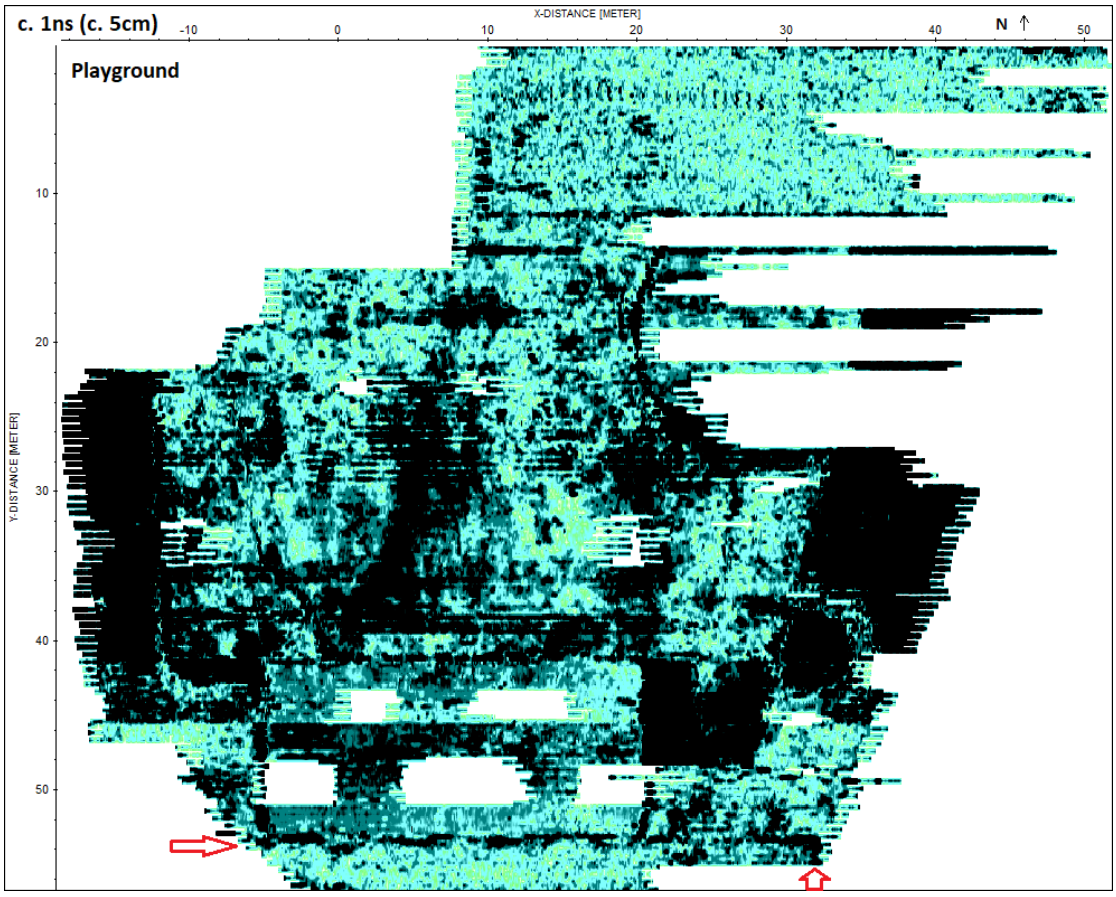

Figure 5: Time Slice at c. 5cm.

Time Slice at 3ns (c. 15cm)

This time slice is also very shallow (Figure 6). It has been selected because of the first appearance of straight lines, notably in the South and East parts of the area. Comparison with the 2-dimensional data suggests that this is primarily backfill, presumably to level the site for the current construction. The straight lines and the partial rectangular outlines that they form may therefore reflect former use of the site although it is possible that they are the result of redevelopment since they do not match the construction visible at lower depths.

The rectangular block along the western edge is probably a reflection of the slight rise when the radar crosses from the playground surface on to the grass at the side and the change in surface material.

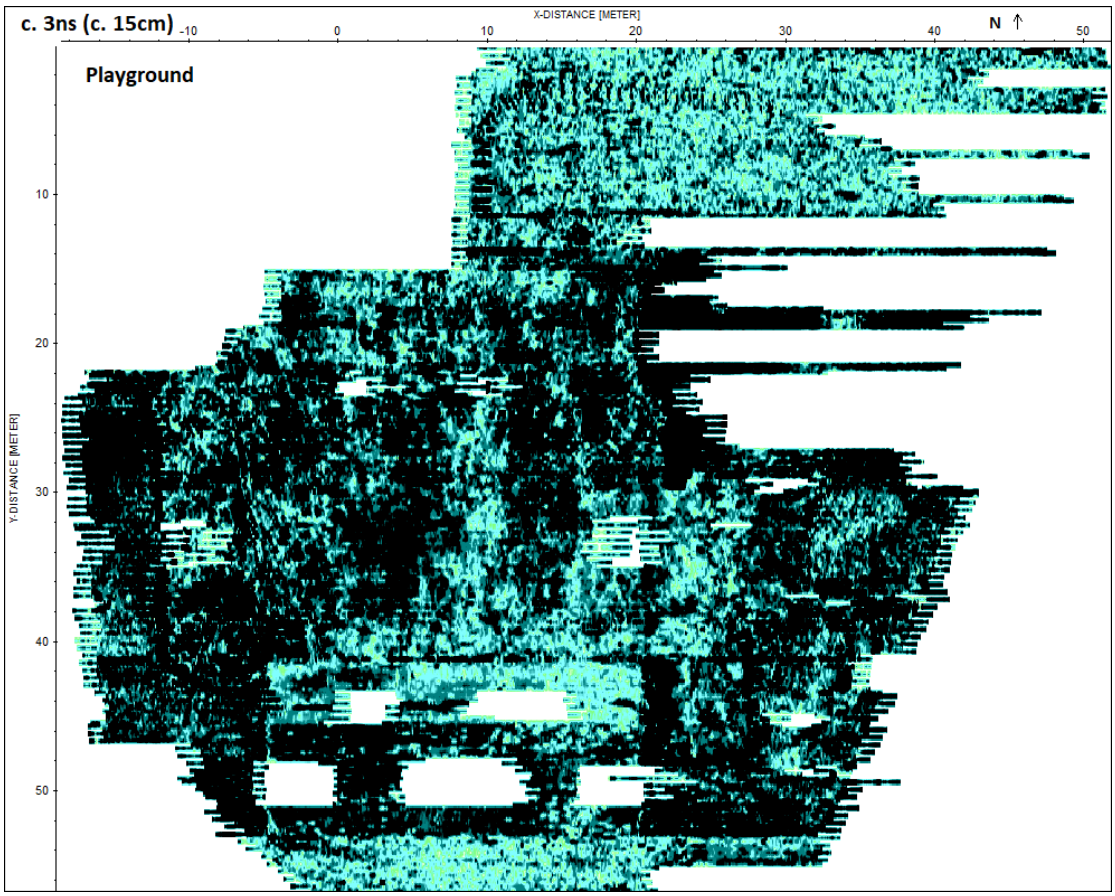

Figure 6: Time Slice at c. 15cm.

Time Slice at 8.2ns (c. 41cm)

At this depth, a rectangular outline with rounded corners appears to the South of the playground, beyond the apparent southern border visible in the previous time slice (Figure 7). From the horizontal image this looks as though it might be the remains of a boundary wall. The 2-dimensional data is consistent with this interpretation. The long part of the feature running approximately West/East corresponds to the long shallow layer signals visible across the potential ditch/pit in certain survey lines. This

vertical patterning can be obtained when the radar path follows along the principal axis of a linear feature such as a wall (or, for example, pipe). Unlike the majority of these signals, there is no repeat layering, implying a single feature rather than some form of backfill. The North/South arms of the feature correspond with signals which cross this pattern. It therefore seems very likely that this is a former boundary to the building remains which lie directly to the North of it.

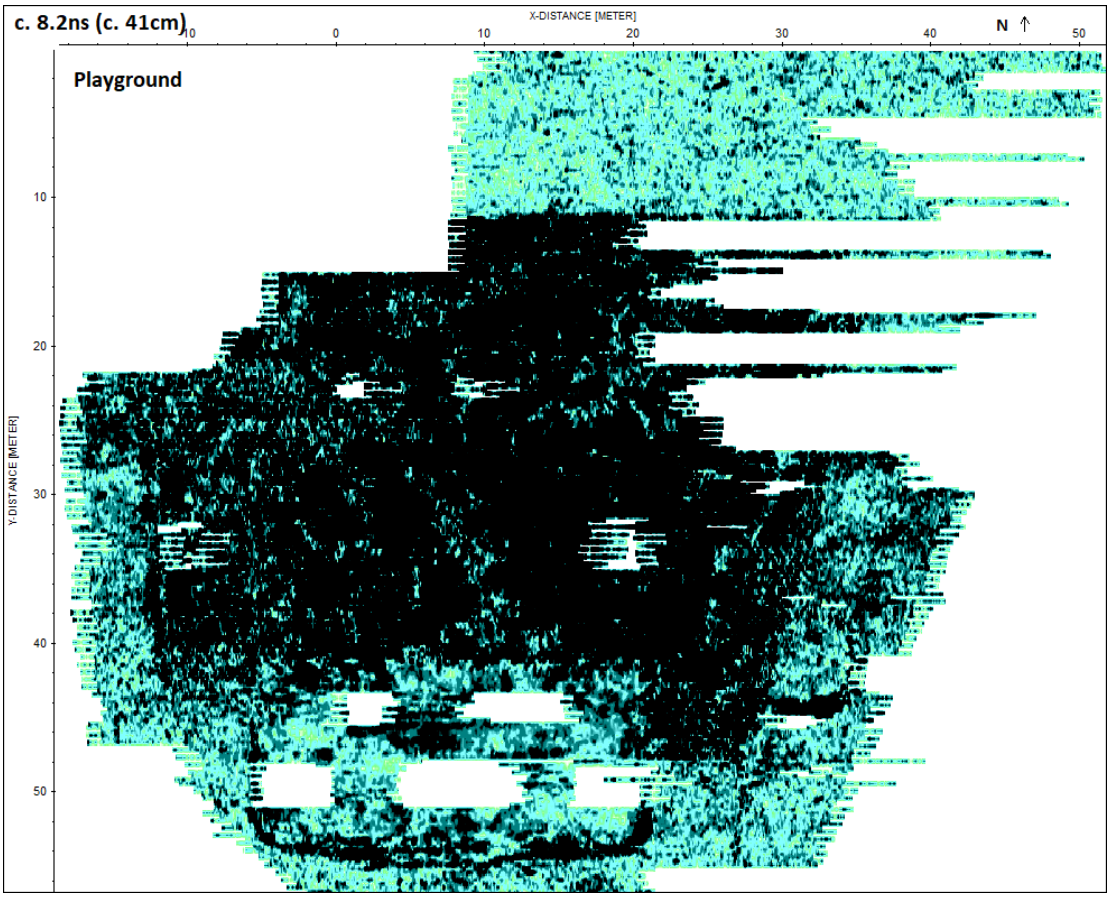

Figure 7: Time Slice at c. 41cm.

Time Slice at 13ns (c. 65cm)

This is the first depth at which the outline of former buildings begins to appear (Figure 8). The former southern boundary is still visible. Between 25m and 30m on the y-axis and stretching across the site on an approximate West/East orientation, there is the outline of a series of rooms forming a long building. There are also indications that the western edge of this building extends towards the South not only along the western edge but potentially also further East.

The 2-dimensional data shows distinctive "layers" within the subsurface which is consistent with a linear structure for which the radar path follows the principal axis of the feature below. This illustrates, as with the possible boundary wall, that many of the "layers" within the subsurface are not constructed backfill but the remains of construction, in this instance, a building.

The large volume of material which is serving as backfill across the site makes this difficult to distinguish. This implies that the materials used for backfill are likely to

be the same as those remaining from the former building. It is likely that the destruction debris from the building has been used for backfilling.

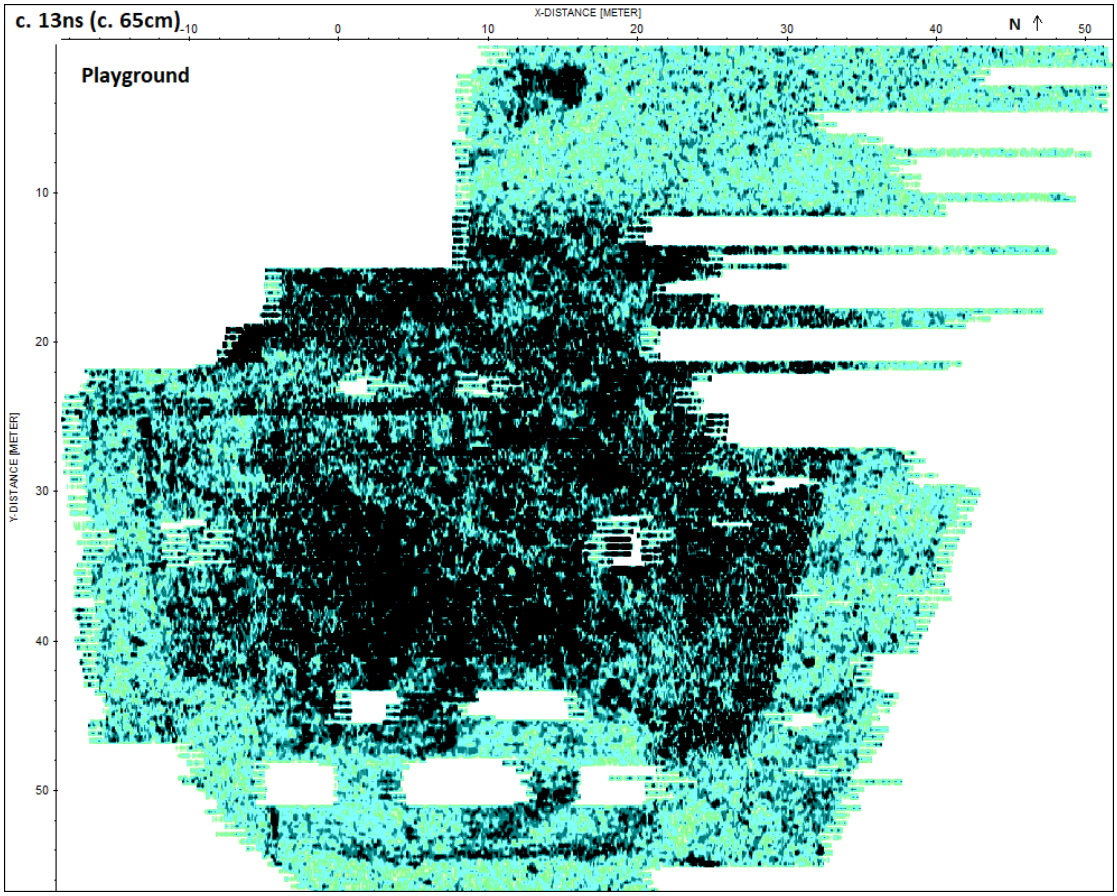

Figure 8: Time Slice at c. 65cm.

In the NW corner of the survey area there is a distinctive near rectangular feature measuring 4.3m by 2.1m. In the vertical plane, this is composed of layers of material. There is no other clue as to what this anomaly might be. As can be seen from Figure 8, it does not appear to connect with any other feature on site (but see also 94cm time slice).

Time Slice at 18.75ns (c. 94cm)

Going deeper into the subsurface improves the definition of the former building in outline and also the delineation of the internal divisions although much of the site is still obscured by debris (Figure 9).

In the NW corner, there is a linear feature which follows the same path as part of the rectangular feature in the previous time slice before turning through a right angle. This is part of the same feature. It is very likely to be a pipe connecting to the building within the car park, tentatively interpreted as being the former pumping station (Tuam Geophysical Report 1 of 2). The rectangular feature observed in the previous time slices is therefore part of the same system. It is not clear if the feature observable in the 2.2m time slice is related but it is highly probable.

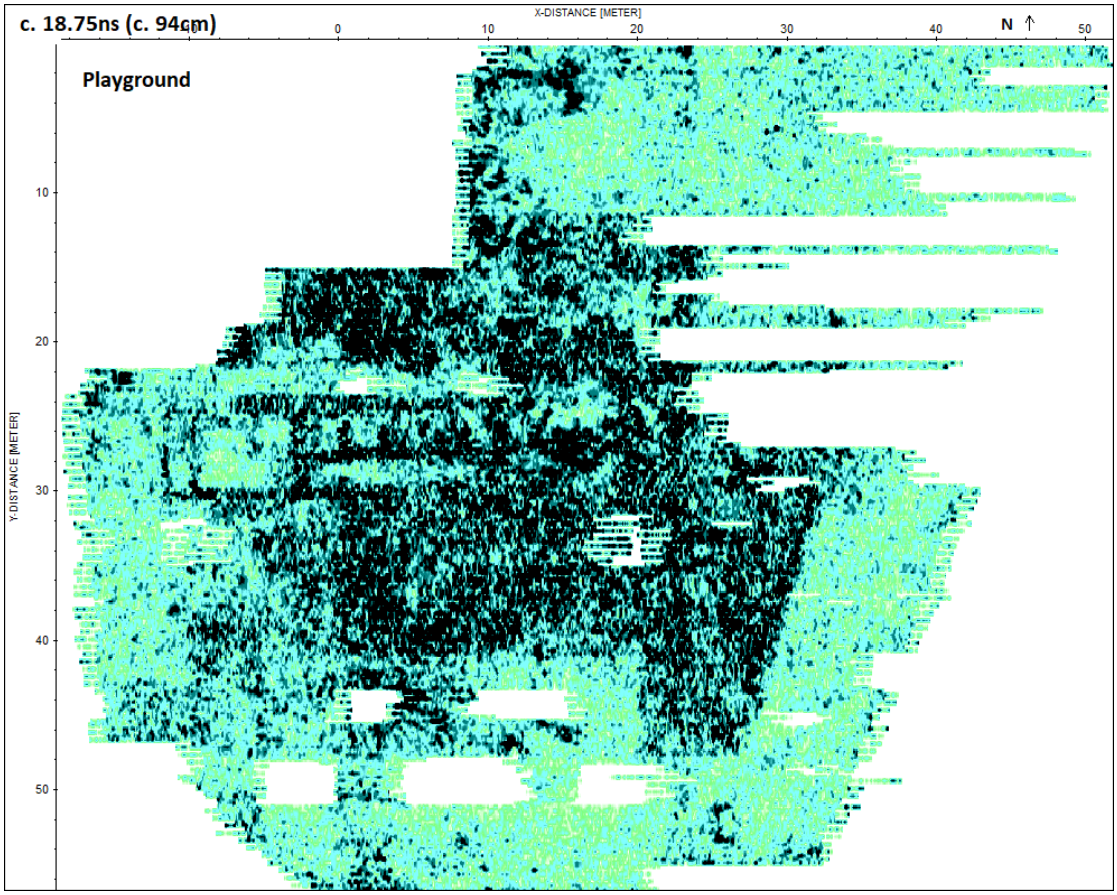

Figure 9: Time Slice at c. 94cm.

Time Slice at 22ns (c. 1.1m)

The building continues to be the dominant feature in this time slice (Figure 10). A rectangular, possibly L-shaped, addition to the building has now become visible, leading southwards along the x = 3m line from y = 30.6m to at least y = 37.4m. The other "arm" of the L lies directly to the South of the previously observed building plan.

The southern site boundary, interpreted as the footings of a wall is no longer visible. This is consistent with the interpretation i.e. the lack of depth of a free standing wall, relative to the greater depth of footings required for a more substantial building.

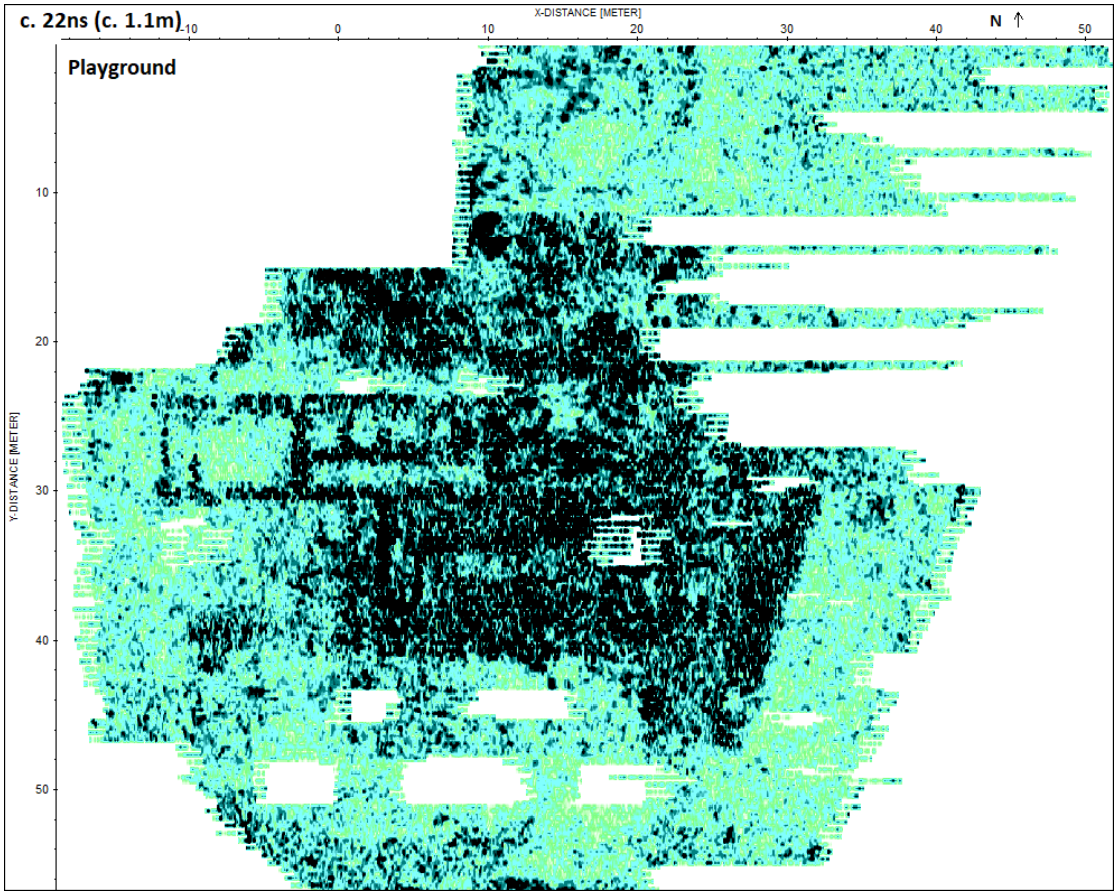

Figure 10: Time Slice at c. 1.1m.

Time Slice at 26.8ns (c. 1.34m)

A large linear feature makes an appearance at this depth, cutting across the North of the area covered by archaeological remains, marked in Figure 11 by an asterisk at one end and a red line at the other. Comparison with the 2-dimensional data reveals this to be a large object hidden within other material. There is a high probability, particularly given the depth of this feature, that it represents a section of a drain. It appears to be truncated at both ends although it is difficult to tell whether this is actually the case or not due to the enclosure around the remaining section of wall to the NW and the various items of play equipment on the eastern side which prevented survey of this area.

The only reason to think that this might be a utility rather than the foundation of a wall is the depth at which it becomes visible. However, part of a wall foundation is also a tenable interpretation. For a definitive answer, trial excavation or fitting the pattern to that of a previous plan, would be necessary. There does not appear to be any connecting features from this feature into either the first section of the road or into the memorial garden. It is possible that historical plans may assist with the interpretation.

The plan of the building is still visible and there seems to be an additional North/South line to the building, parallel to the extension noted in the previously time

slice. This is marked with a red "?" in Figure 11. At this depth, these features are likely to represent the remains of footings rather than the buildings themselves.

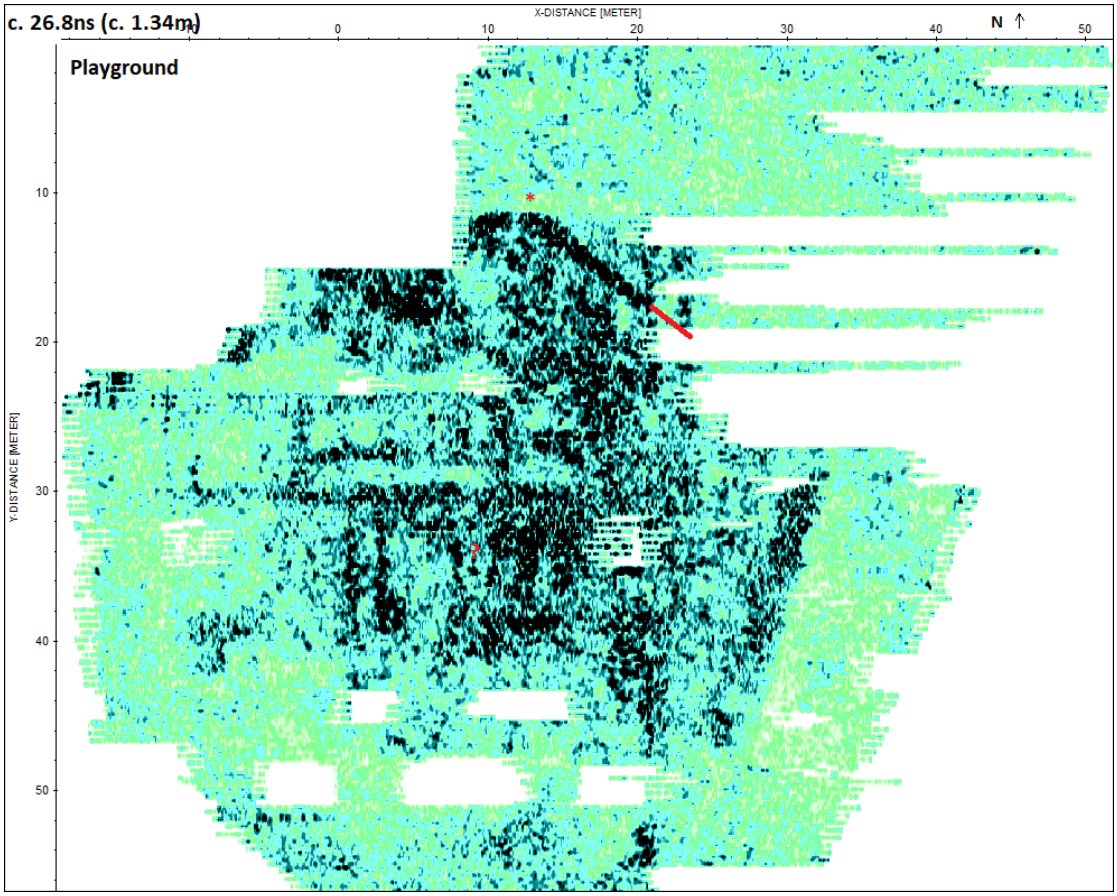

Figure 11: Time Slice at 1.34m depth.

Time Slice at 30.9ns (c.1.54m)

The outline of the building and its associated grounds (as evidenced by the spread of backfill) are still visible at this depth (Figure 12). The outlines are clearer, primarily because there is less debris this far down into the subsurface.

The northern linear feature which might be either a drain or a wall foundation is clearly visible. There is a possibility that it may turn through a sharp angle at its northern end although there is a clear break between the two linear features.

It is not possible to say definitively whether this feature also relates to the fainter traces of a similar line along the eastern side of the complex and the partial line to the South, partly because if this is the case, some of the material has been removed and partly due to surface obstructions. The 2-dimensional data confirms that these lines are made up of large blocks of material. However the outline of the northern feature is much more solid and more closely defined than those of the South and East and there is no evidence of continuity. If the features are continuous, the northern linear feature is more likely to be the foundations for a wall than a drainage channel but the evidence for this is not strong. Comparison with former plans of the area would be

useful but trial excavation is probably the only definitive method of establishing the nature of this feature.

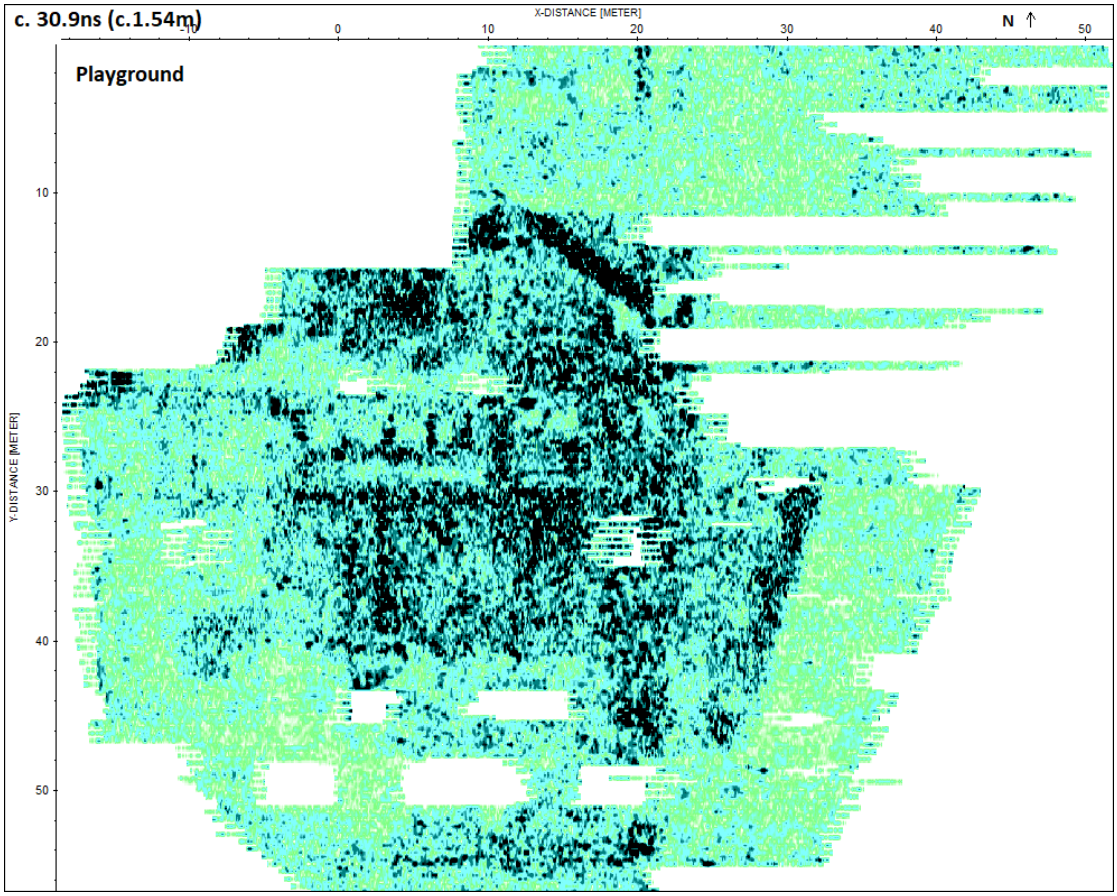

Figure 12: Time Slice at c. 1.54m.

Time Slice at c. 44ns (c.2.2m)

The building outlines are no longer clear at this depth although the area covered by potential building remains is unchanged (Figure 13). Directly to the North of the area of the building between x = 10m and x = 20m is the partial outline of a circular feature. Checking the individual signals out against the 2-dimensional data suggests that most if not all of these signals may actually be echo effects from above. The central dot within the possible circle lies directly under the small mound and is not necessarily related. This appears to be an anomalous object and not a particularly large one. The depth would have to be measured from the top of the mound (which has not been adjusted for the purposes of these time slices).

It is possible that the remaining elements of the circle are echo effects from a void or voids higher up. Normally an echo is identified because it follows the same outline as the original signal. In this case, it is not possible to identify a similar, stronger signal above so that these may be original returned signals but the faintness of the signals is suggestive of an echo.

The same is true of the other signals at this depth, not that they are voids but that they appear to be reflections of material lying slightly shallower in depth.

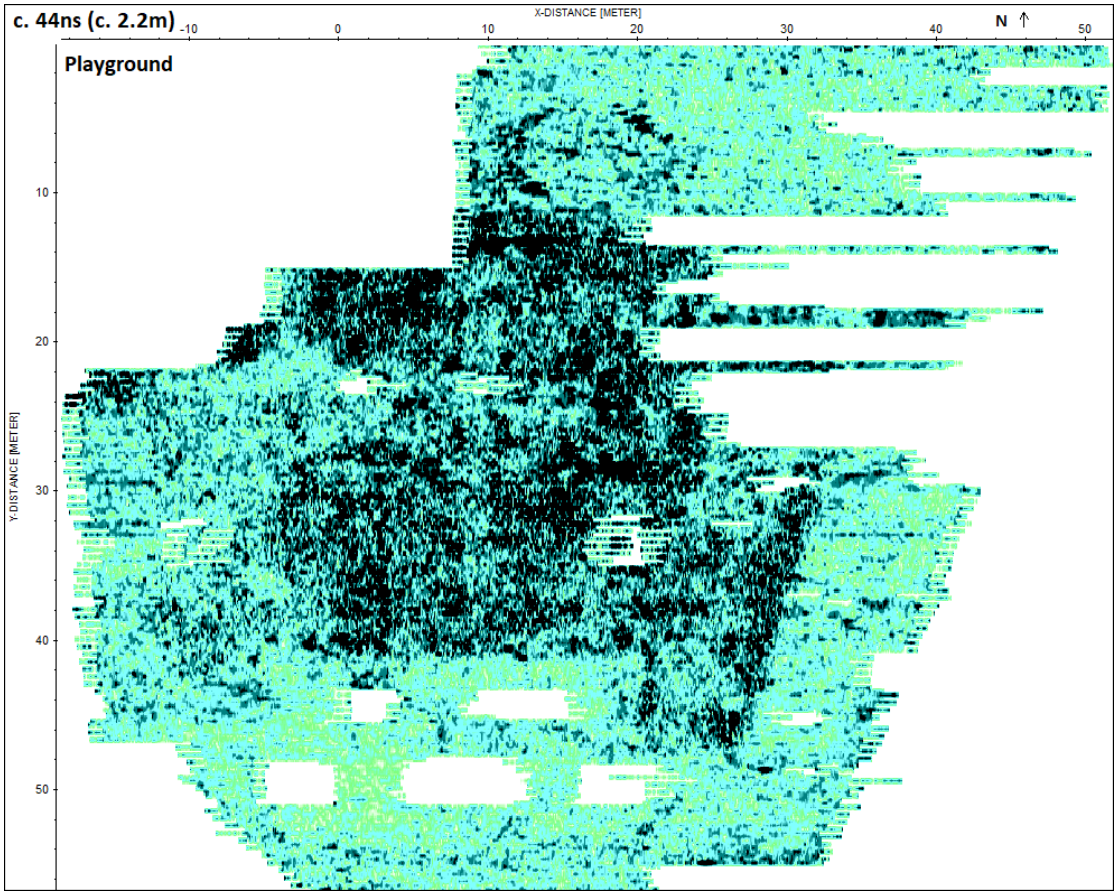

Figure 13: Time Slice at 2.2m.

Conclusions and Recommendations

The survey of the playground has revealed the position of at least one large building and some ancillary linear features whose identity cannot be definitively known from the GPR data alone. Comparison with former plans of the area is strongly recommended and trial excavation may be required to establish the original purpose of certain features.

There is some evidence of possible drainage. Again, this is not definitive. The archaeological remains visible in the time slices do appear to be constructed from building materials but although the backfilling of the site has allowed the outline of a building to be detected, it makes it virtually impossible to distinguish the continuity and the shapes of features that might allow the precise nature of different constructions to be determined definitively on the basis of this data alone.

There is an unexpected lack of connection with the former cess pit in the memorial garden, beyond a very shallow and presumably more modern drain (Figure 5). Although the GPR has not identified other utilities in the area, this may not indicate a lack of such features since, if they do exist, they are very likely to have been rendered undetectable by the large amount of former building material cluttering the site. The only obvious voids are in the grass area to the East of the Car Park. It is not possible to tell whether these do not exist or whether the crowded nature of the subsurface has obscured them from detection.

Magnetometer Survey

The magnetometer used for the investigation was a Magneto MXPDA 5 channel system manufactured by Sensys (Germany) The system contains five fluxgate magnetometer probes spaced at 0.25m centres mounted to cart. Each probe has a range of ±10,000 nT is sensitive to 0.5V/μT.

The magnetometer uses a real-time kinematic global navigation satellite system (RTK-GNSS) to geo-reference each data point acquired. Spatial accuracy is typically ±10mm. Without this level of accuracy, the acquisition software will display a warning and prevent data capture.

Survey Strategy

The survey strategy essentially mimicked that of the GPR survey as was also done for the first four areas investigated (See Report 1 of 2). That first report includes the results of the magnetometry survey of the three road sections and the Memorial Garden (see Figure 1). This report gives the results from the four small sections that surround and form part of the playground.

Use of Magnetometry

Magnetometry is a passive technique whereby the measurement probes are measuring the deviation in the planet's magnetic field caused by subsurface anomalies. Such anomalies can be caused by the excavation and back-fill of a pit or grave, kiln fired material such as brick and buried ferrous objects.

Due to the sensitivity of the device, the anomalous magnetic response caused by hot-rolled asphaltic materials, as encountered on the paved play area~~)~~, saturates any subtle responses from anomalies beneath. After a short trial, it was deemed inappropriate to use the magnetometer on the paved surfaces.

Magnetometer Results

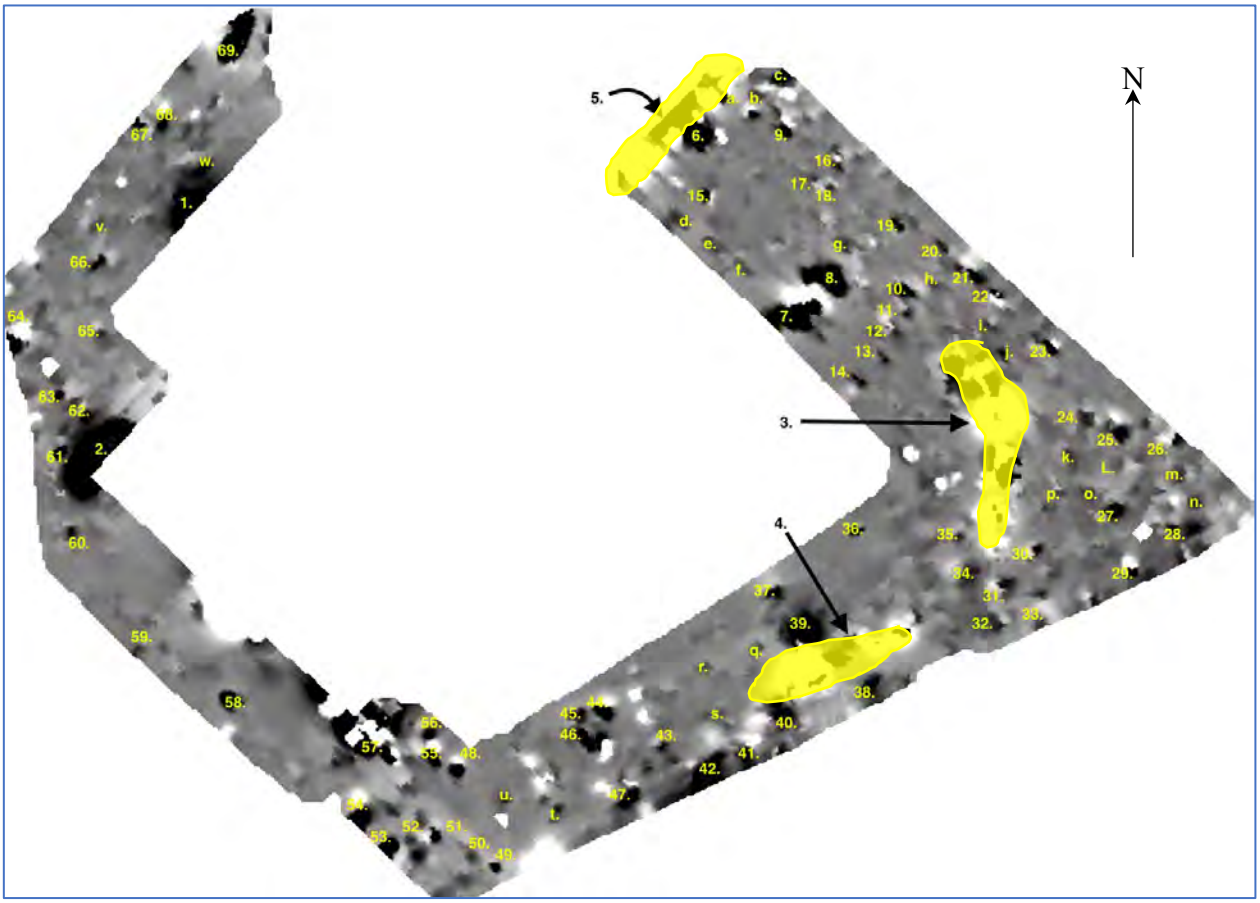

Figure 14: Magnetometer Results from the Grass Areas

The results acquired from the grass area surrounding the paved play area contained approximately 69 anomalous (noted 1. to 69. in Figure 14.) responses with a further 23 subtle, more ambiguous responses (noted a. to w.) that might require further investigation.

Responses 1 to 5 indicated in Figure 14 are from known sources including steel goal posts/basketball hoop, skateboard ramps, fences (no. 5 highlighted in yellow) and apparatus for children to swing from/climb on (no. 3 and 4 highlighted in yellow).

Responses 6 to 8 appear to be structural in nature. The response appears typical of building material, perhaps part of the demolished building that once stood on the grounds.

Responses 10 to 14, while small, approximately 1m x 0.5m in plan, are equidistantly spaced approximately 1.8m apart. Their repetitive response is unlike any other anomaly identified within this survey area.

Responses 15 to 37 appear random in nature and maybe caused by demolition debris or material introduced to the site when the housing estate was constructed.

Reponses 38 to 40 might be caused by the climbing frame although the peak response falls outside this the apparatus. It is possible these responses are backfilled depressions. A similar response was identified in locations 41, 42 and 47.

Responses 44 to 46 are surrounded by three park benches. These appear to be near surface anomalies consistent with fire or objects burned on the ground between the benches.
Response 48 is a cast iron gully/drain cover. The cause of response 55 and 56 is unknown.
Responses 49 to 52 lie outside the memorial garden and might correspond with drainage features leading to/from the memorial garden.
Responses 53 and 54 are unusually high amplitude responses and might be related to the stonework/concrete pillars at the gateway into the memorial garden.
Response 57 appears to be related to the ramps in the skateboard park.
Responses 58 to 69 appear randomly dispersed within the grass area. Estimated depths for these responses is between approximately 1m and 2m below ground level.

The 23 anomalous responses indicated with the letters a. through to w. are subtle and almost impossible to characterise individually. A targeted approach to investigate these locations further is recommended.

Conclusions of the Magnetometer Survey

The magnetometer survey has identified a considerable number of anomalies within the four grass covered areas surveyed as part of the playground investigation and outlined in this report. It is possible the locations indicated with letters (a. to w.) are little more than relics of the demolition process and subsequent construction of the existing housing estate. However, a representative sample should be excavated to ascertain the underlying cause of the responses.

Electromagnetic Utility Locating (EML)

This method is primarily used to detect and trace sub-surface utilities comprising electrically conductive materials. The principal equipment used in this type of survey are known as a CAT (Cable Avoidance Tool) and Genny (signal generator).
A Radio Detection RD8100 CAT and Radio Detection Tx10 signal generator were used for this survey.

The equipment can be used in two modes; Passive mode and Active mode.
Passive mode comprises of "power" and "radio" settings that are used locate utilities already carrying an electrical current or are conducting the ground wave of a transmitted radio wave and therefore generating their own electro-magnetic field.
The primary limitation of this mode is that it is often not possible to identify the nature of a utility when in "radio" mode.

Active mode involves using the transmitter (Genny) to apply an artificially generated electro-magnetic field to a service either by a direct connection using a clamp or by induction from the surface.

Direct connection provides the most accurate and reliable results however require direct access to a particular cable or pipe through a manhole.

Induction does not require access to a manhole but can often produce misleading results as more than one cable or pipe can be inducted at any one time and therefore a utility maybe incorrectly identified.

After a sweep of the entire site in the passive mode, only two responses were identified. A current was induced to the utility in these locations and traced.

The nature of the utility located was unknown but, due to the ease at which it carried an induced current, is likely to be a redundant cast iron water or gas pipe.
The locations of these two utilities are shown in **Figure 15.**

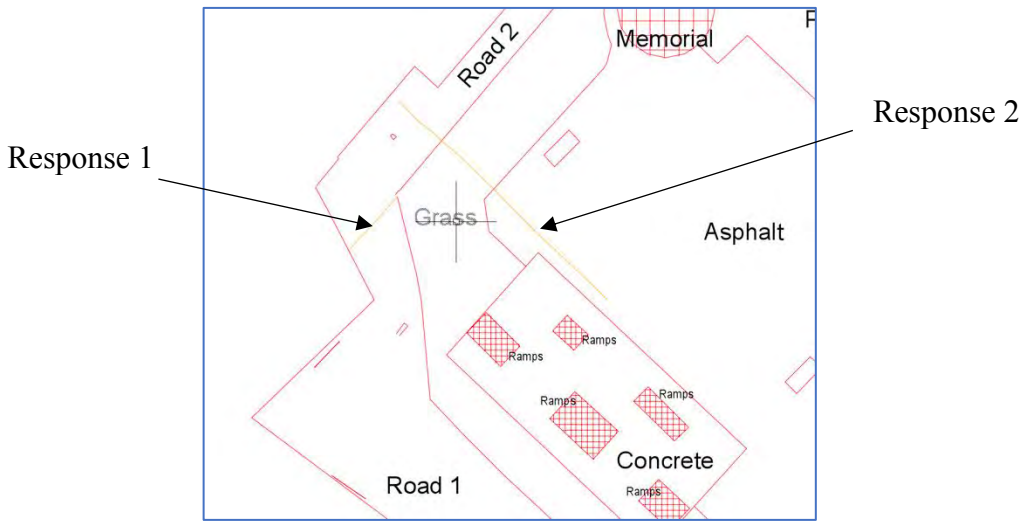

Figure 15: Location of EML responses

Note regarding Site North

The different methods of collecting and presenting data using the magnetometer and the GPR result in a slightly different orientation. For these investigations, magnetometer North is accurate but the GPR North is a "site North", equivalent to NE in terms of either true North or the magnetometer data.

Overall Conclusions of the Geophysical Investigation

The magnetometer and GPR results are essentially complementary because of the differing bases of detection. The geophysical results therefore need to be taken together where the surveys overlap. Their results are not, in any case, in conflict.

The surveys have determined the position and internal subdivision of a substantial building within the area of the playground. No significant voids or graves have been revealed but this is due to a) the dense volume of building debris with which the site has been backfilled prior to construction of the present facilities and b) due to the probable size of any burials. It is possible that burials may be found by association with the building remains and associated features. Due to the packed nature of the site, it will be essential to compare the geophysical results with historical site plans in order to confirm the interpretation of many of the associated features.

There do not appear to be significant voids within the playground subsurface. The impression given by the GPR data is of a densely packed site. The only indications of potential voiding were in the NW of the site, below the grass and immediately adjacent to the car park. For technical reasons, it is possible for voids to have remained undetected among the other buried anomalous material. It is not possible to use GPR to determine whether or not this type of backfill is sufficiently load bearing for heavy machinery to be used on the site. Care should therefore be taken in either excavating or in bringing heavy machinery on to the site.

Apart from the one very shallow drainage channel which leads into the area of the memorial garden there do not appear to be any connecting features from the playground into either the first section of road or the garden itself although both common sense (given the location of the cess pit) and the magnetometer results suggest that this must have existed. One possible explanation may lie in the linear feature first observed at a depth of c. 1.34m (Figure 11). If this feature did originally connect with the eastern linear feature at the same depth in spite of the gaps between them then it is possible that both form part of a former drain which could potentially have led in the direction of the former cess pit. However, it is to be noted that there is no extant connection visible in the time slices between these two features and the memorial garden and that the quality of remains is not the same between the two linear features. This may be due to destruction of the eastern section during the redevelopment of the site but could also be due to the central cavity being packed with building type debris. The possibility also remains that the two are not and were not connected. It is recommended that the nature of these two features is investigated by test excavation.

In the examination of the 2-dimensional data, there appeared to be a large pit or ditch of varying dimensions and with differing types of backfill lying along a North/South axis across the site. Examination of the time slices and comparison of the two suggests that this is not a single feature. Many of the outlines contain foundations from the former building on the site. Some of the shallower outlines probably relate to the reconstruction of the site rather than its former use.

Both the magnetometer and the GPR suggest the existence of structural features beneath the grass to the North of the survey area. These are likely to relate to the building interpreted in the first report as being the former pumping station, located beneath the car park. The magnetometer has also identified a number of small regularly spaced anomalies close by on the eastern side of these features which are likely to have an association with them.

The only extant utilities identified were located by EML in the SW of the survey area. There may be other utilities present which remain unidentified because of the dense packing of materials around the former building. Care should be taken when excavating.

The most significant results from both the GPR and the magnetometer surveys have been incorporated into the Drawing TuamGeo_01 which forms part of this present report along with volume 1 of the reports into the geophysical surveys of the site of the former Mother and Baby Home in Tuam.

Acknowledgements

These surveys were carried out by EMC Radar Consulting working in partnership with Atlas Geophysical Ltd.

EMC Radar Consulting and Atlas Geophysical would like to thank Aidan Harte for his helpful practical support during the survey.

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Further Information

Given the dispersed nature of the remains detected in this series of surveys and the fact that the survey team did not have access to most of the detailed evidence

concerning the use of the site, it may be necessary to check potential interpretations of the geophysical data.

Any queries arising from the content of this report or the GPR survey to which it refers should be addressed in the first instance to Mrs Erica Carrick Utsi, EMC Radar Consulting.

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Haddenham
Ely
CB6 3TD
Tel: 01353 741033

Appendix

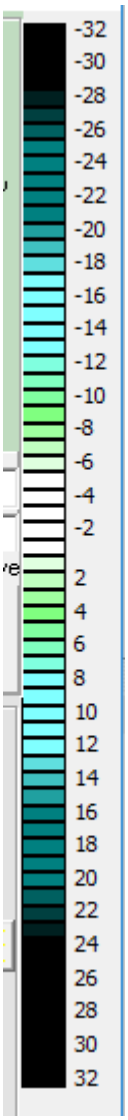

Figure 16: Colour Scale used to Depict Signal Amplitude in the GPR Time Slices

Appendix G – Consultant Engineers Report

DMA CONSULTING ENGINEERS

Project title & address

GROUND EXCAVATIONS AT THE FORMER MOTHER & BABY HOME SITE, TUAM, CO. GALWAY

Report Title

CIVIL ENGINEERING REPORT GROUND EXCAVATIONS

Client

EXPERT GROUP TO PROVIDE TECHNICAL ASSISTANCE TO THE DEPT. OF CHILDREN AND YOUTH AFFAIRS

DMA Consulting Engineers
Unit 14 South Bank,
Crosse's Green, Cork
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Revision 2 September 2017

Project Title:	Ground Excavations Review at the Former Mother & Baby Home Site, Tuam, Co. Galway
Project no.:	17043

Review History:

Description (type):	Rev:	Date:	Originator:	Checked by:	Approved by:
Civil Eng Report	P1	14/08/2017	I W	D M	D M
Civil Eng Report	P2	18/09/2017	I W	D M	D M

Issue History:

Description (type):	Rev:	Date:	Originator:	Checked by:	Approved by:
Report	P1	120/08/2017	I W	D M	D M
Report	P2	18/09/2017	I W	D M	D M

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List of Figures

1.0 Introduction

The former Mother and Baby Home site is located to the south east of Tuam, Co. Galway. The site of the home has been developed over the years and mainly consists of a residential housing development known as "Dublin Rd., Estate" which was constructed during the 1970s. This development is constructed around a green area which formed part of the Mother and Baby site which will potentially be subject to excavation works, in particular a walled memorial garden which is bounded by boundaries of the adjoining properties to the south, east and west. The walled Memorial Garden is believed to be the extents of a historical sewage tank serving the former Mother and Baby home.

This report will provide the Technical Group with a number solutions for the proposed excavation works within the walled Memorial Garden and surrounding areas of interest. Without detailed geotechnical information for the area it is not possible to provide a fully detailed set of design calculations, this report will make assumptions on soil and water conditions within the area and all assumptions will be highlighted within the report. It is advisable that a geotechnical company be consulted to undertake reports of the soil make up and level of the water table as these will impact on the design of any trench control required before any future works.

2.0 Site Location

The site is located within an existing estate known as “Dublin Road Estate” to the south east of Tuam, Co. Galway see Figure 2-1. This development was constructed during 1970s and bounds the existing Memorial Garden potentially subject to excavation works.

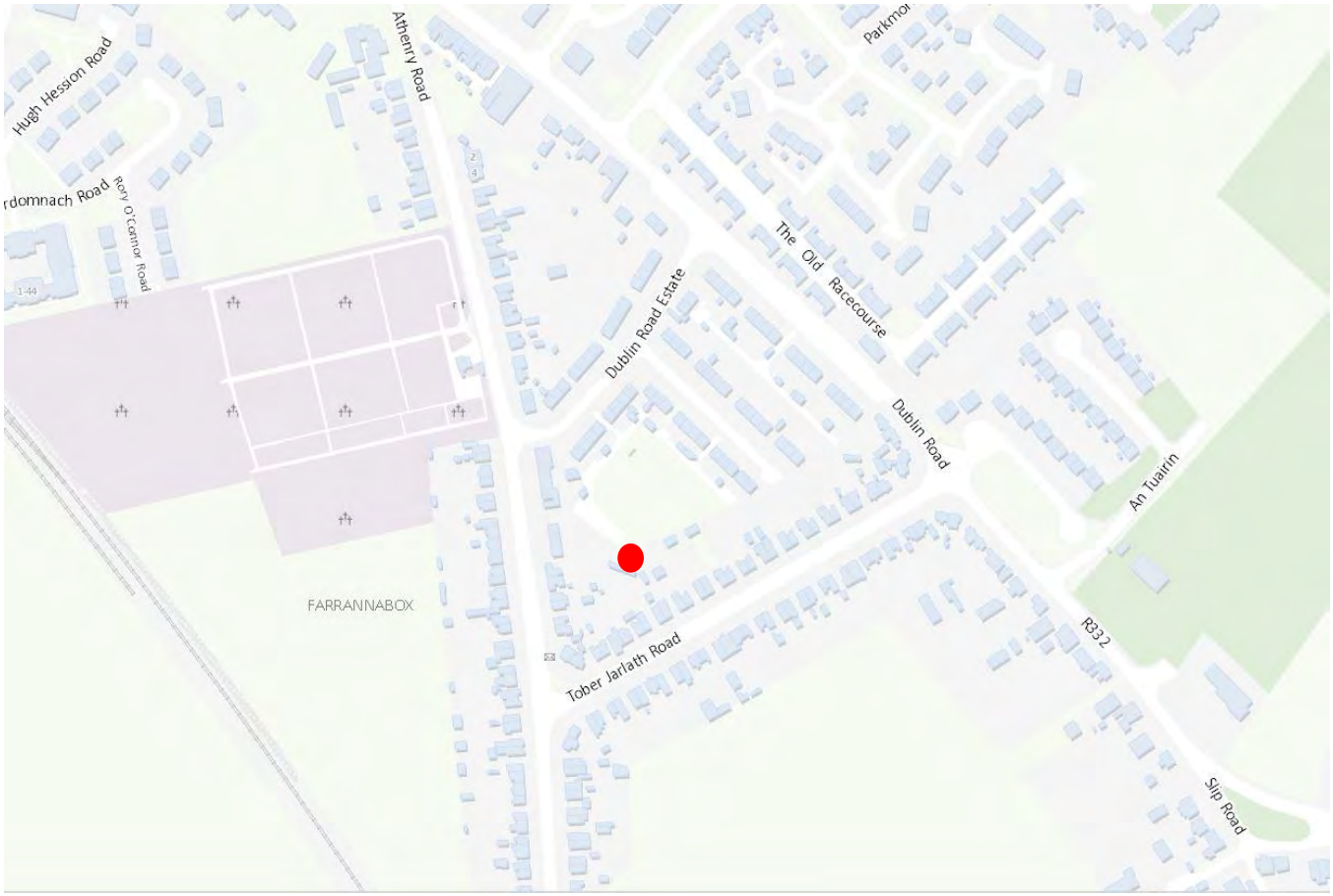

Figure 2-1 – Site Location Map – Memorial Garden Marked by Red Dot (Ordnance Survey Ireland, 2017)

The walled Memorial Garden is bounded by existing block boundary walls to properties to the south, east and west of the garden, these walls vary in height see Figure 2-2. The subject area under review is within the walled garden and in particular the footprint of the historical sewage tank dimensions unknown at the time of this report.

Figure 2-2 Walled Memorial Garden Site (Velvet News , 2017)

3.0 Design Assumptions

All design assumptions to be clarified prior to excavation works commencing on site.

3.1 Soil Details

Without detailed information on the composition of the subsoil and varying strata (e.g. depth of subsoil, made ground if encounter etc.), it is not possible to undertake calculations on the safe angle of repose for the soil. The safe angle of repose for a cohesive organic sandy clay is in the region of 26 – 34 degrees. For the basis of this report the angle of repose will be taken at 30 degrees.

3.2 Water Table and Surface Water Drainage

With no site investigation details presented, it is assumed that the water table for the area is 2.5/3.0 metres below existing ground level. With no details of the existing surface water infrastructure serving the surrounding hardstanding areas it is assumed by this office that the surface water drainage does not discharge into the area surrounding the excavations. Details of the existing surface water infrastructure should be clarified prior to any excavations commencing.

4.0 Excavation Locations and Proposed Methods

A number of areas are under consideration by the Technical Group and this report will break down these potential excavations into four distinct sectors. These sectors are as follows;

1) Area between boundary walls and the perimeter wall of the sewage tank,
2) Area on top of the existing underground chambers,
3) Ground between the internal wall of chamber and external wall sewage tank,
4) Other areas of potential interest

4.1 Sector 1

Sector 1 is located between the perimeter walls (south) of the historical sewage tank and the boundary walls of the adjoining property see figure 4.1. It is this office's recommendation that a number of small trial holes are dug to depths of 1 metre. This will allow future works to determine if this area is of interest and if further excavations are required to greater depths of 3 metres. Trial holes of this nature require little trench controls other than a basic trench box.

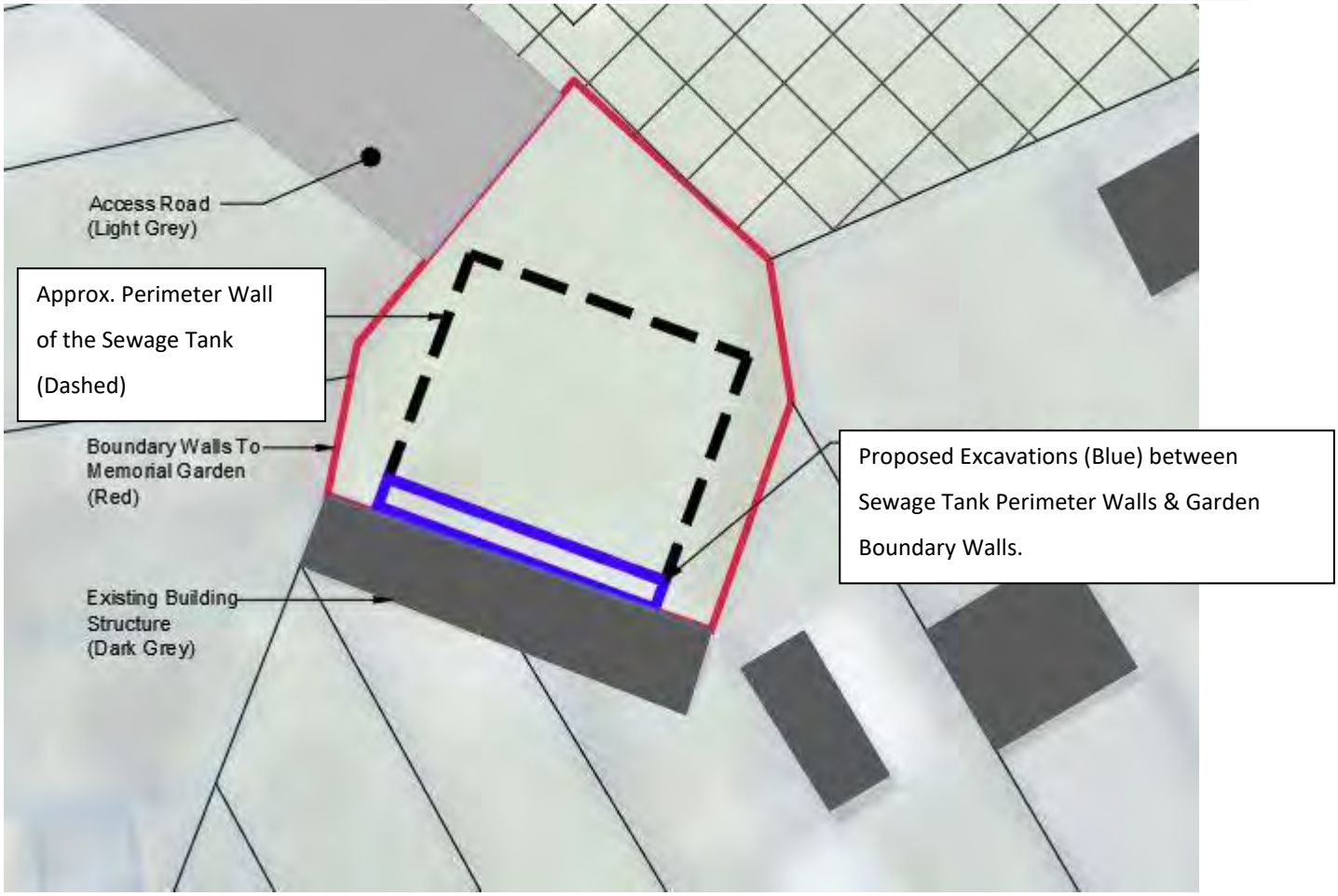

Figure 4-1 – Schematic of Sector 1, Area between Sewage Tank Perimeter Wall and Southern Boundary Walls

Should it be found items of interest requiring a larger dig to take place in this area then control of the excavation sides is important in particular working close to an existing boundary walls. Demolition of the existing boundary walls is considered the most cost effective solution as the trench sides can be safely battered back at 30 degrees. However homeowner approval is required prior to any demolition. Should this approval not be forthcoming then sheet piling is required to ensure the trenches are protected, while maintaining the existing boundary walls.

4.1.1 Excavation Methods

Option 1 – Remove the existing boundary walls to allow for the battering back of the trenches at 30 degrees, the natural repose of the soil see Figure 4-2.

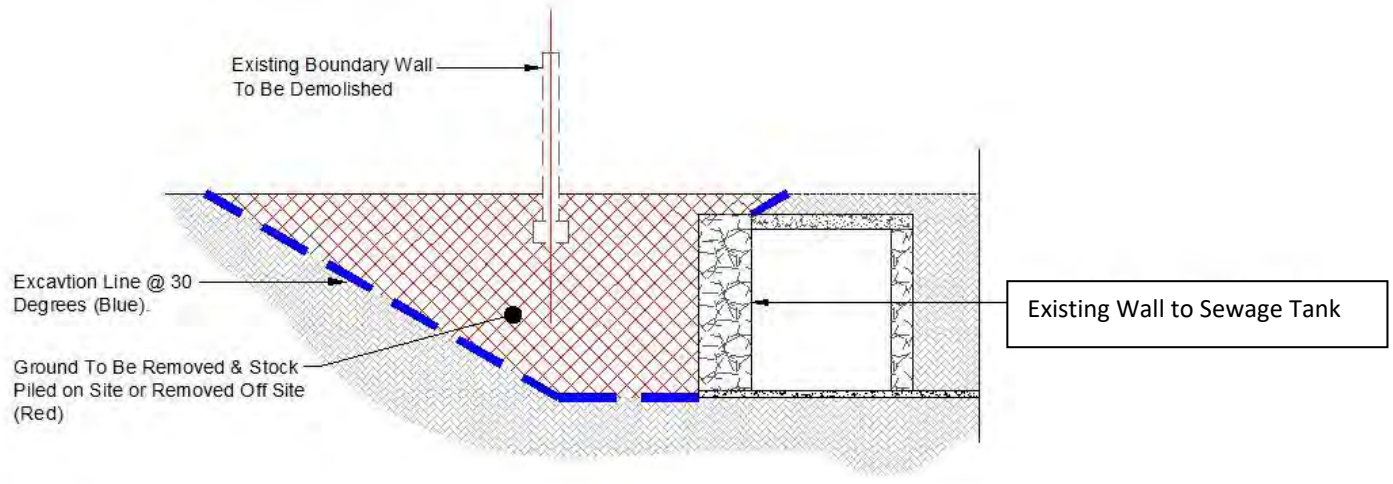

Figure 4-2 – Schematic of Option 1 – Slope Trench Back at Angle of Soil Natural Repose.

Option 2 – Install a temporary retaining structure such as steel sheet piles along the line of the boundary walls see Figure 4-3. The benefits of the sheet pile allow for the existing boundary walls to be retained during the excavation process and on completion of backfilling of the site the sheet piles can be recovered by the contractor. The depth and widths of the foundations supporting the boundary walls are unknown at the time of this report, it is advisable to dig a number trial holes along the boundary walls to determine the extent of the foundations if any.

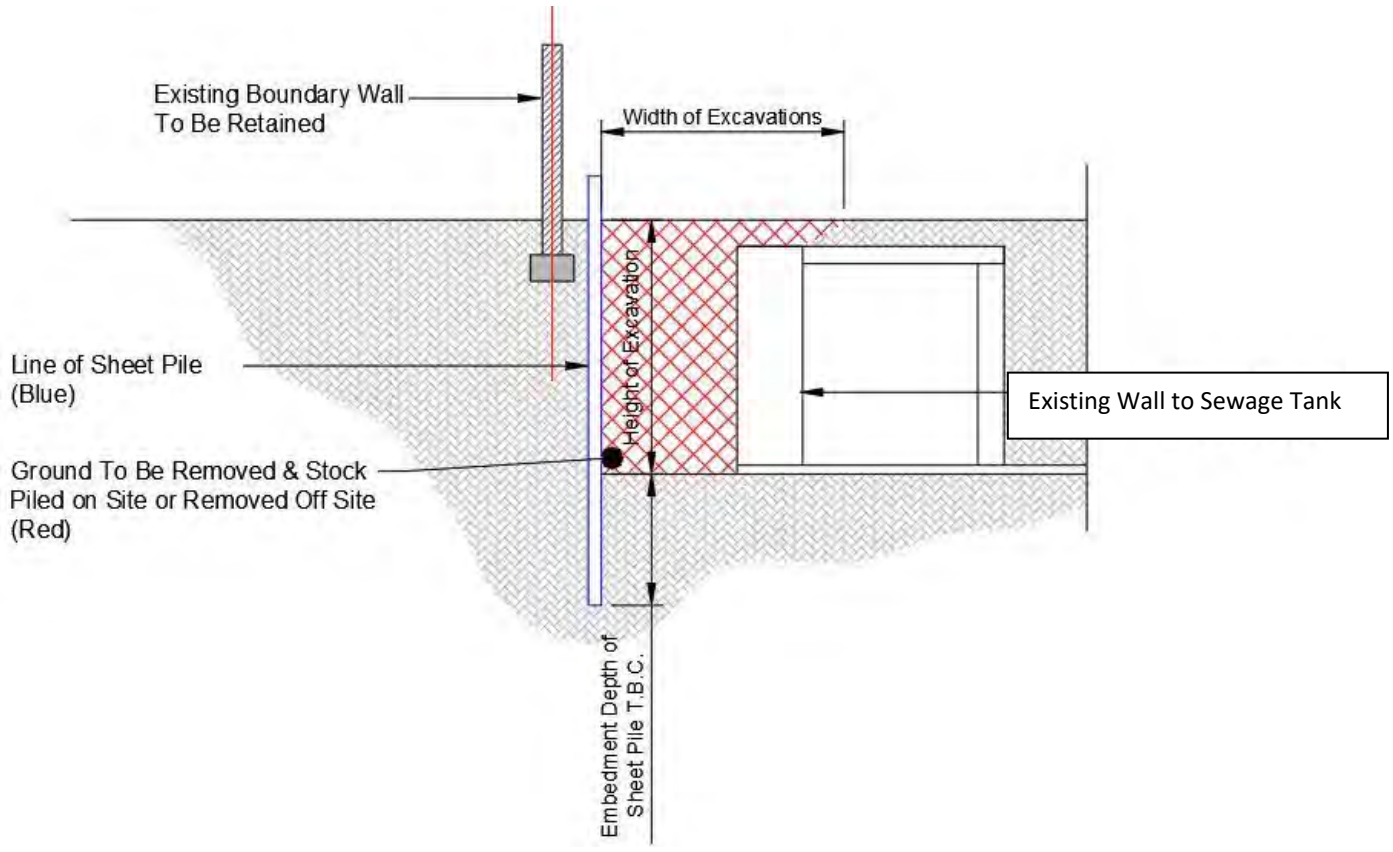

Figure 4-3 – Schematic of Option 2 – Steel Sheet Piling.

4.2 Sector 2

Sector 2 is located over the existing underground chambers approximated by the green hatching as shown in Figure 4-4. It is proposed to limit the excavations to the width of the chambers along the length of the sewage tank. The top of this chamber is closed off by means of a concrete, spanning from perimeter wall to an internal stone wall constructed within the sewage tank.

Access to each is provided with a rectangular opening. This opening does not allow the safe entry or exit. As part of the excavations of sector 2 the concrete slab is to be removed to allow safe entry into the chambers. Removal of the concrete slab allows for the internal dividing walls to be safely demolished.

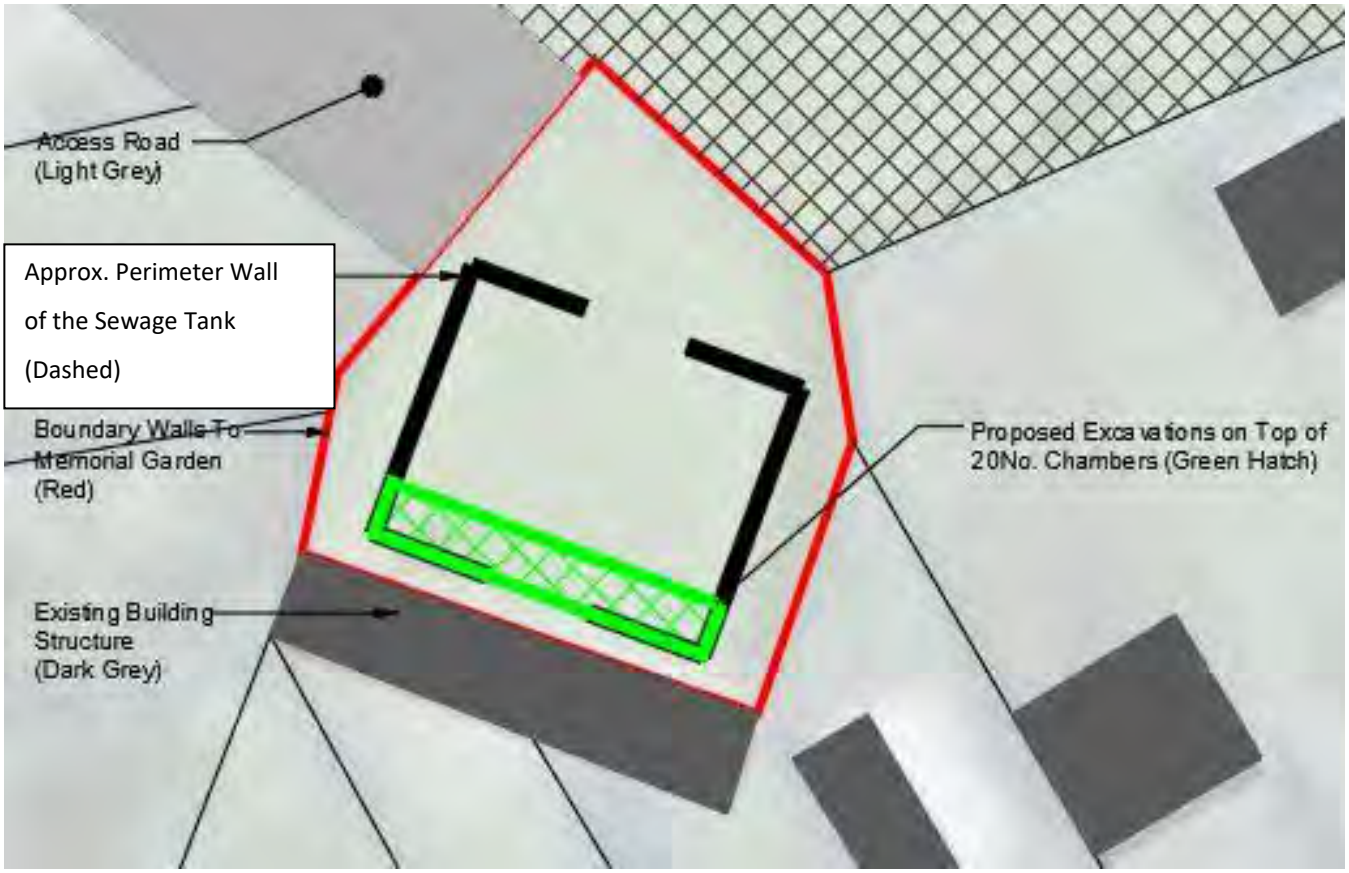

Figure 4-4 – Schematic of Sector 2, Area of underground chambers

4.2.1 Excavation Methods

The top soil above the chambers is to be carefully excavated to the top of the concrete roof slab. Due to the chambers being partially full it is important that the contents within the chamber remain undamaged during the removal of the concrete slab.

It is proposed that a safety screen or air bag protection system is installed below the concrete slab to prevent damage caused by any falling debris. The concrete slab is to be cut up into sections and carefully lifted by means of a suitably sized crane or excavator, ensuring no damage is caused to the sewage tank walls. The lifting of the slab can be achieved by installing a number of chemical anchors at various locations which will act as lifting eyes. A detailed survey of the existing concrete

structure is required to provide details on potential lifting points. A demolition company should be consulted to advice on the best actions.

4.3 Sector 3

Sector 3 comprises of the excavation for the entire plan area of the sewage tank see Figure 4-5. This is considered to be an area of potential importance for the completion of the excavation. Any excavation would likely be carried to the base of the sewage tank to a significant depth estimated 2-3 metres deep from ground level.

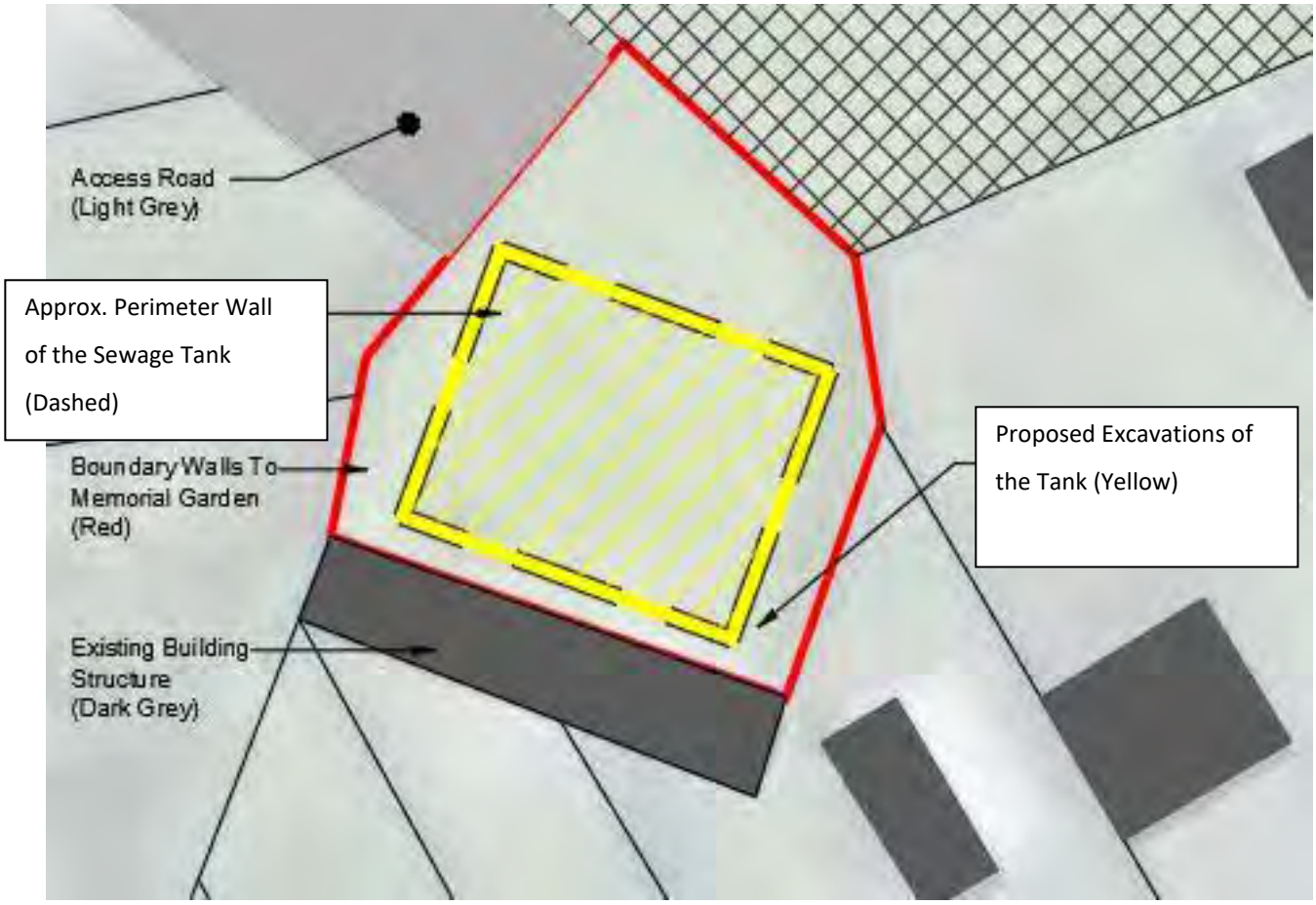

Figure 4-5 – Schematic of Sector 3, Area of Sewage Tank

4.3.1 Excavation Methods

Generally, the nature of such sewage tank requires the perimeter walls to retain the surrounding ground. These existing walls are considered as 'gravity' retaining walls by modern engineering description, where the weight of the wall provides stabilising resistance. The form of construction of these walls and their thickness is unknown at the time of compiling this report. A number of trial holes exposing the perimeter wall is required to determine its structural adequacy. If the walls are considered to be structurally unsound then the perimeter of the sewage tank requires additional geotechnical retaining design. The full area excavation may allow for an alternative access into the underground chambers and provides the demolition contractor access to install protective measures to safely remove the concrete slab.

Option 1 – The perimeter walls is considered structurally sound to allow for the full site to be excavated without additional geotechnical engineering solutions see Figure 4-6. The internal wall to the chamber is to be demolished in sections. Condition of this wall will determine the extent of demolition.

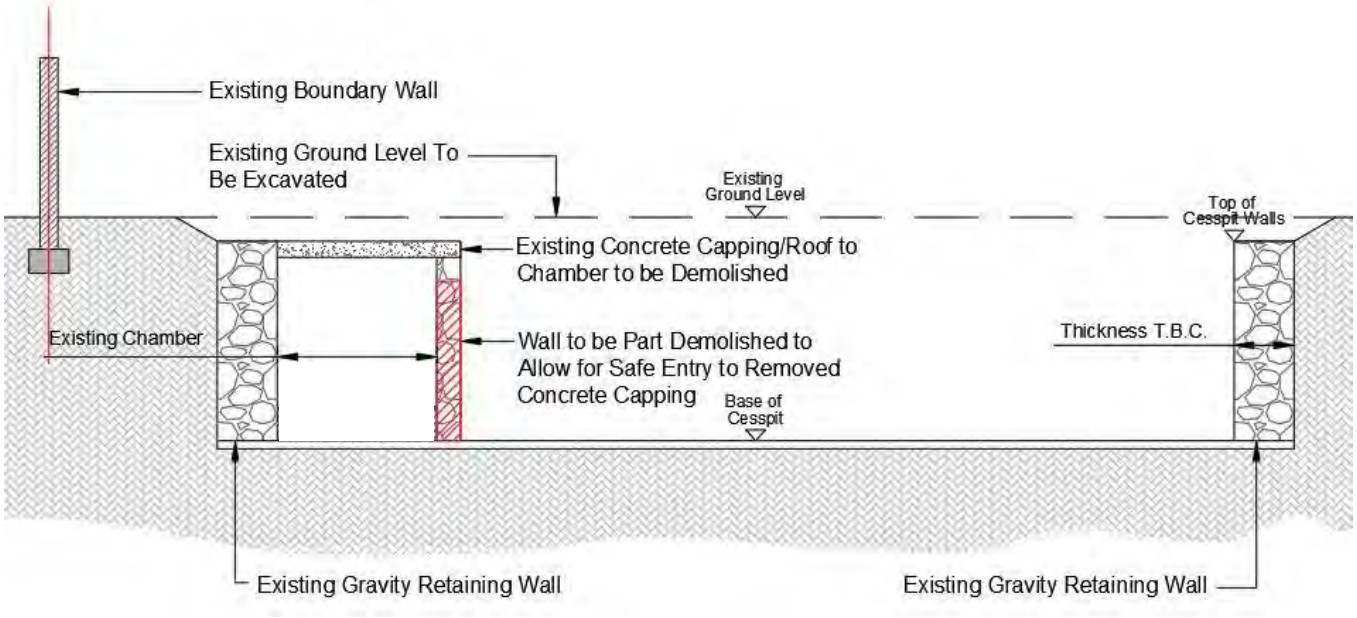

Figure 4-6 – Schematic of Existing retaining walls are structurally stable

Option 2 – The perimeter walls are considered structurally unsound to allow for the safe excavation of the site. It is then required to install steel sheet piling as previously noted within section 4.1.1 option 2. This may become necessary for the full perimeter of the historic sewage tank, see Figure 4-7. Stabilisation of the existing wall may be required on inspection of its existing condition.

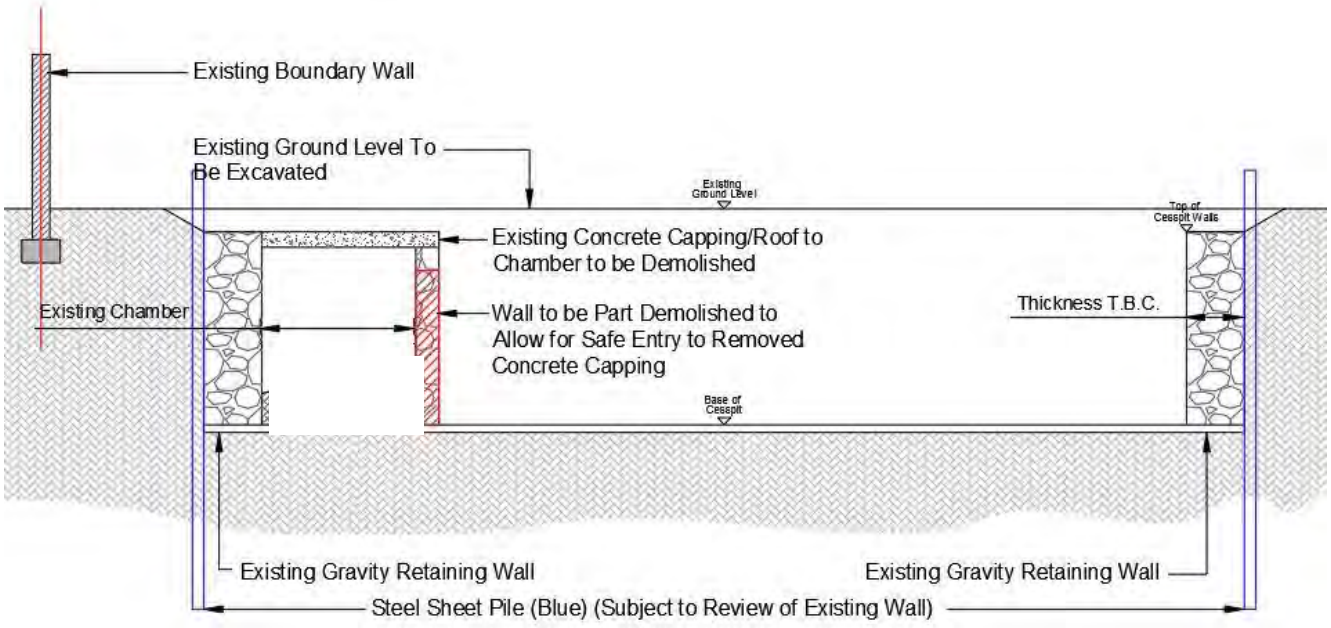

Figure 4-7 – Schematic of Existing retaining walls are structurally unstable and the installation of sheet piling (blue) is carried out

4.4 Sector 4 – Areas of Other Interest

Due to the scale of the former Mother and Baby home site the Technical Group has indicated the potential for a number of areas of interest outside the site of the Memorial Garden.

At this time, it is not known the exact extent, depth or number of potential excavations that may be required. However, excavations can be controlled using methods discussed previously and a combination by the following methods;

1) Full sheeting,
2) Shoring box,
3) Battering the sides of the trench by 30 degree,
4) Circular steel tunnel head system

5.0 Health & Safety

When working within confined spaces and in trenches all health and safety procedures must be followed in accordance with Health and Safety Authority of Ireland. All working permits, method statements, risk assessment etc., are to be fully complied with and suitably qualified and insured contractors to be employed for the duration of the project. Health and Safety consultants should be appointed to advice on the excavations and working within confined spaces.

On site monitoring of the proposed geotechnical measures and existing stone walls are considered essential during the course of the project.

All demolition works to be in accordance with the relevant code of practice and to be completed by a suitably qualified and insured contractor.

6.0 On Site Water Control

It is important that the open trenches do not hold standing water. A sump is to be constructed within all open excavations to allow for a pump to be placed to remove any water gathering in the trenches. Water should be pumped to a nearby storm water gully and all pipe work required to achieve this should be in place prior to excavation works commencing on site.

As per our assumptions our proposals are based on the water table being below the depth of the excavations. Water table levels should be clarified prior to any excavations on site. In order for the removal of ground water to be designed, a geotechnical assessment of the current ground conditions is considered essential.

7.0 Steel Sheet Piling

Steel sheet piling (see Figure 7.1) provides site works with many advantages in particularly where this is potential of encountering poor ground conditions and a water table. The installation of sheet piling is twice as fast as conventional concrete piles. The sheet piles can be re-used for other excavation locations within the site and the sheet piles can be hired from companies for the duration of the project reducing capital expenditure. Sheet piling can be installed by use of either an excavator or crane mounted rig thus providing the contractors with a wide range of solutions for restricted space areas.

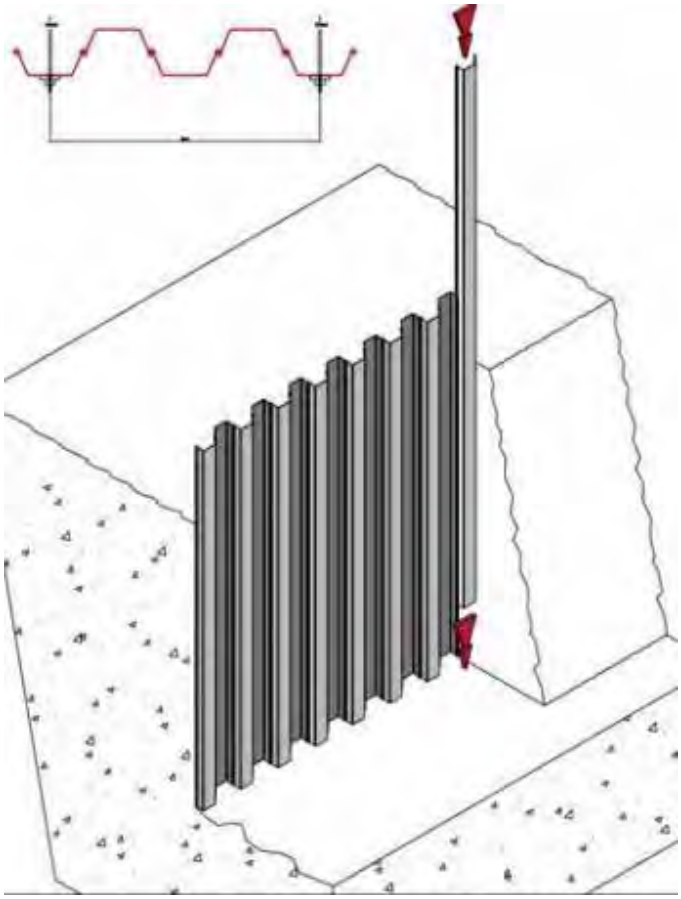

Figure 7-1 Sheet Pile Configuration

It is extremely difficult to install steel sheeting in soil that is rocky or has large boulders. Driving the sheets may cause neighbourhood disturbance. The vibrations from driving the sheets can make, structures close to the piling installation to settle. The use of other forms of piling such as concrete piles (driven or bored) will cause vibrations. It is advisable to undertake structural reviews of the existing properties bounding the Memorial Gardens and install “tell tales” on any existing cracking.

8.0 Budget Price

The pricing noted below are considered budget and are close to market rates at the time of complying this report.

a) Sheet Piling
   - Hire = €3.80/m^2 per week
   - Installation = €18/m^2
   - Extraction = €10/m^2

b) Excavations
   - Due to the nature of the site digging using an excavator may not be possible. It is recommended that any future works assess the ground stability of the site prior to excavation. It should also be outlined where a mechanical excavator can and cannot be used in relation to forensic and archaeological issues. Therefore, the size and type of excavator, together with the extent to which it can be used, will determine the costs.

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Appendix H – Health and Safety Consultants Report

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Technical Group
Advising the
Minister for Children

Consultancy on Health & Safety in relation to Working Activities at Tuam Mother and Babies Home Site

Report Ref. SHORC TCFS0001

Compiled by: John Kelly
John Kelly BSc.

Verification Information		Comment
Final	23/08/2017	Issued, Reviewed

EXECUTIVE SUMMARY

Shorcontrol Safety have been commissioned by Technical Group on behalf of the Minister for Children to consult on construction and confined space activities at the location of Mother and Baby Home Tuam Co. Galway. The activities relate to the excavation of the large chamber and investigation into 20 smaller chambers.

Our conclusions are difficult to assess at present due to not having full visual of the site and processes. Going on information at present and our experience in this type of work we conclude that the large chamber due to its use pre mother and baby home may have residues of sewage and toxic gasses that will have to be investigated as the excavation progresses. Due to the history surrounding the small chambers as well as being part of the original sewage system we would be considering the same issues of sewage and toxic gases as well as materials within these areas causing biological risk to entrants. Another concept to take into account will be the depth of the chamber as well as access and egress from these areas.

All areas can be made safer using various risk reduction controls identified within the risk assessment process, some of these controls are atmosphere monitoring, ventilation, safe system of work, equipment and training. These controls are designed/implemented around the activities of confined space, excavations, working at heights, hazardous substance etc. all of which can be identified with the operations related to the above location and these issues need to be further risk assessed as the activities progress.

Confined spaces in some instincts are not always clear to identify and dynamic risk assessment of the situations in progress is mostly required as ongoing. What we do know is that confined spaces not identified and controlled can cause harm or death to people who are unfamiliar with these working activities.

Training will be recommended for all entrants dealing with these activities, to determine the level of training we will have to await the progress of the excavations and entry status to determine the classification of each confined space. We will also recommend that gas monitoring during excavation and entry would be an important feature to protect workers against toxic atmospheres. Safety and health issues will be controlled by implementing a Safety Management System as in accordance with legislation and best practice in this type of work.

Contents

1.0 INTRODUCTION

1.1 Location

The Former Mother and Baby home site at Dublin Rd, Tuam. Co. Galway. The site has since being developed as a residential estate. Around 1970 approximately, the final demolition of the structures on the site and the building of houses and green areas were adapted. Constructed on the site was a walled off section known as the Walled Memorial garden. This area of the site is the main concern of operations. Although other areas of the complete site will also be taken into consideration during the operations the present location will be the focus of this report.

(Ref; Google Maps)

These locations are:

1. Large chamber designed as a sewage interceptor and containment site. This chamber is filled with various materials placed there over years.
2. Within the chamber at one end are 20 smaller chambers with small access. These chambers may not be entered from the top and may have to be entered from the side after excavation of the material within the large chamber. These chambers may be identified as Confined Spaces.

1.2 Scope

To consult on Health and Safety issues during the construction activities mainly excavations of the old sewerage tank and sectors within the construction location suspected to be confined spaces at the former Mother and Baby home site in Tuam. Co. Galway.

Shorcontrol's remit here is to determine if entering

a. The large chamber as it is and after it has been excavated, will it be identified as a confined space.

b. That each small chamber when being entered after excavation, will be identified as a confined space.

c. That the protection of any entrant entering to carry out any form of work, that the Safety and Health of these entrants are kept a priority. This safe system of work would include a rescue plan if conditions changed or controls fail.

1.3 Confidentiality

Due to the history associated and related to the use of the site, the chambers and surrounding areas, Shorcontrol will treat this report with upmost confidentiality.

2.0 SURVEY DETAILS

2.1 Survey Period & Personnel

22nd August, Shorcontrol Safety Ltd representatives met with Aidan Harte on behalf of the Technical Group to discuss the consultancy process for Confined Spaces at the Tuam Mother and Baby home Tuam Co. Galway. The information given to us on the day will be the only information that we can base our objectives on and give as appropriate suggestions and recommendations as possible.

2.2 Site Sector Location

The sector for operations discussed is the walled area known as the Memorial walled Garden. This sector was built originally as a sewerage collection pit. There is outlets and inlets to this pit which could be connected to mains or other systems. The depth of this pit as informed to us as being approximately 2m to 3m. Within this pit are 20 separate chambers that run along one side of the pit. Each of these chambers has a small inaccessible opening on the top and walled sides. The sector site is completely backfilled with materials some known and some unknown until the excavation process starts. This material will be carefully excavated and a plan to excavate the main pit to allow entrance to the smaller sector chambers

(Ref; Google Maps)

3.0 ASSESSMENT DETAILS

3.1 Methodology

To estimate the requirements for the investigation stage namely the excavation of the sewage tank and the proposed confined spaces. We will be using only the information provided to us at this time, thus we will only use generalised suggestions, and recommendations as per our competency of these subjects.

3.2 Hours of Operation

Consideration of the span of work that will be required and whether work activities will be necessary outside of the regular 9.00am to 5.00pm time scale. Risk assessments will be required and carried out to assess the issues around working during evening times and night time if required.

3.3 Areas Covered

Construction issues related to excavation of the site (4.0) and Confined spaces (5.0).
Listed below are the main issues that may arise during this operation, it is not an exhausted list as we are not on site and the information we are using to determine needs is very broad and nonspecific.

4.0 CONSTRUCTION SITE

Due to the nature of activities planned for this site, the site may be deemed as a construction site, (Mainly 30 days or 500 man days). If this site is determined as a construction site then the SHWW Act 2005 and the SHWW Construction Regulations 2013 will have to be complied with as for the entire site. Roles and responsibilities of different team members will have to be adapted. General duties related to each of these positions. Appointment of a safety officer if the requirements are met or a safety rep if deemed appropriate.

4.1 Safety Policy/Legislation

The Safety and Health policy should be designed to highlight the commitment to work in accordance with the provisions of the Safety, Health and Welfare at Work Act 2005 and all other relevant or associated legislation.
The SHWW Construction Regulations 2013 should be used as the bases to control all construction issues that may arise.

All notifications to the HSA will have to be completed AF1/AF3. A Project Supervisor to Construction Stage (PSCS) will be required and the PCSC notification to HSA (IR2) will be sent.
A safety management system will be required to facilitate all necessary compliance with the regulation. Some of which are listed below.

4.2 Access and Egress/Security

Access and egress to the site will need to be controlled and security will be of the upmost priority. All personal entering the site will require the safe pass standard as a minimum. A safe access and egress system will need to be provided as the excavation progresses. The site should be cordoned off with the use of fencing during the entire operation. A security system to be implemented recording all entering and leaving as well as controlling the site.

4.3 Hazards

A risk assessment will need to be carried out when all works have been agreed. This risk assessment should cover all aspects of the construction operation as identified before the start. Dynamic risk assessment will be required on a day to day to ensure all issues, activities or emergencies are covered. The risk assessment should be carried out by competent personnel.

4.4 Controls

Before any works take place the controls identified from the risk assessment must be implemented, recorded and inspected.

4.5 Training

All training required to complete tasks/activity should be considered and completed before task or activity are required to be completed. CSCS training will be required for plant use for excavation or other activities (ie. scaffolding). All appropriate qualifications and competencies must be met before starting of operations.

4.6 Facilities

Sanitary facilities, washing facilities and canteen facilities will have to be implemented to ensure the employees working in this location have the minimum standard of hygiene etc. changing and drying facilities will be required if weather conditions deteriate.

4.7 Environment

Due to weather conditions areas of work where possible should be covered with a tented facility. This will improve working conditions and provide some security conditions. Disposal of all waste to an accredited facility. Due to the residents position noise should be monitored and controlled.

4.8 Housekeeping

All spoils excavated from the site and when cleared from forensics should be sent to an appropriate facility. Certification etc. should be recorded and filed. The site should be kept clear, clean and safe at all times by good housekeeping practices. Weather conditions should be monitored for work activities such as excavation and confined space entry.

4.9 Plant and Machinery

All plant and machinery must be road worthy and where necessary certified. Persons using this plant must be qualified, certified and competent.

4.10 Emergency

First aid, Evacuation, Emergency planning and accident investigation systems are required and should be implemented before works commence. Emergency communication arrangements should be in place with contact numbers available at all times.

4.11 Excavations

Material will have to be removed from the large area of the sewage tank. Excavating this material will require the use of plant. Safe guarding the edges and ensuring safe access and egress will also be required. The supervision of banking, shoring, shuttering or other methods whichever will be used to avoid collapse and engulfment within the excavation.

4.12 Personal Protective Equipment (PPE)

Ensure that all PPE required and listed as controls due to risk assessment are provided and worn at all times.

4.13 Inspections

Carry out regular inspections of the site to ensure compliance with Health and Safety as per legislation.

5.0 CONFINED SPACES

5.1 Definition

Confined Space refers to any place, including any vessel, tank, container, pit, bund, chamber, cellar or any other similar space which, by virtue of its enclosed nature, creates conditions that give rise to a likelihood of an accident, harm or injury of such a nature as to require emergency action due to the presence or reasonable foreseeable presence of:

- flammable or explosive atmospheres
- harmful gas, fume or vapour
- free flowing solid
- an increasing level of liquid
- excess of oxygen
- excessively high temperature
- the lack or reasonably foreseeable lack of oxygen

Ref: 2017 ACoP Working in Confined Spaces

5.2. Main Principle of Confined Space

A person shall not carry out work in Confined Spaces if it is reasonably practical that it could be avoided.

5.3.0 HAZARDS

The hazards associated with confined spaces of the nature determined to be on this site include:

5.3.1 Toxic Atmosphere

A toxic atmosphere may cause various acute effects, including impairment of judgement, unconsciousness and death. A toxic atmosphere may occur due to the presence or ingress of hazardous substances. Due to previous use of this location and since it has been filled in, it will not be totally certain until removal of layers of materials that no toxic hazards remains in this environment. The identification of connection system to this area will increased the likelihood that contamination has occurred at some time. Monitoring the atmosphere as the excavation progresses will be required.

- These substances may be present in the Confined Space for various reasons such as:
  - remaining from previous processing, activities or storage
  - arising from the disturbance of sludge and other deposited materials
  - seepage from improperly isolated adjoining systems
  - formation during the work processes carried out in the space
  - being released from under scale and in brickwork as a result of the structure, location or work processes

5.3.2 Oxygen Deficiency

The air normally contains 20.9% oxygen which is measured by monitoring level using a gas monitor. If oxygen levels fall the entrants can slowly become unconscious and further die due to lack of oxygen in the body.

- Oxygen can be lacking a confined space for the following reasons:
  - Lack of ventilation both natural or mechanical
  - Displacement of air by another gas
  - Various biological processes or chemical reactions (such as rotting of organic matter, rusting of metals, burning, etc.
  - Absorption of air onto steel surfaces, especially where these are damp

5.3.3 Flammable or Explosive Atmospheres

A flammable atmosphere presents a risk of fire or explosion. Methane gas may be a concern here as materials compiled as the filling and other materials the before the filling in process happened will need to be identified. An explosive atmosphere can arise from the presence in the confined space of flammable liquids or gases or of a suspension of combustible dust in air. If a flammable atmosphere inside a confined space ignites, an explosion may occur, resulting in the expulsion of hot gases, the disintegration of the structure and the harm of entrants.

- Explosive conditions can be hazardous in a confined space for the following reasons:

  - Methane gas due to the natural breakdown of organic substances.

5.3.4 Flowing Liquid or Free Flowing Solids

Liquids or solids can flow into the confined space causing drowning, suffocation, and other injuries. Solids in powder form may also be disturbed in a confined space resulting in an asphyxiating atmosphere.

- Conditions can be hazardous in a confined space for the following reasons:

  - Increased level of liquid from inlet connections, water table or weather conditions.

  - Excavation or removal of materials can cause entrapment due to subsidence, structural failure, temporary works failure, side bank collapse and machinery failure.

5.3.5 Excessive Heat

The enclosed nature of a confined space can increase the risk of heat stroke or collapse from heat stress, if conditions are excessively hot.

- The risk may be exacerbated by:

  - The wearing of personal protective equipment

  - Lack of ventilation

  - Weather conditions.

The above list is a non-exhaustive list of hazards that may occur on this site due to the information as given at present. The hazards listed are recorded within the ACoP for working in confined spaces 2017 as the main hazards to identify a confined space.

5.4.0 OTHER HAZARDS

A list of other hazards identified from conversation may arise and will have to be risk assessed and controlled.

5.4.1 Access and egress

Getting in and out of the large chamber after it will be cleared. Due to its depth (up to 3m) a correct system of access/egress will have to be determined. Due to the size sufficient access/egress system may include a stairway when enough room is made. Ladder systems will probably use until this situation occurs. This ladder access/egress system will have to be sufficient (ensure ladders are tied and footed and kept clean at all times, no carrying of materials or tools while using ladders) a three point connection to be used at all times .

5.4.2 Darkness

Darkness will be an issue within the small chambers; a safe system of lighting work area will have to be implemented. In difficult area torches (Head/Hat torches) will be required by entrants.

5.4.3 Machinery

The use of machinery may cause collision or crushing hazards that will have to be assessed as the excavation process continues. All drivers should hold relevant certification for machinery being used. Recorded daily inspections of this machinery and completed documentation of inspections will be required.

5.4.4 Biological Substances

Due to the nature of work and use of the area the risk of contamination will be greatly increased. Biological hazards will be the main concern and due to confined nature PPE must be chosen in line with the findings of any risk assessment.

5.4.5 Electrical

All electrical systems should be identified and implemented by a qualified competent person.

5.4.6 Temporary Structures

All temporary works put in place will have to be designed by relevant qualified personnel and any change should be recorded and inspected daily by the competent person.

5.5.0 CONTROLS

All hazards will need to be risk assessed and controls put in to avoid harm to entrants. The selection of controls will vary and depend on the risk assessment. The hierarchy of controls will be used to implement a safe system to work in hazardous spaces. Elimination of the hazard, Reduce the risk, Prevent contact, SSOW, and PPE.

The Safety, Health and Welfare at Work (Confined Spaces) Regulations 2001 cover all work in relation to confined spaces.

Regulation 5 states that:

- A person shall not carry out work in Confined Spaces if it is reasonably practical that it could be avoided
- If the work must be carried out Hazard Identification and Risk Assessment must be carried out prior to the work commencing
- A person shall not enter a confined space unless there is a system of work in place that has been planned, organised, performed and maintained so as to render that work safe and without risk to health
- Anyone entering a confined space must be provided with appropriate information, training and instruction appropriate to the particular characteristics of the proposed work activities.

5.5.1 Emergency Plan

An emergency plan is required for all confined space work. It is important to control as to eliminate the need for rescue but if things do go wrong then a planned emergency response has to be implemented.

Regulation 6 of the Confined Space Regulations 2001 states that:

A person shall not enter a confined space unless there is suitable emergency arrangements been made which are appropriate to the confined space in question.

- The emergency arrangements shall include:

  - all practical measures necessary to ensure the health and safety of those taking part in the rescue
  - the provision of a suitable and reliable means of raising the alarm in the event of an emergency
  - having all necessary rescue equipment nearby and in a well maintained, good condition
  - the provision of information, instruction and training to all involved in rescue procedures
  - the provision of equipment and training for resuscitation procedures if there is a foreseeable risk that they will be needed.

5.5.2 Safe Systems of Work

A safe system of work must be established before any entrant to a confined space.
The key elements to be considered when drawing up a safe system of work are:

- Competence, training, supervision and suitability
- Permit-to-work procedure
- Gas purging and ventilation
- Dangerous residues
- Testing and monitoring of the atmosphere
- Mechanical, electrical and process isolation
- Respiratory protective equipment
- Other personal protective equipment
- Safe use of work equipment
- Communications
- Access and egress
- Flammable or explosive atmospheres
- Combustible materials

5.5.3 Construction Site

Due to the nature of activities planned for this site, the site may be deemed as a construction site, (Mainly 30 days or 500 man days). If this site is determined a construction site then the SHWW Construction Regulations 2013 will have to be complied with as regards to Confined space (Part 9 regulation 79) as well as all other parts of this regulation as requirement.

5.5.4 Equipment

All equipment required for entering and working in all levels of confined spaces will have to be identified through risk assessment and the controls reviewed. This equipment will be certified and calibrated to the requirement of the SHWW General application Regulation 2007, Confined Space Regulations and ACoP for working in Confined Space. Training will be required for the use of this equipment.

5.5.5 Conditions at Location

The conditions on the day and time of the activity can vary thus leading to atmosphere changes and increasing risk in excavation. These weather changes will have to be included in the risk assessment and controls reviewed. Natural ventilation versus mechanical ventilation may be required as a means of sustaining air flow while entering chambers. This will be assessed as an ongoing monitoring activity.

6.0 CONCLUSION & RECOMMENDATIONS

The above report for construction/confined space activities is only presented due to information from discussions and information provided. Due to no visual of the site or site visit it is difficult to close down the exact needs and requirements that will be required for Construction Activities or Confined Spaces on this site. The information provided and with our experience of construction activities and confined spaces that we have received, Construction issues and confined spaces will be an issue with this site and entrants will have to be kept safe from harm. Preventative measures (Risk assessment, Training, Equipment, SSOW, Emergency plan) will have to put in place and safe systems of work will have to be designed and implemented. The progress of the excavation and the materials, atmosphere and conditions will determine the identity and classification of confined spaces. These issues will need to be evaluated and risk assessed as to comply with legislation and morally protect person working in this location. The format of the activity of excavation will provide construction related hazards which will need to be controlled and the introduction of a safe management system will ensure that your safety policy and procedures are enacted and followed.

Appendix A – References

- Safety, Health and Welfare at Work Act 2005.
- SHWW Construction Regulations 2013.
- SHWW Confined Space Regulations 2001.
- ACoP Working in Confined Spaces 2017.
- ACoP Chemical Agent 2016.

Appendix B – Blank Evaluation/Risk Assessment Form

Notes

Shorcontrol Safety	**Confined Space Evaluation/Risk Assessment Form**	
	Confined Space No.: CFS-000	Pic
Related Procedures:	**CFS Title:**	
Date:	**Department:**	
Area/Location		
Description of space		
Activities		

SECTION A – Confined Space

1) Term used: Is the space a: Vessel, tank, container, vat, silo, hopper, pit, bund, trench, pipe, sewer, flue, well, chamber, compartment, cellar, ☐Yes ☐No

   a) If the answer is yes to above, is this space large enough and so configured that employee can enter and perform assigned work. ☐Yes ☐No

2) Is this space is substantially enclosed ☐Yes ☐No

3) Has this space limited or restricted means for access or egress ☐Yes ☐No

4) This space is designed for specific work activities not for continuous occupancy. ☐Yes ☐No

5) The space due to its enclosed nature is likely to create conditions that can cause accident, harm or injury ☐Yes ☐No

SECTION B - Hazards

1) The confined space contains or has the potential to contain a hazardous atmosphere (check off below)

☐ Explosive or Flammable atmosphere ☐ Harmful gas, vapour, fumes, dust or mist,

☐ Free flowing solids ☐ Increasing levels of liquid

☐ Excessively high temperature ☐ Oxygen > 23%

☐ The lack or reasonably foreseeable lack of oxygen, (< 19%)

☐ The confined space has an internal configuration that an entrant could be trapped.

☐ Other toxic atmosphere or any hazardous substance capable of causing injury, death, incapacitation, impairment of ability to self-rescue, or acute illness, (list): _____

2) The confined space contains any other recognised serious safety or health hazard (check off below)

☐ Total irrespirable Dust ☐ Radiation ☐ Noise ☐ Heat/Steam ☐ Darkness

☐ Mechanical/Moving Parts ☐ Potential Energy ☐ Electrical ☐ Working from heights

☐ Unprotected openings ☐ Adjacent Traffic ☐ Biological agents ☐ Tools and materials

☐ Manual Handling ☐ Members of the public ☐ Weather ☐ Ground water

☐ Plant and Machinery ☐ Weather ☐ Contaminated Ground ☐ Lighting

Others (describe) : _____

SECTION C -Determination of Confined Space

If the answer to any questions in section A or section B is "yes" then space is considered a confined space
If the answer to all of the questions is "no", then the space is a not considered a confined space

Confined Space ☐ **Yes** ☐ **No**

SECTION D – The Confined Space is classified before controls as: (please check the appropriate box)

High Risk	No	Yes	
Constant presence of any hazard as identified in the ACoP 2017			
More than 3m in depth and may require traversing a distance			
Complex access and egress			☐
No natural or mechanical ventilation			
Method statement/permit/Safe job analysis required			

Medium Risk

Foreseeable presence of any hazard as identified in the ACoP 2017			
More than 3m in depth and/or may require traversing a distance			
Non-complex access or egress			☐
Natural or mechanical ventilation			
Method statement/permit/Safe job analysis required			

Low risk

Unforeseeable presence of any hazard as identified in the ACoP 2017			
Less than 3m in depth and may require traversing into open space			
Easy accessor egress			☐
Natural ventilation			
Method statement/permit/Safe job analysis may be required			

SECTION E-The confined space is considered

☐ **Non-Permit Required Confined Space** ☐ **Permit Required Confined Space**

SECTION F – Space Requirements

1	Confined space number has been assigned	☐Yes	☐No
2	Register has been updated to include confined space details	☐Yes	☐No
3	Suitable confined space signage has been fitted	☐Yes	☐No
4	The confined space has been risk assessed	☐Yes	☐No
5	Has safe system of work been designed	☐Yes	☐No

SECTION G – Emergency Response Plan

Emergency Response Plan Required

No Entry	☐
Rescue by Top Person.	☐
Self-rescue	☐
Emergency Response Team rescue	☐
Emergency Service rescue	☐

First Aid Level Required

Cardiac First Responder	CFR	☐
Occupational First Aider	FAR	☐
Emergency First Responder	EFR	☐
Medical Practitioner	MP	☐

Description of Emergency Management Plan required:

Plan to establish if entry can be prevented by using external resources, Entrant must be in full health and medically fit to conduct activities. A safe access and egress must be established. Atmosphere must be tested before entry and monitored during activity. Entrants will be monitored by outside person at all times. All equipment will be present, maintained and within certification. Emergency communication to be put in place and tested. All equipment to be provided and calibrated/certified as required. All controls as per risk assessment will be secured before any entry to the confined space. Rescue plan to be discussed and implemented before entry.

SECTION H – Equipment Needed **Entry** ☐ **Rescue** ▲

Tripod ☐△	Full Working BA ☐△	Stretcher ☐△	PPE ☐△	Girder Straps ☐△
Winch ☐△	Airline BA ☐△	Oxygen resus ☐△	RPE ☐△	Gantry ☐△
Rope Hoist ☐△	Escape BA ☐△	Lighting source ☐△	Comms ☐△	Bolson Chair ☐△
Harness ☐△	Gas Monitor ☐△	Control Board ☐△	Lifeline ☐△	Cover openers ☐△
Fall Block ☐△	Ventilation ☐△	First aid Equip ☐△	Ropes ☐△	Life Vest ☐△

Others:_____

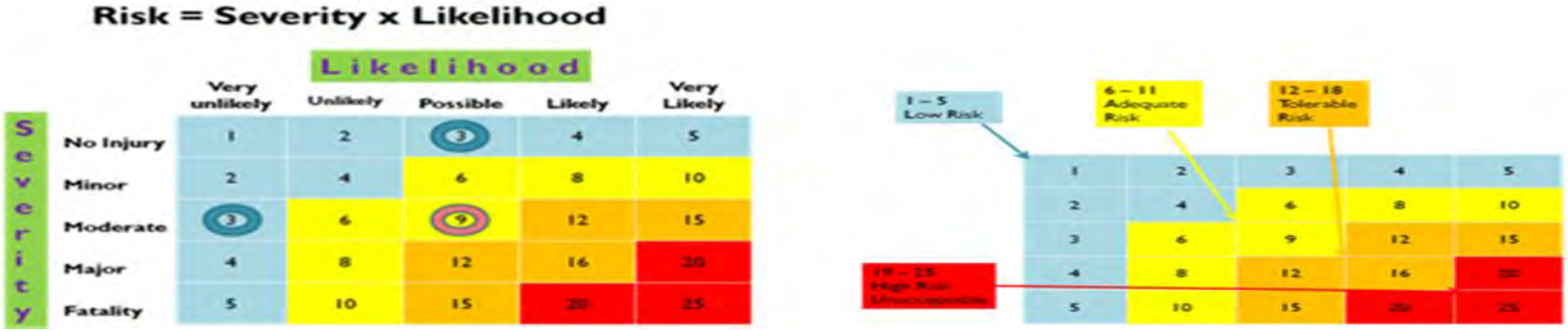
SECTION I- Risk Assessment

CFS-000

Risk Assessment		Gases Monitored	Yes/No	
		O2	20.9	%
		H2S	0	ppm
		CO	0	ppm
		CH4	0	% LEL
	Other			

Hazards	Likelihood	Consequences		Pre – Risk Rate	Controls	Implemented	Residual Risk	Emergency Plan
Toxic Atmospheres	0	Death, Asphyxia,	0	0	0	0	0	0
Oxygen Deficiency	0	Death, Asphyxia, Hypoxia,	**0**	0	0	0	0	0
Oxygen Enrichment	0	Fire Explosion	0	0	0	0	0	0
Flammable or Explosive Atmospheres	0	Serious Injury/Death	0	0	0	0	0	0
Fire	0	Serious Injury/ Death	0	0	0	0	0	0
Flowing/increasing level of Liquids	0	Drowning	0	0	0	0	0	0
Free flowing Solids	0	Engulfment	0	0	0	0	0	0
Excessive Heat	0	LOC, Heat Exhaustion/ Stroke	0	0	0	0	0	0
Excessive Cold	0	Hypothermia	0	0	0	0	0	0
Slip / trip / falls hazards	0	Bodily Injury	0	0	0	0	0	0
Potential for changing conditions:	0	Serious Injury/Death	0	0	0	0	0	0
Fitness / capability to work	0	Medical Emergencies	0	0	0	0	0	0
Nearby work activities	0	Serious injury	0	0	0	0	0	0

Sharps / needles	0	Stick injury, Infection Diseases	0	0	0	0	0	0
Manual Handling	0	Back injury, Sprain, Strain	0	0	0	0	0	0
Darkness	0	Visibility, injury	0	0	0	0	0	0
Biological Hazards/Hygiene	0	Infection,	0	0	0	0	0	0
Electrical	0	Fire, Electrocution	0	0	0	0	0	0



	Controls	Tick
1	Gas Monitors are calibrated to test and monitor the atmosphere within the confined space.	
2	Floor covering/damping to prevent excessive dust.	
3	Ventilation, Natural or Mechanical,	
4	Tripod, Winch and Harness or other fall arrest system. (Certified, Maintained, Inspected)	
5	Top / Rescue Person in Place	
6	Method statement written and communicated	
7	Permit to Work in Place	
8	People are competent and fit to work in Confined Space, (Medicals may be required)	
9	PPE for all workers in the area. Protect the face/eye/ears/feet/overalls	
10	Suitable Ladder / stairs / scaffolding for access/egress	
11	Temperature measured and controlled	
12	Any dangerous residue removed from the space.	
13	Lighting system in place, fixed or portable. LED low energy non heat producing, torches, heads lamps, EX,	
14	Noise levels monitored/measured if required	
15	MSDS sheets for fire glue followed.	
16	Regular breaks to allow for difficulty of working in cramped area and plenty of fluids on standby.	
17	Manual handling, First Aid, Competent where applicable, Safe system to be used, TILE to be adapted,	
18	Fire extinguisher present on all hot works activities, Hot works permit system in place, Ignitions controlled, Mobile phones not to be used within the working area,	
19	All other activities in area of confined space must be controlled and prevented from changing conditions within the confined space.	
20	Respiration protection apparatus, Full, Escape, Filter, PP1, PP2, PP3,	
21	Communication systems to be in place. (Communication with management/outside emergency services)	
22	Lock out/Tag out system to be implemented.	

	Entry Requirement and Details	
A	Competent People – Supervisor, Top / Standby Person, Entrants and Emergency Response Team must be informed.	
B	All Personnel Protective Equipment (PPE) to be worn as per risk assessment	
C	Equipment includes Tripod, Winch, Harness, Gas Monitors, Ropes, Fall arresters, retrievers and torches	
D	Full Working SCBA (Duration decided by risk assessment)	
E	Escape breathing apparatus (Duration decided by risk assessment)	
F	Airline fed breathing apparatus (Duration decided by risk assessment)	
G	Ventilation in place for the area, more openings or forced ventilation.	
H	Method Statement for the entry. Emergency Plan is in place.	
I	Permit for confined space.	
J	Area manager must be informed of the confined space entry operation.	
K	The area cordoned off with secure barriers. Traffic management is in place.	
L	Verify there is no risk to others as a result of the confined space operation.	
M	Consider the size of the openings, access and egress using all types of equipment and rescue.	
N	LOTO system to be in place, proof of same before entry	

SECTION J – The Confined Space is classified after controls as: (please check the appropriate box)

High Risk	No	Yes	
Constant presence of any hazard as identified in the ACoP 2017			
More than 3m in depth and may require traversing a distance			
Complex access and egress			☐
No natural or mechanical ventilation			
Method statement/permit/Safe job analysis required			

Medium Risk

Foreseeable presence of any hazard as identified in the ACoP 2017			
More than 3m in depth and/or may require traversing a distance			
Non-complex access or egress			☐
Natural or mechanical ventilation			
Method statement/permit/Safe job analysis required			

Low risk

Unforeseeable presence of any hazard as identified in the ACoP 2017			
Less than 3m in depth and may require traversing into open space			
Easy accessor egress			☐
Natural ventilation			
Method statement/permit/Safe job analysis may be required			

SECTION-K Emergency plan

	Emergency Response Plan	
1	Self-rescue where possible. Entrant to remove themselves using their own devices.	
2	Self-rescue with the use of an escape breathing apparatus.	
3	Rescue by non-entry methods using the tripod and winch managed by the top person and harness worn by the entrant.	
4	Rescue by co-entrants as they leave CFS.	
5	Rescue by emergency response team using non entry methods.	
6	Rescue by emergency response team personnel using a safe entry method	
7	Rescue by local emergency services (local Fire Brigade) using a safe entry method.	
8	First Aider with CPR/AED must be available and first aid equipment must be available.	
9	Equipment required: Tripod, winch, rescue stretcher, harness, emergency oxygen pack and first aid kit.	
10	Top Person can / may call the emergency services when required, inform the management and security.	
11	Decontamination system	

SECTION L- Signatures

Evaluation Conducted By: Name _____ **Signature** _____ **Date** _____

Evaluation Authorised By: Name _____ **Signature** _____ **Date** _____

Appendix I – Team Biographies

Niamh McCULLAGH, BA MA MSc MCSFS

Forensic Archaeologist

Niamh is an independent consultant Forensic Archaeologist specialising in the search, location and recovery of human remains in a forensic context. As a Forensic Archaeologist, Niamh has worked nationally and internationally on both current and historic casework and she also provides input to training capacity for Forensic Archaeologists. Niamh is Senior Forensic Archaeologist to the Independent Commission for the Location of Victims Remains and has assisted An Garda Síochána in the investigation of multiple criminal cases. She has a BA Major in Archaeology (University College Cork, 2001), MA Archaeology (University College Cork, 2002) and MSc Forensic Archaeology and Crime Scene Investigation (Bradford University, 2007) and has published a number of papers in relation to her specialism. She is recognised as Professional Member of the Chartered Society of Forensic Sciences, an Expert Witness in Ireland, a member of the Irish Association of Forensic Practitioners and has represented Forensic Archaeology at a European level. Niamh directed the previous site investigations at the Children's Burial Ground, Tuam, on behalf of the Mother and Baby Home Commission of Investigation.

Linda LYNCH, BA MA PhD MIAI

Human Osteoarchaeologist

Linda is a professional archaeological consultant and human osteoarchaeologist with over 20 years' experience in Irish archaeology. A member of the Institute of Archaeologists of Ireland, she also served on the Board for three years. She is a license-eligible archaeological excavation expert and a leading professional in the field of osteoarchaeology in Ireland, with a significant profile of publication and lecturing. She has particular expertise in issues similar to those encountered at the Children's Burial Ground at Tuam. Her Masters degree in 1998 focused on neonate and infant remains from *cillíní* or 'children's burial grounds'. In 2014 Linda was awarded a PhD in research that focused on human remains from 19th century workhouse burials. Linda was also the specialist employed to examine the skeletal remains recovered from the archaeological excavation adjacent to Tuam Poor Law Union Workhouse. Linda was the senior osteoarchaeologist for previous site investigations at the Children's Burial Ground, Tuam, on behalf of the Mother and Baby Home Commission of Investigation.

Aidan HARTE, BA MA MIAI ACSFS

Senior Archaeologist

Aidan is an independent, qualified Archaeologist and Geographer, with over 15 years' archaeological experience in Ireland, the UK and France. He is a license eligible Archaeological Excavation Director as recognised by the Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs. He also continues to work as a Senior Team member with the Independent Commission for the Location of Victims Remains. He has been a full member of the Institute of Archaeologists of Ireland since 2007,

has served on the Board of Directors for the Cork Historical and Archaeological Society since 2013 and has more recently been recognised as an Affiliate Member of the Chartered Society of Forensic Sciences. Aidan has lead excavations and surveys of over 35 archaeological sites, of various type, size and period, in a variety of locations and conditions. Following his primary degree, his master's degree in 'Methods and Practices in Irish Archaeology' (UCC) specialized in the use of GPS/GIS for which he was awarded the 'Past Perceptions Prize' 2002. With a diverse range of research interests, he has published papers on survey methodology, GIS and multiple archaeological site types. Aidan was the Senior Archaeologist for previous site investigations at the Children's Burial Ground, Tuam, on behalf of the Mother and Baby Home Commission of Investigation.

Hugh TULLER, MA

Forensic Anthropologist

Hugh Tuller is an American forensic anthropologist/archaeologist currently working for the U.S. government's Defense POW/MIA Accounting Agency, which is tasked with the search, recovery, and identification of US personnel who have gone missing during past and current wars. This employment entails both forensic archaeological field work as well as laboratory analysis of skeletal remains. In the past Mr. Tuller has worked for the United Nations' International Criminal Tribunal for the former Yugoslavia (ICTY) and the International Commission on Missing Persons (ICMP) throughout the Balkans, as well as with the United Nations' backed Committee on Missing Persons in Cyprus (CMP). His past research has included soil analysis for blood proteins and volatile fatty acids at grave and execution sites, spatial analysis of comingled mass graves, and predictive modelling of clandestine grave location.

Dr Tim CLAYTON, BSc PhD MBE

Senior Forensic Scientist, LGC Forensics

Tim holds a BSc honours degree in Biological Science and a doctorate in Genetics both from the University of East Anglia. He joined the Home Office Forensic Science Service (as it was then) in 1990 after a period of postdoctoral research at the John Innes Institute in Norwich. Tim has been an active caseworker for 25 years and has provided written testimony in hundreds of criminal cases and oral testimony at all levels of Court including the Court of Appeal. He was seconded to the Home Office Central Research Establishment (CRE) in 1993 to develop the use of DNA Short Tandem Repeat profiling (STRs) for criminal casework. That project led to the development of the technology to implement the UK National DNA database in 1995. Tim has been instrumental in developing other DNA techniques (Low Copy Number profiling, familial searching) in the UK and has co-developed a number of software packages designed to assist scientists with forensic statistics. For 10 years Tim administrated and collated the National Missing Persons Database. At the FSS, he was a principal forensic scientist with special responsibility for the fields of relationship testing, DVI and body identification. He has published widely in the field and is co-author of a number of chapters in key forensic textbooks. After the closure of the FSS in 2012, Tim joined LGC forensics in Wakefield as a senior forensic scientist. He is the science lead for DNA profiling dividing his time equally between research into new forensic techniques and casework. Between 2003 and 2007 Tim undertook a

period of legal training, and after successfully completing the Bar Vocational Course, he has been called to the English bar by Middle Temple in July 2007. Tim was named in the 2012 New Year's Honours list and received an MBE for his contribution to Criminal Justice.

Dr. Brian FARRELL, M.A. (HSE Law), F.R.C. Path., F.F. Path., MFFLM, B.Sc., Barrister-at-Law

Dr. Brian Farrell is the Dublin District Coroner emeritus and past President of the Coroner's Society of Ireland. A former consultant histopathologist and barrister-at-law, he is a member of the Coroner's Society of England and Wales. Dr Farrell is a fellow of the Royal College of Pathologists (London), Royal College of Physicians of Ireland and the Royal College of Physicians (London) Faculty of Forensic and Legal Medicine. Dr Farrell holds an M.A. in Health and Safety and Environmental Law. Dr. Farrell has served on a number of high level committees, inter alia, Review of the Coroner's Service, Bioethics and Autopsy Practice. Dr. Farrell is the author of the textbook Coroners: Practice and Procedure (Roundhall Ltd. Sweet & Maxwell) 2000. Professional Medicolegal Death Investigation, a textbook and internet resource, is in preparation.