# The construction, survival, and use of Signal Defensible Guard Houses on the Irish Coast

Volume I of II

Stuart Rathbone

Ph.D. Thesis (Archaeology)

IT Sligo

Primary Supervisor: Dr James Bonsall

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I declare that this thesis has been composed solely by myself, and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own.

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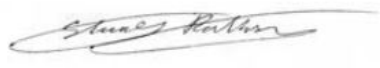

Stuart Rathbone

Supervisor Signature:

Dr James Bonsall

**Abstract**

The construction, survival, and use of Signal Defensible Guard Houses on the Irish Coast

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In the first decade of the 19th century a new system of 81 military signal stations were constructed around the Irish coast. At 74 signal stations, purpose-built signal defensible guard houses were constructed, and some sites also featured stone walled enclosures and/or small storage buildings and outhouses. Four signal stations were added to existing fortifications or lighthouses, and three signal stations were incorporated into newly constructed Martello towers. All of the signal stations featured free-standing signal masts. The signal stations were commissioned in 1803, became fully operational by 1805, and were decommissioned in a piecemeal fashion between 1809 and 1816.

A detailed historical review examines the political, military and technological contexts which influenced the construction Irish Signal Stations. Contemporary letters and illustrations provided important new information about the construction and operation of the signal stations. The signal stations were found to have utilised existing naval signal techniques, and not, as had been previously implied, to relate to the newly developed telegraph systems. The possibility that the design of the signal defensible guard houses was adapted from an older Mediterranean signal tower design was explored. Detailed surveys were undertaken at the signal stations in the provinces of Connacht and Ulster. The signal stations in Leinster and Munster were examined through a detailed desk-based study, in order to examine any possible regional differences. The signal stations throughout Ireland were found to be very consistent in terms of their design, construction methods and building materials. Significant differences were identified between Connacht and Ulster, where structural survival was relatively high and secondary use of the sites was rare; Leinster, where structural survival was very poor and secondary use of the sites was rare; and Munster, where structural survival was also relatively high and secondary use of the sites was common.

**Acknowledgements**

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This project would not have been possible without the initial work on this topic undertaken by Paul Kerrigan.

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# Chapter 1 - Introduction

## 1.1 The Irish Signal Stations

At the start of the 19th century, a system of signal stations was established around the coast of Ireland to convey messages about the location of an expected French invasion fleet. Surviving contemporary documents held at the National Archives in Kew, London, and the National Library of Ireland, Dublin, (NLI Mss 14, 917; NLI Mss 14, 918; NLI Mss 14, 919) refer to the construction and operation of the signal stations. Various lists in those archives provide names and details for 81 sites forming the chain (Figures 1.1 & 1.2), running clockwise from Dublin Bay in County Dublin, to Malin Head in County Donegal (Kerrigan 1995, 159). Kerrigan suggests that there were a small number of late additions to this chain whilst some sites seem to have gone out of use at an early stage or to have never been completed (Kerrigan 1995, 162-3). This uncertainty makes the figure of 81 sites less definite than it appears at first glance and unfortunately it is not possible to provide a precise total for any specific date during the systems active period based on published sources (Kerrigan 1995, 162-3). Rear Admiral James Whitshed was dispatched to Ireland in 1803 to advise on the defence of the coast, raise the Sea Fencibles and oversee the construction of the signal stations (Kerrigan 1995, 157; Hattendorf 2008)

At 74 of the signal station sites, purpose-built '*Signal Defensible Guardhouses*[1]' were constructed; stout square towers complete with an array of defensive features often set within large walled enclosures (Figures 1.3 & 1.4). The towers were in effect small, fortified residences containing quarters for a naval officer and his men, a small office, and a roof-top observation deck. At the sites without purpose-built signal towers the officer and crew were accommodated within existing buildings. Two signal stations were established at existing forts, two at existing lighthouses, and three at some of the newly constructed Martello towers[2] (Kerrigan 1995, 156).

[1] Signal Defensible Guardhouse was the contemporary official designation for the structures referred to throughout this thesis as Signal Towers.

[2] The Martello Towers were more sophisticated cylindrical barrack buildings, which featured roof mounted gun emplacements. Martello Towers were used to defend ports and coastal tow

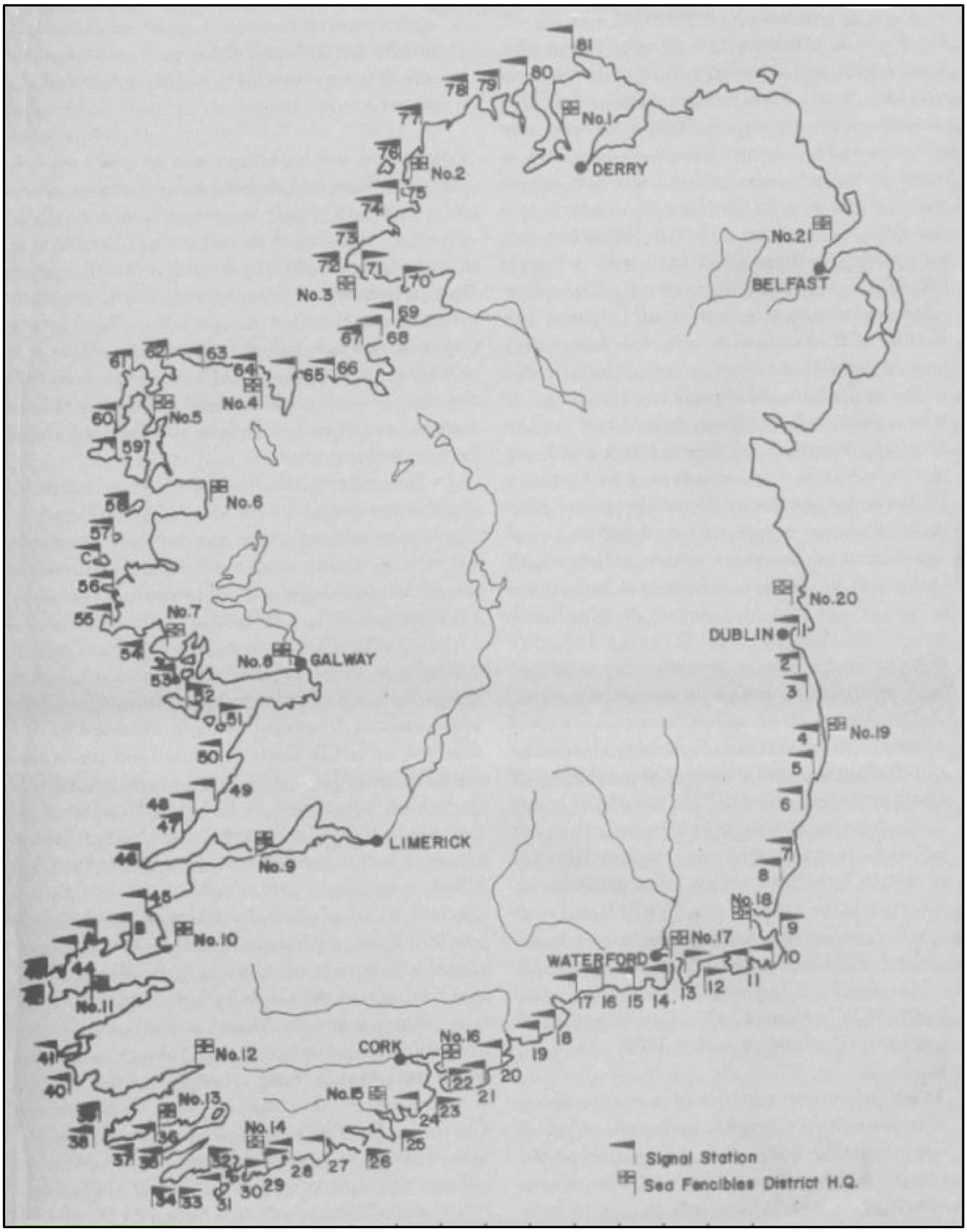


Figure 1.1. Paul Kerrigan's map of the Irish signal stations (Kerrigan 1995, Map 12). The locations marked by the flags are often very inexact. For example, Number 61, Tower Hill Signal Station on the Belmullet Peninsula in County Mayo is shown on the north-west coast of the peninsula, but the signal station is actually located about 4 miles east of this mark, a little to the north of the connection to the mainland.

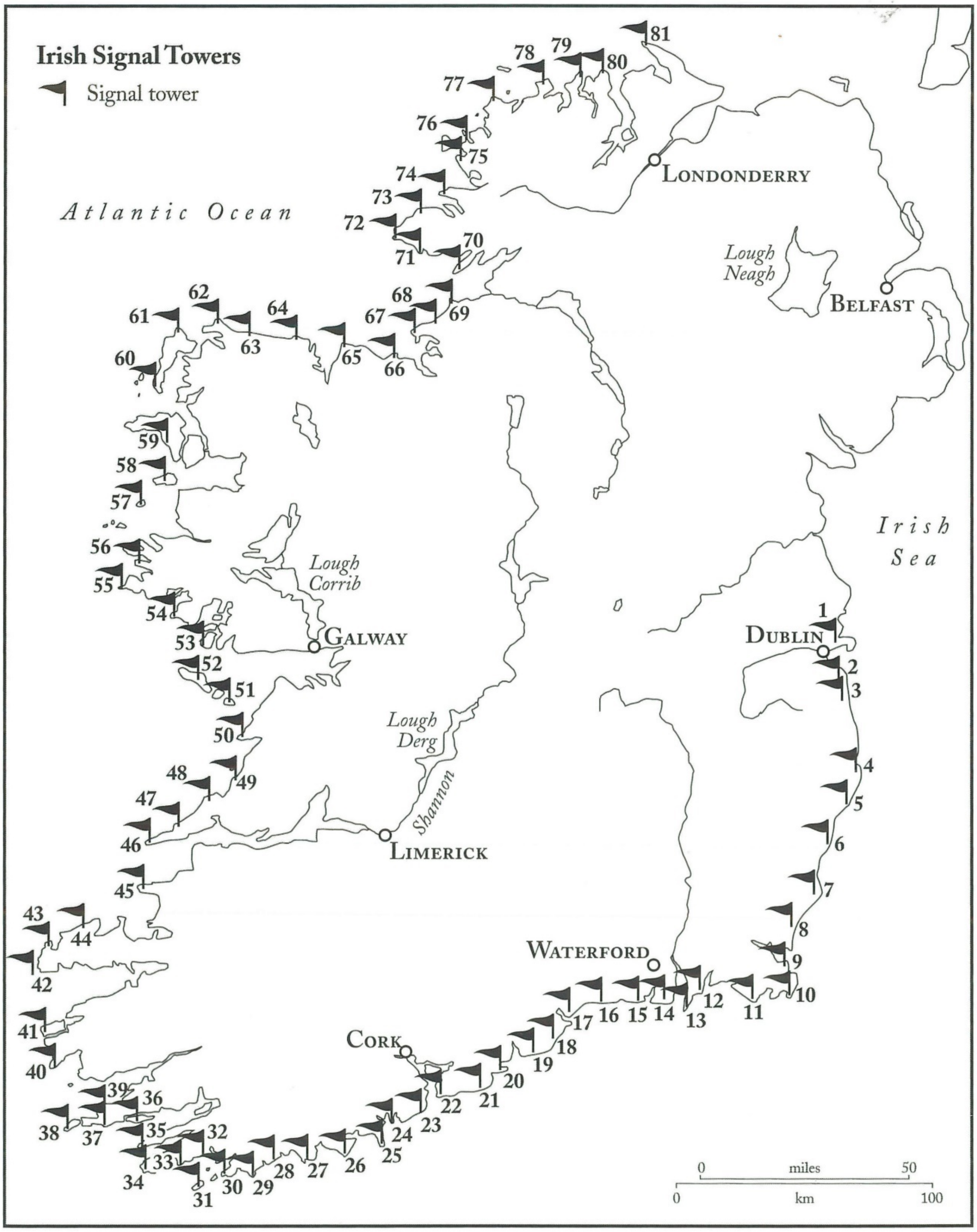


Figure 1.2. Clements' map of the Irish Signal Stations (Clements 2013, Figure 7.17). This map offers more clarity than Kerrigan's due to improved standards of digital illustration and printing, but it is essentially a direct copy of Kerrigan's Map 12 and maintains the same errors of placement.

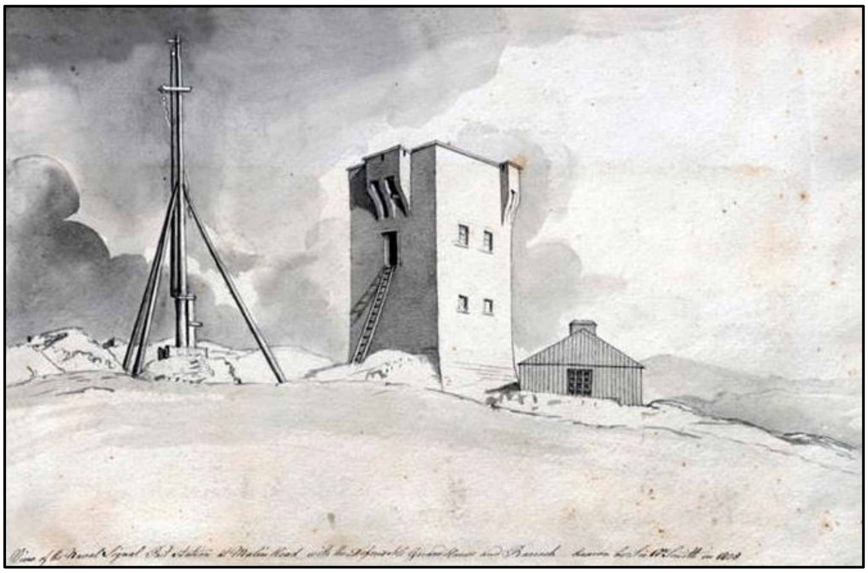

Figure 1.3. A rare contemporary illustration showing Malin Head signal station in County Donegal (TCD MS 942/1: 24). The caption reads 'View of the Naval Signal Port Station at Malin Head with the guardhouse and barrack drawn by Sir Wm Smith in 1808.' Smith was the engineer in charge of constructing several of the signal stations in Northern Donegal. The image shows the signal mast, the signal tower and a smaller barrack building which was used for accommodation whilst the signal tower was being constructed.

Figure 1.4. Crohy Head signal station, County Donegal, an example of a well-preserved site today. The signal towers were square buildings, measuring around 5.8 m (19') across and had heights of between 10 m (32' 10'') and 12 m (39' 4'').

Arguably the most important physical feature of the signal stations were the signal masts from which patterns of canvas flags and balls were suspended to convey a multitude of pre-arranged codes (Kerrigan 1995, 156, 161). Optical signalling technology was a rapidly developing area in the decades either side of the turn of the 19th century. From 1794 onwards, long distance optical signal chains were established in various European countries including France (1794), Sweden (1795), England (1796), Denmark (1801), Norway (1810), Germany (1830), Spain (1845) and Finland (1854) (Wilson 1976, 11-67; Holzmann & Pehrson 2003, 62-79, 97-119, 180-8). None of the contemporary systems in Northern Europe utilised such a numerous and consistent series of purpose-built fortified buildings as were constructed in Ireland.

As will be demonstrated by a brief synopsis below, there is an absence of substantial research and discussion regarding the signal stations. The lack of comprehensive inclusion within the statutory lists, means that the current understanding of the signal stations is severely limited. At the outset of this project no definitive georeferenced list or plan existed that provided an accurate location for all of the signal station sites. Similarly, there were no comprehensive accounts of what originally existed at each of the sites, or what survives at each site today. This lack of data is particularly noticeable given that the sites represent military installations that were only built just over 200 years ago.

Paul Kerrigan's main account provides an excellent introduction that explains the basic chronology and functions of the signal stations and their place within the overall sequence of medieval and post-medieval fortification construction in Ireland. Kerrigan only briefly mentions how the signal stations fit into the larger story of the development of optical signalling technology during the 18th and 19th centuries (Kerrigan 1995, 156-8). Those publications that discuss the development of signalling technology between the 18th and 20th centuries make only brief mention of the Irish signal station system (Wilson 1976, 102-11; Holzmann & Pehrson 2003, 110-12) or omit its discussion entirely (Kent 1993; Mallinson 2005, 48).

The Irish signal stations present an unusual combination of technology and architecture that directly reflects the turbulent political climate of Ireland at the start of the 19th century. Whilst the signal stations purpose was to warn of an expected external threat from France, they also had to be built with the ability to withstand the internal threats posed by the rebellious forces within Ireland. Three cross county telegraph lines constructed in Spain, in the mid to late 1840s, utilise very similar signal towers. The use of fortified signal towers in Spain reflects their construction during a similar period of internal unrest (Wilson 1976, 183-4; Valero 2017). Older 16th and 17th century signal systems found around the coast of the western Mediterranean often utilise similar fortified towers, but lack sophisticated signalling equipment, and were limited to simple smoke and fire signals (Kirk 2017, 319-20, 330-2).

The remains of the signal stations are an important component of the modern archaeological and architectural heritage of Ireland. Curiously, they have attracted only limited previous interest. Kerrigan provided a detailed summary account of the signal stations in a chapter of *Castles and fortifications of Ireland 1485-1945,* which remains the most substantial contribution to the subject (Kerrigan 1995, 156-66). This seminal chapter was preceded by two smaller articles by Kerrigan (Kerrigan 1975; 1983), but those articles are not as comprehensive, and are best regarded as being preliminary works to his main discussion, which rendered them largely redundant. Kerrigan produced one further article discussing the signal stations, which focuses on the stretch of coast between Cork Harbour and Dursey Island in County Cork (Kerrigan 2003). This article provides some additional information about the sites in that specific area and should be considered supplemental to his main discussion. Kerrigan established a naming convention for the sites based on the terms listed in several documents from 1804 and 1806. To avoid confusion, Kerrigan’s naming and numbering convention has been used throughout this thesis, although the modern names are used throughout, with the historic names only being used in Table 1.1, where they are shown in brackets after the modern name, and in the site’s respective entries in Appendices A through G. For the sake of simplicity, the historical County Dublin is referenced throughout this thesis, rather than the current administrative units established in 1994.

Subsequent research, in the form of short (generally non-peer reviewed) articles have assessed individual sites. Occasional attempts at providing brief overviews of the subject have added little to the study beyond discussing the specific details of a small number of individual signal stations (Jones 2004, 227-8; Gosling *et al* 2007, 181-2; O'Sullivan & Downey 2012; Clements 2013, 97-104; McDonald 2016, 43; Moore 2018).

To date there has been only sporadic statutory interest in the sites, as listed in Table 1.1. Only Counties Cork and Galway offer comprehensive inclusion of their purpose-built signal stations within their *Sites and Monuments Records* (SMRs). From the total of 75 purpose-built sites, only 39 are listed on their relevant counties SMRs. County Dublin does not list its single purpose-built site; County Wicklow lists one of its two purpose-built sites; County Wexford does not list any of its five purpose-built sites; County Waterford only lists one of its six purpose-built sites; County Cork lists all eighteen of its purpose-built sites; County Kerry does not list any of its six purpose-built sites (but lists three of the four enclosed barracks sites described below); County Clare lists three of its five purpose-built sites; County Galway lists all six of its purpose-built sites; County Mayo lists two of its eight purpose-built sites; County Sligo lists three of its six purpose-built sites; County Donegal lists five of its twelve purpose-built sites (Table 1.1). A total of 29 of the 39 sites listed in the country SMRs are scheduled to be included in the next revision of the relevant counties *Record of Monuments and Places* (RMPs).

The *National Inventory of Architectural Heritage* (NIAH) states its purpose is;

> "*…to identify, record, and evaluate the post-1700 architectural heritage of Ireland, uniformly and consistently as an aid in the protection and conservation of the built heritage.*" (NIAH 2012, 3).

The NIAH currently identifies 35 sites from the relevant coastal counties under the type 'signal tower,' although only 25 of these sites relate to the purpose-built Napoleonic era signal stations, with the other entries being of later date. Of the purpose-built Napoleonic era signal stations, one is in County Waterford, 12 are in County Cork, two are in County Galway, four are in County Mayo, one is in County Sligo, and five are in County Donegal (Table 1.1).

One of the sites listed by Kerrigan, Station 39, Hog Island in County Kerry, appears to have been planned but not constructed and so its absence from the SMR and the NIAH is correct (Table 1.1). A series of four enclosed barracks were added to the system around the coast of County Kerry at a slightly later date, and three of those sites are listed on the County Kerry SMR, with the example at Brandon Height identified as a 'signal tower', and the examples at Hog's Head and Bolus Head identified as 'barracks' (Table 1.1). Of the seven signal stations that were added to existing forts or lighthouses, or newly built Martello towers, five of the sites are included on the relevant County SMR~~s~~ and four of the sites are identified on the NIAH (Table 1.1).

| Signal Station Name | No. | Province | County | Type | SMR Number | NIAH Number |
|---|---|---|---|---|---|---|
| Pigeon House Signal Station | 1 | Leinster | Dublin | Coastal Fort | DU019-027---- | - |
| Dalkey Signal Station | 2 | Leinster | Dublin | Signal Station | - | - |
| Ballygannon Signal Station | 3 | Leinster | Wicklow | Signal Station | - | - |
| Wicklow Head Signal Station | 4 | Leinster | Wicklow | Lighthouse | - | 16403102 |
| Mizen Head Signal Station | 5 | Leinster | Wicklow | Signal Station | WI036-022---- | - |
| Kilmichael Point Signal Station | 6 | Leinster | Wexford | Signal Station | - | - |
| Cahore Point Signal Station | 7 | Leinster | Wexford | Signal Station | - | - |
| Blackwater Signal Station | 8 | Leinster | Wexford | Signal Station | - | - |
| Fort Point Signal Station | 9 | Leinster | Wexford | Martello Tower | WX038-007002- | - |
| Hill Castle Signal Station | 10 | Leinster | Wexford | Signal Station | - | - |
| Forlorn Point Signal Station (Cross Faranogue) | 11 | Leinster | Wexford | Signal Station | - | - |
| Baginbun Signal Station | 12 | Leinster | Wexford | Martello Tower | - | 15705009 |
| Hook Head Signal Station | 13 | Leinster | Wexford | Lighthouse | WX054-010---- | 15705414 |
| Brownstone Head Signal Station | 14 | Munster | Waterford | Signal Station | - | - |
| Island of Kane Signal Station | 15 | Munster | Waterford | Signal Station | - | - |
| Bunmahon Head Signal Station (Burnmahon Head) | 16 | Munster | Waterford | Signal Station | - | - |
| Ballyvoyle Head Signal Station (Ballyvoil Head) | 17 | Munster | Waterford | Signal Station | - | - |
| Ballynamona Signal Station | 18 | Munster | Waterford | Signal Station | - | - |
| Ardmore Signal Station | 19 | Munster | Waterford | Signal Station | WA040-024---- | 22904006 |
| Knockadoon Signal Station | 20 | Munster | Cork | Signal Station | CO078-015---- | 20907820 |
| Ballynacotter Signal Station | 21 | Munster | Cork | Signal Station | CO089-048---- | 20908931 |

**Table 1.1. SMR and NIAH status of the signal station sites. The table includes the four enclosed barracks in County Kerry that were an addition to the system.**

| Signal Station Name | No. | Province | County | Type | SMR Number | NIAH Number |
|---|---|---|---|---|---|---|
| Fort Davis Signal Station (Carlisle Fort) | 22 | Munster | Cork | Coastal Fort | CO087-058---- | 20908790 |
| Robert's Head Signal Station | 23 | Munster | Cork | Signal Station | CO113-015---- | 20911312 |
| Barry's Head Signal Station | 24 | Munster | Cork | Signal Station | CO113-032---- | - |
| Old Head of Kinsale Signal Station | 25 | Munster | Cork | Signal Station | CO137-008---- | 20913706 |
| Seven Heads Signal Station | 26 | Munster | Cork | Signal Station | CO145-008---- | 20914501 |
| Galley Head Signal Station | 27 | Munster | Cork | Signal Station | CO144-033001- | 20914417 |
| Glandore Signal Station | 28 | Munster | Cork | Signal Station | CO143-086---- | - |
| Toe Head Signal Station | 29 | Munster | Cork | Signal Station | CO151-041002- | - |
| Ballylinchy Signal Station (Kedge Point) | 30 | Munster | Cork | Signal Station | CO150-042---- | 20915015 |
| Cape Clear Signal Station | 31 | Munster | Cork | Signal Station | CO153-022002- | 20915309 |
| Leamcon Signal Station (Lamcon) | 32 | Munster | Cork | Signal Station | CO148-012---- | 20914804 |
| Brow Head Signal Station | 33 | Munster | Cork | Signal Station | CO152-002---- | 20915201 |
| Mizen Head Signal Station | 34 | Munster | Cork | Signal Station | CO152-001---- | 20915202 |
| Sheep's Head Signal Station | 35 | Munster | Cork | Signal Station | CO138-001---- | - |
| Bere Island Signal Station | 36 | Munster | Cork | Signal Station | CO128-013---- | - |
| Black Ball Head Signal Station | 37 | Munster | Cork | Signal Station | CO127-028002- | - |
| Dursey Island Signal Station | 38 | Munster | Cork | Signal Station | CO126-005---- | 20912601 |
| Hog Island Signal Station | 39 | Munster | Kerry | Never Built | - | - |
| Hog’s Head Bastioned Enclosure | N/A | Munster | Kerry | Enclosed Barracks | KE105-004---- | - |
| Bolus Head Signal Station | 40 | Munster | Kerry | Signal Station | - | - |

**Table 1.1. continued. SMR and NIAH status of the signal station sites. The table includes the four enclosed barracks in County Kerry that were an addition to the system.**

| Signal Station Name | No. | Province | County | Type | SMR Number | NIAH Number |
|---|---|---|---|---|---|---|
| Bray Head Signal Station | 41 | Munster | Kerry | Signal Station | - | - |
| Great Blasket Signal Station | 42 | Munster | Kerry | Signal Station | - | - |
| Sybil Head Signal Station | 43 | Munster | Kerry | Signal Station | - | - |
| Ballydavid Head Signal Station (Brandon Head) | 44 | Munster | Kerry | Signal Station | - | - |
| Brandon Height Bastioned Enclosure | N/A | Munster | Kerry | Enclosed Barracks | KE025-004---- | - |
| Rough Point Bastioned Enclosure | N/A | Munster | Kerry | Enclosed Barracks | - | - |
| Kerry Head Signal Station | 45 | Munster | Kerry | Signal Station | - | - |
| Loop Head Signal Station | 46 | Munster | Clare | Signal Station | - | - |
| Knocknagharoon Signal Station | 47 | Munster | Clare | Signal Station | CL065-006---- | - |
| Ballard Signal Station (Baltard Hill) | 48 | Munster | Clare | Signal Station | CL046-005---- | - |
| Mutton Island Signal Station | 49 | Munster | Clare | Signal Station | - | - |
| Hag's Head Signal Station | 50 | Munster | Clare | Signal Station | CL014-010002- | - |
| Inisheer Signal Station (South Isle of Arran) | 51 | Connacht | Galway | Signal Station | GA120-016---- | 30412008 |
| Inishmore Signal Station (Great Isle of Arran) | 52 | Connacht | Galway | Signal Station | GA110-133001- | 30411019 |
| Golam Head Signal Station (Lettertmullan Island) | 53 | Connacht | Galway | Signal Station | GA089-013---- | - |
| Cuileen Hill Signal Station (Ard Castle Hill) | 54 | Connacht | Galway | Signal Station | GA076-006---- | - |
| Bunowen Hill Signal Station | 55 | Connacht | Galway | Signal Station | GA049-017002- | - |

**Table 1.1. continued. SMR and NIAH status of the signal station sites. The table includes the four enclosed barracks in County Kerry that were an addition to the system.**

| Signal Station Name | No. | Province | County | Type | SMR Number | NIAH Number |
|---|---|---|---|---|---|---|
| Cleggan Hill Signal Station | 56 | Connacht | Galway | Signal Station | GA009-007---- | - |
| Inishturk Signal Station | 57 | Connacht | Mayo | Signal Station | - | 31309401 |
| Clare Island Signal Station (Shivel Head) | 58 | Connacht | Mayo | Signal Station | MA084-001002- | 31308401 |
| Saddle Hill Signal Station | 59 | Connacht | Mayo | Signal Station | - | 31304201 |
| Glash Signal Station | 60 | Connacht | Mayo | Signal Station | - | 31302403 |
| Tower Hill Signal Station (Slievemore Hill) | 61 | Connacht | Mayo | Signal Station | - | - |
| Benwee Head Signal Station | 62 | Connacht | Mayo | Signal Station | - | - |
| Glinsk Signal Station (Glensky) | 63 | Connacht | Mayo | Signal Station | - | - |
| Creevagh Signal Station | 64 | Connacht | Mayo | Signal Station | MA007-015002- | - |
| Lenadoon Point Signal Station | 65a | Connacht | Sligo | Signal Station | SL010-001002- | - |
| Rathlee Signal Station | 65 | Connacht | Sligo | Signal Station | SL011-025001- | - |
| Carrowmably Signal Station (Carrowmabla Hill) | 66 | Connacht | Sligo | Signal Station | SL012-008003- | 32401201 |
| Knocklane Hill Signal Station | 67 | Connacht | Sligo | Signal Station | - | - |
| Streedagh Signal Station | 68 | Connacht | Sligo | Signal Station | - | - |
| Kilcologue Point Signal Station | 69 | Connacht | Sligo | Signal Station | - | - |
| St John's Point Signal Station (John’s Point) | 70 | Ulster | Donegal | Signal Station | DG097-020---- | - |
| Carrigan Head Signal Station | 71 | Ulster | Donegal | Signal Station | - | 40909601 |
| Malin Beg Signal Station | 72 | Ulster | Donegal | Signal Station | - | 40908901 |
| Glen Head Signal Station | 73 | Ulster | Donegal | Signal Station | - | 40908001 |

**Table 1.1. continued. SMR and NIAH status of the signal station sites. The table includes the four enclosed barracks in County Kerry that were an addition to the system.**

| Signal Station Name | No. | Province | County | Type | SMR Number | NIAH Number |
|---|---|---|---|---|---|---|
| Dawros Head Signal Station (Dauras Head) | 74 | Ulster | Donegal | Signal Station | DG064-001---- | - |
| Crohy Head Signal Station (Croye Head) | 75 | Ulster | Donegal | Signal Station | - | - |
| Mullaghderg Hill Signal Station | 76 | Ulster | Donegal | Signal Station | - | - |
| Bloody Foreland Signal Station | 77 | Ulster | Donegal | Signal Station | DG023-003---- | - |
| Horn Head Signal Station | 78 | Ulster | Donegal | Signal Station | - | 40901510 |
| Melmore Head Signal Station | 79 | Ulster | Donegal | Signal Station | DG008-027---- | - |
| Fanad Head Signal Station (Fannat Point) | 80 | Ulster | Donegal | Signal Station | - | - |
| Malin Head Signal Station | 81 | Ulster | Donegal | Signal Station | DG001-006---- | 40900101 |

**Table 1.1. continued. SMR and NIAH status of the signal station sites. The table includes the four enclosed barracks in County Kerry that were an addition to the system.**

## 1.2 Aim of the project

The aim of this project was to create a comprehensive understanding of the Napoleonic era signal stations around the coast of Ireland. Although there was a limited range of existing work on the subject at the outset of the project, the existing material all agreed about the general date, function, and historic context of the Irish signal stations. This project therefore utilised a single, very broad research question;

**How should the Irish signal stations be understood as a distinct class of monument?**

To answer this broad research question a series of more specific research questions were developed. In answering each of these more specific research questions the level of detail about each aspect of the subject would be increased. The response to the broad response question would be creating through the combination of the answers to the specific research questions. The specific research questions were;

1. How many signal stations were constructed around the coast of Ireland?
2. When were the signal stations constructed and when were they abandoned?
3. What did each signal station consist of?
4. What happened to each site following its abandonment?
5. Was the design of the signal stations influenced by contemporary military architecture?
6. What signalling technology was used at the signal stations?
7. Were the signal stations a successful communications system?
8. What happened to each site following its abandonment?
9. What level of legal protection is currently afforded to the signal stations?

A number of specific objectives were established in order to allow for the specific research questions to be answered, which would then allow for the broad research question to be resolved. These objectives were;

1. Accurately locate the 19 signal station sites in Connacht and the 12 signal station sites in Ulster that are described in Kerrigan's account. Examine evidence for additional sites in Connacht and Ulster not listed in Kerrigan's account.
2. Perform a detailed multi-faceted survey at each signal station site in Connacht and Ulster. Preparation of accurately scaled site plans, and external and internal elevation drawings of each signal tower that survives as a substantial above ground ruin.
3. Identify and examine related military sites in Connacht and Ulster that were part of the same defensive system as the signal stations, including selected site visits.
4. Create a GIS database for the signal stations in Connacht and Ulster to include accurate location data and a large range of other comparable fields such as form, materials, dimensions *etc*.
5. Utilise the GIS database to create a viewshed analysis of each signal station to determine inter-visibility as a measure of the effectiveness of the signalling system.
6. Accurately locate the 13 signal station sites in Leinster and the 37 signal station sites in Munster that are described in Kerrigan's account.
7. Examine evidence for additional sites in Leinster and Munster that are not listed in Kerrigan's account. Review the existing discussions of the four enclosed barracks sites in County Kerry which have been discussed as possible additions to the signal station system, but whose status is currently unresolved. Present a clear determination on whether the enclosed barracks were a part of the Irish signal station system.
8. Review the published literature, on-line resources, and selected historical sources to determine the nature of signal stations and related coastal fortifications in Leinster and Munster.
9. Undertake visits to a selection of signal stations and related coastal fortifications in Leinster and Munster.

10. Research the development of optical signalling technologies and other types of communications technology, that were in use during the medieval and post-medieval periods in different parts of Europe and the colonial world. Situate the equipment used at the Irish signal stations in this broader context.
11. Research the development of military coastal fortifications, and in particular the development of watchtowers and signal towers, in the medieval and post-medieval periods in different parts of Europe and the colonial world. Situate the architecture of the Irish signal stations in this broader context.
12. Examine how the individual signal station sites have been, or have not been, afforded legal protected and subjected to conservation methods.
13. Create a publicly accessible internet resource that details the signal stations.

## 1.3 Project chronology

The project has had a long gestation and development and involved an informal phase of investigation and a phase of formal study. Section 3.1 details how the project evolved over time, and an outline of this chronology is presented below;

- 2008 & 2009 – Initial investigation of selected sites in County Mayo and trials of recording methodology.
- 2010 & 2011 – Completion of visits to signal station sites in County Mayo and experimentation with data processing methods.
- 2012, 2013 & 2014– Visits to selected sites in Counties Sligo and Galway. Further refinement of field methods and data processing procedures.
- 2015 – Completion of visits to all Connacht and Ulster sites and registration with IT Sligo for post-graduate study. Revision of recorded material and assessment of suitability for inclusion in formal study. Assessment of existing omissions in collected data. Submission of methodological article to the Institute of Archaeologists of Ireland News (Rathbone & Bonsall 2016a).
- 2016 – Final field work stages to complete data collection. Data processing and compiling text. Presentation of initial results at Institute of Archaeologists of Ireland conference. Launch of interactive map detailing the signal stations in Connacht (Rathbone & Bonsall 2016b)
- 2017 – Preparation and submission of MSc to PhD transfer documents. Launch of Wordpress blog detailing the signal stations in Connacht and Ulster (Rathbone & Bonsall 2017a).
- 2018 & 2019 – Preparation of PhD thesis. Revision of interactive map and Wordpress blog in April 2018 to include details of the signal stations in Ulster. Revision of interactive map and Wordpress blog in November 2018 to include details of the signal stations in Leinster and Munster (Rathbone & Bonsall 2016b; 2017a).
- 2020 – Submission of PhD thesis in February 2020. Submission of detailed accounts of each signal station to the National Monuments Service in November 2020.

## 1.4 Structure of the text

The text has been divided into several sections to best answer the research question and the objectives stated above (Section 1.2).

**Chapter 1 – Introduction**

This chapter provides a simple introduction to the project, with the aim of explaining the nature of the subject that is being examined, defining what problems exist within the topic, outlining the approach to the research, discussing the research question, and describing the objectives of the project.

**Chapter 2 – Literature Review**

This chapter provides a comprehensive review of the published literature that is relevant to this project and is divided into six major sections.

Section 2.1 provides a brief overview of the development of post-medieval, industrial and historical archaeology in Ireland, Britain, and other parts of the world. It considers how this project best aligns with these three existing schools of archaeology, and what areas of overlap exist. Section 2.2 reviews the three attempted invasions of Ireland by French led forces, and how these invasions related to internal conflicts within Ireland. It concludes with a review of the military response to the invasion threat, which led to the creation of a new unified system of coastal defence for Ireland. Section 2.3 reviews the wider context of the late 18th and early 19th century conflicts in Europe and around the world, of which the repeated invasions of Ireland were a minor part. It then examines how the science of fortification and siege warfare developed in the post-medieval period. The section concludes with a discussion of Mediterranean coastal defences which seem to have provided a model for the Irish coastal defence system constructed after 1803. Section 2.4 provides a detailed overview of the development of increasingly complex communications technology throughout the post-medieval period across Europe. It identifies specific technologies which relate to the Irish signal stations. Section 2.5 presents an account of modern historical research on the Irish signal stations, highlighting the contributions Paul Kerrigan made to the topic, and discussing the important work undertaken by other researchers.

**Chapter 3 – Methodology**

This chapter describes the methodology used during the fieldwork and post-fieldwork portions of the project. Section 3.1 discusses the lengthy gestation of the project, and how it evolved into the formal study presented in this thesis. Section 3.2 describes the desk-based research that took place prior to the field surveys, and how the field surveys were undertaken. Section 3.3 describes the different techniques and software applications which were used to process the results of the field surveys. Section 3.4 concludes the chapter with a review of the nature of primary historical material that was utilised during this project, including cartographic sources, paintings, sketches and photographs, military documents and 19th century traveller's accounts.

**Chapter 4 – Results**

This chapter presents the main results of the project. Section 4.1 provides an overview of the signal station components and presents a series of tables and maps that describe the components and location of each signal station in Connacht and Ulster. The next four sections (Sections 4.2, 4.3, 4.4 & 4.5) review in detail the nature of the different surviving components of the signal stations. Section 4.6 examines how the signal stations relate to the early 19th century and modern road systems. Section 4.7 reviews the presence of large secondary structures at the signal station sites. Section 4.8 describes the presence of trigonometry points and pillars at several sites. Section 4.9 describes the frequent occurrence of small World War 2 era Look Out Posts (L.O.P.s) either at the signal stations sites, or in the same vicinity as them. Section 4.10 describes the less frequently occurring presence of lighthouses at or close to the signal station sites. Section 4.11 describes the defensive nature of the signal station locations, as illustrated by the presence of earlier and contemporary fortifications. Section 4.12 summarises the results of the desk-based research on the signal stations and associated fortifications in Leinster and Munster. Section 4.13 concludes the chapter with an examination of inter-visibility at the signal stations in the main study area, through GIS analysis, historical and modern meteorological data, and examining the relative elevations and distances between the sites.

**Chapter 5 – Discussion**

This chapter discusses how the results of the project answer the research questions established in Chapter 1.

**Chapter 6 - Conclusion**

This chapter presents the conclusions of the project. It discusses how well the research questions and objectives set out in Chapter 1 were answered and achieved, and highlights areas for further research on this topic.

**Bibliography**

Contains the references that were used during the preparation of the main text and the appendices. The bibliography is divided into five sections, published sources, unpublished sources, online documents, primary sources (historical documents), and websites that were important to the completion of this project.

**Glossary and List of Acronyms**

A list of specialist terms used throughout this thesis. Each entry features a brief explanation of this specific meaning of the term as used in this thesis. The glossary is followed by a list of the various acronyms used in this thesis, accompanied by the full version of the terms they represent.

**Appendices A, B, C & D – The individual surveys**

These appendices contain individual entries for each signal station site in Connacht and Ulster, arranged by county. Each entry begins with a description of the signal stations location, and any common names in use that differ from the naming conventions established by Kerrigan and used in this project. This is followed by a detailed written description of the surviving remains at each site, a plan and, where possible, a complete set of external and internal elevation drawings. Each entry also includes a viewshed analysis from the signal station to its immediate neighbours and details about the site derived from historical sources including maps, military records and traveller’s accounts. The final part of each individual account presents a review of other relevant maritime archaeological and architectural sites which are present in the local landscape. These four appendices therefore present, for the first time, a complete, standardised, and highly detailed account of every signal station site in Connacht and Ulster.

**Appendices E, F & G – Signal stations in the secondary study areas**

Appendix E details the signal stations in Leinster, Appendix F details the signal stations in Munster, and Appendix G details the enclosed barracks in County Kerry which were a late addition to the signal station system. Each site has an individual entry presenting information derived from online sources, published accounts, historical documents, and a selected number of site visits.

# Chapter 2. Literature Review

As mentioned in Section 1.1 the quantity of existing literature and other resources discussing the Irish signal stations is low. The following literature review therefore deviates from the normal practice of providing a detailed review of existing literature relevant to the topic. Section 2.1 discusses three different types of archaeological thought and practice, post-medieval archaeology, industrial archaeology, and historical archaeology, and explores how these related but distinctive approaches might be applied to the study of the Irish signal stations. The next three sections of this chapter provide a detailed historical background for understanding the Irish signal stations. Section 2.2 presents a review of the political and military events in Ireland that led to their creation, operation and abandonment. Section 2.3 discusses the wider political and military events of the time period, and highlight that the creation, operation, and abandonment of the Irish signal stations occurred during a period of global conflicts, of which events in Ireland were only ever small components.  Section 2.4 presents a detailed account of the development of military and civilian communication systems from the middle of the 18th century through to the middle of the 19th century, with the aim of understanding why the signalling method used at the Irish signal stations was selected, and how that system compared to other broadly contemporary communications technologies. Finally, Section 2.5 provides a traditional review of the limited body of existing archaeological and historical literature that relates to the Irish signal stations.

## 2.1 Post-medieval, industrial and historical archaeology

Three distinct but overlapping sub-disciplines of archaeology focus on the large and complex time period that follows the end of the medieval period; post-medieval archaeology, industrial archaeology and historical archaeology. The terms post-medieval archaeology and industrial archaeology originated in Britain, whilst historical archaeology originated in North America.

Significant social changes swept through Europe in the 16th century which are widely accepted as bringing an end to the medieval period (Section 2.1.3). Post-medieval archaeologists study this transition and the archaeology of the centuries which followed these changes. Post-medieval archaeology is therefore an inclusive term and has been utilised in discussions of a diverse range of topics. Examining the published proceedings of a single post-medieval archaeology conference illustrates this breadth well; the second Irish Post-Medieval Archaeology Group Proceedings, from a 2004 conference, includes papers on the improvement of estates, the mass manufacture and export of goods, the lifestyles of remote rural communities, battlefields, Plantation settlements, and Irish and English emigration (Caldwell 2009; Davey 2009; Dalgleish 2009; Dwyer 2009; Logue & O'Neil 2009; Lyttleton 2009; Pope 2009).

Industrial archaeology is generally used to refer to archaeology related to the Industrial Revolution and the subsequent industrialised world. Industrial archaeology is therefore a functional term as well as a chronological term. Traditional topics within industrial archaeology include manufacturing sites, extraction sites, transportation sites and communications sites (Raistrick 1973, 2; Butt & Donnachie 1979, 5-6). The term also encompasses settlements that relate specifically to the owners of industrial sites, and to the workforce, but would not necessarily extend to an early 19th century rural settlement (Rynne 2006, 436-9; Turk 2014). This functional focus makes industrial archaeology the most universal of the terms, and it can be applied to anywhere that industrialisation was attempted (Rynne 2006, 1-3). This functional aspect limits the scope of the term, and apart from particularly dense industrial towns, it cannot cover all the activities within a given territorial unit during a specific time frame. Raistrick argued that the chronology should be extended to much earlier periods, such as Roman Britain, where industrial production and industrial extraction had replaced smaller scale craft industries, but this suggestion, whilst not lacking in merit, has not seen widescale application (Raistrick 1973).

Historical archaeology originated in North America and is widely understood there to refer to the period after European colonists arrived (Orser 2002, xiii; Newman *et al* 2001, 3-4; Horning & Palmer 2009a, xiii). The situation is complicated by the slow territorial expansion westwards across the North American continent, meaning the historical period begins 200 years earlier on the east coast than it does on the west coast (Dixon 2014). This conception of historical archaeology as relating to the process of colonisation is central to the study and makes it a term that is easily transferrable to other parts of the colonial world, such as South Africa and Australasia, where similar processes of European expansion and indigenous replacement occurred, and where there may be no medieval period for any activities to post-date. Some archaeologists in Britain and Ireland have pushed for the adoption of the term, feeling that it offers the most inclusive solution to describing what are clearly heavily interrelated topics (Breen 2009; O'Keefe 2009; Newman *et al* 2001).

Many modern proponents can make a claim to be less concerned with the precise boundaries of where one thematic topic ends and another begins (Beaudry 2005, 302-3; Horning & Palmer 2009a; Gould 2009, 49-50). The debates about nomenclature and the respective scopes and styles of post-medieval, historical, and industrial archaeology do regularly reappear, indicating that concerns over where the respective boundaries lie continue to linger.

The situation is problematic because the terms do not only relate to specific time periods, locations or activity types, they also reflect differing stylistic and theoretical approaches, and may be used both as statements of intent and of prejudice; post-medieval archaeology is seen as "a synonym for atheoretical" and "old fashioned artefact research" (Horning & Palmer 2009a, xiii); historical archaeology is seen as "theory-driven," and strongly linked to a colonial or post-colonial perspective (Horning & Palmer 2009a, xiii); industrial archaeology is viewed as techno-centric and rooted in amateurism (Horning & Palmer 2009b, 3; Gould 2009, 45-50).

Opinions vary as to the usefulness of these internal debates. Some practitioners have embraced these criticisms and used them to broaden the scope of their work, whilst others have used them to more firmly delineate the boundaries of their studies (Gwyn 2009). Johnson reminds all archaeologist working on these topics;

> "*We cannot study social life without a deep understanding of technical processes, and we cannot understand technical processes without a deep understanding of social context*." (Johnson 2009, xvii).

Opinions also vary widely as to when the post-medieval, industrial, and historical archaeological periods begin and end. This issue is hampered by the different chronologies present across different regions, and by what activities are regarded as signalling the transition from the preceding period. The date ranges that relate to these different types of archaeology are discussed below (Section 2.1.3). Within these areas of study there are numerous terms used to describe specific brackets of time, most of which have a self-evident meaning easily deduced by the context, for example the Plantation period in Ireland, or the Civil War period in Britain, the latter equating to the Cromwellian period in Ireland. 'Early Modern' has a broad currency and is a useful term generally used to describe the late-15th through to the late-18th centuries (Herron & Lyttleton 2007). The end of the post-medieval/historical archaeological time period, and even if they should be considered to have ended, is another important consideration (González-Ruibal 2008, 247-8; Mytum 2016, 12). Some authors favour dividing off the modern period, the 19th and 20th centuries, the contemporary period, frequently cited as 1945 to present (Brivati 1996, xvi; Harrison & Schofield 2010, 2-4, 30-4), and even the 'supermodern,' referring to the late 20th century to present (González-Ruibal 2008, 247); others argue further sub-division is unnecessary and potentially even counter-productive (Horning 2011, 161-3; González-Ruibal 2014, 2-4;).

### 2.1.1 Post-medieval, industrial and historical archaeology in Britain

In general terms archaeology in Britain has had a longer period of engagement with archaeological sites of a post-medieval date than has been generally the case in Ireland, particularly in the Republic of Ireland. It appears to be widely acknowledged that it was British archaeologist who first attempted to apply their skills to post-medieval archaeological sites (Sande 1977, 40-1; Buchanan 2000, 19-30; Cossons 2000a, 11-4). It is therefore appropriate to review British approaches before reviewing Irish approaches, which were influenced both directly and indirectly by work first undertaken in Britain.

The sub-disciplines of post-medieval and industrial archaeology in Britain are generally seen as having developed rapidly in the period shortly after World War 2 (Hudson 1979, 1; Crossley 1990, 1; Newman *et al* 2001, 1). Butt and Donnachie (1979, 1-4) argued that the origins of post-medieval archaeology in Britain extended to the 19th century. Two issues, often co-related, seem to be responsible for this disparity. The first issue relates to nomenclature, where early studies that can now be recognised as having significant archaeological components were often labelled and published under different subject titles, principally ethnography, local history, industrial history, and folk life (Raistrick 1973, 4-5). The second issue is that many of the relevant studies took place outside of traditional academic archaeological departments, being the works of local community groups, passionate individuals with backgrounds outside of archaeology, and scholars who were principally identified as being practitioners of other subjects (Butt & Donnachie 1979, 2-4).

Butt and Donnachie (1979, 1) cite John Postlethwaite's (1877) study of mining in the English Lake District as the earliest example of industrial archaeology in Britain. Isaac Fletcher's (1878) study of the coal trade in West Cumberland followed in the next year (Butt & Donnachie 1979, 1). Butt and Donnachie describe a number of projects from the first half of the 20th century that can be identified as having components of industrial archaeology. They repeatedly highlight that many of the projects were conducted by local communities living around abandoned industrial sites, by people interested in recreating aspects of the recent past as 'living history' projects, and by various hobbyists with a passionate interest in the past, such as groups that have restored canals, railways, and various types of steam engine (Butt & Donnachie 1979, 2-4). Crucially they identify the period after World War 2 as the time when industrial archaeology began to be established as a separate sub-discipline within university archaeology departments, rather than being the period when such studies were first initiated (Butt & Donnachie 1979, 2). Hudson identifies Michael Rix as first coining the term industrial archaeology in 1955, in an article that marked the first traditional academic work on the subject (Hudson 1979, 1). Raistrick was not impressed by the claims that industrial archaeology was a new development of the 1950s, arguing that industrial history had developed as a university subject in the early-20th century. He noted that industrial history included significant amounts of overlap with the later industrial archaeology, including fieldwork, and was only lacking actual archaeological excavation, which would not become a major component in industrial archaeology until quite late in the 20th century (Raistrick 1973, 2-13; Martin 2009, 288). As the subject developed the Inspectorate of Ancient Monuments at the Ministry of Works developed a definition of the subject which remains representative;

> "*An industrial monument is any building or other fixed structure, especially of the period of the Industrial Revolution, which either alone or associated with primary plant or equipment, illustrates the beginning and development of industrial and technical processes, including means of communication.*" (Raistrick 1973, 2).

The Society for Post-Medieval Archaeology (SPMA) was founded in 1966. Initially post-medieval archaeology in Britain concentrated on a narrow range of site types reflecting the interests of the disparate groups undertaking research. Early interest was centred on industrial sites, military sites, upper class housing, and churches. Mytum's recent review has demonstrated that the scope of work increased rapidly and soon encompassed such areas as ornamental gardens, landscapes and follies, agricultural processing sites, field systems and rural settlements, upland agricultural practices and settlements, urban housing developments, and municipal facilities, amongst many others (Major 1975, 10; Mytum 2016, 10). Studies were focused on material culture, and numerous discussions about artefact manufacture, development and distribution were produced (Mytum 2016, 7-8).

Newman *et al* (2001, 1-2) have highlighted that changes in the quantity and goals of pre-development archaeology in the 1980s triggered a dramatic increase in the excavation of 16th century and later material across Britain (Evans 2014). They also noted that the visibility of post-16th century sites in pre-excavation desk-top studies created a climate in which post-medieval deposits on complex multi-period sites were identified and studied on their own terms, rather than simply being encountered reluctantly or disinterestedly as excavators proceeded downwards towards the layers of more long-standing archaeological interest (Newman *et al* 2001, 1-2). The nature of careers in pre-development archaeology meant that commercial archaeologists seldom chose what they excavated according to their specific interests or expertise, and this has had an effect in breaking down boundaries between specialist areas and encouraging generalisation. A positive effect of this may be a weakening of tribalism, a negative effect is a potential lack of the depth of knowledge needed to fully appreciate the results of certain excavations (Pannell 1966, 10-2; Raistrick 1973, 11-3; Newman *et al* 2001, 2, 183-6).

As will be discussed in detail below, the age at which sites become relevant to archaeologists has been continually pushed forwards, expanding the range of sites considered suitable for study. Today post-medieval archaeology is a very broad subject that extends well into the 20th century where it dovetails with the later developments in ‘contemporary archaeology’ that brought archaeological study into the present time (Horning 2011; Fowles & Heupel 2013; Rathbone 2014, 256-9).

### 2.1.2 Post-medieval, industrial, and historical archaeology in Ireland

The 1921 partition of the island of Ireland into two separate political entities and legal jurisdictions added a layer of additional complexity to how post-medieval and industrial archaeology developed. The lesser importance of industry and the greater focus on farming across Ireland, particularly in the Republic of Ireland, also influenced the way in which the sub-disciplines were to develop.

Almost a century prior to partition a major early contribution was made by the Topographical Branch of the Ordnance Survey's 'memoir project.' In the face of much criticism, the memoir project attempted to create a supplementary body of geographically referenced ethnography, local history, folklore studies, and historical linguistics during the 1830s and early 1840s (Andrews 1975, 144-75; Hewitt 2010, 270-88). A similar breadth of investigation was often exhibited by various antiquarians working in the late 19th century, and these early accounts form an important and much utilised foundation for later studies (Dillon 1967; Harris 2018, 25-39). Between 1909 and 1911 a large multi-faceted team of scholars descended on Clare Island, County Mayo, to record as much scientific information about the island as possible. T. J. Westropp prepared the study of the history and archaeology of Clare Island and the adjacent parts of County Mayo's coast. Although he concentrated on earlier sites, he does describe a number of late medieval and early post-medieval sites, for example the tower house on Clare Island, and the bastioned fort on Inishbofin (Westropp 1911, 37-42, 69-72). Westropp mentions the signal tower on Inishturk, but does not describe it, and also mentions a signal tower on Inishbofin, County Galway, which is of uncertain date, but is shown on the 1st edition Ordnance Survey Map, surveyed 1838-1839, as having a circular plan (Westropp 1911, 46, 64). James Wilson recorded the agricultural history of the island and his account contains some useful information for post-medieval archaeologists, embedded in a very dated pseudo-historical and historical narrative (Wilson 1911). Many of these early works were concerned with the premise that Ireland was a repository for surviving customs that might date back as far as the prehistoric period. The study of the recent past was often used by early- and mid-20th century archaeologists in their attempts to illuminate the remote past, rather than being seen as an area of archaeological interest in its own right (McManus 2000; Whelan 2000, 187-8).

### 2.1.2.1 Northern Ireland

The development of these subjects in Northern Ireland after partition reflects the greater development of industry in parts of Ulster, and the presence of Ulster Scots and Unionist communities which had an inherent interest in the history of the Plantation, and of the periods which followed.

The formal training of a key figure in the development of post-medieval archaeology in Northern Ireland, Emyr Estyn Evans, was in historical geography and anthropology. He developed an interest in archaeology in the 1920s whilst recuperating from tuberculosis in Wiltshire, where he assisted with a number of important excavations of some of the premier prehistoric sites in that region (Evans 1999, 134). In 1928 he was appointed by Queen's University Belfast to establish a geography department (Evans 1999, 134-6), which gradually broadened its scope to encompass archaeology and latterly paleoecology. Evans combined his interests in archaeology and anthropology throughout his career, and his classic works on the customs and practices of rural Northern Ireland suggest only a somewhat half-hearted interest in using the material gathered as analogies for more ancient practices (Evans 1951; 1957). As an excavator, Evans worked on sites from a variety of periods. Evans and Proudfoot's pioneering 1957 excavation of a transhumant 'booley' settlement at Deer's Meadow, County Down, is one of the first instance of a post-medieval site being deliberately selected for excavation anywhere in Ireland, and complemented Evan's survey work undertaken at other transhumant sites in the Mourne Mountains (Evans 1957, 136-7; Evans & Proudfoot 1958; Rathbone 2010). This early interest in transhumant practices sowed seeds that were to come to fruition in the 1980s with a series of important excavations that investigated potential booley sites in County Antrim (Williams & Robinson 1983; Brannon 1984; Williams 1984; Williams 1988).

Buchanan, Johnson and Proudfoot had begun their excavations of a clachan at Murphystown in County Down one year earlier, continuing work in 1958 and 1959, giving the impression that the last years of the 1950s were particularly portentous for post-medieval archaeology in Northern Ireland (Buchanan *et al* 1958; Buchanan *et al* 1959). Archaeological investigations of Plantation settlements and towns were of more interest to researchers in Northern Ireland than was the case for a long time in the

Republic of Ireland, and archaeological investigations began at a much earlier date in Northern Ireland (Delaney 1977).

Breen's claim that research in historical archaeology in Ireland began with Colin Martin's investigations of Armada shipwrecks in the 1960s and 1970s[3] is erroneous (Breen 2009, 55-6), but Martin's work on the wreck of the *Santa Maria de la Rosa* off Dunmore Head, County Kerry and *La Trinidad Valencera* in Kinnagoe Bay, County Donegal, were undoubtedly important early projects (Martin 1975; Breen 2009, 55-6). The establishment of the Centre of Maritime Archaeology at the Ulster University Coleraine Campus in 1999 was an important event, and their staff and students have made many important contributions to the study of post-medieval and industrial sites, both under water and along the coastal zone (Breen 2009, 56).

Another crucial factor that may have led to an earlier engagement with post-medieval archaeology in Northern Ireland was the stronger connection to the archaeological community in the rest of the United Kingdom. It was under the influence of this cross-pollination that the earliest monograph detailing industrial archaeology from the United Kingdom was written, focusing on the industrial heritage of County Down (Green 1963; Rynne 2006, 6). The fieldwork for Greens' survey of County Down was undertaken during the 1950s and it was published in 1963 (Green 1963). Green's work served as a pilot for the '*Survey of Industrial Archaeology of Northern Ireland*' undertaken in the 1960s and published as a monograph in 1980 (McCutcheon 1980; 1983). Gwyn presents Green's 1949 book, '*The Lagan Valley 1800 – 1850: A local history of the Industrial Revolution*' as the beginning of industrial archaeology in Northern Ireland, and it is such an early foundational text that it predates Rix's coining of the term industrial archaeology (Green 1949; Gwyn 2009, 21). In the early 1970s a visiting American folklorist, Henry Glassie, undertook a comprehensive and multi-faceted study of a single rural community in Northern Ireland, Ballymenone in County Fermanagh. His publication includes a sizeable section on architecture and the quality of his

[3] In the paper Breen makes it clear that he is using the term historical archaeology in an inclusive fashion, as a replacement or synonym for post-medieval archaeology. Breen is therefore not making a subtle distinction, with Martin's work being identified as historical archaeology in the American, colonial, sense. Such a distinction might have legitimately allowed the exclusion of the earlier work in Ireland dating from the 1950s, if that was seen as specifically belonging to the separate category of post-medieval archaeology, but this does not seem to have been his intention.

illustrations, which include building elevations, cross sections, and plans, was extremely high (Glassie 1982, 327-424).

The development of post-medieval Archaeology in Northern Ireland broadly followed the same chronology as Great Britain, including the establishment of an open-air museum of historical buildings (via an Act of Parliament in 1958), and demonstrates the same gradual expansion of topics as different researchers became involved (Hansard for Northern Ireland 1958, 487-501; Evans 1965, 355). In the *Encyclopaedia of Historical Archaeology,* Orser (2002, 296) stated that as of the year 2000, post-medieval archaeology was more developed in Northern Ireland than the Republic of Ireland. After that date, Northern Ireland did not witness the same scale of dramatic increase in pre-development archaeological excavations as the Republic of Ireland (Chapple 2013), and that early lead has presumably now vanished.

#### 2.1.2.2 Republic of Ireland

The 'Celtic Revival' was important for all communities in Ireland in the late-19th century and the early-20th century, but it became a central theme in the Republic of Ireland following Partition in 1921. Archaeology, alongside folk studies, and historical linguistics played an important role in the early years of the Irish Republic. That early archaeology reflected a politicised mindset which emphasised the uniqueness of Irish culture and attempted to recover information about Irish prehistory and, for later periods, identify and investigate aspects of indigenous Irish culture which had not been heavily impacted by centuries of domination by a foreign power (Bourke 2011, 321-30; Harris 2018, 8-14). Despite this, several of the earliest post-partition archaeological studies were undertaken by teams of visiting foreign academics (Bourke 2011, 334, 406).

Formal ethnographic study in the Republic of Ireland is probably best seen as beginning in the 1930s with a team of Swedish scholars, most notably Albert Eskeröd and Åke Campbell, who recorded many aspects of traditional Irish life (Campbell 1935; Evans 1940). Of particular use to later archaeologists are the detailed studies of vernacular houses recently celebrated in a traveling exhibit by the National Museum of Ireland entitled '*Through a Swedish lens*' that toured a number of Irish museums in 2012. The value of this work has yet to be fully realised through comprehensive re-examination and publication. Between 1935 and 1971 the Irish Folklore commission was responsible for recording considerable amounts of information about traditional Irish life, using a variety of techniques and involving scholars from many backgrounds (Agozzino 2005, 21-3; uí Ógáin 2010). These records of agricultural life are of vital importance to the understanding of 19th century and early-20th century archaeology in rural Ireland.

This systemic disinterest in post-medieval archaeology persisted into the late-20th century, hampered to a considerable degree by the legislation and guidance which described archaeology as an entity that stopped around AD 1700, and therefore material remains after that date were not covered by statutory protection (Donnelly & Horning 2002, 558; Gwyn 2009, 21; Rynne 2009, 168; Whelan 2011a, 129; Horning & Brannon 2012).

Prior to the late-1990s, it was extremely rare for individual post-medieval sites to be investigated or for post-medieval layers at multi-period sites to be given proper consideration. A rare example of the former was Theresa McDonald's work at the Deserted Village on Slievemore (SMR MA042-016001-)[4], Achill Island, County Mayo, which took place between 1991 and 2004 (McDonald 1998; 2016, 67-9). A rare example of the latter was Kenneth Wiggin's excavations at King John's Castle (SMR LI005-017014-) in Limerick which took place in different phases between 1990 and 1998 (Wiggins 2001).

It was not until the onset of the construction driven 'archaeological boom' circa 1997 that post-medieval sites began to be investigated with some regularity in the Republic of Ireland, and not until the mid-2000s that they genuinely began to be regarded as being on equal footing with sites of other periods (Donnelly & Horning 2002, 558; Rathbone 2016). To a lesser degree this attitude also hampered the development of medieval archaeology in the Republic of Ireland (Barry 2000a, 110-12). This attitude is no longer current, and much stimulating work has been done regarding contacts with Britain, North America, and other locations that were once part of the British Empire (Brannon & Horning 2009; Breen 2009, 56; Horning 2013). The notion that post-

[4] Where a site is mentioned in the text for the first time that is listed in an SMR inventory the SMR number is given in brackets (NMS 2019a). Where sites mentioned in the text for the first time are listed in the National Inventory of Architectural Heritage (NIAH) the Reg. No. is given in brackets, following the SMR number if a site is listed in both inventories (NIAH 2019).

medieval archaeology should be used as a proxy for earlier periods is now rather out of favour, and post-medieval sites are largely studied for their own merits; Gwyn has described folk life studies as a one-generation discipline (Gwyn 2009, 21). The older paradigm still retains some value; there are definite instances of extreme continuity, perhaps exemplified by horizontal watermills which were in use from the 7th century through to the 20th century (Rynne 1989; 2011).

#### 2.1.2.3 Organisations

The formation of the Irish Post-Medieval Archaeology Group (IPMAG) in 1999 is regularly cited as marking a particularly crucial event for post-medieval archaeology in Ireland (Breen 2009, 56; O'Keeffe 2009, 68). Brannon and Horning (2009, xv) have claimed that IPMAG itself only '*came of age'* in 2004 when it affiliated with the Society of Post-Medieval Archaeology (SPMA) at a conference held in Derry/Londonderry, County Derry/Londonderry. The organisation, and in particular its peripatetic annual conference, continues to be a central focus of archaeologists interested in the archaeology of Ireland after the end of the medieval period.

IPMAG is largely an organisation of academics and heritage professionals of various types, and its formation in 1999 reflects the delayed engagement of the academic community in post-medieval studies across Ireland, particularly in the Republic of Ireland. The formation of volunteer societies interested in industrial heritage follows a chronology much closer to that seen in Great Britain. The Irish Railway Recording Society was established in 1946, the Inland Waterways Association of Ireland was established in 1954, an all-Ireland Steam Preservation Society was founded in 1965, all of which are still active groups. They reflect the same enthusiasm for industrial heritage seen in Great Britain, and undertake a similar range of activities, including recordation and restoration (Rynne 2006, 7-8).

An organisation with a broader remit, the Irish Society for Industrial Archaeology (ISIA), was established in the early 1970s but was defunct by the end of that decade. During its period of operation, the ISIA produced regular publications for a wide readership (Rynne 2006, 8). An organisation with similarly broad interests but a provincial scope, the Society for Industrial Archaeology in Munster, was established in 1986 but was a short-lived effort (Rynne 2006, 8).

The Industrial Heritage Association of Ireland (IHAI) was established in 1996 and continues to operate, stating its mission as being;

> *"...to foster a greater understanding and appreciation of the many thousands of sites, monuments and items of machinery that together constitute our industrial heritage~~,~~"* (IHAI 2018).

The IHAI defined industrial heritage as having five components: extractive industries, manufacturing industries, transport, communications and prime movers (energy generation) (Hammond & McMahon 2002, 9). The IHAI maintains a large physical archive of printed books, pamphlets, journals and papers that are held at the Irish Architectural Archive in Merrion Square, Dublin. The IHAI has published four conference proceedings, one more than IPMAG, and a quarterly newsletter. The IHAI regularly interacts with local historical societies and other heritage related groups.

Various governmental initiatives have also been responsible for recording and publishing details about post-medieval and industrial archaeological sites and buildings across Ireland. The most important and wide ranging of these is the National Inventory of Architectural Heritage (NIAH) which was created by the *Oireachtas* in 1999 (NIAH 2012, 3). Currently the NIAH has recorded approximately one million buildings and gardens, with individual records freely accessible via the NIAH website (NIAH 2019). It has also produced a series of county by county publications, although it does not include sites in Northern Ireland. A large number of county and city level initiatives have also led to the recording of post-medieval and industrial archaeology sites and buildings, and this work has been succinctly summarised by Rynne (Rynne 2006, 9-10).

It remains a curiosity as to why the efforts of the NIAH, IHAI and ISIA seldom get mentioned in Irish post-medieval archaeological literature. The tendency to emphasise the importance of IPMAG may simply result from an omission of convenience, where the goal of the author is really to discuss other matters and mentioning the creation of IPMAG is simply expedient scene setting. Whilst that might be the case, the regular omissions of other organisations may also reflect an ongoing degree of separation between post-medieval and industrial archaeologists working in Ireland.

### 2.1.3 Date ranges

The commencement of the post-medieval period has been subject to some debate and various calendar years have been used, often relating to specific historic events that marked a significant cultural change in a particular region. However little agreement has been reached, and the stated beginning of the period varies widely by source. Newman *et al* (2001, 5-8) claim that changes throughout the 16th century relate to the principal themes of the post-medieval world, the rise of capitalism, the expansion of consumerism, and the onset of colonialism. They propose that if a single date were to be chosen to mark the transition in Britain, 1540 AD when the dissolution of the monasteries was completed, is the best candidate (Newman *et al* 2001, 6). In Ireland various dates have been utilised to mark the start of the post-medieval period, with the calendar dates of 1500, 1550 and 1600 all having been used, whilst the onset of the Plantation c.1580 and the date of the 'Flight of the Earls' in 1607 have also been argued for (Orser 2002, 296; Brannon & Horning 2005, 16; Horning *et al* 2007).

The end of the period is also difficult to determine. As sites and subjects become younger the term post-medieval becomes less appropriate, because there are less direct relationships to medieval precedents, and other more specific terms are often substituted according to taste and relevance; the use of 'historical archaeology' would certainly be more elegant in this regard. Newman *et al* (2001, 8-9) argue that 1900 is an appropriate date to use for the end of the post-medieval period. They highlight that by the last years of the Victorian period a range of interconnected processes relating to industrialisation and modernisation had been completed, and that a slew of technological developments and social movements had come to maturity, ushering in a period of rapid social change at the start of the 20th century. Given the political links between Ireland and Britain in that era it may be appropriate to utilise the same date for Ireland. However, many of the processes of modernisation did not occur in Ireland, and perhaps the beginning of the period of struggle which eventually led to the division of Ireland into two states is better suited for this purpose. In that case either 1913, the year of the 'Dublin Lock-Out,' 1916, the year of the Easter Rising, or 1921 the year of Partition, are more appropriate dates (Metscher 2002, 135-152; Rynne 2009, 167-9).

This forces us to consider an appropriate term to describe the period after the post-medieval has ended. In recent years 'contemporary archaeology' has become a popular term but in practice it has tended to reflect the archaeology of the present, and is an area perhaps overly concerned with theoretical discourse and existential angst (Graves-Brown *et al* 2013). As with historical archaeology, in the North American sense, it is indicative of a particular style of archaeological discussion, as opposed to a chronological division (Dixon 2009, 101; Graves-Brown *et al* 2013, 2-3). The potential to perform archaeological studies of the very recent past remains compelling and the broad range of topics covered, transit vans, drug dens, hardcore raves, toilet cubicles, protest camps, lunar landing sites, and Boy Scout camps, amongst many others, reflects the exciting range of possibilities that exist for archaeologists examining the latter parts of the 20th century and the beginnings of the 21st century (Schofield & Anderton 2000; Bailey *et al* 2009; Kiddey & Schofield 2011; Graves-Brown & Schofield 2011; Crea *et al* 2014; Rathbone 2014; Bonsall & Chapple 2017).

The origin of an Industrial Revolution in Britain in the mid-18th century is widely acknowledged, but as with so many large events identifying a specific start date is complex. Thomas Newcomen invented his atmospheric engine in 1712, but it was James Watt's improvements to Newcomen's design which had matured by 1775, which truly initiated the steam age, and which is often utilised as the elusive singular moment (Easton 1961, 567). Hobsbawn makes a compelling argument that although the precursor's to industrialisation were present decades earlier, the process matured in the 1780s, as demonstrated by rapid changes in numerous metrics, which he refers to as the "take off" (Hobsbawn 1962, 27-9). The spread of industrialisation around the globe was complicated and dependent on many varied factors, and even in the 21st century not all territories have been industrialised.

Archaeologists obviously have an ingrained interest in the antecedents of a process such as industrialisation, and their date ranges often reflect a slightly extended chronology. Pannell mentions the development of steam power in the mid-18th century as an obvious date but stresses the importance of changes in British society during the 16th and 17th centuries as providing the conditions in which industrialisation could occur (Pannell 1966, 1). Raistrick does not establish hard dates for the industrial period but identifies the 16th and 17th centuries as the ‘prelude’ to the Industrial Revolution which occurred in the 18th century (Raistrick 1973). Butt & Donnachie state that many industrial archaeologists have seen their period of study as beginning in 1700 and ending in 1914, although they note that they themselves do not favour such a rigid definition, following Raistrick’s lead (Butt & Donnachie 1979, 5). Rynne uses a date of 1750 for the beginning of industrialisation in Ireland but stresses the process was not successfully introduced into much of the country until the late-19th and early-20th centuries (Rynne 2006, 1-3). In many areas, such as large parts of the main study area, the process has been limited to small scale mechanisation, such as the introduction of tractors and mechanical excavators, and a reliance on manufactured goods brought into the regions in freight vehicles, over craft produced good; industrial production sites were never established. Although using 1921 as a major point of change in Irish society in other places, Rynne uses 1930 as the ending date for his synthesis of industrial archaeology in Ireland, although he does not explain this choice (Rynne 2006; Rynne 2009).

Western countries are now frequently claimed to have entered a post-industrial economic period, a process presented as beginning in the decades after World War 2 (Rifkin 1995). It can be argued that rather than having actually moved beyond industrialism, western countries have used the development of globalism to move their most pollutant industries to foreign territories, but that debate lies well beyond the scope of this study (Grossman & Krueger 1993; Mertes 2004). Post-industrial archaeology has yet to emerge as a specific area of study, although that is surely just a matter of time.

### 2.1.4 Situating the study of the Irish signal stations

This current study is focused on a group of sites from the first decade of the 19th century and the technological developments spanning a period of around fifty or sixty years on either side of that decade. The sites were constructed and used during a very short and precisely delineated time period between 1803 and 1816.

The signal stations are a curious site type that straddle several sub-disciplines. They would fit comfortably into the general field of post-medieval archaeology, given how openly this term is utilised within Ireland. The consideration of the site's status within the legal framework of Ireland and their current levels of protection and management mark this study as topical for Irish post-medieval archaeology, where a lack of proper protection for post-medieval sites has been an ongoing concern (Section 2.1.2). The lack of any consideration of artefacts might at one stage have been considered as problematic for a post-medieval approach but, in Ireland at least, the focus on artefacts is no longer a defining characteristic of the sub-discipline.

Certain aspects of the current study might make historical archaeology a more appropriate designation than post-medieval archaeology. If there are some doubts as to the colonial position of Ireland in the 19th century (Rynne 2009), this study does attempt to place the signal stations in relation to the globally spanning Revolutionary and Napoleonic Wars, and uses a broad perspective commonly found in historical archaeology.

This study also examines the nature of the signal technology utilised at the signal stations, the naval codes used by the signal station crews, and attempts to place the signal station sites within a chronology of evolving communications technology from the 18th century through to the 20th century. This technological emphasis is very representative of industrial archaeology, and of course communications sites have long been recognised as a key component of industrial archaeology (Raistrick 1973, 2; Hamond & McMahon 2002, 9; Rynne 2006, 443-8). The detailed recording of the signal towers that was undertaken is also very typical of an industrial archaeological project.

The signal station sites are also considered in relationship to the coastal landscapes they are located within, and in relationship to the contemporary coastal fortifications they were constructed alongside. However, neither of these elements, coastal archaeology (O'Sullivan & Breen 2007) or military archaeology (Grier *et al* 2011), are the main focus of this particular study.

Johnson made a compelling argument that the urge to sub-divide the subject risks needlessly diluting the study of topics and reducing the useful interchange of ideas between different practitioners working on less directly related topics (Johnson 2009). It is a reflection of the specialised nature of the Irish signal stations that they lie at the intersection of numerous different sub-disciplines, post-medieval archaeology, historical or colonial archaeology, industrial archaeology, coastal archaeology, military archaeology, and any combination of these approaches could have been usefully brought to the fore front in this study. It is the technological and functional aspects of the Irish signal stations as a communications system that have been the main focus of this project, and as such the project is identified as most being closely aligned to industrial archaeology.

## 2.2 – French invasions of Ireland in the late 18th century

At the end of the 18th century an invasion of Ireland by French forces was determined to be a useful for several reasons. A French conquest of Ireland could potentially provide a staging post for a subsequent invasion of Britain. Perhaps more importantly it was seen as a way of disrupting the functionality of the British military by halting the flow of large quantities of men and supplies from Ireland (Bartlett *et al* 1988, 48; Carroll 1996, 226). French forces departed for Ireland several times. They successfully broke through the British blockade on three occasions, but only managed to land large numbers of troops once. The invasions were planned to coincide with internal rebellions but delays to the one successful landing meant the full potential of a co-ordinated effort was not realised. In response to the ongoing threat of further French invasions, the British undertook a major program to expand and update the coastal fortifications of Ireland. The Irish signal stations were an important element in that comprehensive scheme of improved defences.

### 2.2.1 The 1796 invasion

The *Society of United Irishmen* had formed on 9 November 1791 in Dublin. The group advocated for progressive political reform that would lead to a more independent but still avowedly loyal status for Ireland (Boylan 1997, 21). Following a non-denominational philosophy, they gathered support from the Protestant Ascendency, and amongst Presbyterians and Catholic communities, the latter two holding second-class and third-class status respectively (Bartlett *et al* 1988, 3-4). A lengthy diplomatic campaign in 1796 by Lord Edward Fitzgerald, Arthur O'Connor and Theobald Wolfe Tone, leading members of the United Irishmen, led the *Directory of the French Republic* to commit to an invasion of Ireland, which had been under repeated consideration since 1793 (Come 1952; Carroll 1996, 226).

In October 1796, orders were issued to *Contre-amiral* le Comte de Villeneuve and Vice-Admiral Morard de Galles to prepare an invasion fleet at Brest, the main military port in Brittany (Ireland 2000, 141). An army was assembled under the leadership of General Lazare Hoche, which is generally listed as containing between 12,000 and 15,000 men (Packenham 1997, 17; Quinn *et al* 2002, 414; Hartnett McEnery 2006, 44). On the 15 December 1796 *Expédition d'Irlande* (Expedition to Ireland) set sail from Brest for

Ireland with a fleet consisting of 17 ships of the line, 19 smaller fighting ships, seven transports, and a powder ship (Gardiner 1996, 138). The French were accompanied by Tone, serving as an Adjutant General (O'Brien & O'Brien 1972, 90-1; Boylan 1997, 85).

One ship of the line, the *Séduisant*, was lost as the fleet departed Brest. The intervention of Commodore Edward Pellew in the British heavy frigate *Indefatigable* caused the fleet to become scattered as it left port; Pellew fired rockets and cannons to completely disrupt French communications as darkness fell (Mahan 1893, 353; Gardiner 1996, 138, 158-9). The early sinking of the *Séduisant* and the presence of a non-combatant powder ship may be the source of confusion that leads to the size of the fleet being stated as either 43, 44, or 45 ships in different texts (Foster 1988, 278; Gardiner 1996, 138; Clements 2013, 8). Despite harassment by the Royal Navy and poor weather conditions on the journey to Ireland, a sizeable remnant of the fleet, 33 ships, managed to arrive in Bantry Bay, County Cork (Carroll 1996, 238-47; Quinn *et al* 2002, 414). A combination of indecision about whether to wait for the entire force to regroup and consistently poor weather, led to the eventual abandonment of the endeavour and the fleet returned to France by the middle of January, less five further ships that had been wrecked, and seven that had been captured (Bolan 86-106; Gardiner 1996, 138; Ireland 2000, 142; Moody *et al* 2002, xvii-xviii; Quinn *et al* 2002; Clements 2013, 8).

Following the failed invasion at the end of 1796 there was a period of rapid reorganisation of British political and military officials and practices across Ireland. In 1797 new tactics were enacted for the conduct of naval blockades, new networks of informants were established, and suspected malcontents were routed out of the armed forces, particularly from the militia (Foster 1988, 278; Bartlett *et al* 1998, 65, 75-7). A swath of prominent military officers, such as Generals Sir Hew Dalrymple, Robert Stewart (Viscount Castlereagh) and Jeffrey Amhurst were replaced, as was the Commander in Chief, the Earl of Carhampton (Bartlett *et al* 1998, 78-80).

In the spring of 1797 General Gerard Lake was dispatched with a mixed force of yeomanry, fencibles and militia[5] to 'disarm' Ulster, conducting what has been described as a 'policy of military terror' (Bartlett *et al* 1998, 67-73). Around this time the Orange Order[6] gained a level of semi-official recognition as a military force which exhibited loyalty to the crown, presaging the shift in allegiances that the Ulster Presbyterians would follow after the 1798 rebellion (Pakenham 1972, 352-3; Foster 1988, 272-5, 280; Bartlett *et al* 1998, 73-5). The new Commander in Chief, General Sir Ralph Abercromby, proved to be an unsatisfactory appointment, demonstrating too much leniency in the eyes of the Lord Lieutenant, John Pratt, the Earl Camden, and the British Prime Minister William Pitt; Abercromby was shortly replaced by General Lake, who then extended his campaign of violence into other provinces (Bartlett *et al* 1998, 85-7; Newman 1991, 1, 101).

[5] The Irish Yeomanry were volunteer regiments, organized at a county level, to provide a military response in the advent of civil unrest or an invasion. The Irish Yeomanry were founded in September 1796 and included both cavalry and infantry units. The Fencibles were irregular units of the British Army raised for self-defence. Fencibles from Scotland arrived in Ireland throughout 1796 in enough numbers to relieve the regular British forces stationed in Ireland, who were required in the West Indies (Bartlett et al 1998, 59-60). The Irish Militia were a slightly older irregular force, which had been founded in 1793 to replace the volunteer units which were raised during the American War of Independence and which were viewed with suspicion after the fall of the Bastille (McDonnell 2019, 3-4).

[6] The Orange Order was a Protestant group founded at Loughgall in County Armagh in 1795 to combat the threat posed by the Defenders, a Catholic group which had in turn formed to counter the threat of the Protestant Peep O' Day Boys. Initially the Orange Order had been considered to be lawless bandits by the British (O'Brien & O'Brien 1972, 92; Newman 1991, 146).

### 2.2.2 The 1798 invasion

The failed French invasion of 1796 had not triggered the widescale uprising which Tone and the other leaders of the United Irishmen had promised. The south of the country had remained quiet whilst the French remained in their ships offshore. (Boylan 1997, 74-5; Pakenham 1997, 24). The suspicions that the Presbyterians in Ulster were on the verge of insurrection caused a large military force to remain in place in Ulster, suppressing the north of the country; it was this potential of rebellion which led to the dispatch of General Lake to the province in 1797 (Bartlett *et al* 1998, 67). The campaign of repression and reprisal that followed the failed landing at Bantry Bay was one of the key factors that changed the political situation across much of Ireland. By early in 1798 groups representing the three denominations organised by the United Irishmen, (Catholics, Protestants, and Presbyterians), were finally prepared to revolt (Forester 1988, 278-9; Newman 1991, 208-9).

The preparations for the uprising, and the subsequent organisation of those in revolt, were drastically hampered when a series of raids in the middle of May 1798 led to the imprisonment or flight of most of the leadership of the United Irishmen (Bartlett *et al* 1998, 91-6). The uprising began as planned on the evening of 23 May 1798 when mail coaches leaving Dublin for Belfast, Athlone, Limerick, and Cork were stopped, their non-arrival the following morning being the signal that actions had started (Tyrrell 2001, 16). The rebellion in Dublin and surrounding counties petered out by the end of the month, following numerous small engagements and battles which were typified by heavy rebel casualties (Bartlett *et al* 1998, 102). The surviving forces in the east retreated to two camps, one at Timahoe, County Kildare, in the Bog of Allen, the other above Blessington, County Wicklow, at the edge of the Wicklow Mountains (Pakenham 1972, 269-70). In County Wexford, where government intelligence gathering efforts had failed, the rebellion was more successful. A number of towns, including Wexford itself, were captured and on the 31 May the Republic of Wexford was declared (Bartlett *et al* 1998, 111-6; Tyrrell 2001, 28-9). The success of the rebels in Wexford finally prompted the United Irishmen in Ulster to act rather, than continuing to wait for the arrival of French forces. Action in Ulster began on 7 June, and ended with their surrender on 13 June, following the Battle of Ballynahinch, in County Down (Bartlett *et al* 1998, 123-7). The Wexford Republic effectively ended following the routing of rebel forces at the Battle of Vinegar Hill on 21 June (Bartlett *et al* 1998, 128-32; Tyrrell 2001, 60-1). The remaining rebels fled to the mountains of County Wicklow and the bogs of the Midland Counties, where they proved difficult to track down and dislodge, although their offensive capabilities were effectively neutralised (Pakenham 1972, 269-77; Tyrrell 2001, 62-91).

On the 6 August 1798 a second French invasion force, consisting of just three ships under the command of Commodore Daniel Savary, set sail from Rochelle, Nouvelle-Aquitaine (formerly Poitou-Charentes), to Ireland. Around 1,150 French troops landed at Kilcummin Head, near Killala, County Mayo, on the 22 August hoping to support Irish rebels whose revolutionary efforts had already been largely quashed by that point in the year (Gardiner 1997a, 98; Tyrrell 2001, 94-9; Clements 2013, 8). Tone was embedded with a larger force of 3,000 troops at Brest, and was due to depart around the same time, but was unable to set sail due to unfavourable weather conditions and disputes over pay (Tyrrell 2001, 94). The small French army, led by General Jean Joseph Humbert, had early successes and captured Killala from a small force of Yeomen and Fencibles on the day of their arrival. On the 24 August they captured Ballina, County Mayo, after the confused garrison evacuated to nearby Foxford, following a night-time skirmish where they had misunderstood the size of Humbert's force (Tyrrell 2001, 98-101). After the fall of Ballina, Humbert was joined by an estimated 600-700 local volunteers (Tyrrell 2001, 100). Leaving a small force at Killala, Humbert made a difficult night march on the 26 August and scored a remarkable victory at Castlebar, County Mayo, on the 27 August, which led to the declaration of the First Republic (The Republic of Connacht) on the 31 August (Tyrell 2001, 104-5).

On the 3 September Humbert's force-marched east hoping to unite with rebel forces holding out in the midlands. The following day the United Irishmen's Napper Tandy departed Dunkirk in the fast corvette, the *Anacreon*, loaded with supplies, guns, and ammunition, and started a long journey through the North Sea, intending to round Scotland and approach Ireland from the north-east (Tyrrell 2001, 112-3). Over the next few days Humbert's numbers both increased and decreased as Irish fighters alternately joined and deserted, and casualties were accrued during a number of engagements. The combined army had its final battle on the 8 September at Ballinamuck, County

Longford. British forces consisted of two separate contingents, a force of c.14,000 under the command of General Lake and c.15,000 under the command of Lord Charles Cornwallis, 1st Marquess Cornwallis. The surviving combined French and Irish force at this point is estimated at around 850 French soldiers and 1,000 Irish allies (Pakenham 1997, 326). They were defeated after only a short engagement, with few casualties on either side (Gribayedoff 1890, 124-5, 138). The French soldiers surrendered and were treated as prisoners of war. 96 officers, 746 men, 100 horses, and three field guns were taken to Dublin, where the men were ransomed back to France (Gribayedoff 1890, 138; Boylan 1997, 128; Hartnett McEnery 2006, 53). The surviving Irish forces could expect no such treatment and fled. Their dispersed groups were pursued for several weeks and large numbers were killed (Gribayedoff 1890, 135-7; Tyrrell 2001, 122). The most cohesive group still at large attempted to retake Castlebar unsuccessfully, and then fell back towards Killala (Tyrrell 2001, 134-5).

On the 16 September Tandy arrived at Aran Island off the north-west coast of County Donegal (Tyrrell 2001, 128). Having discovered little news about the fate of Humbert, beyond that he had gone into the Midlands rather than into Ulster, no indication that a French force was still in control of Killala, and nothing regarding Tone and the forces from Brest, Tandy slipped away the following day, heading back to the north-east and eventually making port in Norway (Tyrrell 2001, 132).

The 16 September was also the day that the large French force with Tone finally departed from Brest. The fleet, under the command of Commodore Jean-Baptiste-François Bombart, comprised of one ship of the line, seven frigates and a schooner. Although the fleet had departed unseen it was spotted on the morning of the 17 September. The British frigate *Boadicea* returned to Plymouth to relay news of the departure, whilst a second frigate and a sloop pursued from a distance (Tyrell 2001, 133).

On the 23 September Killala was retaken by a combined British force commanded by Major-General Nugent and General Trench. The surviving rebels were again pursued but the onset of winter weather meant the pursuits were not overly lengthy, although exposure and hunger would also cause many casualties (Tyrell 2001, 136-7). On the same day, the *Boadicea* reached Plymouth to deliver its warning. A small but powerful squadron consisting of a ship of the line and two frigates, under the command of Sir John Warren, immediately departed for Ireland. The sloop pursuing the Brest fleet was sent to Cork harbour to warn Vice-Admiral Sir Robert Kingsmill. The frigate *Ethalion* commanded by Captain George Countess continued to pursue the Brest fleet from a safe distance, and was subsequently joined by two more frigates, the *Amelia* and the *Anson* (Tyrell 2001, 138-40). The three frigates lost contact with the Brest fleet during bad weather on the 4 October. The frigates were driven northwards where they joined with the small fleet commanded by Sir John Warren on the 11 October (Tyrell 2001, 144). Later that day the two opposing fleets spotted each other off the north-west coast of County Donegal. Bad weather hindered French efforts to evade the British fleet.

At 7.20 am on the morning of the 12 October the two fleets engaged in the Battle of Tory Island (Gardiner 1997a, 98; Tyrell 2001, 146; Cooper 2011, 106). Just before 11am the French flagship, the *Hoche*, surrendered, along with the frigate the *Embuscade*. Tone was aboard the *Hoche*. The remaining seven French ships escaped but the *Coquille* and the *Bellone* were captured later in the day. The *Resolue* was captured in Sligo Bay on the 13 October. The *Loire* was captured on the 18 October, after being spotted near Achill Island on the 15 October, and being relentlessly pursued for several days (Clowes 1899, 349-50; Tyrell 2001, 150-5). The *Immortalite* was captured on the approach to Brest on the 20 October (Tyrell 2001, 156). The *Romaine* returned to Brest on the 23 October, and on the same day the *Sémillante* arrived at the French port of Loriente, Brittany (Gardiner 1997a, 114-5). Two Dutch ships, the *Waakzamheid* and the *Furie* which were carrying 287 troops, ordnance stores and 6,000 stands of arms to support the invasion were captured in the English Channel on the 24 October by the frigate *Sirius,* having left port in the Netherlands the previous day (Clowes 1899, 516-7; Gardiner 1997a, 115).

Meanwhile Savary had returned to France, restocked, and departed from Rochefort in the Bay of Biscay on the 12 October. He arrived in Killala Bay on the 27 October ready to disembark troops from his four ships. Having captured a British boat and learned of the apparent defeat of the entirety of the French forces, he returned to France, heavily pursued until the 30 October (James 1826, 211; Gardiner 1997a, 98; Tyrell 2001, 158, 162). After scattering to evade the chasing British, the four ships reunited and successfully entered Rochefort on the 4 November.

The captured vessels were taken to various ports as prizes and many entered British service. The heavily damaged *Hoche* was slowly towed to Lough Swilly by the almost equally badly damaged *Robust,* but towing duties were taken over by the *Doris* on the 15 October (Tyrell 2001, 148). The *Hoche* eventually arrived at Lough Swilly on the 1 November, the length of the journey relating to the extent of the damage the ship had taken (Tyrell 2001, 148; College 2010, 113). From Lough Swilly, Tone was taken to Dublin where he committed suicide on the 19 November prior to being executed, an event commonly taken to mark the end of the rebellions of that particularly volatile year (O'Brien & O'Brien 1972, 91; Boylan 1997, 136-7).

### 2.2.3 Attempted invasions and rebellions

In addition to the invasions detailed above (Sections 2.2.1 & 2.2.2), numerous other invasions of either Britain, Ireland, or both, were planned during the 1790s and 1800s. In 1794 the Dublin born Rev. William Jackson returned to Dublin from London having spent time in France where he was commissioned by the French Ministry of Foreign Affairs to investigate the chances of a successful invasion of either England or Ireland (Boylan 1981, 41-2). In Dublin he contacted the United Irishmen and discussed a possible invasion with several key members, including Tone. Jackson had been accompanied to Dublin by a British spy and the effort was immediately betrayed, leading to Jackson's suicide during his trial in 1795 and to Tone's exile to America (Boylan 1981, 49).

A more serious threat of an invasion of Ireland was present throughout June and July 1797. A fleet of 17 ships of the line was assembled in Brest which was set to combine with a small Dutch fleet based in the Texel. In July plans were sufficiently developed that troops had embarked the ships, but unfavourable winds kept the fleets ashore (Gardiner 1996, 138-9). When Admiral Hoche died in September 1797 the threat of invasion diminished. Tone, who had remained in France after the failed invasion of Bantry Bay, was aboard the waiting flagship in Texel and was bitterly disappointed by its failure to set sail (Boylan 1997, 114-9).

On the 26 October 1797 Brigadier General Napoleon Bonaparte was appointed to lead an *Armée d'Angleterre (Army of England)* and to continue planning the invasion of England (Boylan 1997, 120; Bartlett *et al* 1988, 97). Whilst presenting the plan to the Directorate as one of several valid options, he seems to have favoured an invasion of Egypt himself, and subtly pushed for this option (Forrest 2011, 93-6). In May 1798 a French fleet sailed from Toulon with thirteen ships of the line and four hundred transports carrying 35,000 troops under the command of Bonaparte (Gardiner 1997a, 20). This began Rear Admiral Horatio Nelson's famous pursuit which concluded at the Battle of the Nile at the start of August 1798, but for much of the summer the destination of Bonaparte's army was unknown, and Ireland was considered a likely prospect (Gardiner 1997a, 18, 28).

On the 26 April 1799 a fleet of twenty-four ships of the line escaped the blockade of Brest. The following day a French lugger, the *Rebecca*, was captured by the Royal Navy, and was found to have dispatches indicating the fleet was destined for southern Ireland. The dispatches indicating an Irish destination were dismissed as a ruse by the Royal Navy; because the French crew would have had time to destroy any sensitive papers, the discovered dispatches were considered to be a deliberate plant. This deduction was correct, and the French fleet was ultimately determined to be destined for the Mediterranean (Gardiner 1997a, 124).

In 1801 Bonaparte revived the plan to invade Britain via Ireland, and this remained a prominent threat for several years (Saunders 1989, 132). On the 5 July 1803, flush with funds from the Louisiana purchase, Bonaparte issued orders for the construction of over two thousand vessels to add to the French fleet, and began amassing troops at various ports along the channel, with their headquarters at Boulogne (Gardiner 1997b, 10-1). The invasion was ultimately halted by the success of the continuous British blockade, and French ships could seldom put to sea.

On 23 July 1803 Robert Emmet launched a short-lived rebellion which attempted to seize control of several strategic assets in Dublin, and to thus inspire the country at large to rise up (Chambers 2003, 21). The planning phase of the rebellion was lengthy and involved consultation with French operatives and Michael Dwyer, the leader of the last surviving force of rebels from 1798, who had remained at large in the Wicklow Mountains (Bartlett *et al* 1988, 147; Foster 1988, 286). The rebellion scarcely lasted a single evening. The main outcomes were the arrest of several hundred rebels, the execution of Emmet, and the replacement of Lieutenant General Henry Edward Fox by Lord William Schaw Cathcart (Section 2.2.5), as Fox's preparedness was found severely wanting (Hartnett McEnery 2006, 67). Following Emmet's execution, Michael Dwyer surrendered and negotiated for passage to America, but was ultimately transported to Australia (Newman 1991, 56; Bartlett *et al* 1998, 147).

Another tentative attempt to launch the French invasion fleet was made in July 1804 but met with no more success at breaking the blockade than they had the previous year (Gardiner 1997b, 98). Bonaparte began to devise his 'grand strategy' which would allow his Mediterranean and Atlantic fleets to combine into a large enough force to vanquish the opposing British fleet, and permit the planned invasion (Tracy 1996, 161-2). The invasion of Ireland would involve a fleet from Brest, carrying 18,000 French troops, combining with a fleet from Texel, carrying 25,000 Dutch and French troops. They would land at Lough Swilly and then march on Dublin (Gardiner 1997b, 92, 98). Troops were embarked at Brest on the 23 March 1805 and they sailed along the coast to Bertheaume Bay, but the arrival of 28 British ships on the 27 March, the day of their planned departure, saw them return to Brest (Gardiner 1997b, 93). Throughout the summer and early autumn of 1805 Bonaparte was able to carry out much of his grand strategy, and a series of feints and mis-directions allowed the Mediterranean fleet to combine with the Spanish fleet and escape into the Atlantic unpursued by the British. The immediate threat of an invasion ended in August 1805 when the Grand Army marched to the Danube to defeat a combined force from Austria and Russia (Saunders 1989, 132). The Franco-Spanish fleet was drawn into battle whilst attempting to reach Brest on 21 October 1805. The decisive victory of the British fleet at the Battle of Trafalgar ceded control of the seas to Britain and marked the effective end of the plan to invade either Ireland or Britain. The invasion would remain a planned objective of Bonaparte until his eventual surrender in 1814, after the Battle of Paris (Saunders 1989, 132; Tracy 1996, 213-6).

### 2.2.4 The re-fortification of the Irish coast after 1798

This succession of French invasions triggered a slow response from the British authorities. The vulnerability of the Irish coast, the ability of the Irish rebels to seek foreign assistance, and the willingness of the French to invade Ireland was very apparent (Clements 2013, 8-17; Knight 2013, 220-1). Whilst there had been sporadic attempts to provide adequate defences for the Irish coast in the preceding centuries, much of what had been constructed had been poorly designed and located, and had then subsequently been neglected (Hartnett McEnery 2006, 42; Clement 2011, 8). Even acknowledging that some of the fortifications had been competently constructed, by the start of the 19th century there was still no cohesive set of defences around the Irish coast as a whole, and much of what did exist had been rendered obsolete by the continuing development of more accurate and more powerful firearms (Hartnett McEnery 2006, 32-46; Kerrigan 1995, 129-49). When the invasion occurred in 1798 there seem to have been less than 200 cannons spread around the entire coast, with only Cork Harbour being heavily defended (Hartnett McEnery 2006, 40-44).

Despite the seriousness of the situation, it took several years for the different elements of British authority to agree on a plan of action to improve the defences of Ireland's coast, although some emergency action was taken as early as November 1798 (Kerrigan 1995, 152; Hartnett McEnery 2006, 51-58). At least some of the reason for this delay can be attributed to a major reorganisation of how Ireland was administered, resulting from the initiation of the Act of Union of 1801. One consequence of the Act of Union was the disbanding of the independent Irish Board of Ordnance which had been overseen by the Lord Lieutenant, at that point Cornwallis, who was based in Dublin (Hartnett McEnery 2006, 53). After the Act of Union this organisation ceased to exist. Control of Irish defences was passed to the British Board of Ordnance administered from London, with matters relating to Ireland being handled by a body called the Respective Officers that was established in Dublin in 1801 (Hartnett McEnery 2006, 56).

After lengthy debates between different members of the British parliament, the Admiralty and the British Board of Ordnance (Section 2.2.5), a general plan was agreed upon. It was felt the plan would provide comprehensive protection for the Irish Coast, and in particular the large harbours that were identified as places where French forces might again attempt to land (Hartnett McEnery 2006, 59-64; Clements 2013, 13-5). Construction of the new defences began in the first years of the 19th century. The most important elements were a series of fortifications set up to defend key strategic locations on the approaches to the major harbours. The fortifications included Martello towers, a small number of larger quadrangular towers, a few circular redoubts and a range of gun batteries of different types (Hartnett McEnery 2006, 84-116; Clements 2013, 107-12). Although frequently built in isolation, these different elements were also employed in combinations, depending on the needs of a particular location. Small fleets of gunboats were also stationed at harbours in Dublin Bay, Wexford, the Shannon Estuary, Galway Bay, Killala and Lough Swilly, tasked with protecting both the harbours and the adjacent stretches of the coast (Hartnett McEnery 2006, 67).

In addition to these impressive towers, batteries, and the gunboat fleets, a chain of signal stations, mostly consisting of purpose-built lightly fortified signal towers, provided observation points and communications clockwise around the coast from Pigeon House Signal Station in Dublin (SMR DU019-027), to Malin Head (SMR DG001-006) in the far north of County Donegal (Section 1.1). None of the published accounts make explicit mention of why it was felt unnecessary to create a complete circuit of towers that would also encompass the remaining coast of Ulster and the coast of northern Leinster. Perhaps it was considered impossible for a French fleet to enter that area without being observed by the existing signal stations or by shipping traversing the Irish Sea and the north coast of Ulster. Another explanation may have been the absence of a suitable landing point that was not heavily defended by existing fortifications, making an approach by a French fleet along those stretches of coast extremely unlikely, a point that had been made by Colonel Alexander Hope in 1801 (Hartnett McEnery 2006, 59).

The first fortification undertaken as a response to the rebellion of 1798 was the military takeover of the Pigeon House Hotel complex in Dublin, the need for a coastal strong point in Dublin having already been recommended by Major General Chief Engineer Charles Vallency in 1797 (Hartnett McEnery 2006, 50-1). The existing hotel, dock and blockhouse were commandeered in May 1798, and an ammunition store was improvised, and temporary batteries erected (Hartnett McEnery 2006, 53).

Kerrigan mentions that temporary defences were constructed around Bantry Bay between 1776 and 1778, although specific details of what these consisted of have not been published (Kerrigan 1995, 152; Carroll 1996, 257; Shiels & Maloney 2015, 13). Following the Battle of Tory Island, eight captured French cannons from the *Hoche* were deployed around Lough Swilly, to supplement recently purchased and already positioned British guns (Hartnett McEnery 2006, 53). The new arms were spread between the existing fortifications, where they probably joined a small number of cannons thought to have been placed at the head of the lough at the start of 1798. A total of 22 cannon were located around Lough Swilly in 1800~~,~~ (Hartnett McEnery 2006, 53-5).

The Commander-in-Chief in Ireland, General Abercromby, submitted a memorandum on the defences of Ireland in 1798, on behalf of Lord Lieutenant Camden. The memorandum highlighted the importance of holding Cork Harbour, stressed the current vulnerability of Bantry Bay, the Shannon Estuary, and Galway Bay, and identified Lough Swilly as the most likely target for another invasion (Hartnett McEnery 2006, 50-1; Clements 2013, 14).

As of 1800, Duncannon Fort, County Wexford, was equipped with 28 cannons mounted on garrison carriages, and two mortars (Figures 2.1 & 2.2). The six fortifications around Cork Harbour had a combined total of 159 cannon mounted on garrison carriages, nine field pieces, and 19 mortars. Charles Fort in Kinsale Harbour, County Cork, had 32 cannons mounted on garrison carriages, two field pieces, and three mortars. The battery at Oyster Haven had two cannons mounted on garrison carriages (Figures 2.3 & 2.4). At Bantry Bay in County Cork there were 23 cannons mounted on garrison carriages. At Tarbert Battery, on the County Kerry side of the Shannon Estuary, there were 22 cannons mounted on garrison carriages. At Lough Swilly there were 22 cannons mounted on garrison carriages, and two field pieces distributed between the different batteries and forts. At Carrickfergus Castle in County Antrim there were 16 cannons mounted on garrison carriages, and four field pieces. In addition, a small number of cannons were located at Pigeon House Fort and South Wall in Dublin, and at Cheekpoint in Waterford Harbour (Hartnett McEnery 2006, 55).

Figure 2.1. Duncannon Fort, County Wexford, from the landward side, looking west. Construction of the fort began in 1587.

Figure 2.2 Duncannon Fort, County Wexford, from the adjacent beach, looking north.

Figure 2.3. Charles Fort, Kinsale, County Cork. Originally constructed in 1602 this bastioned shaped fort was poorly located, and although it was refortified in the late-18th century, it was decommissioned in the early-19th century.

Figure 2.4. The impressive range of buildings in the interior of Charles Fort, Kinsale, County Cork, demonstrate plentiful evidence of the fort's long period of use.

By the end of 1800, a total of around 350 guns were deployed around the coast of Ireland. This figure represented a substantial increase in the amount of ordinance available to protect the coast over what was available at the time of the 1798 invasion.

Following the disbanding of the Irish Board of Ordnance in 1801, a series of reports assessing the extant state of Irish defences, and suggesting programs of expansion and repair, were undertaken. In November 1801 Colonel Hope, the Adjutant General, submitted his report to the Commander of the Forces in Ireland and to Prince Frederick, the Duke of York, Commander-in-Chief of the Forces in the United Empire (Hartnett McEnery 2006, 59-60; Clements 2013, 14). Hope identified Lough Swilly, Galway Bay, the Shannon Estuary, Bantry Bay, Cork Harbour, and Waterford Harbour as the locations where an invading fleet might land. He suggested that three inland forts should be constructed, one in the north near Omagh, one in the west near Loughrea and one in the south near Cashel, for use once an army had landed and was trying to cross the country to seize Dublin (Hartnett McEnery 2006, 59-60). The Duke of York asked Lieutenant General David Dundas to comment on Hope’s report, and then submitted both the report and Dundas’ comments to the Master General of the Ordnance, John Pitt, the Earl of Chatham (Clements 2013, 14). Chatham dispatched Colonel William Twiss to Ireland to review the situation. Twiss submitted a report in January 1803 which largely agreed with Hope’s assessment of the coast. He disagreed with the need for Hope’s scheme of inland forts and suggested that a single inland fort be constructed at Derryholmes on the River Shannon, about three miles south-east of Shannonbridge, County Offaly. He also argued that a large fort should be built in Phoenix Park to protect the western approach to Dublin, replacing or supplementing the earlier Magazine Fort (Hartnett McEnery 2006, 33, 61; Clements 2013, 14-5). The Duke of York passed the reports on to Cornwallis, who had been replaced as Lord Lieutenant by Lord Philip Yorke, 3rd Earl of Hardwicke in May 1801. Cornwallis returned a memorandum in April 1803 which sided with Twiss, but which recommended Tullamore, County Offaly, as the location for a singular inland fort (Hartnett McEnery 2006, 63). It should be noted that these discussions occurred during the Peace of Amiens, indicating that the British utilised the cessation of hostilities with France to prepare for future conflicts (Section 2.3.1). In October 1803 Lieutenant General

Cathcart was appointed military commander in Ireland and continued to make progress on the refortification of Ireland (Hartnett McEnery 2006, 67).

Although the differences in opinion were never resolved, there were some points on which all the reports were agreed. Work began at some of the locations where there was broad concurrence. Defences at Pigeon House Fort in Dublin Bay, Cork Harbour, Charles Fort in Kinsale Harbour, Whiddy Island in Bantry Bay, and defences along the River Shannon were all improved in 1803 (Clements 2013, 56-7). Gunboats were stationed in Dublin Bay, Wexford Harbour, the Shannon Estuary, Galway Bay, Killala Bay and Lough Swilly, tasked with delaying and harassing an enemy fleet attempting to land (Kerrigan 1995, 212-3; Hartnett McEnery 2006, 67). A naval squadron was stationed at Berehaven anchorage in Bantry Bay, tasked with protecting the coast from Valentia Sound to Galway Bay (Hartnett McEnery 2006, 67).

By June 1803 Hardwicke had determined a need for an early warning system to announce an attack by sea (Clements 2013, 98). Initially Lieutenant Colonel Benjamin Fisher (promoted to Colonel in 1805 and Major-General in 1811) of the Royal Engineers seems to have been tasked with organising the construction of the signal stations, but the responsibility was rapidly transferred to Rear Admiral James Whitshed (Ward 1949, 32; Kerrigan 1995, 157). Whitshed had been dispatched to Dublin in September 1803, to act as Naval Adviser to the Lord Lieutenant, and to raise a large force of sea fencibles (Hartnett McEnery 2006, 67; Clements 2013, 98). At the start of 1804, Cathcart ordered that Bere Island in Bantry Bay be fortified and that an extensive scheme to fortify the coast around Dublin be undertaken. Work on the latter would not start until July 1804 (Hartnett McEnery 2006, 68-9). Around the same time construction began on new defences at Fort Point and Baginbun, County Wexford. 1804 was therefore an important year when three new types of fortification were introduced to Ireland.

### 2.2.4.1 Irish Martello towers

The most widely built of the new defences were the Martello towers. The development of Martello towers has been assessed elsewhere (Saunders 1989, 141-7; Kerrigan 1995, 167-247; 65-116; Clements 2011; 2013). In summary small gun towers had been a common feature of the Mediterranean coast for several centuries, used to defend smaller harbours without extensive fortifications. The design gained notoriety amongst the British fleet in 1794, when a tower at Mortella Bay on Corsica (Figure 2.5) caused considerable problems during two successive landings (Clements 2013, 9-11; Knight 2013, 217). It was Dundas who first proposed a design influenced by the Corsican tower, in a memorandum in 1797. In 1798 Major Reynolds proposed 143 sites where such towers would be useful along the southern coast of England, but his plan was not immediately implemented (Saunders 1989, 141-2). The British first built prototype 'Martello' towers' on Minorca between 1798 and 1802 (Clements 2011, 59-64; Clements 2013, 11; Knight 2013, 217). Similar precursors to the Martello towers proper were constructed in Canada, South Africa, and on St Helena during the late 1790s (Clements 2011). In 1803 Dundas and Twiss worked together to promote the idea, but despite agreement in principle, they faced bureaucratic and political delays. Construction of 74 towers along the south-east coast of England began in 1805, with those along the southern stretch being largely completed by 1808, and those along the eastern stretch being largely completed by 1812. The two lines of Martello towers each featured a large circular redoubt as a main fortification, Dymchurch Redoubt for the southern line, and Harwich Redoubt for the eastern line (Saunders 1989, 142-3).

The British built Martello towers are generally similar in design to each other, being stout stone built circular, elliptical or cam shaped towers, with thick battered walls, often thickest on the seaward side (Clements 2013, 15-6). The towers had two floors, with a first-floor doorway accessed via a ladder or drawbridge, and often featured 'bomb proof' arched ceilings supported by central pillars. The roof level featured between one and four cannons mounted on traversing carriages, and was protected by a parapet with machicolations. Some towers were surrounded by ditches with external glacis slopes (Saunders 1989, 142-3). Many of the towers were supported by gun batteries, either immediately adjacent to them, or located a short distance away.

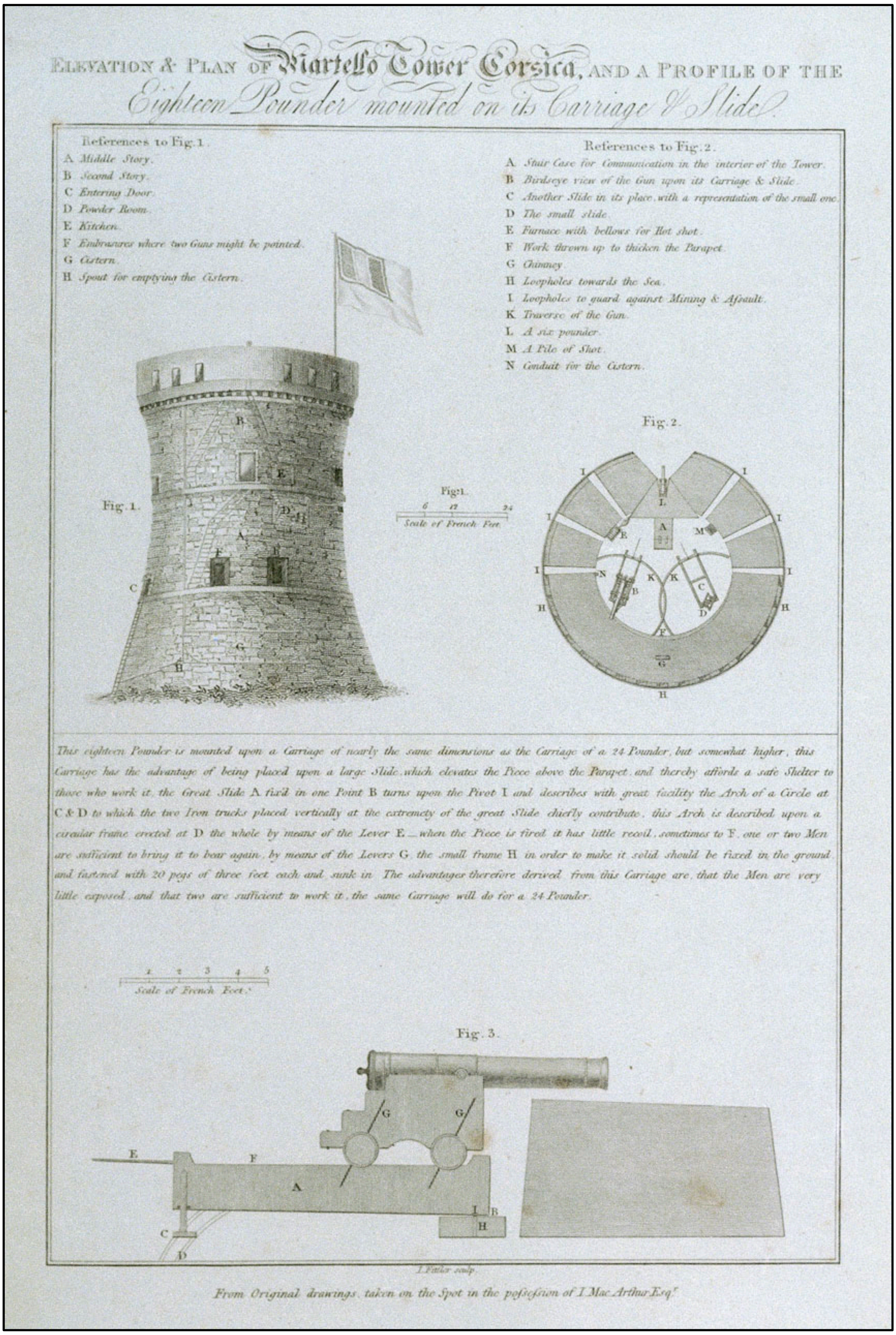


Figure 2.5. Illustration of Mortella Tower, Corsica. Based on original sketches by J MacArthur, Secretary to Lord Hood (Royal Museums Greenwich, Object ID PAD1624).

The positioning and size of armament of the batteries was dependent on two factors. The local topographic conditions, and the predicted nature of the threat they were designed to repel.

Construction began on 35 Martello towers in Ireland in 1804, meaning they predated the introduction of the towers into Britain, if only by a year (Saunders 1989, 147). Of this initial building project, 28 towers were located along the coast to the north and south of Dublin, two were located to protect Rosslare Harbour and Fethard Bay in County Wexford, and five were constructed in Bantry Bay, County Cork; one on Garnish Island, and four on Bere Island (Table 2.1).

**2.2.4.2 Irish Quadrangular Towers**

The second new type of fortification introduced to Ireland in 1804 were the quadrangular towers, although only one example, the Western Redoubt on Bere Island, was constructed that year (Clements 2013, 87-97; Shiels & Maloney 2015, 46-7). This design was selected as a substitute for a Martello tower where the perceived threat was higher. The quadrangular towers followed the same design philosophy as Martello towers, with thick battered walls, two-storeys, the use of bomb proof arched ceilings and cannons mounted on the roofs. The buildings were however larger, and had narrow rectangular plans, allowing them to mount a larger number of cannon, and to house a larger number of troops and supplies. The quadrangular towers were set at the rear of embanked batteries with substantial defensive perimeters and a second set of cannons (Figure 2.6) (Saunders 1989, 147-8; Clements 2013, 87-97). Construction of the remaining nine quadrangular towers to be built in Ireland would not begin until 1810 (Table 2.1).

**2.2.4.3 Irish Circular Redoubts**

The third new type of fortification introduced to Ireland in 1804 were circular redoubts, three of which were constructed on Whiddy Island on the southern side of Bantry Bay (Kerrigan 1981, 7; Carrol 1996, 257-9; Hartnett McEnery 2006, 97-8). The circular redoubts consisted of a 100’ (30.5 m) wide circular glacis slopes, leading up to 30’ (9 m) wide steep sided ditches. Inside the ditches there were 20’ (6 m) wide walls, with cannons mounted around the inner edges. The flat central areas had diameters of between 170’ and 220’ (52 m and 67 m), and each example contained rectangular barracks buildings. At Western Redoubt the barracks buildings were enclosed by a second smaller circular wall, with a diameter of approximately 95’ (29 m). Middle Redoubt was the larger of the three, with a total diameter of around 520’ (159 m), measured from opposing edges of the glacis slope. The eastern and western examples (Figure 2.7) were smaller, both having a diameter of around 470’ (143 m), again measured from opposing edges of the glacis slope. Middle Redoubt was armed with twelve cannon and housed one hundred and fifty men. The Eastern and Western Redoubts were both armed with eight cannon and housed one hundred men each (Kerrigan 1981, 5-6).

Figure 2.6. Rathmullan Quadrangular Tower, County Donegal. The quadrangular tower is in the background and the Gun Battery is in the foreground.

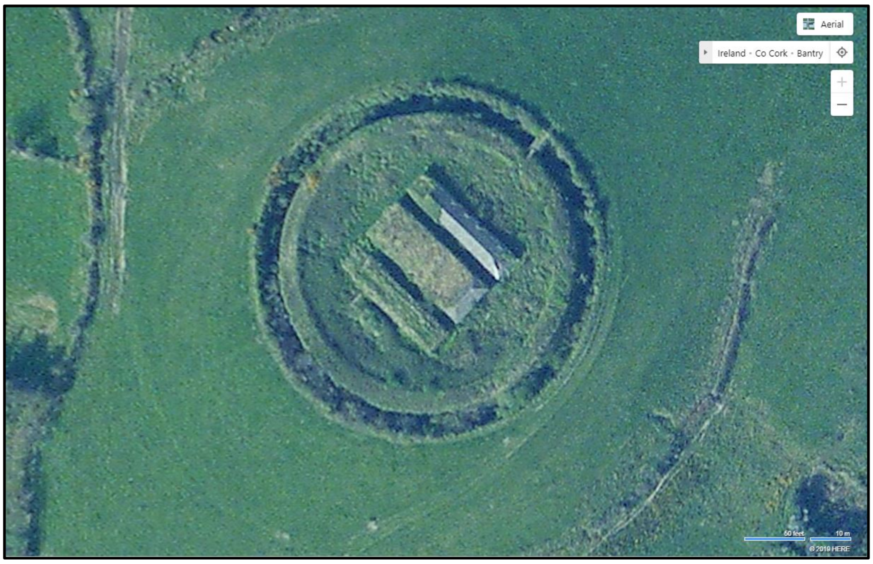


Figure 2.7. Aerial view of Middle Redoubt on Whiddy Island, County Cork (Bingmaps 2019).

### 2.2.5 Further fortification programmes in Ireland

In 1805 Cathcart submitted a new report to the Duke of York which recommended new fortifications along the River Shannon and the Shannon Estuary, updating an existing fortress at Athlone to provide the singular inland fort, improving the defences of Limerick, fortifying Galway City and Galway Bay, and small improvements to the works around Dublin and Cork Harbour (Hartnett McEnery 2006, 71). Cathcart's report led to the formation in July 1805 of a senior committee of engineers to review the defences of Ireland, the Gother Mann Committee. Cathcart departed Ireland to command the British Expedition to Hanover and the first report from the Gother Mann Committee was delivered in November 1805, after he had left Ireland. Only a few small recommendations from his report had been enacted by the time of his departure (Hartnett McEnery 2006, 71).

The first Gother Mann Report argued that permanent fortifications could not adequately protect Dublin from the west, but it suggested a major expansion to Pigeon House Fort in order to provide a safe store for government records. Killuran, County Offaly, to the south of Tullamore, was suggested as the location for the single inland fort. A second report from the Gother Mann Committee was submitted in January 1806, detailing improvements to the coastal defences, but the report is not known to have survived and details are sparse (Hartnett McEnery 2006, 74). In 1807 reports were prepared by Arthur Wellesley, then Chief Secretary for Ireland and the future Duke of Wellington, after touring the south-west of the country in 1806, and by French Royalist General François Dumouriez, who never visited Ireland. Both were harshly criticised by the Gother Mann Committee, and it was the Gother Mann Committee's proposals that would be enacted (Hartnett McEnery 2006, 75).

Between 1810 and 1817 a second phase of defensive construction was undertaken. This included new Martello towers (Figures 2.8 & 2.9), Quadrangle Towers, and Gun Batteries near Duncannon Fort, in Galway Bay and Lough Swilly (Table 2.1). By 1817 versions of the recommendations of the Gother Mann Committee had been completed in all areas, except for the expansion of Pigeon House Fort and the construction of a citadel in County Offaly, which were abandoned, and the new fortification at Spike Island in Cork Harbour, which was still under construction and had yet to be armed

(Hartnett McEnery 2006, 79). At this point, following Bonaparte's final defeat, Ireland was defended by a total of 491 cannons, 37 howitzers and 22 mortars, spread between 71 locations~~.~~ (Hartnett McEnery 2006, Table 8). Table 2.1 presents a summary of the fortifications of Ireland at the end of the Napoleonic Wars. Figure 2.10 presents a simplified map of fortifications created or updated during this period.

Figure 2.8. Duncannon Martello Tower South (Reg. No. 15618025) was constructed on raised ground to the east of Duncannon Fort, County Wexford. It is located in the rear garden of a recently renovated bungalow.

Figure 2.9. Duncannon Martello Tower North (Reg. No. 15704413) located on raised ground to the north-east of Duncannon Fort, County Wexford. The tower has been converted into residence.

| Location | Type | Date | Condition | Purpose | Reference |
|---|---|---|---|---|---|
| Drogheda | 1 Martello tower with gun battery | 1808 | Museum | Defending Drogheda Port on the River Boyne | Clements 2013, 77-9 |
| Dublin North | 11 Martello towers | 1804 | 4 Residential<br>1 Museum<br>1 State Owned<br>5 Disused | Defending coast north of Dublin | Clements 2013, 39-42, 107 |
| Dublin North | 1 Large Martello tower | 1804 | 1 Disused | Defending coast north of Dublin | Clements 2013, 39-42, 107 |
| Pigeon House Fort | Fortified Harbour | 1798-1803 | Largely Destroyed | Defending Dublin Port/Stronghold for Government | Hartnett McEnery 2006, 84 |
| Phoenix Park | Star shaped fort | 1735 | State Owned | Defending West Approach to Dublin/Magazine | Hartnett McEnery 2006, 33 |
| Dublin South | 4 Martello towers | 1804 | 1 Residential<br>1 Museum<br>2 Destroyed | Defending coast south of Dublin | Clements 2013, 42-8, 108 |
| Dublin South | 7 Martello towers with gun battery | 1804 | 2 Residential<br>2 Museum<br>3 Destroyed | Defending coast south of Dublin | Clements 2013, 42-8, 108 |
| Dublin South | 2 Large Martello towers | 1804 | 2 Disused | Defending coast south of Dublin | Clements 2013, 42-8, 108 |
| Dublin South | 1 Large Martello towers with gun battery | 1804 | 1 Disused | Defending coast south of Dublin | Clements 2013, 42-8, 108 |
| Dublin South | 2 gun batteries | 1804 | 2 Destroyed | Defending coast south of Dublin | Clements 2013, 42-8, 108 |
| Fort Point | 1 Martello tower | 1804 | Destroyed | Defending Rosslare Harbour | Clements 2013, 74-6 |
| Baginbun | 1 Martello tower | 1804 | Residential | Defending Fethard Bay | Clements 2013, 74-6 |
| Duncannon | 2 Martello towers | 1814 | 1 Residential<br>1 Disused | Supporting Duncannon Fort | Clements 2013, 76-7 |
| Duncannon Fort | Bastioned fort | 1587 | Museum | Defending Waterford Harbour | Colfer 2004, 106-13 |
| Fort Westmorland | Barracks inside incomplete bastioned fort | 1791 | Museum | Defending Cork Harbour | Hartnett McEnery 2006, 89, 92-3 |
| Fort Carlisle | Bastioned fort | 1796 | Military Base | Defending Cork Harbour | Hartnett McEnery 2006, 89-90 |
| Fort Camden | Large gun battery | 1798 | Museum | Defending Cork Harbour | Hartnett McEnery 2006, 89-90 |
| Cork Harbour | 5 Martello towers | 1813 | 1 Residential<br>1 State Owned<br>4 Disused | Defending Cork Harbour | Clements 2013, 80-6 |
| Charles Fort | Bastioned fort | 1602 | Museum | Defending Kinsale Harbour | Hartnett McEnery 2006, 94-5 |
| Glengariff Harbour (Bantry Bay) | 1 Martello tower with gun battery | 1804 | Museum | Defending Glengariff Harbour | Clements 2013, 18-22 |
| Whiddy Island (Bantry) Bay | 3 circular redoubts | 1804 | 3 Disused | Defending Bantry Bay | Clements 2013, 22-4 |

**Table 2.1. Late-18th and early-19th century coastal defences in Ireland, from Drogheda, clockwise around the island to Carrickfergus.**

| Location | Type | Date | Condition | Purpose | Reference |
|---|---|---|---|---|---|
| Bere Island (Bantry Bay) | 4 Martello towers | 1804 | 1 Museum<br>1 Disused<br>2 Destroyed | Defending Bere Haven Anchorage | Clements 2013, 24-31 |
| Bere Island (Bantry Bay) | 1 quadrangular tower | 1804 | 1 Destroyed | Defending Bere Haven Anchorage | Clements 2013, 89-92 |
| Galway Bay | 1 Martello tower | 1810 | 1 Disused | Defending Galway Bay | Clements 2013, 66-70 |
| Galway Bay | 2 Large Martello towers | 1810 | 1 Residential<br>1 State Owned | Defending Galway Bay | Clements 2013, 66-70 |
| Shannon Estuary | 6 quadrangular towers with gun batteries | 1810 | 5 disused<br>1 Destroyed | Defending Shannon Estuary | Clements 2013, 87-97 |
| Athlone Castle (R. Shannon) | Medieval castle converted into a barrack | 1210/ 1793 | Museum | Inland Fortress | Sweetman 1999, 86 |
| Athlone Batteries (R. Shannon) | 7 gun batteries | 1805 | Poorly Preserved Earthworks | Defending western approach to Athlone | Hartnett McEnery 2006, 111 |
| Shannon Bridge (R. Shannon) | 2 barracks | 1804 | 2 Disused | Defending crossing of River Shannon | Hartnett McEnery 2006, 111 |
| Shannon Bridge (R. Shannon) | 1 quadrangular tower | 1814 | Private Business | Defending crossing of River Shannon | Hartnett McEnery 2006, 114-5 |
| Shannon Bridge (R. Shannon) | 3 gun batteries | 1805 | Demolished | Defending crossing of River Shannon | Hartnett McEnery 2006, 111 |
| Banagher Bridge (R. Shannon) | Fortified house converted into gun battery | 1640/ 1805 | Disused | Defending crossing of River Shannon | Hartnett McEnery 2006, 112 |
| Banagher Bridge (R. Shannon) | 1 Martello tower | 1812 | Disused | Defending crossing of River Shannon | Hartnett McEnery 2006, 114 |
| Banagher Bridge (R. Shannon) | Bastioned fort converted into a barracks and gun battery | 1624/ 1790 | Disused | Defending crossing of River Shannon | Hartnett McEnery 2006, 112 |
| Banagher Bridge (R. Shannon) | 1 gun battery | 1812 | Disused | Defending crossing of River Shannon | Hartnett McEnery 2006, 112 |
| Keelogue Ford (R. Shannon) | 3 gun batteries | 1805 | 2 Well-Preserved Earthworks<br>1 Destroyed | Defending crossing of River Shannon | Hartnett McEnery 2006, 112 |
| Keelogue Ford (R. Shannon) | 1 quadrangular tower | 1812 | Disused | Defending crossing of River Shannon | Hartnett McEnery 2006, 114 |
| Meelick Ford (R. Shannon) | 2 gun batteries | 1805 | 2 Destroyed | Defending crossing of River Shannon | Hartnett McEnery 2006, 112 |
| Meelick Ford (R. Shannon) | Martello tower | 1812 | Disused | Defending crossing of River Shannon | Hartnett McEnery 2006, 114 |

**Table 2.1. continued. Late-18th and early-19th century coastal defences in Ireland, from Drogheda, clockwise around the island to Carrickfergus.**

| Location | Type | Date | Condition | Purpose | Reference |
|---|---|---|---|---|---|
| Lough Swilly | 4 Martello towers with gun batteries | 1810 | 1 Residential<br>1 Disused<br>2 Destroyed Tower/Disused Battery/Museum in Battery | Defending Lough Swilly | Hartnett McEnery 2006, 49-58 |
| Lough Swilly | 2 quadrangular towers with gun batteries | 1810 | 1 Museum<br>1 Disused | Defending Lough Swilly | Clements 2013, 87-97 |
| Lough Foyle | 1 Martello tower | 1812 | Museum | Defending Entrance to Lough Foyle | Hartnett McEnery 2006, 58-65 |
| Lough Foyle | 1 Martello tower with bastioned fortress and gun battery | 1812 | 1 Museum | Defending Entrance to Lough Foyle | Hartnett McEnery 2006, 58-65 |
| Carrickfergus Castle | Large gun battery | 1809 | Museum | Defending Belfast Lough | Hartnett McEnery 2006, 110 |

**Table 2.1. continued. Late-18th and early-19th century coastal defences in Ireland, from Drogheda, clockwise around the island to Carrickfergus.**


Figure 2.10. Major new or upgraded fortifications in Ireland, c1817, shown with the positions of the signal stations, which were already defunct by this point. The map is adapted from the Heritage Councils Coastal and Marine map layers (Heitagemaps.ie 2019)

## 2.3 – The broader context of the Irish signal stations

The Irish signal stations have been accurately placed in the chronology of a short-lived military response to the attempted invasions of 1796 and 1798, and the perceived threat of further French invasion. The context of the signal stations has been firmly set amongst the contemporary Martello towers, artillery forts, and gun batteries (Section 2.2). It is also necessary to consider the signal stations from a less insular perspective, and there are several areas which benefit from expanding the scope of the discourse.

### 2.3.1 Two decades of war between France, Britain, and their allies

Relationships between Britain and France entered a tense phase following the French intervention in the American War of Independence, which played a decisive role in the outcome of that conflict (Ferguson 2002, 98-101). The French Revolution of 1789 met with mixed reactions across Britain and Ireland; its attack on the established social order being lauded by some elements in Scotland and Ireland, whilst in England a militia was raised to protect against the threat of revolution. Liberal intellectuals were initially supportive of the French experiments, whilst the ruling class were understandably horrified. Prime Minister Pitt strategically reacted with studied indifference (Hobsbawn 1962, 79; Durant & Durant 1975, 516; Schama 1989, 680-6; Harvey 2006, 85-8). Crucially there was little popular support for the replacement of the ruling class amongst the lower classes in England (Schama 1989, 292-3; Harvey 2006, 118). The execution of Louis XVI in January 1793 led Pitt to expel the French Ambassador, and in response the French National Convention declared war against Britain, the Netherlands, and Spain (Gardiner 1996, 9; Harvey 2006, 117). The ensuing conflict would not be fully resolved until 1815 and can be divided into seven distinct phases, referred to as the Coalition Wars, as they involved different combinations of the same antagonists fighting alternatively alongside and against each other (Harvey 2006; Forrest 2011). A simpler tripartite scheme is also often used; the French Revolutionary Wars (1792 – 1802), the peace of Amiens (1802 – 1803), and the Napoleonic Wars (1803 – 1815) (Saunders 1989, 130- 53; Ireland 2000, 120-2, 164-8). Some commentators have identified the succession of conflicts as the first truly global war, as they spanned much of Europe and beyond, with land battles in North Africa and North America and

Naval Actions in the Atlantic Ocean, the North Sea, the Baltic Sea, the Mediterranean Sea, the Aegean Sea, the Caribbean Sea, the Gulf of Mexico, and the Indian Ocean (Gardiner 1996, 180-3; Gardiner 1997a, 13; Harvey 2006, xi).

A consistent threat of French invasion of either Britain and/or Ireland was present between 1793 and 1805, and this threat was realised on the three occasions when French forces did actually launch invasions of Ireland (Section 2.2). A fourth rather anticlimactic invasion occurred in Pembrokeshire, Wales, in 1797 (Come 1952, 185-6; Longmate 2001, 224-39; Rose 2003; Harvey 2006, 224). A fleet of four ships with around 1,200 troops, *La Legion Noir* (the Black Legion), departed Brest on 16 February, led by the elderly Irish-American Colonel William Tait (Rose 2003, 77). The army landed at Carreg Wastad, near Fishguard, on 22 February and whilst heavily outnumbering the local forces, they met with little success. The professional part of the force consisted of approximately 600 regular soldiers, mostly regular infantry but also some grenadiers. The regular forces were accompanied by approximately 600 penal soldiers who have been alleged to have had little interest in fighting (Rose 2003, 76). Although the invading force outnumbered the hastily assembled defensive force by around 2:1, Tait surrendered unconditionally on 24 February (Rose 2003, 82). The incidence tends to be referred to as an amusing oddity, but this does a disservice to the level of damage that would have been caused if the ultimate goal to sack Bristol had succeeded (Harvey 2006, 224).

The threat of invasion was slowly reduced as the Royal Navy developed into the dominant maritime force, but this was no simple process. The full complexities need not be examined here, but several key points are worth describing to avoid the frequent oversimplification of this process. On 'the Glorious First of June' (1 June 1794), a massive fleet battle took place out in the Atlantic, where, despite taking heavy damage themselves, the British under Admiral Lord Richard Howe, caused enough damage that the French Atlantic Fleet was driven into port where it would be kept heavily blockaded for most of the following conflicts (Gardiner 1996, 27-41). At the Battle of Camperdown, 11 October 1797, the British North Sea Fleet under Admiral Adam Duncan crippled the Dutch Navy, giving the British the upper hand in the North Sea (Gardiner 1996, 173-9). At the Battle of the Nile, 3 August 1798, the British Mediterranean Fleet under Rear-

Admiral Nelson scored a significant victory over the French Mediterranean Fleet which lead to the temporary British dominance of the Mediterranean, effectively sealed after the successful blockade and capture of Malta on 5 September 1800 (Gardiner 1997a, 26-39, 67-71). At the Battle of Copenhagen, 2 April 1801, the British North Sea Fleet under Admiral Sir Hyde Parker and Rear-Admiral Nelson destroyed the Danish fleet, finalising British control of the North Sea and regaining access to the important Baltic ports (Gardiner 1997a, 169-70, 178-83). The Spanish declaration of war on Britain on 12 December 1804, triggered by British ships attacking Spanish vessels on the approach to Cadiz, led to a sudden doubling of the number of ships available to the French under Bonaparte, who had been rapidly rebuilding the French navy since the onset of the Peace of Amiens (Harvey 2006, 430). Finally, the Trafalgar Campaign, culminating in the Battle of Trafalgar, 21 October 1805, ended with such a convincing victory over the combined Franco-Spanish Fleet that the Royal Navy came to be the dominant naval force in the world, a situation that lasted until well into the 20th century (Gardiner 1997b, 130-5; Gardiner 1998, 9-11; Horning & Herman 2004, 414-18).

Following the Battle of Trafalgar, the various British Fleets continued to engage whichever enemy ships they could legitimately attack, and to blockade those that remained in port (Gardiner 1998). By 1808, just two years after the Irish signal station system was completed, the likelihood of a fourth invasion of Ireland was reduced to the extent that the future of the system was under discussion (Kerrigan 1995, 165). In September 1809 orders were issued to abandon large parts of the system, between Dalkey, County Dublin, and Fort Davis, County Cork, and between Inishmore, County Galway, and Horn Head, County Donegal, leaving only the signal stations around the south-west coast and at the approach to Lough Swilly operational (Kerrigan 1985, 165).

Whilst the Royal Navy slowly came to pre-eminence after 1794, the British Army did not begin to see substantial success until much later in the ongoing wars with the French Republic, whose armies had a remarkable series of victories during the 1790s and early 1800s (Guérard 1969, 261-6, 271-4; Harvey 2006). Still smarting from losing the conflict in North America, the British Army continued a pattern of non-decisive victories and semi-regular defeats during the first, second, third, and fourth Coalition Wars (Mallinson 2005, 66-7; O’Shaughnessy 2013).

The Iberian Peninsula War marked the start of a reversal of fortune for the British Army, although it never truly matched the level of dominance achieved by the Royal Navy (Snow 2010, 8-9). A 14,000 strong army landed at Mondego Bay on the western coast of Portugal at the start of August 1808, initially led by Lieutenant General Arthur Wellesley (Snow 2010, 10-11). Command was transferred to General Sir John Moore, Lieutenant General Sir Harry Burrard, and Lieutenant General Sir Hew Dalrymple by 21 August 1808, and shortly after Wellesley returned to Britain and became Chief Secretary for Ireland based in Dublin (Harvey 2006, 618; Snow 2010, 32, 36). Wellesley returned to Portugal in April 1809 and based on numerous successful actions ascended the remaining ranks (Durant & Durant 1975, 537-9). By August 1812 he had been made Marquis of Wellington and given command of all allied forces in Spain (Snow 2010, 44). The British found rather ineffective allies in the Spanish Army, but essentially created a new Portuguese Army with whom they effectively collaborated for many years (Durant & Durant 1975, 213, 222—5, 532; Urban 2001, 75-6; Muir 2006, 3-6; Snow 2010, 216-7). The Peninsular War continued through the periods of the Fifth and Sixth Coalition Wars and concluded at the capitulation of Paris and the abdication of Bonaparte in April 1814 (Harvey 2006, 856-7; Snow 2010, 231-2). The signing of the Treaty of Paris on the 30 May 1814 marked the formal end of the Sixth Coalition War (Schom 1997, 703; Forrest 2011, 266-8).

As the wars on the European continent were coming to towards an end, tensions between America in Britain were rising. The cause of this conflict was American dissatisfaction with the British blockading of American trade with Europe, devised to weaken the French economy, mixed with an American desire to expand control into the remaining British held territory on the North American continent (Ireland 2000, 202-3). In 1811, with conflict looming, parts of the abandoned signal station system along the west coast of Ireland were recommissioned, and this action likely relates to the second phase of fortification that was initiated in 1810 (Section 2.2.5) (Kerrigan 1995, 163). The War of 1812 was declared by America on 1 June 1812. Beyond the various naval engagements, sixteen land battles were fought, concentrated along the Canadian border, the Great Lakes, and in land from Chesapeake Bay (Ireland 2000, 216-22; Holmes 2006, 96-9). Ultimately the conflict led to no exchange of territory. A peace treaty negotiated in December 1814 was ratified by the government in Washington DC on 17 February 1815. During the conflict there were various small naval engagements across the Atlantic (Ireland 2000, 205-16). Of particular importance were American privateers, who claimed between 1,400 and 1,900 merchant vessels, far in excess of the 254 British merchant vessels seized by the American Navy (Black 2008; Leiner 2014; Kert 2015, 7, 80). One of the hunting grounds for the privateers was the south-west coast of Ireland, and this seems to have led to the recommissioning of parts of the signal station system. It has been implied that the four enclosed barracks in County Kerry might be attributable to this conflict (Mould 1994, 24; Kerrigan 1995, 162; Clements 2013, 102). Although frequently mentioned, the published sources have not determined exactly which of the signal stations were recommissioned during the war. Clements states that the signal station system was abandoned in its entirety by 1816 (Clements 2013, 102).

Following Bonaparte's abdication in April 1814 he was exiled to Elba, over which he was given sovereignty, accompanied by several hundred troops[7] which he had been permitted to retain under the Treaty of Fontainebleau (Forrest 2011, 272-80). On Elba, Bonaparte committed himself to a characteristic course of governmental reform, which included increasing his army to around 2,000 troops and even establishing a small navy (Forrest 2011, 279). When Neil Campbell, the British officer stationed on Elba, left the island to visit a doctor in Venice in February 1815, Bonaparte returned to mainland Europe with the best parts of his small military to begin his final campaign, often referred to as 'The Hundred Days' (Snow 2010, 246). The 7th Coalition was formed in response to Bonaparte's return, and that combined force delivered Bonaparte's final defeat at the Battle of Waterloo on 18 June 1815 (Harvey 2006, 895-903). The victory by the coalition forces at Waterloo, saw Wellington immortalise his reputation as a peerless tactician, and he capitalised on his success to launch a lengthy and high-profile political career, including serving as Prime Minister (Snow 2010, 312-7; Cornwell 2014).

[7] The listed size and composition of this force varies considerably between different sources. Harvey simply says he was escorted to Elba by 60 Polish cavalry and returned to France in 1815 with 1,000 troops (Harvey 2006, 856-68). Forrest claims six hundred former Imperial Guard elected to follow Bonaparte to Elba whilst Holmes repeats the figure of 600 soldiers without describing their nature (Forrest 2011, 279; Holmes 2015, 129). Schom states the "nearly thousand-man force" was under the command of General Cambronne (Schom 1997, 704). Cornwell writes that 1,000 soldiers accompanied Bonaparte to Elba, including 400 Imperial Guard veterans and a battalion of Polish lancers (Cornwell 2014, 17). Snow indicates that Bonaparte was allowed to take over 1,000 troops to Elba but does not mention the composition of the force (Snow 2010, 235).

Bonaparte was exiled for a second time, to the remote island of St Helena, where he died in exile on 5 May 1821 (Forrest 2011, 295-311; Zaretsky 2015).

### 2.3.2 British rule in Ireland 1798 – 1830

In the immediate aftermath of the 1798 rebellion there was a period of persecution where the British Army and the Irish Yeomanry attempted to capture as many of the rebels as possible, a process that continued into 1801. Capture alternately meant summary execution or imprisonment, depending on various circumstances. Trials of the captured rebels would lead to execution, incarceration, corporal punishment, or acquittal. A sample of 659 sentences awarded to these prisoners during the trials of 1799 indicated 35% of defendants received death sentences, 2% were imprisoned, 4% received corporal punishment, 36% were transported, and 23% were acquitted. The total death toll resulting from the conflict, both military and civilian, and in combat and during the aftermath, has been estimated to be as high as 30,000 people (Foster 1988, 280-1).

In May 1800 Chief Secretary Viscount Castlereagh introduced the Act of Union to the British parliament. The Irish Commons voted in favour of the Act in June 1800, a vote for their own abolishment, and the Act came into force on January 1, 1801 (Newman 1991, 206-7). William Pitt had campaigned hard for the measure, which was to be accompanied by Catholic emancipation. Pitt hoped that this would be a permanent solution for Ireland, switching the Catholic's position from being a disenfranchised majority in a small country, to be an enfranchised minority in a larger country. The Act of Union was completed in 1801 but Catholic emancipation was ultimately blocked under pressure from George III and the protestant ascendancy. Following the failures of 1798, the Irish Presbyterians rejected the United Irish movement *en masse* and joined the cause against Catholic emancipation (O'Brien & O'Brien 1972, 91-2). Pitt was forced to resign as Prime Minister, and Lord Lieutenant Cornwallis, Chief Secretary Viscount Castlereagh, and Under Secretary of State Edward Cooke resigned in protest (Newman 1991, 23, 38; Pakenham 1997, 353-4).

The 1798 rebellion holds a very prominent place in modern Irish history, regarded as an important milestone along the road to political independence. Given the scale of conflicts raging across the world at that time, it was in some ways a minor affair, often omitted from accounts of the French Revolutionary Wars or given very scant coverage. Foster referred to the Republic of Connacht as a “strange episode” that is a “footnote to Irish history” (Foster 1998, 280). Poor timing, unhelpful weather and a lack of effective communications all played important roles in reducing the actual scale of the threat (Tyrell 2001). The threat was still serious enough that it triggered a major period of political and military re-organisation in Ireland and the spectre of another French Invasion lingered for many years (Section 2.2.4).

The start of the first decade of the 19th century saw a continuation of the poor economic conditions which had been one of the sources of discontent that had led to the rebellion. Emigration reached 50,000 people a year and outbreaks of violence and reprisal attacks continued (Packenham 1997, 348-9).

Although Catholicism was officially accepted in the United Kingdom of Great Britain and Ireland, the Irish Catholic population were impoverished, lacking both land and political office, and were heavily taxed. By 1815, Artz states their position was clearly worse than the condition of the peasantry in England (Artz 1963, 41). Such conditions were bound to lead to another political reform movement, and opposition to British rule coalesced around Daniel O’Connell’s Catholic Association in the 1820s (Artz 1963, 222-3; O’Brien & O’Brien 1972, 101-3). The Catholic Association’s peaceful mass protests were diametrically opposed to the tactics of the rebels of the late 1790s (Foster 1998, 297-317). Violent ‘direct action’ techniques were still an active part of Irish political resistance to British rule, but such activities were restricted to secretive small-scale activities practiced by the ‘agricultural radicals.’ This mixture of open and peaceful political engagement and guerrilla-style direct actions would characterise Irish politics into the 20th century (Foster 1998, 292-6; Casey 2013; King 2013).

### 2.3.3 Global patterns in post-medieval fortifications up to the early-19th century

The designs of fortifications in post-medieval Ireland were derived from larger trends in the development of fortifications occurring across Europe. The amount of indigenous innovation was extremely limited. At the beginning of the post-medieval period, the effectiveness of medieval castles began to be undermined by developments in weaponry and explosives (Herman 1992, 3-6, 9-11; Kerrigan 1995, 1-7). In response to the increased use of cannons and gunpowder to break the masonry walls of castles, experimental designs of new types of fortifications were constructed, eventually coalescing into the different variants of the bastioned fort (Kerrigan 1995, 1-15; Tabraham & Grove 1995, 13-9). These consisted of a series of angled bastions projecting out from a perimeter wall or bank, with the bastions providing firing platforms to attack advancing forces and then enfilade the attackers once they had reached the perimeter. A complex series of consecutive slopes, banks and ditches were added to hamper the advance of attacking forces, alternatively leaving them exposed to fire from the defenders, and making them climb up and down steep slopes to slow their progress, tire the attackers, and expose them to a variety of new dangers (Herman 1992, 14-9; Kerrigan 1995, Figure 2). The star shaped fort was the ideal implementation of this new design philosophy, although the same principles were used for more linear defences and to supplement or replace town defences, without the overtly symmetrical geometry of the star shaped forts (Herman 1992, 11-9, 32-8). Between the end of the 16th century and the end of the 18th century this design was subject to a process of continual refinement, fine tuning the design of the projecting bastions to create the most efficient firing platforms, and gradually adding new features to make any attacker's progress increasingly dangerous (Herman 1992, 19-32). Many existing medieval fortifications were altered to incorporate elements of this new type of design (Kerrigan 1995, 1). Versions of the bastioned fort were constructed throughout Europe, in many of the European colonies, and across North America in Spanish, French, and British occupied areas, and after the War of Independence, in the new United States territory (Herman 1992, 82-92, 117-32).

Fortifications of this type were constructed in Ireland in some quantity, both in coastal locations and for inland defences. Coastal examples include Charles Fort and James Fort on the approach to Kinsale Harbour, County Cork, Duncannon Fort on the approach to Waterford Harbour, County Wexford, and Cromwell's Barracks on Inishbofin, County Galway. Inland examples include Thomas De Burgh's Star Fort and the adjacent Magazine Fort in Phoenix Park in Dublin (Kerrigan 1995, 1-16; Hartnett McEnery 2006, 6-40). Fort Westmoreland on Spike Island conforms to this design paradigm although it was not fully completed until late in the 1850s (Hartnett McEnery 2006, 120).

With European fortifications having become so standardised, well-defined procedures for attacking and defending these sites became established. These effectively became codified after the preeminent engineer of fortifications of the 17th century, Sebastian le Prestre de Vauban, wrote down his collected thoughts in *Traité de fortifications* and *Traité de l'attaque des places* in the late-17th century (Herman 1992, 39-58). The period between the late-17th century and the end of the 18th century saw little innovation, and sieges became predictable if horrific processes, orchestrated according to the schedule established by de Vauban (Herman 1992, 61).

At the end of the 18th century new ideas about fortification emerged. The British use of Martello towers in Minorca, England and Ireland has been described in Section 2.2.4. These new forms were widely employed across the British Empire during the 19th century. British Martello towers were constructed in Scotland, Wales, the Channel Islands, Canada, Sicily, Corfu, Curzola (Croatia), Aden, South Africa, Sierra Leone, Mauritius, Sri Lanka, India, Australia, Canada, Bermuda, and throughout the West Indies. Construction of new towers continued until 1860 (Clements 2011).

Once promoted out of the artillery regiments, Bonaparte showed little interest in fortifications. His methods of warfare concentrated on fast marching his armies to outmanoeuvre opponents, and carefully using the terrain to provide tactical advantages during battle (Doughty *et al* 1996, 195-6, 205-6; Holmes 2006, 54-7). When his armies surrounded cities or fortifications, he preferred to force surrender without undertaking a lengthy siege, and he proved adept at extracting such capitulations, for example the capture of Mantua, Italy, in 1797, the capture of Malta in 1798, and the capture of Vienna, Austria, in both 1805 and 1809 (Doughty *et al* 1996, 206; Schom 1997, 396; Harvey 2006, 254-6, 666). French engineers would therefore provide little to the development of the science of fortification in the first half of the 19th century. Lazore

Carnot was the most prominent French contributor after the final defeat of Bonaparte, but his ideas involved retaining the form of the bastioned fortress and increasing the number of guns (Herman 1992, 75-6).

The French engineer Marc-René, Marquis de Montalembert (1714 – 1800), had limited opportunities to employ his ideas in France during his lifetime, but posthumously became very influential in Northern Europe and the United States (Herman 1992, 74, 136-41). Montalembert had argued for three innovations, the polygonal system of fortification - forts with long flat fronts facing the likely direction of attack - to replace the bastioned fortresses, the use of small, detached forts supporting larger forts, and the employment of vast numbers of cannons to defend forts (Herman 1992, 71-5). Polygonal forts would be built in considerable number in Northern Europe and North America, and arguably the quadrangle towers in Ireland, with their large sets of guns facing out to the most likely approach, represent an adaption of this idea (Herman 1992, 74-5; Clements 2013, 87-97). Post-independence, the United States undertook two large programs of fortification. The First System (constructed 1794-1799) utilised the latest developments of the bastioned fortifications (Herman 1992, 117-24; Chartrand 2012, 7-13). The Second System (constructed 1802-1812) used a mixture of older styles and new designs influenced by Montalembert; the three new multi-level circular fortifications built to protect New York were the absolute epitome of Montalembert's 'vast number of cannons approach' and formed a template for US coastal fortifications into the second half of the 19th century (Herman 1992, 132-9; Chartrand 2012, 13-19).

### 2.3.4 Watch Towers and Fortified Towers around the Mediterranean coast

The bastioned fortifications represented a pan-European response to the development of armaments in the post-medieval period. Parts of an older system, with medieval origins, persisted around the coast of the Mediterranean. In the medieval period, large areas of the Mediterranean coast were protected by a system of castles and watch towers. In the post-medieval period, the castles lost their primacy as defensive structures, their role replaced by bastioned fortifications, although many were retained as defensible residences. In contrast the watch towers continued to perform the function they were created for, and they were still being constructed into the 19th century. As defensive features they often featured a small number of cannons, but they could only provide a minor delay to a large invading force. Their primary role was to provide observation points along the coast and, in the event of an attack, announce the threat via smoke, fire, or sound signals. This would allow the population to respond to the threat rapidly, mustering defensive forces, and relocating vulnerable people (Altamura 2015, 3; Ierapetritis 2013, 221; Kirk 2013, 329). It should be noted that watch towers were in use in parts of the Mediterranean during antiquity, for example on the Greek Coast, on the Aegean Islands, and on the Croatian island of Hvar (Olber 1983; Gaffney & Stančič 1991, 61-3; UNESCO 2014). A consideration of possible connections between the medieval towers and the towers used in antiquity is beyond the scope of this project.

The watch towers were typically arranged as cohesive systems protecting an entire island or a particular stretch of the coast. In the medieval period the Dodecanese Islands under the Order of the Knights of the Hospital of St John of Jerusalem, Rhodes, and Malta (Knights Hospitaller), were protected by such a network, as was Chios, where the Genoese rulers wished to protect mastic production from Ottoman raids (Zafiris & Brokou 2002; Valkana 2005; Ierapetritis 2013).

Ierapetritis states that known locations of these watchtowers, termed *viglae* from the Latin *vigilia* (guard post, observation point, watchtower), include;

> *"Greece, on Samos, Santorini, Mykonos, Amorgos and other islands of the Cyclades, Euboea, Rhodes, Ikaria, Mytilene, Kalymnos, the Ionian Islands, Crete, Antikyra and Cyprus, as well as in the broader Mediterranean area, such as in the regions of Istria, Dalmatia and Albania, Sicily, Naples, Malta, the Algarve, Cartagena, Sardinia, Corsica, Valencia, Barcelona and elsewhere"* (Ierapetritis 2013, 221).

The 15th through 17th Centuries featured a notably intense period of watch tower construction, related to an increase in piracy and slave raids following the fall of Constantinople (Murru 2014, 90; Ierapetritis 2013, 224-5; Kirk 2017, 318, 333). It was during this period that Sicily acquired a particularly dense network; by the end of the 17th century, Sicily was protected by 168 watch towers, providing observation of every stretch of the coast, and of the valleys leading up from the coast into the interior of the island (Kirk 2017, 327).

The study of these Mediterranean watch towers is in its infancy, and comparative studies between different parts of the Mediterranean are not yet fully developed (Rodríguez-Navarro *et al* 2016; Lo Faro *et al* 2017). The watch towers were either circular, square, or rectangular in plan, and were typically only two- or three-storeys tall (Rodríguez-Navarro *et al* 2016, 3). The original 'Martello' tower at Mortella Bay on Corsica represents an example of the circular style of building (Gardiner 1996, 100-1; Altamura 2016).

One design may be of particular importance to this study, a square tower design dating to the 16th and 17th century constructed across the Crown of Aragon[8]. These watch towers were square, two- and three- storey buildings, with a pronounced talus wall (a pronounced battered wall face designed to deflect cannon shot and hinder the operation of siege equipment) around the ground-floor.

[8] The Crown of Aragon was a Mediterranean empire under the control of the Kingdom of Aragon, which developed between the 12th and 15th century. At its greatest expanse the Crown of Aragon consisted of the Valentia and Barcelona regions of the Iberian Peninsula, the Balearic Islands, Corsica, Sardinia, Southern Italy, Sicily, Malta, and parts of Greece. Much of this territory was gradually subsumed into unified Spain in the 16th century.

Examples of the design include Torre de l'Aguilo, and Torre de San Millan in Valencia, constructed in 1585 and 1589 respectively; Tower of Giraglia and Tower of Pinareddu, Corsica, constructed in 1571 and 1591 respectively (Altamura 2015, 10; Monumentum 2014); Torre Clementina, in Portonovo, Southern Italy, constructed 1716 (Formaglini *et al* 2015); Torre Vigliena, Torre di Mezzo and Torre Scalambri in Sicily, constructed 1595-1607, 1600 and 1596-1597 respectively (Frascari *et al* 2015, 309-11).

The *viglae* in the Crown of Aragon were typically around 30% larger in plan than the later Irish signal towers, but they share a noteworthy resemblance. The ground-floor was often accessible via an external entrance but there was no access from the ground-floor to the upper floors, which were entered via an upper floor doorway accessed via a retractable ladder. These towers also often incorporated barrel-vaulted ceilings, and the roof was designed to support the weight of the cannons. The slope of the talus walls at the ground-floor level was often very pronounced.

One subset of this group bear a stronger resemblance to the later Irish signal towers; the five small watch towers built on Malta between 1636 and 1657, during the reign of Grand Master Jean Paul Lascaris de Castellar, the thirteen small watch towers constructed between 1657 and 1660, during the reign of Grand Master de Redin (Figures 2.11 & 2.12), and a final tower of this type, Mgarr-ix-Xini on Gozo, which was constructed a year after de Redin's death but prior to the reign of the next Grand Master, Nicholas Cottoner which began in 1663 (Stephenson 2004, 17-8; Maltese History & Heritage 2019).

The Lascaris towers were square, two-storey towers with a steep talus slope around the ground-floor and a single entrance on the first-floor, accessed via a ladder. Each floor consisted of a single room, with only the first-floor room having windows. The roof was supported by timber beams and was protected by a parapet wall. The Lascaris towers were around 11 m (36') high and measured 6 m (20') across (Maltese History & Heritage 2019). The de Redin towers were of a similar size but utilised a barrel vault to support the roof and thus could support the weight of a cannon (Maltese History & Heritage 2019).

Figure 2.11. Ħamrija Tower on the south-west coast of Malta. This is one of the 13 towers built by Grand Master de Redin. Photograph by James Bonsall.

Figure 2.12. Ħamrija Tower on the south-west coast of Malta. The de Redin towers are a little stockier than the Lascaris towers. Photograph by James Bonsall.

Of all the Mediterranean *viglae*, the Lascaris towers most closely match the Irish Signal Towers (see Section 4.2 for a detailed assessment of the Irish design). Despite the general similarities in form there are important differences; the Lascaris towers lacked the symmetrical sets of windows on the side walls, and did not feature machicolations and bartizans at the parapet level.

This degree of similarity may be entirely co-incidental. The buildings were constructed for similar reasons using similar technologies, and there was nothing so unique about their design that the similarities must indicate a direct connection. However, it has been demonstrated that the design of the original Corsican Mortella Tower was adapted by the British for their own use during the same period during which the Irish Signal Towers were conceived and constructed. The possibility of a direct connection between the Mediterranean *viglae,* and the Irish signal towers is considered in detail in Section 5.3.

## 2.4 Telecommunications technology

Until relatively recently, basic methods of communication established at an early date seem to have sufficed; they remained largely unchanged for thousands of years. Simple systems for direct messengers, relay messengers, audible signals, and visual signals were developed in antiquity and persisted through to the medieval period with little in the way of innovation. Developments in telecommunications technology began slowly during the 16th and 17th Centuries, and by the late-18th century the introduction of the telegraph in post-Revolutionary France announced the beginning of a period of rapid development. This period of innovation continued through the 19th and 20th centuries, and into the 21st century, where the advances of communications technology are a major contributing element of the societal changes that have been dubbed ‘supermodernity’ (González-Ruibal 2008, 247).

### 2.4.1 Pre-18th century messenger systems

The simplest systems involve a single messenger either memorising a verbal message or carrying a written message. The messenger transmits the message from the sender to the receiver by physically moving from the location of the former to the location of the latter by foot, by horse, or by boat, or some combination thereof. The account of Phidippides carrying a warning 22.5 miles from Marathon to Athens in 490 BC is clearly an example of this type of simple system and is frequently used to begin discussions of the development of telecommunications (Holzmann & Pehrson 2003, 1-2; Headrick 2000, 183). This very direct system of transmitting information by foot or by rider was widely employed in antiquity, and it must surely pre-date the more complicated relay messenger services which are known to have been in use by the late second millennium BC. The procedure remained popular over time because of its simple nature. The method was particularly popular in medieval Europe where informal direct messenger systems using pilgrims, butchers (a peripatetic profession at the time), students, and other travellers were often cheaper and more secure than official messenger and postal services, benefits which negated their slowness and lack of regular schedules (Headrick 2000, 184). In the modern world direct messengers are still used for specific purposes, such as the bicycle and motorbike courier services which move physical copies of documents around and between cities.

The use of multiple messengers in a relay system is a simple improvement over the single messenger system. Each message is transferred by foot or by horse between different messengers located at messenger stations. Because each individual runner or rider is required to travel a shorter distance, they can maintain a faster pace without succumbing to exhaustion, the supposed fate of Phidippides. The use of relay systems extends back into the early second millennium BC, in Egypt and Babylon (Holzmann & Pehrson 2003, 2). The Persians utilised a horse rider relay in the 5th century BC, and the Roman Empire was served by a foot relay system until a horse relay was introduced, and the direct continuation of the system was utilised in the Byzantium Empire into the 6th century AD (Holzmann & Pehrson 2003, 4-5; Headrick 2000, 183-4). Headrick notes that these early imperial relay systems were frequently reserved for official messages (Headrick 2000, 184). Private messages would either be transmitted along the relay illicitly, or would have to be transmitted more slowly using single messengers. The horse relay was perhaps last deployed in a serious manner by the Pony Express that crossed western America in the mid-19th century, and it was unusual in being open for civilian use (Hardesty 1979; Holzmann & Pehrson 2003, 6).

Postal services often use a combination of messenger relays running along major routes and simple messenger systems connecting to those major routes. In the modern sense postal services are accessible to the public but most cited examples of ancient postal services were confined to official mail (Heaton 1905, 289). The first recognisable postal service was created in 6th century BC Persia by Cyrus the Great, which was an exception, being accessible to the public (Holzmann & Pehrson 2003, 3-4). The Mauryan Empire in India established a post service in the 3rd century BC, but it is unclear if it was a publicly accessible system or if it was restricted to the empires extensive bureaucracy (Seneviratne 1978). The Roman *cursus publicus* postal service was limited to official mail, but this included official shipment of what we would identify as freight (Holzmann & Pehrson 2003, 4-5; Beale 1998, 1-7).

The first genuine postal system in Europe was established in 1489 by Franz von Taxis, postmaster to the Holy Roman Emperor Maximilian I. The Taxis postal service was unpopular with many governments as it was not under state control, but it continued to operate until 1867, remaining under the control of the Taxis (and later the Thurn und

Taxis) family (Headrick 2000, 184). In France, a regular courier service between five cities was created in 1622, and it was opened to the public as a postal service in 1627. In Britain, the existing Royal Mail service was opened to the public as a postal service in 1635 (Headrick 2000, 184). These early postal services would remain slow and expensive until improvements in carriage design and road surfaces occurred, in the late 18th and early 19th Centuries respectively (Mallinson 2005, 24-5). A defining aspect of the early systems in France and Britain is that all of the post passed through a central node, lengthening the transmission time between towns and cities other than the capital, and where messages would be routinely read by representatives of the crown, making them very unsecure services[9] (Headrick 2000, 185-8). Because the official postal services generated revenue for the government and provided an easy way to spy on the population, privately operated alternatives were typically quashed shortly after being established (Headrick 2000, 185-6, 189-90). A basic postal service had been established in North America in the 1690s, but a much larger service was established in the United States in 1792. It played an important role in the expansion of the administration during the post-Independence period, and later in distributing newspapers which helped the widely spaced populations maintain a sense of unity through shared information (Headrick 2000, 189-91; Gallagher 2016).

Pigeons were also trained to carry messages, with the earliest records of such a system dating to the early 3rd millennium BC in Mesopotamia and Egypt, and later in Ancient Greece and Rome. The last regular use of messenger pigeons was in the 1980s, to communicate with a group of engineers at a remote Lockheed plant in California, and during periods of flooding in the remote Odisha region in India (Holzmann & Pehrson 2003, 6-8; Singha 2018).

Stentors, men who shouted messages, are a curious variation of the relay system, where only the message is transmitted, the messenger remained at his station. Lines of stentors are thought to have been used in Athens at the end of the 5th century BC, and during the 3rd century BC in Persia (Holzmann & Pehrson 2003, 20).

[9] Knight mentions that the Secret Office of the Post Office intercepted letters which compromised the United Irishmen during 1798 (Knight 2013, 112).

## 2.4.2 Pre-18th century visual signal systems

Visual signals were also used from antiquity into the modern period, but until the development of more complex codes during the 18th century they were generally quite limited in the quantity of information they could convey. Early visual signal systems included fire beacons, smoke and flag signals, and heliographs (Gaffney & Stančič 1991, 61-3; Holzmann & Pehrson 2003, 8-20; Mallinson 2005, 18). In their early incarnations visual signals were limited to a choice between one of two binary states, on (lit/smoking/hoisted/flashing) or off (unlit/not smoking/stowed/flashing). They could only transmit a very small number of pre-arranged messages, typically a form of warning indicated by the 'on' state. The complexity of the system could be expanded by increasing the number or intensity of the signal sources, for example a text from the Scottish parliament in 1455 states that burning one bale of faggot indicated the approach of the English 'in any manner', two bales that the English were 'coming indeed,' and four bales that they were 'coming in earnest' (Holzmann & Pehrson 2003, 30).

Holzman & Pehrson define a telegraph as a system which can transmit complex information in two directions, and stress that apart from a method for encoding complex messages, they also require protocols that relate to the process of transmission, such as acknowledgments of a transmissions beginning and ending, requests to repeat, and requests to speed up or slow down the rate of transmission (Holzmann & Pehrson 2003, 24). Wilson claims a functioning telegraph must be able to display a minimum of around twenty separate signal positions to achieve simple alphabetical spelling, but several hundred signal positions are needed to work with a fully developed code system (Wilson 1976, 8).

The first known telegraphic system was developed in the middle of the 4th century BC by Aeneas in Ancient Greece. It was essentially a pair of calibrated and inter-visible water clocks which allowed lit torches to descend into a water filled jar at a set rate, the point at which their descent was stopped equating to a specific pre-set message (Holzmann & Pehrson 2003, 24). The Romans are also thought to have used this system in the 2nd century BC (Holzmann & Pehrson 2003, 24). Torch telegraphs capable of signalling individual letters to form complex messages were in use during the 3rd century BC in Greece and Macedonia (Holzmann & Pehrson 2003, 28-9). In the 9th century AD a pair of synchronised clocks were placed at either end of a chain of fire beacons between Constantinople and Loulon near to the eastern frontier of Byzantium. The divisions on the clock were matched to twelve pre-set messages and by lighting the fires at a particular time of day that specific message could be transmitted along the four hundred and fifty mile chain (Holzmann & Pehrson 2003, 30).

The invention of the telescope at the start of the 17th century allowed for the consideration of more elaborate visual signalling systems, most of which appear to have remained hypothetical designs (Holzmann & Pehrson 2003, 31-4). In 1684 Robert Hooke presented a lecture to the Royal Society in London, 'On showing a way to communicate one's mind at great distances' (Holzmann & Pehrson 2003, 35; Mallinson 2005, 46). Hooke's method involved moving representative shapes out from behind a shutter. Hooke also realised the need for protocol codes to permit two-way communication and encryption to stop the message being intercepted (Holzmann & Pehrson 2003, 35-8). Holzmann & Pehrson imply that Hooke never actually built his device and cannot claim to have been the inventor of the modern telegraph, but both Huurdeman and Wilson state that he demonstrated his system in 1672, sending messages between the garden of Arundel House and a boat moored on the far shore of the Thames, half a mile away (Wilson 1976, 5; Huurdeman 2003, 15).

Around 1690 Guillaume Amontons is mentioned as having used letters attached to the sails of two windmills to convey messages from Meudon to Paris, a distance of around 9 km, or 5.5 miles (Holzmann & Pehrson 2003, 38-9). Amontons also developed a system similar to Hooke's which he is believed to have demonstrated to the French court (Wilson 1976, 5).

### 2.4.3 Pre-18th century British naval flag systems

A small number of different visual ship to ship signals used by the British fleet are recorded in the mid-14th century '*Black Book of the Admiralty*.' By the mid-16th century only a single flag signal, the flag of council, seems to have been in use (Kent 1993, 1-2). At the start of the 16th century the French, Spanish, and Venetian navies began utilising simple flag signal systems for ship to ship and ship to shore signalling, although details about the system are scarce (Holzmann & Pehrson 2003, 30). During the first Anglo-Dutch War, 1652-1654, the Royal Navy started using a combination of three flags (red, white, and blue) and a pennant to convey ship to ship messages, using simple pre-set codes. Less immediate and more complex messaging required hanging items from the yard arm, a cask indicated a need for water, a hatchet a need for wood, and a tablecloth an invitation to the officers to come for dinner, for example (Kent 1993, 3). Given the limitations of these systems the primary methods of communicating between ships was either shouting messages between vessels, often aided by shouting trumpets, or by sending messages between vessels by boat (Headrick 2000, 206).

### 2.4.4 18th century merchant ship flag signals

A well-known set of ship to shore signal posts used to communicate with merchant shipping began to be erected on Bidston Hill on the Wirral Peninsula in the second half of the 18th century (Irvine 1893, 76-7). The signal posts may have begun to be erected in 1763, although the land was not leased by the Liverpool Corporation until 1771. The signal posts were used to inform the merchants in Liverpool docks that one of their ships had been spotted approaching, and it was the merchants who organised the system. The signals consisted of flags, balls, and other shapes, and Bidston Hill was close enough to Liverpool docks that the signals could be observed with the naked eye. When a ship was spotted a first flag or symbol was hoisted to indicate the identity of the ship and a second flag or symbol was raised to indicate the type of cargo (Wilson 1976, 68-9). Numerous illustrations of the site exist, showing as many as seventy-six separate poles located on the hilltop, accompanied by a lighthouse, a windmill, and a number of huts (Scott 2016) (Figures 2.13 & 2.14). The system remained operational until 1827 when it was superseded by the Holyhead to Liverpool telegraph line (Section 2.4.7.9). Located at one of the major British ports, the signal posts would have been well known to sailors and it is quite possible that they were a point of reference for the Admiralty when they began to contemplate creating their own ship to shore signal post system in 1785 (Wilson 1976, 64).

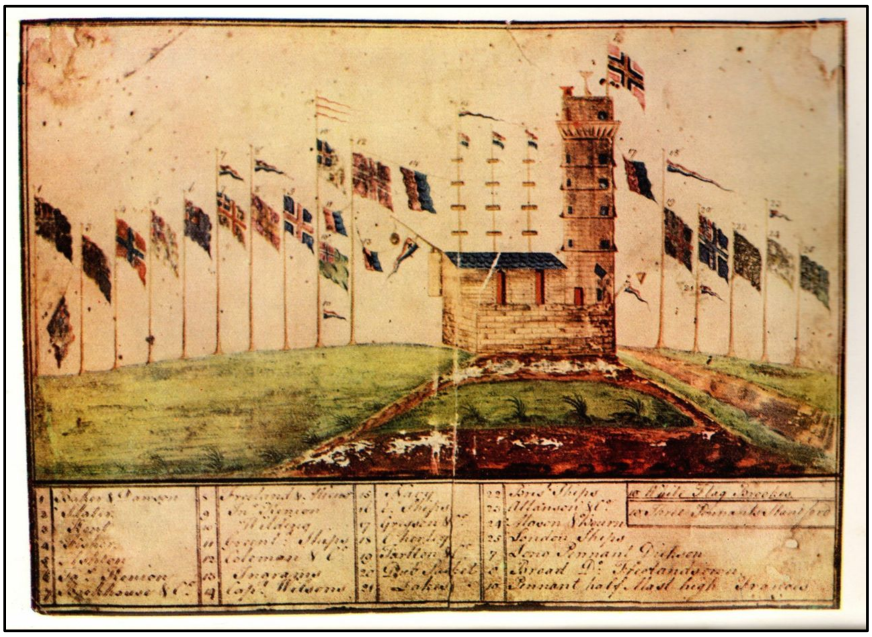

Figure 2.13. An unprovenanced image of Bidston Hill lighthouse and flag poles (http://www.bidstonlighthouse.org.uk/bidston-signals/).

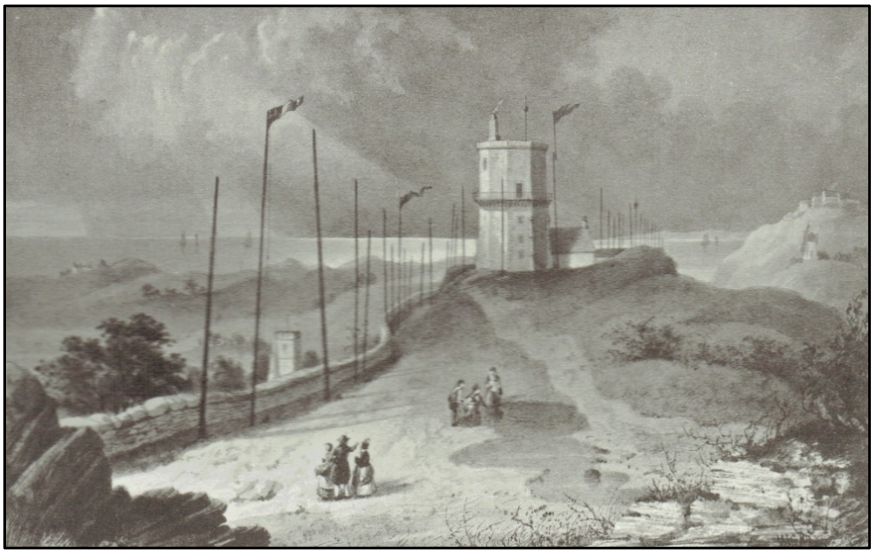

Figure 2.14. Bidston Hill Observatory, by William Gawin Herdman, 1830 (Herdman 1843).

### 2.4.5 18th century British naval flag systems

In the mid-18th century, the science of communications technology underwent a prolonged period of rapid innovation, beginning with increasingly complicated uses of flag signals both for naval and mercantile purposes (Wilson 1976; Kaukiainen 2001; Holzmann & Pehrson 2003; Mallinson 2005). The first printed naval signal books were created between 1714 and 1717, as a private enterprise undertaken by Jonathon Greenwood. In Greenwood's books the name and meaning of a signal was written underneath a picture of a ship showing where each component flag should be hung, and Greenwood boasted that any signal could be located in the books within half a minute (Kent 1993, 3). In 1748 John Millan produced the next printed signal book, also as a private venture (Kent 1993, 3).

After 1750 the number of flags began to increase dramatically, in proportion to the number of official instructions it became necessary to communicate. In 1776 Admiral Lord Howe attempted to rationalise the system, reducing the number of flags in use, and creating a book of signals and a book that explained their use, alongside discussions of conduct and procedure for naval officers (Kent 1993, 3).

In 1780, Rear Admiral Richard Kempenfelt who had long been interested in signals, devised a new scheme involving the use of just twelve flags, ten of which indicated numbers, but this was rejected by the Admiralty as being too complicated. When Howe attempted a second revision of his signal system in 1790, he adopted many of the Kempenfelt's ideas (Kempenfelt had died in 1782). Howe's new system consisted of ten numerical flags and a dozen other flags and pennants which mostly indicated signal protocols (Kent 1993, 4). Howe's new book also included instructions for communicating at night with lanterns, rockets, and guns. Howe circulated a revised version of his signal book in 1794, and a simplified but expanded version in 1799. The 1799 version contained 340 signals and was widely adopted. Because the signal books were not printed, individual officers had to arrange to have their own copies made and this allowed different fleets and squadrons to make additions and changes specific to their needs. Around the same time a two-pennant code was introduced that allowed ships to signal their identity. The 1799 book remained in use until November 1803, when a reorganised version was issued after a copy of the 1799 book had fallen into French hands (Kent 1993, 4-5).

#### 2.4.5.1 18th century British coastal signal posts

A natural extension of the production of rationalised and widely adopted signal books for ship to ship communication in the 1790s was the updating of ship to shore communications, which could also be used to transmit information along the coast. The first system to be erected was a ring of ten signal masts around the island of Jersey that were constructed in 1792. An eleventh mast was erected later in the same year inland at *La Hougue Bie*, which had views to all of the coastal sites, and which is where the commanding officer of the Royal Flotilla was resident (Ford 2012, 2). The system was abandoned briefly during the Peace of Amiens, but rapidly re-established in 1803 as hostilities restarted (Wilson 1976, 94). The last surviving signal station, at Fort Regent, remains in use for ceremonial purposes, although the signal system was completely overhauled in the early 19th century (Section 2.4.7.6) and the preserved site reflects the later form (Ford 2012, 1). Kavanagh describes the signal system as follows;

> *"The system of signaling used locally consisted of Flags, Pennants, and Balls. Each Signal Station had one Main Mast and two Yard-Arms, the Four Points on the two Yard Arms [sic] represent direction, top yard-arm East and West, lower one North and South. A Pennant or Flag hoisted at the mast head referred to the vessel, a Black Ball placed at the Yard-Arm referred to direction and number of Vessels. A total of 56 Signals were used."* (Kavanagh 1970, 139).

An illustration of the signals in use on Jersey has survived and provides a clear picture of the system in operation (Figure 2.15). Fire beacons and cannon were to be used to raise alarms during the night (Kavanagh 1970, 138-9). The stated number of 56 signal positions is appropriate to the number of signals listed in Howe's 1790 signal book. Each station was manned by a lieutenant, a midshipman, and two seamen. Naval personnel were chosen to man the stations because they were already familiar with signalling (Ford 2012, 2).

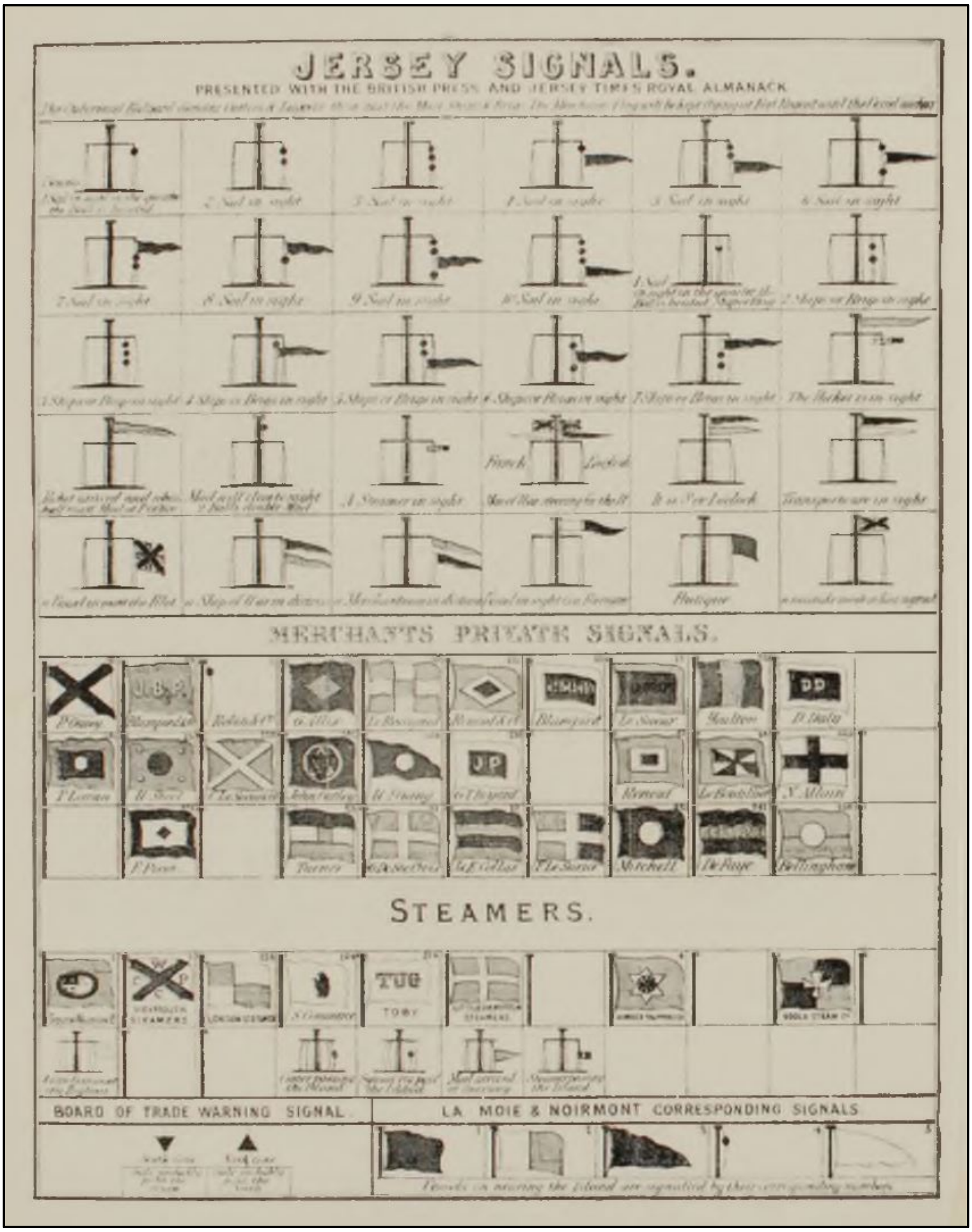


Figure 2.15. Flag and ball signal masts and ship identification flags from Jersey, in an image dated to 1880 (Kavanagh 1970).

A second system of ship to shore signal posts was subsequently constructed along the southern coast of England;

> *"In the year 1795, signal posts were established along the south coast of England. The approach of fleets, squadrons, or enemy's cruisers was immediately made known, and our convoys apprised of any danger. These stations were furnished with a comfortable residence for a lieutenant, a midshipman, and two seamen, whose salary and comfort depended on their vigilance; their signals were made with balls and flags, or pendants [sic] displayed on a mast or yard, rigged for the purpose."* (Pelham Brenton 1837, 44-5).

Initially 25 stations were constructed, starting at Land's End in Cornwall and ending at Ballard Down, overlooking Poole Harbour in Dorset (Kitchen 1990, 337; Knight 2013, 124). The stations were located between six miles and 22 miles apart and used a 50 foot tall, recycled ships mast;

> *"fitted with a cap, cross-trees and fidd. To this was clamped a flagstaff 30ft long, and a truck and two sleeves for the ropes. A yard or gaff 30ft high was added from which signals could be suspended" (Goodwin 2005, 35-6).*

Designed by Captain John Clements, the signal posts were located in order to communicate with ships up to 20 miles out to sea, and with their adjacent signal posts (Goodwin 2005, 35). The stations were manned by sea fencibles, with a naval lieutenant assisted by a petty officer or midshipman, and two seamen (Kitchen 1990, 340). The crew were housed in a simple, partially pre-fabricated, wooden signal house located next to the mast, with windows arranged to observe the adjacent signal posts rather than the coast, to the consternation of the crews (Goodwin 1992, 32; Goodwin 2005, 36). The code book was designed by Admiral John McBride, Commander-in Chief, Plymouth. The code book contained ninety-two set signals which in combination was versatile enough to convey information about most situations involving isolated attacks or full-scale invasions. For security reasons the code book was actually split into two volumes, '*Signals to be made at the Several Signal Posts along the Coast*' which showed the signal patterns matched to numerical codes, and '*Signification of Signals to be made at the Several Signal Posts along the Coast*' which explained the meaning of the numerical codes (Goodwin 2005, 36-7). Numerical and alphabetical codes could also be used to slowly spell out messages beyond the scope of the set codes;

> *"About half the total signals were about the type of vessel seen and directional details about the actual or anticipated movement of enemy ships from the French ports. There were signals for ships on blockade duty and others about the procedure for message sending or cancellation. The landing of a French army on the vulnerable south coast of England was dealt with by signals giving orders and information to the Sea Fencibles and generals of the defending armies"* (Goodwin 2005, 37).

The first stations having proved successful, a further nineteen were added, starting at Hengistbury Head in Dorset and ending at North Foreland in Kent, having run across the Isle of Wight along the way. Seven further stations were added in 1796, and two more were added in 1797, in between existing stations where inter-visibility had proved to be problematic (Kitchen 1990, 341-2). In the event of an emergency, the signal posts could communicate with the shutter telegraph lines (Section 2.4.7.5), although only the most senior officers were permitted to use this facility (Goodwin 2005, 37). Once some initial wariness had been overcome, the army forces stationed along the south coast under the Duke of York also communicated with the system (Goodwin 1992, 32-3). In 1798 the Admiralty commissioned a third line of 19 signal posts running from the port of Yarmouth in Norfolk to Shoeburyness, on the Essex side of the Thames Estuary (Kitchen 1990, 342).

The system was judged so useful that the army adapted it to their own cross-country communications in 1803 (Goodwin 1992, 33-4). This system of flags, pennants and balls become a standard method for British communications for around two decades. It was an iteration of this system that was utilised at the Irish signal stations.

## 2.4.6 18th century optical telegraphs

The 18th century saw a continued interest in telecommunications, but as with the previous centuries most of the discussion appears to have been of hypothetical devices. One of the most prolific early scholars who deserves specific mention was the German, Johann Andreas Benignus Bergsträsser, who published a five-volume treatise in 1784 describing all the known methods of telecommunications (Wilson 1976, 5). Bergsträsser proposed a rocket-based message system, which never seems to have been field tested (Huurdeman 2003, 16).

### 2.4.6.1 Edgeworth's Early Experiments

In 1767 Richard Lowell Edgeworth of Edgeworthstown, County Longford, invented a working telegraph system which he attempted to use to convey the winner of a horse race in Newmarket to London (a distance of 108 km or 67 miles) allowing him to win a substantial bet. When his intention to use mechanical methods became apparent there was enough confidence in his ability to convey information correctly that the bet was called off (Wilson 1976, 103). Edgeworth subsequently performed several successful tests to communicate messages across London. He reported his experiments in telegraphy to the Royal Society of Ireland, but unfortunately found too little interest and no market for his invention, and soon he had moved on to other pursuits (Kirwan 2017, 211). One early design featured two movable wings mounted on a single pivot, others involved hanging large cut out letters in windows (Wilson 1976, 102-3; Holzmann & Pehrson 2003, 188; Mallinson 2005, 45-6).

### 2.4.6.2 Captain de Courrejolles' signal post

In 1783 Captain de Courrejolles of the French Marines erected an unknown design of signalling system on a mountaintop in western Greece. He used the apparatus to communicate with the French flagship of a small fleet which had been blockaded by a British fleet commanded by Admiral Hood. Made aware of the movements of the enemy ships, the French fleet was able to chase off the opposing British force (Holzmann & Pehrson 2003, 51; Huurdeman 2003, 16).

### 2.4.6.3 Claude Chappe and the first modern telegraph system

In 1789 Claude Chappe and his brothers began developing their pendulum system which probably involved modified clocks, with symbols replacing the numbers on the faces and the hands replaced by pointers. As the pointer moved around the face of the device a loud sound was used to indicate when a particular symbol should be read (Figure 2.16). The use of a sound signal limited the systems range to around 400 m (Holzmann & Pehrson 2003, 51-2; Huurdeman 2003, 18-9). On March 2, 1791 Chappe demonstrated his tachygraphe system, which again used the modified clock face, replacing the sound signal with a colour coded shutter. Chappe also experimented with an electrical signal but failed to create a usable signal. Chappe was able to use his tachygraphs to transmit a message 15 km between Brûlon and Parcé in around six minutes (Holzmann & Pehrson 2003, 53-5; Huurdeman 2003, 18-20; Mallinson 2005, 52). In 1792 Chappe began experimenting with a form of shutter telegraph, but these were repeatedly destroyed by suspicious mobs (Holzmann & Pehrson 2003, 57-9; Mallinson 2005, 54-5).

On the 12 July 1793 Chappe performed a public demonstration of a new design (Holzmann & Pehrson 2003, 61). The T telegraph consisted of a tall post with a centrally pivoting regulator arm, which had rotating indicator arms attached to either end (Figure 2.17). The regulator could be set in four positions (horizontal, vertical, right inclined, and left inclined), and each indicator could be set in seven positions (0, 45, 90, 135, 225, 270, and 315 degrees). A total of 196 identifiable positions could be achieved using a series of ropes and cranks to manipulate the device. The operator was positioned in a small room at the base of the post with the controls. The position of the controls replicated the position of the regulator and indicators in miniature (Huurdeman 2003, 2). Using three T telegraphs in a chain, Chappe transmitted a 27 word message over a distance of 26 km (16 miles) and received a 20 word reply. From start to finish the transmissions took about 20 minutes (Holzmann & Pehrson 2003, 61).

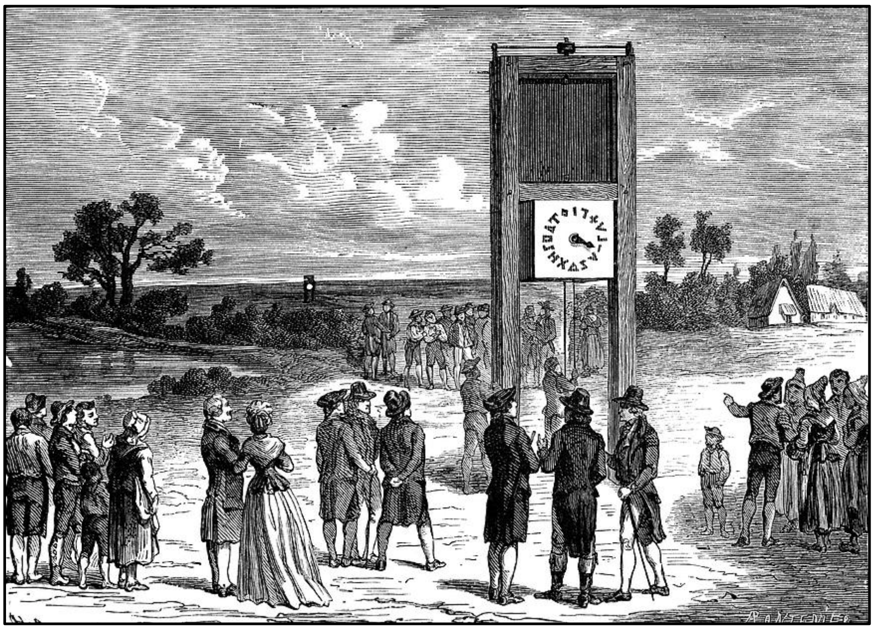

Figure 2.16. Max de Nansouty's 1911 image which purports to show one of Chappe's early clock face style tachygraphes. The accuracy of this image has been questioned by Holzmann & Pehrson who point out that no contemporary illustrations exist meaning this must be based solely on written descriptions (Holzmann & Pehrson 1995, 52-3).

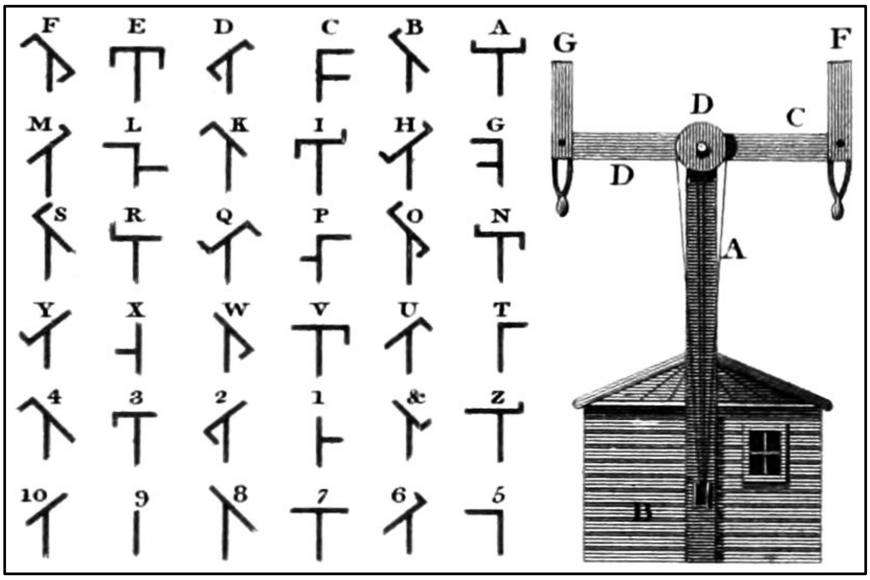


Figure 2.17. J. Farey's illustration of a Chappe style telegraph, 1818 (Rees 1820, 326).

The National Convention were impressed and Chappe and his family were instructed to create a telegraph system between Paris and Lille. The 190 km (118 mile) long route required the construction of 18 telegraph stations and officially opened on 16 July 1794. The first official message, announcing the French recapture of LeQuesnoy from the Austrians and Prussians, was transmitted on 15 August (Holzmann & Pehrson 2003, 61-4). A horse messenger dispatched from Lille with the same news arrived in Paris 20 hours after the telegraph message had arrived (Mallinson 2005, 66). The telegraph stations were generally added to existing buildings with towers, rather than using newly built structures. Where new buildings were constructed, they do not seem to have followed any standardised design (Holzmann & Pehrson 2003, 61-5).

An initial vocabulary was derived from diplomatic correspondence and contained 9,999 words, phrases, and expressions, each represented by a number. The original vocabulary proved to be too time consuming to transmit and in 1795 Chappe introduced a new vocabulary. This used three books, each containing 92 pages with 92 symbols on each page, for a total of 25,392 different words, phrases, letters, and numbers. To send a message the transmitting station would position its regulator and arms and then wait for the receiving station to replicate the pattern, before moving to the next arrangement. Encoding and decoding were only undertaken at the origin and destination of the message, and only a small number of protocol signals were needed (Huurdeman 2003, 20-2).

Chappe's optical telegraph instigated a genuine revolution in communications (Headrick 2000, 181-211; Holzmann & Pehrson 2003, 59-64, 101-5). Before the end of the 18th century, a number of new telegraph lines had been created, with Paris acting as a central hub in a radial network (Holzmann & Pehrson 2003, Figure 2.9). In 1798 the Paris to Lille line was extended to Dunkirk, and new lines were opened between Paris and Strasbourg, and between Paris and Brest. In 1799 the line to Strasbourg was extended to Huningue. By the end of 1799 eight major cities were connected via the T telegraphs (Holzmann & Pehrson 2003, 67; Mallinson 2005, 66-9).

### 2.4.6.4 Edgeworth's second telegraph

Edgeworth returned to his family estate in Ireland in 1782 (Kirwan 2017, 211). When he heard of Chappe's successful development of a telegraph line it renewed his interest in telegraphy (Wilson 1976, 103). Edgeworth's new design involved four columns supporting triangular pointers which could be placed in one of eight positions, zero through seven, giving each signal a potential range of 7,778 positions. To initiate a transmission the thousand and hundred pointers were rotated until the receiving station was seen to repeat the signal, acknowledging readiness to receive. The receiving station would set its pointer to 0002 to acknowledge it was ready to receive, and then move to 0000 to indicate the signal had been received. The transmitting station would move to 0000 to indicate acknowledgement that the code had been received, and seeing this the receiver would return to 0002, indicating it was ready to receive the next transmission (Kirwan 2017, 221-5).

The design was simple and versatile. The pointers could be constructed to different sizes, depending on the distance over which it was needed to be read. Edgeworth's smallest versions were portable machines designed for field communications. His largest versions, with 30' (9.1 m) long pointers, were able to transmit between Donaghadee, County Down, and Port Patrick in Dumfries and Galloway, a distance of 34 km (21 miles) across the Northern Channel of the Irish Sea (Wilson 1976, 103-5; Kirwan 2017, 219, 221-2). Examining the vocabulary Edgeworth designed for his telegraph system it is clear he was envisioning two threats to Ireland, an external threat from France and her allies, and an internal threat from Irish rebels (Kirwan 2017, 226).

Edgeworth submitted his design to Lord Lieutenant Camden on May 30, 1795. Despite frequent communications, performing several demonstrations, and receiving considerable interest in his portable devices by the Duke of York, during 1796 Edgeworth had come to accept that the Admiralty had chosen a different device for use in England. He continued to promote his telegraph for use in Ireland (Wilson 1976, 107; Kirwan 2017, 217-9, 226-7).

### 2.4.6.5 The English shutter telegraph

News of Chappe's T telegraph quickly reached Britain via written descriptions and a pair of scale models. Documents found on a French prisoner included a drawing of the T telegraph and an alphabet. A study of optical signalling was quickly commissioned by the Duke of York and was prepared by Reverend John Gamble in 1795. It was subsequently published in 1797 (Wilson 1976, 11). The report suggested that simple shutters pivoting on a horizontal axis would provide a cheaper and more easily operated alternative to Chappe's complex system.

In August 1795 Gamble, at the behest of the Admiralty, successfully tested a five-shutter apparatus, with the shutters arranged in a single column. About the same time Lord George Murray had proposed a six-shutter system to the Admiralty, using two columns containing three shutters in each, with the columns separated by a half column width gap. Gamble's design allowed for 37 positions, but Murray's design allowed for 63 positions. The 37 positions of Gamble's design would not have been able to encompass the full alphabet, ten numbers, protocol signals and a simple range of standard phrases, which are considered the minimum requirements for an efficient telegraph. Murray's design was selected, and he was appointed to establish the first telegraph lines to run from the Admiralty offices in London to Portsmouth and to Deal, with a side branch from the Deal line running to Sheerness (Wilson 1976, 13). The London to Deal line used ten intermediary stations, the side branch used two intermediary stations to reach Sheerness from the station at Beacon Hill on the main line, and the London to Portsmouth line used eight intermediary stations (Wilson 1976, 17-22, Figure 1). The London to Deal line was operational by January 1796. The London to Portsmouth line was operational by the end of 1796 (Wilson 1976, 17).

Most of the intermediary stations consisted of small newly constructed two room huts with the shutter apparatus mounted to the roof (Wilson 1976, 14). Sadly, none of these specialised buildings have survived, but their form is known from various illustrations, and from a scale model built by Murray which is held at the National Maritime Museum, Greenwich (Figure 2.18). The huts consisted of a small operations room and a larger general living room combined with a kitchen. The frame holding the shutters was 20' (6.1 m) tall.

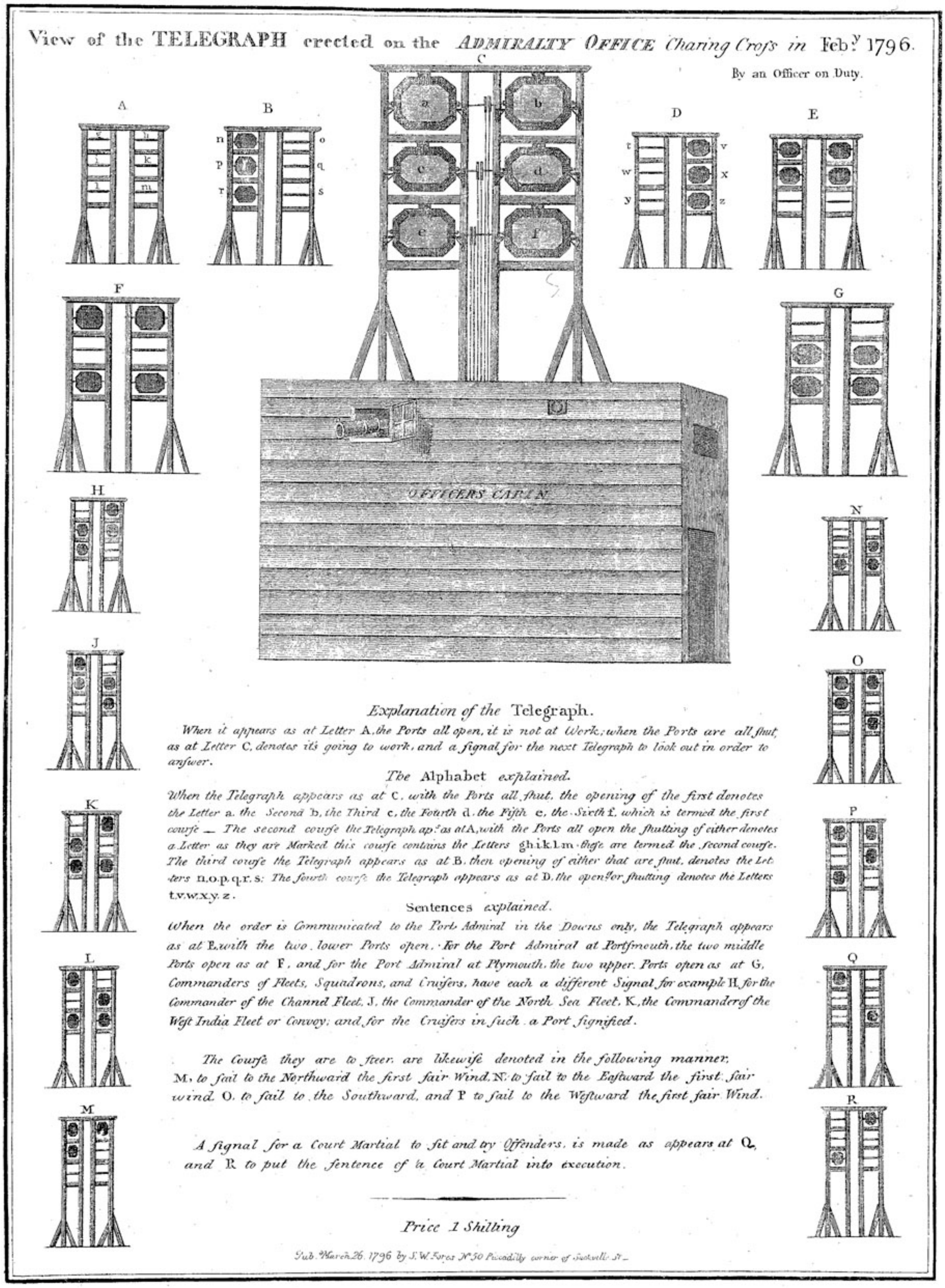


Figure 2.18. Illustration of the shutter telegraph system, 1796. By S. W. Fores (Royal Museums Greenwich Object ID PAH2206).

Each station cost £215 to construct (Kent 1993, 14). The full complement of staff at a signal station would have been a Royal Navy Lieutenant, a midshipman, and two assistants who would have been seamen of the lowest ranks. The officer wrote the message into a ledger, the midshipman observed one of the adjacent stations through a telescope, and the assistants worked the ropes that operated the shutters and observed the other adjacent station (Wilson 1976, 14-5). Some of the shutter telegraphs were mounted to the roofs of existing buildings, particularly at the terminals of the lines. The shutter telegraph was able to transmit an average length message between London and Portsmouth in about fifteen minutes (Wilson 1976, 15-6).

#### 2.4.6.6 The Swedish telegraph

The Swedish scholar, librarian, and theatre director, Abraham Edelcrantz introduced the optical telegraph to Sweden in October and November 1794 (Wilson 1976, 167). Directly influenced by Chappe's success, Edelcrantz's initial design involved a horizontal beam with centrally rotating indicator arms at each end. The design allowed for sixteen separate positions, and Edelcrantz developed a compressed alphabet for use with the apparatus. Three telegraphs were constructed in a line between Stockholm and Drottningham, a total distance of 12 km (7.5 miles). An average length message could be transmitted along the line in seven minutes (Wilson 1976, 167-9; Holzmann & Pehrson 2003, 101-2).

Although Edelcrantz discussed using eight positions for each indicator to increase capacity to 64 positions, he quickly began to develop a grander scheme for a ten-shutter telegraph. Edelcrantz began testing his new design in late 1794. It consisted of a three by three matrix of nine shutters with a tenth shutter located above the matrix. The system worked by generating a three-digit code by adding the values of each closed shutter in each column. The upper row of shutters were assigned the numerical value of one, the middle row of shutters two, and the bottom row of shutters four. The large tenth shutter added the prefix 'A' to the code if it was closed. The shutters were operated using an ingenious switch-based control panel, that was first set and then activated by a foot pedal. Because the control panel had two full sets of switches the operator could arrange the next instruction while waiting for the preceding code to be acknowledged. The telegraph had a total of 1,556 positions and was noticeably more sophisticated than other early devices (Wilson 1976, 169; Holzmann & Pehrson 2003, 103-5). In 1796 Edelcrantz published a book length treatise on telegraphy, which has been reproduced in its entirety as Chapter 4 in Holzmann & Pehrson's book (Holzmann & Pehrson 2003, 131-78).

The first line of shutter telegraphs in Sweden ran between Stockholm and Vaxholm and became operational on 28 July 1795. By the end of 1797 two more lines had been built, one from Stockholm to Frederiksborg and the other from Grissleham to Signilsskär and Eckerö. In 1799 a short line was constructed near Göteborg (Holzmann & Pehrson 2003, 105-6).

### 2.4.7 19th century optical telegraphs

In the early-19th century, the French and British continued to refine and expand their telegraph systems. Four other European countries developed optical telegraphs during the 19th century, and a small number of systems were constructed in other parts of the world.

#### 2.4.7.1 Continuing use of the telegraph in France

France embraced the new technology with more vigour than any other country, utilising the telegraph to communicate across an expanding empire. Unfortunately, the financial strain of undertaking so much work in such short order, without having established a proportional way of receiving payment, led Claude Chappe to take his own life in 1805. Chappe died at the headquarters of the telegraph service in Paris, but his family would remain heavily involved with the telegraph system until it was finally decommissioned in 1853 (Holzmann & Pehrson 2003, 77-8; Mallinson 2005, 69).

The new century began with the first closures, when the line from Strasbourg to Huningue was closed in 1800 and the line from Lille to Dunkirk was abandoned in 1801. Ten new lines were added to the system between 1800 and 1810, but the system contracted between 1810 and 1820 when only two new lines were added, and nine lines closed. Between 1820 and 1830, six new lines were added, there were no further abandonments, and the line between Lyon and Toulon was upgraded in 1821. Eleven new lines were added between 1830 and 1845, and the final addition to the system was constructed in 1846. The remaining lines remained operational until 1852 or 1853, when the system was decommissioned (Holzmann & Pehrson 2003, 67-75). In 1852 there were 556 individual telegraph stations in the system, which had a combined length of 4,800 km (2982 miles) and connected 29 cities to Paris (Holzmann & Pehrson 2003, 79). The long duration of the French system is attributable to the expansion of its use to the administration of French territories and, beginning in 1799 and continuing for many years, to communicate winning lottery numbers (Wilson 1976, 132, 137-41; Mallinson 2005, 68-9).

### 2.4.7.2 The development of the French semaphore system

The semaphore was invented in France in 1801 by Charles Depillon, who attached movable signal arms to the mast of a ship allowing ship to shore communications (Wilson 1976, 5; Kent 1993, 11, 16; Holzmann & Pehrson 2003, 196). Wilson argues that the term semaphore specifically refers to devices consisting of an upright post with one or more arms working in a vertical plane. Wilson notes that the term has been frequently misused by English speakers since the early-19th century, whereas the French have maintained a strict distinction between telegraph and semaphore. That strict separation of terms may reflect the two French systems almost mutually exclusive distribution; semaphores were located around the coast, telegraphs were largely located inland (Wilson 1976, 6).

By 1807 semaphore posts had been erected from Bayonne on the north coast of France to Vlissingen on the coast of the Netherlands (Holzmann & Pehrson 2003, 196). Huurdeman describes Depillon's design as consisting of three movable arms that could convey 301 signal positions and states that 97 semaphore posts were erected along the north coast of France, 32 were constructed along the Mediterranean coast, and six were constructed along the coast of Algiers (Huurdeman 2003, 39). Mallinson (2005, 131) indicates this deployment had occurred prior to the end of 1803. Following the Battle of Trafalgar, the semaphore posts were frequently attacked by British raiding parties, under the direction of Admiral Thomas Cochrane, who would have the masts burned and the semaphore books destroyed (Wilson 1976, 131). Pelham Brenton claims that by 1810 the Royal Navy was in possession of the semaphore code book and were able to read the signals on the French posts (Pelham Brenton 1837, 46). Following the end of the Napoleonic Wars the semaphore system was used to communicate with merchant shipping, and they were eventually electrified and integrated with the French electrical telegraph system (Wilson 1976, 131-2). The system remained in use in France into the early-20th century (Huurdeman 2003, 39).

#### 2.4.7.3 Continuing use of the shutter telegraph in Britain

In October 1805, the British Admiralty decided to construct a new telegraph line to Plymouth. The line branched off the Portsmouth line, at Beacon Hill, the penultimate intermediary station on that line. From Beacon Hill there were 21 intermediary stations before the line reached its terminal station, Plymouth Mount Wise. The line was operational by May 1806 (Wilson 1976, 24).

The final addition to the shutter telegraph was a line running from London to Yarmouth, ordered in 1807. The line required 16 intermediary stations and was operational by 24 August 1808 (Wilson 1976, 26-30).

The new additions used the same design as the earlier lines, with the telegraph apparatus extending from the roof of a small two room hut. An extension of the Beacon Hill to Plymouth line to Falmouth was apparently under consideration in 1805, although there is no evidence that this was ever constructed (Wilson 1976, 30).

Following the signing of the Peace of Paris on 30 May 1814, the Admiralty ordered that the shutter telegraph be closed, and for the apparatus and buildings to be taken down and sold (Wilson 1976, 31). A number of the huts became private residences.

#### 2.4.7.4 Continuing use of the British Signal Posts

The flag and ball signal posts along the southern coast of England had ceased operating on 22 April 1802, during the Peace of Amiens. The system was re-established in September 1803 after hostilities had restarted, which at most sites involved completely rebuilding the signal posts which had been dismantled eight months earlier (Goodwin 2005, 42). Four new signal posts were added to the system during its refurbishment, again added to places where there had been visibility problems, and two of the earlier sites were repositioned (Kitchen 1990, 342). During 1804 an isolated signal post was constructed at St Anne’s Head near Milford Haven, a line of eight signal posts was established between Point of Linus on Anglesey and Formby Point north of Liverpool[10], a line of 15 signal posts was established between Edinburgh and Hartlepool and a line of 21 signal posts extended the line that had ended at Yarmouth as far as Flamborough Head in Yorkshire. Three new signal posts were also constructed in Sussex and Essex,

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[10] This system did not make the signal posts on Bidston Hill redundant because it was reserved for military use.

again to improve the functioning of the existing line in that area. By 1812 another 22 signal posts had been added around the south coast, including one located on a barge in the middle of the Thames, in order to connect the existing lines. By this point an almost complete chain from Edinburgh to Land's End had been constructed. The signal posts were closed again in 1814, as the Napoleonic Wars came to their conclusion, but parts of the system were re-opened for a short period in 1815, after Bonaparte's escape from Elba (Kitchen 1990, 343; Sockett 1991, 423-5; Knight 2013, 233). The Admiralty developed a plan to replace the signal posts with the new semaphore equipment in 1815, and work began on this in Kent. It was intended that the semaphore line would be extended to Land's End. The value of the scheme for peace time use was severely questioned and work ground to a halt. The plan was eventually abandoned in 1820 which Goodwin (2005, 42) identified as the final closure of the signal post system.

#### 2.4.7.5 Edgeworth's Dublin to Galway telegraph

Following another demonstration of his apparatus in 1803, Lord Lieutenant Hardwicke requested Edgeworth establish a pilot cross county telegraph using his portable devices. The line began at the Royal Hospital, Kilmainham, County Dublin, and terminated in Galway City, County Galway. The line consisted of 15 stations, each with a temporary guardhouse and a version of Edgeworth's portable telegraph. The stations were staffed by a telegraphic corps, derived from the Edgeworth Yeomanry (Kirwan 2017, 230-1). On 14 January 1804, Edgeworth claimed to have completed the line between Dublin and Galway, although it did not become properly functional until July 1804. Transmission of simple messages along the length of the line took around eight minutes; lengthy messages could be transmitted in around half an hour (Kirwan 2017, 232). Edgeworth had proposed a more extensive system, with a network of lines radiating out from Dublin to the major coastal cities, where they could inter-communicate with the coastal signal stations, although this never came to fruition (Figure 2.19). Late in 1804 the Dublin to Galway telegraph line was suspended. Mounting costs for the new coastal defences and signal stations led to the closure, and Edgeworth's system was only operational for around six months (Kirwan 2017, 232-3). Wakefield described the system in favourable terms and stated that construction of the system "cost the country only £15,000" (Wakefield 1812b, 830).

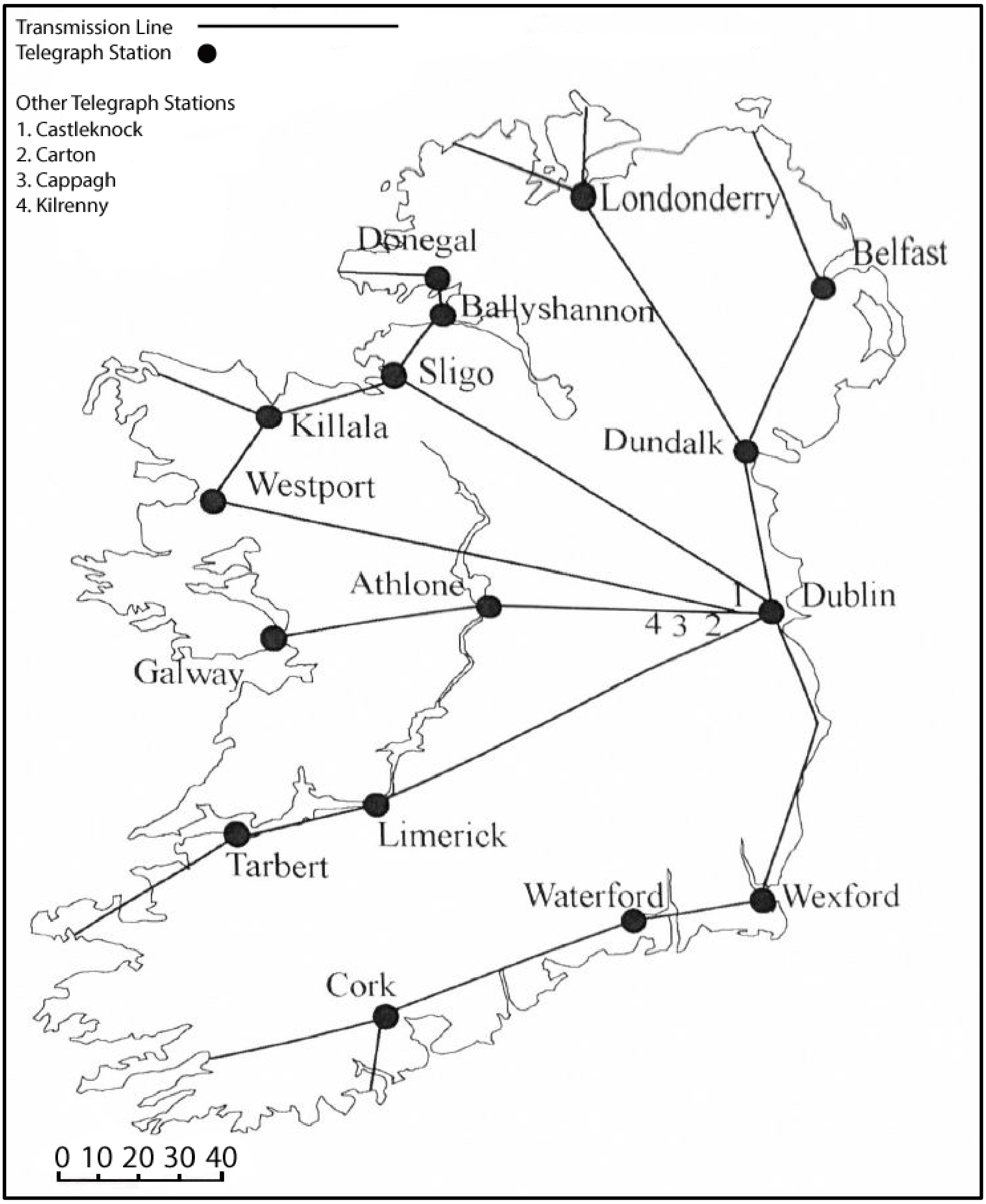


Figure 2.19 Map of Edgeworth's proposed national telegraph system (After Kirwan 2017).

### 2.4.7.6 The development of the semaphore telegraph in Britain

The first British use of a semaphore telegraph occurred in the Channel Islands in 1809 when the existing flag and ball signal stations on Jersey were upgraded. New signal stations with semaphore masts were subsequently established on Guernsey, Alderney and Sark, with Sark acting as a small node in the centre of the system, allowing inter-communication (Wilson 1976, Figure 21). The semaphore system was designed by Peter Mulgrave and consisted of a mast with a single pivot on which a straight arm and a cross shaped arm were mounted. The arms allowed for a total of 56 positions. The masts originally featured additional top masts and a yard, indicating some continuity with the earlier flag and ball system. It is not known how many extra positions could be indicated through the use of these features, or when they were removed (Wilson 1976, 94-7). Ten semaphore masts were constructed in a ring around the coast of Jersey, eight were constructed in a ring around the coast of Guernsey, and Alderney and Sark each had a single semaphore mast. Given the proximity of the Channel Islands to France it is not unsurprising that a semaphore system was adopted at an early date (Mallinson 2005, 131). The system was decommissioned after the signing of the Treaty of Paris in May 1814 but recommissioned in April 1815. The system was permanently closed in July 1815, although individual signal stations continued to operate after this point, as has already been mentioned (Section 2.4.5) (Wilson 1976, 100). Mulgrave would later move to Tasmania where he would also be involved in constructing telegraphs (Wilson 1976, 95, 203).

Having closed the shutter telegraphs in 1814 Britain was left wanting during the Hundred Days conflict in 1815. Only 11 days after the Battle of Waterloo on June 29, 1815, a new act of parliament authorised the reestablishment of telegraph lines. The new lines would use apparatus resembling the French coastal semaphore posts, arranged in chains to allow long distance communications (Mallinson 2005, 131). The first design was developed by Admiral Sir Home Riggs Popham and featured two indicator arms, mounted one above the other on a mast. Each arm could take seven positions and in combination provided 49 possible combinations, significantly lower than the earlier shutter telegraphs (Holzmann & Pehrson 2003, 195-6). The mast could be rotated in a collar at its base, and thus a single mast could operate in multiple directions. Popham's new design was quicker and easier to operate, and the signal arms had improved visibility over the shutter design (Wilson 1976, 33-4, 41). Popham's design would also be utilised for ship to ship communication, with semaphore masts mounted to the decks of ships (Kent 1993, 11-2; Holzmann & Pehrson 2003, 195).

The first line was designed to be a temporary test of the new Popham design, running from London to the docks at Chatham. It was operational by the end of July 1816. The line followed a different route than the shutter telegraph, which had been plagued by fog along this section. In 1820 the tests were considered to have been successfully concluded and a permanent installation between London and Chatham was ordered, with large extensions to Sheerness, Deal, and Dover. The extension largely followed the lines taken by the shutter telegraph. The London to Chatham line and its extensions were cancelled in February 1822, prior to completion (Wilson 1976, 35-8).

In 1822 Colonel Charles Pasley developed an update of Popham's device, which featured two indicators mounted to a mast via a single pivot. Each arm could take one of eight positions, giving a total of 64 possible positions, the same as the French semaphore system (Holzmann & Pehrson 2003, 196).

A second new line was commissioned to run from London to Portsmouth. It was subsequently extended to Plymouth (Wilson 1976, 35). Surveying for the line began in 1818 but work proceeded slowly because the route of the shutter telegraph was not reused. Construction of the signal stations only began in 1821 and it was Pasley's design that was used. About the same time Pasley's design replaced Popham's design for ship-based applications (Wilson 1976, 116-7; Holzmann & Pehrson 2003, 196). Accommodation at the sites was provided by one of three different purpose designed buildings, a bungalow, a three-storey house, and an octagonal tower, utilised as the terrain necessitated. The line terminated at the docks in Portsmouth where a telegraph house was constructed. The telegraph house was demolished in July 1822 and the terminal moved to the Magazine on High Street. The London to Portsmouth line became fully operational in 1824 (Wilson 1976, 39-40). In 1833 the terminal was returned to the docks where a small octagonal tower (Figure 2.20), which still survives, was constructed on top of the existing Sail Loft and Rigging House.

Figure 2.20. The octagonal signal tower on top of the Sail Loft and Rigging House at the Royal Docks Plymouth, Hampshire, constructed in 1833.

The Magazine site was placed on reserve but not dismantled (Wilson 1976, 59). The line utilised 13 intermediary stations (Wilson 1976, Figure 7; Kent 1993, 17).

In July 1825 the Admiralty ordered that the London to Portsmouth line be extended to Plymouth. Again, the route of the shutter telegraph was not reused. The line branched at Chatley Heath where a tall tower, which still survives, was constructed (Figure 2.21). The line consisted of thirty-two intermediary stations and two terminals. (Wilson 1976, Figure 7; Kent 1993, 17). The new lines ceased operating in 1847 and were replaced by electric telegraphs, whose wires had been laid along existing railway grades (Wilson 1976, 60-2).

**2.4.7.7 Continuing development of the British naval flag system**

In 1803, the same year that Admiral Lord Howe's code book was being re-organised, Sir Home Popham produced an expanded version of his vocabulary code, which had been in private circulation for several years. The new code book contained around two thousand words which could be indicated using the numerical flags established in Howe's code book. A telegraph flag was flown to indicate that the vocabulary code was in use. Popham continued to expand his vocabulary after 1803. Three numerical flags were found to be the maximum for practical use, using more became too time consuming. By combining two letter flags, A and O, with the three numerical flags, the number of available combinations was increased to 11,000 codes, and many more combinations were possible if four letter flags were utilised. A new expanded edition was issued in 1813, and in 1816 the Admiralty released another version as the official '*Vocabulary Signal Book*' (Kent 1993, 5-6; Ireland 2000, 51-3).

In 1817 a mercantile code book, '*Code of Signals for the Merchant Service*', was released by Captain Frederick Marryat. Although resembling Popham's code in function, Marryat's code carefully avoided duplicating any of the naval signals and had a strong specialisation in transmitting the names of ships. Marryat's code was revised in 1857 by the Board of Trade, which included an 18-letter alphabet, and was published in two volumes, one for British use and the other a universal system which was then adopted by most sea faring nations.

Figure 2.21. The octagonal tower at Chatley Heath Signal Station, Surrey, where the line to Plymouth split from the line to Portsmouth. It was constructed in 1822 and is now fully restored as a council run museum.

Marryat's code was subject to a second revision in 1901 and a third time in 1931 (Mead 1933; Kent 1993, 6-9). Much of Marryat's code underpins the current '*International Code'*, although the scope of that code is greatly reduced (Mead 1933, 370-1). The use of hand-held flags for signalling semaphore codes, in direct imitation of Popham's semaphore apparatus, and which would seem to be such a defining format of naval signalling, was only introduced in 1880 (Kent 1993, 12).

#### 2.4.7.8 Telegraphs, flag and ball signals in Portugal

During 1806 an innovative telegraph system was developed in Portugal. Designed by Captain Francisco Ciera, the system used three different types of signalling apparatus, all of which used the same code book, making them largely interchangeable. Ciera's designs were a simple four panel shutter telegraph, a rotating pointer telegraph, and a three-ball telegraph, each designed to convey three digit codes and a small number of operational protocols. The Portuguese telegraph had three main lines radiating out from Lisbon, a short line running to the Tagus Estuary, and two much longer lines running to the fortresses of Almeida and Elvas close to the Spanish border. The telegraph equipment was far lighter than other contemporary systems and is often referred to as 'portable.' Records indicate that new telegraph stations could be erected in under three days, if needed (Thompson 2016, 2-3, 5). The service was initially operated by the Portuguese Navy, but it was transferred to the Portuguese Army in March 1810 (Wilson 1976, 185).

Wellington utilised the Portuguese telegraph system extensively between July and September 1810, initially to communicate with the besieged garrison at Almeida, but soon adopting the system for a wide variety of communications, until he began his retreat to the Lines of Torres Vedras. Wellington had instigated the construction of that system of over 150 fortified sites to the north of Lisbon the previous year, fully expecting to have to retreat at the end of the campaigning season. In May 1810 work began on adding signal posts to 12 locations within the Lines of Torres Vedras, the design used was a variant of the British coastal flag and ball system. The apparatus at the 'Balloon Telegraph' sites consisted of a mast with a single yard, extending out from one side of the mast, from which balls and flags could be suspended. Contemporary illustrations disagree to the exact arrangement of balls and flags. In a letter to

Lieutenant General Rowland Hill dated 24 June 1810 Wellington himself provided a sketch of a prospective design, with a horizontal yard with five balls suspended from it in a row, and the second and fourth positions distinguished by blocks placed above the yard (Gurwood 1836, 215-6). A series of illustrations in a letter received by Wellington the following day, 25 June 1810, from Lieutenant Colonel Richard Fletcher, show a mast supporting a yard that sloped upwards which could hold up to ten balls in two rows, which could be substituted in their entirety for flags, and which had positions for a combination of up to three balls and flags at the top of the mast (Wellington 1860, 547). Whichever arrangement was used, its single-sided design would have been different to the other Royal Navy signal posts of the era. The balloon telegraph utilised a version of Popham's vocabulary (Thompson 2015, 20).

The signal posts were manned by sailors under secondment to the Army, which caused problems regarding pay and conditions (Thompson 2016, 4-5.) In September 1810 the sailors were temporarily withdrawn, and Portuguese signal crews were briefly utilised. New Ciera style telegraphs were constructed as they were not familiar with the British style flag and ball equipment (Thompson 2016, 5). The sailors returned in early October of 1810, but it is not clear which set of equipment was used after their re-introduction. These minor difficulties aside, the use of the telegraphs at the Lines of Torres Vedras was considered very successful and they formed a key component in Wellington's plans to remain on the continent. Wellington subsequently made use of a simple flag/fire signalling system during a few weeks whilst in the Pyrenees in 1814, but this seems to have been a far simpler system only capable of transmitting a few pre-arranged warnings (Thompson 2016, 6).

Wilson discussed a Lisbon to Porto telegraph which was operational at least as early as 1828, and which continued in regular service until 1855 (Wilson 1976, 184-5). A small part of this system, crossing the wide Tagus Estuary, was maintained until 1889. A shutter telegraph was also used to communicate with the Isle of Berlenga from the adjacent part of the mainland until a similarly late date (Wilson 1976, 185). It is not clear if there was any continuity between the early designs of Ciera and these later telegraph lines, but Huurdeman lists the Lisbon to Porto line as being in operation from 1810, which would indicate their contemporary use, at the very least (Huurdeman 2003, Table 5.1).

#### 2.4.7.9 Commercial telegraphs in Britain

The British Admiralty had always maintained strict control over the telegraph and semaphore lines and had never permitted their use for other purposes. There was no development of the administrative use of optical signalling, to parallel those developments in France (Kirwan 2017, 234). This also meant that in times of peace there was little reason to fund the manning and upkeep of the telegraphs and semaphores.

Given the Admiralty's singular focus it was left to private individuals to recognise the value of telegraphs for commercial purposes. This was quite different from France where, in 1837, the government passed legislation to claim a monopoly over the telegraphs, halting the in-progress development of private telegraph lines (Flichy 1993, 97). Pre-eminent in these efforts was Barnard Lindsay Watson, who claimed to be a former Lieutenant in the Royal Navy, all though his attainment of this rank appears to be questionable (Wilson 1976, 69).

Watson developed his first commercial telegraph line between Liverpool and Holyhead, replicating the route of the abandoned military signal post line dating from 1803 (Section 2.4.7.4). The system consisted of purpose-built bungalows with free standing semaphore masts (Figure 2.22 & 2.23). The masts had three pairs of indicator arms, each pair mounted to a single pivot. Each pair of arms could be set in one of nine positions indicating the digits one through nine and hidden entirely to represent zero, allowing for the transmission of 999 signals. The addition of coded flags to the top of the mast increased the range of the system dramatically. Liverpool Dock Trustees commissioned Watson to create the telegraph system in 1826, and it was operational by October 26, 1827. The Liverpool to Holyhead telegraph was very successful and generated a steady income. It operated until 1860 before it was finally replaced by an electric telegraph (Wilson 1976, 68-80).

Figure 2.22. Voel Nant Telegraph Station, constructed 1841.


Figure 2.23. Llysfaen Telegraph Station, constructed 1841.

Following his success connecting Liverpool to Holyhead, Watson developed several other commercial telegraph systems. Watson designed a system which ran from the docks at Hull to New Sand Light, in the mouth of the Humber. This line opened in September 1839 and operated until some point in 1857 (Wilson 1976, 83-5). In 1840 Watson was operating two individual ship to shore telegraphs which were connected to the new penny postal service, one at Flamborough Head in Yorkshire, the other at North Foreland in Kent (Wilson 1976, 85). In 1841 Watson opened a new telegraph line which ran from London to North Foreland and Kingsdown in Kent. The line closed after the London terminal burnt down in 1843, and it was replaced by an early electric telegraph (Wilson 1976, 86-91).

Watson was involved with a number of other schemes, but it is not clear if they were ever completed or for how long they operated. These included a line running from the Isle of Wight to Southampton, and another system near Bristol (Wilson 1976, 85, 91-3). Watson's business was ultimately replaced by the electric telegraph. For a period of around 25 years his optical telegraphs proved very successful. No other individual made such an impact in Britain in the field of commercial optical telegraphy.

### 2.4.7.10 Other 19th century telegraph systems

During the first half of the 19th century optical telegraphs were constructed in numerous other countries, including Russia, Australia, Canada, and India. The main innovators and innovations have been described above and most of the later systems are identifiable as being derived from the four main designs, Chappe telegraphs, shutter telegraphs, semaphore telegraphs, and flag and ball or ball telegraphs. Because these later systems did not directly influence or derive influence from the Irish signal stations, there is no need to review them in detail here.

Table 2.2 summarises information regarding each of these systems, including the type of telegraph used and the dates during which each example was operational. The systems set up by the French Empire in Italy, Switzerland, and the Netherlands are not included because these were discussed as part of the French system (Section 2.4.7.1). The different systems either went out of use when their military or economic function became redundant, because they were found to perform their function inadequately, or when they were superseded by the development of electric telegraphs between 1845 and 1855.

| Country | Type | Line | Operational Dates | Reference |
|---|---|---|---|---|
| Denmark | Shutter Telegraph | Maglebylille - Nakkehoved | 1801 - 1801 | Wilson 1976, 173-4; Holzman & Pehrson 2003, 182 |
| USA | Chappe Telegraph | Martha's Vinyard, MA – Boston, MA – Salem, MA | 1801 - 1807 | Wilson 1976, 210-1; Holzman & Pehrson 2003, 201 |
| St Helena | ? | ? | 1803 - ? | Wilson 1976, 193-4 |
| Spain | Unknown | Province of Cadiz | 1805 - ? | Wilson 1976, 183 |
| Norway | Flag Signals | Fredriksvern - Kristiania | 1807 - 1808 | Wilson 1976, 175; Holzman & Pehrson 2003, 180 |
| Canada | ? | Ilse Vert – Quebec City | 1808 – 1839? | Wilson 1976, 208-9 |
| Denmark | Shutter Telegraph | Hessinger - Kiel | 1808 - 1862 | Wilson 1976, 173-4; Holzman & Pehrson 2003, 182 |
| Norway | Shutter Telegraph | Kristianiafjord – Fredrikshald | 1808 - 1814 | Wilson 1976, 175-6 |
| Norway | Shutter Telegraph | Jeløy - Hitterøy | 1808 - 1814 | Wilson 1976, 175-6 |
| Portugal | Multiple types | Lisbon - Oporto | 1810 - 1855 | Wilson 1976, 184-5; Huurdeman 2003, Table 5.1 |
| Norway | Shutter Telegraph | Holden – Oslo - Trondheim | 1810 - 1814 | Holzman & Pehrson 2003, 180 |

**Table 2.2. Telegraph systems around the world between 1800 and 1855. The telegraph lines are arranged chronologically, based on the year they became operational. The table excludes the lines built in France and across Europe under Bonaparte, and the lines built in Britain and Ireland by the British Military during the Napoleonic Wars.**

| Country | Type | Line | Operational Dates | Reference |
|---|---|---|---|---|
| Tasmania | Flag and Ball | Hobart – Mount Nelson | 1811 - 1828 | Wilson 1976, 202-3; Holzman & Pehrson 2003, 200 |
| USA | Ball Telegraph | Brooklyn Naval Yard, NJ – Staten Island, NY | 1812 – 1816? | Wilson 1976, 213-4 |
| India | Ball Telegraph | Calcutta - Chunar | 1821 - 1828 | Wilson 1976, 195-8 |
| USA | Semaphore Telegraph | Long Island Head, NY – Boston Light, MA | 1822 - 1856 | Wilson 1976, 211-213 |
| Egypt | Chappe Telegraph | Cairo - Alexandria | 1823 - 1855 | Wilson 1976, 188-9 |
| Russia | Chappe Telegraph | St Petersburg - Schlüsselburg | 1824 - 1854 | Wilson 1976, 181-2 |
| USA | Semaphore Telegraph | Wall Street, NY – Navesink Highlands, NJ | 1827 – 1856? | Wilson 1976, 214-5; Holzman & Pehrson 2003, 200-1 |
| Britain | Semaphore Telegraph | Liverpool - Holyhead | 1827 - 1860 | Wilson 1976, 68-80 |
| Tasmania | Semaphore Telegraph | Hobart – Mount Royal | 1828 – 1880 | Wilson 1976, 203-6; Holzman & Pehrson 2003, 200 |
| Netherlands | Shutter Telegraph | The Hague - Helvoirt | 1831 - 1839 | Wilson 1976, 156-7 |
| Spain | Shutter Telegraph | Madrid – Aranjuez – San Ildefonso | 1831 - 1837 | Wilson 1976, 183 |

**Table 2.2. continued. Telegraph systems around the world between 1800 and 1855.**

| Country | Type | Line | Operational Dates | Reference |
|---|---|---|---|---|
| Australia | Semaphore Telegraph | South Head – Port Phillip (Sidney) | 1833 – 1844 | Wilson 1976, 202; Holzman & Pehrson 2003, 200 |
| Germany | Semaphore Telegraph | Berlin - Koblenz | 1833 - 1852 | Wilson 1976, 161-5; Holzman & Pehrson 2003, 185 |
| India | ? | Calcutta – Sugar Island | 1833 - 1845? | Wilson 1976, 199 |
| Russia | Chappe Telegraph | St Petersburg - Kronstadt | 1834 - 1854 | Wilson 1976, 181-2 |
| Russia | Chappe Telegraph | St Petersburg - Pushkin | 1835 - 1854 | Wilson 1976, 181-2 |
| Russia | Chappe Telegraph | St Petersburg - Gatachina | 1835 - 1839 | Wilson 1976, 181-2 |
| Tasmania | Semaphore Telegraph | Hobart – Port Arthur | 1836 – 1880 | Wilson 1976, 203-6 |
| Germany | Semaphore Telegraph | Hamburg - Cuxhaven | 1837 - 1850 | Wilson 1976, 159-60; Holzman & Pehrson 2003, 186 |
| Egypt | Chappe Telegraph? | Cairo - Suez | 1839 - 1856 | Wilson 1976, 188-9 |
| Britain | Semaphore Telegraph? | Hull – New Sand Light | 1839 - 1857 | Wilson 1976, 83-5 |
| Russia | Chappe Telegraph | St Petersburg - Warsaw | 1839 - 1854 | Wilson 1976, 181-2 |
| USA | ? | New York, NY – Philadelphia, PA | 1840 - 1845 | Wilson 1976, 215; Holzman & Pehrson 2003, 202 |

**Table 2.2. continued. Telegraph systems around the world between 1800 and 1855.**

| Country | Type | Line | Operational Dates | Reference |
|---|---|---|---|---|
| Britain | Semaphore Telegraph? | London – North Foreland – Kingsdown | 1841 - 1843 | Wilson 1976, 86-91 |
| South Africa | Semaphore Telegraph | Fort Beaufort – Governor's Kop – Fort Peddie | 1846 - ? | Wilson 1976, 188-92 |
| Spain | Shutter Telegraph | Madrid - Irún | 1846 - 1855 | Wilson 1976, 183-4 |
| Germany | Semaphore Telegraph | Bremen - Bremerhaven | 1847 - 1848 | Wilson 1976, 160; Holzman & Pehrson 2003, 186-8 |
| Spain | Shutter Telegraph | Madrid – Zaragoza - Pamplona | 1849 - 1855 | Wilson 1976, 183-4 |
| Spain | Shutter Telegraph | Madrid – La Junquera | 1849 - 1855 | Wilson 1976, 183-4 |
| USA | ? | Telegraph Hill, CA – Point Lobos (San Francisco Bay), CA | 1849 - 1853 | Wilson 1976, 216-7; Holzman & Pehrson 2003, 201 |
| Spain | Shutter Telegraph | Madrid - Cadiz | 1850 - 1855 | Wilson 1976, 183-4 |
| Finland | Shutter Telegraph | Hangö - Porkkala | 1854 | Wilson 1976, 177 |
| Finland | Shutter Telegraph | Hangö - Nystad | 1855 | Wilson 1976, 177-8 |

**Table 2.2. continued. Telegraph systems around the world between 1800 and 1855.**

### 2.4.8 19th century postal services in Britain and Ireland

An outcome of railway development was the introduction of railway postage services. The first service was introduced in Britain 1830, on the line between Manchester and Liverpool, which had itself opened as the first passenger service that year. The obvious advantages of transporting mail on the new rail services led to its rapid adoption and by 1838 it had become the standard method for moving mail over distance (Foster 2014). The following year a national 'penny post' was briefly established, but the service was cancelled after a number of months. In 1840 a second attempt was made which saw the introduction of the Penny Black stamp, and the Royal Mail became a true mass communication system (Daunton 2015, 17-25).

The first railway in Ireland became operational in 1834 and ran between Westland Row, Dublin, and Salthill, Monkstown, County Dublin. It took three further years for the short extension of the line as far as Kingstown Harbour (*Dún Laoghaire*) to be completed. Mail was carried on the train almost as soon as the line was opened, and indeed the reason for constructing the line was in part to carry international mail, which at that time was transported by ship from Holyhead to Kingstown Harbour, and from there to Dublin by coaches (Kullman 2018, 1-3). Dedicated Travelling Post Office carriages were introduced to Britain in 1838, allowing mail to be sorted whilst it was already in transit (Foster 2014).

### 2.4.9 19th century electrical telegraphs, radio and telephones

The introduction of electric telegraphy in the mid-19th century rendered optical telegraphy at least partially obsolete (Headrick 2000, 203-6; Holzmann & Pehrson 2003, 202-6; Cocroft 2013; Liffen 2013). After almost 100 years of experimentation the first non-experimental electrical telegraph lines became operational in Britain in 1839, in Germany in 1843, in the United States in 1844, in France in 1845, in Canada in 1846, and in Austria in 1847 (Headrick 2000, 203-6; Huurdeman 2003, 48-61, 66-83).

The speed and impact at which the electric telegraph affected communications is amply illustrated by the closure of the US 'Pony Express' mail service from Missouri to Sacramento a mere two days after the first transcontinental telegraph was completed on 24 October 1861, and just 19 months after the Pony Express had begun operating (Hardesty 1979: 1-3; Ambrose 2000: 76; Holzmann & Pehrson 2003, 6). By 1858 a transatlantic cable had been laid. The first message, from Queen Victoria to the US President James Buchanan, was transmitted in August of that year. That cable, and several of those that followed, failed rapidly, but ten years later a secure and lasting cable was established (Headrick & Griset 2001; Müller 2010).

Early experiments with radio communications began around the same time that the first transatlantic telegraph cables were being laid. Several decades of further research and innovation led to the first practical applications of radio telegraphy in the last decade of the 19th century. Experimental telephones were developed during the period in which electric telegraphy matured (Kent 1993, 25-38; Keegan 2003, 99-106; Liffen 2013; Raboy 2016). Telephones would begin to replace the electric telegraph following a rapid development of the technology during the 1870s and 1880s. Serious encroachment began in the 1890s and replacement had been largely completed by the 1910s, although the electric telegraph remained in use for specialised purposes for some time afterwards (mer 2012, 4-5). Radio technology matured rapidly in the early decades of the 20th century to include audio transmissions and subsequently tele-visual broadcasts (Nye 1997, 1075-6). It should be noted that many of these later developments did not reach Ireland in a timely fashion, and a proper telephone network was not established in many parts of rural Ireland until the middle of the 20th century (Kennedy 2008, 42-8).

### 2.4.10 Codes and cyphers in the late 18th and early 19th centuries

The development of telecommunications technology up to and through the 19th century has been explored in-depth (Sections 2.41 to 2.49). It has been demonstrated that from the late-18th century through to the early-19th century the apparatus of conveying messages was rapidly evolving, and particular technologies seldom maintained a position of primacy for long. These processes continued through the 19th and 20th centuries and are undoubtedly still ongoing today. Conversely, the techniques for encryption and decryption of information scarcely advanced during this period (Huurdeman 2003, 351).

Urban (2001) states that by the 18th century French politicians, informants and administrators were utilising the most advanced encryption procedures in Europe. Between the 16th and 18th centuries many countries had developed numerical code tables, used to substitute letters and syllables for numbers or hieroglyphs. These codes were simple systems, known as *the petits ciffres*, which delayed decryption, but would eventually be translated through frequency analysis, the substitution of commonly occurring letters and diphthongs into a cipher, to decode common words and reveal other associated parts of the cipher. Frequency analysis was a well-known method by the mid-18th century and is described in detail in David Arnold Conradus' '*Cryptography or the art of deciphering'*, first published in 1732 (Churchhouse 2001, 15-27; Urban 2001, 63, 95-6; Ellison 2017, 59). Versions of the g*rande ciffre* from the early part of the reign of Louis XV (reigned 1715-1774) might have six hundred entries in the code table; by 1750 this figure had risen to twelve hundred (Urban 2001, 63). The most preferable way to decrypt these codes was to capture the code table.

The naval flag systems and the naval telegraph and semaphore systems used lengthy but relatively simple substitution tables. As discussed above (Section 2.4.5), if the code book fell into enemy hands the only mitigation available was to re-issue the code in a different combination. One measure used to reduce this risk of code books being captured was to split the book into separate volumes, with all volumes being needed to understand the code. The use of a low numbers of flags to convey specific pre-determined messages chosen from extremely long lists meant that frequency analysis could not be applied to naval flag systems and they were relatively secure unless a complete code book could be captured (Pelham Brenton 1837, 46).

If naval signalling retained the use of rather simple encryption techniques into the 19th century, the situation for the armies fighting on the continent were somewhat different. A naval battle was a prolonged affair allowing for an ample amount of time for officers to destroy the code books prior to capture. The frequent capture of soldiers and officials carrying coded information on land provided more opportunity to apply frequency analysis on encoded communications, and this necessitated the development of more complex encryption techniques amongst Europe’s armies.

During the Peninsular War the ambitious junior officer George Scovell made his name by breaking the codes used by French and Spanish forces. In 1809 Scovell had been tasked with creating a new corps of guides and, having proved effective in their leadership, he was promoted to Major in 1811 (Urban 2001, 93). The guides occasionally intercepted coded communications and he was thus ideally placed to attempt the task of cracking the French codes (Urban 2001, 78). In 1811 the Army of Portugal introduced a new cipher for communication between the division commanders. It had one hundred and fifty numbers in its code table, far less than Louis XV had been using almost 100 years earlier. Scovell decrypted the cipher on his first attempt (Urban 2001, 107-11). At the very end of 1811 a new 1,400 number *grand chiffre* was introduced to the French forces in Iberia, representing a minor increase over the *grand chiffre* of 1750. Scovell began working on the new cipher in April 1812 and had it largely deciphered by the middle of July (Urban 2001, 161, 203). Scovell was aided by the poor practices of the French and Spanish cryptographers, who only encoded parts of their communiques, providing Scovell with contextual information which aided his attempt. Had the messages been fully encrypted it is unlikely that Scovell would have been able to perform the decryptions with the methods he had available (Urban 2001, 162).

## 2.5 – Modern research focusing on the signal stations

The signal stations have attracted little research interest, as either archaeological or architectural sites for a number of reasons. Despite the slow development of post-medieval archaeology in the Republic of Ireland described above (Section 2.1.2), there is now a flourishing community of researchers working in many areas, including coastal archaeology (Brannon & Horning 2005; Horning *et al* 2007; O' Sullivan & Breen 2007, 199-240). Topics that have received attention in post-medieval coastal or maritime archaeology include vernacular boat building, shipwrecks, anchors, sites associated with pirates and smugglers, light houses, World War 2 Look Out Posts (L.O.P.s), salt pans, maritime trade, and a range of larger and more complicated military sites (Kerrigan 1995; Colfer 2004, 84-91; Hartnett McEnery 2006; Meide 2006; Kennedy 2008; MacCarthaigh 2008; Horning & Brannon 2009a; Brady *et al* 2012; Clements 2013; Kelleher 2013; Forsythe 2014).

The identification of the signal stations as symbols of the unwanted occupation of Ireland by its militarily dominant neighbour may be partly to blame for this oversight. Studies of related sites such as Martello towers and artillery forts have certainly taken place, despite their presence also being attributable to the British Board of Ordnance, the same organisation that commissioned the signal towers (Mould 1994; Hartnett McEnery 2006, 84-116; Clements 2013, 13-4, 87-97; Shiels & Maloney 2015). Many Martello towers and larger fortifications are well regarded by the local communities who live alongside them, for instance the recently restored Richmond Fort (LH024-041009-/Reg. No. 13622082) in Drogheda, County Louth, where they are viewed as an important part of the collective history, whatever their origins and purpose (Clements 2013, 78-9). Rynne has specifically challenged the sort of post-colonialist narrative that would identify the signal stations as symbols of a former oppressive power, arguing that the portrayal of Ireland as a victim of British colonialism does not reflect the deep integration of the two countries, and misrepresents the status and management of Ireland in comparison to genuine British colonies (Rynne 2009, 167-9). Rynne concludes his discussion by suggesting Ireland in the 19th century should be seen as a marginal area of the United Kingdom rather than a colonised territory (Rynne 2009, 174).

The signal stations are listed as a distinct class by the National Monument Service under the term *Signal Tower* but as discussed in Section 1.1, their inclusion within the County SMRs is sporadic and inconsistent. The definition of the monument classification is important as it clearly identifies the specific system established in 1804 (and therefore should not include other sites, such as the signal posts, used at a later date by the early coast guard stations, or the signalling equipment found within some of the larger coastal fortifications):

> *"A tower in a semaphore communication system erected around the east, south and west coasts of Ireland from Dublin to Malin Head between 1804 and 1806. Communication was with ships of the Royal Navy offshore and between adjacent signal stations along the coast. The towers were built to a standard design though not all are identical. Usually square in plan, they are two-storeys high often with a first-floor doorway and are defended with machicolations and bartizans."* (NMS 2019b).

As already described, only the SMRs for Counties Cork and Galway provide comprehensive coverage of the signal stations at present, with other counties either only listing some of their signal stations or omitting them entirely (Section 1.1). The National Inventory of Architectural Heritage (NIAH) also provides inconsistent coverage of the signal stations, although understandably it only ever includes sites where substantial building remains survive (NIAH 2012; 2017; 2019). A number of later signal towers and World War 2 era Look Out Posts (L.O.P.s) are also listed in the NIAH under the same site type, *Signal Tower*, although in the case of the NIAH no strict definition is given. Where an account of a signal station in Connacht or Ulster exists in either of these two databases it has been noted within Tables 1.1 (Section 1) & 4.1.1 through 4.1.5 (Section 4.1).

Important studies of early 19th century coastal fortifications of Ireland (Hartnett McEnery 2006; Clements 2011, 2013) contain useful data for the study of signal stations, however they were conducted by two individuals without a traditional background in archaeological research or employment. Bill Clements and John Hartnett McEnery should not be dismissed as 'amateur' archaeologists or historians, which would do them a serious disservice, especially as they have worked on topics that have been rather neglected elsewhere. Both authors pursued military careers, Hartnett McEnery served with the British Army in Burma before entering the civil service and

Clements served with the British Army for 32 years, is a Fellow of the Royal Historical Society, and served as the Chairman of the Fortress Study Group (Hartnett McEnery 2006, front flap; Bell 2014). However, Hartnett McEnery's research lacks a properly developed narrative and tends towards being a chronologically arranged list of information (Hartnett McEnery 2006). The focus of Clements' work on Martello towers is so restricted that little attention is given to the context in which they were developed and constructed (Clements 2011, 2013).

The most important published source of information regarding the signal towers is Paul Kerrigan's account in *Castles and Fortifications of Ireland*, which provides a detailed overview of the entire system of early 19th century defences (Kerrigan 1995, 155-247). This account follows up on earlier work by Kerrigan published in *An Cosantóir. The Irish Defence Journal* (Kerrigan 1975, 1983). Kerrigan explains the main details of the signal station system, provides a map of the approximate locations of each site (Figure 1.1, Section 1.1) and reviews some of the primary sources that indicate the costs and dates of construction. Whilst Kerrigan's work does not appear to have been peer reviewed, its value cannot be understated. A subsequent paper by Kerrigan repeats the narrative presented in his earlier works, but usefully it provides detailed descriptions of individual signal stations around the west coast of County Cork (Kerrigan 2003).

Due to the clarity of Kerrigan's coverage concerning the basic details of the Irish signal stations, his account has been utilised by all subsequent researchers, and little has been added by other authors beyond the details of particular sites or case studies. Thus everything from the account of the signal station on Clare Island, County Mayo, in the *New Survey of Clare Island Volume 5*, the account of the Arran Island Signal Towers in *The Burren and the Arran Islands*, a *Know your Monuments* article from Archaeology Ireland magazine, Hurley & Rynne's important survey of the Old Head of Kinsale Signal Station in County Cork, and Moore's recent account of the Rathlee and Carrowmably Signal Stations in County Sligo all repeat the same basic outline, as defined by Kerrigan, without having made any substantial new contributions to the topic as a whole (Jones 2004, 227-8; Gosling *et al* 2007, 181-2; Hurley & Rynne 2012; O'Sullivan & Downey 2012; Moore 2018). None of these later studies are peer reviewed articles, although all are the products of professional archaeologists. Rynne included a brief description of the Irish Signal Stations in his book '*Industrial Ireland 1750-1930: An archaeology*,' in a section focussed on the development of communications technology in post-medieval Ireland (Rynne 2006, 444-5). The brief passage introduces some new details about the provision of engineered roads with culverts to access the signal stations in County Cork (Rynne 2006, 445). More importantly the description is situated within a longer discussion about the development of telecommunications systems in Ireland, which expands the scope provided by Kerrigan (Rynne 2006, 443-448).

There is an unfortunate pattern of missed opportunities regarding signal station research; many authors of works where coverage might be expected have either failed to provide an account of the signal stations at all or have only provided the scantest details about the sites in their respective study areas. For example, the monograph *Lough Swilly: A living Landscape* (Cooper 2011) includes only a small paragraph about the signal stations, despite Lough Swilly having stations on either side of the approach, and two of the forts within the Lough seemingly having signal posts that allowed them to communicate with the signal towers (Cooper 2011, 106-7). The monograph *The Hook Peninsula* (Colfer 2004) supplies great detail about the Hook Head Lighthouse, County Waterford, and nearby fortifications such as Duncannon Fort and the two Martello towers positioned on high ground overlooking the fort (see Appendix E), but proceeds directly from the garrisoning of the lighthouse during the 1798 rebellion to the modernisation of the lighthouse in the mid-19th century making no mention of the erection of a signal mast at the site in 1805 or the housing of the officer and signal crew within the lighthouse complex (Kerrigan 1995, 161; Colfer 2004, 84-113). Similarly, *The Book of Arran* (Waddell *et al* 1994) makes no mention of either of the signal stations on the Arran Islands despite being such prominent features in the Arran landscape. Carleton Jones' book *The Burren and the Arran Islands. Exploring the archaeology* (Jones 2014) includes only a very brief account of the signal stations on Inisheer and Inishmore and offers no new insights or information (Waddell *et al* 1994; Jones 2004, 227-8). Joan and Ray Stagles make no mention of the signal station on Great Blasket in the text of their book on the Blasket Islands, although it is shown on several of their maps (Stagles & Stagles 1998, Maps 3, 7 & 9). Raymond White's local history of the Old Head of Kinsale, County Cork, contains a passage about the signal station that is largely a summary of Kerrigan's account (White 2003, 177-8). However, a significant contribution that White does make is noting the presence of a semi-basement below the ground-floor level of the signal tower, an important detail omitted by Kerrigan (White 2003, 177). O' Sullivan and Breen's monograph *Maritime Ireland* (O' Sullivan & Breen 2007) contains a brief paragraph on the signal stations, although given that the scope of the book encompasses archaeology from the Mesolithic period through to the 20th century, this limited level of coverage is more understandable (O' Sullivan & Breen 2007, 216).

Mould (1994) examined three of the enclosed barracks sites in County Kerry, which are related to the signal stations, Hog's Head (SMR KE105-004), Bolus Head (SMR KE104-001), and Rough Point, prior to the publication of Kerrigan's main account. Mould was uncertain about the origins of the sites but suggested that they could be later additions to the signal station system. Mould's brief report is an important article that provides a rare instance of work that adds to the narrative presented by Kerrigan (Mould 1994). Clements' suggestion that these sites housed small garrisons that provided a rotating staff for the nearby signal stations has merit and is worth further investigation, although that may only apply to Bolus Head Enclosed Barracks, which was sited close to an existing signal station. Clements' identification of the demolished Kerry Head Signal Station as being a fourth example of this type seems erroneous; although the site is marked as a "Barrack & Signal Tower (in ruins)" on the 1st edition Ordnance Survey map, it is shown with the typical form rather than having the form of a bastioned enclosure (Clements 2013, 99). These sites are discussed in detail in Section 4.12.3.

Kirwan's recent discussion of Edgeworth's overland telegraph system (Section 2.4.7.5) was the first detailed publication about this short-lived system which had previously only attracted brief mentions (Kerrigan 1995, 165; Wilson 1976, 102-11; Kirwan 2017). Many details about this physical nature of this system remain to be discovered, including the locations of each stations; Kirwan only provides locations for six stations but indicates 15 stations were present along the line. Even for these sites the location information is vague, and few details are given about what was present at the stations (Kirwan 2017, 231). Previous work has indicated that a second line was added to the system, running from the existing station at Athlone to Limerick, but Kirwan does not address this line, and it is unclear if this was ever actually constructed (Kerrigan 1995, 165; Wilson 1976, 102-11). It is also not clear if the western terminals of the overland line connected in some way to the coastal signal station system, although the equivalent systems in southern England were connected in this way (Section 2.4.5.1).

Three detailed surveys of individual signal stations have been published previously. A detailed survey of Clare Island Signal Station, County Mayo, was undertaken as part of the 'New Survey of Clare Island' (Gosling *et al* 2007, 181-2). A detailed survey of the Old Head of Kinsale Signal Station, County Cork, was recorded in advance of the restoration of the signal tower that took place between 2014 and 2015 (Hurley & Rynne 2012). A detailed survey of Bere Island Signal Station, County Cork, was included as part of a comprehensive survey of the 19th century fortifications of Bere Island (Shiels & Maloney 2015). Rothery includes a plan and elevation of the signal tower at Carrowmably Signal Station, County Sligo, (SMR SL012-008003/Reg. No. 32401201) alongside a very brief piece of text giving an outline of the signal station system (Rothery 1997, 67).

A website detailing a community project involving lighting fires at a number of signal stations in 2006, to commemorate their 200th anniversary, contains an archive of photographs of signal towers, associated buildings and a basic interactive map (Beara Historical Society 2006). The site contains only limited information regarding the sites but the map, despite a lack of precision, proved useful during the early stages of this project. A website by a Dutch enthusiast of military architecture contained very useful sets of photographs of seven of the signal stations in County Cork (Castles.nl 2019).

Three additional online resources were used throughout this project that provided information about peripheral topics; a website with an interactive map detailing the 'Eire' signs (Lynch 2018a), a website detailing an art project involving the Look Out Posts (L.O.P.s) which included detailed map and photographs of most of the extant buildings (Schmeltzer 2014), and a section of the *Óglaigh na hÉireann's* (Defence Forces Ireland) website that contains scans of the logbooks of most of the Look Out Posts (L.O.P.s) tied to a *Google Map* called 'Lookout Posts & Coast Watchers' (Defence Forces Ireland 2017). Each of these resources is well executed, and considerably shortened the length of time which would have been required to locate all of the relevant sites had they not existed.

There were very serious limitations and challenges with the state of knowledge concerning the Irish signal stations at the outset of this project. Firstly, it was not possible to determine from the literature what currently remained of the system and what, precisely, was present originally. Kerrigan’s account is vague in the details given about many of the individual sites and subsequent work has focused on only a small number of sites. The sporadic coverage of the signal stations in the two national data bases, the SMR and the NIAH, did not permit a robust assessment of either the original nature or current survival of the sites (NIAH 2019; NMS 2019a). Beyond Kerrigan’s and Clements’ discussions of the historical documents that were used to illustrate the costs and construction dates of individual sites, no primary historical research had been published that discussed, for example, how effectively the sites functioned or what the thought processes were that led to the unique form of the Irish signal station sites (Kerrigan 1995, 276-80; Clements 2013, 117).

Serious questions remain unanswered about many aspects of the Irish signal stations. Kerrigan noted some confusion about the exact number of sites, as some signal stations seem to have never been completed or were built and not utilised (Kerrigan 1995, 160, 162, 163). This degree of confusion remains unresolved, and Kerrigan was unsure about the status of the buildings in County Kerry identified as enclosed barracks (Figures 2.26 & 2.27) (Kerrigan 1995, 161-2).

The noted absences in Kerrigan’s work, and the limited detailed assessments that post-date Kerrigan have confirmed that there are substantial contributions to the study of the Irish signal stations that remained to be undertaken. Attempting to answer the research questions for this project (Section 1.2) has yielded significant amounts of new and unique data. The way this data was collected, recorded and interrogated is outlined in the following chapter.

# Chapter 3. Methodology

## 3.1 – Introduction

This study is structured to address the research question and objectives identified in Chapter 1. The three major components are the field surveys, the data processing of the results of the field surveys, and the desk-based historical research which supplemented the results of the field surveys. These are discussed below as three separate elements although work on all three areas was undertaken concurrently as data was gathered.

The first field surveys occurred as an informal investigation into the signal stations on Saddle Hill on Achill Island, and Glash on the Belmullet Peninsula, both in County Mayo. These locations were visited repeatedly and initial attempts at recording these sites were made. The study expanded to include all County Mayo signal station sites as the field recording methodology became more formalised. When the decision was made to formally expand the study as a post-graduate research project encompassing the whole of Connacht, a number of additional elements were added to answer key research questions outlined in Section 1.2, such as 3D modelling and viewshed analysis (Sections 3.4.6 & 3.4.7). As the methodology evolved organically over a long period, new developments in software and hardware outpaced the project to some degree. In particular 3D photogrammetry software became readily available during the latter stages of the field survey, but it was not financially viable to revisit all of the sites surveyed in the earliest stages of the project to obtain new sets of photographs suitable for the generation of 3D models. However, several sites were revisited specifically for this purpose. When the decision was made to develop the project into a PhD thesis the study area was expanded to cover the entire system of Irish signal stations, with detailed field-analysis focused on the Connacht and Ulster examples. A desk-based study of the signal towers in Leinster and Munster was prepared, using a variety of resources to capture a range of information similar to that which had been acquired for the signal stations in Connacht and Ulster. Based on the experience gained of the Connacht and Ulster signal stations, it proved possible to analyse the sites in the secondary Leinster and Munster study area using a variety of cartographic, pictorial and photographic sources.

## 3.2 – The Field Surveys

The field surveys had two distinct phases. The first comprised desk-based assessments which identified the location of each site to be surveyed and considered the logistics and schedule of accessing each signal station. The second phase was the field survey itself.

### 3.2.1 Desk-Based Assessments

The first step of the field survey was to accurately locate each signal station in Connacht and Ulster so that they could be visited. Working from Kerrigan's map (Figure 1.1, Section 1.1) and the descriptions of the sites he provided, the general area of each site was identified to within approximately 10 miles (16 km) (Kerrigan 1995, 161-4). The online versions of the 6-inch Ordnance Survey maps, available for free through the National Monument Service's *Historic Environment Viewer* (NMS 2019a) were then consulted in order to identify the actual position of each signal station to within 5 m, with the 1st and 3rd editions proving most useful. The 1st and 3rd edition versions of the Ordnance Survey maps show all but one of the 32 signal station sites in the main study area (Kilcologue Point Signal Station, County Sligo, is not depicted). Unfortunately, the online version of the 2nd edition Ordnance Survey map does not include large areas of the coastline, and therefore only 13 signal stations are depicted (the former location of Fanad Head Signal Station is also shown on the 2nd edition Ordnance Survey map, but it had already been replaced by the Fanad Head Lighthouse by the time the 1st edition map was surveyed).

Having identified the location of all known signal stations on the 1st and 3rd edition Ordnance Survey maps, those same locations were identified on printouts from the modern Ordnance Survey Map layer available for free within the National Monument Service's *Historic Environment Viewer.* The modern Ordnance Survey map layer actually depicts the locations of all but six of the signal stations in the main study area, but without identifying labels (the low ruins at Benwee Head, County Mayo, and Mullaghmore and Dawros Head, County Sligo, and the destroyed sites at Creevagh, County Mayo, and Bloody Foreland and Fanad Head, County Donegal, are omitted) (NMS 2019a). Using this information schedules to visit each site were decided. Routes to access each site were prepared as well as could be determined based on modern mapping and aerial photography, again accessed via the *Historic Environment Viewer* and through the *Bing Maps website* (Bingmaps 2017; NMS 2019a). The aerial photographs were also used to assess the likely complexity of the surviving elements of each site in order to allot adequate time to each survey.

Desk-based assessments were also undertaken of each of the signal station sites in Leinster and Munster. The same resources were used to identify the locations of the sites. Where the signal stations were not visible on the 1st edition Ordnance Survey maps, attempts were made to locate the sites on older maps, if available (Section 3.4.1). Because the majority of the sites were not subject to field survey information about the individual sites was gathered from existing publications and a wide variety of online sources (Section 2.5).

### 3.2.2 Field Survey Methodology

Each signal station location in Connacht was visited and subjected to a detailed multi component field survey. The majority of the surveys were undertaken by the author working alone, and with assistance from Carroll Rocky at Clare Island Signal Station in County Mayo, and Dr James Bonsall at Inisheer, Inishmore, and Golam Head Signal Stations in County Galway, and Inishturk Signal Stations in County Mayo. The survey work at each site took between 1 and 2 hours to complete, depending on the difficulty of working at a particular site and the size and complexity of the surviving remains. Accessing signal stations such as Glash Signal Station, County Mayo, and Rathlee Signal Station, County Sligo, was particularly easy because they were located adjacent to or close to modern roads. Many sites involved lengthy hikes over a variety of terrain, substantially increasing the total length of time the survey took to perform. Because it was not possible to take a car out to the small islands in Counties Galway and Mayo on which several signal stations are located, reaching those sites involved a ferry journey and lengthy hikes, although the sites could be approached via roads. On Inishmore, County Galway, it proved possible to hire bicycles, substantially reducing the length of time taken to reach the signal station. Golam Head Signal Station was particularly difficult to access and required the survey party to walk through waist height seawater, across a rocky intertidal zone. The crossings and survey were timed to coincide with one of the lowest tides of the year. Details about how each site can be accessed are included in the individual entries presented in Appendix A.

The remote locations of many signal stations and the solo nature of most of the field surveys necessitated a lightweight surveying kit, consisting of as few items as possible. The complete survey kit had to portable for a single person, and apart from the ranging rod, would fit comfortably within a small backpack. The surveying kit consisted of:

- 1 x 30 m measuring tape (surveyors' tape)
- 1 x 5 m measuring tape (hand tape)
- 1 x 1 m ranging rod
- 1 x 0.5 m ranging rod
- An orienteering compass
- A set of surveyor's arrows

- 2 small field notebooks (in case one got wet)
- Pencils and a ruler
- Simple digital camera
- GPS unit (optional)
- Safety equipment (Section 3.2.2.1)

A high-quality large format hardback notebook was purchased for use as the archive notebook which was not carried into the field. Notes and sketches were transferred into the archive notebook as soon as feasible, typically during the evening after a day of surveying.

On arriving at a signal station site an initial walk over was performed in order to determine what features were present and any potential problems were identified, and possible solutions considered. During the initial walkover short notes were taken in one of the field notebooks describing the main features of the site. At the end of each survey additional notes were added covering any further details noted whilst the detailed survey was performed. These notes were later expanded in full in the archive notebook to accompany the sketches described below.

The next stage was to prepare a detailed set of sketches of the site and record as many relevant measurements as needed using the 30 m surveyor's tape and 5 m hand tape measures as appropriate. When working alone the end of the 30 m tape would be secured at an appropriate point using a surveyor's arrow. At simple sites the only sketch needed was a plan of the signal tower. At more complex sites with additional buildings and/or enclosures, a series of sketches was needed, the first being a large-scale sketch showing the signal tower and a smaller scale sketch showing the position of the tower and any associated features such as enclosures, lime kilns, or additional building foundations. Figures 3.1, 3.2, and 3.3 show a selection of different sketches as an example to illustrate how this was accomplished at different sites. These sketches were recorded in the small field notebooks and subsequently transferred to the larger archive notebook.

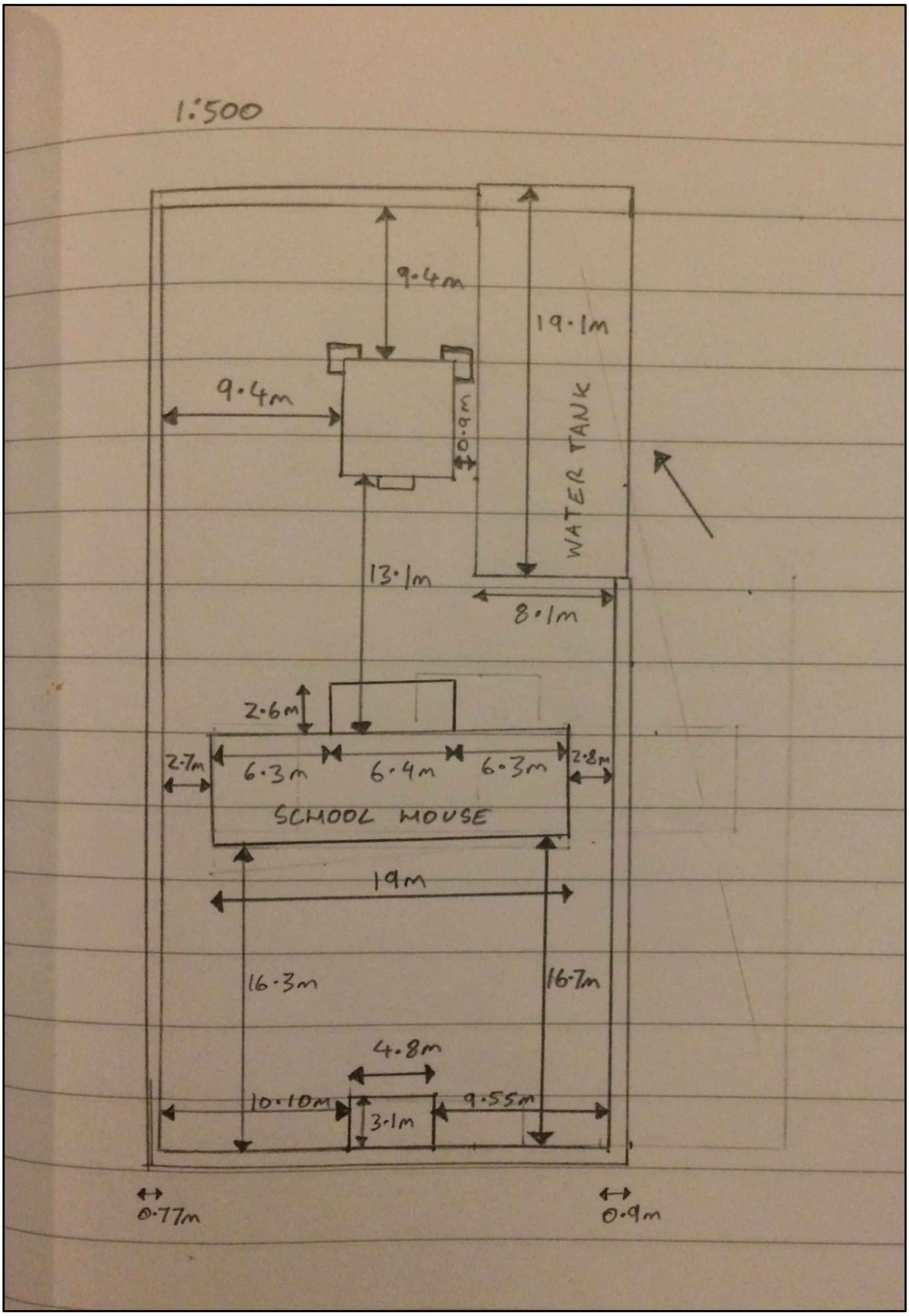


Figure 3.1. Field Sketch of Inisheer Signal Station, County Galway, and surrounding features.

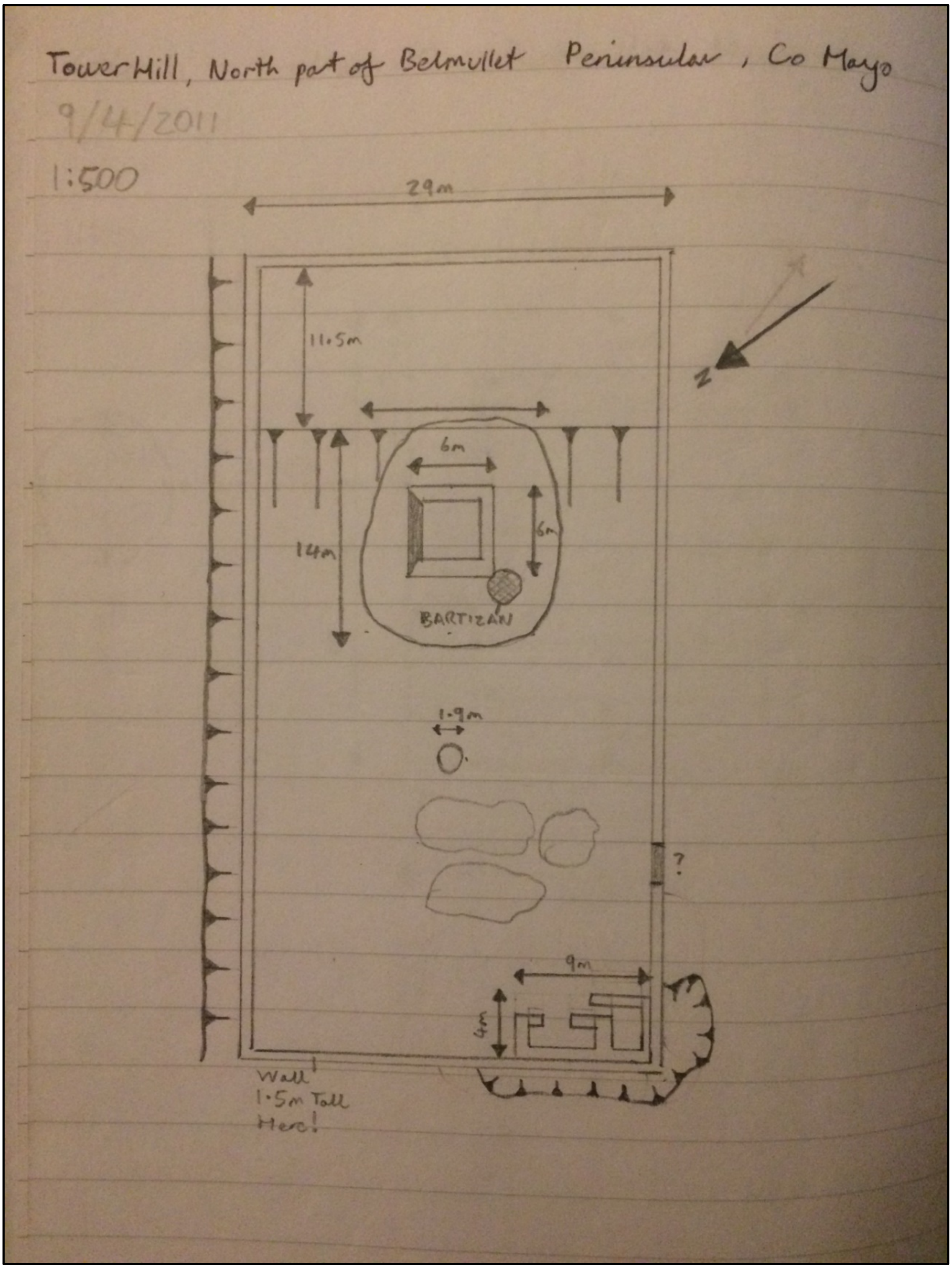


Figure 3.2. Field Sketch of Tower Hill Signal Station, County Mayo.

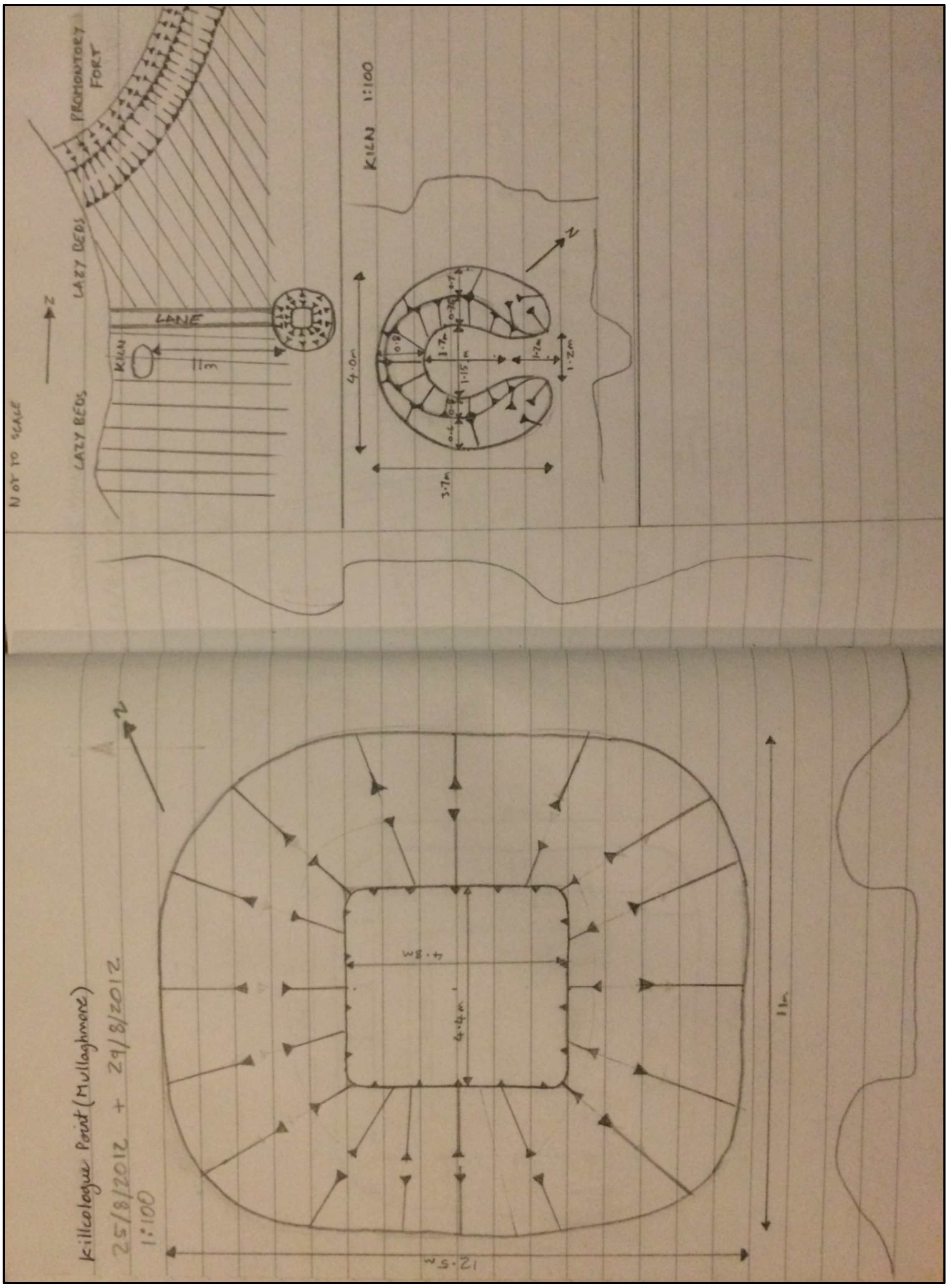


Figure 3.3. Field Sketch of Kilcologue Point Signal Station, County Sligo.

Whilst visiting and surveying some of the sites the author was able to borrow GPS equipment from colleagues and friends. During the early field surveys undertaken in County Mayo, a simple Garmin GPS 12 handheld GPS unit was borrowed from Achill Archaeological Field School. Whilst surveying the signal stations in Connemara, County Galway, the author was able to borrow a more accurate Trimble GeoExplorer XT 6000 handheld GPS unit from Achill Archaeological Field School. During the survey of the signal station on Golam Head Signal Station a highly accurate Trimble RTK pole mounted GPS unit was provided by Dr James Bonsall/Earthsound Archaeological Geophysics. These GPS units were used to record digital plans of the sites, but these were always created as supplements to the tape surveys and sketches and were never used as replacements for the primary recording methods.

Upon completion of the tape survey and sketch plans a photographic survey was undertaken. A similar process was followed whether almost complete, largely complete, or low ruins of signal towers were encountered. Standing at a distance of roughly 30 m to the signal tower square-on photographs (i.e. with the camera parallel to the wall and the centre of the shot in line with the approximate midpoint of the wall) were taken of each external wall, with care being taken that the entire wall was included within a single shot, and diagonal shots facing into the corners of the tower were also taken (Figure 3.4). In some cases, pairs of overlapping shots were also taken to allow for the sides of the signal towers to be recorded at a closer range. The overlapping shots were later combined in one of the versions of *Panorama Maker* to create a single more detailed image (Section 3.3.3).

Ranging rods were placed against the wall of the signal tower in order to have a reference that would allow the photograph to be accurately scaled in *AutoCad a*nd this was checked against tape measurements made during the survey (Section 3.3.3 & 3.3.4). In a few instances where use of a ranging rod was not possible the measurements from the tape survey were used to allow the photographs to be scaled instead. During the recording stage, notes were taken to explain the order and nature of the individual photographs. As soon as possible, preferably during the same day, the photographs from each site were downloaded onto a laptop PC, organised, and labelled.

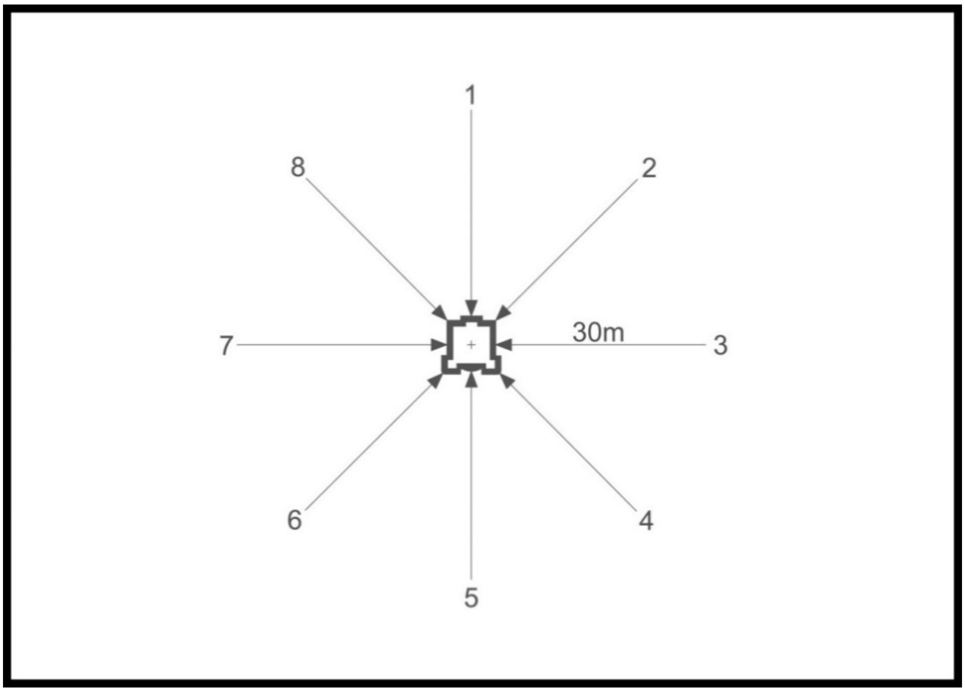


Figure 3.4. Position of photographs taken during simple photogrammetric survey of signal tower. In practice the distance between from the photographer and the tower was highly variable due to physical obstructions and changes in topography that often necessitated taking photographs from a closer distance which increased the level of perspective distortion present in those shots.

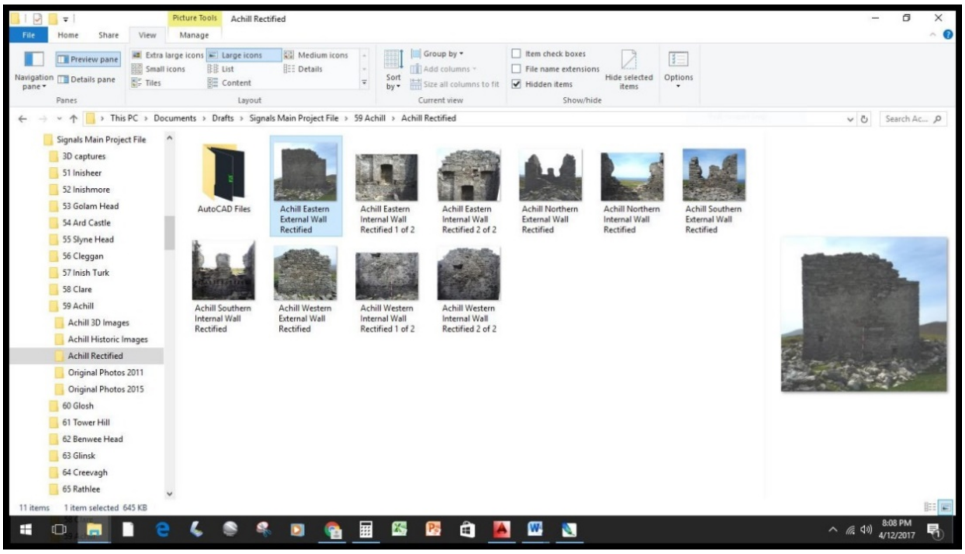

Figure 3.5. File structure used to archive photographs and illustrations from a signal station.

Each distinct group of photographs was placed into a separate folder (internal shots, external shots, landscape shots, 3D capture etc) and the file name of each photograph was changed to include a specific description of the photograph (i.e. northern external wall, eastern internal wall, shot from signal tower looking north to adjacent tower etc) (Figure 3.5). In the initial phases of the project, a number of external shots were taken at oblique angles, capturing two sides of the signal tower with one of the towers' corners in the centre of the frame. In the later stages of the project when the possibility of 3D photogrammetry had been realised a different approach was used. To successfully create 3D models in this way, best practice requires large numbers of overlapping photographs (Moraes *et al* 2013; Olsen 2016).

Starting at a point in line with one of the midpoints of the signal tower's walls, photographs were taken at 3 to 5 pace intervals until the tower was fully encircled and the final shot overlapped with the first shot in the sequence. Undertaking a circuit in this manner meant that between 30 and 60 separate photographs would be taken, depending on how far out the circuit was from the tower. Figure 3.6 illustrates the locations of the various external photographs that were taken, although the local topography often affected the distance from the tower that each photograph was taken, meaning Figure 3.6 is very much an idealised image.

Internal photography followed a quite different procedure. Given the small internal widths of the signal towers and the height of the walls at the more complete examples, approximately 4.2 m wide and 12 m tall respectively, it proved impossible to take a single shot that contained an entire internal wall with the available cameras. Instead, a series of photographs were taken that overlapped horizontally in order to completely capture each internal wall. The photographs were taken standing against the midpoint of the facing wall, the maximum distance from the subject wall that could be obtained without shooting obliquely. At least three separate overlapping shots were needed for each internal wall, the first catching the semi-basement level and the ground-floor, the second capturing the top of the ground-floor, the whole first-floor and parts of the attic level, and the third capturing the top of the first-floor and the attic level and parapet at the top of the tower. Occasionally a fourth overlapping photograph was needed in order to fully capture a single internal wall. If possible, a ranging rod was placed along the base of the wall and included in the first photograph in each sequence which allowed the photographs to be accurately scaled in *AutoCAD* and checked against tape measurements made during the survey. Where it was not possible to use a ranging rod, measurements recorded during the tape survey were used exclusively. Using this technique, the four internal walls of a complete or almost complete signal tower would typically be recorded in 12 to 16 photographs. No attempt was made to generate a 3D photogrammetry model of the interior of a tower, although the latest iterations of the software packages might make this possible.

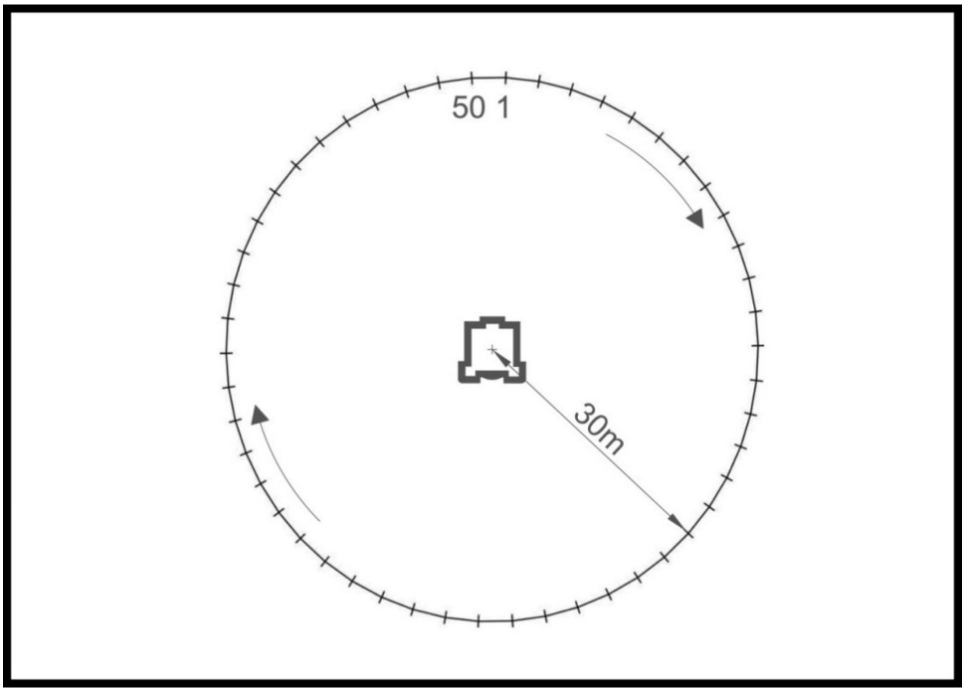


Figure 3.6. Photographic positions during 3D photogrammetric survey of a signal tower. Each dash around the circumference of the circle marks the hypothetical position of one of the photographs taken during the survey. As with the photographic procedure shown in Figure 3.4, it proved difficult to maintain a constant distance from the tower during the full circuit due to physical obstructions and changes in topography.

The next stage in the photographic recording process was to take shots of useful details present at a particular tower, i.e. unique variations or rare instances of the survival of features absent at the majority of the sites. The nature of these shots varied considerably from site to site, but might include details of the dressed stonework around windows and doors, close up shots of fireplaces and alcoves, shots showing *in-situ* timber elements, shots showing pieces of fallen masonry etc. When the features were accessible from the ground level, ranging rods were placed into these shots, but this was not possible for features located higher up on the structure.

At signal station sites where only low ruins of signal towers were present, the same procedure was followed, with external square and oblique on shots being taken. When attempting to produce a 3D photogrammetric model, a full circuit of the surviving part of the signal tower was made, taking between 30 and 60 separate shots, as described above. Wherever the internal wall faces were available to be recorded these were recorded in the same way as described above for the more intact towers, although it was often possible to record entire surviving internal wall faces in a single shot. At a number of these more ruinous sites the internal wall faces could not be seen as the interior was entirely filled with rubble. In these cases, no additional shots were taken to record the interiors.

Having completed the detailed photographic survey of the signal tower, photographs were also taken of any associated features. Where enclosures were present photographs were taken that illustrated the nature of the surviving elements. However, the enclosures were so large, often in the region of 50 m by 30 m, that it usually proved impossible to take a single photograph, or even a series of overlapping photographs, that adequately illustrated the nature of the enclosure as a whole in a single image (Section 4.3).

Where the foundations, or the partially standing remains, of buildings could be seen in the proximity of the unenclosed signal towers, or within or adjacent to the enclosures at the enclosed signal stations, these were photographed from multiple angles with ranging rods used to indicate their scale (Sections 4.4.1 and 4.4.2). At a number of sites, the remains of lime kilns and possible signal post mounts were identified. These were photographed from multiple angles, again using ranging rods to indicate scale (Sections 4.4.3 and 4.5).

The final stages of the photographic survey were usually performed whilst leaving the site. This stage involved taking a series of photographs that illustrated the position of the signal station within the landscape, views from the signal station towards the two neighbouring signal stations (if weather conditions permitted useful photographs to be taken), and shots of other architectural and archaeological elements in the landscape such as Look Out Posts (L.O.P.s), 'Eire' signs, trigonometry points, and promontory forts. These final sets of photographs were not taken in a systematic fashion, instead the most appropriate angles and distances, were identified, considering the nature of the particular subject and the weather conditions at the time of the survey (Sections 4.6 through 4.11).

The photographic archive created specifically for this project contains 2,691 unique photographs. This figure includes both the formal shots of the towers, shots taken for 3D photogrammetry, landscape shots and shots of associated sites, such as Martello towers, lighthouses, Look Out Posts (L.O.P.s), contemporary signal towers in England and Malta, and two of the signal stations on the Liverpool to Holyhead Telegraph. Broken down into regions and topics the archive consists of 471 photographs of signal stations in County Galway, 545 photographs of the signal stations in County Mayo, 315 photographs of signal stations in County Sligo, 756 photographs of signal stations in from County Donegal, 337 photographs of signal stations in Leinster and Munster, 198 photographs of signal towers in Malta (taken by James Bonsall), 36 photographs of signal towers in England, and 33 photographs of telegraph stations in Wales.

#### 3.2.2.1 Health and safety

A health and safety assessment was undertaken during the preparation for the fieldwork portion of this project (Connolly 2005). Two main areas of risk were identified, and suitable risk management strategies were implemented to minimize these risks (Connolly 2005, 4-9).

The first area of risk that was identified involved accessing the signal station sites (Connolly 2005; 3). Access to most of the sites meant hiking over rough ground, typically without the benefit of marked trails. The length of the hikes required varied between different sites, from less than 100 meters up to several kilometres. The terrain that had to be traversed also varied between sites, and whilst some sites could be accessed over flat ground covered in low grass, other sites required crossing rough bog, wet ground, steep and rocky ground, and in one instance a shallow tidal channel. Dangers that could be expected included slips and falls, animal encounters, exhaustion, exposure, and getting lost. The potential consequences of these risks increased when surveys were to be undertaken solo (Section 3.2.2). To mitigate these risks the field survey equipment always included stout, well broken-in hiking boots, lightweight waterproof clothing, sun-cream, printed maps, a magnetic compass, an emergency whistle, sufficient food and water, a small first aid kit, and a mobile phone (Section 3.2.2). Animals were rarely encountered but always given a wide berth. The weight of the surveying equipment was kept to a minimum to facilitate safer hiking. Whenever Dr Bonsall was not present on a survey he was informed of the intended route, departure time, and expected time of return. When Dr Bonsall partook in a survey, a suitable substitute was nominated to receive the same information. On completion of each survey a text message was sent to Dr Bonsall or the substitute to let them know the survey had been completed safely. The use of rented bicycles on Inishmore altered this area of risk slightly. During that specific survey particular care was taken when cycling in traffic and down hills, and no off-road cycling was undertaken.

The second area of risk that was identified involved working around abandoned, partially collapsed, and fully collapsed buildings. Only one of the signal station sites in the main study area, Fanad Head Signal Station in County Donegal, comprised of occupied and fully maintained buildings, although even during that survey the ruined buildings at the nearby coast guard station were visited. Derelict and partially collapsed buildings pose numerous risks, including slips and falls, sharp structural elements, broken structural elements, falling masonry, confined spaces, stagnant water, and animal waste. Access to the interior areas of some buildings involved passing through irregular openings in the building’s walls or climbing through ground floor windows. To mitigate these risks a survey strategy was devised that meant that loose masonry rubble and building debris would not be walked on, that flooded buildings would not be not entered, that unstable walls would not be approached, that confined spaces would not be entered, that no attempts would be made to access the first-floor levels of buildings, that buildings would not be entered through ground-floor windows if significant drops into the interiors would be involved, and that no areas with animal waste would be approached.

## 3.3 – Digitising the results of the field surveys

A workflow was developed to process the results of the field surveys in a variety of ways using different software packages, based upon the dataset. For each site where substantial remains of a signal station were still present a written description, a series of plans, a series of external elevation drawings, and a series of internal elevation drawings were prepared. For sites where survival was less complete as many of these same elements that could usefully be created were prepared.

### 3.3.1 – Written description

The expanded notes written in the archive notebook (Section 3.2.2) were manually transcribed into a *Microsoft Word* document. At this stage any clarification of the text that was needed was performed and any additional notes pertaining to observations made at later stages in the project were added. The written descriptions follow a standardised format and include descriptions of the signal towers, associated features, landscape setting, access routes, and associated monuments.

A total of 32 detailed site descriptions were prepared during this project. These written accounts form a substantial part of the individual site descriptions presented in Appendices A - D (Appendix A, County Galway; Appendix B, County Mayo; Appendix C, County Sligo; Appendix D, County Donegal). Shortened and simplified versions of these descriptions are presented in the blog associated with this project (Rathbone & Bonsall 2017a). Digital copies of the appendices to this project were submitted to the National Monuments Service.

### 3.3.2 – Creating plans

The first stage in the creation of digital plans from the field survey data was a manual process; sketches were transferred from the field note books to the archive notebook, taking great care to introduce an accurate scale and detailed annotations, creating a more accurate sketch based directly on the original field sketches. These enhanced sketches were scanned as a jpeg image which were imported into *AutoCAD*. The enhanced sketch was correctly scaled within *AutoCAD* (using the *scale* function) and digitised by tracing over the jpeg with a series of *polylines.* A digital map of the site was thus created based on the enhanced sketch. In the case of complex sites with multiple features, images captured from Bing Map's aerial layer (Bingmaps *2017*) were imported into the *AutoCAD* environment and placed behind the line drawing based on the enhanced sketch. Any discrepancies between the two images were corrected with a preference given to the aerial photograph, unless there was clear evidence of distortion on the aerial image, or a feature was in some way obscured. From this edited image a final plan was created by exporting the *AutoCAD* drawing as a PDF which was then edited for presentation in *Photoshop CS2 or Photoshop Elements 10*.

Where GPS units had been used to record plans of the sites, the GPS data were imported into *AutoCAD* according to the manufacturer's guidelines for the particular model. Once the GPS data had been imported into the *AutoCAD* environment the data were used as a third comparative layer, adding additional details to the process described above.

A total of 30 plans were prepared during this project. These plans form a vital part of the individual site records presented in Appendices A – D. It was not possible to prepare plans for two sites, Bloody Foreland and Fanad Head, both in County Donegal.

### 3.3.3 – External elevations

The square-on photographs described above (illustrated in Figure 3.4) were initially processed using *PaintShop Pro XI or X8* software. A *perspective correction tool* was used to adjust the perspective distortion inherent in photographs of tall objects from a close range (King 2011, 324-6), i.e. where the top of a building appears narrower than the base, and the sides of a building appear to slant inwards (Figure 3.7). Some photographs were also altered using the *barrel distortion correction tool*, to adjust the barrel distortion that occurs when using a camera with a small highly curved lens to photograph objects at close range (King 2011, 322-4), although this was only an issue in a small number of cases. Once the photographs were adjusted to remove as much distortion as possible, copies were saved as high-resolution *jpeg* files.

In a few instances multiple overlapping shots of the same wall were also taken alongside the single shots. These were joined together using the *Panorama Maker 4* or *6* software packages. This process tended to considerably increase the distortion of the image, adding an outwardly curving aspect to the walls (Figure 3.8). In some instances, this could be corrected using the *barrel distortion correction tool* in *PaintShop Pro* and subsequently processed using the *perspective correction tool*. The results were compared to the perspective corrected version of the single shot of the same wall. A decision was made about which version to utilise based on the level of detail present in the photo, which was generally greater in the conjoined panoramic version, and the amount by which the photograph had been altered during the barrel distortion correction and perspective correction processes, which was generally less in the single shot version. More detailed conjoined shots with low levels of barrel distortion were selected over less detailed single shot versions, but single shot versions with less detail were selected over more detailed conjoined shots that had undergone significant amounts of barrel distortion correction.

Figure 3.7. Perspective correction south-west wall of the signal tower at Golam Head Signal Station, County Galway, in *PaintShop Pro X8*. The corners of the perspective correction tool are dragged over the corners of the building (top), and the software makes the required adjustments (bottom).

Figure 3.8. This image of the south-east wall of the signal tower on Inishmore, County Galway, is a compilation of several images joined together in *Panorama Maker 6*. It displays extreme curvature of the walls beyond the level that could be adjusted for using the Barrel Distortion Correction tool in *PaintShop Pro X8*. The presence of abutting buildings meant that the photographs could not be taken at a more appropriate distance from the wall.

The four images of the external walls that were selected for use were imported into *AutoCAD*. The images were then scaled using the *scale* function to alter the image to correspond to known distances recorded during the field surveys. These scaled images were cross referenced by measuring ranging rods included in the photographs, and finer adjustments were made until a sub 0.05 m level of accuracy had been reached. Once scaled, the photographs were carefully digitised using the *polyline* function to trace the major elements of the wall. During the initial attempt at using this technique based on the photographs from Glash Signal Station, County Mayo, every single stone in each external wall was traced, creating incredibly dense ‘stone by stone’ images (Figure 3.9). It was quickly established that whilst this time-consuming process produced impressive results, there was no reason to reproduce every stone in each of the signal tower walls. The photographs themselves already contained this information at a high resolution; the purpose of the photogrammetry was to provide illustrations which highlighted the construction details of the signal towers, and information about how the buildings functioned. Subsequent attempts traced each of the following elements:

- Cut stone around the doors.
- Windows and along the wall tops.
- The stones forming the edge of each wall.
- Selected patches of stonework from different parts of each wall that were representative of the nature of the stonework in those areas of the buildings.

A well-preserved signal tower digitised in this fashion took around 40 hours to complete the internal and external elevations. The exterior elevations of the tower at Glash Signal Station where every stone was traced took approximately 80 hours to complete. The additional time spent was not found to have increased understanding of the construction or function of the building.

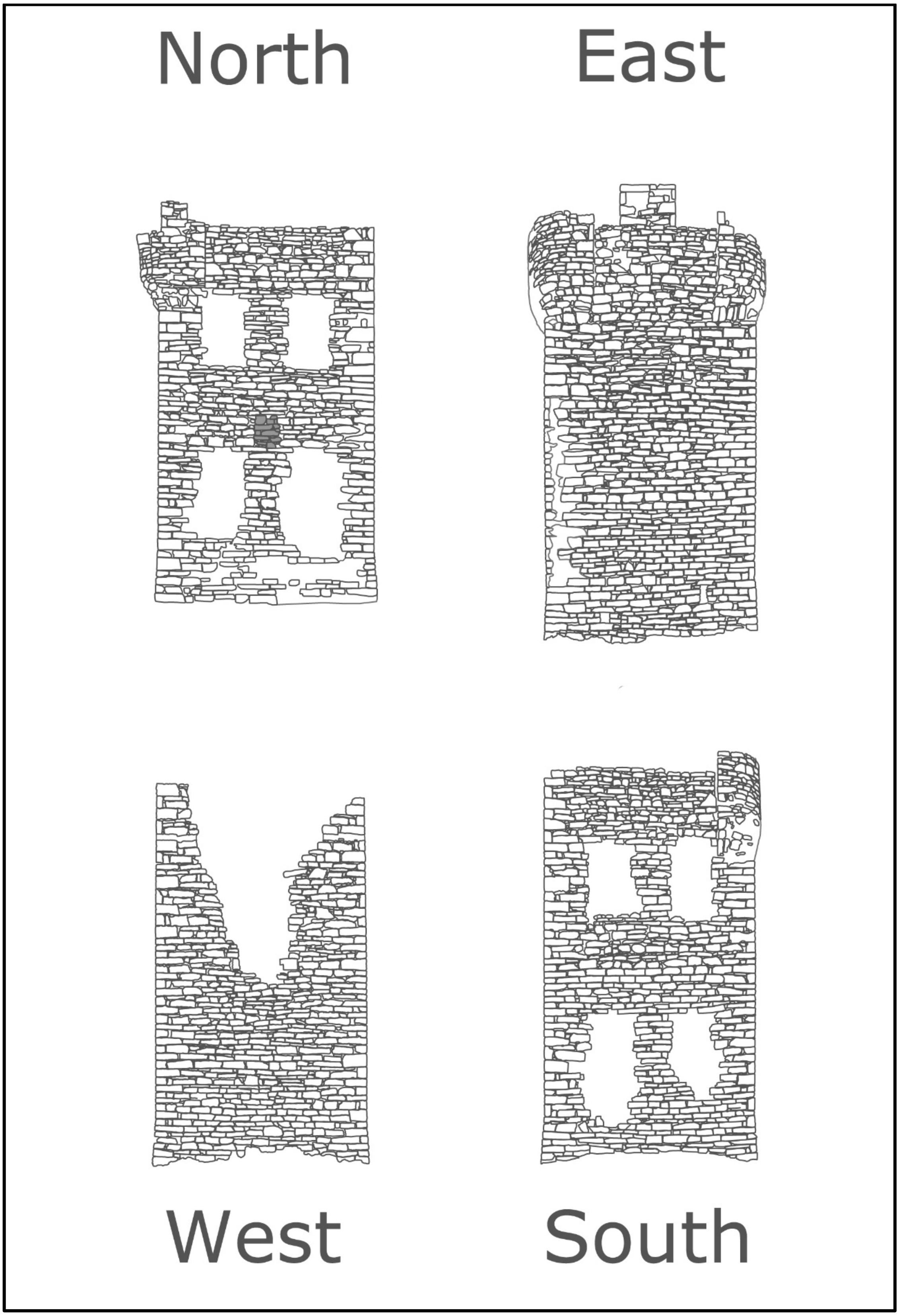


Figure 3.9. Stone by stone drawing of the exterior of the signal tower at Glash Signal Station, County Mayo.

This style of illustration follows the best practice established by Sean Rothery's *Field Guide to the Buildings of Ireland* (Rothery 1997). As Maurice Craig explained in his foreword to Rothery's book this 'succinct and clear' style is particularly useful;

> *"…only in a drawing can a building be shown as its designers and builders intended it to be seen. By his sensitivity of line and texture he has brought out latent qualities invisible to the casual eye"* (Craig 1997).

The author cannot claim to have matched the deftness of Rothery's artistic renditions, and the illustrations presented here have an undeniably mechanistic quality to them, but they present the building's important diagnostic features with a similar level of clarity. The process of digitising photographs allows key elements of the structure to be discerned in a way which is not present in photographs alone; photographs contain an overabundance of visual information which paradoxically masks detail, as demonstrated in Figure 3.10.

It is also important to note that the labour-intensive process of digitising the images allows for an extremely detailed examination of the walls surface. Details of the construction become apparent during this process that could possibly be missed when viewing the walls during the field surveys, or through a less intensive examination of the photographs at a later date. Different elements of the construction were placed into separate *AutoCad* layers allowing them to be coloured, shaded and have their line weights altered independently (Figure 3.11). Once completed the *AutoCAD* drawings were exported as PDF files and then imported into *Photoshop CS2* or *Photoshop Elements 10* for final preparation and presentation as jpeg files.

The same methodology was largely followed irrespective of how well a signal tower had survived. The exceptions to this were the few sites where the external wall faces were concealed by rubble or the adjacent ground surface, as was the case at Streedagh in County Sligo, or where the signal tower had been entirely or almost entirely removed, as was the case at Bunowen Hill (SMR GA049-017001) in County Galway, so that no meaningful illustrations could be produced.

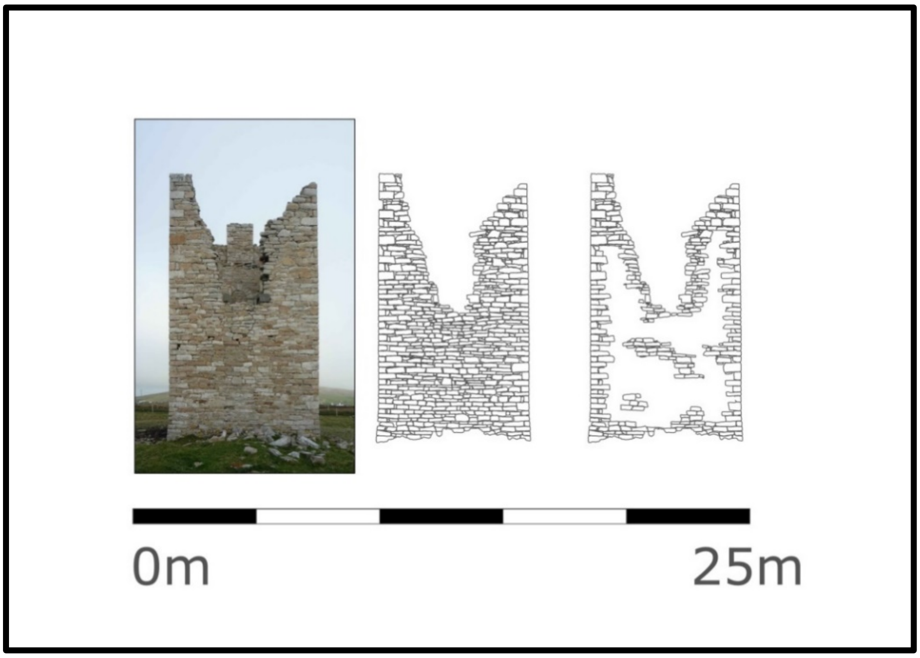


Figure 3.10. Comparison between rectified photograph, stone by stone drawing and selective drawing of the western wall of Glash signal tower, County Mayo.

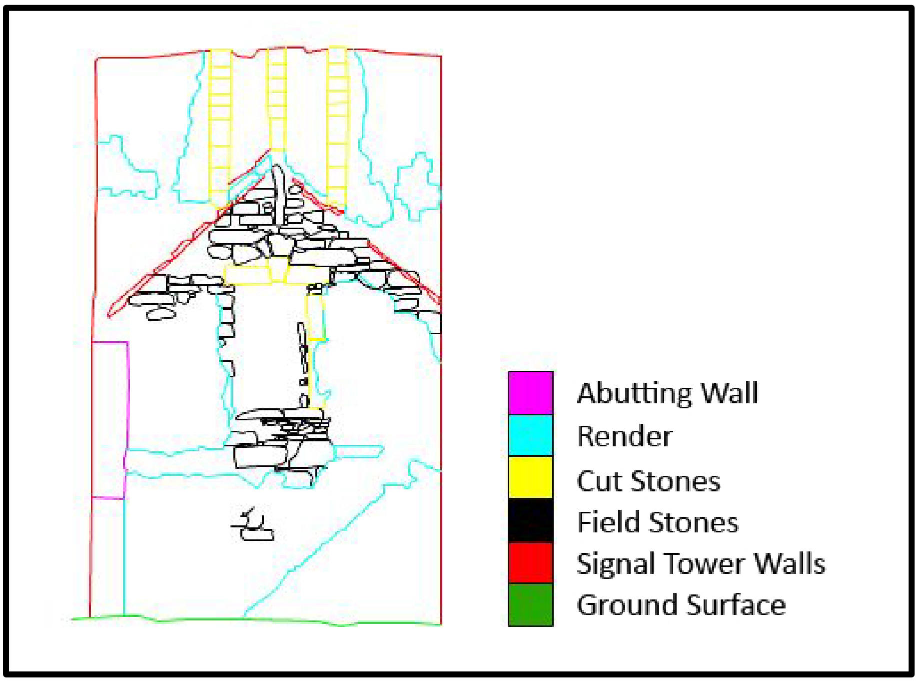


Figure 3.11. Illustration of south-west wall of the signal tower on Inishmore showing how the different elements of the building are drawn as separate colour coded layers. These layers are all changed to blacks and greys during the final stages of preparing the drawing.

In a few cases some of the external walls could be drawn, but others could not, and fewer drawings were produced. In two cases, Inisheer and Inishmore Signal Stations in County Galway, later buildings obscured parts of the external walls. Where this occurred the estimated outlines of the missing portions of wall were drawn, shaded and marked as '*not visible'* on the relevant drawings. At Carrigan Head Signal Station, County Donegal, the base of the northern wall was obscured by the sharp cut of a terrace on which the signal tower had been constructed, this area was also shaded and marked as '*not visible.'*

The method provides a simple form of photo rectification. At the outset of the project in 2008 the technology involved in true photo rectification was prohibitively expensive and complicated (Andrews *et al* 2005, 78; Andrews *et al* 2009, 11-3). Physical markers had to be placed onto a building, impossible at the more complete signal towers without using climbing equipment, scaffolding, or a mechanical lift. The position of the reference points needed to be recorded using a Total Station, an expensive and cumbersome piece of equipment which would have been difficult to transport to many of the remote upland sites. Processing the results of such a survey also necessitated the use of complex and expensive software packages (Haukaas & Hodgetts 2016, 41). Whilst the results of this present study might potentially have had a greater degree of accuracy than those produced using enhanced photographs, it would not be possible to undertake such work within the confines of the available budget and the solo nature of the majority of the field surveys. Use of a 3D laser scanner to directly capture a high-resolution 3D model was also ruled out for reasons of cost, expertise, and transportation. A traditional hand drawn survey could also have been performed, but that is an extremely time-consuming processes which would have also necessitated the use of climbing equipment, scaffolding, or a mechanical lift.

The finished drawings can be compared favourably to detailed measured sketches, and compare well to the practices established by industrial archaeologists for recording buildings in the mid to late 20th century (Pannell 1966, 92-116; Major 1975, 89-131). A chance to assess the level of accuracy of the method used in this project was presented when the signal tower at the Old Head of Kinsale, County Cork, was subjected to a program of complete restoration between August 2014 and May 2015. Prior to work beginning at the site, a 3D laser scanner was used to record the exterior of the tower and the 3D model created was draped in a full colour skin derived from a photographic survey (Hurley & Rynne 2012).

Aware of this survey, in April 2016 the author visited the site and performed a field survey following the method described above, without any modification to attempt to increase accuracy. Whilst the 2016 photo rectification is of the restored building it can still be usefully compared to the earlier laser scanner survey. As can be seen in Figure 3.12 and 3.13 the two surveys are close matches concerning the size of the structure and the location of various architectural elements visible from outside of the structure, providing a positive qualitative check of the accuracy achieved by the method used in this project (Table 3.1). Further consideration of the accuracy of the methodology developed during this project is presented in Chapter 5.

A total of 75 external elevations were prepared during this project. These form a vital part of the individual site records presented in Appendices A – D. This total represents a considerable reduction from the hypothetical total of 128 external elevations which would have been possible if all of the signal towers had survived to a recordable height. 15 external elevations were prepared for signal towers in County Galway, 20 external elevations were prepared for signal towers in County Mayo, 12 external elevations were prepared for signal towers in County Sligo, and 28 external elevations were prepared for signal towers in County Donegal.

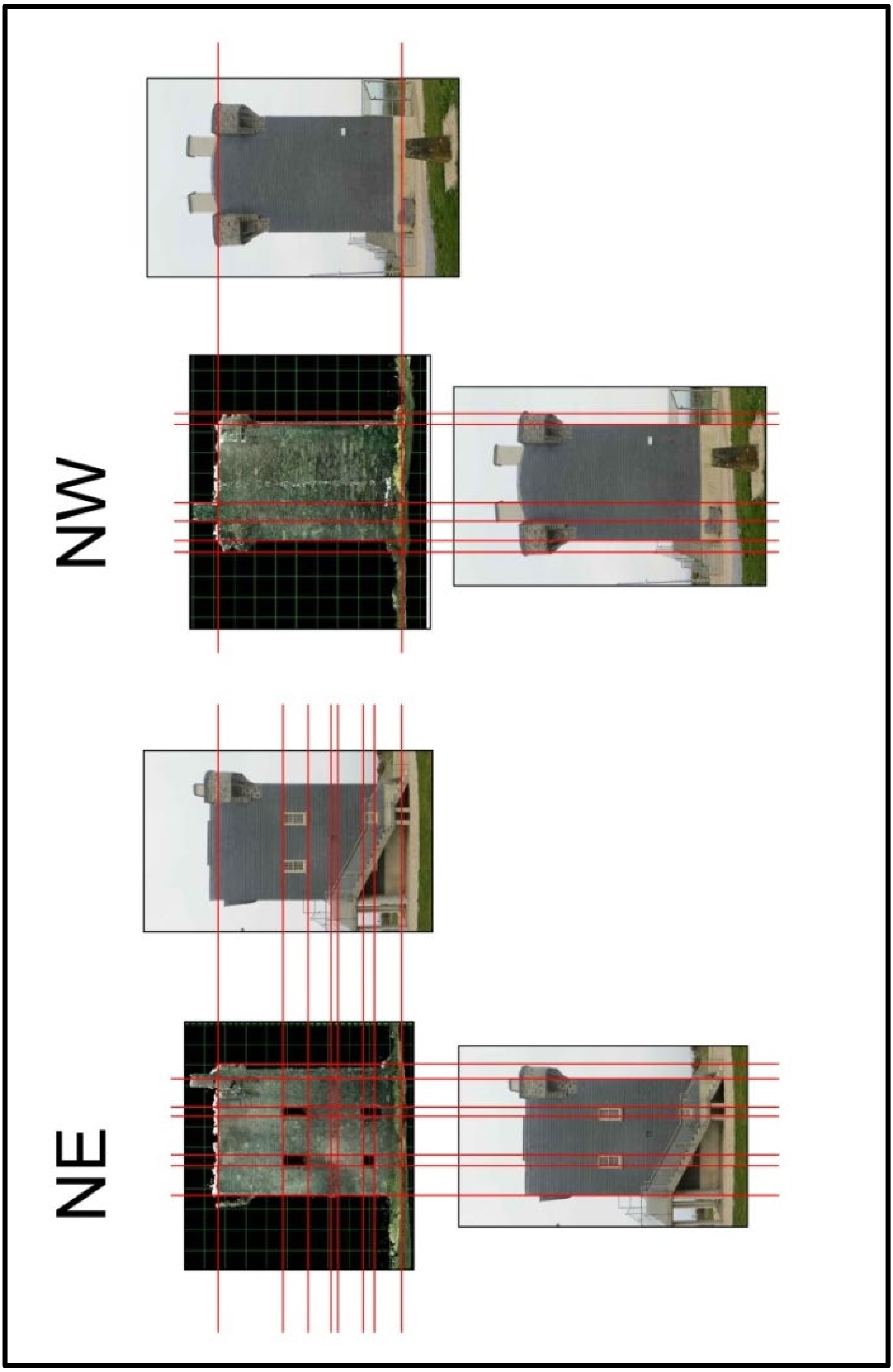


Figure 3.12. Comparison 1 between laser scan survey and photogrammetric survey of Old Head of Kinsale signal tower, County Cork.

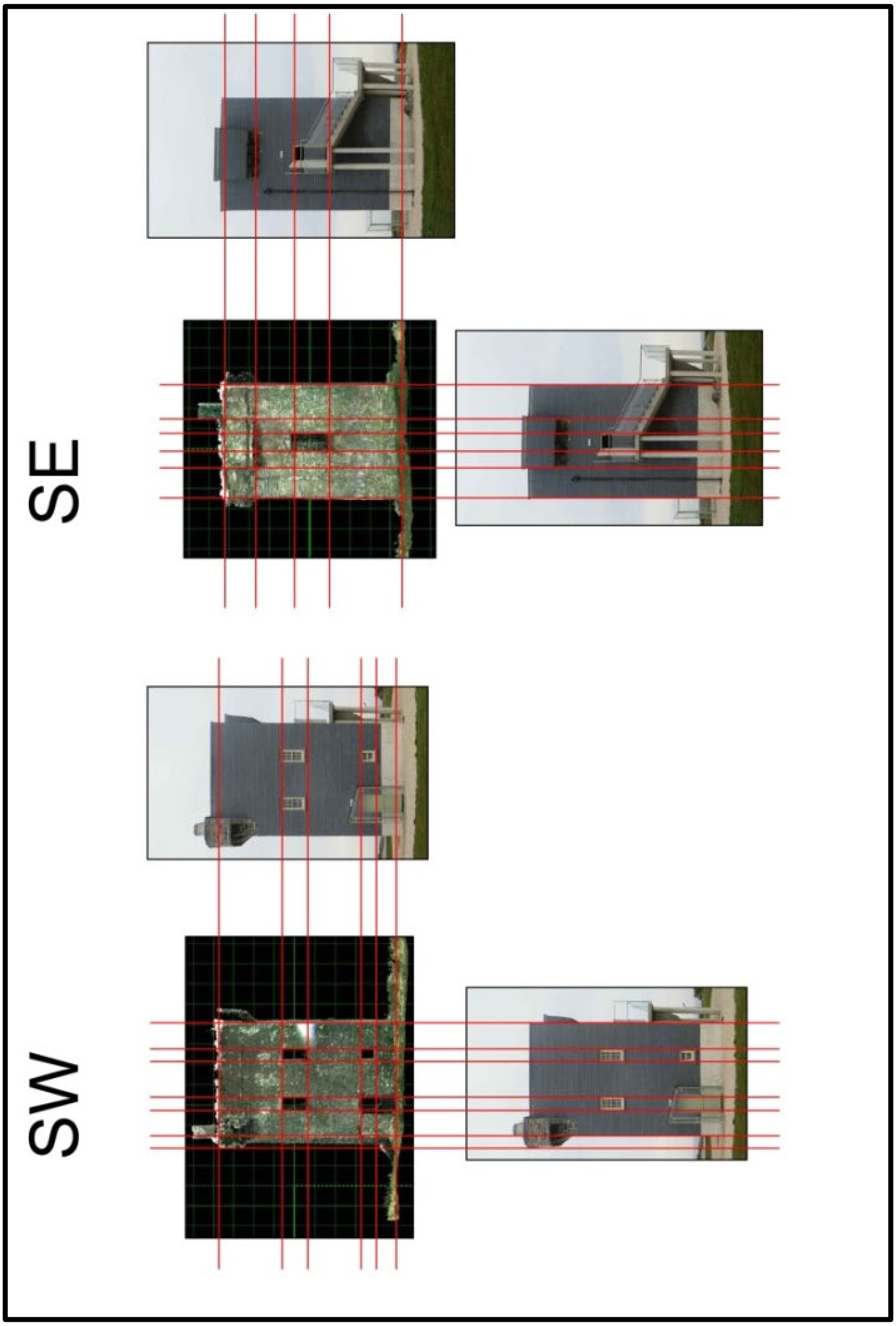


Figure 3.13. Comparison 2between laser scan survey and photogrammetric survey of Old Head of Kinsale signal tower, County Cork.

| | SW Wall Photogrammetry | SW Wall Laser Scan |
|---|---|---|
| Height | 9.9 m | 9.16 m |
| Width | 5.9 m | 5.86 m |
| Distance between ground-floor and first-floor windows | 2.82 m | 2.76 m |
| Distance between first-floor windows | 1.84 m | 1.84 m |
| | **SE Wall Photogrammetry** | **SE Wall Laser Scan** |
| Height | 9.99 m | 9.33 m |
| Width | 5.86 m | 5.82 m |
| Distance between top of door and top of wall | 3.63 m | 3.61 m |
| | **NE Wall Photogrammetry** | **NE Wall Laser Scan** |
| Height | 9.8 m | 9.31 m |
| Width | 5.84 m | 5.83 m |
| Distance between ground-floor and first-floor windows | 2.81 m | 2.79 m |
| Distance between first-floor windows | 1.77 m | 1.76 m |
| | **NW Wall Photogrammetry** | **NW Wall Laser Scan** |
| Height | 9.88 m | 9.46 m |
| Width | 5.85 m | 5.85 m |
| Distance between bartizans | 4.01 m | 3.98 m |

**Table 3.1. Comparison between measurements of the Old Head of Kinsale signal tower, County Cork. The consistent disagreement between heights can be explained by the repair to the top of the walls and the addition of replacement coping stones, and by the clearing away of material from the base of the wall. The other measurements are all in very close agreement and indicate that the simple photogrammetry method utilised in this study can produce results with a similar accuracy to the complicated and expensive laser scan method, when working on relatively simple buildings (Hurley & Rynne 2012).**

## 3.3.4 – Internal elevations

The process of creating internal elevation drawings at well-preserved signal towers was more complex than that used for external elevation drawings (Section 3.3.3). Because of the restrictive internal space and the height of the internal walls, multiple overlapping images were required (Section 3.2.2). In most instances it was not possible to join three or more of these internal images in *Panorama Maker 4* or *6* without adding an unacceptable level of distortion. Attempts to correct for this distortion in *PaintShop Pro XI* or *X8* were unconvincing, and higher levels of distortion were introduced as the software attempted to correct the initial distortion.

A new workflow for these scenarios was devised. Each individual shot was adjusted to correct for perspective in *PaintShop Pro XI or X8* and imported into *AutoCAD* and scaled. The separate 'perspective corrected' and 'scaled' images were aligned manually creating a single image of each internal wall within the *AutoCAD* environment, which was traced over, using essentially the same procedure described for the external images (Section 3.3.3). However, the interior wall faces contain more features than the external wall faces and each visible detail of these was individually traced, creating a more complete, less stylised image, albeit one where the level of accuracy has to be assumed to be slightly less than was achieved for the external walls.

For different reasons the interior of the Old Head of Kinsale Signal Tower could not be surveyed using either the laser scanner in 2014, or the photographic method in 2016. In both instances this relates to a lack of space in the interior meaning the respective equipment could not be used. Instead accuracy of the internal elevations was assessed via a comparison between the position and sizes of the door and window openings on the internal and external wall faces at one of the best-preserved signal towers, the example at Golam Head Signal Station, County Galway. Figure 3.14 illustrates the level of accuracy that was achieved.

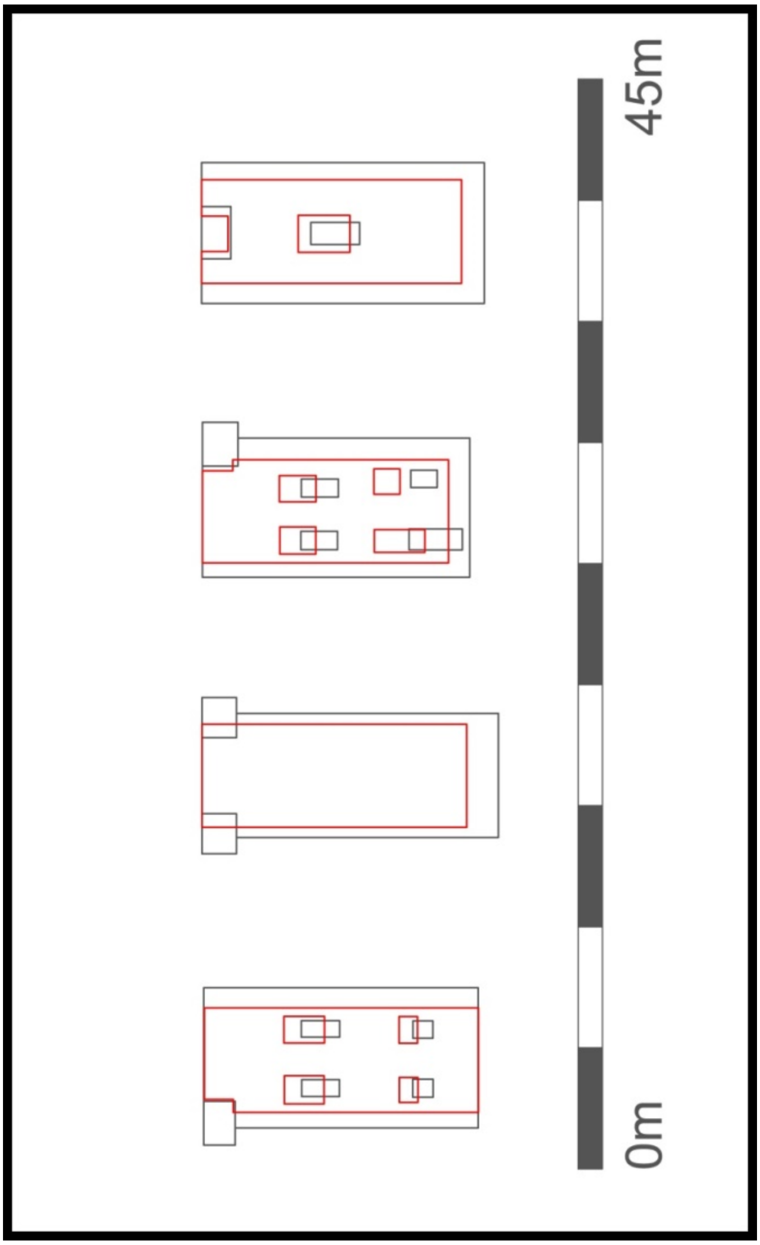


Figure 3.14. Comparison between the wall sizes and the positions of external (black lines) and internal (red lines) features at the signal tower at Golam Head Signal Station, County Galway. The differences in the building's height can be explained by the partial infilling of the semi-basement level, whilst the differences in the buildings width simply represent the width of the walls. The increase in width of the internal window and door openings results from the internal splaying of these features (not present on the secondary ground-floor entrance). The vertical displacement of the internal window and door openings reflect the sub-optimal positioning of the camera during the recording of the interior, which was too close to the wall being photographed, leading to a considerable degree of vertical displacement. As explained in Section 3.3.3 the external elevations are highly accurate records. The internal elevations can only be equated to detailed sketches that record the internal walls in detail, but which are not to true scale.

For signal towers where the upper portions had collapsed, it was sometimes possible to capture the internal wall faces in a single photograph. In these cases, the single images could be subjected to the perspective correction procedures in *PaintShop Pro XI or X8* and imported into *AutoCad,* without introducing additional levels of distortion seen with the more complete internal elevations. At many of the sites where only the base of the signal tower survived, the interiors were entirely filled with rubble, as has already been discussed (Section 3.2.2) and no illustrations could be prepared as no photographs were taken.

A total of 59 internal elevations were prepared during this project. These form a vital part of the individual site records presented in Appendices A – D. This total represents an even greater reduction from the hypothetical possible total of 128 internal elevations that occurred with the external elevations, reflecting four sites where the interior of the signal towers could not be accessed, and a number of the sites where collapsed material obscured the interior walls. One interesting exception to this pattern was Streedagh Signal Station in County Sligo where the external walls were concealed by the surrounding ground, but the interior walls could be recorded. 14 external elevations were prepared for signal towers in County Galway, 16 external elevations were prepared for signal towers in County Mayo, 16 external elevations were prepared for signal towers in County Sligo and 13 external elevations were prepared for signal towers in County Donegal.

## 3.3.5 – GIS analysis

The results of the survey were incorporated into four different Geographical Information System (GIS) software packages, each serving a different purpose. The first GIS project was created with the user-friendly internet resource *ArcGIS Online* to produce a publicly accessible interactive map (Rathbone & Bonsall 2016b). The second GIS project was a more detailed GIS database created in *QGIS* that was used for analysing signal station location, compiling and georeferenced a large amount of data relating to the individual signal stations and creating maps for use within the thesis and subsequent publications. The third GIS project utilised the viewshed functionality built into *Google Earth Pro* in order to create simple viewsheds projected from each signal station location. This simple process delivered a basic understanding of how much of the adjacent coastline and landmass could be directly observed from each site. The fourth GIS project involved using *ArcGIS* to present the location and height data of the signal station sites over a detailed 3D topographic model of the north and north-west coastal regions of Ireland. This locational and topographic data was used to perform a Viewshed Analysis to investigate the level of inter-visibility between the signal stations, with the aim of determining how weather conditions which altered visibility conditions would hamper the operation of the signal stations.

### 3.3.5.1 – ArcGIS Online

ESRI's *ArcGIS Online* software package was initially used to create an inventory of the locations of the signal station sites in a convenient format, given the lack of a pre-existing map that accurately displays the locations (Figures 1.1 & 1.2). After some experimentation, the *World Imagery* layer was selected as the sole background mapping layer as it provides a continuously scrolling high resolution aerial photographic image of the whole of Ireland and the individual signal station sites can be readily identified once fully zoomed in. Each signal station site was marked using a *Push Pin* from the *Map Notes* function, placed directly onto the signal station (or its estimated location in the cases where the site has been levelled), and labelled with the name of the signal station. Even in this simple form the interactive map proved exceedingly useful allowing both an overview of the locations, and the accurate location of each individual site, to be accessed from a single source, something that would be quite impossible with a paper map printed at any sensible scale. For this function alone, the

*ArcGIS Online* map remained in constant use throughout the project and, incidentally, was the first accurate map of the locations of all of the signal stations ever assembled, given the problems described above regarding Kerrigan's map and the incomplete coverage of the sites on the National Monuments Service's *Historic Environment Viewer* (Section 1.1).

The second stage involved creating an album in the free online photograph storage system *Photobucket* which contained a single representative image of each signal station. Links to these photographs were embedded into the *Map Note* so that selecting each *Push Pin* opened a pop-up window with the name of the site and a single photograph depicting the site. The design of the *Push Pin* was edited to present a small square symbol colour coded to denote the condition of the signal station utilising a 'traffic light' style for visual clarity;

- Green squares indicate largely complete sites (75 – 100% of masonry survives).
- Yellow squares indicate sites where substantial remains are present (50 – 74% of masonry survives).
- Red squares represent sites where only low ruins survived (1 – 49% of masonry survives).
- Black squares represent sites that had been demolished (0% of masonry survives).

The third stage involved adding brief written description of the features that currently survive at each signal station site to the pop-up window that opened when each *Push Pin* was selected. A summary text was also added to the *Details* panel that sits at the side of the view screen, which included a brief overview of the Irish signal station system, instructions on how the map works, and an explanation of the symbology used on the map. In April 2016 a version of the database that detailed all of the signal stations in Connacht was made publicly available following its launch at the Institute of Archaeologists of Ireland annual conference (Rathbone & Bonsall 2016b).

The fourth and final stage involved the creation of a *WordPress* blog (Rathbone & Bonsall 2017a) in which each signal station was given a separate page containing: a detailed written description, directions on safe access, a selection of photographs, an aerial photograph, and a simple viewshed image created in *Google Earth Pro* (Rathbone & Bonsall 2017a). Links to individual pages of the blog were embedded within the picture that opened in the pop-up window on the *ArcGIS Online* map (Rathbone & Bonsall 2016b). Clicking on the image within the pop-up window would trigger the individual blog page for that particular site to open in a new window in the web browser being used to access the *ArcGIS Online* map. The blog was made publicly accessible in March 2017, containing entries for each signal station in Connacht. Both the *ArcGIS Online* map and the *WordPress* blog were updated in April 2018 to include all of the signal station sites in Ulster (Rathbone & Bonsall 2016b; 2017a). Both the *ArcGIS Online* map and the *WordPress* blog were updated in November 2018 to include all of the signal station sites in Leinster and Munster (Rathbone & Bonsall 2016b; 2017a). The *ArcGIS Online* map was also used to create the maps of the signal station locations in Leinster and Munster, presented in Section 4.12.1 and 4.12.2 (Figures 4.58 & 4.59) and the map of the enclosed barrack locations in County Kerry in Section 4.12.3 (Figure 4.60).

**3.3.5.2 - QGIS**

A GIS database was created in *QGIS* which allowed for increased detail over the *ArcGIS Online* map. A Digital Elevation Model (DEM) was loaded as the primary layer and the *Bing Aerial* photographic layer was also added. The location of each signal station site was identified on the *Bing Aerial* layer and a *Point* was placed at each location which generated a National Grid Reference (NGR). The *Points* were then colour co-ordinated to indicate which county the site was located in, and the name of each site was added as a *Label.* The maps generated in QGIS are presented in Section 4.1.

A large attribute table containing a range of details about each of the sites in Connacht and Ulster was created and linked to each *Point* (a version of this attribute table is presented here as Table 4.1.1 through 4.1.5, Section 4.1). The QGIS database was used to generate the maps of signal station locations used in Appendices A - D. The attributes table was in constant use throughout the project as it contained many important fields for each site (e.g. altitude, grid references, descriptions from Ordnance Survey maps *etc*.).

### 3.3.5.3 – Viewshed analysis

Viewshed analysis was undertaken using two different GIS software packages, *Google Earth Pro* and *ArcGIS*. The signal stations were originally constructed in positions that ensured its purpose; viz. a visual communications system the required each station to be visible from its two neighbouring sites. This means that inter-visibility could be assumed for each site. The focus of the viewshed analysis was firstly to examine how much of the adjacent coast and landmass was visible from each site and secondly to establish how weather conditions that affected visibility ranges affected the functioning of the signal station system. The usefulness of GIS software to examine visibility patterns associated with signal towers has been recognised since the earliest applications of GIS software to archaeology (Gaffney & Stančič 1991, 61-3).

### 3.3.5.4 – Google Earth Pro

Creating a viewshed analysis in *Google Earth Pro* follows a similar procedure to that described above in the section detailing the creation of the interactive map using *ArcGIS Online* (Section 3.3.5.1). After locating each individual signal station site, a *Placemark* was added using the *Add Placemark* function. When adding the *Placemark* the altitude was set at 12 m to represent the approximate eye height of an observer standing on the roof platform at the top of a signal tower. The figure represents an average height of the towers roof level being set at 10.3 m or 34’, based on the results of the survey, and with the eye height of an observer being set at 1.7 m or 5’ 6’’. Recent research into historical heights in England suggest this feature might be a slight over-estimate, although not to the degree that the analysis would have been impacted in a significant fashion (Galofré-Vilà *et al* 2018). Right clicking on the *Placemark* brings up a drop-down menu with various options including *Show Viewshed*. Selecting this option calculates a *viewshed* with a 20 km diameter (10 km radius from the signal tower), showing the areas which can and cannot be seen from the *Placemark* which equates to the view from the top of the signal tower. Using the *Print* function each *viewshed* was exported as a PDF file with a unique title and a key. This function was extremely useful as it allowed the *viewshed* from each signal station to be examined and to confirm observations made during the field surveys that the view available from certain signal towers would have been limited in specific directions. It also has the advantage of being a very easy to use function. The process has two serious limitations. Firstly, it is not possible at present to alter the diameter of the viewshed, it is locked to 20 km. Unfortunately, the 20 km viewsheds were frequently too small to encompass the adjacent signal station sites (See Table 4.6 in Section 4.13.4), meaning that in many cases the line of sight between towers could not be fully assessed from a single image. Secondly, it is not possible to display multiple viewsheds from different *Placemarks* at the same time. This limitation meant that it was not possible to examine whether a series of adjacent sites provided comprehensive coverage along a stretch of the coastline. The viewsheds generated in *Google Earth Pro* are included in the individual site descriptions presented in Appendices A - D and were incorporated into the individual site entries on the WordPress blog described above (Section 3.3.5.1) (Rathbone & Bonsall 2017a). It became apparent from this experience, that an alternative method of assessing viewsheds and inter-visibility was required.

**3.3.5.5 – ArcGIS**

Because of the limitations inherent in the viewshed function in *Google Earth Pro* it was necessary to undertake a second viewshed analysis using *ArcMap,* the main component in ESRI's powerful GIS package *ArcGIS*. Four viewshed maps were produced using the *Viewshed 2* toolbox in *ArcMap*, one for each county in the main study area (Figures 4.69 - 4.72 in Section 4.13.2). The Viewshed 2 tool determines which locations on a digital elevation model are visible from a set of *observer points* (ESRI 2016). A Digital Elevation Model (DEM) of Ireland was imported into *ArcMap.* The DEM used, *the Digital Elevation Model of Ireland,* was based on NASA's *Shuttle Radar Topography Mission* (SRTM) dataset, which is freely available to download from the Open Data Unit website under Creative Commons Attribution 4.0 (Open Data Unit 2018). The location of each signal tower was utilised as an observer point, with their position established using the coordinates included in Tables 4.1.1 - 4.1.4. The *observer points* were again set to a height of 12 m above the ground surface, to simulate the view of an observer on the roof level of each signal tower.

The toolbox was run four times for each county to create raster plots of various view distances, at 7, 12, 16 and 22 kilometres respectively. Using the *Raster to Polygon* toolbox the different raster images of overlapping view distances were converted to different colour polygons which were exported, and then *Merged*. These polygons were presented in each county viewshed map, with the viewshed from each signal tower shown simultaneously at four different distances, each denoted by a separate colour. The resulting viewshed maps show the areas that could be observed from the signal towers in each county, at each visibility range simultaneously. The viewshed maps therefore illustrate how the viewsheds were affected by the local topography and by atmospheric visibility levels.

### 3.3.6 – 3D models

Two different software packages were used to create 3D photogrammetry models of the signal towers, Autodesk's *123D Catch* and Arcsoft's *PhotoScan*. In addition, a more traditional 3D textured polygon model was generated in Google's *SketchUp Pro* software.

Generating 3D models through photogrammetry requires large numbers of overlapping shots encircling the tower as explained above (Section 3.2.2). This software became available to the project at a late stage, in the spring of 2015 when only three signal stations remained to be surveyed, Inisheer, and Golam Head Signal Stations, County Galway, and Lenadoon Point Signal Station, County Sligo. In these instances, the encircling photographs were taken as part of the field survey. It proved possible to generate 3D models based on existing sets of photographs of the signal stations at Malin Beg, Glen Head, Mullaghderg Hill, Horn Head, and Malin Head in County Donegal. In June 2016 the opportunity was taken to revisit the signal station on Saddle Hill, County Mayo, and a series of encircling photographs were obtained. During the summer of 2016 Glash Signal Station, County Mayo, was revisited in order to take an additional set of encircling photographs. It was hoped that the signal stations on Inishturk and Clare Island in County Mayo, Rathlee and Carrowmably in County Sligo and Carrigan Head and Crohy Head in County Donegal could also be re-recorded in this way but ultimately it did not prove feasible to revisit these sites. The signal station at Cleggan Hill, County Galway, is considered unsuitable because of the steep slope to the east of the tower that restricts the view from several sides, whilst the manner in which the signal tower at Inishmore signal station, County Galway, is embedded in the later lighthouse complex meant that it is considered unsuitable for this procedure because so little of the tower would be visible. The surviving remains at the other sites are so ruinous that no discernible benefit could justify a revisit and subsequent data processing.

**3.3.6.1 – 123D Catch**

The production of 3D models in *123D Catch* was an essentially automated process. The encircling photographs were selected and uploaded via the *123D Catch* website and processing took place within Autodesk's own servers with no input needed by the uploader. Once the model had been generated it was accessible via the website, and could be rotated and examined using a simple '3D orbit' style tool. A flight path around the model was created running between the locations where the individual photographs were taken. This flightpath was used to generate a video fly pass around the subject and this video could be exported in the *AVI* file format. *Autodesk* discontinued *123D Catch* in January 2017. Its functionality is now included in a new software package, *Recap 360,* which was not examined during this project. Five models of signal towers were generated using *123D Catch,* Glash Signal Station, County Mayo, Lenadoon Point Signal Station, County Sligo, and Malin Beg, Glen Head and Malin Head Signal Stations, County Donegal. The models are displayed as a video on the 'recording the signal stations page' of the project blog (Rathbone & Bonsall 2017b). The models proved useful during the project as they allowed parts of the signal towers which may not have been well captured with individual photographs to be examined. However once converted to static images they were less useful; 2D captures of the 3D models essentially replicated existing photographs at lower resolutions and exported images were not reproduced within this thesis. Unfortunately access to these models was lost when 123D Catch was discontinued. All of the models except for the signal tower at Glash Signal Station, County Mayo, were subsequently reproduced in *Photoscan*, which as described in the following section, allowed for the creation of higher quality models.

### 3.3.6.2 – PhotoScan

The process of creating 3D models in Agisoft's *PhotoScan* software is similar to that used in *123D Catch*, but it is less automated, and the processing occurs on the user's computer rather than on a remote server. A series of photographs are uploaded into the software from which a point cloud model of the building or object is created (Figure 3.15). Once the point cloud has been generated it is used to create a mesh model showing the building or object with a simple grey texture draped over the point cloud (Figure 3.15). Finally, a detailed texture based on the photographs is added to the mesh model, creating a realistic representation of the building or object (Figure 3.15).

The models created in *PhotoScan* have a higher resolution than those created in *123D Catch*. The finished models can be manipulated using a 3D orbit tool and they can be uploaded to the online 3D model sharing website *Sketchfab.* It is possible to create physical versions of these models using a 3D printer, although this was not attempted during this project. A total of six 3D models of signal towers were completed during this project, Inisheer and Golam Head Signal Stations, County Galway; Saddle Hill Signal Station, County Mayo; Lenadoon Point Signal Station, County Sligo; Malin Beg and Glen Head Signal Stations, County Donegal. As with the models generated in *123D Catch*, the models generated in *Photoscan* proved useful for interrogating the signal towers. In particular by rotating the models to gain plan views, it proved possible to obtain clear representations of the building's plans, even though these were never observed by the camera during the field surveys. These plan views were used to check the details of the hand drawn plans of the signal towers. However, the exported 2D images from *PhotoScan* were still of lower resolution than the images captured with the digital camera and therefore they were not reproduced within the thesis. The models were uploaded to the author's *Sketchfab* page, where they can be interrogated in three dimensions (Rathbone 2017). These models were also exported as 3D object files (.obj) and form part of the project archive. Photographic sets from three sites, Glash Signal Station, County Mayo, and Mullaghderg Hill and Horn Head Signal Stations, County Donegal were not processed, given the limited usefulness that the 3D models from other sites were found to have. The project archive contains these sets of photographs and they could be processed in the future if there was an interest.

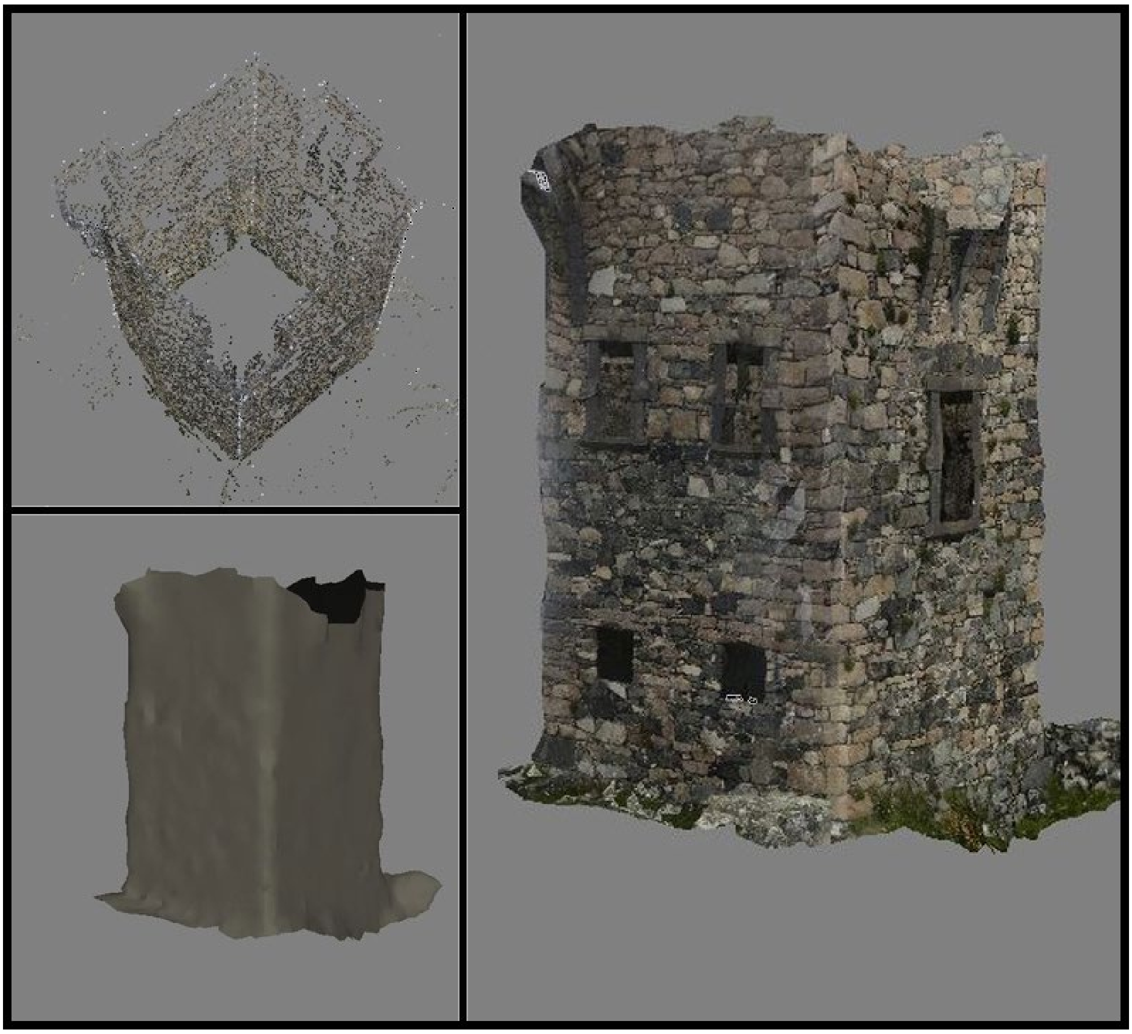

Figure 3.15. Generating a 3D model from overlapping photographs in PhotoScan. A selection of photographs were uploaded and used to generate a point cloud (top left). A simple mesh texture is then added to the point cloud (bottom left). Finally, the photographs are used to drape a realistic texture over the mesh (right).

### 3.3.6.3 – SketchUp Pro

Producing 3D models in *SketchUp Pro* is a more time-consuming process than using the 3D photo-rectification software described above (Sections 3.3.6.1 and 3.3.6.2). In *SketchUp Pro 3D* models are created by drawing 2D shapes and then *pushing* or *pulling* the shape along a third axis. The dimensions of the 2D shape can be manually entered and the distances they need to be extended along the third axis can also be manually entered allowing the shapes to be accurately sized. Holes passing through 3D objects, and indents into 3D objects, can be created by drawing a 2D shape of the correct dimensions onto the objects surface and then *pushing* or *pulling* the 2D shape into the 3D object by a manually entered distance. Complex 3D objects can be added to existing 3D objects by manually drawing a 2D cross section of the desired object and then using the *follow* tool to drag them around the perimeter of the 3D shape.

A 3D signal tower model was constructed using these simple processes to slowly create the basic shape and adding details individually, based on the signal tower at Carrowmably Signal Station, County Sligo, which was considered to be the most complete and least altered example in the main study area. The dimensions of the various shapes required to create the walls and features of the tower were taken by measuring the dimensions from the *AutoCAD* drawings of the internal and external walls, and gradually building up a complex model of the correct size. Once this polygon model was completed textures were added to the various surfaces, selected from a limited palette included in the software. The textures were added to give a more realistic finish to the model.

Once the model was constructed it was rotated and positioned using a 3D orbit tool and annotated measurements were added to the model. A PDF of each desired view was then created. Sections through the tower model were created using the *Plane View* tool, where a plane is positioned along one of the three axis and moved through the model, removing all elements that fall on the selected side of the plane. Using this tool, it was possible to create a series of views of each internal wall. The images generated from this model are presented in Chapter 4 (Figures 4.1 through 4.16). The finished models were exported into the online 3D model viewing and sharing service *Sketchfab* (Rathbone 2017).

The *Sketchup* model was also uploaded into *Google Earth* and placed accurately onto the locations of signal towers and then viewed within *Google Earth's* photo-textured 3D world model (see Appendix A, Figures A.46 & A.47). The usefulness of this process was limited by the currently poor resolution of the coverage of much of the coast of the West of Ireland in *Google Earth*. It is also possible to import sections of the aerial imagery from *Google Earth* into *SketchUp Pro*, draped over an accurate localised terrain model, and place the model onto the location of a particular signal tower. Again, the poor coverage of high-resolution imagery for the West of Ireland limited the usefulness of this process. The potential of these techniques is high should the resolution of the *Google Earth* coverage of the study area ever be upgraded.

## 3.4 – Historical research

During this project a wide range of historical documents were consulted and interrogated. Much of this research was undertaken as part of the literature review (Chapter 2). The historical research in this section refers to data specifically pertaining to signal stations and associated features. The documentary narratives offered by this material is, as noted in the Literature Review, inconsistent. The following sections describe the primary sources that were consulted.

### 3.4.1 – Cartographic sources

The 1st, 2nd and 3rd editions of the Ordnance Survey six inches to the mile maps were amongst the first resources consulted, in order to identify the actual position of the signal stations in the main study area (Section 3.2.1). Dates for individual Ordnance Survey maps were taken from a reference document prepared by Trinity College, Dublin (Trinity College University Library 2018). This was initially undertaken prior to the field surveys, in order to plot routes to the site and to understand which features might be present at each location. During the processing of the results, the Ordnance Survey maps were used for regression analysis to understand changes at the signal stations throughout the 19th century, and to examine how the sites related to other features in the landscape, in particular the road network (Figure 3.16). This was repeated for the desk-based survey of signal stations in the secondary study area, to ascertain signal station locations, the components of the signal stations, and how they were altered during the 19th century.

This variation in 19th century naming conventions used by the Ordnance Survey was described above (Section 3.2.1). This might indicate a level of confusion amongst the surveyors about the nature of the sites they were recording, or a legacy issue from the re-use or re-purposing of sites at a later date. Whilst the latter explanation may apply to a small number of sites, for example Mullaghderg Hill Signal Station, County Donegal, which was re-occupied by the coast guard (see Appendix D.76), it is best regarded as reflecting a lack of concern for the terminological precision. This lack of verbal precision is apparent in many early accounts of signal systems, exemplified by the interchangeable use of telegraph and semaphore (Section 2.4.7.2).

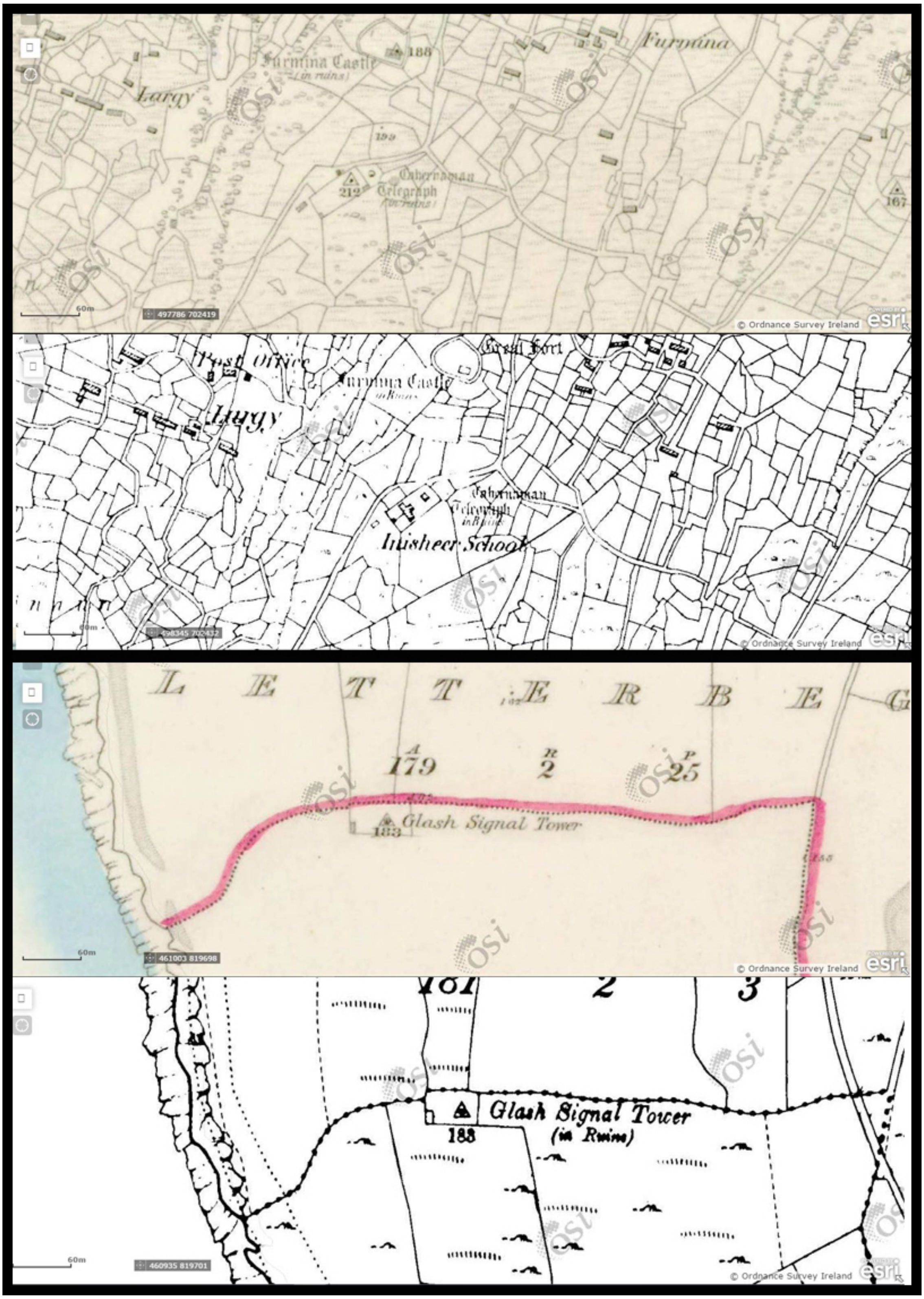


Figure 3.16. Comparison of representations of signal stations on the 1st Edition (sepia) and 3rd Edition (black & white) Ordnance Survey Maps, with Inisheer Signal Station, County Galway, shown at top and Glash Signal Station, County Mayo, at bottom.

Other early cartographic sources were consulted and found to be of some use, particularly for sites which were not shown in detail on the 1st edition Ordnance Survey maps. William Bald's map of County Mayo was surveyed between 1809 and 1816 shortly after construction of the signal stations began in 1804, and at least partially whilst they were still in operation (Bald 1830). Bald's map was surveyed at a scale of four inches to the mile and reproduced at a scale of 3 inches to the mile. Each of the signal stations in County Mayo is shown in plan view. Along the upper and lower edges of the map there are profile drawings of prominent ranges of hills which depict the location of several of the signal towers.

William Larkin produced a number of detailed county maps in the second decade of the 19th century that were published at two inches to the mile (Bendall 1997, 246). His maps of Counties Waterford (1818), Galway (1819) and Mayo (1809-1817) mark the position of the signal stations but lack useful details of the sites. His map of Sligo (1819) omits the signal stations. His map of County Waterford was found to be useful during the desk-based survey of the secondary study area; the map shows the locations of signal stations, a number of which had already been demolished or collapsed by the time the 1st Edition Ordnance Survey map was surveyed (1839-1841). Larkin's other maps of coastal counties were useful in examining the arrangement of roads and other features around the coast, but do not show the positions of the signal stations.

### 3.4.2 – Pictorial evidence

A small number of paintings and photographs that feature signal stations provided vital information about the condition of the sites at particular points in time, revealing details about parts of the sites which were no longer present. Problems associated with historical images that impact on their use as a source of archaeological and architectural information include; determining if an image is based on first hand observation or secondary sources; if an image is representative or fantastical; assessing the extent to which an image has been staged; understanding the political context in which an image was created (Burke 2001, 85-7). The correct method for citing a historical image is a currently unresolved issue (Layton-Jones 2008). Burke identified a range of subjects in the study of material culture where historical imagery can provide important evidence about form and function with a brevity and clarity unmatched by textual accounts. Building exteriors, interiors and mechanical equipment feature prominently in his list of useful subjects (Burke 2001, 81-3). The historical images of the signal stations utilised in this study are highly accurate and trustworthy; they are not based on secondary sources, do not suffer from fantastical embellishment or unrealistic staging, and do not appear to be unduly influenced by British and Irish politics.

### 3.4.3 – Military Documents

Contemporary accounts discussing the Irish signal stations are held within various military archives. Kerrigan and Clements both previously examined much of this material and included information derived from it in their published accounts (Kerrigan 1995, 276-80; Clements 2013, 117). Repeating or expanding their historical research was not identified as an objective of this particular project, which focused on the signal stations as archaeological resources. However, it was recognised that the National Library of Ireland held three bound volumes which compile letters to, from, and forwarded to Admiral Whitshed dated to between 1803 and 1806, the years during which the signal stations were constructed (NLI Mss 14, 917; NLI Mss 14, 918; NLI Mss 14, 919). Copies of these volumes were acquired as the letters had the potential to reveal specifically relevant information regarding the design, construction and operation of the signal towers. Information derived from these collections of letters has been used throughout the following chapters. The three volumes contain copies of the original letters transcribed in several different hands. The volumes do not contain page numbers or any numbering system for the individual letters making referencing the correct letter somewhat laborious. To identify a specific letter, it is necessary to state the volume, the author and recipient, and the date of the letter e.g. NLI Mss 14, 917; letter from Admiral Whitshed to the Right Honourable William Wickham, dated 6 November 1803.

Within the second of these volumes are two letters which contain simple plan illustrations of enclosed signal stations, both of which seem to be suggestions for how enclosures should be added to the recently constructed stations. These illustrations are discussed in Section 4.3. Table 3.2 contains the names, births/deaths or floruits, the positions held at the time of writing, and a bibliographic reference for the authors and recipients of the letters used during this project.

| Name | Birth/Death or Floruit | Position (at time letter was written) | Bibliographic Reference |
|---|---|---|---|
| Sir James Hawkins Whitshed | 1762 - 1849 | Naval Adviser to the Viceroy of Ireland/Vice-Admiral | (Hattendorf 2008) |
| John Berrell | 1779 - 1820 (*) | Architect to the Barrack Department of Ireland | (Dictionary of Irish Architects 1720 – 1940. 2019a) |
| John Hughes, Esq. | 1775 – (?) | Secretary to the Barrack Department of Ireland | (Burke & Burke 1850, 173-4) |
| Alexander Stewart | (?) - 1808 | Mason and Clerk of Works (?) | (Dictionary of Irish Architects 1720 – 1940. 2019b) |
| Major General Sir James Affleck | 1782 - 1833 | Major General 16th Light Dragoons | (The United Service Journal (1833), 227) |
| Sir Evan Nepean | 1752 - 1822 | Secretary to the Board of Admiralty | (Lee 1894, 222-3) |
| Captain James Lecky, Esq | (?) - 1820 | Captain of the Irish Sea Fencibles | (Brown 1999) |
| Thomas Soden | 1787 - 1817 (*) | Provost of Sligo (?) | (NUIG Landed Estates Database 2011) |
| Right Honourable William Wickham | 1761 - 1840 | Chief Secretary for Ireland | (Lee 1900a, 177-8) |
| Lord Sir Alan Gardiner | 1742 - 1809 | Commander in Chief Cork Station | Stephen 1889, 430 |
| William Wolesley | 1756 - 1842 | Commander of the Sea Fencibles | (Lee 1900b, 324-5) |
| Respective Officers | N/A | Representatives of the British Board of Ordnance | (Hartnett McEnery 2006, 56) |
| Sir Edward Baker Littlehales | 1764 - 1825 | Secretary at War for Ireland | (Scadding 1899, 3) |

**Table 3.2. Authors of contemporary letters used during this project. Floruits are marked with an asterisk.**

### 3.4.4 – Traveller's accounts

Travel writing was a particularly popular genre between 1750 and 1850, and over 600 examples of texts detailing journeys within Ireland have been identified (Kleinman 2010). A number of potential sources of information were checked. A comprehensive review of this resource would likely provide more useful information, particularly because British travellers could not safely visit the many areas of Europe during the Napoleonic Wars, and Ireland became a popular substitute destination (MacRaild 2014, 85).

Two passages were identified that contained material concerning the Irish signal stations. Edward Wakefield includes an account of the signal station on Kerry Head, County Kerry, which he visited in 1808, in *An Account of Ireland, statistical and political in two volumes* (Wakefield 1812a; 1812b). Wakefield was an early statistician and the account was undertaken at the behest of John Foster, 1st Baron of Oriel, who was the Irish Chancellor of the Exchequer between 1804 and 1806 (Webb 1878, 212). Caesar Otway's account of the signal station on Saddle Hill, County Mayo is included in *A tour in Connaught: Comprising of Clonmacnoise, Joyce Country and Achill* (Otway 1839, 372-3). Otway was a clergyman and author whose written work aimed to examine and improve the lives of Ireland's poor (Webb 1878, 426). He describes visiting the Achill signal station in the 1830s, about 20 years after it had been abandoned. Although not from a traveller's account another brief description of a signal tower that provided some useful information was found in Francis H. Tuckey's 'Cork Remembrancer' for the year 1804 (Tuckey 1837).

# Chapter 4. Results

## 4.1 Results of the surveys of the Signal Stations

Of the 81 signal stations originally constructed around the coast of Ireland (Section 1.1), 32 were constructed in the main study area of Connacht and Ultser, and 49 were constructed in the secondary study area of Leinster and Munster. At 18 signal stations (56%) in the main study area the sites were assessed to be 'largely complete,' or feature 'substantial remains' (Section 3.3.5.1). These sites demonstrated such consistency that it was clear that they were constructed according to a singular template, as was suggested by Kerrigan (Kerrigan 1995, 158). At the 10 signal stations (32%) in the main study area where only 'low ruins' survived, there was no indication that this pattern had been deviated from to any significant degree. Of the four sites (12%) within the main study area which had been demolished, little information could be obtained regarding the form of the buildings at three of the sites, whilst contemporary illustrations of the fourth site, Fanad Head in County Donegal, indicate the signal tower conformed to the standard design (Figures D.113 - D.115).

The main feature at each signal station was the signal tower (signal defensible guardhouse) which was replicated from site to site with only minor differences, as will be described in detail below (Section 4.2). Following the field surveys, it was found that the signal towers were so similar in design that it was considered unnecessary to describe each site in full detail, to avoid significant amounts of duplicated text. Instead, a diagnostic description of a 'standard' signal tower is given at the start of the following section (Section 4.2). Individual site descriptions are presented in Appendices A through D, which note the presence or absence of standard features recorded in the standard signal tower design, and any significant variations or additional features. The standard signal tower described is an aggregate of information derived from visiting all the sites in Connacht and Ulster. The sites where substantial remains were present provided much of the detail. The less well-preserved examples also provided significant information about the construction methods, e.g., exposed internal elements such as chimney flues or otherwise hidden details of the bartizans and machicolations.

Whilst it is of course possible that features in the upper portions of the now incomplete towers differed in some way, there is no evidence to indicate that this was actually the case. The consistency with which the features in the fragmentary towers conformed to those same sections of the better-preserved examples strongly supports this suggestion. The other elements of the signal stations offer enough variety, in terms of both their original form and their surviving components, that they are described in full in each individual entry in Appendices A through D. The features present at each site in the main study area are recorded county by county in Tables 4.1.1 to 4.1.5, at the end of this section. Accurate maps showing the locations of the signal stations in each county in Connacht and Ulster are presented after the tables (Figures 4.1 - 4.4). The results of the surveys of the additional features are briefly presented in Sections 4.3 through 4.11 and discussed in detail in Section 5.3.

Nine of the signal towers (28%) in the main study area were set within large rectangular enclosures defined by tall stone walls, four further sites (12%) utilised smaller and less regular enclosures, and the remaining 19 sites (60%) appeared to have been unenclosed. The nine large rectangular enclosures also demonstrated considerable similarity in design and layout, again taken to be indicative of the existence of a standardised design. The results of the surveys of the enclosures are presented in Section 4.3 and discussed in Section 5.3.2.

At 11 signal stations (34%) in the main study area there were additional buildings which seemed to be contemporary elements of the signal stations. These contemporary buildings are reviewed in Sections 4.4.1 and 4.4.2. The results of the surveys of the contemporary buildings are presented in Sections 4.4.1 and 4.4.2 and discussed in Section 5.3.3.

An important element now missing from all of the signal station sites were the large signal masts whose development was discussed in Sections 2.4.5, 2.4.5.1 and 2.4.6.7. None of these remain *in-situ*, but at six of the signal station sites in the main study area (19%) small oval features were recorded which may have been infilled mast sockets. The results of the surveys of the mast sockets are presented in Section 4..4.3 and discussed in Sections 5.3.3 and 5.6.

At eight of the signal station sites (25%) in the main study area small oval kilns were present, generally in quite ruinous condition, or are known to have been present from the 1st edition Ordnance Survey maps. The results of the surveys of the kilns are presented in Section 4.5 and discussed in Section 5.3.3.

A total of 17 signal station sites (53%) in the main study area were accessible directly from extant roads or tracks but it was not always clear whether these were pre-existing features, if they were contemporary features constructed specifically to provide access to the signal stations. The results of the surveys of the roads are presented in Section 4.6 and discussed in Section 5.3.4.

A total of 18 of the signal station sites (56%) in the main study area featured extant buildings or building remains which were later additions to the sites, representing various periods of re-use in the nineteenth and twentieth centuries. These secondary buildings, trigonometry points, Look Out Posts (L.O.Ps) and Lighthouses are reviewed in Sections 4.7, 4.8, 4.9 and 4.10. The results of the surveys of these secondary buildings, trigonometry points, Look Out Posts (L.O.Ps) and Lighthouses are presented in Sections 4.7, 4.8, 4.9 and 4.10 and discussed in Section 5.4. A small number of signal stations were associated with earlier fortifications. The results of the surveys of these fortifications are presented in Section 4.11 and briefly discussed in Section 5.3.2.

Section 4.12 presents the results of a preliminary survey of signal stations in the remaining two Irish provinces, Leinster and Munster, which were in general not visited and not subject to detailed field surveys. Information about the sites was instead gathered from 19th century maps, published accounts of the sites, and published photographs of the signal stations (Sections 3.2.1. and 3.4). The results of this work in the secondary study area are not comparable with those from the main study area, in terms of the level of detail established about the buildings and features present at each site. However, it was possible to acquire details regarding levels of preservation, general design trends and the positioning of the signal stations within the landscape. Individual accounts of each site are presented in Appendices E, F, and G.

Section 4.13 presents the results of the two different types of viewshed analysis that were undertaken for sites within the main study areas, and an analysis of meteorological data that investigates the impact of weather conditions on the inter-visibility of the sites. These results are discussed in detail in section 5.7.

| Name | Inisheer Signal Station | Inishmore Signal Station | Golam Head Signal Station | Cuileen Hill Signal Station | Bunowen Hill Signal Station | Cleggan Hill Signal Station |
|---|---|---|---|---|---|---|
| Station Number | 51 | 52 | 53 | 54 | 55 | 56 |
| Easting (ITM) | 498197 | 486065 | 481934 | 476581 | 459378 | 460557 |
| Northing (ITM) | 702212 | 709901 | 721418 | 732713 | 742626 | 759685 |
| Elevation | 65 m | 126 m | 29 m | 101 m | 65 m | 147 m |
| SMR Number | GA120-016---- | GA110-133001- | GA089-013---- | GA076-006---- | GA049-017002- | GA009-007---- |
| NIAH Number | 30412008 | 30411019 | - | - | - | - |
| Province | Connacht | Connacht | Connacht | Connacht | Connacht | Connacht |
| Semi-Basement | ? | ? | Y | ? | ? | Y |
| Semi-Basement Chutes | ? | ? | N | ? | ? | ? |
| Ground-Floor | Y | Y | Y | Y | Y | Y |
| Ground-Floor Fireplace | Y | Y | Y | ? | ? | ? |
| Ground-Floor Alcove | 2 | 2 | 2 | ? | ? | ? |
| Ground-Floor Alcove Chutes | ? | ? | N | ? | ? | ? |
| Ground-Floor Windows | 4 | 4 | 4 | ? | ? | 2 |
| Ground-Floor External Window Bars | ? | ? | ? | ? | ? | ? |
| Ground-Floor Internal Window Bars | N | N | N | ? | ? | ? |
| Split Mezzanine Level | Y | Y | Y | ? | ? | ? |
| First-Floor | Y | Y | Y | ? | ? | ? |
| First-Floor Fireplace | Y | Y | Y | ? | ? | ? |
| First-Floor Alcoves | 2 | 2 | 2 | ? | ? | ? |
| First-Floor Windows | 4 | 4 | 4 | ? | ? | ? |
| First-Floor Internal Window Bars | Y | Y | Y | ? | ? | ? |
| First-Floor Door | Y | Y | Y | ? | ? | ? |

**Table 4.1.1. Surviving Features and Signal Station Data for County Galway. Where a particular field did not apply this is marked by a '–' symbol. Where the status of a particular field was not established this is marked by a '?' symbol.**

| Name | Inisheer Signal Station | Inishmore Signal Station | Golam Head Signal Station | Cuileen Hill Signal Station | Bunowen Hill Signal Station | Cleggan Hill Signal Station |
|---|---|---|---|---|---|---|
| Internal Door Bar | N | N | N | ? | ? | ? |
| Attic Level | Y | Y | Y | ? | ? | ? |
| Parapet Level | Y | Y | Y | ? | ? | ? |
| Bartizans | 2 | 2 | 2 | ? | ? | ? |
| Machicolation | Y | Y | Y | ? | ? | ? |
| Vertical Drain | Y | Y | Y | ? | ? | Y |
| Chimney Bulge | N | N | Y | ? | ? | ? |
| Chimney Stack | N | N | N | ? | ? | ? |
| Coping Stones | N | N | Y | ? | ? | ? |
| Internal Render | Y | Y | Y | ? | ? | Y |
| External Render | Y | Y | ? | ? | ? | ? |
| Weather-proof Slates | Y | Y | ? | ? | ? | ? |
| Enclosure | Y | Y | N | Possible | N | Y |
| Contemporary Buildings | N | N | N | Possible | N | 1 |
| Contemporary Road | Y | Y | N | N | N | N |
| Lime Kiln | Y | ? | ? | ? | Y | Y |
| Signal Mast Mount | ? | ? | ? | ? | ? | ? |
| Secondary Buildings | 5 | 10+ | N | N | N | N |
| Look Out Post (L.O.P.) | N | N | Y | N | Y | N |
| Distance to L.O.P. | - | - | 867 m | - | 13 m | - |
| Eire Sign | N | Y | N | N | Y | N |
| Distance to Eire Sign | - | 194 m | - | - | 27 m | - |

**Table 4.1.1. continued. Surviving Features and Signal Station Data for County Galway.**

| Name | Inisheer Signal Station | Inishmore Signal Station | Golam Head Signal Station | Cuileen Hill Signal Station | Bunowen Hill Signal Station | Cleggan Hill Signal Station |
|---|---|---|---|---|---|---|
| 1st Edition OS Map | **Telegraph in Ruins**. Tower not shown but triangular height marker given in its position. Shows enclosure with small buildings inside NE and SW corner and small building outside NW wall. Possible Lime Kiln shown immediately NE of enclosure. | **Light House**. Tower not distinguished amongst later Lighthouse complex. | **Tower**. Shown as Triangular symbol. | **Telegraph.** Shown as small rectangle. | **Volunteer Tower.** Shown as small rectangle. Lime Kiln shown 75 m to ENE, past a small NW-SE trackway. Small rectangular building shown 49 m to the west. | **Cleggan Tower.** Marked as small rectangle. Lime Kiln shown immediately NW of tower. Small rectangular building shown 39 m to west of tower. |
| 2nd Edition OS Map | **Telegraph in ruins.** Shows Inisheer Schoolhouse and outhouse constructed in middle of SW enclosure wall connected to Schoolhouse by a wall. | **Lighthouse in Ruins.** | **Tower.** Shown as Triangular symbol. | **Telegraph in ruins**. Shown as triangular symbol. | Small irregular shape shown. | **Cleggan Tower.** Shown as triangular symbol. |
| Tower to clockwise | 52 | 53 | 54 | 55 | 56 | 57 |
| Distance to clockwise station | 8.9 miles<br><br>(14.3 km) | 7.6 miles<br><br>(12.2 km) | 7.8 miles<br><br>(12.6 km) | 12.3 miles<br><br>(19.8 km) | 10.6 miles<br><br>(17 km) | 9.6 miles<br><br>(15.4 km) |
| Tower to anticlockwise | 50 | 51 | 52 | 53 | 54 | 55 |
| Distance to anticlockwise station | 8.1 miles<br><br>(13 km) | 8.9 miles<br><br>(14.3 km) | 7.6 miles<br><br>(12.2 km) | 7.8 miles<br><br>(12.6 km) | 12.3 miles<br><br>(19.8 km) | 10.6 miles<br><br>(17 km) |

**Table 4.1.1. continued. Surviving Features and Signal Station Data for County Galway.**

| Name | Inishturk Signal Station | Clare Island Signal Station | Saddle Hill Signal Station | Glash Signal Station | Tower Hill Signal Station | Benwee Head Signal Station | Glinsk Head Signal Station | Creevagh Signal Station |
|---|---|---|---|---|---|---|---|---|
| Station Number | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 |
| Easting (ITM) | 460548 | 465182 | 461745 | 460843 | 472295 | 481243 | 494970 | 516852 |
| Northing (ITM) | 775201 | 785381 | 807342 | 819531 | 836074 | 843018 | 841686 | 840168 |
| Elevation | 192 m | 143 m | 195 m | 56 m | 132 m | 160 m | 253 m | 72 m |
| SMR Number | N | MA084-001002- | N | N | N | N | N | MA007-015002- |
| NIAH Number | 31309401 | 31308401 | 31304201 | 31302403 | - | - | - | - |
| Condition | Partially complete | Partially complete | Partially complete | Largely complete | Low ruin | Low ruin | Low ruin | Demolish -ed |
| Semi-Basement | Y | Y | Y | Y | ? | ? | ? | ? |
| Semi-Basement Chutes | ? | ? | 1 | 2 | ? | ? | 1 | ? |
| Ground-Floor | Y | Y | Y | Y | Y | Y | Y | ? |
| Ground-Floor Fireplace | Y | Y | Y | Y | ? | ? | ? | ? |
| Ground-Floor Alcove | 2 | 2 | 2 | 2 | ? | ? | ? | ? |
| Ground-Floor Alcove Chutes | 1 | N | 1 | N | ? | ? | ? | ? |
| Ground-Floor Windows | 4 | 4 | 4 | 4 | ? | ? | ? | ? |
| Ground-Floor External Window Bars | ? | ? | ? | ? | ? | ? | ? | ? |
| Ground-Floor Internal Window Bars | ? | ? | ? | ? | ? | ? | ? | ? |
| Split Mezzanine Level | ? | N | N | N | ? | ? | ? | ? |
| First-Floor | ? | Y | N | Y | ? | ? | ? | ? |

**Table 4.1.2. Surviving Features and Signal Station Data for County Mayo. Where a particular field did not apply this is marked by a '–' symbol. Where the status of a particular field was not established this is marked by a '?' symbol.**

| Name | Inishturk Signal Station | Clare Island Signal Station | Saddle Hill Signal Station | Glash Signal Station | Tower Hill Signal Station | Benwee Head Signal Station | Glinsk Head Signal Station | Creevagh Signal Station |
|---|---|---|---|---|---|---|---|---|
| First-Floor Fireplace | ? | ? | Y | Y | ? | ? | ? | ? |
| First-Floor Alcoves | ? | ? | 2 | 2 | ? | ? | ? | ? |
| First-Floor Windows | ? | 2 | ? | 4 | ? | ? | ? | ? |
| First-Floor Internal Window Bars | ? | ? | ? | ? | ? | ? | ? | ? |
| First-Floor Door | ? | ? | ? | Y | ? | ? | ? | ? |
| Internal Door Bar | ? | ? | ? | ? | ? | ? | ? | ? |
| Attic Level | ? | ? | N | N | ? | ? | ? | ? |
| Parapet Level | ? | ? | Y | Y | ? | ? | ? | ? |
| Bartizans | ? | Y | Y | Y | Y | ? | ? | ? |
| Machicolation | ? | ? | ? | ? | ? | ? | ? | ? |
| Vertical Drain | N | N | N | N | ? | ? | ? | ? |
| Chimney Bulge | Y | Y | Y | N | ? | ? | ? | ? |
| Chimney Stack | ? | ? | ? | Y | ? | ? | ? | ? |
| Coping Stones | ? | ? | ? | N | ? | ? | ? | ? |
| Internal Render | ? | Y | Y | Y | ? | ? | ? | ? |
| External Render | ? | ? | Y | ? | ? | ? | ? | ? |
| Weather-proof Slates | ? | ? | ? | ? | ? | ? | ? | ? |
| Enclosure | N | Y | Y | Y | Y | N | Y | Y* |
| Contemporary Buildings | 0 | 2 | 1 | 1 | 1 | 0 | 1 | 0 |
| Contemporary Road | N | N | N | N | N | N | N | Y |
| Lime Kiln | Y | Y | Y | ? | ? | ? | ? | ? |

**Table 4.1.2. continued. Surviving Features and Signal Station Data for County Mayo.**

| **Name** | **Inishturk Signal Station** | **Clare Island Signal Station** | **Saddle Hill Signal Station** | **Glash Signal Station** | **Tower Hill Signal Station** | **Benwee Head Signal Station** | **Glinsk Head Signal Station** | **Creevagh Signal Station** |
|---|---|---|---|---|---|---|---|---|
| Signal Mast Mount | ? | ? | Y | Y | Y | ? | ? | ? |
| Secondary Buildings | N | 2 | 1 | N | N | N | N | N |
| Look Out Post (L.O.P.) | N | N | N | Y | N | N | N | N |
| Distance to L.O.P. | - | - | - | 2066 m | - | - | - | - |
| Eire Sign | N | N | N | Y | N | N | N | N |
| Distance to Eire Sign | - | - | - | 124 m | - | - | - | - |
| 1st Edition OS Map | **Signal Tower**. Shown as triangular symbol. Lime Kiln shown 21 m NW of tower. | **Signal Tower**. Shown as triangular symbol inside rectangular enclosure. | **Signal Tower**. Shown as small rectangle inside trapezoidal enclosure. | **Glash Signal Tower**. Shown as triangular symbol inside rectangular enclosure. Small building shown within SW corner of enclosure. | Small rectangular building shown inside rectangular enclosure. | **Signal Post**. Shown as small rectang-le. No road is shown. | **Old Signal Tower**. Shown as small square. | **Tower**. Shown as small rectangle . |
| 2nd Edition OS Map | **Signal Tower**. Shown as triangular symbol. | **Signal Tower**. Shown as triangular symbol inside rectangular enclosure. | **Signal Tower (In Ruins)**. Shown as a small rectangle within a rectangular enclosure containing other marks of unknown meaning. | **Glash Signal Tower (In Ruins)**. Shown as triangular symbol inside rectangular enclosure. Small building shown within SW corner of enclosure. | Small rectangular building shown inside rectangular enclosure. A smaller building is shown in NW corner of enclosure. | Neither tower or road shown. | **Old Signal Tower (In Ruins)**. Shown as small square with bench mark symbol and B.M. 915.1. | Nothing shown |
| Tower to clockwise | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65a |
| Distance to clockwise station | 6.4 miles (10.3 km) | 13.8 miles (22.2 km) | 7.8 miles (12.6 km) | 12.1 miles (19.4 km) | 7.3 miles (11.7 km) | 8.8 miles (14.2 km) | 13.5 miles (21.7 km) | 9.1 miles (14.6 km) |

**Table 4.1.2. continued. Surviving Features and Signal Station Data for County Mayo.**

| Name | Inishturk Signal Station | Clare Island Signal Station | Saddle Hill Signal Station | Glash Signal Station | Tower Hill Signal Station | Benwee Head Signal Station | Glinsk Head Signal Station | Creevagh Signal Station |
|---|---|---|---|---|---|---|---|---|
| Tower to anticlockwise | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
| Distance to anticlockwise station | 9.6 miles (15.4 km) | 6.4 miles (10.3 km) | 13.8 miles (22.2 km) | 7.8 miles (12.6 km) | 12.1 miles (19.4 km) | 7.3 miles (11.7 km) | 8.8 miles (14.2 km) | 13.5 miles (21.7 km) |

**Table 4.1.2. continued. Surviving Features and Signal Station Data for County Mayo.**

| **Name** | **Lenadoon Point** | **Rathlee** | **Carrowmably** | **Knocklane Hill** | **Streedagh** | **Kilcologue Point** |
|---|---|---|---|---|---|---|
| Station Number | 65a | 65 | 66 | 67 | 68 | 69 |
| Easting (ITM) | 531350 | 532185 | 542668 | 556252 | 563137 | 569623 |
| Northing (ITM) | 838795 | 837337 | 835073 | 844589 | 851226 | 857933 |
| Elevation | 7 m | 29 m | 83 m | 58 m | 15 m | 23 m |
| SMR Number | SL010-001002- | SL011-025001- | SL012-008003- | N | N | N |
| NIAH Number | - | - | 32401201 | - | - | - |
| Condition | Largely Complete | Partially complete | Largely Complete | Low ruin | Low ruin | Low ruin |
| Semi-Basement | Y | Y | Y | ? | Y | ? |
| Semi-Basement Chutes | 1 | ? | 1 | ? | ? | ? |
| Ground-Floor | Y | Y | Y | Y | Y | ? |
| Ground-Floor Fireplace | ? | Y | Y | Y | ? | ? |
| Ground-Floor Alcove | ? | 2 | 2 | 2 | ? | ? |
| Ground-Floor Alcove Chutes | ? | N | N | 2 | ? | ? |
| Ground-Floor Windows | ? | 4 | 4 | ? | ? | ? |
| Ground-Floor External Window Bars | ? | ? | Y | ? | ? | ? |
| Ground-Floor Internal Window Bars | ? | Y | Y | ? | ? | ? |
| Split Mezzanine Level | ? | Y | Y | ? | ? | ? |
| First-Floor | ? | Y | Y | ? | ? | ? |
| First-Floor Fireplace | ? | Y | Y | ? | ? | ? |
| First-Floor Alcoves | ? | 2 | 2 | ? | ? | ? |
| First-Floor Windows | ? | 4 | 4 | ? | ? | ? |
| First-Floor Internal Window Bars | ? | Y | Y | ? | ? | ? |
| First-Floor Door | ? | Y | Y | ? | ? | ? |
| Internal Door Bar | ? | Y | N | ? | ? | ? |
| Attic Level | ? | N | Y | ? | ? | ? |

**Table 4.1.3. Surviving Features and Signal Station Data for County Sligo. Where a particular field did not apply this is marked by a '–' symbol. Where the status of a particular field was not established this is marked by a '?' symbol.**

| Name | Lenadoon Point | Rathlee | Carrowmably | Knocklane Hill | Streedagh | Kilcologue Point |
|---|---|---|---|---|---|---|
| Parapet Level | ? | Y | Y | ? | ? | ? |
| Bartizans | ? | 2 | 2 | ? | ? | ? |
| Machicolation | ? | Y | Y | ? | ? | ? |
| Vertical Drain | N | N | Y | Y | Y | ? |
| Chimney Bulge | Y | Y | Y | Y | ? | ? |
| Chimney Stack | ? | Y | N | ? | ? | ? |
| Coping Stones | ? | N | Y | ? | ? | ? |
| Internal Render | ? | Y | Y | Y | Y | ? |
| External Render | ? | Y | ? | ? | ? | ? |
| Weather-proof Slates | ? | ? | ? | ? | ? | ? |
| Enclosure | N | N | N | N | N | N |
| Contemporary Buildings | N | N | N | N | N | ? |
| Contemporary Road | N | Y | N | N | N | Y |
| Lime Kiln | N | Y | ? | ? | ? | Y |
| Signal Mast Mount | Y | ? | ? | ? | ? | ? |
| Secondary Buildings | N | N | N | N | N | N |
| Look Out Post (L.O.P.) | N | Y | N | Y | N | Y |
| Distance to L.O.P. | - | 13 m | - | 82.5 m | - | 651 m |
| Eire Sign | N | N | N | N | N | N |
| Distance to Eire Sign | - | - | - | - | - | - |
| 1st Edition OS Map | Small rectangular building shown at angle between two sections of field wall following the shoreline | **Tower**. Shown as Triangular symbol | **Carrowmabla Tower (In Ruins)**. Shown as small square building inside large oval field boundary | **Ruins of Telegraph**. Shown as a small rectangular building | Shown as small rectangular building | Not shown. |

**Table 4.1.3. continued. Surviving Features and Signal Station Data for County Sligo.**

| Name | Lenadoon Point | Rathlee | Carrowmably | Knocklane Hill | Streedagh | Kilcologue Point |
|---|---|---|---|---|---|---|
| 2nd Edition OS Map | **Tower (In Ruins)**. Shown as small square building | **Tower (In Ruins)**. Shown as small square building | **Carrowmabla Tower (In Ruins)**. Shown as small square building inside large oval banked and ditched enclosure | **Watch Tower (In Ruins)**. Shown as small square building | Shown as small square building | Not shown. |
| Tower to clockwise | 65 | 66 | 67 | 68 | 69 | 70 |
| Distance to clockwise station | 1.1 miles (1.8 km) | 6.7 miles (10.8 km) | 10.3 miles (16.6 km) | 5.9 miles (9.5 km) | 5.8 miles (9.3 km) | 7.0 miles (11.3 km) |
| Tower to anticlockwise | 64 | 65a | 65 | 66 | 67 | 68 |
| Distance to anticlockwise station | 9.1 miles (14.6 km) | 1.1 miles (1.8 km) | 6.7 miles (10.8 km) | 10.3 miles (16.6 km) | 5.9 miles (9.5 km) | 5.8 miles (9.3 km) |

**Table 4.1.3. continued. Surviving Features and Signal Station Data for County Sligo.**

| Name | St John's Point | Carrigan Head | Malin Beg | Glen Head | Dawros Head | Crohy Head |
|---|---|---|---|---|---|---|
| Station Number | 70 | 71 | 72 | 73 | 74 | 75 |
| Easting (ITM) | 570522 | 556111 | 548926 | 551891 | 563836 | 570912 |
| Northing (ITM) | 869121 | 874852 | 879699 | 886940 | 898015 | 908349 |
| Elevation | 26 m | 227 m | 35 m | 227 m | 12 m | 49 m |
| SMR Number | DG 097A020---- | N | N | N | DG 064A001---- | N |
| NIAH Number | - | 40909601 | 40908901 | 40908001 | - | - |
| Condition | Demolished | Largely Complete | Largely Complete | Largely Complete | Low ruin | Largely Complete |
| Semi-Basement | ? | ? | Y | ? | ? | Y |
| Semi-Basement Chutes | ? | N | N | N | ? | ? |
| Ground-Floor | ? | Y | Y | Y | Y | Y |
| Ground-Floor Fireplace | ? | ? | Y | ? | Y | Y |
| Ground-Floor Alcove | ? | ? | 2 | ? | 2 | 2 |
| Ground-Floor Alcove Chutes | ? | N | N | N | ? | N |
| Ground-Floor Windows | ? | 4 | 4 | 4 | ? | 4 |
| Ground-Floor External Window Bars | ? | Y | Y | Y | ? | ? |
| Ground-Floor Internal Window Bars | ? | ? | N | ? | ? | N |
| Split Mezzanine Level | ? | ? | N | ? | ? | Y |
| First-Floor | ? | ? | Y | Y | ? | Y |
| First-Floor Fireplace | ? | ? | Y | ? | ? | Y |
| First-Floor Alcoves | ? | ? | 2 | ? | ? | 2 |
| First-Floor Windows | ? | 4 | 4 | 4 | ? | 4 |
| First-Floor Internal Window Bars | ? | ? | N | ? | ? | N |
| First-Floor Door | ? | Y | Y | Y | ? | Y |
| Internal Door Bar | ? | ? | ? | ? | ? | N |

**Table 4.1.4. Surviving Features and Signal Station Data in the South of County Donegal. Where a particular field did not apply this is marked by a '–' symbol. Where the status of a particular field was not established this is marked by a '?' symbol.**

| Name | St John's Point | Carrigan Head | Malin Beg | Glen Head | Dawros Head | Crohy Head |
|---|---|---|---|---|---|---|
| Attic Level | ? | ? | Y | ? | ? | Y |
| Parapet Level | ? | Y | Y | Y | ? | Y |
| Bartizans | ? | 2 | 2 | 2 | ? | 2 |
| Machicolation | ? | Y | Y | N | ? | Y |
| Vertical Drain | ? | ? | Y | ? | Y | Y |
| Chimney Bulge | ? | Y | Y | Y | ? | Y |
| Chimney Stack | ? | Y | Y | N | ? | Y |
| Coping Stones | ? | Y | Y | Y | ? | N |
| Internal Render | ? | ? | Y | Y | ? | Y |
| External Render | ? | ? | Y | Y | ? | Y |
| Weather-proof Slates | ? | ? | ? | ? | ? | ? |
| Enclosure | Y | Y | N | N | N | N |
| Contemporary Buildings | ? | N | N | 2 | 1 | N |
| Contemporary Road | N | Y | Y | Y | N | ? |
| Lime Kiln | ? | ? | ? | ? | ? | ? |
| Signal Mast Mount | ? | ? | ? | ? | ? | Y |
| Secondary Buildings | ? | ? | 1 | ? | ? | ? |
| Look Out Post (L.O.P.) | Y | Y | N | N | N | Y |
| Distance to L.O.P. | 100 m | 15 m | - | - | - | 197 m |
| Eire Sign | Y | N | N | N | N | N |
| Distance to Eire Sign | 435 m | - | - | - | - | - |

**Table 4.1.4. continued. Surviving Features and Signal Station Data in the South of County Donegal.**

| **Name** | **St John's Point** | **Carrigan Head** | **Malin Beg** | **Glen Head** | **Dawros Head** | **Crohy Head** |
|---|---|---|---|---|---|---|
| 1st Edition OS Map | **Old Watch Tower**. Shown as a triangular symbol located immediately SW of rhomboid shaped enclosure. Road to lighthouse not shown | **Carrigan Head Tower.** Shown as triangular symbol. A trackway is shown leading to the site from the NE | **Malin Beg Tower.** Shown as small rectangular building. A road is shown leading directly to the site | **Glenhead Tower.** Shown as triangular symbol. Road shown leading to the site from the SE | **Ruins of Signal Tower.** Shown as small rectangular building | **Crohy Tower.** Shown as small square building |
| 2nd Edition OS Map | **Not shown** | **Signal Tower (In Ruins).** Shown as square building with rectangular enclosure to the immediate NE. A trackway is shown leading to the site from the NE | **Malin Beg Tower (In Ruins).** Shown as small rectangular building and Bench Mark (B.M.115.5). Road shown leading directly to the site from the NE | **Glenhead Tower (In Ruins).** Shown as small square building. Road shown leading to the site from the SE | **Signal Tower (In Ruins).** Shown as small rectangular building | **Crohy Tower.** Shown as small square building |
| Tower to clockwise | 71 | 72 | 73 | 74 | 75 | 76 |
| Distance to clockwise station | 9.6 miles (15.5 km) | 5.4 miles (8.7 km) | 4.9 miles (7.8 km) | 10 miles (16.2 km) | 7.8 miles (12.6 km) | 8.2 miles (13.1 km) |
| Tower to anticlockwise | 69 | 70 | 71 | 72 | 73 | 74 |
| Distance to anticlockwise station | 7 miles (11.3 km) | 9.6 miles (15.5 km) | 5.4 miles (8.7 km | 4.9 miles (7.8 km) | 10 miles (16.2 km) | 7.8 miles (12.6 km) |

**Table 4.1.4. continued. Surviving Features and Signal Station Data in the South of County Donegal.**

| **Name** | **Mullaghderg Hill** | **Bloody Foreland** | **Horn Head** | **Melmore Head** | **Fanad Head** | **Malin Head** |
|---|---|---|---|---|---|---|
| Station Number | 76 | 77 | 78 | 79 | 80 | 81 |
| Easting (ITM) | 570522 | 556111 | 601324 | 613529 | 623392 | 639699 |
| Northing (ITM) | 869121 | 874852 | 941739 | 945241 | 947718 | 959518 |
| Elevation | 52 m | 60 m | 187 m | 48 m | 15 m | 69 m |
| SMR Number | N | DG 023-003---- | N | DG 008-027---- | N | DG 001-006---- |
| NIAH Number | N | N | 40901510 | N | N | 40900113 |
| Condition | Largely Complete | Demolished | Low Ruin | Low Ruin | Demolished | Largely Complete |
| Semi-Basement | Y | ? | ? | ? | ? | ? |
| Semi-Basement Chutes | ? | ? | ? | ? | ? | ? |
| Ground-Floor | Y | ? | Y | Y | Y | Y |
| Ground-Floor Fireplace | Y | ? | ? | N | ? | ? |
| Ground-Floor Alcove | 2 | ? | 1 | ? | ? | ? |
| Ground-Floor Alcove Chutes | ? | ? | ? | ? | ? | ? |
| Ground-Floor Windows | 4 | ? | 3 | ? | Y | ? |
| Ground-Floor External Window Bars | ? | ? | ? | ? | ? | ? |
| Ground-Floor Internal Window Bars | N | ? | N | ? | ? | ? |
| Split Mezzanine Level | Y | ? | Y | ? | ? | ? |
| First-Floor | Y | ? | Y | ? | Y | Y |
| First-Floor Fireplace | Y | ? | ? | ? | ? | ? |
| First-Floor Alcoves | 2 | ? | ? | ? | ? | ? |
| First-Floor Windows | 4 | ? | ? | ? | Y | ? |
| First-Floor Door | N | ? | ? | ? | ? | Y |
| Internal Door Bar | N | ? | ? | ? | ? | ? |
| Attic Level | Y | ? | ? | ? | Y | ? |
| Parapet Level | N | ? | ? | ? | Y | Y |

**Table 4.1.5. Surviving Features and Signal Station Data in the North of County Donegal. Where a particular field did not apply this is marked by a '–' symbol. Where the status of a particular field was not established this is marked by a '?' symbol.**

| Name | Mullaghderg Hill | Bloody Foreland | Horn Head | Melmore Head | Fanad Head | Malin Head |
|---|---|---|---|---|---|---|
| Bartizans | ? | ? | ? | ? | Y | 2 |
| Machicolation | ? | ? | ? | ? | ? | Y |
| Vertical Drain | Y | ? | ? | ? | ? | ? |
| Chimney Bulge | Y | ? | ? | ? | ? | N |
| Chimney Stack | ? | ? | ? | ? | Y | Y |
| Coping Stones | ? | ? | ? | ? | ? | ? |
| Internal Render | Y | ? | Y | ? | ? | ? |
| External Render | Y | ? | Y | ? | ? | ? |
| Weather-proof Slates | Y | ? | ? | ? | ? | ? |
| Enclosure | N | N | Y | Y | N | Y |
| Contemporary Buildings | N | ? | 3 | 2 | 1 or 2 | ? |
| Contemporary Road | N | N | Y | N | ? | N |
| Lime Kiln | ? | ? | ? | ? | ? | ? |
| Signal Mast Mount | ? | ? | Y | ? | N | ? |
| Secondary Buildings | N | ? | N | N | Y | Y |
| Look Out Post (L.O.P.) | N | N | Y | Y | Y | Y |
| Distance to L.O.P. | - | - | 779 m | 2211 m | 173 m | 115 m |
| Eire Sign | N | Y | N | Y | N | Y |
| Distance to Eire Sign | - | 404 m | - | 1619 m | - | 185 m |

**Table 4.1.5. continued. Surviving Features and Signal Station Data in the North of County Donegal.**

| Name | Mullaghderg Hill | Bloody Foreland | Horn Head | Melmore Head | Fanad Head | Malin Head |
|---|---|---|---|---|---|---|
| 1st Edition OS Map | **Mullaghderg Tower.** Shown as small rectangular building | **Signal Tower.** Shown as small triangular symbol | **Horn Head Tower.** Shown as small triangular symbol | **Melmore Tower.** Shown as small square building inside a rectangular enclosure. A small building is shown built against the SE corner of the enclosure | May be visible as a small rectangular building immediately SE of the Lighthouse but this may be a building that is contemporary with the Lighthouse | **Malin Tower.** Shown as small triangular symbol inside rectangular enclosure. Second similar sized rectangular enclosure located 58 m to the south |
| 2nd Edition OS Map | **Mullaghderg Signal Tower (In Ruins).** Shown as a small rectangular building. A rectangular enclosure is shown a short distance to the W. Two points in the enclosure are marked S.P. (Signal Post) and F.S. (Flagstaff?) presumably part of a later signalling station | **Signal Tower (In Ruins).** Shown as small square building | **Horn Head Signal Tower (In Ruins).** Shown as a confusing set of lines denoting a small but complicated building inside a rectangular enclosure. A small building is shown built against the NW corner of the enclosure | **Melmore Tower (In Ruins).** Shown as a small square building inside a rectangular enclosure. A field wall connects to the SE and SW corners of the enclosure | Lighthouse complex shown as having expanded considerably covering the area where the tower may have been shown on the first edition map | **Malin Tower (Lloyds Signal Station).** Shown as small triangular symbol. Surrounded by labels Semaphore, Watch House and Barometer |
| Tower to clockwise | 77 | 78 | 79 | 80 | 81 | - |
| Distance to clockwise station | 8.7 miles (14.3 km) | 13.2 miles (22.2 km) | 7.9 miles (12.6 km) | 10 miles (16.2 km) | 6.3 miles (10.1 km) | - |
| Tower to anticlockwise | 75 | 76 | 77 | 78 | 79 | 80 |
| Distance to anticlockwise station | 8.2 miles (13.1 km) | 8.7 miles (14.3 km) | 13.2 miles (22.2 km) | 7.9 miles (12.6 km) | 10 miles (16.2 km) | 6.3 miles (10.1 km) |

**Table 4.1.5. continued. Surviving Features and Signal Station Data in the North of County Donegal.**

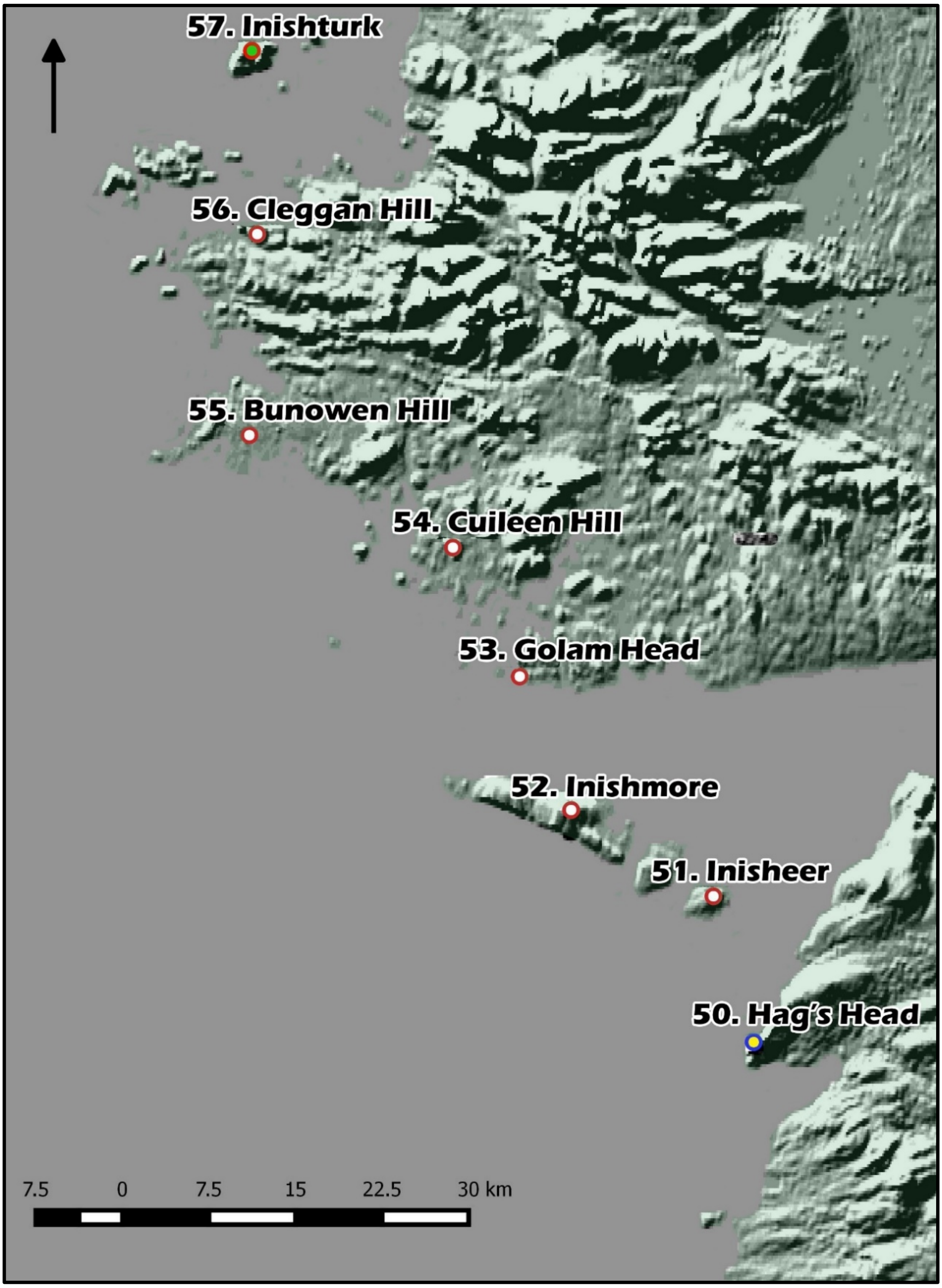


Figure 4.1. Map showing locations of County Galway signal stations (white and red) and adjacent signal stations in County Clare (yellow and blue) and County Mayo (green and red).

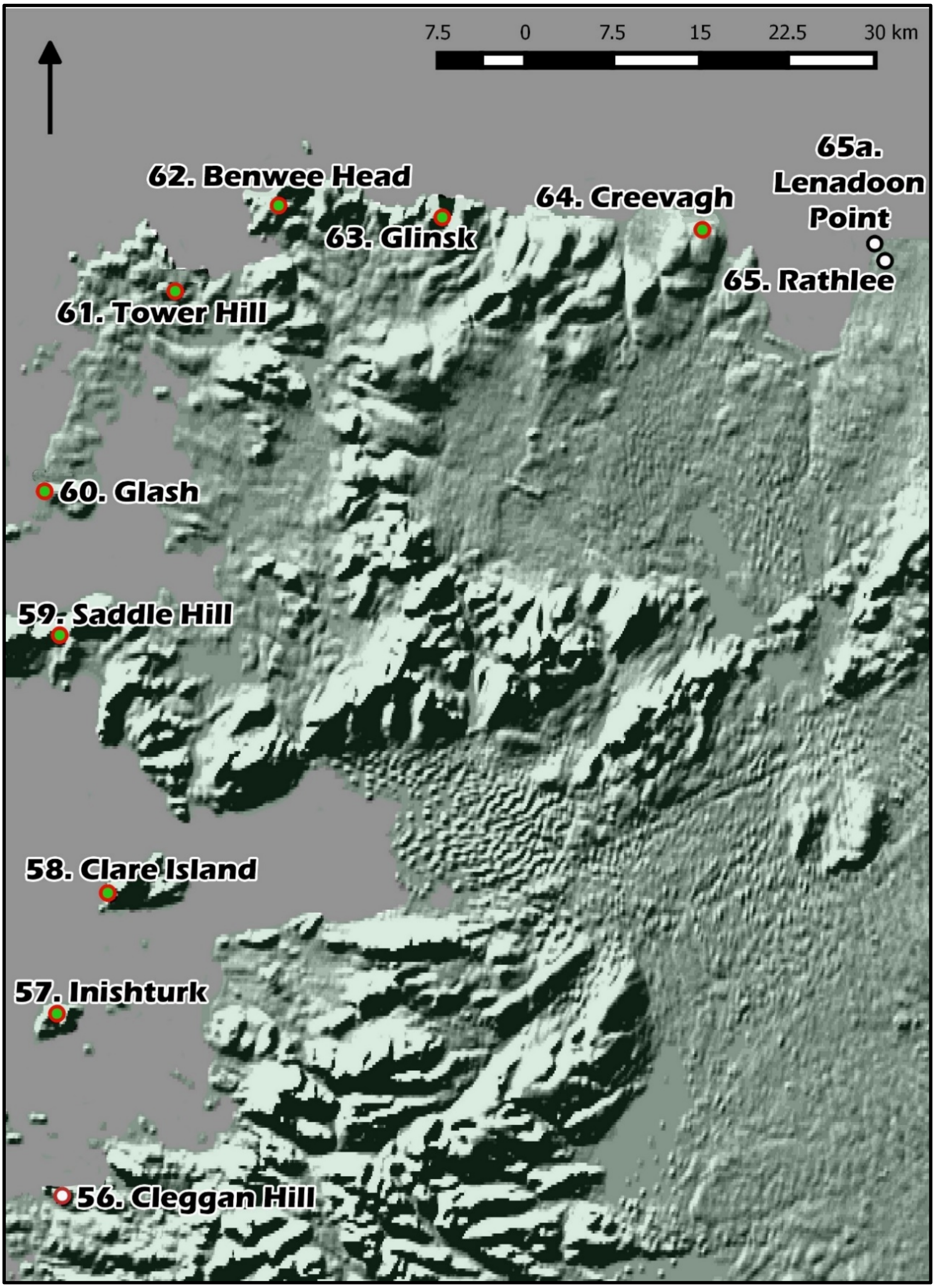


Figure 4.2. Map showing locations of County Mayo Signal Stations (green and red) and adjacent signal stations in County Galway (white and red) and County Sligo (white and black)

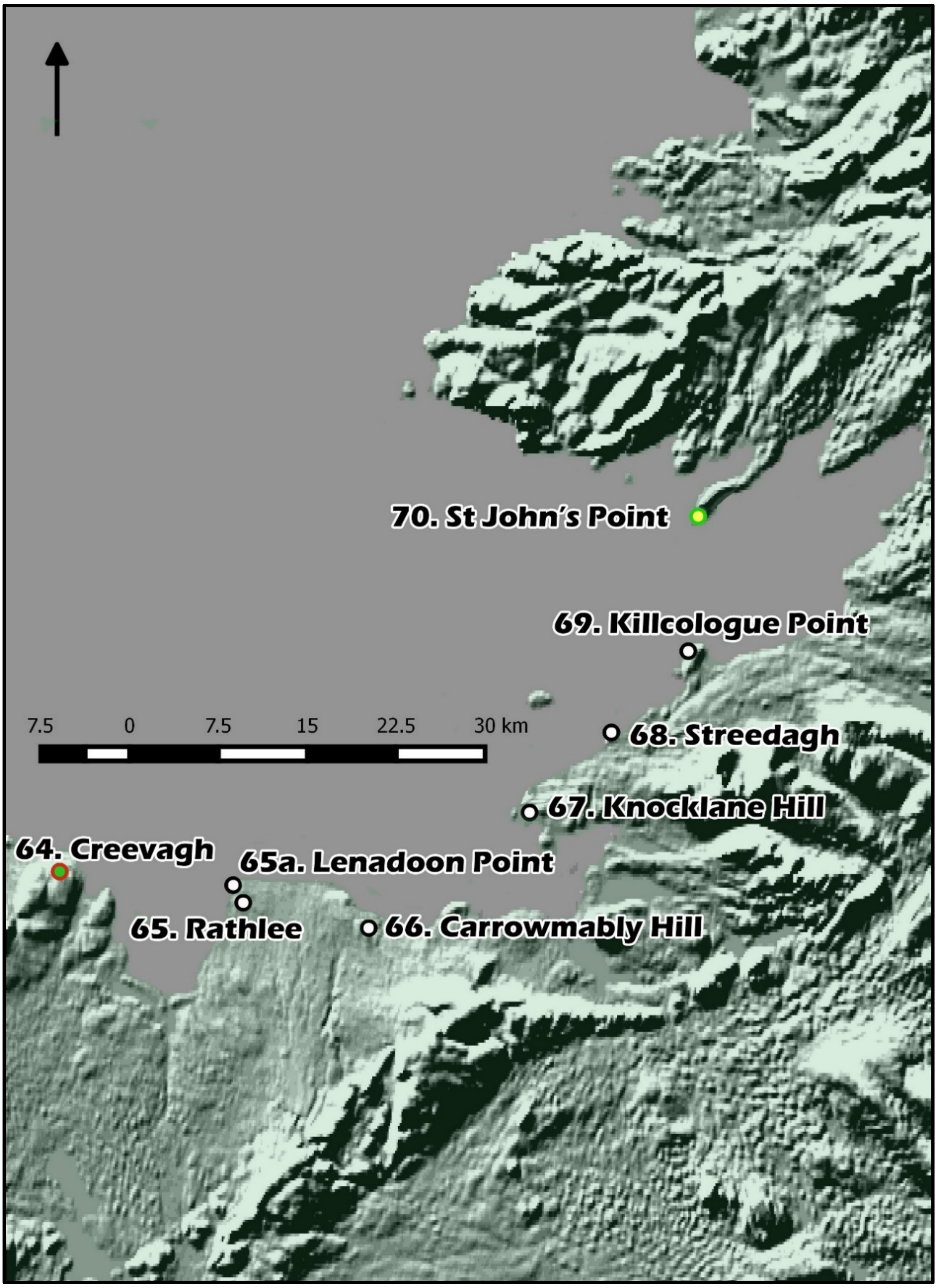


**Figure 4.3. Map showing locations of County Sligo Signal Stations (white and black) and adjacent signal stations in County Mayo (green and red) and County Donegal (yellow and green).**

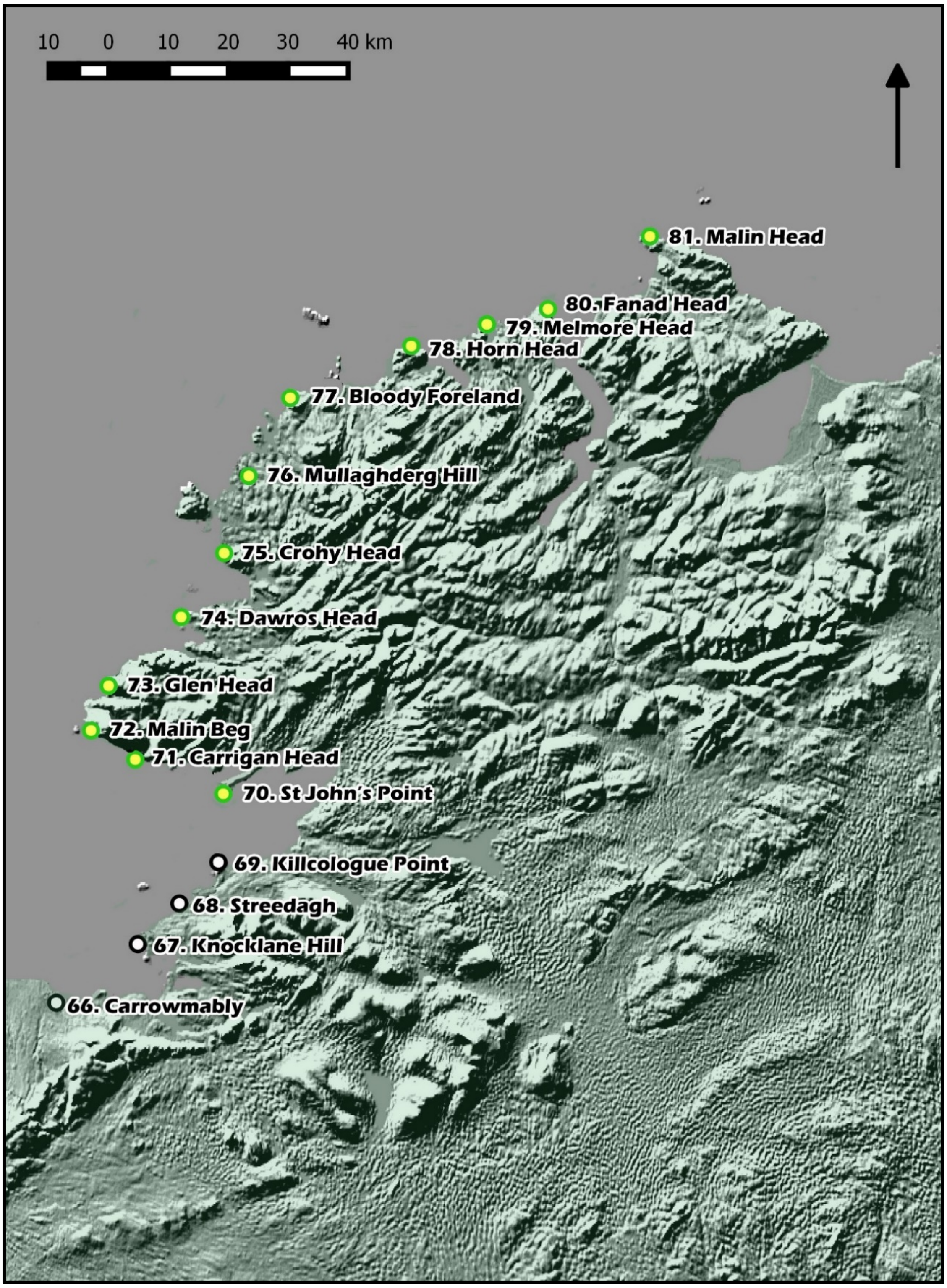


Figure 4.4. Map showing locations of County Donegal Signal Stations (yellow and green) and adjacent signal stations in County Sligo (white and black).

## 4.2. The standard Signal Tower

The signal towers that formed the most prominent surviving element at the signal station sites followed a very consistent design[11] (Figures 4.5). Each tower was square, or very nearly square in plan, measuring between 5.8 m and 6.1 m (19' and 20') externally and 4.25 m and 4.35 m (13' 11'' and 14' 3'') internally, giving a wall thickness of between 0.75 m and 0.9 m (2' 6'' and 3'). The building foundations were typically excavated to a depth of between 1.06 m and 1.37 m (3' 6'' and 4' 6'') into bedrock and a drain or sewer ran under the base of the tower (NLI Mss 14, 918; letter from Alexander Stewart to Major General Affleck, dated 4 May 1805).

The walls consisted of roughly coursed stones with long rectangular horizontal quoin stones at the corners, laid in an alternating pattern where the long side of a block ran down a different side of the building to the blocks immediately above and below it. Between the quoin stones the courses consisted of a random assortment of large and medium field stones, with smaller stones used to fill in the gaps. Although the coursed stonework was mortared it very much resembled the style of dry-stone wall building found in the vernacular building tradition across Ireland in the 19th century (Ó Danachair 1957, 68-9; Kingston 1990; Aalen 2011a, 221-3).

At most of the well-preserved sites in the main study area, dressed stones were used around the doorway, the windows, and for the supports and floors of the machicolation and bartizans. At five of the signal towers (16%) the tops of the walls were capped by dressed wedge-shaped coping stones that projected a little beyond the external wall face. These coping stones would have been particularly easy to remove, and it is suspected that they were originally used far more extensively. In all cases the cut stone used at the signal towers was quite different from the stones making up the bulk of the walls, which consisted of locally sourced undressed field stones. At well-preserved sites where the cut stone surrounds of the windows and door were missing the former presence of the surrounds was indicated by shallow gaps in the outer wall faces where the stones had been removed.

[11] It was noted during the survey that the buildings were constructed according to standardised imperial measurements. Tape measurements were recorded in metric for convenience and subsequently converted to imperial values using an online conversion program.

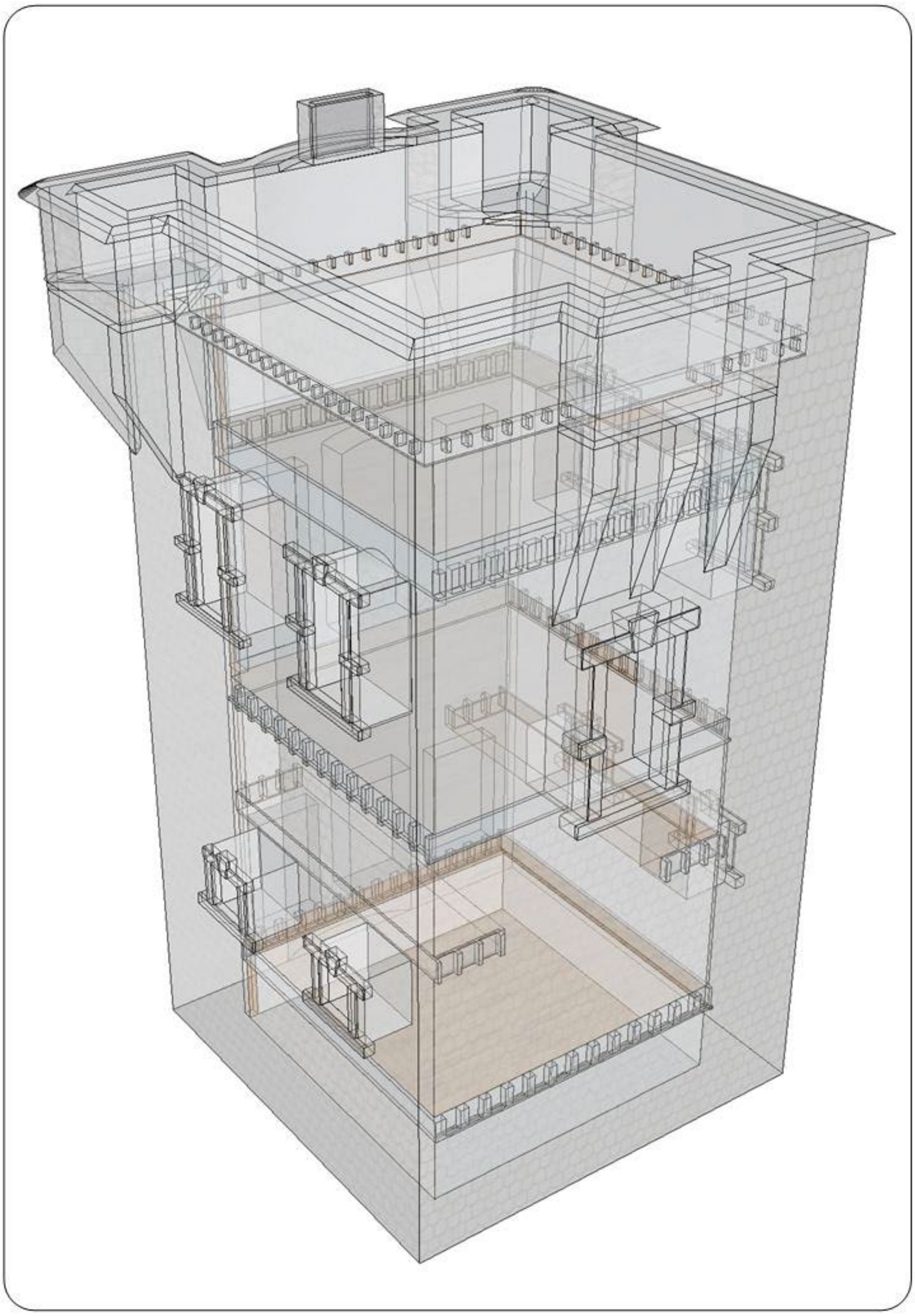

Figure 4.5. Transparent 3D model of an idealised signal tower showing internal structures, with the front wall at the front right and the rear wall at the rear left.

Although not subject to detailed petrographic analysis, the cut stone found across the main study area appeared to be a mixture of limestone, schist, quartzite, or gneiss blocks. The origin of the cut stone has not been determined, but it may have been derived from the locality of the signal stations. Details of the cut stones are included in the individual entries in Appendices A – D.

The original height of the walls was difficult to establish. In some cases, towers were built on slightly sloping ground requiring the downslope portions to be taller than the upslope portions, most notably at Cleggan Hill Signal Station, County Galway. Concealment of the contemporary ground surface by rubble or overgrowth also prevented accurate measurements. Heights of the external walls at the largely intact signal towers varied between 10.7 m and 12.2 m (35’ and 40’), based on the results of the photogrammetry surveys.

Previous accounts of the signal towers have stated that the exterior walls were covered in render over which there was a dense layer of small ‘weather-proof’ slates (Kerrigan 1995, 158; Clements 2013, 100). Fragments of render can be seen on the external walls at most of the sites with substantial remains, but only the signal towers at Inisheer and Inishmore Signal Stations, County Galway, feature extensive intact areas of intact slates. Fragments of slates can also be seen at Crohy Head and Mullaghderg Hill Signal Stations, County Donegal. Descriptions of the external render and slate cladding are detailed in the individual entries in Appendices A through D. The signal tower at Golam Head Signal Station is now entirely devoid of external render and weather slates, even though their presence is fully attested to in a contemporary document, indicating that a modern absence of render need not be an original feature.

## 4.2.1 The exterior walls

Each of the well-preserved signal towers demonstrated the same arrangement of basic features;

- A ‘front’ wall with a door on the first-floor, originally accessed via a ladder.
- Two ‘side’ walls with opposing pairs of windows on the ground-floor and first-floor
- A ‘rear’ wall with no large openings but a slight bulge in the central portion that incorporates a chimney flue. The wall would have been topped by a centrally located chimney stack, although this was rarely still present.

Figures 4.6 through 4.9 show oblique views of the 3D model of the standard signal tower (Section 3.3.6.1). Figure 4.10 shows a top-down view of the 3D model of the standard signal tower. Figures 4.11 through 4.14 show side elevations of the 3D model of the standard signal tower.

### 4.2.1.1 The front wall

The front wall was identified by the presence of a doorway on the first-floor which was positioned facing out towards the sea in the majority of recorded examples. In examples where the upper parts of the tower had not survived the location of ground-floor features on the other walls could normally be used to identify which was the front wall. The wall consisted of roughly coursed rubble with alternating quoin stones at the corners. When the top of the wall was capped by dressed wedge-shaped coping stones, they projected a little beyond the line of the wall. The doorways were located between 4.6 m and 5.2 m (15’ and 17’) above the ground level and were always centrally placed in the wall. Where the surround of the door survived it consisted of 10 dressed stones, with a single large sill stone at the bottom, two long stones on each side separated by a smaller rectangular stone block set perpendicular to the side of the doorway, and two short stones separated by a trapezoidal or rectangular key stone across the top. The internal measurements of the door openings were typically around 2 m (6’ 6’’) by 0.92 m (3’). Simple discharging arches were incorporated into the body of the wall above the doorways, constructed of short, rectangular field stones. The discharging arches transfer downward force (super-incumbent weight) away from the opening.

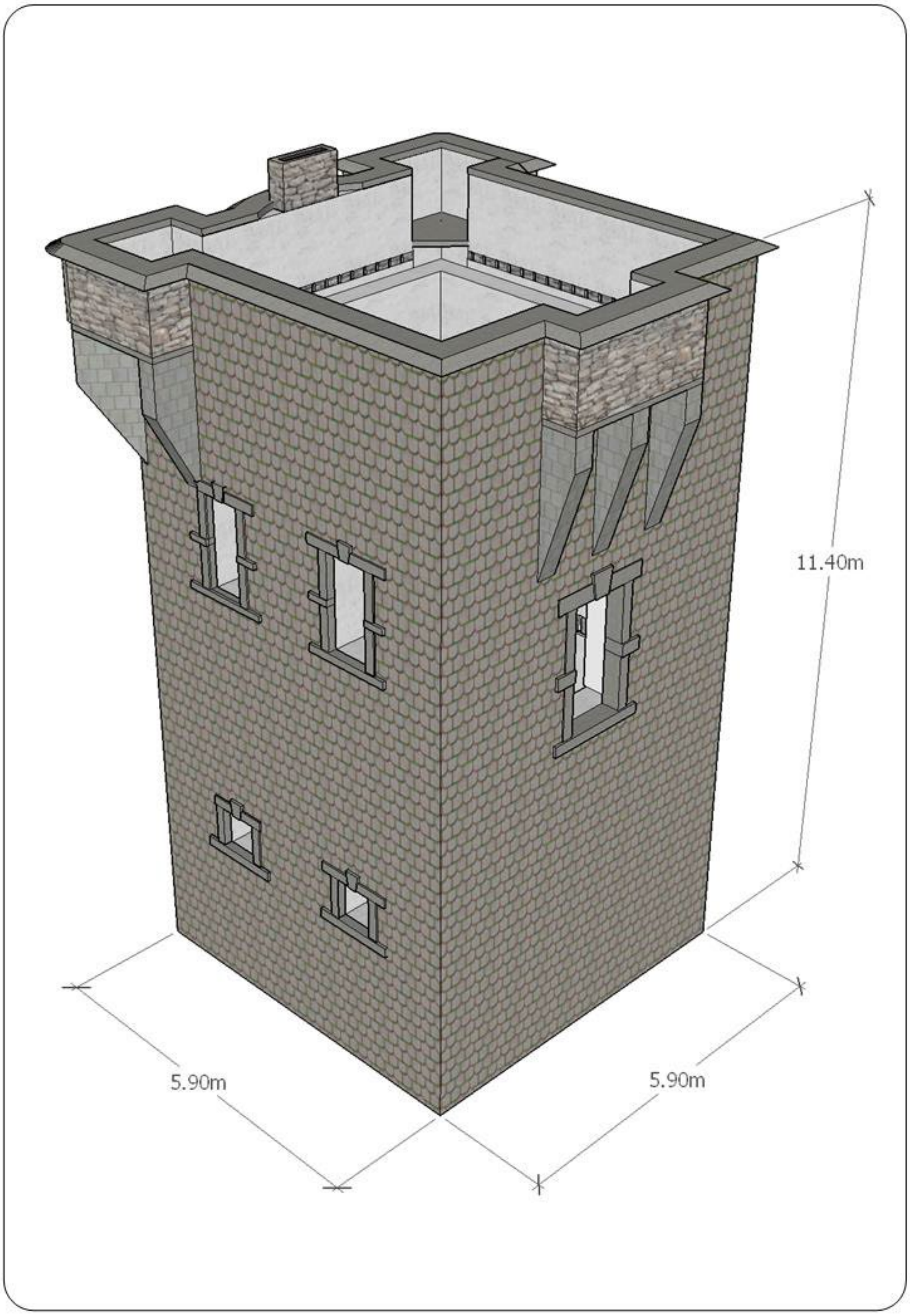


Figure 4.6. Oblique external view of rendered 3D model for an idealised signal tower showing front wall and side wall.

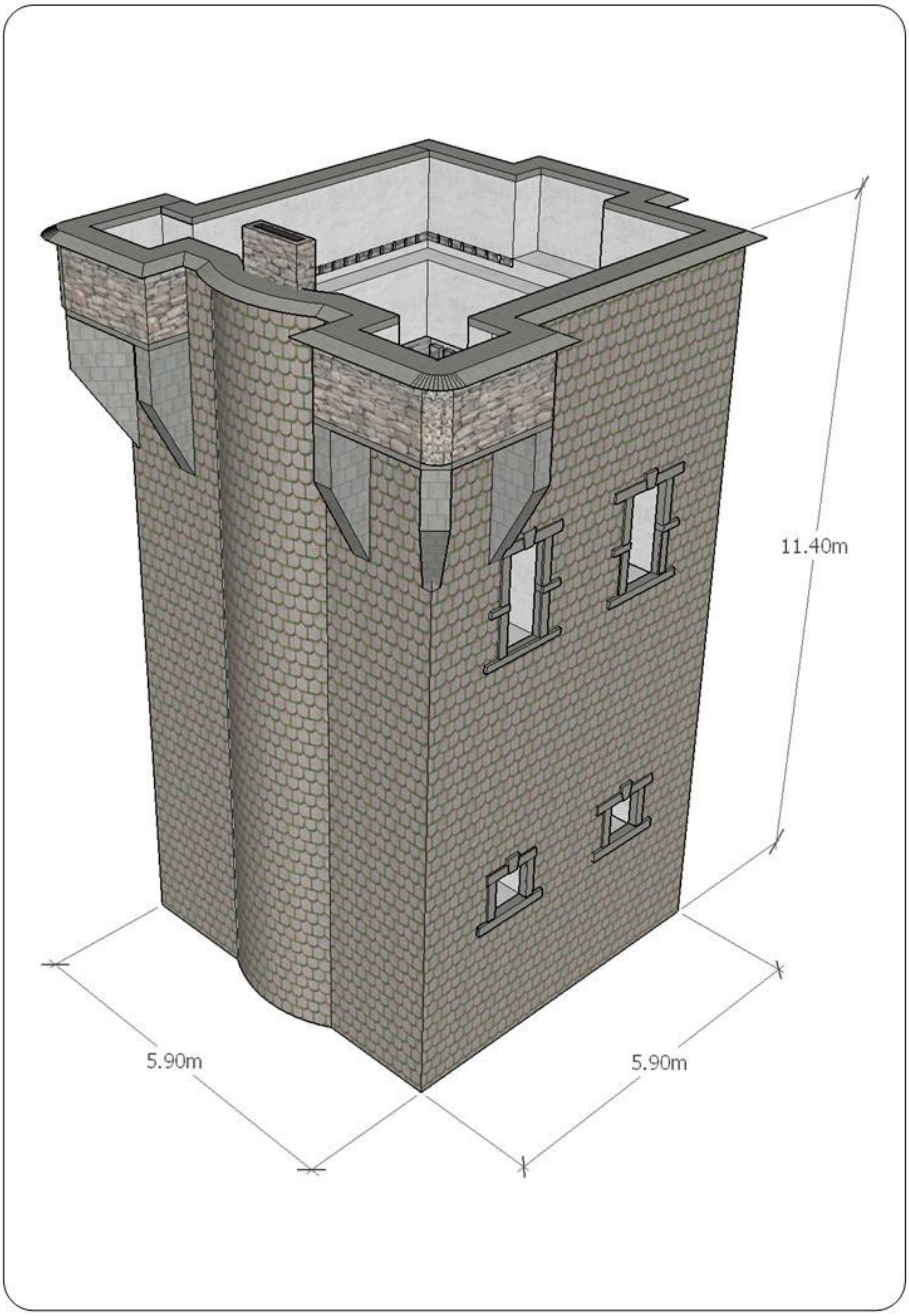


Figure 4.7. Oblique external view of rendered 3D model for an idealised signal tower showing side wall and rear wall.

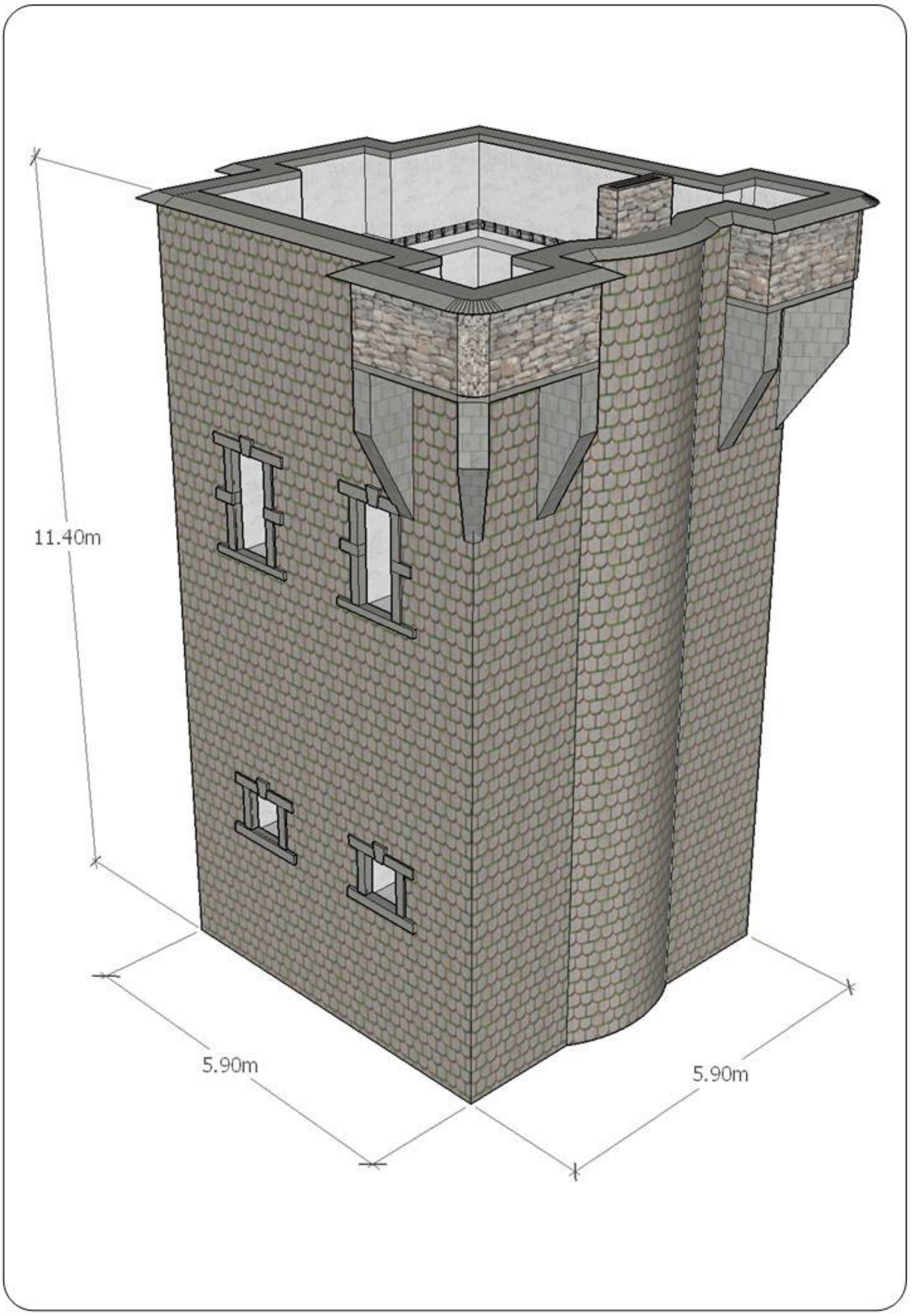


Figure 4.8. Oblique external view of rendered 3D model for an idealised signal tower showing rear wall and side wall.

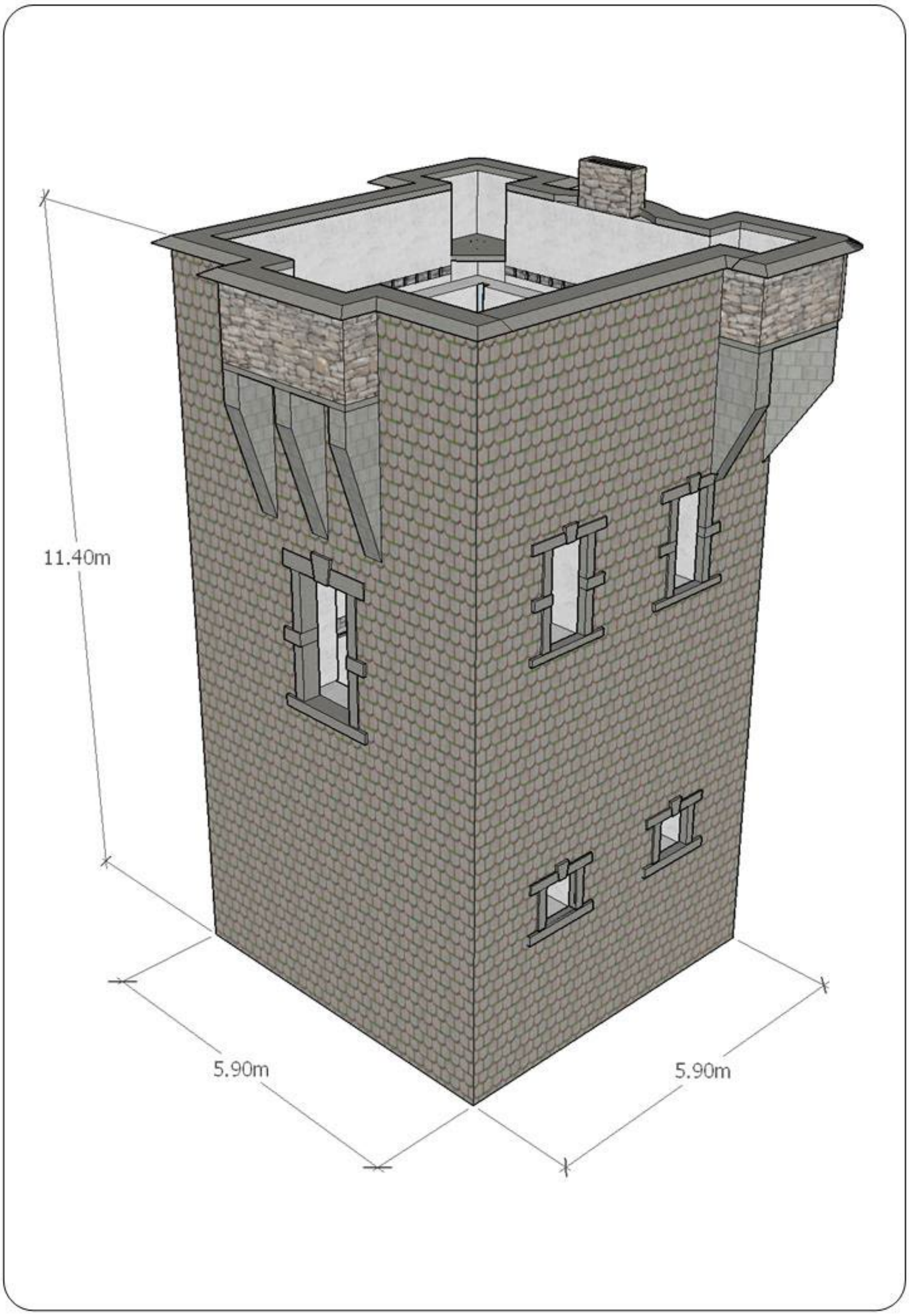


Figure 4.9. Oblique external view of rendered 3D model for an idealised signal tower showing side wall and front wall.

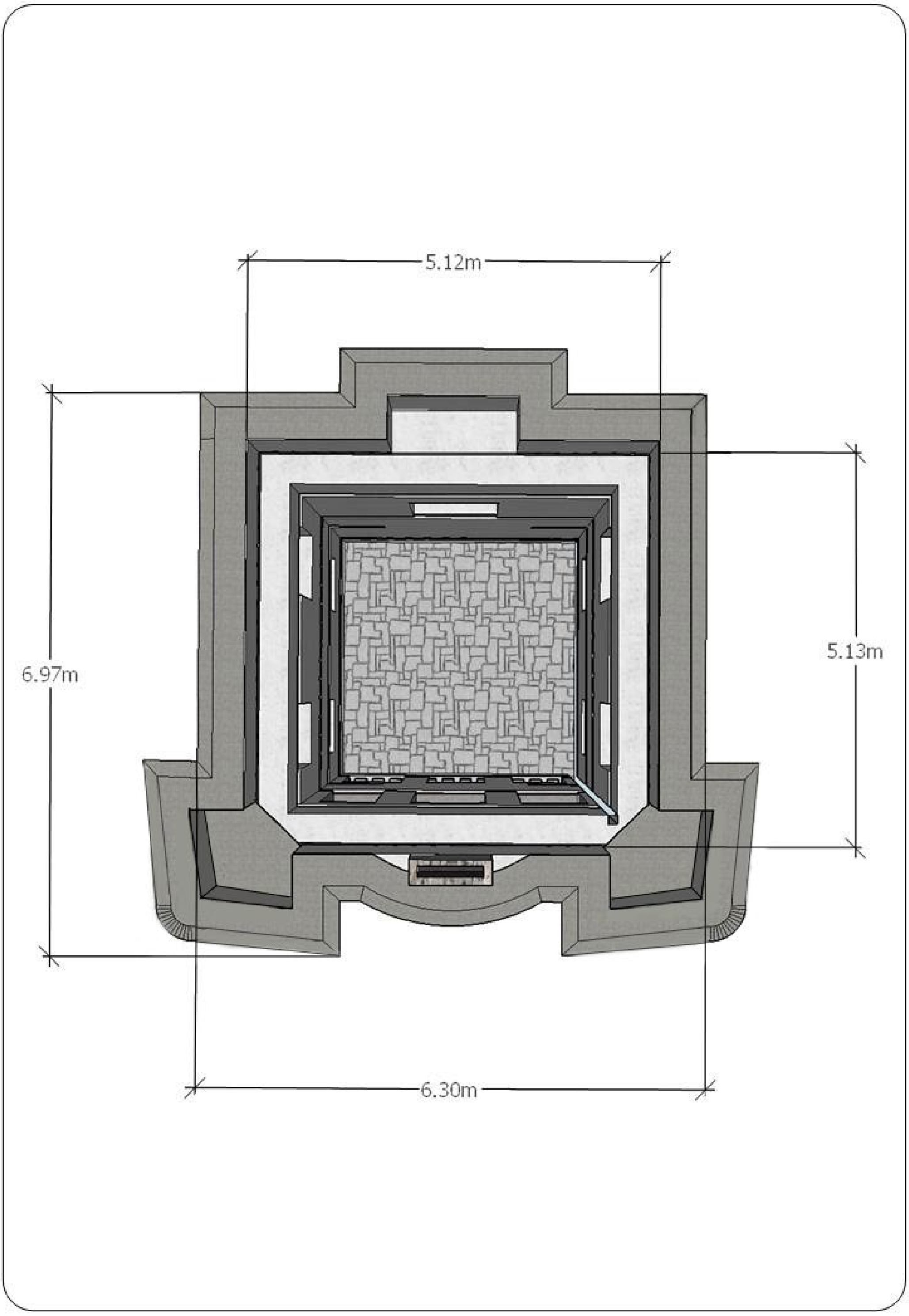


Figure 4.10. Plan view of rendered 3D model for an idealised signal tower showing access points to machicolation and bartizans and the ledge upon which the roof was set.

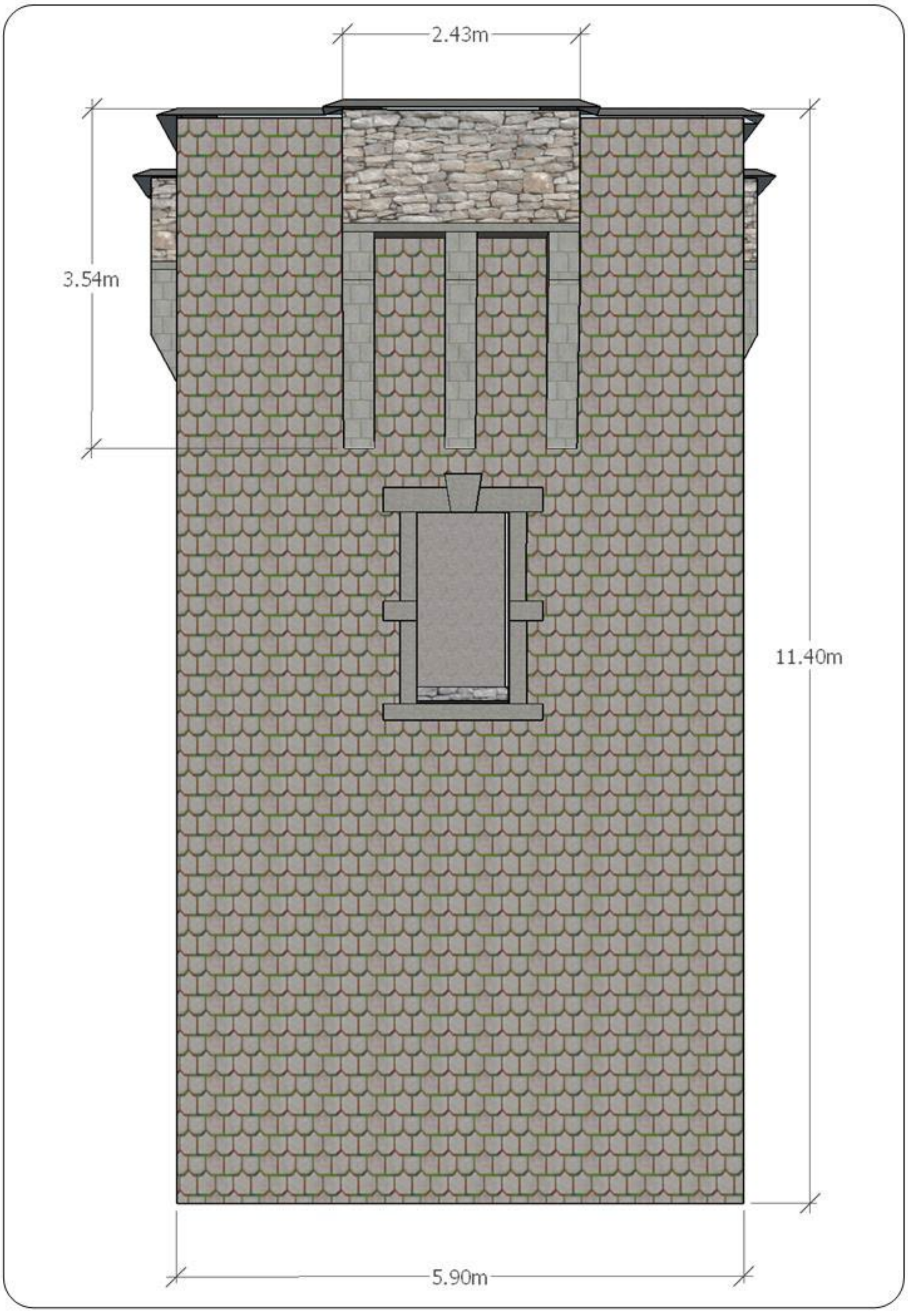


Figure 4.11. Rendered 3D model for an idealised tower showing front wall elevation with door and machicolation. Because this model was largely based on Carrowmably Signal Tower, County Sligo, the central corbel has a rectangular form and does not narrow to a point.

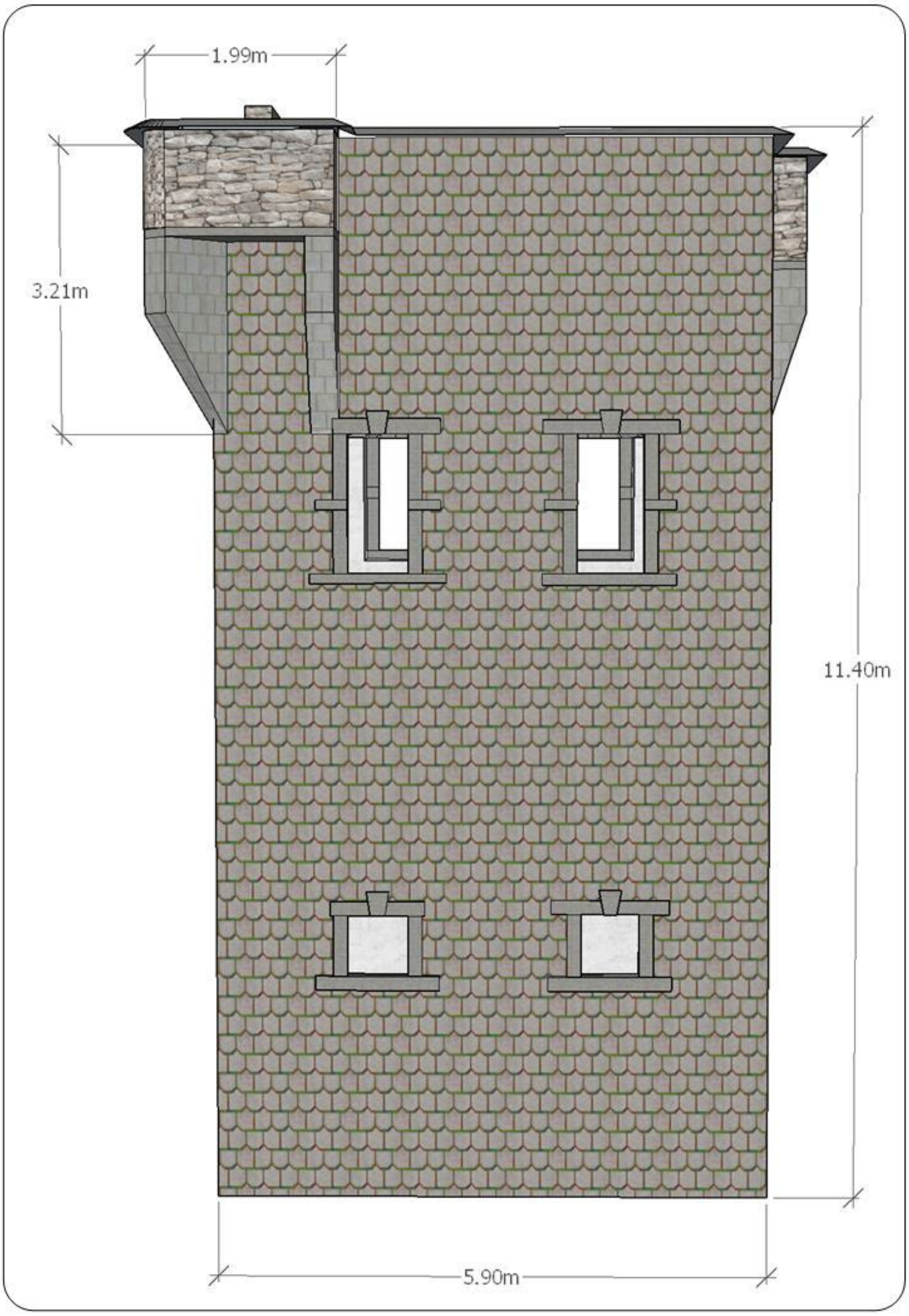


Figure 4.12. Rendered 3D model for an idealised tower showing side wall elevation with windows and bartizan.

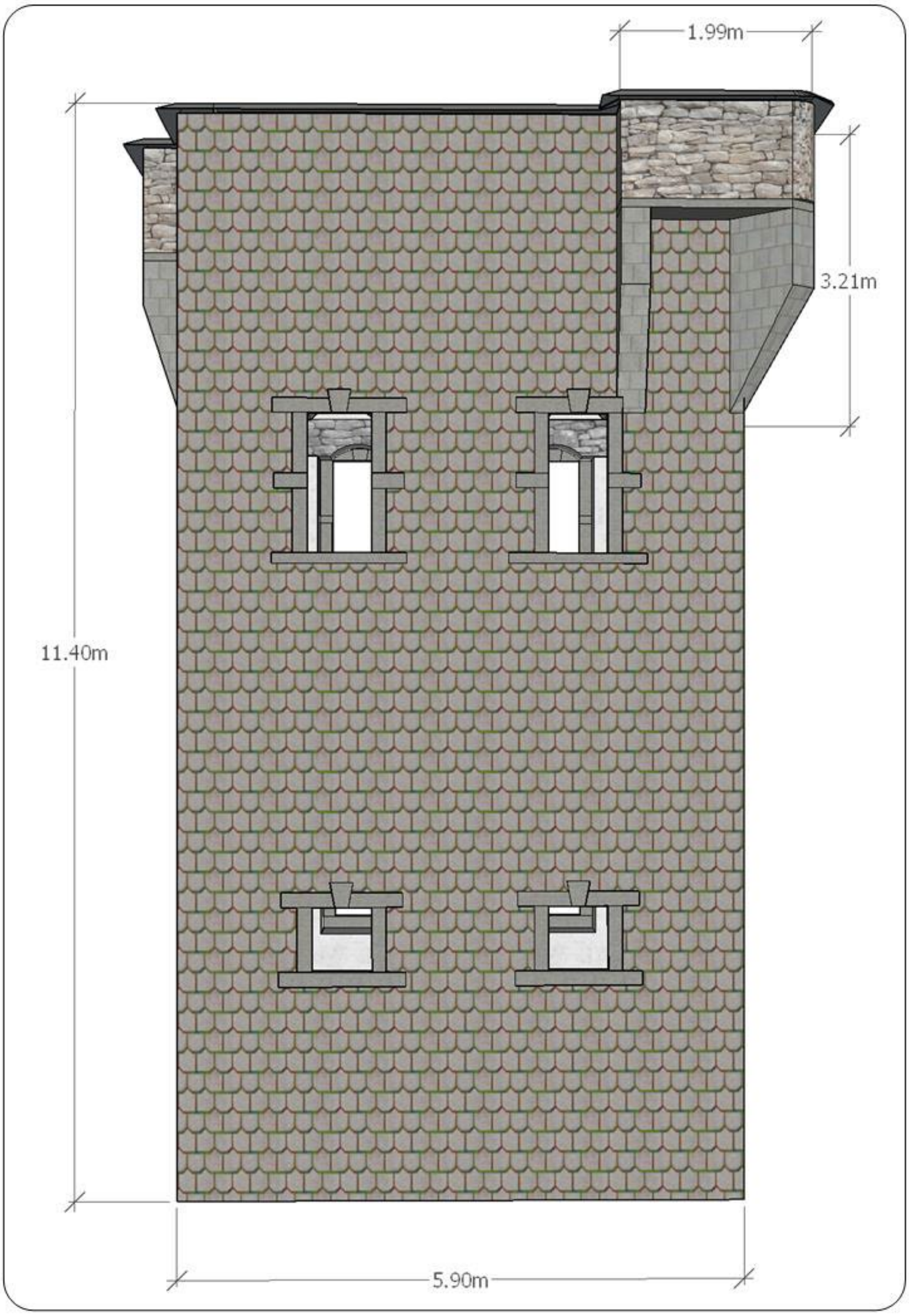


Figure 4.13. Rendered 3D model for an idealised tower showing side wall elevation with windows and bartizan.

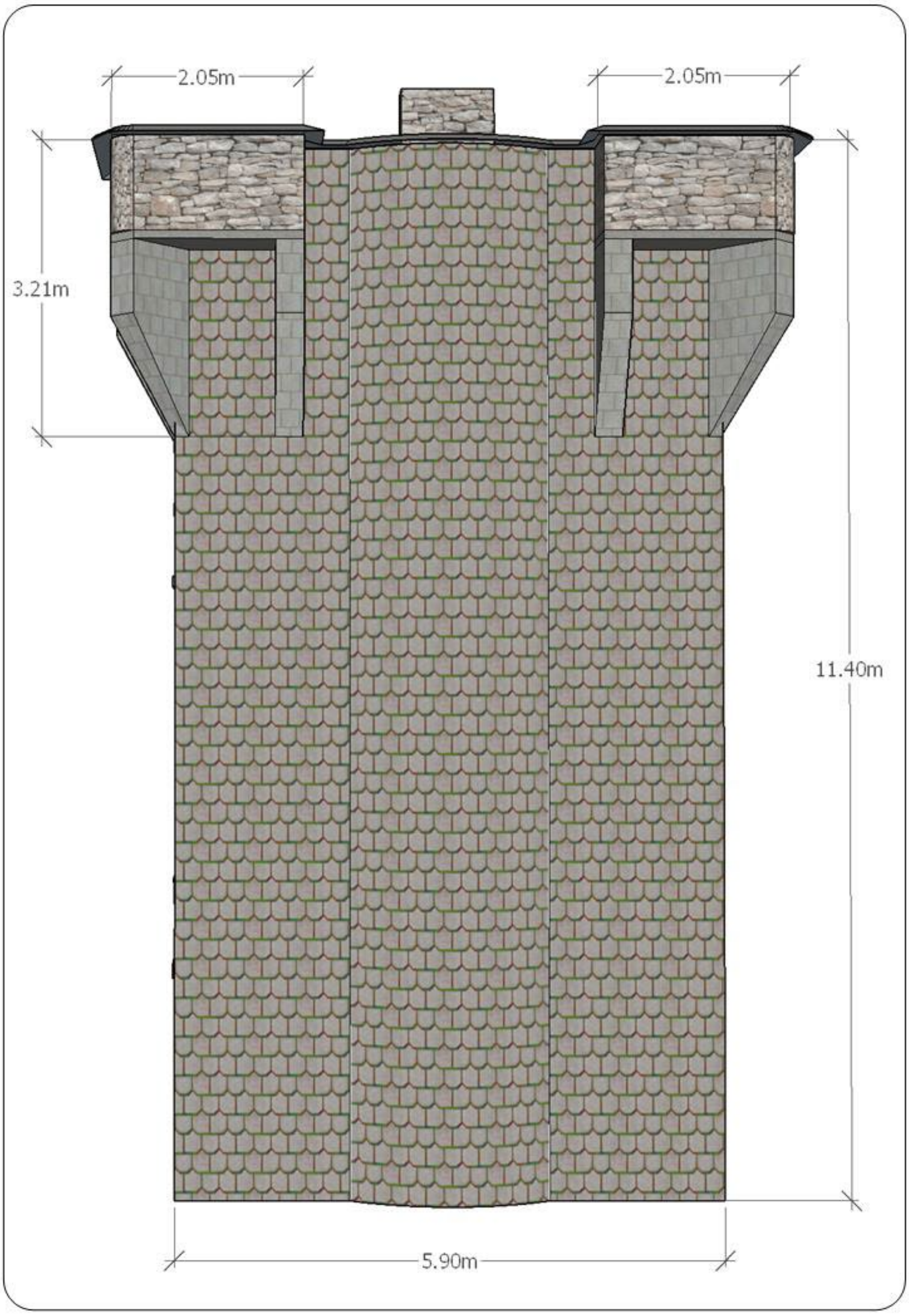


Figure 4.14. Rendered 3D model for an idealised tower showing rear wall elevation with chimney flue, chimney stack and bartizans.

The doorways were protected by a shallow projecting machicolation accessed from the roof level. The machicolations were supported by three sloping corbels that extended from the area immediately above the discharging arches over the doors to a set of piers that supported the machicolation's base. The corbels consisted of a number of dressed stone blocks that were embedded into the main body of the wall, their projecting length increasing with height to produce an outwards slope. Apart from Carrowmably Signal Station, County Sligo, all of the towers had a central corbel that narrowed to a sharp point at its base. At Carrowmably all three corbels had parallel sides and rectangular forms. The sloping corbels were topped by short piers of rough field stones, which ran straight up towards the base of the machicolations. Each corbel and pier had a combined height of around 2.75 m (9') and was 0.3 m (1') wide. The bases of the machicolations consisted of dressed slabs that provided a solid floor in the area where they projected beyond the line of the walls. The walls of the machicolations followed the same style of roughly coursed locally sourced stones as the main body of the walls, although there were no quoin stones on the corners. The machicolations were around 2.14 m wide (7'), 0.46 m deep (1' 6''), and 1.1 m tall (3' 6''). At the sites with coping stones these extended around the tops of the machicolations, projecting slightly beyond the external wall face.

#### 4.2.1.2 The side walls

The side walls follow the same pattern as the front walls, featuring roughly coursed stones with alternating quoins at the corners. Where the side walls were topped with dressed coping stones, they featured the same shallow projection beyond the wall faces. Each side wall had four windows, with two small square windows on the ground-floor, and two slightly larger rectangular windows on the first-floor. Each window opening was edged by 10 dressed stones, following a variation of the same pattern that surrounded the doorways; they featured a large sill stone across the base, two large stones on each side separated by a smaller perpendicular stone, and two large stones across the top, separated by a smaller key stone. A discharging arch was present immediately above each window, built into the main body of the wall. The openings of the ground-floor windows were around 0.55 m (1' 9'') wide and 0.55 m (1' 9'') tall and were located about 2 m (6' 6'') above the ground level. The openings of the first-floor windows were around 0.55 m (1' 9'') wide and 1.22 m (4') tall. The distance between the top of the ground-floor window opening and the bottom of the first-floor window opening was around 3.2 m (10’ 6’’). The distance between the top of the window openings on the first-floor and the top of the side walls was around 2.67 m (8’ 9’’). At three of the sites where the stone surrounds of the ground-floor windows were intact (Carrowmably Signal Station, County Sligo, and Carrigan Head and Malin Beg Signal Stations, County Donegal) rows of holes marking the former the positions of three horizontal metal bars could be seen on the window’s side stones. Similar holes for bars were not present on the first-floor window surrounds. Given how frequently the ground-floor window surrounds were no longer present it cannot be determined if horizontal bars on the ground-floor windows were part of the standard design or only utilised at specific locations. The restriction of the use of horizontal metal bars to the ground-floor windows indicates that they were security features.

#### 4.2.1.3 The rear wall

The rear walls continued the same pattern as the other walls, featuring roughly coursed stones with alternating quoins at the corners. At the sites with coping stones on top of the walls these continued across the rear wall with the same shallow overhangs. The rear walls were largely devoid of other features beyond a slight bulge that housed the chimney flue.

A total of thirteen signal stations (41%) had bulges in the rear walls that contained the back of the chimney flue, four of the sites did not feature bulges in the rear wall (12%), and the presence or absence of bulges in the rear wall could not be determined at 15 of the sites (47%). The bulges themselves were one of the more variable features and recorded examples ranged in width between 1.83 m (6’) and 3.66 m (12’). The bulges were located in the centre of the wall and in most cases consisted of a gentle curve extending outwards to a maximum of about 0.2 m (8’’), but some examples had a slightly pointed form. At seven of the sites (22%) a rectangular chimney stack projected from the centre of the top of the rear wall. The chimney stacks were rectangular and rather narrow, measuring around 1.45 m (4’ 9’’) in width, 0.6 m (2’) in depth, and 1.45 m (4’ 9’’) in height. Particularly well-preserved examples were identified at Glash Signal Station, County Mayo, Rathlee Signal Station, County Sligo, and Malin Beg and Carrigan Head Signal Stations in County Donegal. The projecting chimney stacks were presumed to have been part of the standard design, and their limited occurrence is thought to reflect their vulnerability to collapse or removal. The presence or absence of a bulge in the rear wall did not seem to corelate with whether a chimney stack would be present.

In five cases (Saddle Hill, Glash, and Glinsk Head Signal Stations in County Mayo, and Lenadoon Point and Carrowmably Signal Stations in County Sligo) one or two small square chutes were present, that led from the exterior, close to ground level, into the semi-basement level within the tower. The square chutes accessing the semi-basement were simple holes through the wall, measuring around 0.3 m (1’) across and located around 0.6 m (2’) above the external ground surface. Some examples ran horizontally through the wall whilst others sloped downwards into the building. Although these chutes were only recorded at five sites in Counties Mayo and Sligo, it is possible that additional examples existed which were concealed by collapsed material at some of the more ruinous sites.

At the better-preserved sites, the corners where the side walls met the rear wall were protected by square bartizans, apart from two examples, Glash Signal Station, County Mayo, and Rathlee Signal Station, County Sligo, which featured rounded bartizans. Amongst the rubble of the badly collapsed signal tower at Tower Hill Signal Station, County Mayo, an intact rounded bartizan can still be seen, adding a third example to this list of sites with the rounded variant (Figures B.66 & B.67). The mid-twentieth century photographs of the signal tower at Saddle Hill Signal Station, County Mayo, appear to depict a fourth example of a rounded bartizan (Figures B.31 & B32).

The square shaped bartizans were executed in a complicated fashion, following a similar design to that described above for the machicolation. The square bartizans began just past the edge of the first-floor windows and projected out at 90 degrees to the wall. They extended outwards for around 0.69 m (2’ 3’’) before turning approximately 95 degrees and running not quite parallel to the wall for around 1.85 m (6’). They then turned approximately 80 degrees at a sharply curved corner and then continued to run not quite parallel to the rear wall for around 1.85 m (6’) before turning 95 degrees at another sharply curved corner. The walls then continued for around 0.69 m (2’ 3’’) before connecting onto the rear walls at a 90 degree junction.

The square bartizans were constructed of well coursed stonework with several large slabs of dressed stone forming the floors. As with the machicolations these bartizans were supported by three narrow sloping corbels constructed of increasingly large blocks of dressed stone. The corbels were around 0.3 m (1’) wide and 1.92 m (6’ 4’’) tall.

The central corbel was placed at the corner of the two walls and extended out from the tower on the diagonal, whilst the others were placed at the points where the bartizan began and ended and extended out from the walls in a perpendicular fashion. Where present, the wedge-shaped coping stones continued around the tops of the square bartizans.

Two forms of rounded bartizans were present. At Glash Signal Station, County Mayo, the stonework began just past the outer edge of the first-floor window, around 1 m (3’ 3’’) from the corner of the building. Each bartizan projected outwards at 90 degrees to the side wall for around 0.55 m (1’ 9’’) before turning 90 degrees and curving around the corner of the building. It then continued along the rear wall for around 1.22 m (4’) before turning 90 degrees to reconnect with the rear wall. The bodies of the two bartizans were around 1.75 m (5’ 9’’) tall and below this there was a conical mass of mortar and stone around 0.84 m (2’ 9’’) tall that sloped inwards into the main body of the wall. The stonework of the two rounded bartizans consisted of a mass of roughly coursed stonework in the same style as the main walls. The examples at Saddle Hill and Tower Hill Signal Stations, County Mayo, both appear to have been very similar to the form described at Glash Signal Station, County Mayo. At Rathlee Signal Station, County Sligo, the bartizans on the signal tower were again constructed out of the same style of stonework as the main walls, but they were fully rounded, curving out of the side walls, wrapping around the corner, and then curving back into the rear wall (Figures C.18 & C.19). The bartizans were around 2.4 m (7’ 10’’) tall and 1.2 m (3’ 11’’) wide.

Coping stones were not present at the tops of the walls at the signal towers at Glash and Rathlee Signal Stations. They are not shown on the mid-twentieth century photograph of the Saddle Hill Signal Tower, County Mayo, when it was still largely complete, and they were not observed in the rubble at Tower Hill Signal Station, County Mayo. It is possible that coping stones may never have been present at these four signal towers. If they were utilised but subsequently removed then particularly complex shaped stones would have been required, if they had extended around the tops of the rounded bartizans.

#### 4.2.1.4 Signal Towers with batters at the base of their walls

At ten of the signal towers (31%) within the main study area, a slight batter was visible at the base of the walls. The lower 0.6 m (2’) of the signal tower walls visibly widened by a small amount, between 0.1 m and 0.2 m (4” and 8’’). If present, measurements for the width of the signal tower walls were taken above the batter, and at the base of the batter. Subtraction of the first value from the second value established the width of the batter. The largest values were found at the signal towers at Malin Head Signal Station and Cleggan Hill Signal Station, County Donegal.

The batter at the signal tower at Malin Head Signal Station was found to be 0.4 m (16’’) wide. The possibility that this pronounced batter could have been a secondary addition to the much-modified signal tower required consideration. It was clear that the batter consisted of stonework covered in a thin layer of render, rather than being built up mostly of render. Given how difficult it would have been to key new stonework into an existing wall face it appeared that the batter was an original feature of the signal tower. Smith’s contemporary drawings of the signal tower (Figure 1.3 and Figure 4.33) show the batter, confirming it to be an original feature.

The signal tower at Cleggan Hill Signal Station had a batter that was found to be up to 0.3 m (12’’) wide. This related to the position of the signal tower at the edge of a steep slope, where the base of the wall on one side continued down the slope (Appendix A, Number 56).

The remaining signal towers where batters were recorded all fell within the 0.1 m and 0.2 m (4” and 8’’) range. The signal towers at Clare Island Signal Station, Saddle Hill Signal Station, and Glash Signal Station, County Mayo, and Carrigan Head, Malin Beg, Glen Head, Mullaghderg Hill, and Melmore Head Signal Stations, County Donegal, all featured minor batters.

At the signal towers that were largely collapsed it often proved impossible to determine if batters were present either because the lower part of the tower was obscured by rubble or because the upper portion of wall was no longer present, and it was unclear if there was a change in width. The well-preserved signal towers at Inisheer Signal Station, Inishmore Signal Station and Lettetmullan Island Signal Station, County Galway, Rathlee Signal Station and Carrowmably Signal Station, County Sligo, and Crohy Head Signal Station, County Donegal, did not feature batters at the base of their walls.

### 4.2.2 The interior walls

The interior walls of the towers were more complicated than the external walls, but they displayed the same level of similarity between the different sites. This consistency again allows for a singular generalised description to be presented here, with unique variations, exceptions, and additional features being highlighted in the individual site entries presented in Appendices A through D. The interior walls were originally covered in render and in many cases large areas of this survive within the towers. The presence of various internal features that had not survived were occasionally indicated by impressions in these layers of render. Because these layers of internal render and the impressions they contain are so central to the understanding of the internal design of the towers they are described in the generalised description here, with variations, additions and exceptions detailed in the individual site entries presented in Appendices A through D. One limitation of the survey methodology was that all observations of the interiors took place from ground level from within the tower. The uppermost areas of the well-preserved towers were therefore viewed at very oblique angles, making some details difficult to discern and others, such as the interior areas of the bartizans or the bases of the first-floor door and windows impossible to observe. Figures 4.15 through 4.18 illustrate an idealised view of the internal walls of the signal towers. Figures 4.19 and 4.20 illustrate how the floors and roof would have been incorporated into the recorded internal features.

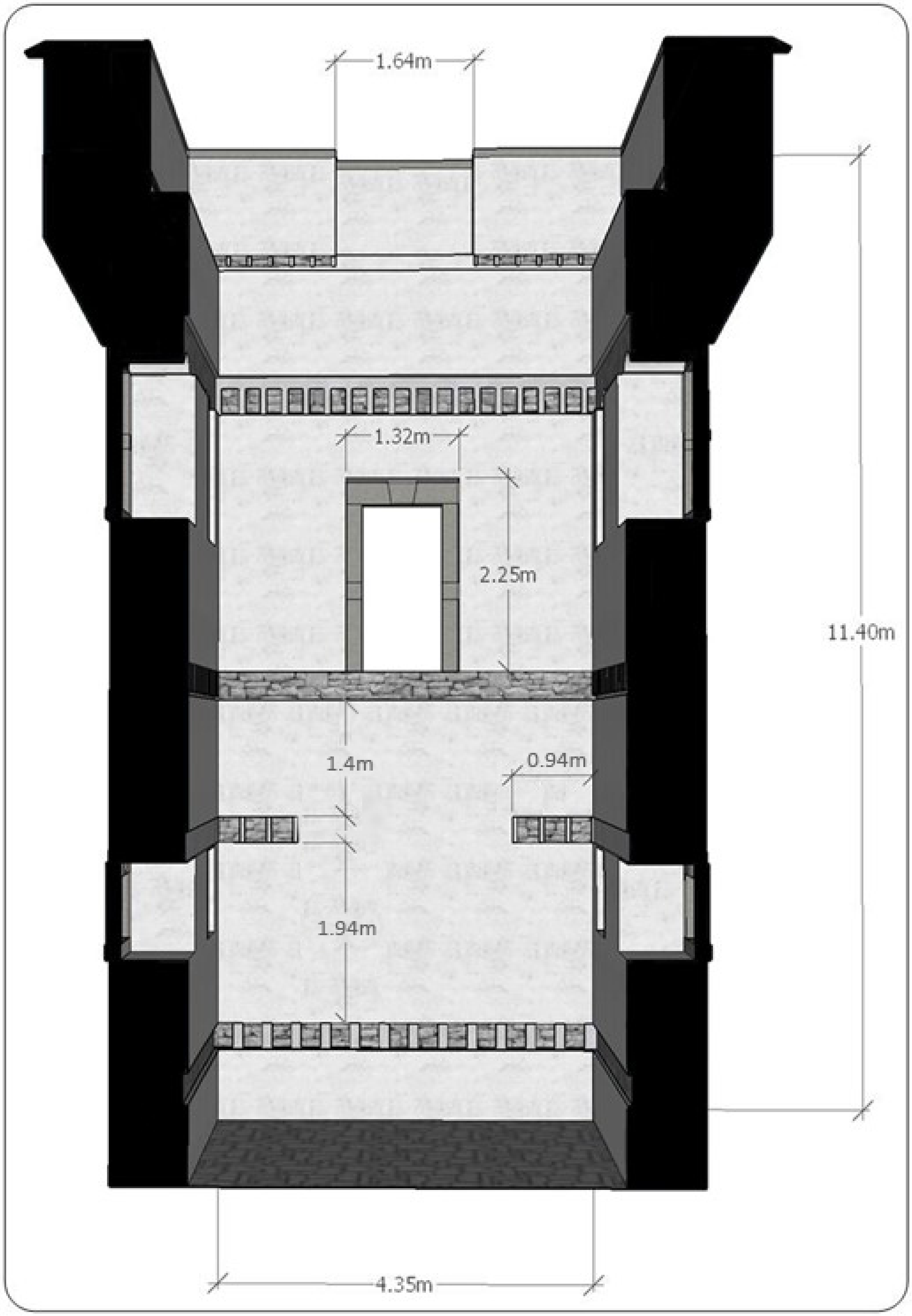


Figure 4.15 Cut away view of 3D model for an idealised tower showing interior face of front wall, door and entrance to machicolation.

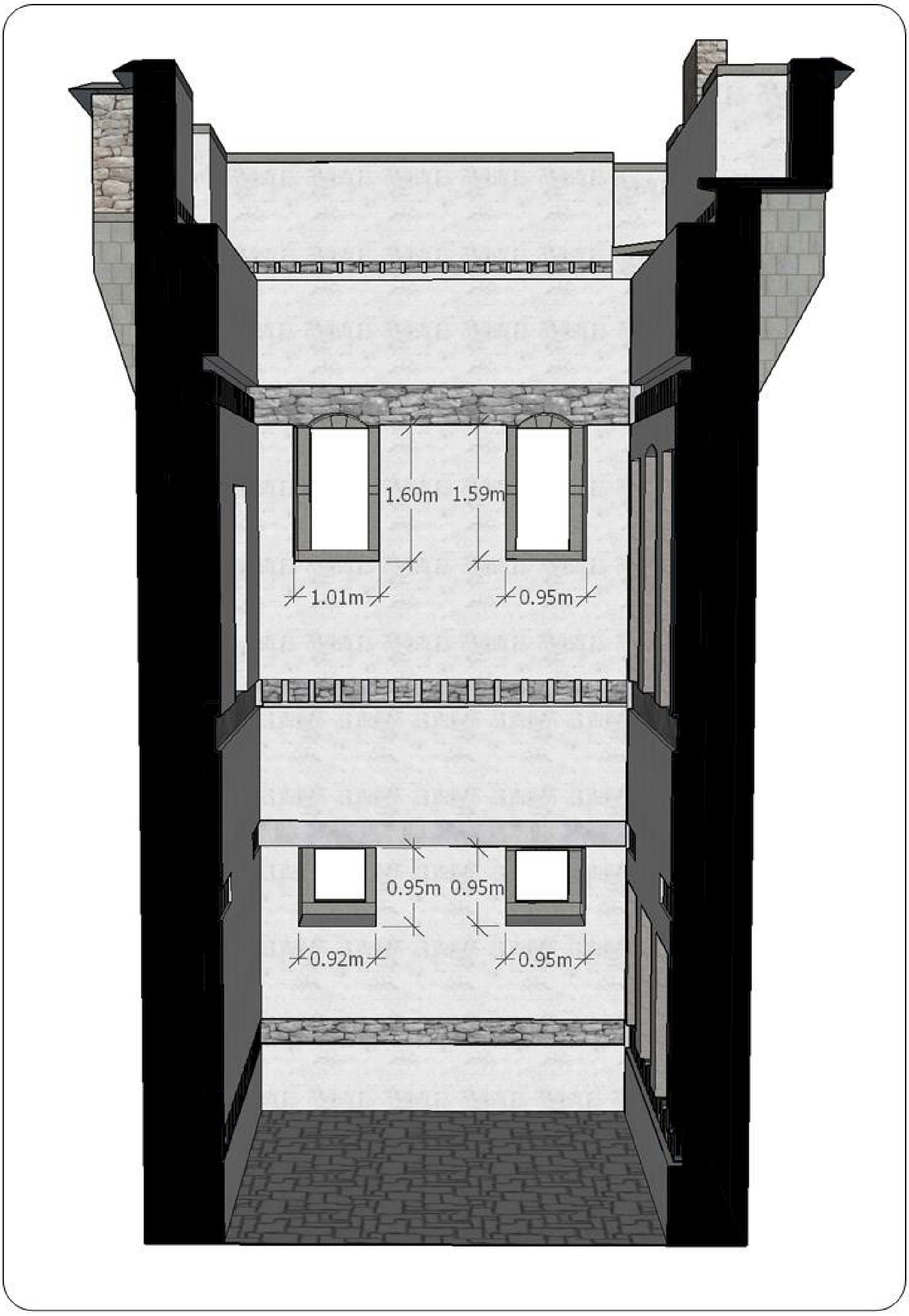


Figure 4.16. Cut away view of 3D model for an idealised tower showing interior face of side wall, windows and entry to bartizan at top right.

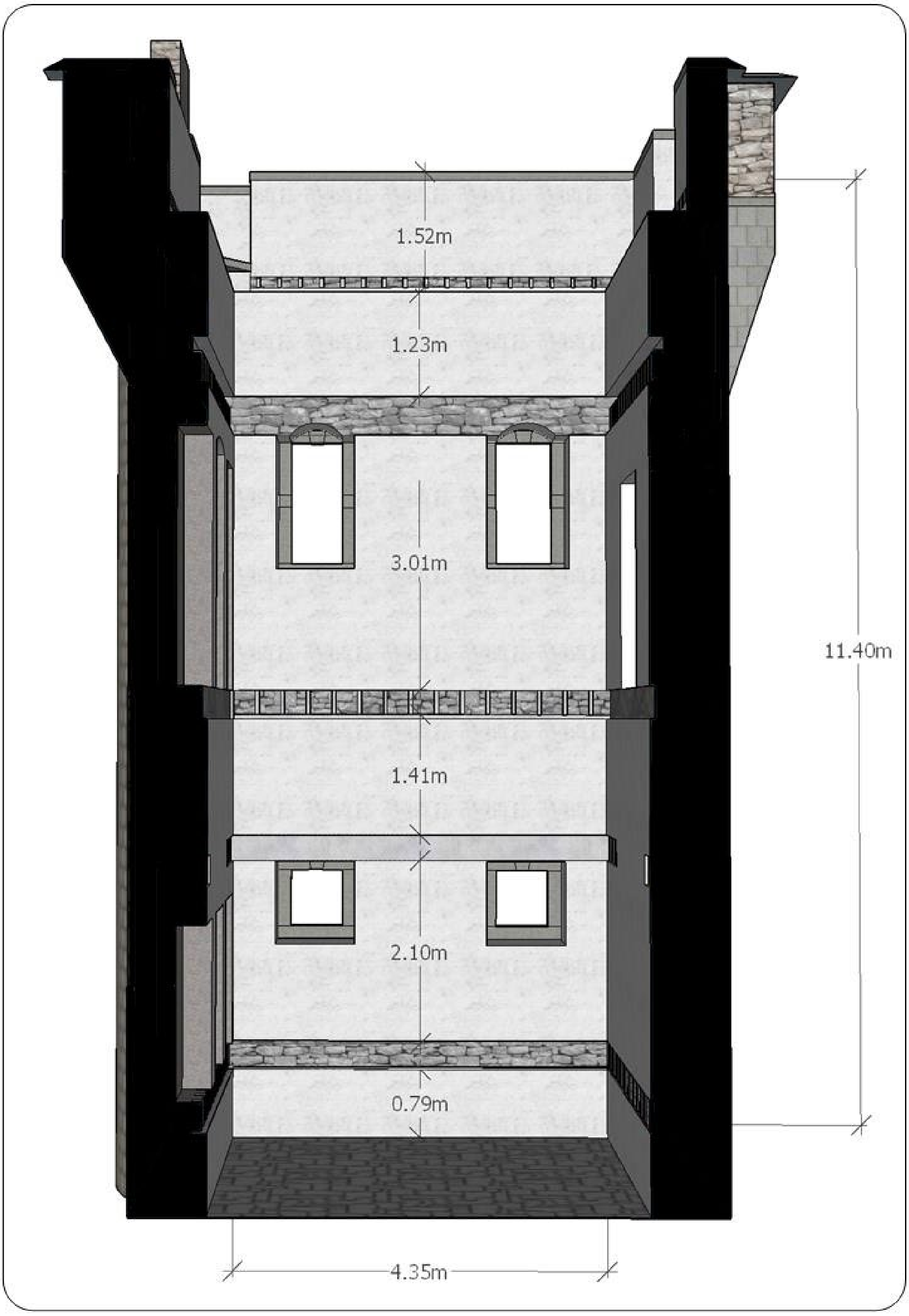


Figure 4.17. Cut away view of 3D model for an idealised tower showing interior face of side wall, windows and entry to bartizan at top left.

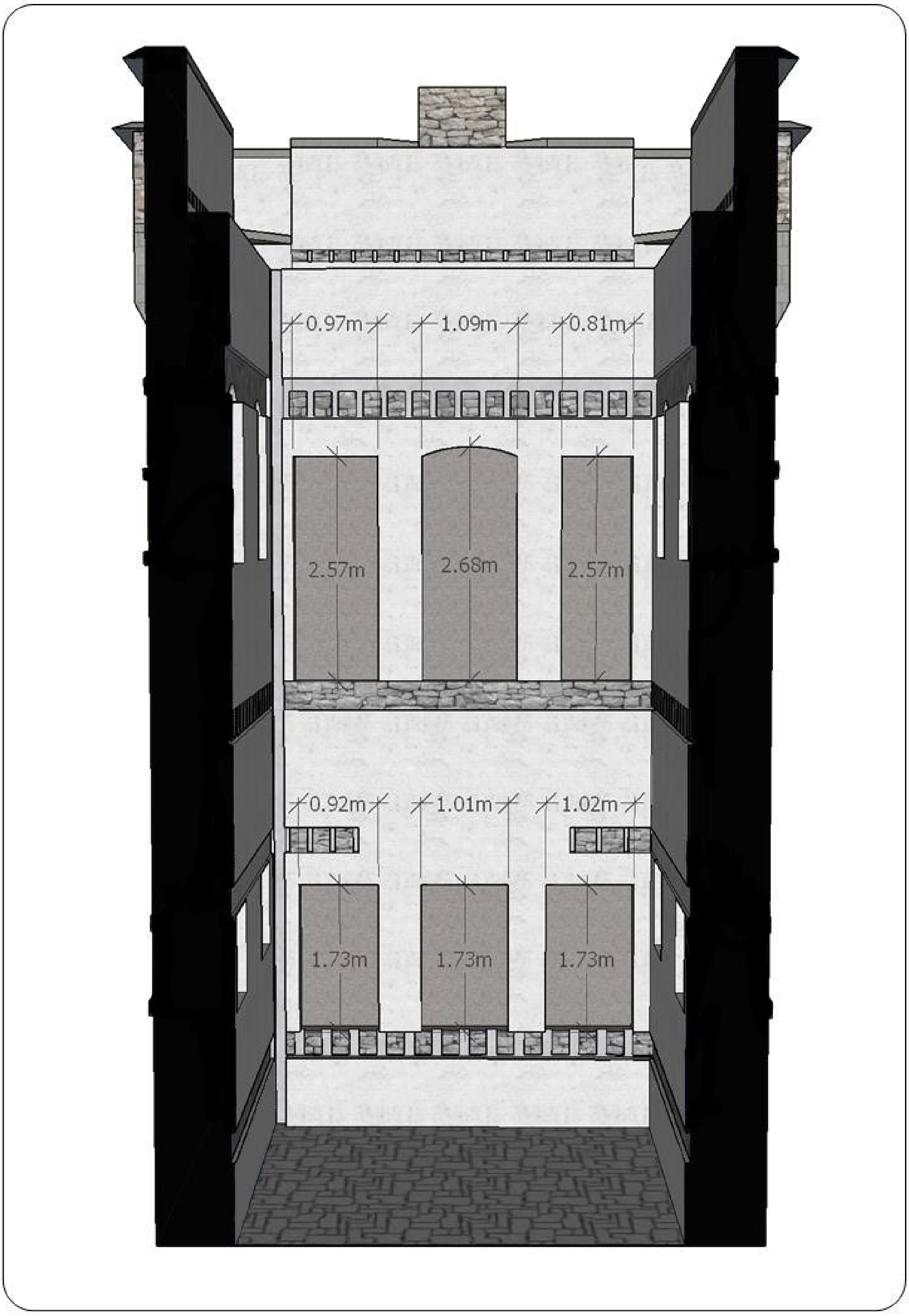


Figure 4.18. Cut away view of 3D model for an idealised tower showing interior face of rear wall with alcoves and fireplaces.

Figure 4.19. Rendered cut away version of the 3D model for an idealised tower showing the internal floors with the front wall removed, viewed obliquely. The red lines indicate a possible location of a dividing wall that separated the first-floor into two spaces.

Figure 4.20. Rendered cut away version of the 3D model for an idealised tower showing the internal floors with the front wall removed, viewed square on.

#### 4.2.2.1 The front wall

The internal face of the front wall was the plainest of the four, in terms of the number of features that were present (Figure 4.15). The lowest recorded feature was a horizontal slot for the ground-floor that featured a large number of individual joist holes. The joist holes were separated by individual rectangular blocks of masonry extending out from the back of the slot almost as far as the rendered surface of the wall. These blocks consisted of a small number of undressed stones mortared together and presumably keyed into the main body of the wall at the back of the slot. The individual blocks often did not extend as far as either the top or the bottom of the slot, an arrangement which created deep continuous grooves above and below the blocks running along the entire length of the slots. The slots were around 0.3 m (1’) tall and 0.3 m (1’) deep. The upper and lower grooves were around 0.06 m (2’’) tall and extended to the rear of the slots. The individual blocks of masonry were typically between 0.24 m and 0.3 m (9’’ and 1’) tall, 0.24 m and 0.3 m (9’’ and 1’) wide and 0.24 m deep (9’’), meaning that the faces of the blocks were recessed in from the main wall surface by around 0.06 m (2’’). The slots were often quite damaged but appear to have contained between 13 separate masonry blocks, with 15 gaps between them, with each gap being around 0.09 m (3’’) wide. The slots were therefore designed to hold 15 timber joists that ran from the front wall to the rear wall. The upper and lower grooves presumably held floorboards.

The space below these lowermost slots was identified as a semi-basement in the County Cork Inventory (Power *et al* 1992, 360-1), and by White (2003, 177) in his description of the signal tower at the Old Head of Kinsale, County Cork. Gosling identified this feature of the signal tower at Clare Island Signal Station, County Mayo, as a “low, windowless, basement or void, possibly for water storage” (Gosling 2007, 182). The term semi-basement indicates that it was only a partially subterranean space, but it is not clear if this was a full or reduced height room as the semi-basement floor surface was not exposed at any of the sites in the study area, and unknown depths of rubble and soil covered the floor surface. Kerrigan makes no mention of this additional space within the signal towers and it is possible that he was unaware of its existence, despite it having been mentioned in the County Cork Inventories (Kerrigan 1995, 157-8; Power *et al* 1992, 360-1). Interestingly where render was occasionally recorded on the walls of the semi-basement level, it had a far rougher finish that the render covering the internal walls of the other floors, suggesting a less sophisticated finish was applied to these semi-basement spaces.

The position of the ceiling of the ground-floor room/floor of the first-floor room was indicated by a shallow slot running horizontally across the wall, immediately below the base of the first-floor doorway. The orientation of the joists supporting the first-floor was rotated through 90 degrees from the ground-floor joists and so no joist holes were present within this slot. The slot did not extend into the body of the wall, it was simply an absence of render where the outermost timber joist and floorboards had been located. The distances between the tops of the ground-floor slots and the first-floor slots were between 3.2 m and 4 m (10’ 6’’ and 13’ 3’’), and this distance directly reflects the heights of the ground-floor rooms.

Between the ground-floor and first-floor slots at eight sites there were two further slots on the front wall that contained joist holes which were mirrored on the rear wall. The slots were set at the same height and their bases aligned with the height of the top of the ground-floor windows on the adjacent side walls, which varied between 1.68 m and 2.06 m (5’ 6’’ and 6’ 9’’). The slots each extended out from sides of the front walls for a distance of between 1.22 m and 1.6 m (4’ and 5’ 3’’). The slots contained two or three individual masonry blocks defining three or five separate joist holes and in some instances these slots had upper and lower grooves. These joists seem to have supported two narrow partial floors, each occupying about a third of the width of the internal space, leaving a wide gap running across the middle of the ground-floor room running from the front wall to the back wall. These features are not described by Kerrigan, but their presence was noted by Gosling in his description of the signal tower at Clare Island Signal Station, County Mayo, who identified them as “the remains of a mezzanine floor or landing” (Gosling 2007, 182). For want of a better term these partial floors are identified here as split mezzanine floors.

The openings of the first-floor doorway began immediately above the slots that marked the position of the first-floor. The opening of the doorway was around 2.15 m by 1.53 m (7’ by 5’), making it slightly larger than the opening on the external wall face. This difference can be accounted by a splaying of one side of the opening as it passed through the body of the wall, and the absence of dressed stonework around the internal opening. The rear faces of the cut stone surrounds, that framed the exterior of the openings, were often clearly visible from within the towers. Square holes were located at the top of the sides of the doorway, which would have held the head of a wooden door frame. It is assumed that similar holes were present to hold the sill at the base of the door frame, but these were not directly observed. Jambs would have connected the head to the sill, forming the sides of the door frame. Narrow horizontal slots extended into the body of the wall above the position of the head at some sites. These slots held timber planks which lined the top of the door opening. *In-situ* timbers had survived in the doorways at Golam Head Signal Station, County Galway, and Crohy Head Signal Station, County Donegal. The sides, and perhaps the bases, of the door opening were covered in render. At the sites which did not feature the slots for timber planking, the top of the opening was covered in render. This style of framing was widely used in Irish vernacular architecture and can still be seen in use in some buildings in the west of Ireland today (Ó Danachair 1957, 67). The features of the door frame suggest a stout wooden door was utilised, although none have survived.

A third joist slot was located between 0.68 m and 0.92 m (2’ 3’’ and 3’) above the top of the opening of the doorway. This followed the same form as the ground-floor slot and was around 0.3 m (1’) wide with 13 masonry blocks creating spaces for 15 joists running from the front wall to the rear wall. Grooves for floorboards were present at some sites, above and below the masonry blocks. The distance between the bottom of these slots and the top of the slots below the doorway was between 3.2 m and 3.58 m (10’ 6’’ and 11’ 9’’), indicating the height of the first-floor room.

The front wall continued above the slots marking the ceiling of the first-floor room for between 0.6 m and 1.22 m (2’ and 4’). At this point the body of the wall narrowed by what appeared to be about 0.3 m (1’), although this measurement could not be extracted from the rectified photographs, and this dimension is estimated from various photographs taken showing the upper portions of various signal towers. This thinning created an internal step or ledge upon which the timbers of the roof would have rested. At the base of the thinner section of the walls there was often another slot that contained masonry blocks creating individual joist holes used by the roof joists. These slots were smaller, being only around 0.18 m (7′′) tall, although the individual joist holes were still around 0.09 m (3′′) wide indicating the use of joists of the same width as elsewhere in the building. The space between the ceiling of the first-floor room and the roof varied in height between 0.6 m and 1.22 m (2′ and 4′). This is too low a space to have been a proper second-floor, and it is identified here as an attic space.

The thinner portion of wall above the step, the parapet wall, was broken by an opening that allowed access to the internal area of the machicolation over the doorway. The opening was centrally placed and was between 1.45 m and 2 m (4′ 9′′ and 6′ 6′′) wide. The thinner parapet walls continued for around 1.52 m (5′) above the joist slot for the roof timbers.

#### 4.2.2.2 The side walls

The interior of the side walls featured a continuation of the different slots that held the joists for the different floors, as well as the interior parts of the ground-floor and first-floor window openings. The position of the ground-floor was visible as either a horizontal line, where the render on the ground-floor room begam and below which was exposed stonework, or as a slot with exposed stonework, below which was the rough covering of render of the semi-basement wall.

The openings of the ground-floor windows were located between 0.84 m and 1.22 m (2′ 9′′ and 4′) above the floor of the ground-floor room. The damaged nature of most of the ground-floor windows meant it was difficult to measure the original internal dimensions at many sites. Where they could be measured the openings were around 1.22 m (4′) wide and 0.84 m (2′ 9′′) high, making them significantly wider and taller than the corresponding openings on the external wall face. This difference can be accounted for by a slight splaying of the openings as they passed through the body of the wall, and the absence of dressed stone surrounds. At the top and bottom of the sides of the openings for the windows there were small square holes which had held the heads and sills of the wooden window frames. Jambs would have connected the head and the sill to form the sides of the window frames. At most sites narrow slots extended into the body of the wall above the heads which had held the timber planks that lined the top of the window opening. The sides and bases of the windows were covered in render. At sites which lacked the slots above the windows, the top of the openings were also covered in render.

Immediately above the ground-floor windows there was a well-defined horizontal gap in the render which marked the position of the outermost joist of the mezzanine floors that were located between the ground-floor and first-floor. The rectangular stones of discharging arches above the ground-floor windows were visible within these gaps in the render.

Above the slots for the mezzanine floors were the slots that marked the position of the first-floor. These consisted of between 11 and 14 masonry blocks separating between 13 and 16 joist holes, each measuring around 0.3 m by 0.22 m (1’ by 9’’). Some of these slots also featured grooves for floorboards at the top and bottom, which were around 0.06 m (2’’) tall.

The openings of the first-floor windows were located around 1 m and 1.14 m (3’ 3’’ and 3’ 9’’) above the slots which marked the position of the first-floor. The openings of the windows measured between 1.14 m and 1.38 m (3’ 9’’ and 4’ 6’’) wide, and between 1.6 m and 1.83 m (5’ 3’’ and 6’) tall, again making them significantly wider and taller than the corresponding openings on the external wall faces. As with the ground-floor windows, this is attributed to a slight splaying of the openings as they passed through the body of the wall and the absence of dressed stone surrounds. The first-floor window frames followed the same design principles as the ground-floor window frames and the door frame, utilising wooden heads, sills and jambs.

Immediately above the first-floor windows there were well-defined horizontal gaps in the render which marked the position of the outermost joists of the ceilings of the first-floor. The rectangular stones of discharging arches above the first-floor windows were visible within these gaps in the render. The walls extended above this gap in the render by between 0.6 m and 1.22 m (2’ and 4’) before reaching the in-step in the walls, above which the parapet walls were located. At some sites slots that held the joists of the roof were present, immediately above this step. These slots typically held 12 masonry bocks that defined 14 narrow joist holes that were around 0.18 m (7’’) tall and 0.13 m (5’’) wide. Gaps existed in the parapet walls at the corners which connected the side walls to the rear wall. These gaps permitted entrance to the bartizans. The parapet wall continued for between 1 m and 1.22 m (3’ 3’’ and 4’) above the slots for the roof.

The presence of joist holes on all four of the parapet walls indicates that the roof joists were arranged in a complex pattern, but it is currently unclear what pattern was used. A dense grid pattern could have been formed using a large number of cross-lap joints at each point where the perpendicular joists crossed (Figure 4.21). Another interpretation would require staggered sets of joists extending out from each wall and connecting to some arrangement of diagonal beams via pegs or complex joints (Figure 4.22). A more detailed examination of the uppermost parts of the well-preserved signal towers would be needed to resolve how the roofs were constructed.

**4.2.2.3 The rear wall**

In contrast to the rather featureless nature of the external face of the rear walls of the signal towers, the internal faces of the rear wall were particularly complicated. The lowest feature on the rear wall was a continuation of the slot that held the joists and floorboards of the ground-floor. Unsurprisingly this was a mirror image of the slot on the front wall, with a height of 0.3 m (1’), a depth of 0.3 m (1’) and an equal number of masonry blocks and joist holes. Some examples featured floorboard grooves above and below this slot which were around 0.06 m (2’’) tall.

Immediately above this slot there were two rectangular alcoves flanking a central fireplace, all three of these features taking the form of large indents into the body of the wall. The alcoves were between 1.75 m and 1.98 m (5’ 9’’ and 6’ 6’’) tall, around 0.92 m and 1 m (3’ and 3’ 3’’) wide, and had a depth of around 0.3 m (1’). Some examples had arched tops, and others had horizontal tops. The render that covered the internal walls extended into these alcoves and in one case, Rathlee Signal Station, County Sligo, the impressions of shelves could be seen within the render inside the alcoves. These alcoves are referred to by Lecky as “recesses” (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden).

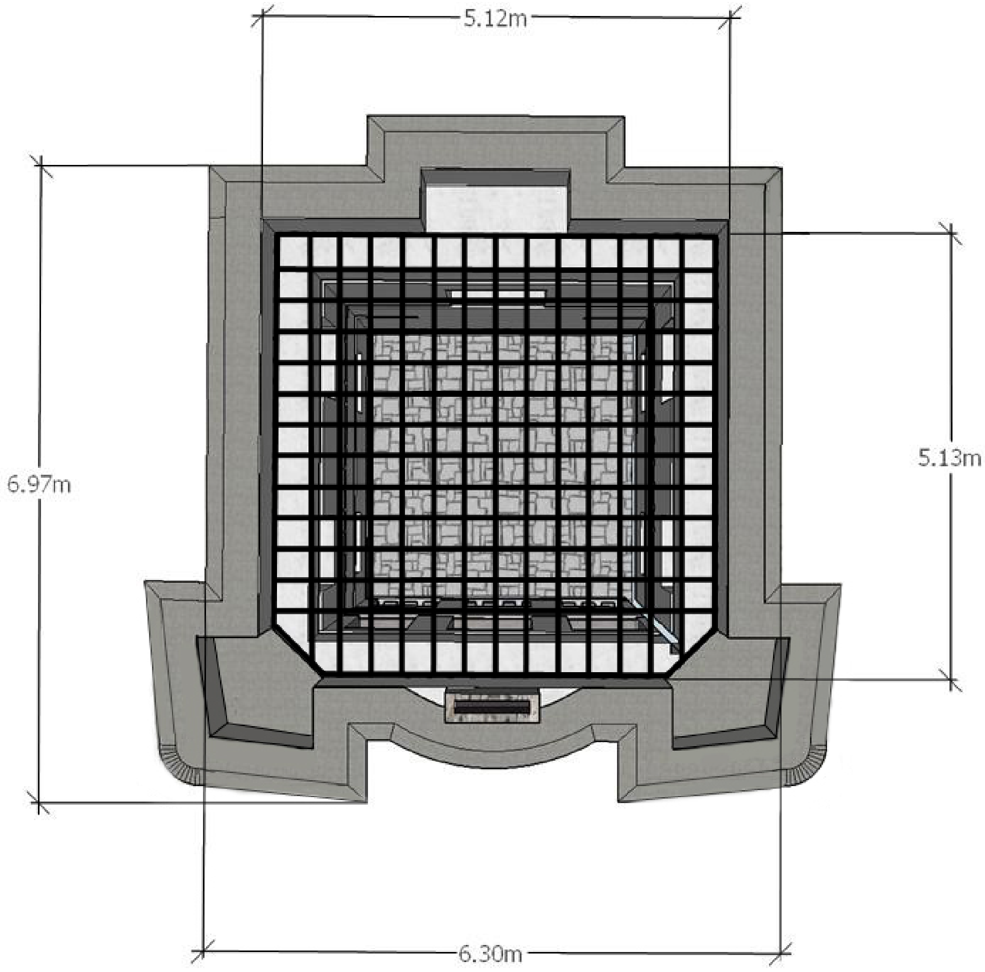


Figure 4.21. One possible layout of the timber joists that supporting flat roof, based on a grid of timbers with cross lap joints at every intersection.

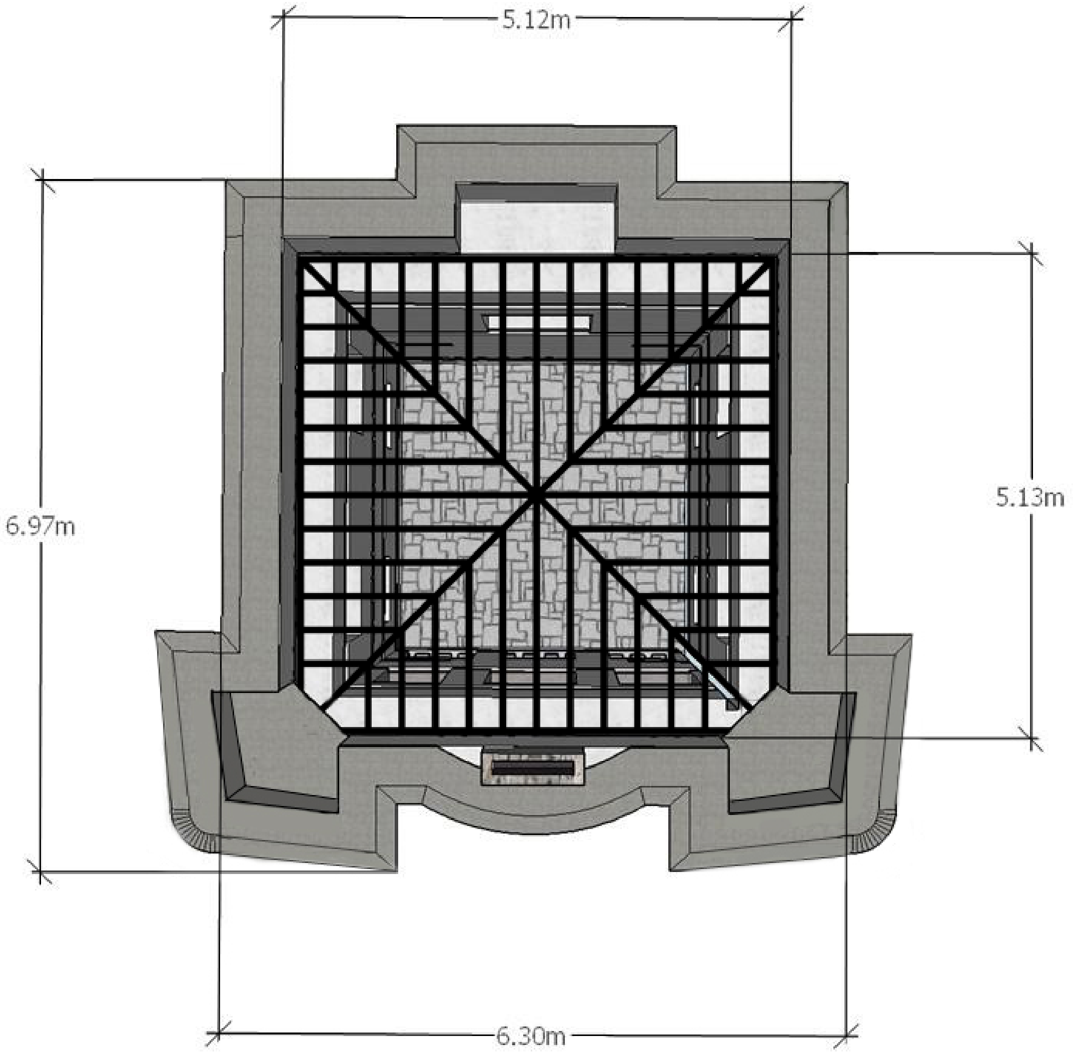


Figure 4.22. A different possible layout of timber joists supporting flat roof, using staggered joists connected to diagonal beams running from corner to corner.

The fireplaces varied in size between 1 m and 1.6 m (3’ 3’’ and 5’ 3’’) in width, between 1.22 m and 1.75 m (4’ and 5’ 9’’) in height, and typically had depths of around 0.6 m (2’). The tops of the fireplaces were either flat or arched. Where the render was missing above the alcoves and fireplaces discharging arches could be seen built into the walls above the features.

The slots that held the joists of the partial mezzanine floors between the ground-floor and the first-floor were located immediately above the tops of the alcoves. These slots were mirror images of those found on the front wall.

The slot that marked the position of the first-floor was also a mirror image of the matching slot on the front wall. The slot was visible as a gap in the wall render that was around 0.3 m (1’) tall. Above this slot the first-floor level featured a second pair of alcoves on either side of a second fireplace. These features were very similar to the examples found on the ground-floor but were noticeably taller. The alcoves were between 0.92 m and 0.98 m (3’ and 3’ 3’’) wide and between 2.28 m and 2.6 m (7’ 6’’ and 8’ 6’’) tall. The render on the walls often extended into the alcoves. At two examples the imprints of shelves could be seen in this render; Inishmore Signal Station and Golam Head Signal Station, County Galway. The central fireplaces were between 0.88 m and 1.1 m (2’ 10’’ and 3’ 7’’) wide, and between 1.51 m and 1.7 m (4’ 11’’ and 5’ 7’’) tall. The depths of these first-floor features could not be measured directly but they appeared to be similar to the equivalent features on the ground-floor. The tops of the central fireplace were either arched or flat. Discharging arches could be seen built into the walls above these features at sites where the render was missing.

The use of flat and arched tops over the fireplaces and alcoves did not demonstrate any particular patterning. For example; at Glash Signal Station, County Mayo, and Mullaghderg Hill Signal Station, County Donegal, all six features had flat tops; at Crohy Head Signal Station, County Donegal, the ground-floor alcoves had flat tops and flanked an arched top fireplace, while the alcoves and fireplace on the first-floor were all flat topped; at Golam Head Signal Station, County Galway, the ground-floor alcoves and fireplace had flat tops and the first-floor alcoves and fireplace had arched tops.

The slot that supported the joists of the ceiling of the first-floor mirrored the position and composition of the equivalent slot on the front wall. The position of the instep in the wall that created the ledge that supported the roof matched the arrangements on the front and side walls. The parapet wall above the instep had gaps at either side through which the bartizans over the corners of the signal towers could be accessed. Immediately above the instep in the wall the final section of the slot that held the joists of the roof was located. This was the same height as the slot on the front wall but was shorter in length and held fewer joist holes because of the gaps that led to the bartizans.

A final feature present at many sites was a vertical drainage channel that ran down one of the junctions between the rear wall and one of the side walls. Where the towers survived to their full height these drainage channels could be seen to run almost the entire height of the wall, from the semi-basement level up to the point where the wall stepped inwards to hold the roof. These channels could often be identified in the lower portions of the sites which survived in poor condition. Given the consistency of the buildings it is assumed that in all instances these truncated channels had originally continued up as far as the roof level. The drainage channels were square in section and measured between 0.09 m and 0.12 m (3’’ and 4’’) across. These features are not mentioned by Kerrigan (1995, 157-8). It is suggested here that they were part of a rain capture system that collected rainwater from the roof and drew it down into the semi-basement where it could have been stored in a cistern or in barrels.

## 4.3 The stone walled enclosures

Based on field observations and the early cartographic depictions and contemporary documentation it appears that 16 signal stations (50%) in the main study area featured purpose-built enclosures, 15 signal stations (47%) did not feature purpose-built enclosures, and the status of one site (3%), Fanad Head, County Donegal, is currently unknown. Table 4.2 summarises the setting of each of the signal stations within the main study area and notes the elevation and presence or absence of enclosures.

In general, the outline of the enclosures can be traced quite easily on the ground, and some additional details can be noted. The large rectangular enclosure at Glash Signal Station, County Mayo, has been removed to such an extent that it is difficult to identify on the ground, whilst the large rectangular enclosure at Malin Head Signal Station, County Donegal, was removed in its entirety during the 19th century and is only known from its depiction on the 1st edition Ordnance Survey map (dated 1834 - 1836). Importantly the contemporary illustrations of the Malin Head Signal Station (Figure 1.3, D.129 through D.133.) do not show the enclosure, indicating it was constructed after the signal tower was completed.

The large rectangular enclosure at Inisheer Signal Station, County Galway measures 52 m by 30 m (170’ by 100’) and was defined by a finely built stone wall which was between 0.76 m and 0.92 m (2’ 6’’ and 3’) wide and still stands up to 2.3 m (7’ 6’’) tall (Figure 4.25). The north-eastern corner of the enclosure has been built over by a large, modern, water tank.

At Inishmore Signal Station, County Galway, an enclosure built around the later lighthouse complex seems to have altered the northern portion of the enclosure around the signal station, but the southern half seems to have survived reasonably well (Figures 4.23 & 4.24). The large rectangular enclosure measures 54.4 m by 25 m (178’ 6’’ by 82’) and is defined by a finely built stone wall which is between 0.7 m and 0.92 m (2’ 2’’ and 3’) wide. It stands up to 2.75 m (9’) tall at the south-west and 2.14 m (7’) tall around the north-east, where its height has been deliberately and consistently reduced and the new top of the wall has been capped by concrete.

| Signal Station | Number | Province | County | Topographic Description | Elevation (m) | Type of Enclosure | Naturally Defensible Site |
|---|---|---|---|---|---|---|---|
| Inisheer | 51 | Connacht | Galway | Exposed Hilltop Site | 65 | Large Rectangular | Yes |
| Inishmore | 52 | Connacht | Galway | Exposed Hilltop Site | 126 | Large Rectangular | Yes |
| Golam Head | 53 | Connacht | Galway | Low Hilltop Site on Tidal Island | 29 | None | Yes |
| Cuileen Hill | 54 | Connacht | Galway | Exposed Hilltop Site | 101 | Small Irregular (unknown date) | Yes |
| Bunowen Hill | 55 | Connacht | Galway | Exposed Hilltop Site | 65 | None | Yes |
| Cleggan Hill | 56 | Connacht | Galway | Exposed Hilltop Site | 147 | Small rectangular | Yes |
| Inishturk | 57 | Connacht | Mayo | Exposed Hilltop Site | 192 | None | Yes |
| Clare Island | 58 | Connacht | Mayo | Exposed Hillside Site | 143 | Large Square | Yes |
| Saddle Hill | 59 | Connacht | Mayo | Exposed Hilltop Site | 195 | Large Rectangular | Yes |
| Glash | 60 | Connacht | Mayo | Exposed Hilltop Site | 56 | Large Rectangular | No |
| Tower Hill | 61 | Connacht | Mayo | Exposed Hilltop Site | 132 | Large Rectangular | Yes |
| Benwee Head | 62 | Connacht | Mayo | Inland Site | 160 | None | Yes |
| Glinsk | 63 | Connacht | Mayo | Exposed Hilltop Site | 253 | Large Rectangular | Yes |
| Creevagh | 64 | Connacht | Mayo | Gently Sloping Ground | 72 | Large Rectangular | No |
| Lenadoon Point | 65a | Connacht | Sligo | Coastal Plain | 7 | None | No |
| Rathlee | 65 | Connacht | Sligo | Coastal Plain | 29 | Large Rectangular | No |
| Carrowmably | 66 | Connacht | Sligo | Inland Site | 83 | Pre-existing Oval | No |
| Knocklane Hill | 67 | Connacht | Sligo | Low Hilltop Site | 58 | None | Yes |
| Streedagh | 68 | Connacht | Sligo | Coastal Plain | 15 | None | No |
| Kilcologe Point | 69 | Connacht | Sligo | Coastal Plain | 11 | None | Yes |
| St John’s Point | 70 | Ulster | Donegal | Coastal Promontory | 26 | Small Rectangular | No |
| Carrigan Head | 71 | Ulster | Donegal | Exposed Cliff Edge Site | 227 | Small Rectangular | Yes |

**Table 4.2. Surviving enclosure elements at or near signal stations in the main study area.**

| Signal Station | Number | Province | County | Topographic Description | Elevation (m) | Type of Enclosure | Naturally Defensible Site |
|---|---|---|---|---|---|---|---|
| Malin Beg | 72 | Ulster | Donegal | Coastal Plain | 35 | None | Yes |
| Glen Head | 73 | Ulster | Donegal | Exposed Cliff edge site | 227 | None | Yes |
| Dawros Head | 74 | Ulster | Donegal | Coastal Plain | 12 | None | No |
| Crohy Head | 75 | Ulster | Donegal | Low Sloping Ground | 49 | None | Yes |
| Mullaghderg Hill | 76 | Ulster | Donegal | Exposed Hilltop Site | 52 | None | Yes |
| Bloody Foreland | 77 | Ulster | Donegal | Coastal Plain | 58 | None | Yes |
| Horn Head | 78 | Ulster | Donegal | Exposed Cliff Edge Site | 187 | Large Square | Yes |
| Melmore Head | 79 | Ulster | Donegal | Exposed Cliff Edge Site | 48 | Large Trapezoid | Yes |
| Fanad Head | 80 | Ulster | Donegal | Exposed Cliff Edge Site | 15 | Unknown | Yes |
| Malin Head | 81 | Ulster | Donegal | Exposed Hilltop Site | 69 | Large Rectangular | No |

**Table 4.2. continued. Surviving enclosure elements at or near signal stations in the main study area.**

Figure 4.23. Part of the well-preserved enclosure wall at Inisheer Signal Station, County Galway, looking south-east. The building constructed against the wall is thought to be a toilet block for the schoolhouse constructed in the enclosure later in the 19th century (see Section 4.7).

Figure 4.24. The modified enclosure at Inishmore Signal Station, County Galway, still gives a good impression of what an intact enclosure would have looked like. Looking north-west.

Currently there are two entrances through the north-west wall. The first entrance near the central point of the wall consists of a narrow opening flanked by two square coursed stone pillars with pyramidal capstones, which may be a re-working of the original entrance. The second, wider, entrance is located further north along the north-west wall and is clearly a relatively modern alteration.

Three further gaps in the enclosure wall at Inishmore Signal Station exist. Neatly constructed narrow entrances pierce the enclosure wall on the north-east and south-west walls, and there is a ragged breach in the south-east wall. All three appear to be secondary alterations. The internal dividing walls that split the enclosure into three sections are presumed to have been added when the height of the wall of the north-eastern half of the enclosure was reduced.

The enclosures at Saddle Hill Signal Station, Tower Hill Signal Station, and Glinsk Signal Station, County Mayo, are defined by low ruined wall foundations. The large rectangular enclosure at Saddle Hill Signal Station, County Mayo, measures around 54 m by 27 m (177’ by 89’). It is defined by the low remains of a stone wall which is set within the base of a shallow ditch (Figure 4.25). A simple entrance is located one third of the way along the southern wall.

Tower Hill Signal Station, County Mayo, is set within a large rectangular enclosure which measures around 55 m by 29 m (180’ by 95’). It is defined by a narrow stone wall that has largely collapsed, but which survives to a height of around 1.4 m (4‘ 6’’) in some places (Figure 4.26). Along the north-east side there is a slight external ditch, presumably cut to aid with drainage.

The large rectangular enclosure at Glinsk Signal Station, County Mayo, measures at least 43 m (141’) in length and is around 28 m (91’ 10’’) wide. The enclosure is defined by a ruined stone wall that is 0.9 m (3’) wide and survives to a maximum height of 1 m (3’ 3’’) along the western side. No remains of the wall are present at the northern end of the enclosure, which may never have been completed.

Figure 4.25. Corner of the enclosure wall at Saddle Hill Signal Station, County Mayo, looking west.

Figure 4.26. A tall section of the enclosure wall at Tower Hill Signal Station, County Mayo, looking north-west.

The large rectangular enclosure at Glash Signal Station, County Mayo, measures approximately 55 m by 30 m (180’ by 98’). The enclosure has been largely removed and is only visible as stretches of a largely infilled ditch and occasional lines of rubble. Identification at this site is made more difficult by the presence of later infilled drainage ditches and relic field boundaries that have a similar appearance.

The signal tower at Malin Head, County Donegal, is shown on the 1st edition Ordnance Survey map as being located within a large rectangular enclosure measuring approximately 45 m by 30 m (147’ 8’’ by 98’ 5’’), closely matching the style of enclosures seen elsewhere. On the 2nd edition Ordnance Survey map, surveyed 1848, the enclosure has been removed and the signal tower is surrounded by new structures relating to weather monitoring.

In addition to the seven signal stations which featured large rectangular enclosures surrounding the signal tower, six signal stations featured enclosures of other designs. Three signal stations have signal towers surrounded by large square or trapezoidal shaped enclosures that bear a strong resemblance to the large rectangular enclosures. The similarity is so pronounced that it is suspected that these three sites were using the same design but were hampered by the local topography leading to minor variations in form.

The signal tower at Clare Island Signal Station, County Mayo, was set within an almost square enclosure defined by a largely collapsed stone wall. The enclosure measures around 22 m by 26 m (72’ by 85’). The western side of the enclosure was defined by a natural rock outcrop and no actual wall was constructed along that side.

The signal tower at Horn Head, County Donegal, was set within a large square enclosure measuring approximately 28 m by 28 m (91’ 10’’). The perimeter is defined by a stone wall which varies in width between 0.65 m and 0.8 m (2’ 2’’ and 2’ 7’’) and survives as a low foundation to the north but has a height of several feet around the south.

The signal tower at Melmore Head, County Donegal, was set within a trapezoidal enclosure measuring approximately 38 m by 28 m (124’ 8’’ by 91’ 10’’). The perimeter is defined by a stone wall which is 0.65 m (2’ 2’’) wide and survives as a low foundation around most of its circuit, with only occasional sections that are more intact.

Two adjacent signal stations in County Donegal featured smaller rectangular enclosures built adjacent to the signal towers, rather than containing them. The enclosure immediately north-east of the suspected signal tower foundation at St John's Point measures 20 m by 28 m (65' 7'' by 91' 10''). It is defined by a wide and low grassy bank (Figure 4.27). Stones are frequently visible and occasional sections of intact wall foundation can be seen.

The enclosure immediately north of the signal tower at Carrigan Head measures 26 m by 10.7 m (85' 4'' by'35' 1'') and consists of a low grassy bank with some sections of collapsed stone wall present towards the east end (Figure 4.28). Whilst it could be claimed that the topography at Carrigan Head was a constraining factor, this was clearly not the case at St John's Point, meaning the rationale behind the deviation from the standard design is unclear.

At Cleggan Hill Signal Station, County Galway, an L-shaped section of wall is located to the south and west of the signal tower, which appeared to be the remains of a small sub-rectangular enclosure with the signal tower located at the eastern end. The steep natural slopes to the north and east seem to have formed the rest of the perimeter as no wall remains were identified in those areas. If this interpretation is correct, then the enclosure would have had dimensions of approximately 21 m by 11 m (69' by 36').

In addition to the sites described above, the presence of rectangular enclosures surrounding the signal towers at the adjacent Creevagh Signal Station, County Mayo, and Rathlee Signal Station, County Sligo, is strongly implied in the letter from Captain Lecky to Thomas Soden (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden). Lecky claims to have constructed this arrangement at both sites and the alterations were approved by the Lord Lieutenant and General Dalrymple. Although lacking any corroboration from field work or other documentary sources, Lecky's statement has here been taken at face value and the sites are listed as enclosed in Table 4.2. Until corroborating evidence is identified the identification of these two sites as enclosed should be regarded as provisional.

Figure 4.27. The enclosure at St John’s Point, County Donegal, is visible as a sporadic line of stones, behind the square hollow where the signal tower probably stood and in front of the cairn with L.O.P. 70 on top. Looking north-east.

Figure 4.28. The stone wall of the enclosure at Carrigan Head Signal Station, County Donegal, can be seen in the midground, to the north-east of the rear wall of the signal tower. Looking south-west.

During the field survey extremely fragmentary wall foundations were identified adjacent to the base of the signal tower at Cuileen Hill Hill Signal Station, County Galway. These may also represent the former presence of a small walled enclosure surrounding the signal tower, but the dimensions are impossible to determine based on surface evidence alone, and it is possible that they are the remains of several small buildings constructed next to the signal tower. It is important to note that the early Ordnance Survey maps show neither an enclosure or any additional buildings at this site and these walls may therefore have resulted from activity in the 20th century. The presence of an enclosure at the site is listed as 'unknown' in Table 4.2.

Finally, an enclosure associated with Mullaghderg Hill Signal Station, County Donegal, does not seem to have been an original feature dating to the use of the site in the first decade of the 19th century, despite conforming to the same design as the large rectangular enclosures described above. The enclosure is no longer visible. It is shown on the 3rd edition Ordnance Survey map, surveyed 1900-1905, as measuring approximately 50 m by 20 m (164' by 65' 6''). It was located a short distance to the west of the signal tower (marked as 'in ruins') on the 3rd edition map. A small rectangular building is shown inside the enclosure, which appears to be the same building shown adjacent to the signal tower on the 1st edition Ordnance Survey map, surveyed 1834-1836, which does not depict the enclosure. A flagstaff and a signal post are also marked inside the enclosure, suggesting that the site had been taken over by the coast guard, and that the enclosure is a secondary addition to the site. The site is not listed as enclosed in in Table 4.2.

Rathlee Signal Station is the only site in County Sligo which may have featured a purpose-built enclosure, although the existence of an enclosure at the site is only known from a single contemporary letter (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden). The signal tower at Carrowmably Signal Station was built within the interior of a pre-existing large oval enclosure of unknown date, (see Section 4.11), alternately claimed to have originated in the Neolithic, iron age, or early medieval periods (Section 4.11). The site is not listed as enclosed in in Table 4.2 because it was not located within a purpose-built enclosure.

It is not known whether the signal station at Fanad Head, County Donegal, featured an enclosure or not. That site was demolished around 1817 to make way for a lighthouse (Section 4.10) and the 1st edition Ordnance Survey map, surveyed 1834-1836, depicts the lighthouse with no features that could be associated with the earlier signal station. As with the adjacent site at Malin Head, no enclosure is shown in Smith's contemporary illustrations of the site (Figures 5.4, D.109 through D.115). The presence of an enclosure at the site is listed as 'unknown' in Table 4.2.

## 4.4 Additional buildings at the Signal Stations

Alongside the signal towers many sites in the main study area featured additional structures. This section focuses on buildings and structures that are thought to have been contemporary elements of the signal stations. Buildings and structures which are thought to have been added to signal station sites after they were decommissioned are dealt with in Section 4.7 through 4.10.

### 4.4.1 Contemporary buildings at enclosed signal stations

Identifying additional buildings as contemporary elements of a particular signal station was most convincing at the enclosed sites where buildings were within the enclosed area and either follow the general alignment of the enclosure or were actually built up against the enclosure wall. At some sites, foundations of these buildings remained visible whilst at others their former presence was known only from the early editions of the Ordnance Survey maps.

At Inisheer Signal Station, County Galway, the 1st edition Ordnance Survey map, surveyed 1838-1839) shows a long rectangular building at the eastern corner of the enclosure, extending along the enclosures south-eastern wall. A second smaller square building is shown in the southern corner of the enclosure. A third small square building is shown built against the external face of the northern enclosure wall. The position of the rectangular building is now covered by a modern rectangular water tank. The position of the first square building lies in an area of long grass and it is not known if any foundations survive at that location. The second small square building would be located in what is now a walled off field between the enclosure and the road and it is not known if any traces of the structure survive.

At Inishmore Signal Station the 1st and 3rd edition Ordnance Survey maps, surveyed 1838-1839 and 1915-1920) show a number of additional buildings within the enclosure, but it is unclear if these related to the original use of the signal station or the later period when it was converted into a lighthouse. These buildings are discussed below in the section dealing with the secondary buildings (Section 4.7).

At Cleggan Hill Signal Station, County Galway, a large rectangular building was located approximately 40 m (130’) west of the signal tower, and outside of the small enclosure surrounding the signal tower (Figures 4.29 & 4.30). It was constructed of mortared rubble walling and measured 7.7 m by 4.4 m (25’ 3’’ by 4’ 6’’) externally and 6.8 m by 3.5 m (22’ 4’’ by 11’ 6’’) internally. The walls survived to a maximum height of 1.22 m (4’) and were around 0.45 m (1’ 6’’) wide. There was a single entrance in the middle of the southern long wall. The building is surrounded by a dense rubble spread.

At Saddle Hill Signal Station, County Mayo, traces of a possible rectangular foundation were visible close to the north-west corner, extending along the northern wall. The foundation measured 7.5 m by 3 m (24’ 7’’ by 9’ 10’’) and consisted of an L-shaped set of earthen banks with stone facing along the southern side of the longer southern bank. The building is not shown on any of the early Ordnance Survey maps.

At Glash Signal Station, County Mayo, the first edition Ordnance Survey map shows a long rectangular building in the south-western corner of the enclosure, extending along the western wall of the enclosure. Given the generally poor condition of the enclosure it was unsurprising that no traces of this building were visible during the survey.

At Tower Hill Signal Station, County Mayo, the foundation of a stone walled building was located in the western corner of the enclosure (Figure 4.31). The building was rectangular with two rooms and measured 9 m by 4 m (29’ 6’’ by 13’ 2’’). The building is shown on the second edition Ordnance Survey map, surveyed 1913-1917, but not on the 1st edition Ordnance Survey map, surveyed 1837-1839, casting some doubt as to whether it was a contemporary element of the signal station or a later addition.

At Glinsk Signal Station, County Mayo, a substantial wall was located approximately 1 m (3’ 3’’) north of the signal tower, running from east to west. The wall was 5.65 m (18’ 6’’) long and 2 m (6’ 6’’) wide. It seemed likely that this was part of a large contemporary building, but no other walls were visible making its plan impossible to determine. The building is not shown on the early editions of the Ordnance Survey maps, but neither is the enclosure which is surely a contemporary element of the signal station.

Figure 4.29. The rectangular building to the west of Cleggan Signal Station, County Galway, looking south-east. The signal tower is visible at the left of the photograph.

Figure 4.30. The rectangular building to the west of Cleggan Signal Station, County Galway, looking west.

Figure 4.31. The two-room building in the western corner of the enclosure at Tower Hill Signal Station, County Mayo, looking north-west.

Figure 4.32. The building in the north-west corner of the enclosure at Horn Head Signal Station, County Donegal, looking north-west.

At Horn Head Signal Station, County Donegal, the remains of a small rectangular building (Figure 4.32) were present in the north-west corner of the enclosure, extending along the western wall. The building measured 7.45 m by 3.2 m (24’ 5’’ by 10’ 6’’) externally and 5.8 m by 2.6 m (19’ by 8’ 6’’) internally. The outline of the building was visible as a neat grassed over footing, with stones sporadically visible along most of its circuit. At the south-east corner there was a substantial surviving portion of the buildings mortared stone wall that had a maximum height of 1.8 m (6’). The building is shown on the 3rd edition Ordnance Survey map, surveyed 1900-1905, but not the 1st edition Ordnance Survey map, surveyed 1834-1836, which also omits the enclosure. Along the southern wall of the enclosure there were two further foundations that appeared to be contemporary elements of the signal station. The first was a large well-built stone foundation located halfway along the interior side of the enclosure wall. It measured 3.2 m by 2.4 m (10’ 6’’ by 7’ 10’’) and appeared to be part of the entrance, possibly the foundation of a guardhouse or an elaborate gate structure. The foundation was covered by collapsed stone from the nearby signal tower and presumably from its own upper portions, and it proved difficult to examine. On the exterior side of the southern enclosure wall, 5.8 m (19’) east of the south-west corner and west of the foundation associated with the entrance, there was a smaller stone foundation measuring 3.2 m by 1.5 m. (10’ 6’’ by 4’ 1’’). The purpose of this structure is unknown. Neither of these two buildings are depicted on the early Ordnance Survey maps.

At Melmore Head the 1st edition Ordnance Survey map, surveyed 1834-1836, shows a long rectangular building in the south-east corner of the enclosure, extending along the eastern wall. A foundation was visible in that location, consisting of neat grassed over wall footings with frequent visible stonework (Figure 4.33). The building measured 7.95 m by 1.8 m (26’ by 6’) externally and 7 m by 1.45 m (23’ by 4’ 9’’) internally.

Figure 4.33. The building foundation in the south-east corner of the enclosure at Melmore Head Signal Station, County Donegal, looking north.

Figure 4.34. The building foundation in the south-west corner of the enclosure at Melmore Head Signal Station, County Donegal, looking north.

A second rectangular foundation was present in the south-west corner of the enclosure, extending along the western wall. It consists of a grassed over earthen bank with frequent protruding stones and was less well built than the first foundation (Figure 4.34). It measured approximately 4 m by 2.15 m (13’ by 7’) externally and 3.35 m by 1.7 m (11’ by 5’ 6’’) internally. This building is not shown on the early Ordnance Survey maps and given its cruder appearance in comparison to the first foundation it is possibly a later addition to the site.

### 4.4.2 Contemporary buildings at unenclosed signal stations

Identifying additional buildings at unenclosed signal stations as contemporary elements is more challenging than is the case with the enclosed signal stations. Standing remains of possible contemporary buildings do not survive at any of the sites. The possible existence of contemporary buildings at unenclosed sites are only known from cartographic sources. Given the lack of physical connections between these additional buildings and either signal towers or enclosures known to belong to the signal stations it is not possible to be certain of the associations. These buildings do conform to approximately the same size and shape ranges as those found at the enclosed sites.

Using the 1st edition Ordnance Survey map as the main source of information is problematic, because of the long gap between signal station abandonment and when the maps were recorded. It is also clear that the surveyors did not always depict all of the features that were present, especially if they were ruinous. It is also important to note that these additional buildings can clearly be removed from the sites without leaving visible traces. Given these various issues it is certainly possible that other buildings were originally present at some of the unenclosed signal stations that were not depicted by the Ordnance Survey and are not currently visible at the sites.

At Bunowen Hill Signal Station, County Galway, the 1st edition Ordnance Survey map, surveyed 1838-1839, shows a large rectangular building some 44 m (144’) west-south-west of the signal tower. Nothing is now visible at this location.

This building is shown on the 1st edition Ordnance Survey map, surveyed 1838-1839 but not on the 2nd edition Ordnance Survey map, surveyed. Curiously it is shown on the 3rd edition Ordnance Survey map, surveyed 1915-1920, where the signal tower is shown as having a small addition on its western end, which may explain why the rubble spread extends further to the west of the building than it does to the east.

At Dawros Head Signal Station, County Donegal, the 1st edition Ordnance Survey map, surveyed 1834-1836, shows a large rectangular building almost immediately east of the signal tower. Given the amount of coastal erosion that has affected this site it is unsurprising that no traces of this building are now visible.

At Mullaghderg Hill Signal Station, County Donegal, the 1st edition Ordnance Survey map, surveyed 1834-1836, shows a large rectangular building located approximately 18 m (59’) west of the signal tower. The 3rd edition Ordnance Survey map, surveyed 1900-1905, shows that this building was incorporated into the rectangular enclosure described above (Section 4.3). No traces of the rectangular building, or the enclosure, are now visible.

### 4.4.3 Signal Masts

Small circular or oval features were recorded at six of the signal station sites in the main study area during the survey, which appeared to have different forms to the lime kilns described in the following section (Section 4.5). At least some of these features may have been the partially filled in sockets for signal masts. Archaeological excavation would be required to examine these features in more detail and to properly determine their nature.

An oval feature was identified 12.7 m (41’ 8 ’’) west of the ruined signal tower at Saddle Hill Signal Station, County Mayo, on the long axis of the enclosure. It consisted of a grassed over oval hollow measuring 3.7 m by 2.5 m (12’ 2’’ by 8’ 2’’). Traces of intact stone walling were visible around one side of the hollow. A circular feature was identified 5.7 m (18’ 8 ’’) west of the signal tower at Glash Signal Station, County Mayo, on the long axis of the destroyed enclosure. It had a diameter of 2.6 m (8’ 6’’) and was simply a shallow circular depression. A circular feature was identified 11.8 m (38’ 9’’) north-west of the ruined tower at Tower Hill Signal Station, County Mayo, again located on the long axis of the enclosure. It had a diameter of 1.8 m (5’ 11’) and was a steep sided hollow filled with large stones.

An oval feature was identified 14.5 m (47’ 7’’) west of the ruined signal tower at Lenadoon Point, County Sligo. It consisted of an oval hollow measuring 2.9 m by 1.7 m (9’ 6’’ by 5’ 7’’) which was filled with rubble and traces of intact stone walling were visible around one side.

An oval feature was located 9 m (29’ 6’’) to the north-west of the signal tower at Crohy Head, County Donegal. It had been cut into the slope near the top of the hillock on which the signal tower was constructed. It consisted of an oval shaped hollow with steep sides that measured 3.1 by 2.4 m (10’ 2’’ by 7’ 10’’) and was open towards the north-east. An oval feature was identified 6.7 m (22’) north of the ruined signal tower at Horn Head Signal Station, County Donegal, on the long axis of the enclosure. It measured 1.9 m by 1.7 m (6’ 3’’ by 5’ 7’’) and was simply a shallow grassed over depression.

## 4.5 Contemporary Lime Kilns at signal stations

Lime kilns were recorded at five of the signal station sites within the main study area, and cartographic sources indicated the presence of lime kilns at three further sites. These features ranged in size between 2.5 m and 4 m (8′ 2′′ and 13′) in maximum length and were sometimes visible as shallow depressions, sometimes as deeper pits and occasionally as the remains of small stone structures.

The two most intact examples were located at Inishturk and Clare Island Signal Stations, County Mayo. The features are identified as kilns of the ‘pot kiln’ type common to western Ireland (Whelan 2011b, 247; figure 5). The kilns likely date to the construction phase of the signal stations, when lime would have been needed for the preparation of mortar and render. It is possible that they were kept serviceable for use during periods of repair or alteration (Section 4.2.1). Support for the interpretation of the kilns as specifically being lime kilns was provided when the symbol that denotes lime kilns (a small open circle with a pronounced dot at the bottom) was identified on some of the early Ordnance Survey depictions of the signal stations. Bishop and Thomas state that this symbol was used by the Ordnance Survey in central Scotland to specifically denote circular pot kilns, with U-shaped symbols being used for clamp kilns and square symbols indicating more elaborate stone-built draw kilns (Bishop & Thomas 2013, 22; Figure 3). They identify the pronounced dot as indicating the location of the ‘draw’ through which air entered the kiln. Although contemporary documents discussing the presence of lime kilns have not yet been identified, this cartographic evidence suggests that the Ordnance Survey surveyors believed the features to have been lime kilns.

The lime kiln at Inishturk Signal Station is located 11.5 m (37′ 9′′) to the north-west of the signal tower. It was an oval kiln with a well-defined bowl and a long flue extending to the south-east (Figure 4.35). The kiln measured 3.4 m (11′ 2′′) from north-east to south-west and 3.1 m (10′ 2′′) from north-west to south-east. Internally the bowl of the kiln measured 1.6 m (5′ 3′′) across. It had a sub-circular plan, with sides that sloped inwards. An intact lintel stone was present at the point where the flue met the bowl. This is the only lime kiln in the study area that was both recorded in the field and marked on the relevant 1st edition Ordnance Survey map, surveyed 1837-1839.

Figure 4.35. The lime kiln at Inishturk Signal Station, County Mayo, looking north-west along the flue into the bowl.

Figure 4.36. The lime kiln at Clare Island, County Mayo, looking north-east with part of western side of the signal tower in the background.

The lime kiln at Clare Island Signal Station, was located approximately 10 m (33’) south-west of the signal tower (Figure 4.36). The lime kiln measured 4.1 m (13’5’’) from north to south and 3.7 m (12’ 2’’) from east to west. It featured a prominent bowl shape that opened to the south and lacked the extended flue seen at Inishturk. This lime kiln has its own listing in the SMR under the number MA084-001003-.

A less well-preserved example was identified at Kilcologue Point, County Sligo. This was an oval feature located 6.9 m (22’ 6’’) north-west of the foundation of the demolished signal tower. It was defined by a low grassy bank measuring 4 m by 3.7 m externally with a pronounced central hollow. A break in the bank at the north-east appeared to be a flue leading into a bowl.

The National Monuments Service noted the presence of a small lime kiln approximately 15 m north of the signal tower at Rathlee Signal Station, County Sligo (O’Shaughnessy 2013). This was not located during the field survey and no additional details are known.

The 1st edition Ordnance Survey maps show lime kilns at three more signal stations, all in County Galway. The kiln at Inisheer Signal Station was located immediately north-east of the enclosure. The location is within a small walled field that was not examined during the fieldwork phase of this project, and it is not known whether traces of this feature are still visible. The lime kiln at Bunowen Hill is marked as being 75 m (82 yards) east-north-east of the signal tower. This places it on a steep slope leading down from the summit of the hill, in an area now covered in dense gorse bushes, meaning it was not possible to visit its location. It is possible that the lime kiln is still present in this area. The lime kiln at Cleggan is shown a few meters north-west of the signal tower, in an area now covered by the spread of rubble from the collapsed tower. It is possible that the feature is preserved under the rubble. Adding the cartographic depictions to the examples recorded during the field work and by the NMS, a minimum of eight signal stations in the main study area are now known to have featured lime kilns.

## 4.6 Roads

Fourteen of the signal stations (44%) in the main study area are currently accessible from roads or tracks. Reviewing the 1st edition Ordnance Survey maps it is clear that many of these were later additions. Only four of these roads and tracks (29%) appear likely to have been in use contemporaneously with the signal stations, nine of the roads and tracks (64%) are later than the signal stations and the relationship between the road and the signal station is uncertain at one of the sites (7%).

A walled road runs immediately south of the signal station at Rathlee, County Sligo. Whilst the age of the road is not certain, the drive leading to the now demolished Rathlee House connects to the road, suggesting it dates from sometime in the 18th century (McTernan 2009, 171-2). The road is shown on Larkin's map of County Sligo, published in 1819, proving that it was at least present shortly after the signal station was decommissioned in 1809 (Section 2.3.1).

A rough track approaches the Carrigan Head Signal Station, County Donegal, from the north-east. The track is shown on both the 1st and 3rd editions of the Ordnance Survey maps, surveyed 1834-1836 and 1900-1905, and, given that the track terminates at the signal station and there are no other destinations in the vicinity, it was very likely a route used specifically to access the signal station.

The 1st edition Ordnance Survey map shows a track running directly to Malin Beg Signal Station, County Donegal, from the small settlement of Malin Beg to the north-east. The 3rd edition Ordnance Survey map shows the western portion of this track had been abandoned and field boundaries crossed the area. The abandoned stretch of track is still a visible earthwork running across the fields. It appears to have been a track that was created specifically to access the signal station.

The 1st and 3rd edition Ordnance Survey maps both show a switchback track climbing up the steep slope to the north of Glencolumbkille and then heading across the open bog directly towards Glenhead Signal Station, County Donegal. The track still exists today, and the section which climbs the steep hillside appears to have been carefully engineered, rather than being a simple mountain track (Figures 4.37 & 4.38). Given that there are no other obvious destinations in the vicinity, it appears that this track was constructed specifically to access the signal station.

The road that runs a little to the north of Glash Signal Station, County Mayo, is not present on either the 1st or 3rd editions of the Ordnance Survey map, surveyed 1837-1839 and 1893-1900, and clearly post-dates the use of the signal station. The track that runs a little to the east of Benwee Head Signal Station, County Mayo, is not present on either the 1st or 3rd editions of the Ordnance Survey map and clearly post-dates the use of the signal station.

The track that runs a little to the east of Streedagh Signal Station, County Sligo, is not present on either the 1st or 3rd editions of the Ordnance Survey map, surveyed 1837 and 1909-1912. It seems to have been created to access a boat house that is visible on the 3rd edition Ordnance Survey map, although at that point the road followed a different alignment.

The road that runs past the west side of St John's Point Signal Station, County Donegal is shown on the 2nd edition Ordnance Survey map, surveyed 1848, but not on the 1st edition, surveyed 1834-1836. It is presumably a mid-19th century road constructed to access the lighthouse where the road terminates. The 1st edition Ordnance Survey map shows access to the lighthouse was originally via a landing at the shore.

The road that runs past the southern side of the demolished Bloody Foreland Signal Station, County Donegal is clearly a recent edition that is not present on either the 1st or 3rd editions of the Ordnance Survey maps.

Figure 4.37. A section of the road which leads to Glen Head Signal Station, County Donegal. This track utilises multiple switch backs as it climbs the steep hillside to the north of Glencolumbkille and has clearly been carefully designed and executed.

Figure 4.38. The road to Glen Head Signal Station, County Donegal. After climbing the steep hillside, it crosses a flat plateau, shown here. Even in this section the road appears to have been built with a proper roadbed.

The location of the demolished signal station at Fanad Head, County Donegal, is now approached via a walled road that leads to the Lighthouse. The 1st edition Ordnance Survey map shows an informal track leading to the lighthouse following the same winding course as the modern road, but it is not known if the same track was in use for the signal station or if it was a subsequent addition. The signal station at Malin Head, County Donegal, is now approached by a walled road. The road is not shown on any of the early editions of the Ordnance Survey map, indicating that this road is a relatively recent addition to the landscape.

The location of Creevagh Signal Station, County Mayo, is approached from the village of Creevagh via a walled road which turns 90 degrees to the south about 38 m (124’) east of the signal station. The 1st edition Ordnance Survey map shows the main field boundaries as established, but the 3rd edition Ordnance Survey map shows that system had been repeatedly sub-divided, indicating the landscape in this area was developing throughout the 19th century. The cartographic evidence does not provide a clear answer as to whether this route was used to access the signal station or if it was a later addition.

The two signal stations on the Aran Islands, Inisheer and Inishmore, are currently accessed via walled roads that run through the dense network of stone walled fields which define the island landscapes. Both roads are shown on the 1st edition Ordnance Survey maps, running through well-established field systems.

## 4.7 Secondary Buildings

Many of the signal station sites in the main study area had buildings added to them after their primary period of use came to an end. These secondary additions range from simple hut foundations to complex stone buildings. Detailed descriptions of all of these buildings are provided in the individual entries in Appendices A through D. An absence of cartographic depictions of the simple hut foundations and their non-diagnostic forms means that it is currently impossible to determine when they were added to the sites. Conversely the larger, more complex stone buildings can often be dated with some level of precision.

Small hut foundations were identified at Clare Island and Saddle Hill Signal Stations, County Mayo, and at Malin Beg and Glen Head Signal Stations, County Donegal. The hut foundations were either sub-rectangular or ovoid in plan and consisted of low earthen banks with some having traces of intact stone walling. The hut foundation at Clare Island Signal Station had an almost square plan measuring 4.3 m by 3.6 m (14’ 1’’ by 11’ 10’’) externally and 3.1 m by 1.75 m internally (10’ 2’’ by 5’ 9’’). The hut foundation at Saddle Hill Signal Station had an oval plan and measured 5.7 m by 4.5 m (18’ 8’’ by 14’ 9’’) externally and had a small, poorly defined internal space (Figure 4.39). The hut foundation at Malin Beg had an oval plan and measured 9.15 m by 8.55 m (30’ by 28’) externally and 4.1 m by 3.3 m (13’ 5’’ by 10’ 10’’) internally. All of these hut foundations were located in the immediate vicinity of the signal towers.

At Glen Head two small rectangular hut foundations were located approximately 29 m (95’) to the north-east of the signal tower, very close to the cliff edge (Figure 4.40). The two huts were located just 1.22 m (4’) apart and shared the same alignment. The larger north-western hut measures 4.85 m by 4.1 m (15’ 1’’ by 13’ 5’’) externally and 2.25 m by 1.4 m (7’ 5’’ by 4’ 7’’) internally. The smaller south-eastern hut measures 4.1 m by 3.2 m (13’ 5’’ by 10’ 6’’) externally and 3.5 m by 2.8 m (11’ 6’’ by 9’ 2’’) internally. A narrow wall divided the internal space into two small rooms.

Figure 4.39. The secondary hut foundation to the south of the signal tower at Saddle Hill Signal Station, County Mayo, looking south.

Figure 4.40. The two adjacent secondary hut foundations to the north-east of the signal tower at Glen Head Signal Station, County Donegal, looking west.

A large stone-built side gabled-roofed schoolhouse with a projecting double entrance was located within the enclosure at Inisheer Signal Station, County Galway (Figure 4.41). It is shown on the 3rd edition Ordnance Survey map, surveyed 1915-1920, and probably dates to the late 19th century. A small rectangular stone built shed-roofed out-building constructed against the midpoint of the south-western wall of the enclosure is probably a toilet block associated with the school. A stone wall ran from the toilet block to the midpoint of the rear wall of the schoolhouse, dividing the south-western part of the enclosure into two separate yards.  This arrangement may reflect the separation of the children into two separate classes, each with their own yard and toilet.

The most complex additions were made to Inishmore Signal Station, County Galway (Figure 4.42). In 1818 the signal tower was converted into a lighthouse (SMR GA110-133001-/Reg. No. 30411019). Three gabled-roofed additions were built against the north-east, south-east and south-west walls respectively, with those at the south-east and south-west being two-storeys tall and that at the north-east being only a single-storey tall. Remains of all three additions survive to varying degrees. This modified T-shaped structure is shown on both the 1st and 3rd edition Ordnance Survey maps, surveyed 1838-1839 and 1915-1920).

Subsequently a free-standing circular lighthouse was constructed to the north-east of the signal tower (Reg. No. 30411020). It was built of finely cut stone and its location seems to have necessitated the partial demolition of the north-eastern addition to the signal tower. The surviving remains of the addition were adapted to form a protected entrance to the new lighthouse. The NIAH listing for this lighthouse states a construction date of 1835. The lighthouses absence on the 3rd edition Ordnance Survey map is puzzling. A very similar lighthouse (Reg. No. 20915308) built at Cape Clear Signal Station, County Cork, is listed by the NIAH as having been constructed in 1818 and becoming disused in 1854.

Figure 4.41. The schoolhouse built within the enclosure at Inisheer Signal Station, County Galway, looking west.

Figure 4.42. Inishmore Signal Station, County Galway, showing the secondary additions to the signal tower and the later lighthouse in the back ground, looking north.

The 1st edition Ordnance Survey map also shows a number of other buildings within the enclosure, as was mentioned above (Section 4.4.1). The map shows two long rectangular buildings running along the north-eastern wall of the enclosure, one extending from the eastern corner, and the other extending from the northern corner. Another rectangular building is shown against the south-eastern wall of the enclosure, level with the north-eastern addition to the signal tower. Two small square buildings are shown along the south-western wall of the enclosure, one in the western corner, the other further to the south-east, built up against a dividing wall that ran from the western corner of the south-western addition of the signal tower and which is no longer extant (a replacement dividing wall now runs from the southern corner of the south-western addition). The three rectangular buildings are shown on the 3rd edition Ordnance Survey map, as is the centrally positioned square building. The square building in the western corner of the enclosure is no longer shown, but a larger square building is shown in the southern corner of the enclosure. No traces of these buildings were noted during the survey of the site. It is unclear which phase these buildings belong to, and any combination of them might belong to either the signal station phase or the first or second lighthouse phases.

A large stone built shed-roofed building is located immediately north-east of the enclosure. It is not clear when this building was added to the site, but a similarly sized building is shown in this position on the 3rd edition Ordnance Survey map. A small stone-built side-gabled building has been constructed against the external side of the north-west enclosure wall, immediately south-west of the larger gate. This building is not shown on the early Ordnance Survey maps and it is probably a relatively recent addition to the site.

The third site where complex buildings were added is Malin Head Signal Station, County Donegal. This site has a complex history of communications technology, of which the signal stations was the earliest part, later becoming a Lloyds signal station in the late 19th century, a Marconi telegraph station in the early 20th century, a post office facility and finally a Look Out Post for the Coast Watching Service during World War 2. The details of these later phases remain confused with many contradictory and/or factually challenged accounts existing (i.e. Haggan 2014, 30-1). Untangling the complex chronology of the later activity of this site lies beyond the scope of this project, but the NIAH entry (Reg. No. 40900101) provides a succinct summary.

The signal tower itself maintains its overall form, but the original windows and door have been blocked and new windows and doors have been added. To the east of the signal tower there is a small rectangular enclosure defined by a tall stone wall which is identified on the 3rd edition Ordnance Survey map as a 'barometer' and which is thought to be an enclosure to house meteorological equipment (Homer & Brown 2014a). To the north-west of the signal tower there is a complex single-storey poured concrete building identified as 'semaphore' building on the 3rd edition Ordnance Survey map (Figure 4.43). Various early 20th century photos show this building as surrounded by different masts and antennas, none of which survive. To the north-east of the signal tower there is a small rectangular poured concrete building (Figure 4.44) identified alternatively as an accommodation building or an ancillary structure (Homer & Brown 2014a). It is set within a large trapezoidal enclosure defined by a four feet tall poured concrete wall. Neither the enclosure or the small building are shown on the 3rd edition Ordnance Survey map indicating they are later additions than the barometer and semaphore building. Finally, further to the north-west of the signal tower there is the Look Out Post (L.O.P. 80) already mentioned, and which is described below in Section 4.9.

Figure 4.43. The semaphore building at Malin Head Signal Station, County Donegal, to the north-west of the signal tower, looking north.

Figure 4.44. The accommodation building or ancillary structure at Malin Head Signal Station, County Donegal, to the north of the signal tower, looking north.

## 4.8 Trigonometry Points

The 1st edition Ordnance Survey maps show trigonometry point symbols at 23 of the signal stations in the main study area, with spot heights given at two further signal stations (Table 4.3). This suggests that either 72% or 78% of the sites were utilised by the Ordnance Survey for triangulation, depending on how the spot heights functioned. Of the sites with trigonometry points, 14 of the sites had the point marked on the signal tower or replacing the signal tower on the map (Section 3.2.1), and seven of the sites had the trigonometry point adjacent to the signal tower. In both cases where spot heights are given these are marked on the signal towers.

Of the 13 signal station locations depicted on the 2nd edition Ordnance Survey maps (Section 3.2.1), seven show trigonometry points. Of the seven sites with trigonometry points, three of the sites had the point marked on the signal tower and four of the sites had the trigonometry point adjacent to the signal tower. A further two sites show benchmarks, both of which were marked on the signal towers. It is not clear if there was a functional difference between a trigonometry point and a benchmark at this period. The results from examining the 2nd edition Ordnance Survey maps represent a smaller sample because of the reduced coverage (Section 3.4.1). Of the sites with coverage, either 54% or 69% of the signal stations recorded on the 2nd edition maps were utilised by the Ordnance Survey for triangulation, depending on how the benchmarks functioned.

The 3rd edition Ordnance Survey maps show trigonometry point symbols at 14 of signal stations, with benchmarks shown at four sites, and a spot height given at one site (Table 4.3). This suggests that either 44%, 56%, or 59% of the sites were used by the Ordnance Survey for triangulation, depending on how the benchmarks and spot heights functioned. Of the sites with trigonometry points, nine of the sites had the point marked on the signal tower and five of the sites had the trigonometry point adjacent to the signal tower. In all cases where benchmarks are shown they are marked on the signal towers. The single spot height is shown adjacent to the signal tower.

| Name of Signal Station | County | 1st Edition OS Map | 2nd Edition OS Map | 3rd Edition OS Map | Trigonometry Pillar |
|---|---|---|---|---|---|
| Inisheer | Galway | TP on Tower | ? | x | x |
| Inishmore | | SH near Tower | ? | x | 150 m from Tower |
| Golam Head | Galway | TP on Tower | ? | TP on Tower | x |
| Cuileen Hill | Galway | TP near Tower | TP on Tower | TP on Tower | x |
| Bunowen Hill | Galway | TP near Tower | TP near Tower | TP near Tower | x |
| Cleggan Hill | Galway | SH on Tower | x | TP on Tower | x |
| Inishturk | Mayo | TP near Tower | ? | TP near Tower | 6.5 m from Tower |
| Clare Island | Mayo | TP on Tower | ? | TP on Tower | x |
| Saddle Hill | Mayo | x | BM on Tower | BM on Tower | x |
| Glash | Mayo | TP on Tower | x | TP on Tower | x |
| Tower Hill | Mayo | TP on Tower | ? | x | x |
| Glinsk | Mayo | SH near Tower | ? | BM on Tower | x |
| Lenadoon Point | Sligo | TP near Tower | BM on Tower | BM on Tower | x |
| Rathlee | Sligo | TP on Tower | TP on Tower | TP on Tower | 3.3 m from Tower |
| Carrowmably | Sligo | TP near Tower | TP near Tower | TP near Tower | x |
| Knocklane Hill | Sligo | TP near Tower | TP near Tower | TP near Tower | 114 m from Tower |
| St John’s Point | Donegal | TP on Tower | x | SH near Tower | x |
| Carrigan Head | Donegal | TP on Tower | x | TP on Tower | x |

**Table 4.3. Signal station sites with trigonometry points (TP), benchmarks (BM), spot heights (SH) and trigonometry pillars. (?) symbols denote the sites not shown on the 2nd edition Ordnance Survey maps. (x) symbols indicate where no feature is shown on the relevant map.**

| | | | | | |
|---|---|---|---|---|---|
| Malin Beg | Donegal | TP on Tower | ? | BM on Tower | x |
| Glen Head | Donegal | TP on Tower | ? | x | x |
| Mullaghderg Hill | Donegal | TP on Tower | ? | x | X |
| Bloody Foreland | Donegal | TP on Tower | ? | x | x |
| Horn Head | Donegal | TP on Tower | ? | TP on Tower | x |
| Melmore Head | Donegal | SH on Tower | TP on Tower | TP on Tower | x |
| Malin Head | Donegal | TP on Tower | TP near Tower | TP near Tower | x |

**Table 4.3. continued. Signal station sites with trigonometry points (TP), benchmarks (BM), spot heights (SH) and trigonometry pillars. (?) symbols denote the sites not shown on the 2nd edition Ordnance Survey maps. (x) symbols indicate where no feature is shown on the relevant map.**

At two of the signal station sites, Inishturk, County Mayo (Figure 4.45), and Rathlee, County Sligo (Figure 4.46), concrete trigonometry pillars were present, erected close to the signal towers (Table 4.3). These would have been erected as part of the 1959 retriangulation project undertaken by Ordnance Survey Ireland (Lynch 2018). Neither of these trigonometry pillars are located in the same positions as the earlier trigonometry points. A trigonometry pillar was also located approximately 150 m (165 yards) south-east of the signal station on Inishmore, County Galway, now built into a field wall. A fourth trigonometry pillar was located approximately 114 m (125 yards) south-east of the signal station at Knocklane Hill, County Sligo, on top of a possible barrow mound (SL007-048----). It is possible that further trigonometry pillars were located in the landscape in the vicinity of signal stations which were not observed during the field surveys. An encased benchmark from the same 1959 retriangulation is set on the roof of LOP 53, 23 m (25 yards) west of the signal tower at Bunowen Hill, County Galway.

Figure 4.45. The trigonometry pillar at Inishturk Signal Station, County Mayo, looking north-west with the ruined signal tower in the background.

Figure 4.46. The trigonometry pillar at Rathlee Signal Station, County Sligo, looking north-west with the signal tower and L.O.P. 66 in the background.

## 4.9 Look Out Posts (L.O.P.)

Five of the signal stations sites in the main study area have examples of the ‘137 block’ type prefabricated Look Out Posts (L.O.P.s) in their immediate vicinity (Kennedy 2008). These ‘kit’ buildings are named after the 137 concrete blocks used to build their walls (Kennedy 2008, 48-9). At Bunowen Hill Signal Station, County Galway, a well-preserved Look Out Post (L.O.P. 53) was located 13 m (42’ 8’’) to the west of the site of the demolished signal tower (Figure 4.47). It was set within a small rectangular enclosure defined by a low mortared rubble wall, which measured 6.9 m by 5.2 m (22’ 8’’ by 17’ 1’’) externally and 4.8 m by 3.2 m (15’ 9’’ by 10’ 6’’) internally. The enclosure had a simple entrance on the northern wall. At Rathlee Signal Station, County Sligo, the well-preserved L.O.P. 66 was located 13 m (42’ 8’’) to the north of the signal tower (Figure 4.48). At St John’s Point Signal Station, County Donegal, the well-preserved L.O.P. 70 (Reg. No. 40909727) was located 92 m (100 yards) to the north-east of the of site of the demolished signal tower (Figure 4.27), on top of a prominent conical mound which is listed as a possible burial cairn (SMR DG097A005----). At Carrigan Head Signal Station, County Donegal, the mostly collapsed L.O.P. 71 was located 15 m (49’ 3’’) south of the signal tower. At Malin Head Signal Station, County Donegal, the well-preserved L.O.P. 80 was located 42 m (45 yards) to the west of the signal tower.

Beyond the five signal stations in the main study area where Look Out Posts (L.O.P.s) were constructed close to the sites, there are a number of signal station sites which clearly share the same general location as the later buildings. The recently renovated L.O.P. 51 was located on top of a rocky outcrop on Lettertmullan Island, County Galway, approximately 870 m (882 yards) east of Golam Head Signal Station (Figure 4.49). The demolished L.O.P. 68 was located approximately 80 m (87 yards) to the south-east of the position of the demolished signal tower at Knocklane Hill Signal Station, County Sligo. The position is slightly closer to the top of the hill than the position of the signal station. The well-preserved L.O.P. 69 was located on the crest of a hill overlooking a large quarry, approximately 660 m (721 yards) east of Kilcologue Signal Station, County Sligo. The well-preserved L.O.P. 74 was located on top of a rocky hill overlooking and approximately 197 m (215 yards) south of Crohy Head Signal Station, County Donegal (Figure 4.50).

Figure 4.47. The Look Out Post (L.O.P. 53) at the west of Bunowen More Signal Station, County Galway, looking south-east. An encased benchmark is located on the roof of this structure.

Figure 4.48. The Look Out Post (L.O.P. 66) to the north of Rathlee Signal Station, County Sligo, looking north-east.

Figure 4.49. The renovated Look Out Post (L.O.P. 51) on Lettertmullan Island, County Galway, overlooking Golam Head Signal Station.

Figure 4.50. View of Look Out Post 74 from Crohy Head Signal Station, County Donegal.

The location of L.O.P. 76 at Bloody Foreland, County Donegal is unclear, but 'Eire Sign 76' is located approximately 370 m (404 yards) north-west of the position of the demolished signal station.

The well-preserved L.O.P. 77 was located on top of a rocky hill overlooking and approximately 780 m (853 yards) south of Horn Head Signal Station, County Donegal. Finally, at Fanad Head, County Donegal, a disused early 20th century coast guard watch house was repurposed for use as L.O.P. 79 (Figure 4.51). The structure was located on an adjacent promontory to that on which the demolished Signal Station had been located, some 180 m (196 yards) to the east of the watch house. The repurposed watch house was well-preserved. A large derelict poured concrete coast guard station was located approximately 100 m (109 yards) to the south-west. Four of these seven sites (Lettertmullan Island/Golam Head, County Galway, Kilcologue Point, County Sligo and Crohy Head and Horn Head, County Donegal) featured a significant elevation change, where the L.O.P.s were located on higher ground than the roof levels of the signal stations.

Beyond these 12 sites where there is a clear spatial relationship between the signal station and a Look Out Post, there were 12 more signal station sites which had a Look Out Post located between 2 km and 7 km (1.2 miles and 4.4 miles) away. These sites (Cuileen Hill and Cleggan in County Galway, Saddle Hill, Glash, Tower Hill, Benwee Head and Creevagh in County Mayo, Carrowmably in County Sligo, Malin Beg, Glen Head, Dawros Head and Melmore Head in County Donegal) can only be said to share a vague association with the signal station sites on the same part of the coast. The Look Out Post on Achill Island, located 7km (4.4 miles) to the west of Saddle Hill Signal Station is a second example of an early 20th century coast guard watch house being repurposed as a Look Out Post (L.O.P. 59) (Figure 4.52).

Figure 4.51. The early 20th century watch house at Fanad Head, County Donegal, looking south-west.

Figure 4.52. The early 20th century watch house at Moyteogue, Achill Island, County Mayo, looking north-east.

## 4.10 Lighthouses

The most direct relationship between a lighthouse and a signal station in the main study area is found at Inishmore, County Galway, where the signal tower was initially converted into a lighthouse prior to the site being recorded on the 1st edition Ordnance Survey map, surveyed 1838-1839. Later, a short cylindrical lighthouse (Figure 4.53) was constructed within the signal station enclosure (Section 4.7).

A stout cylindrical lighthouse located approximately 260 m (280 yards) to the south-west of St John's Point Signal Station, County Donegal, which was constructed between 1829 and 1831 (Reg. No. 40909717). The lighthouse is set within a tall walled enclosure which contains a large lighthouse keepers house (Reg. No. 40909718) and several ancillary buildings and structures (Figure 4.54). The first lighthouse at Fanad Head was constructed between 1814 and 1817. The Commissioner of Irish Lights' website states that the signal station located on the same promontory was demolished during the construction of the lighthouse and the stones were reused (Irish Lights 2019). The current large lighthouse complex dates from 1886 and overlies the position of the Fanad Head Signal Station (Figure 4.55). A large lighthouse keepers house is located immediately south of the lighthouse, and a tall wall defines an irregularly shaped enclosure surrounding both buildings.

Figure 4.53. The cylindrical lighthouse built within the enclosure at Inishmore Signal Station, County Galway, looking south-east.

Figure 4.54. St John's Point lighthouse, County Donegal, looking north-east. St John's Point Signal Station was located in the distance, at the right of the shot, in front of the Look Out Post (L.O.P 70) on top of the conical mound.

Figure 4.55. Fanad Head Lighthouse (1886), County Donegal, looking west. The signal station was located on the same promontory and was demolished when the original lighthouse was constructed between 1814-1817.

## 4.11 Signal Stations associated with other fortifications

A small number of signal stations in the main study area are associated with much older fortifications. Knocklane Hill Signal Station, County Sligo[12], was located about 325 m (355 yards) east of a well-preserved promontory fort at Dooneragh Point (SMR SL007-001001-), which featured two widely spaced sets of banks and ditches (Figure 4.56). Kilcologue Point Signal Station, County Sligo, was located immediately south of a heavily eroded promontory fort (SMR SL007-001001-) (Figure 4.57). Bloody Foreland Signal Station, County Donegal, was located about 400 m east of a very heavily eroded promontory fort (SMR DG023-004----). Despite their physical proximity to substantial existing fortifications none of these signal stations took advantage of their defensive potential, and all three of the sites were left unenclosed. The promontory forts at Kilcologue Point and Bloody Foreland may have been too badly damaged by coastal erosion to have contributed to the defence of these sites. The earthworks close to Knocklane Hill remained substantial features and were actually utilised by a later fortification, Knocklane Castle (SMR SL007-001002-/SMR SL007-001003-).

[12] Knocklane Castle is located within the enclosed area of the promontory fort. It is a poorly understood site that was constructed between the embankments of the promontory fort at Dooneragh Point. The site is not shown on the 1st edition Ordnance Survey map, surveyed 1837, but the 2nd and 3rd edition Ordnance Survey maps, surveyed 1885-1888 and 1909-1912, both show a small pentagonal enclosure containing several buildings, indicating it must have been constructed in the mid-19th century, after the 1st edition map was surveyed. The ditch of the enclosure and a fragment of one of the buildings were still visible at the site. The site has not yet been studied in detail and it is not clear exactly how it functioned, but it was clearly sited to provide some protection for the approach to Sligo Bay. This surely demonstrates that the existing banks and ditches of the promontory fort were indeed still useful defences, and that the builders of the Knocklane Hill Signal Station chose not to take advantage of them.

Figure 4.56. Dooneragh Point promontory fort, County Sligo, located to the west of Knocklane Hill Signal Station, looking west. The promontory fort contains the remains of the 19th century fortification called Knocklane Castle, visible within the small enclosed area in the centre of the image.

Figure 4.57. The surviving part of the promontory fort to the north of the site of Kilcologue Signal Station, County Sligo, looking north.

Carrowmably Signal Station, County Sligo, was located within a large oval earthwork (SMR SL012-008001-) identified by the NMS as a 'Hilltop Enclosure.' The enclosure measured 127 m north to south and 111 m east to west and was defined by a substantial bank with an internal ditch. This enclosure has been subject to considerable debate regarding its date and purpose, but it clearly predates the signal station (Kelly 2018, 109-12). In this case it does appear that the defensive potential of the early feature might have been utilised by the signal station. However, the defensive capabilities of the site have been questioned, and the identification of contemporary accounts of the enclosures as principally providing protection from the weather may be a more realistic explanation for siting the signal station within the tall banks of this enclosure (Raftery 1976, 94; Kelly 2018).

## 4.12 Signal Stations in Leinster and Munster

A total of 49 signal stations were established around the coasts of Leinster and Munster. The following account of these 49 signal stations is based largely on desk-based research (Section 3.2.1), and was created using contemporary cartographic, pictorial, and written sources, and information drawn from the small number of modern academic sources that are available. Purpose-built signal stations were constructed at 43 locations, and six signal stations were established at existing fortifications, lighthouses, or Martello towers (Figures 4.58 & 4.59). An additional signal station was planned off the Munster coast, at Hog Island, County Kerry, but it does not seem to have been constructed.

Seven of the eight (88%) purpose-built signal stations in Leinster have been lost to coastal erosion or demolition (Figure 4.58). Ten out of the thirty five (29%) purpose-built signal stations in Munster have been lost to demolition. These sites are concentrated in the eastern part of County Waterford, the northern part of County Kerry, and the southern part of County Clare (Figure 4.59).

The signal towers at the purpose-built signal stations generally follow the standard design identified throughout the main study area. Two of the sites may have used a slightly different design for the signal towers, Dalkey Signal Station, County Dublin, and Ardmore Signal Station, County Waterford. In both cases the signal towers have been subject to extensive modification and, without a detailed on-site examination having been undertaken, it is unclear if their original form was significantly different to the standard design or not. Two of the sites in County Cork feature larger and more complex three-storey towers with gabled-roofs, Robert's Head Signal Station and Mizen Head Signal Station. Recently published photographs of these two sites suggest that the signal towers were originally of the standard design and that a second-floor level was added by extending up from the original parapet wall (Harris 2020a; Harris 2002b). Again, without a detailed on-site examination it is not possible to clarify the status of these signal towers.

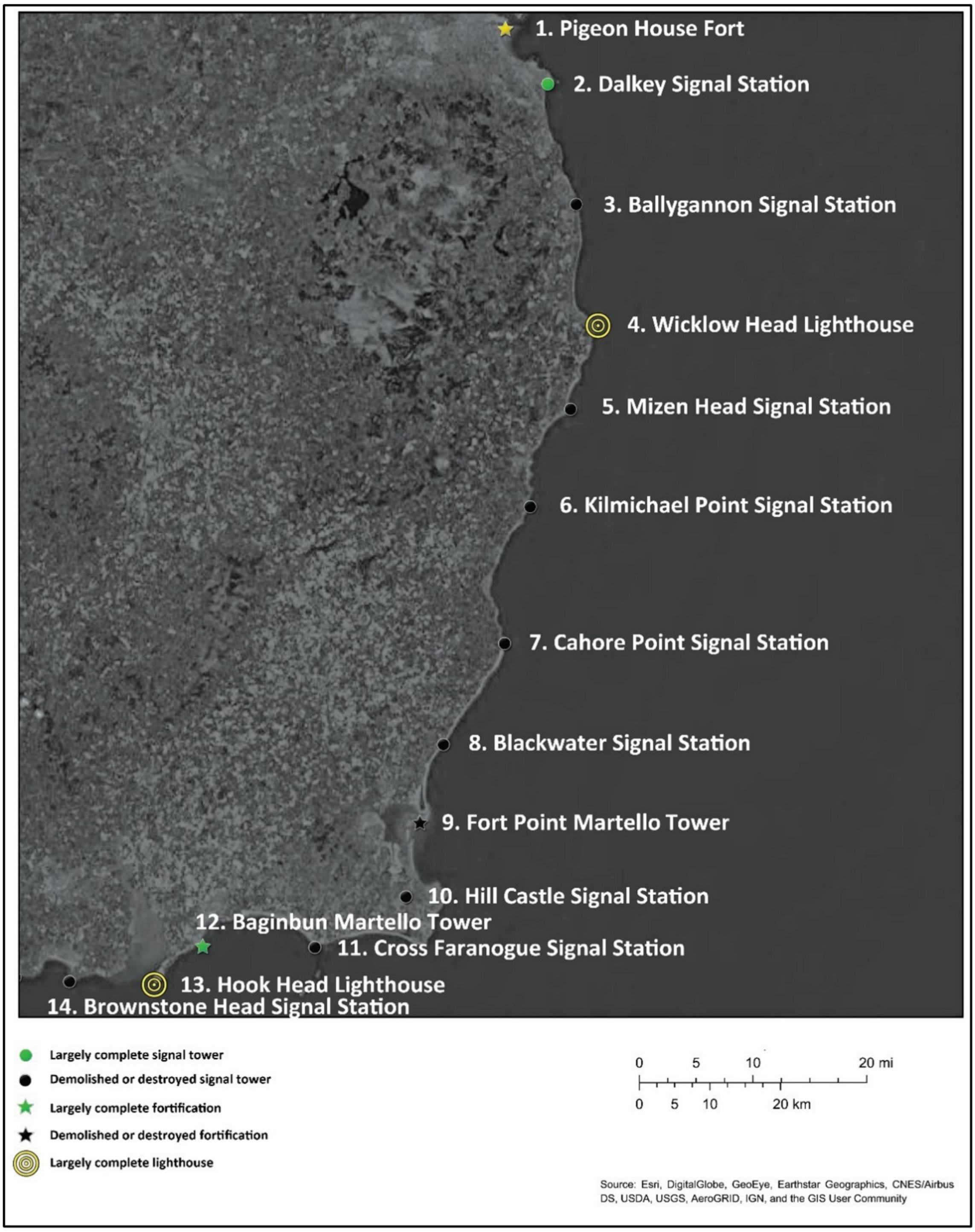


Figure 4.58. Signal station locations in the Province of Leinster.

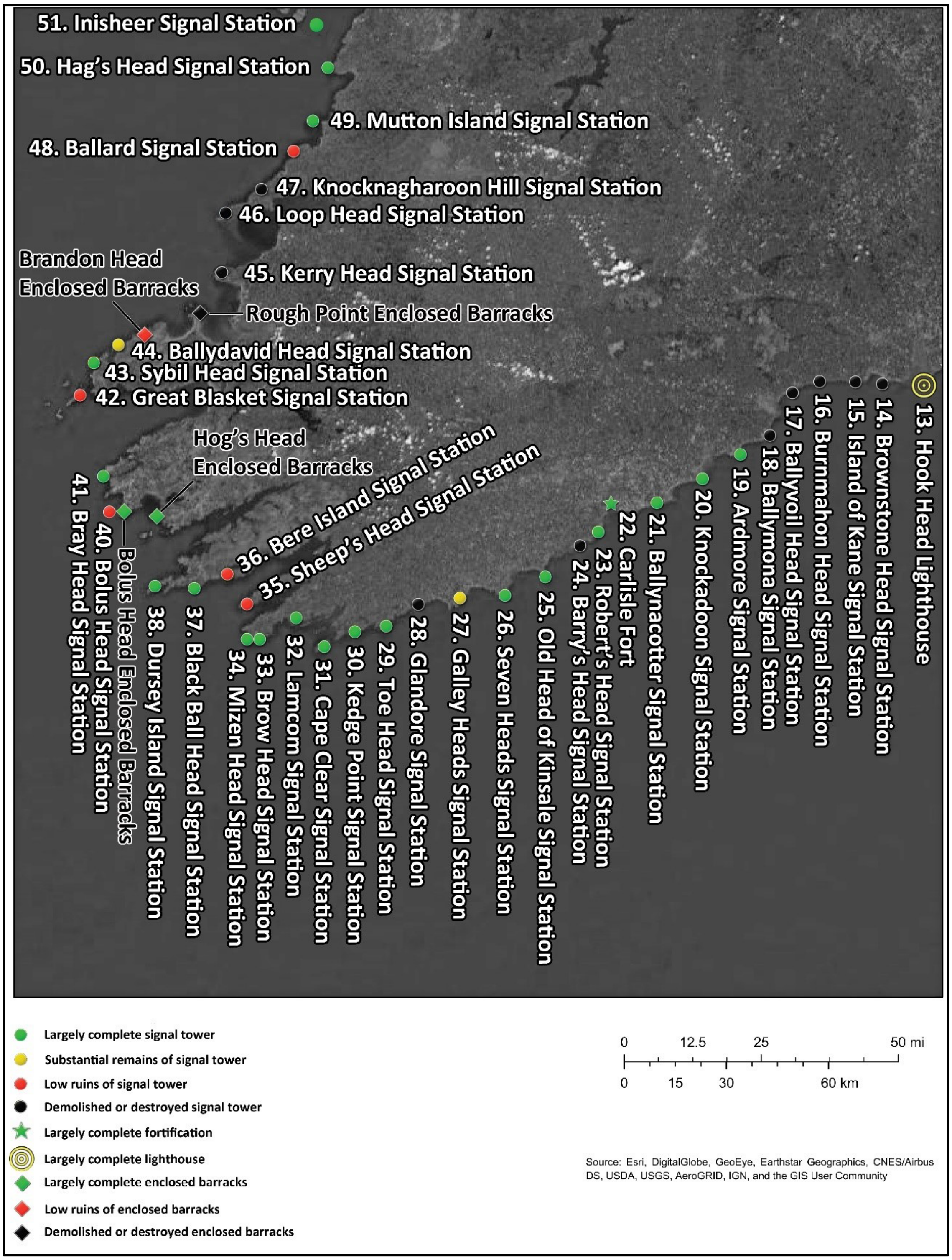


Figure 4.59. Signal Station locations in the province of Munster.

Extensive modification of the signal station sites is recorded at the one surviving signal tower in Leinster, and at 17 of the sites in Munster. The figure for Munster does not include the restored signal tower at the Old Head of Kinsale Signal Station, County Cork, which was fully recorded in 2012, prior to the restoration. Prior to the 2012 restoration it was found to be unmodified, other than having had one of the ground-floor windows on the south-west wall expanded into an entrance.

The number of purpose-built sites in Munster which have been classified as 'largely complete' signal stations (17 out of 35 or 49%) on Figure 4.59 is therefore somewhat misleading. Only between six and eight of the sites classified as largely complete (19% - 23%) feature signal towers which have not been heavily modified.

A small group of enclosed barracks (Section 2.5) were present along the coast of south-west Munster which are thought to be directly related to the signal stations (Figure 4.60). Only four sites of this type have been identified. Two of the sites, Hog's Head and Bolus Head, are largely complete. The enclosed barracks at Brandon Height is now an extensive low ruin, and the example at Rough Point has been demolished and removed.

More details about the signal stations in Leinster (Section 4.12.1), the signal stations in Munster (Section 4.12.2), and the enclosed barracks in County Kerry (Section 4.12.3) are presented in the following three sections. Short accounts of each of the sites are presented along with a selection of illustrations in Appendix E. Signal Stations in the Province of Leinster; Appendix F. Signal Stations in the Province of Munster; and Appendix G. Enclosed Barracks in County Kerry.

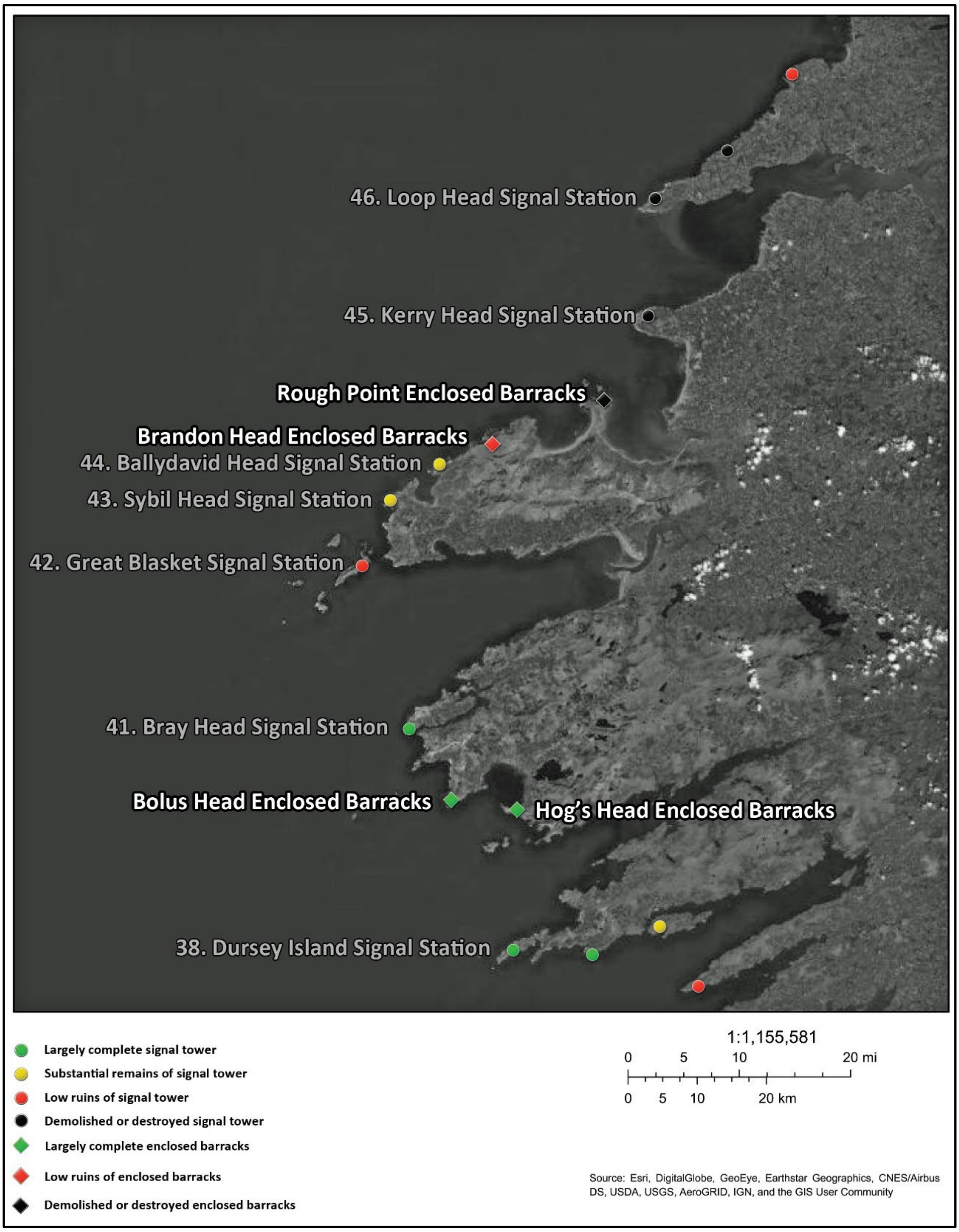


Figure 4.60. Enclosed barracks locations in County Kerry.

### 4.12.1 Signal Stations in Leinster

Thirteen signal stations were established in Leinster (Table 4.4), starting at Pigeon House Signal Station in Dublin Bay, running down the east coast and then along the south coast as far as Hook Head in County Wexford (Figure 4.58). Five of the signal stations, Pigeon House Signal Station, County Dublin, Wicklow Head Lighthouse, County Wicklow, and Fort Point Martello Tower, Baginbun Martello Tower, and Hook Head Lighthouse, County Wexford, were incorporated into existing facilities or new Martello towers, and did not require the construction of purpose-built signal towers (Kerrigan 1995, 161). The 1st edition Ordnance Survey maps do not identify any features at these sites which can be positively identified as being associated with the signal stations.

The remaining eight sites, Dalkey Signal Station, County Dublin, Ballygannon and Mizen Head Signal Stations, County Wicklow, Kilmichael Head, Cahore Point, Blackwater Hill Castle and Forlorn Point Signal Stations, County Wexford, were purpose-built sites which featured signal towers (Kerrigan 1995, 161). Of the purpose-built sites only Dalkey Signal Station and Mizen Head Signal Station are depicted on the 1st edition Ordnance Survey maps, surveyed 1843 and 1838, respectively.

The signal stations in Leinster seem to have been particularly vulnerable to coastal erosion or demolition, and nine of the thirteen sites (69%) have been lost. Dalkey Signal Station is the only purpose-built signal station in Leinster which has survived. Four of the pre-existing sites (80%), Pigeon House Signal Station, County Dublin, Wicklow Head Lighthouse, County Wicklow, and Baginbun Martello Tower and Hook Head Lighthouse, County Wexford, have survived, but no features that could be related directly to the signal stations were identified during this project.

The poor level of survival makes any analysis of the purpose-built signal stations in Leinster extremely difficult. Only Dalkey Signal Station, County Dublin, and the demolished site at Mizen Head Signal Station, County Wicklow, are available for in-depth study (Appendices E.2 & E.5).

| Signal Station Name | County | Location | Type | Enclosure Type | Modifications |
|---|---|---|---|---|---|
| Pigeon House Signal Station | Dublin | Coastal fort | Converted hotel with harbour | N/A | N/A |
| Dalkey Signal Station | Dublin | Signal station | Possible tower variant | Rectangular | Single-storey addition |
| Ballygannon Signal Station | Wicklow | Signal station | Unknown, absent | Unknown | Unknown |
| Wicklow Head Signal Station | Wicklow | Lighthouse | Octagonal Lighthouse | N/A | N/A |
| Mizen Head Signal Station | Wicklow | Signal station | Unknown, demolished | Unenclosed | Unknown |
| Kilmichael Point Signal Station | Wexford | Signal station | Unknown, absent | Unknown | Unknown |
| Cahore Point Signal Station | Wexford | Signal station | Unknown, absent | Unknown | Unknown |
| Blackwater Signal Station | Wexford | Signal station | Unknown, absent | Unknown | Unknown |
| Fort Point Signal Station | Wexford | Martello tower | Martello tower | N/A | N/A |
| Hill Castle Signal Station | Wexford | Signal station | Unknown, demolished | Unknown | Unknown |
| Forlorn Point Signal Station | Wexford | Signal station | Unknown, demolished | Unknown | Unknown |
| Baginbun Signal Station | Wexford | Martello tower | Martello tower | N/A | N/A |
| Hook Head Signal Station | Wexford | Lighthouse | Cylindrical Lighthouse | N/A | N/A |

**Table 4.4. Details of the signal stations in Leinster. Where the building has been lost without record, its type is marked as unknown. If it is known whether the building was demolished or lost to coastal erosion this is noted. If this information has not been established the building is noted as absent.**

The locations of six of the purpose-built sites (75%) are not known with any level of precision, Ballygannon Signal Station, County Wicklow, and Kilmichael Signal Station, Cahore Point Signal Station, Blackwater Signal Station, Hill Castle Signal Station, and Forlorn Point Signal Station, County Wexford. For six of the eight (75%) purpose-built signal stations in Leinster, there is currently no evidence regarding whether they were provided with enclosures, the sites having been lost prior to being recorded on the 1st edition Ordnance Survey maps, surveyed between 1838 and 1840.

Dalkey Signal Station, County Dublin, is shown on the 1st edition Ordnance Survey map, surveyed 1843, as having a sub-rectangular enclosure, with the north-west end defined by the ragged edge of Dalkey Quarry, the south-east side following a staggered line, and the other two sides being parallel to each other, and at right angles to the south-east side. The 2nd edition Ordnance Survey map, surveyed 1871-1875, shows that the north-east side of the enclosure had been demolished and the circuit extended considerably to the east. This expanded enclosure is still present. The 1st edition Ordnance Survey map does not show the presence of a road connecting directly to the site. A road terminates approximately 200 m (220 yards) to the south-east of the site, and another road runs to the north of the site, although accessing it would have involved a 300 m (330 yard) long route around Dalkey Quarry. It is not known if either road would have existed when the signal station was constructed.

The signal tower has been heavily modified, and it is unclear if it originally followed the standard design, or it was a variant design. The parapet wall has mostly been removed but a small section appears to be intact at the north-east. There are no bartizans and no machicolation over the now blocked up first-floor doorway. A pair of vertical slots defined by yellow bricks were located over the first-floor door on the south-west wall. These may indicate the former presence of a machicolation, but it is possible that they could be a later alteration of an unknown purpose. A ground-floor door is present on the south-west wall, likely to be a modification. A centrally placed ground-floor window and a first-floor door were located on the south-east walls, both of which had been bricked up. The tower features a separate small square tower-like chimney on the north-east corner. It is unclear if this is an original feature or a later modification.

A large single-storey addition abuts the north-east side of the signal tower. The addition is not shown on the 1st edition Ordnance Survey map, but it is clearly depicted on the 2nd edition Ordnance Survey map, indicating it was added in the mid-19th century, at some point between 1843 and 1875.

Mizen Head Signal Station, County Wicklow, is shown as an unenclosed site on the 1st edition Ordnance Survey map, surveyed 1838. The 1st edition Ordnance Survey map does not show a road connecting to the signal station; the nearest road is 1050 m (1150 yards) to the west. The signal tower is marked with a trigonometry point. The signal tower is still visible on the 2nd edition Ordnance Survey map, surveyed 1885-1887, and on the 3rd edition, surveyed 1908-1909, and is marked as 'in Ruins' on both maps. The ruined signal tower must therefore have been cleared sometime after 1908.

Because the location of the other six purpose-built signal stations are not known, it is not currently possible to comment on whether they were demolished or lost through coastal erosion. The signal station located at Fort Point Martello Tower, County Wexford, was demolished around 1821, after it was irreparably damaged by coastal erosion (Clements 2013, 75).

Despite the problems associated with the locations of the Leinster signal stations, it is still possible to comment on the association between the signal stations and the World War 2 era Look Out Posts (L.O.P.s), even if it only to note the existence of the later buildings in the same local areas as the signal stations. L.O.P. 7 is located 840 m to the north-east of Dalkey Signal Station, County Dublin (Ryan 2014, 57-8). L.O.P. 9 is located 200 m (220 yards) to the east of the earlier lighthouse at Wicklow Head, County Wicklow, with traces of 'Eire Sign 9' nearby (Ryan 2014, 62-3). L.O.P. 10 was located approximately 450 m (490 yards) to the south of the location of the coast guard station at Kilmichael Point, County Wexford (Ryan 2014, 64-5). The collapsed L.O.P. 11 is located close to Cahore Point, County Wexford (Ryan 2014, 67-8). A well-preserved Look Out Post (L.O.P. 15) was located about 315 m (345 yards) to the west of the quay at Kilmore, County Wexford, and is likely to be close to the currently unknown location of Forlorn Point Signal Station (Ryan 2014, 75-6). The concrete slab foundation of L.O.P. 16 was located to the immediate south-west of the lighthouse at Hook Head, County Wexford.

### 4.12.2 Signal Stations in Munster

Thirty-six signal stations were established in Munster (Table 4.5), starting at Brownstone Head in County Waterford, running along the south coast, and then up the south-west coast as far as Hag's Head in County Clare (Figure 4.59). Of this total, 35 sites (97%) utilised purpose-built signal stations. The only signal station that was incorporated into an existing facility was located at Fort Davis, County Cork, on the eastern approach to Cork Harbour. Eighteen of the purpose-built Munster Signal Stations (51%) currently feature well-preserved signal towers. Of these, 14 closely resemble those found in Connacht and Ulster and can be identified as having been constructed according to the standard design used within the main study area.

The signal tower at Ardmore, County Waterford, bears a close resemblance to the signal tower at Dalkey Signal Station, County Dublin, and may be a variant design. The signal tower has been heavily modified, and it is possible that its original form was of the standard design. At two of the signal station sites in County Cork, Robert's Head and Mizen Head, large three-storey towers with gabled-roofs are present, indicating that either radically different designs were used, that the original signal towers have been replaced by larger more complex buildings, or that the sites have been heavily modified, but the original form was of the standard design. Both towers are around 6 m (19') square, so the latter suggestion is at least possible. The current two-storey building at Sybil Head is either a very heavily modified standard design signal tower, or a replacement structure.

The signal stations in the east of Munster seem to have been just as vulnerable to coastal erosion or demolition as their counterparts in Leinster; only one of the six signal stations in County Waterford features a surviving signal tower. That signal station, Ardmore, is the most westerly in that County Waterford.

| Historical Name | County | Location | Type | Enclosure Type | Modifications |
|---|---|---|---|---|---|
| Brownstone Head Signal Station | Waterford | Signal Station | Unknown, demolished | Unknown | Unknown |
| Island of Kane Signal Station | Waterford | Signal Station | Unknown, demolished | Unknown | Unknown |
| Bunmahon Head Signal Station | Waterford | Signal Station | Unknown, absent | Unknown | Unknown |
| Ballyvoyle Head Signal Station | Waterford | Signal Station | Unknown, absent | Unknown | Unknown |
| Ballynamona Signal Station | Waterford | Signal Station | Unknown, absent | Unknown | Unknown |
| Ardmore Signal Station | Waterford | Signal Station | Small tower variant | Unenclosed | Historical residential conversion, external stairs |
| Knockadoon Signal Station | Cork | Signal Station | Standard | Small Rectangular | - |
| Ballynacotter Signal Station | Cork | Signal Station | Standard | Small rectangular | Modern residential conversion |
| Fort Davis Signal Station | Cork | Coastal Fort | Bastioned Fortresses | N/A | N/A |
| Robert's Head Signal Station | Cork | Signal Station | Complex 3 storey tower | Rectangle, with wide fan shaped end | Possible replacement tower |
| Barry's Head Signal Station | Cork | Signal Station | Unknown, demolished | Rectangle, wide fan shaped end | Unknown |
| Old Head of Kinsale Signal Station | Cork | Signal Station | Standard | Rectangle, with rounded protrusion | Recent restoration |
| Seven Heads Signal Station | Cork | Signal Station | Standard | Small square with wide rounded protrusion | Single-storey addition |
| Galley Head Signal Station | Cork | Signal Station | Standard | Rectangle, narrow fan shaped end | Single-storey addition and external stairs |
| Glandore Signal Station | Cork | Signal Station | Unknown, demolished | Rectangle, narrow fan shaped end | Unknown |
| Toe Head Signal Station | Cork | Signal Station | Standard | Rectangle, narrow fan shaped end | Single-storey addition |
| Ballylinchy Point Signal Station | Cork | Signal Station | Standard | Rectangle, narrow fan shaped end | Two-storey addition |

**Table 4.5. Details of the signal stations in Munster. Where the building has been lost without record, its type is marked as unknown and the reason for its loss is noted. If this information has not been established the building is noted as absent.**

| Historical Name | County | Location | Type | Enclosure Type | Modifications |
|---|---|---|---|---|---|
| Cape Clear Signal Station | Cork | Signal Station | Standard | Rectangle, rounded end | Lighthouse complex |
| Lemcon Signal Station | Cork | Signal Station | Standard | Rectangle. narrow fan shaped end | Modern residential conversion |
| Brow Head Signal Station | Cork | Signal Station | Standard | Rectangle, rounded end | Minor changes |
| Mizen Head Signal Station | Cork | Signal Station | Complex 3 storey tower | Rectangle, rounded end | Possible replacement tower |
| Sheep's Head Signal Station | Cork | Signal Station | Standard, collapsed | Rectangle, rounded end | Free standing adjacent building |
| Bere Island Signal Station | Cork | Signal Station | Standard, collapsed | Rectangle, rounded end | Free standing adjacent building |
| Black Ball Head Signal Station | Cork | Signal Station | Standard | Rectangular, with triangular protrusion | Free standing adjacent building |
| Dursey Island Signal Station | Cork | Signal Station | Standard | Rectangle, rounded end | Single-storey addition and free-standing adjacent building |
| Hog Island Signal Station | Kerry | Never Built | N/A | N/A | N/A |
| Bolus Head Signal Station | Kerry | Signal Station | Standard, collapsed | Unenclosed | Unknown |
| Bray Head Signal Station | Kerry | Signal Station | Standard | Rectangular | Historical renovation |
| Great Blasket Signal Station | Kerry | Signal Station | Standard, collapsed | Irregular | Unknown |
| Sybil Head Signal Station | Kerry | Signal Station | Unknown, modified or replaced | Rectangular | Historical replacement or conversion |
| Ballydavid Head Signal Station | Kerry | Signal Station | Standard | Rectangular | Free standing adjacent building |
| Kerry Head Signal Station | Kerry | Signal Station | Unknown, demolished | Rectangular, with rounded end | Unknown |
| Loop Head Signal Station | Clare | Signal Station | Unknown, demolished | Rectangular | Unknown |
| Knocknagharoon Signal Station | Clare | Signal Station | Unknown, demolished | Unenclosed | Unknown |
| Ballard Signal Station | Clare | Signal Station | Standard, collapsed | Rectangular | Unknown |
| Mutton Island Signal Station | Clare | Signal Station | Standard | Rectangular | - |
| Hag's Head Signal Station | Clare | Signal Station | Standard | Unenclosed | - |

**Table 4.5. Details of the signal stations in Munster continued. Where the building has been lost without record, its type is marked as unknown and the reason for its loss is noted. If this information has not been established the building is noted as absent.**

The exact location of Brownstone Head Signal Station, the most easterly station in County Waterford, has not been established, so it is not possible to determine what process led to its removal. The construction of two circular beacons (Reg No. 22902609) at Brownstone Head between 1819 and 1821 may have led to the signal stations demolition. The location of the signal station is not shown on the 1st edition Ordnance Survey map, surveyed 1839-1841. L.O.P. 17 (Reg. No. 22902610) is also located on Brownstone Head.

The next signal station in County Waterford, Island Kane Signal Station, is marked as 'site of telegraph' on the 1st edition Ordnance Survey map, surveyed 1839-1841. The 2nd edition Ordnance Survey map, surveyed 1897-1905, shows that the location of the demolished signal station had been lost to coastal erosion.

The positions of the next three sites to the west, Bunmahon, Ballyvoyle, and Ballynamona Signal Stations, are not shown on the 1st edition Ordnance Survey, meaning they must also have been removed prior to 1842. Their positions are only known from Larkin's 1818 map of County Waterford, a source which lacks the precision required to determine if the sites were demolished or lost to coastal erosion (Appendices F.16; F17; F18).

Survival rates are much higher in County Cork. Thirteen of the eighteen (72%) purpose-built signal stations in County Cork have towers which survive to their full height, although as already mentioned the three-storey towers at Robert's Head and Mizen Head may be later replacements. In addition, the signal towers at Toe Head Signal Station and Leamcon Signal Station have been heavily modified and incorporated into modern residences, and the tower at the Old Head of Kinsale has been sensitively restored. Only the ground-floor level of the signal tower at Galley Head survives, and the signal towers at Sheep's Head and Bere Island Signal Stations survive only as low ruins. Barry's Head Signal Station and Glandore Signal Station have been demolished.

The signal tower at Barry's Head Signal Station is shown on the 1st edition Ordnance Survey map, surveyed 1841-1842, but it is not marked on the 2nd edition Ordnance

Survey map, surveyed 1897-1904, indicating that it was likely demolished in the second half of the 19th century. The signal tower at Glandore Signal Station is shown on the 2nd edition Ordnance Survey map, surveyed 1897-1904, but it is not marked on the 3rd edition Ordnance Survey map, surveyed 1926-1937, indicating that it was likely demolished in the first half of the 20th century. The other two signal stations where signal towers do not survive to full or considerable heights, Sheep's Head and Bere Island Signal Stations, both feature signal towers that have collapsed, rather than having been demolished. The date when the signal towers at Sheep's Head Signal Station collapsed is not known, but it is marked as 'in ruins' on the 1st edition Ordnance Survey map. The signal tower at Bere Island Signal Station was damaged by a lightning strike in 1959 and then collapsed during high winds in 1964 (Shiels and Maloney 2012, 47).

It is thought that only six signal stations were constructed in County Kerry, and that a planned seventh signal station, on Hog Island (Sections 1.1 & 4.12.3), was not actually built (Kerrigan 1995, 278). Of the six sites in County Kerry, only one site (17%) features a signal tower that survives to a considerable height or greater, Bray Head Signal Station. The signal tower at Bray Head Signal Station was subject to some modification when it was renovated during the First World War for use by the Royal Navy as a Naval War Signal Station, but the original mass and pattern of fenestration survives (Clements 2013, 102). The building that now stands at Sybil Head Signal Station is partially collapsed but it has either been very heavily-modified, to the point that the form of the original structure cannot be easily determined, or the original tower was replaced with a larger structure of a different design. The Sybil Head Signal Station was also used as a Naval War Signal Station during the First World War (Clements 2013, 102). Bolus Head, Great Blasket, and Ballydavid Head Signal Stations all feature the low ruins of collapsed signal towers. It is not known when the signal tower at Bolus Head collapsed, but the signal tower at Great Blasket Signal Station is marked as 'in ruins' on the 1st edition Ordnance Survey map, surveyed 1841-1842, and the signal tower at Ballydavid Head Signal Station is marked as 'in ruins' on the 2nd edition Ordnance Survey map, surveyed 1894-1898. The signal station at Kerry Head has been demolished. The signal tower is marked as 'in ruins' on the 1st edition Ordnance Survey map and is no longer shown on the 2nd edition Ordnance Survey map, indicating the site was likely cleared in the second half of the 19th century.

Five purpose-built signal stations were constructed in County Clare, and again preservation levels are quite low. The two most northerly signal stations in County Clare, Mutton Island and Hag's Head, both feature well-preserved signal towers, meaning that 40% of the signal towers survive to a considerable height or greater. The signal tower at Ballard Signal Station has collapsed and is now a low ruin. It is not clear when the signal tower collapsed, but it appears to be intact on the 1st edition Ordnance Survey map and is marked as 'in ruins' on the 3rd edition Ordnance Survey map, surveyed 1913-1918. Two signal stations, Loop Head and Knocknagharoon Hill, have been demolished. The signal stations at Loop Head and Knocknagharoon Hill Signal Stations are both marked as 'in ruins' on the 1st edition Ordnance Survey map, surveyed 1840-1842, and they are no longer depicted on the 2nd edition Ordnance Survey map, surveyed 1893-1897.

Of the six purpose-built signal stations in County Waterford, there is no information currently available about the presence or absence of enclosures for five of the sites, Brownstone Head, Island of Kane, Bunmahon Head, Ballyvoyle Head, and Ballymona Head. Ardmore Signal Station appears to have been an unenclosed site.

Of the 29 purpose-built signal stations in Counties Cork, Kerry and Clare, only two sites do not seem to have been enclosed, Bolus Head Signal Station, County Kerry, and Hag's Head Signal Station, County Clare (Appendices F.40 & F.50). In the main study area, 50% of the signal stations are known to have featured purpose-built enclosures (Section 4.3). The frequency of signal stations with enclosures is much higher in the west of Munster; 93% seem to have been enclosed sites. Many of the depictions on the early Ordnance Survey maps indicate that the enclosures at the signal stations in Munster were frequently altered during the 19th century and/or early 20th century. This is a very noticeable difference between the sites in the secondary study area and the main study area, where the enclosures show no sign of modification, beyond occasional clearance.

The signal stations in County Cork have a unique resource associated with them, contemporary plans surveyed in 1806 by John Hampton. Copies of two of these plans were reviewed during this study (Figures 4.61 & 4.62). Kerrigan has summarised the details shown on the other plans and that information has been incorporated into this study (Kerrigan 2003, 38).

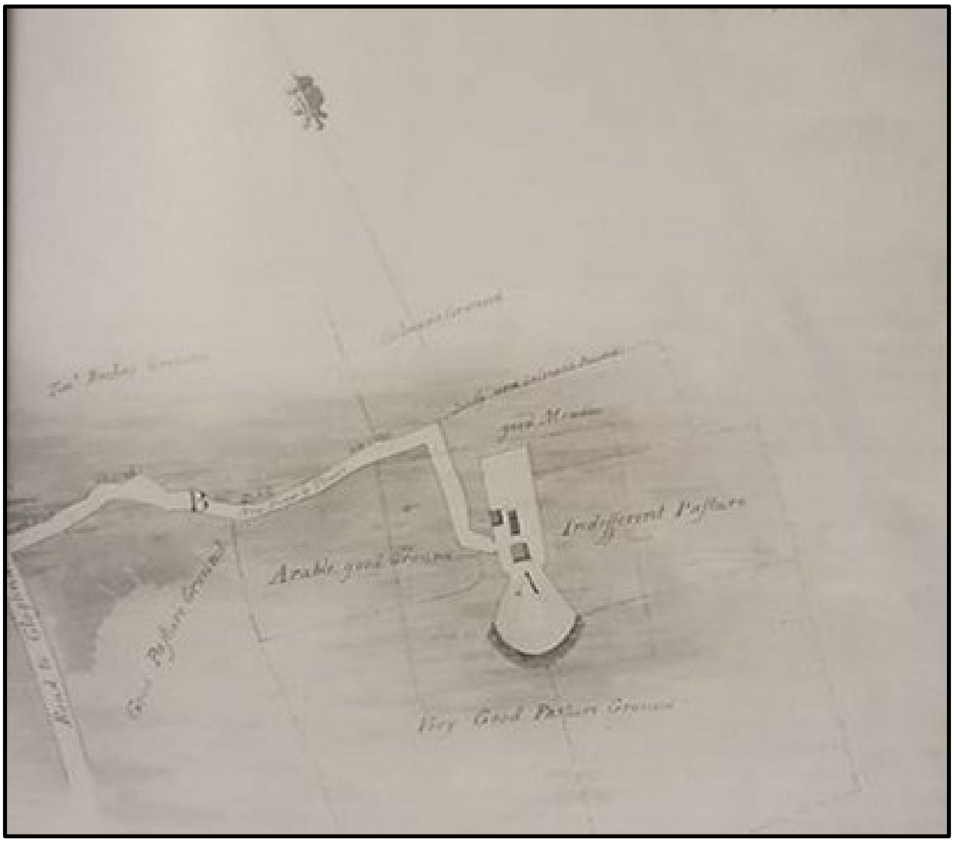


Figure 4.61. Extract from John Hampton's 1806 plan of Galley Head Signal Station, County Cork (NLI Manuscript map: 15 B. 13 (18).

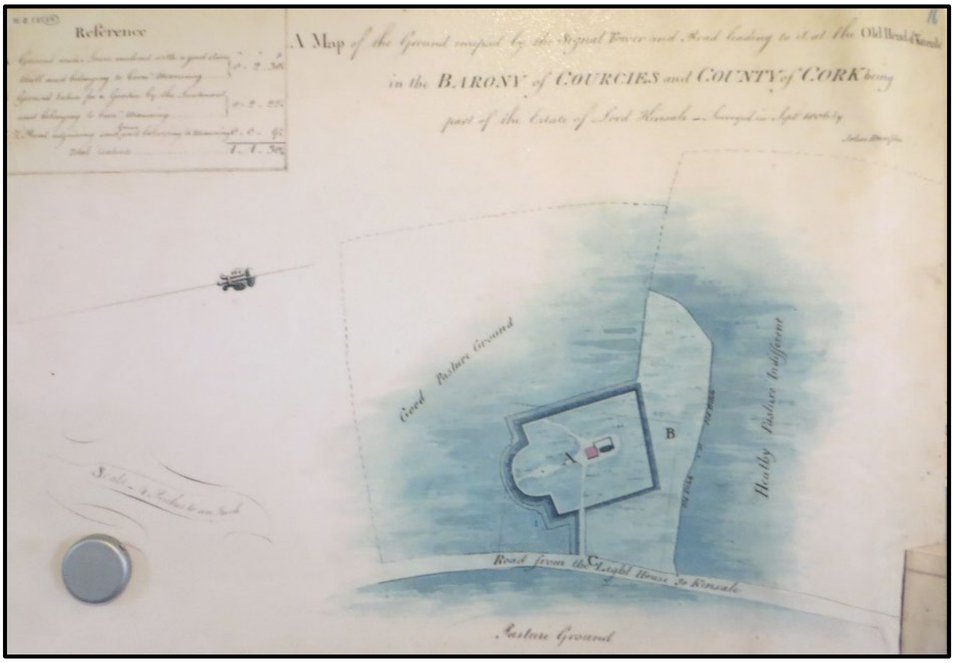


Figure 4.62. Extract from John Hampton's 1806 plan of the Old Head of Kinsale Signal Station, County Cork (NLI Manuscript map: 15 B. 13 (16).

The enclosures in County Cork have a greater variety of shapes than were present in the main study area. Based on Hampton's plans Kerrigan describes a particular style of enclosure in County Cork, with a narrow rectangular shape that has either an expanded end facing out to sea, which was either rounded, had a narrow fan shape (Figure 4.61), or a wide fan shape (Kerrigan 2003, 37-9). Kerrigan identified 13 sites in County Cork with these forms (Table 4.5), of which six have rounded ends, five have narrow fan shaped ends, and two have wide fan shaped ends (Kerrigan 2003, 37). Two of the remaining sites in County Cork, the Old Head of Kinsale and Black Ball Head Signal Stations, had large rectangular enclosures that resemble those recorded in the main study area sites, although the enclosure at the Old Head of Kinsale had a large semi-circular extension on the seaward side of the enclosure (Figure 4.62). Ballynacotter and Knockadoon Signal Stations featured small rectangular enclosures, and Seven Heads Signal Station had a small square enclosure with a large semi-circular extension on the seaward side.

Threes sites in County Kerry, Bray Head, Sybil Head, and Ballydavid Head Signal Stations, had rectangular enclosures resembling those recorded in the main study area. The demolished Kerry Head Signal Station is shown on the 1st edition Ordnance Survey map, surveyed 1841-1842. It depicts the signal station as having a rectangular enclosure with a rounded end at the north-west, seaward, side. It is not clear if this was the original form, or if it was originally a true rectangle. The signal station at Bolus Head was not enclosed.

In County Clare three sites, Loop Head, Ballard and Mutton Island Signal Stations, had rectangular enclosures resembling those recorded in the main study area. Knocknagharoon and Hag's Head Signal Stations were unenclosed.

Neither of the two purpose-built signal stations in County Waterford shown on the 1st edition Ordnance Survey maps, surveyed 1839-1841, are shown as being connected directly to roads. A track is located 230 m (250 yards) east of the Island of Kane Signal Station. The track runs for 190 m (210 yards) to the north where it connects to a road. A track is located 160 m (175 yards) north of the Ardmore Signal Station. The track runs for 165 m (180 yards) to the north where it connects to a road. Of the 29 purpose-built signal stations in the rest of Munster, 25 (86%) are shown as connected directly to roads or tracks on the 1st edition Ordnance Survey maps, surveyed 1840-1842 (Appendix F). Robert's Head and Seven Heads Signal Stations, County Cork, are located 100 m and 200 m, respectively, from roads shown on the 1st edition Ordnance Survey map, while Bous Head Signal Station is shown as being 900 m from a road. The signal station on Mutton Island, County Clare, is not shown as being connected to or near to a road or a lane; the 1st edition Ordnance Survey map depicts Mutton Island as being completely devoid of roads and lanes.

Modifications of the signal stations in Munster have occurred in a number of different ways; some signal towers have been renovated but retain their general form; some signal towers have been modified but their original form is still identifiable; some signal towers may have been modified to the extent that their original form is no longer visible; some signal towers have had additions abutting one or more of their walls; some signal stations have had one or more free standing buildings added to either the enclosed area, or to the areas immediately outside their enclosures. At some signal stations multiple different forms of modification have occurred. Without having undertaken detailed field surveys of the sites, it is not possible to fully understand the nature or chronology of the modifications that have occurred at individual sites in Munster.

The signal tower at Ardmore Signal Station (Appendix F.19), County Waterford, was reutilised as a watch tower with a semaphore post in the early 20th century, as depicted on the 3rd edition Ordnance Survey map, surveyed 1922-1923 (Clements 2013, 102). The parapet wall of the tower has been crenelated, a wrap-around external staircase has been added to provide access to the first-floor doorway, the pattern of fenestration may have been altered, a tall chimney extends from one corner of the tower, and the exterior walls have been covered in a smooth layer of render. The tower does not feature bartizans at any of its corners, or a machicolation over the door, and it is possible that the top of the tower has been lowered. The signal tower has roughly the same pattern of fenestration as the signal tower at Dalkey Signal Station, County Dublin, and it is possible that neither of these sites originally followed the standard design. L.O.P. 20 was located 120 m to the south-east (Reg. No. 22904010).

At Knockadoon Signal Station, County Cork, the 1st edition Ordnance Survey map, surveyed 1841-1842, shows a small rectangular building and a small L-shaped building to the north of the signal tower.  These buildings are not shown on the 2nd or 3rd edition Ordnance Survey maps, surveyed 1897-1904 and 1926-1937 respectively. The 2nd edition Ordnance Survey map shows a staggered section of wall running past the north-west side of the signal tower. Sections of this wall are still visible at the site.  L.O.P. 21 was located 30 m (98’) south of the signal tower.

The signal towers at Ballynacotter Signal Station, County Cork, has been incorporated into a large modern residential building. The first-floor windows and the door have been blocked up, and the ground-floor windows have been glazed with modern PVC windows. A large modern gabled-roof bungalow abuts the western side of the signal tower and presumably the interior of the tower is accessible from inside the bungalow.

The signal tower at Robert’s Head Signal Station, County Cork, does not follow the standard design. It is a tall three-storey building, with a gabled-roof. Photographs of the site strongly suggest that this building originally followed the standard design, and that an extra storey was added at some point, by extending the height of the parapet walls and then adding gables to the front and rear walls (Harris 2020a). The signal tower has also had a large single-storey gabled-roofed addition abutting the north-west wall, a small two-storey shed-roofed addition abutting the north-east wall, and a low, flat roofed rectangular water cistern is located adjacent to the south-east, seaward wall (Harris 2020a).

It is not known if the demolished Barry’s Head Signal Station, County Cork, was ever associated with additional buildings. No additional buildings are shown on the early Ordnance Survey maps.

The 1806 plan of the Old Head of Kinsale Signal Station (Figure 4.62) shows a long narrow rectangular free-standing building to the north-west of the signal tower. The building is not shown on the 1st edition of the Ordnance Survey map, surveyed 1841-1842, but a small addition is shown on the south-east side of the signal tower. The 2nd and 3rd editions of the Ordnance Survey map, surveyed 1897-1904 and 1926-1937 respectively, show an L-shaped addition wrapping around the north-west corner of the signal tower and a small free-standing rectangular building to the north-west of the signal tower.  L.O.P. 25 was located on the Old Head of Kinsale, some distance south of the signal station, but it has been demolished.

At Seven Heads Signal Station, County Cork, a single-storey addition with a steeply pitched gabled-roof was added to the northern side of the signal tower. This addition has been removed, leaving a triangular hole in the wall to indicate its former presence. The addition is shown on the 1st edition Ordnance Survey map, surveyed 1841-1842, but not on the later revisions. L.O.P. 26 is located 100 m (110 yards) to the west of the signal tower.

The signal tower at Galley Head Signal Station, County Cork, only survives to the top of the ground-floor level. It has a single-storey gabled-roofed addition abutting the western wall. A wrap-around external staircase has been added to the east and south side of the signal tower. Two free standing single-storey gabled-roofed buildings are currently located within the enclosure, to the north of the signal tower. The early Ordnance Survey maps show that this site underwent a complex sequence of buildings being added and removed between 1842 and 1937. The 1st edition Ordnance Survey map, surveyed 1841-1842, shows the signal tower overlaid by a trigonometry point.

At Glandore Signal Station, County Cork, the 1st edition Ordnance Survey map, surveyed 1841-1842, shows a long rectangular building occupying the centre of the enclosure, suggestive of a signal tower with an addition. A small square building is shown to the north of the signal tower, against the inner edge of the enclosure. The 2nd edition Ordnance Survey map, surveyed 1897-1904, shows the signal tower as being ‘in Ruins.’ The building is not depicted on the 3rd edition Ordnance Survey map, surveyed 1926-1937.

At Toe Head Signal Station, County Cork, a large two-storey gabled-roofed addition abuts the north wall of the signal tower, and a small single-storey shed-roofed addition abuts the north wall of the addition. The depictions of the site on the 1st edition Ordnance Survey map, surveyed 1841-1842, indicates a large square building with a small addition on the northern wall. The 2nd edition Ordnance Surrey map, surveyed

1897-1904, appears to show the arrangement currently at the site. L.O.P. 28 is located in the wider end of the enclosure, to the south of the signal tower.

At Ballylinchy Point Signal Station, County Cork, a large two-storey gabled-roofed addition abuts the north wall of the signal tower, and a small free-standing single-storey shed-roofed building is located to the north of the addition. The ruins of a small rectangular building are located on the external side of the north-west corner of the enclosure. This arrangement is shown on the 1st edition Ordnance Survey map. The collapsed remains of L.O.P. 29 are located in the wider end of the enclosure, to the south-west of the signal tower.

At Cape Clear Signal Station, County Cork, a small shed-roofed addition abuts the north-east side of the signal tower. The signal tower does not have bartizans, but there is a machicolation over the door, suggesting it originally followed the standard design and that the bartizans were subsequently removed. A short cylindrical lighthouse was added to the south-west of the signal tower in 1818 (Reg No. 20915308). When the lighthouse was added, the first-floor door of the signal station was blocked up and a ground-floor door was added underneath it. The 1st edition Ordnance Survey map shows a narrow passage connected the two buildings, which is no longer present. The lighthouse was decommissioned in 1854, when Fastnet Lighthouse was constructed offshore (Reg. No. 20915315). To the north-east of the signal tower there was a large square shaped building with a double gabled-roof, and beyond this there was a large rectangular building with a shed-roof. These buildings fill the north-east half of the enclosure. A small rectangular building abuts the outer edge of the enclosure, at the north-west. The 1st edition Ordnance Survey map, surveyed 1841-1842, depicts all of these buildings, indicating they were constructed during the first half of the 19th century.

At Leamcon Signal Station, County Cork, the signal tower has been adapted into a residential building. The parapet wall has been extended to allow for a full third-floor to be created, the machicolations and the bartizans have had windows added to their outer faces, an external metal staircase has been added, the pattern of fenestration has been changed and the exterior of the tower has been covered in cement render. Despite these changes the signal tower is still recognisable as being of the standard design. A large single-storey bungalow abuts the western wall of the signal tower. The

1st edition map shows that a large rectangular building was located to the east of the signal tower, surveyed 1841-1842, and that a large square enclosure encompassed the original narrow rectangular enclosure. The signal tower is overlaid by a trigonometry point. The 2nd edition Ordnance Survey map, surveyed 1897-1904, shows that the rectangular building and the original enclosure had been demolished.

During the mid-late 19th century, a small number of coast guard buildings and a flagstaff were constructed immediately next to Brow Head Signal Station, County Cork, and a small watch house was constructed to the south. In 1901 Guglielmo Marconi established an experimental transmitter at the site, to communicate with a transmitter at Poldhu in Cornwall (Raboy 2016, 162-3). A new building was constructed immediately south of the end of the enclosure, with an antenna mount immediately west of the building. All of these buildings are now ruined. Facilities listed at the site in 1917 include a Lloyd’s signal station with signal flags and lamps, and a radiotelegraph operated by the General Post Office (Hydrographic Office 1917, 54). The tower is of standard design, but the pattern of fenestration has been slightly altered at some stage.

The signal tower at Mizen Head Signal Station, County Cork, is an exact match for the signal tower at Robert’s Head (Harris 2020b). The three-storey gabled-roofed building also has a series of additions that are a close match to those found at Robert’s Head Signal Station. The 1st edition Ordnance Survey map, surveyed 1841-1842, shows an L-shaped building, with one mass running north-east to south-west, and the second mass running north-west to south-east, with the connection at the north. A small free-standing building is located to the west of the northern end of the L-shaped building. The 2nd edition Ordnance Survey map, surveyed 1897-1904, shows a square building with a rectangular addition extending to the north-east. A north-west to south-east rectangular building abuts the north-west corner of the addition, creating an L-shaped pattern flipped 90 degrees from the original L-shaped building. The original narrow rectangular enclosure has been replaced by a much large rectangular enclosure, apparently divided into small garden plots. The 3rd edition Ordnance Survey map, surveyed 1926-1937, shows the same arrangement. Neither of these depictions matches the arrangements visible at the site today, indicating at the very least, that the current additions do not date to the 19th century. L.O.P. 30 is located to the south-west of the signal tower, in the centre of the rounded end of the original enclosure.

It is not known if Sheep's Head Signal Station, County Cork, was ever associated with additional buildings. No additional buildings are shown on the early Ordnance Survey maps. L.O.P. 31 is located 600 m to the west of the signal station.

The ruined signal tower at Bere Island Signal Station, County Cork, was surveyed during a research project in 2012 (Shiels & Maloney 2012). It was determined that an addition abutted the north-west wall of the signal tower, and a small free-standing rectangular building was located at the north end of the enclosure. A mast mount was identified in the centre of the southern end of the enclosure (Shiels & Maloney 2012, 49). The 1st edition Ordnance Survey map, surveyed 1841-1842, indicates that the addition extended as far as the southern wall of the free-standing building, and that a second small building occupied the north-west corner of the enclosure, abutting the western side of the first building. The 2nd edition Ordnance Survey map, surveyed 1893-1897, shows that the building in the north-west corner of the enclosure was no longer present.

At Black Ball Head Signal Station, County Cork, the signal tower is located in a small triangular protrusion at the north-east corner of the rectangular enclosure. To the north-east of the signal tower, a small freestanding building occupies the apex of the triangular protrusion. The free-standing building is shown on the 1st edition Ordnance Survey map, surveyed 1841-1842. The signal tower overlaid by a trigonometry point. A large rectangular building is also shown, occupying the south-west part of the rectangular enclosure. This building is not shown on the 2nd edition Ordnance Survey map, surveyed 1893-1897.

The signal tower at Dursey Island Signal Station, County Cork, features the impression of a now demolished single-storey gabled-roofed addition on the north-east wall of the signal tower. A small single-storey free standing shed-roofed building is now located to the north-east of the tower, sharing its alignment. The 1st edition Ordnance Survey map, surveyed 1841-1842, depicts the signal tower as a long rectangular building, which may represent the signal tower and the original gabled-roofed addition. The 3rd edition

Ordnance Survey map, surveyed 1926-1937, shows the same long rectangular building, suggesting the free-standing shed-roofed building is a late addition to the site. The 1st edition Ordnance Survey map also shows a small rectangular building at the north-west of the enclosure, on the external side of the enclosure wall. This building is not shown on the 3rd edition Ordnance Survey map, suggesting it was demolished in the late 19th century or the early 20th century. An 'Eire Sign 32,' is located to the west of the signal station, but the associated L.O.P. 32 is located on the mainland.

It is not known if Bolus Head Signal Station, County Kerry, was ever associated with additional buildings. No additional buildings are shown on the early Ordnance Survey maps.

The signal tower at Bray Head Signal Station, County Kerry, has retained its general form, but it was renovated when it was re-used by the Royal Navy during the First World War as a Naval War Signal Station. Its exterior now features more modern stylings dating from that period of re-use (Clements 2013, 102; Section 4.12.2). The signal tower was marked as 'in Ruins' on the 2nd and 3rd editions of the Ordnance Survey map, surveyed 1894-1898 and 1914-1915 respectively.

It is not known if Great Blasket Signal Station, County Kerry, was ever associated with additional buildings. No additional buildings are shown on the early Ordnance Survey maps. 'Eire Sign 38' was located immediately west of the signal station, although the associated L.O.P. 38 was located on the mainland

The signal tower at Sybil Head Signal Station, County Kerry, has either been heavily modified and expanded to twice its original size, or it has been replaced by a large rectangular two-storey building. This site was used by the Royal Navy during the First World War as a Naval War Signal Station, and its current form likely relates to that period (Clements 2013, 102; Section 4.12.2). The 1st edition Ordnance Survey map, surveyed 1841-1842, shows a rectangular building close to the middle of the rectangular enclosure. The 2nd and 3rd edition Ordnance Survey maps, surveyed 1894-1898 and 1914-1915 respectively, both show a square building in approximately the same position that the rectangular building is shown on the earlier map, with an adjacent rectangular building on the same alignment to the north-east. The sequence of construction and modification at this site is currently unclear.

Adjacent to the signal tower at Ballydavid Head Signal Station, County Kerry, there is a large rectangular free-standing building, which shares the same alignment. A small rectangular building is located in an instep in the northern corner of the rectangular enclosure. This arrangement is shown on 1st, 2nd, and 3rd editions of the Ordnance Survey maps, and in Victor du Noyer's 1856 sketch of the site, suggesting that no modifications have occurred at the site since the mid-19th century.

The demolished Kerry Head Signal Station is shown on the 1st edition Ordnance Survey map, surveyed 1840-1842, as having a large rectangular building to the south-east of the signal tower and two smaller rectangular buildings to the north-east of the enclosure. On the 2nd edition Ordnance Survey map, surveyed 1894-1898, these buildings have been removed, and the only building present is a long thin rectangular building overlying the former position of the signal tower. The long thin rectangular building is still shown on the 3rd edition of the Ordnance Survey map, surveyed 1914-1915, but no traces of the building are visible today.

Reviewing the 1st, 2nd, and 3rd editions of the Ordnance Survey maps of County Clare, surveyed 1840-1842, 1893-1897, and 1913-1918 respectively, revealed no evidence of modifications at the signal station sites, beyond their gradual collapse or demolition. The signal towers at Loop Head, Ballard and Mutton Island Signal Stations are overlaid by trigonometry points of the 1st edition Ordnance Survey maps. Only two of the signal stations in County Clare had additional buildings beside the signal towers. It is not known if Loop Head Signal Station or Knocknagharoon Hill were ever associated with additional buildings, but none are shown on the early Ordnance Survey maps. A small rectangular building is located in the south-east corner of the rectangular enclosure at Ballard Signal Station. The building is shown on all of the editions of the early Ordnance Survey maps. A small rectangular building is located in the north-west corner of the rectangular enclosure at Mutton Island Signal Station. The building is shown on all of the editions of the early Ordnance Survey maps. It is not known if Hag's Head Signal Station was associated with additional buildings, during the 19th century or early 20th century, but none are shown on the early Ordnance Survey maps. The badly preserved ruins of L.O.P. 47 are located immediately south-west of the signal tower.

### 4.12.3 Enclosed Barracks in County Kerry

As mentioned above (Section 2.5 and 4.12), the four enclosed barracks around the coast of County Kerry seem to be related to the signal station system. The enclosed barracks are, from south to north, Hog's Head, Bolus Head, Brandon Height, and Rough Point (Kerrigan 1995, 162; Mould 1994). Clements' identification of the Kerry Head Signal Station as belonging to this group is rejected on morphological grounds, but it is identified as a barracks on the 1st edition Ordnance Survey map, surveyed 1841-1842, suggesting that it may have been operated in a similar fashion at some point (Clements 2013, 99). The four sites all consisted of large square enclosures with square bastions located on each corner (Figures 4.63 & 4.64). Inside the enclosures there was a large two-storey rectangular building with a shed-roof, constructed against one side of the enclosure, and actually forming the perimeter wall in that location (see Appendix G for details). The 1st edition Ordnance Survey map, surveyed 1841-1842, identifies the enclosed barracks at Brandon Height as being 'in ruins.' The 3rd edition Ordnance Survey map, surveyed 1914-1915, identifies the examples at Hog's Head and Bolus Head as 'disused', but not as being ruined. The condition of the enclosed barracks at Rough Point is not identified on any of the early Ordnance Survey maps, but the site appears to still be largely intact on the 3rd edition Ordnance Survey map, surveyed 1914-1915.

Given that Signal Station 39 on Hog Island, County Kerry (Appendix F.39), is thought to have never been constructed, the sequence of signal stations and enclosed barracks around this part of the coast is presented in Table 4.6. The distances between some of these signal stations exceeds the maximum distance found in Connacht and Ulster, which was the 22.2 km (13.8 miles) span between Clare Island and Saddle Hill Signal Stations in County Mayo. Prior to the additions of the enclosed barracks the distances would have been 24 km (14.9 miles) between Dursey Island Signal Station and Bolus Head Signal Station; 11.6 km (7.2 miles) between Bolus Head Signal Station and Bray Head Signal Station; 24.6 km (15.3 miles) between Bray Head Signal Station and Great Blasket Signal Station; 10.3 km (6.4 miles) between Great Blasket Signal Station and Sybil Head Signal Station; 8.8 km (5.5 miles) between Sybil Head Signal Station and Ballydavid Head Signal Station; 36.9 km (22.9 miles) between Ballydavid Head and Kerry Head; 16.9 km (10.5 miles) between Kerry Head Signal Station and Loop Head Signal Station.

Figure 4.63. Hog’s Head Enclosed Barrack, looking west, with the western bastion in the foreground.

Figure 4.64. The imposing rear wall of the two storey building at Hog’s Head Enclosed Barrack, County Kerry, looking west. This wall formed part of the perimeter along the eastern side of the enclosure.

Comparing these distances, it is clear that the addition of the enclosed barrack at Hog's Head reduced the distance clockwise from Dursey Island Signal Station by around 4 km (2.5 miles), and the additions of Brandon Height and Rough Point split the 36.9 km (22.9 miles) distance between Ballydavid Head and Kerry Head into 8.2 km (5.1 miles), 17.3 km (10.8 miles), and 13.7 km (8.5 miles) intervals. No mitigating factors could compensate for the remaining large span of 24.6 km (15.3 miles) between Bray Head Signal Station and Great Blasket Signal Station as there was no intervening land to utilise.

| **Station Number** | **Name** | **County** | **Distance to clockwise station** | |
|---|---|---|---|---|
| 38 | Dursey Island Signal Station | Cork | 20.5 km | 12.7 miles |
| - | Hog's Head Enclosed Barrack | Kerry | 9.7 km | 6 miles |
| - | Bolus Head Enclosed Barrack | Kerry | 12 km | 7.5 miles |
| 40 | Bolus Head Signal Station | Kerry | 11.6 km | 7.2 miles |
| 41 | Bray Head Signal Station | Kerry | 24.6 km | 15.3 miles |
| 42 | Great Blasket Signal Station | Kerry | 10.3 km | 6.4 miles |
| 43 | Sybil Head Signal Station | Kerry | 8.8 km | 5.5 miles |
| 44 | Ballydavid Head Signal Station | Kerry | 8.2 km | 5.1 miles |
| - | Brandon Height Enclosed Barrack | Kerry | 17.3 km | 10.8 miles |
| - | Rough Point Enclosed Barrack | Kerry | 13.7 km | 8.5 miles |
| 45 | Kerry Head Signal Station & Barracks | Kerry | 16.9 km | 10.5 miles |
| 46 | Loop Head Signal Station | Clare | - | - |

**Table 4.6. The expanded signal station system along the coast of County Kerry. Note that the distance given for Bolus Head Enclosed Barracks is to Bray Head Signal Station, not to Bolus Head Signal Station.**

## 4.13 Viewshed analysis of the Connacht and Ulster Signal Stations

The results of the two types of viewshed analysis (Sections 3.13.5.3 and 3.4.5.4) proved particularly useful. As described below (Section 4.13.1) inherent limitations in the *Google Earth* viewsheds reduced the usefulness of the results. The viewsheds created in *ArcGIS* (Section 4.13.2) were found to be more useful. They were subsequently combined with meteorological data (4.13.3) and elevation data (4.13.4) and used to produce a new assessment of how well the signal station system would have functioned.

### 4.13.1 Google Earth Viewsheds

The *Viewshed* tool in *Google Earth Pro* provided a simple visual representation of what could be seen from each site. However, when the viewsheds were first created in 2016 there were some clear issues, with areas which obviously should have been shown as being visible from the top of some signal towers being marked as not visible. The problem was most apparent where the view was towards the sea, where certain parts of the sea-surface was shown as being invisible from the signal tower, despite their being no apparent blockage to the line of sight (Figures 4.65 & 4.66). In 2019 the viewsheds were regenerated using the same procedure to see if any improvements to the software had occurred. The problems were still apparent, and because of this, and the limitations already discussed in Section 3.3.5.4, the function remains of only restricted use (Figures 4.67 & 4.68).

These viewsheds confirmed observations made in the field regarding field of view with blocked lines of site. For example, the viewshed from Saddle Hill Signal Station, County Mayo, confirmed field observations that the lines of site were blocked to the east and west by the adjacent Slievemore and Croaghaun mountains. The views to the north and south were open, allowing the adjacent signal towers to be seen but the mass of Croaghaun limited how usefully the ocean to the west could be observed.

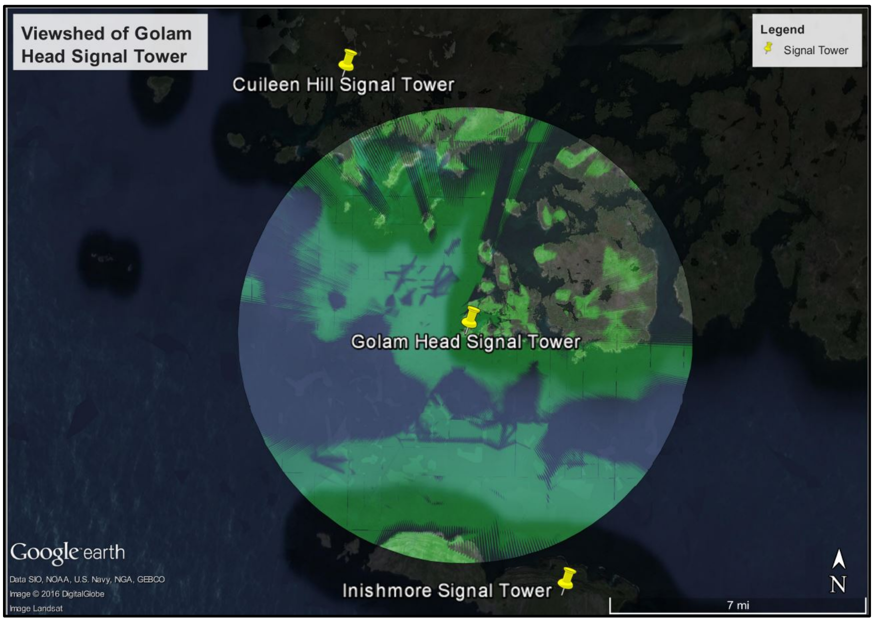


Figure 4.65. The *Google Earth Pro* Viewshed from Golam Head Signal Station generated in 2016. Areas shown in green are calculated to be visible from the top of the signal tower. There is no reason why the sea to the west of this signal station would not be fully visible.


Figure 4.66. The Google Earth Pro Viewshed from Golam Head Signal Station generated in 2019. Areas shown in green are calculated to be visible from the top of the signal tower. The issue with the sea to the west of the signal station displaying as not visible has persisted.

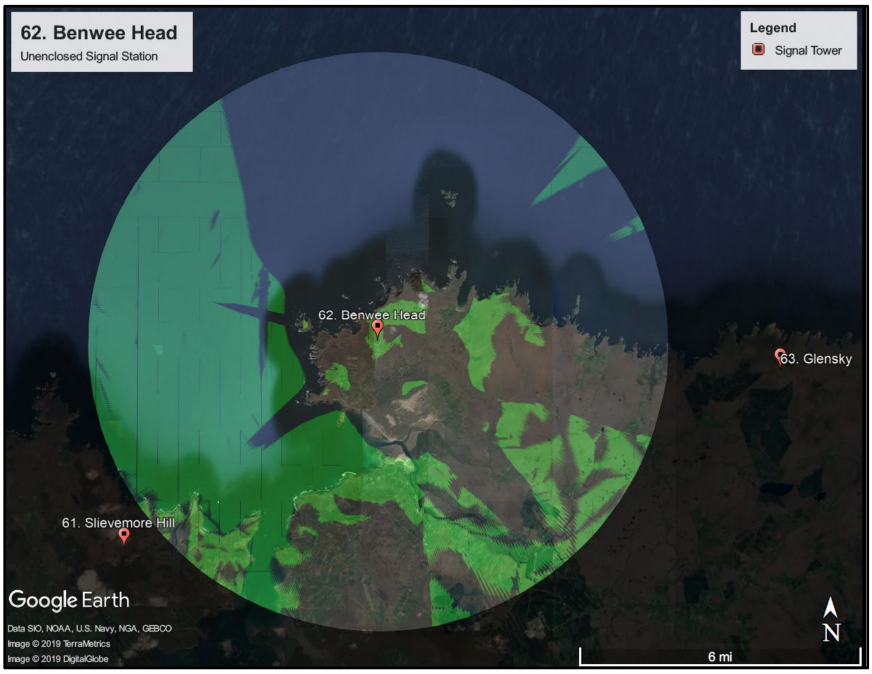


Figure 4.67. The *Google Earth Pro* Viewshed from Benwee Head Signal Station. Areas shown in green are calculated to be visible from the top of the signal tower. The image displays the 160-degree arc of the adjacent coast which would not be visible from the top of the signal tower

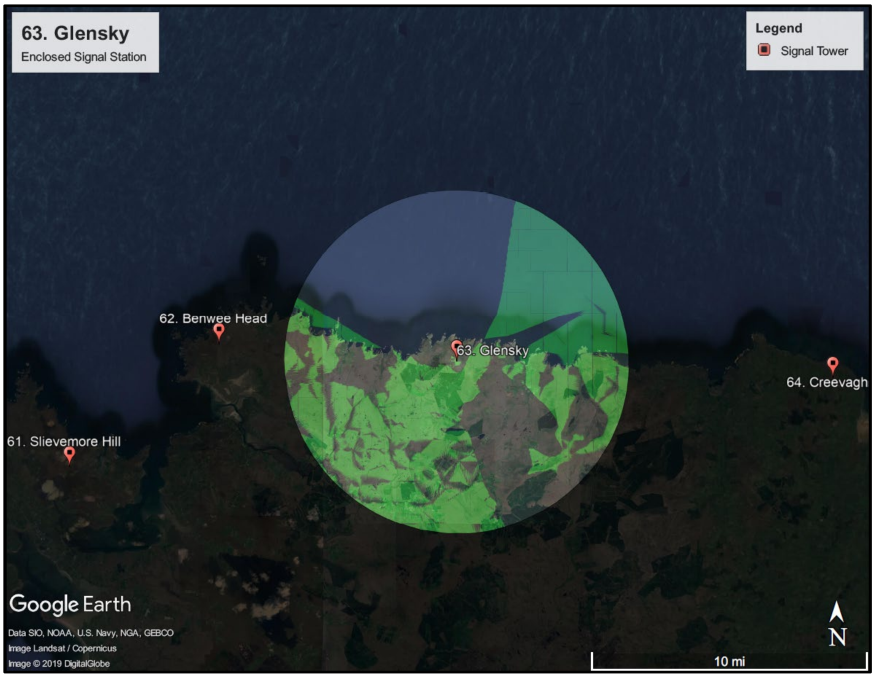


Figure 4.68. The *Google Earth Pro* Viewshed from Glinsk Signal Station. Areas shown in green are calculated to be visible from the top of the signal tower. The image displays the 90-degree arc of the adjacent coast which would not be visible from the top of the signal tower

The most useful application of the *Google Earth Pro Viewshed* tool involved the ability to calculate what could have been seen from the top of a particular signal tower, which obviously couldn't be checked in the field. For example, it was speculated during the field survey that even from the top of the collapsed signal towers at Benwee Head and Glinsk Signal Stations, County Mayo, the adjacent coast to the north may not have been visible. The viewshed confirmed that this speculation was correct; a 160˚ arc at Benwee Head Signal Station, County Mayo, and a 90 degree arc at Glinsk Signal Station, County Mayo, would have been obscured by the summit of the hills on which the signal stations were built. The results of these simple viewsheds are summarised in Table 4.7.

| Signal Station | County | Visible (degrees) | Not Visible (degrees) |
|---|---|---|---|
| 51. Inisheer | Galway | 0-210; 300-360 | 210-300 |
| 52. Inishmore | Galway | 0-240; 290-360 | 240-290 |
| 53. Golam Head | Galway | 0-30; 95-360 | 30-95 |
| 54. Cuileen Hill | Galway | 0-10; 115-360 | 10-115 |
| 55. Bunowen Hill | Galway | 0-270; 320-360 | 270-320 |
| 56. Cleggan Hill | Galway | 0-50; 195-360 | 50-195 |
| 57. Inishturk | Mayo | 0-135; 145-230; 260-360 | 135-145; 230-260 |
| 58. Clare Island | Mayo | 0-30; 120-360 | 30-120 |
| 59. Saddle Hill | Mayo | 0-40; 160-230; 295-360 | 40-160; 230-295 |
| 60. Glash | Mayo | 0-70; 120-360 | 70-120 |
| 61. Tower Hill | Mayo | 0-305; 340-360 | 305-340 |
| 62. Benwee Head | Mayo | 110-325 | 0-110; 325-360 |
| 63. Glinsk | Mayo | 20-130; 165-290 | 0-20; 130-165; 290-360 |
| 64. Creevagh | Mayo | 0-120; 270-360 | 120-270 |
| 65a. Lenadoon Point | Sligo | 0-100; 160-360 | 100-160 |
| 65. Rathlee | Sligo | 0-360 | - |
| 66. Carrowmably | Sligo | 0-275; 320-360 | 275-320 |
| 67. Knocklane Hill | Sligo | 0-45; 110-360 | 45-110 |
| 68. Streedagh | Sligo | 0-120; 230-360 | 120-230 |
| 69. Kilcologue Point | Sligo | 0-65; 190-360 | 65-190 |
| 70. St John's Point | Donegal | 0-30; 50-360 | 30-50 |
| 71. Carrigan Head | Donegal | 85-305 | 0-85; 305-360 |
| 72. Malin Beg | Donegal | 115-340 | 0-115; 340-360 |
| 73. Glen Head | Donegal | 0-45; 200-360 | 45-200 |
| 74. Dawros Head | Donegal | 0-60; 130-360 | 60-130 |
| 75. Crohy Head | Donegal | 0-60; 180-310; 340-360 | 60-180; 310-340 |
| 76. Mullaghderg Hill | Donegal | 0-110; 210-360 | 110-210 |
| 77. Bloody Foreland | Donegal | 0-80; 195-360 | 80-195 |
| 78. Horn Head | Donegal | 0-120; 215-360 | 120-215 |
| 79. Melmore Head | Donegal | 0-125; 235-360 | 125-235 |
| 80. Fanad Head | Donegal | 0-155; 275-360 | 155-275 |
| 81. Malin Head | Donegal | 0-105; 195-360 | 105-195 |

**Table 4.7. Arcs of visibility from the Connacht and Ulster Signal Stations.**

### 4.13.2 ArcGIS Viewsheds

The viewsheds created in ArcGIS were in general agreement with the results from *Google Earth Pro* regarding visibility from individual signal stations. The ability to simultaneous show viewsheds from long stretches of the coast provides a useful visual representation of how successfully the system would have operated (Figures 4.69 - 4.72). Although not particularly intuitive at first glance, the overlapping circles clearly show how climate-determined visibility conditions would have interfered with the systems functionality.

If the climate (low cloud, fog, mist) or daylight reduced visibility to a range of 7 km or less, none of the signal stations would have been inter-visible and the system would have been entirely dysfunctional (Figures 4.69 - 4.72).

With a visibility range of 12 km or less, 48% of the system failed in Connacht and Ulster. At the 12 km or less visibility range two of the five spans in County Galway were inter-visible, three of the seven spans in County Mayo were inter-visible, three of the four spans in County Sligo were inter-visible and six of the eleven spans in County Donegal were inter-visible. At this level of visibility therefore, the signal stations along short stretches of the coast would have been able to send signals to each other, allowing a local level of warning to be sounded, but the system would have been dysfunctional for long-distance, county-wide, and province-wide signalling (Figures 4.69 - 4.72). It would of course have been possible for any signal station that spotted an enemy fleet approaching or passing to dispatch a messenger to the nearest military force stationed along the coast or in the interior. At this level of visibility, it would have been possible to transmit information between the adjacent signal stations in Counties Sligo and Donegal, but communication between County Galway and County Mayo, and between County Mayo and County Sligo would have been impossible.

With a visibility range of 16 km or less, only 26% of the system failed in Connacht and Ulster. At the 16 km or less range three of the five spans in County Galway were inter-visible, four of the seven spans in County Mayo were inter-visible, all four of the spans in County Sligo were inter-visible and nine of the eleven spans in County Donegal were inter-visible. At this level of visibility, the system would have been able to send messages around most of the coast of Counties Sligo and Donegal, which would have potentially been useful in getting a signal to British forces based in Lough Swilly, but the system remained dysfunctional around the coasts of Counties Galway and Mayo (Figures 4.69 - 4.72). At this level of visibility, it would have been possible to transmit information across all of the county boundaries within the main study area.

At 22 km visibility all of the spans between signal stations in Connacht and Ulster were inter-visible (a 100% success rate) and the long-distance signalling system would have been fully functional.

Whilst these results were evident from the distances between signal stations listed in Tables 4.1.1 to 4.1.5, the visibility maps provide a useful visual representation of the level of functionality at different visibility levels. What is most useful about the visibility maps is the representation of how much of the adjacent coast could be observed without gaps.

In County Galway, almost the entire coast was observable at the 7 km visibility level and the entire coast was observable above the 12 km visibility level. In County Mayo there are four substantial gaps at the 7 km visibility level, and two small gaps at the 12 km and 16 km visibility levels, located to the west of Saddle Hill Signal Station and north of Benwee Head Signal Station. At the 22 km visibility level coverage was essentially complete, with the possible exception of a small sliver to the north-north-east of Benwee Head. In County Sligo, almost the entire coast was observable at the 7 km visibility level and the entire coast was observable at the 12 km visibility level. In County Donegal, almost the entire coast was observable at the 7 km visibility level and the entire coast was observable at the 12 km visibility level, with the possible exception of some small slivers to the north-west of Crohy Head, which remained stubbornly unobservable even at the 22 km visibility level. These results indicate that above the 12 km visibility levels the signal stations provided an almost continuous watch on the coast of Connacht and Ulster.  It is hardly feasible that an approaching fleet could have purposely approached down one of the very limited gaps in the coverage at the above 12 km visibility level, and none of the gaps would have led to a usable landing place. At the above 7 km visibility level there was still almost complete coverage around the coast of Counties Galway, Sligo, and Donegal.

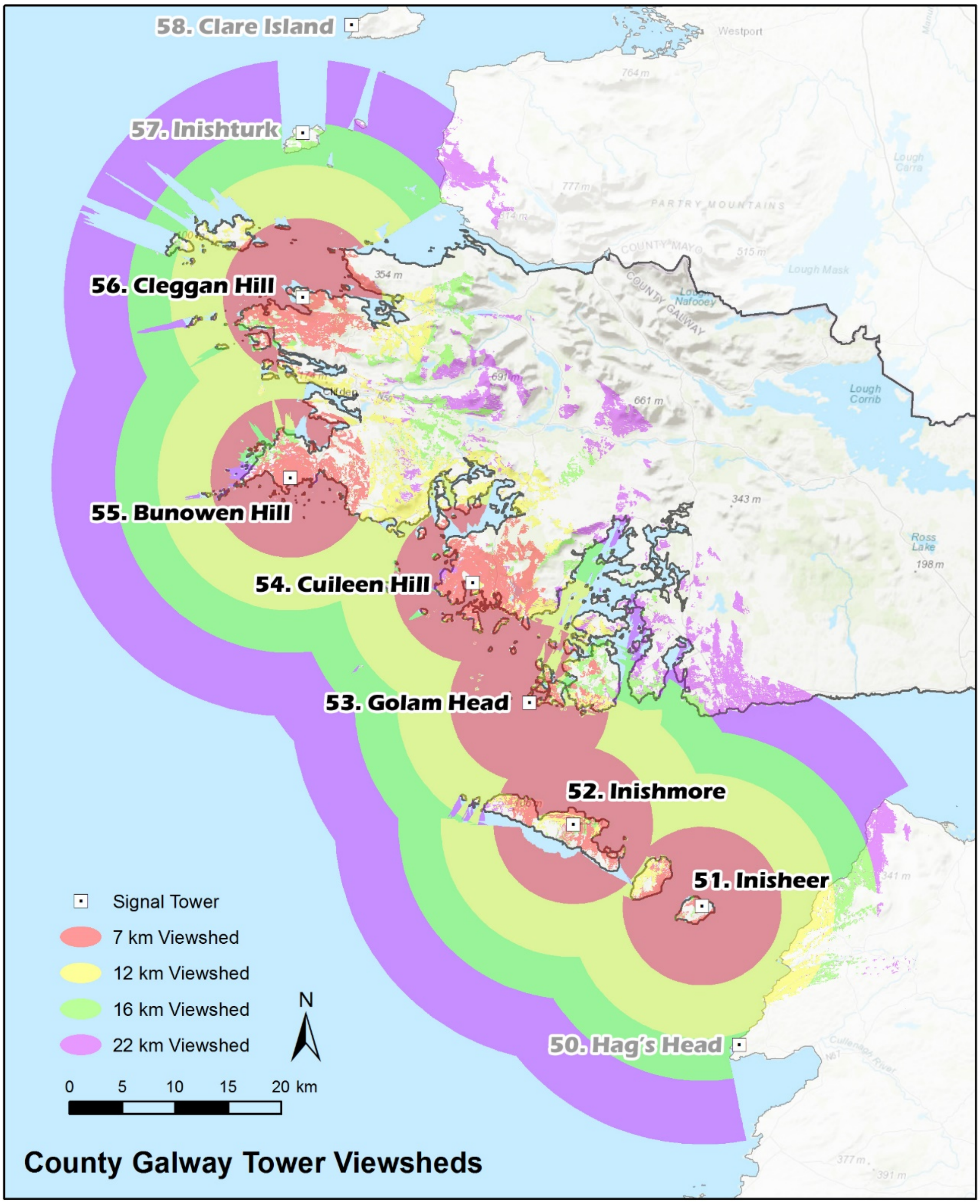


Figure 4.69. *ArcGIS* Viewsheds from the County Galway Signal Stations.

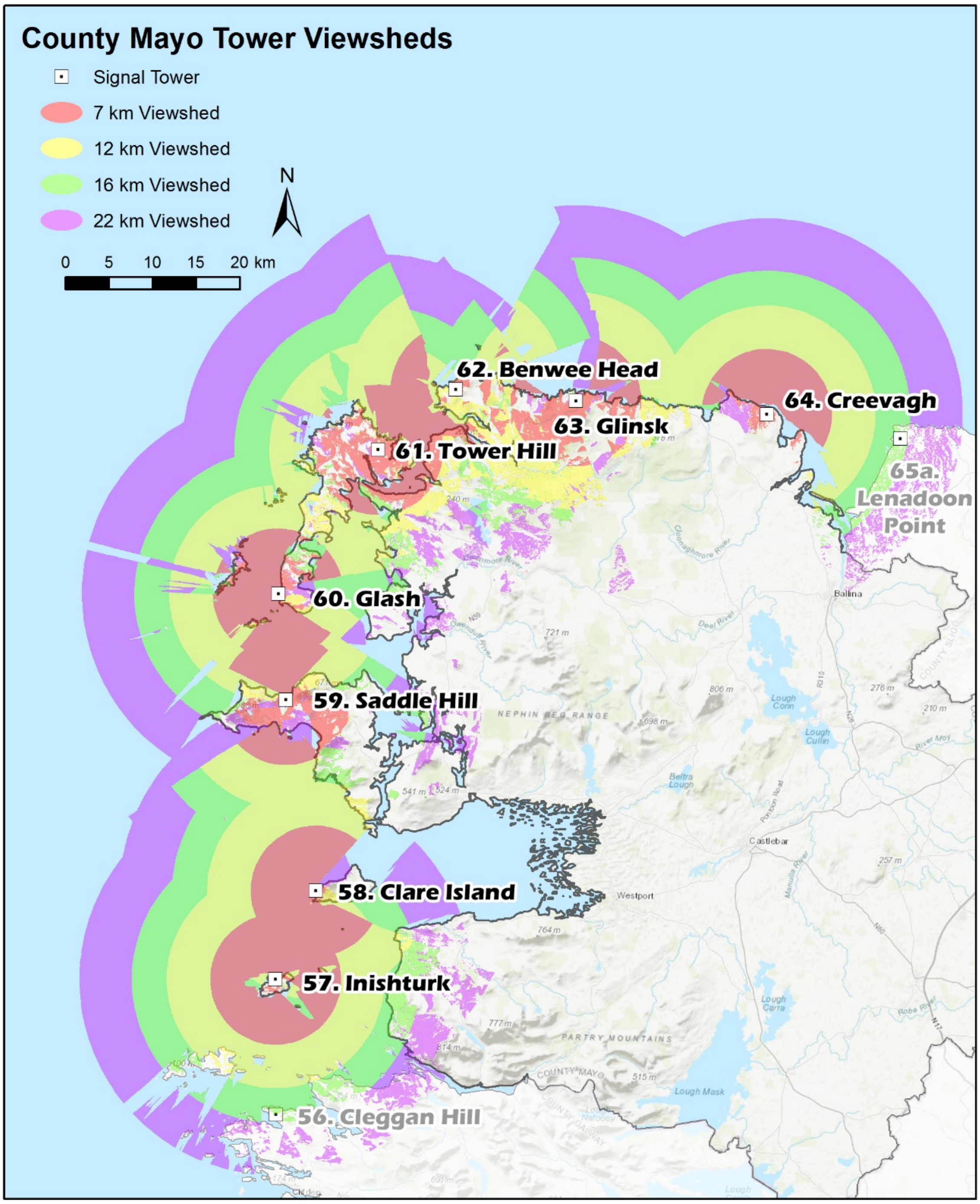


Figure 4.70. *ArcGIS* Viewsheds from the County Mayo Signal Stations.

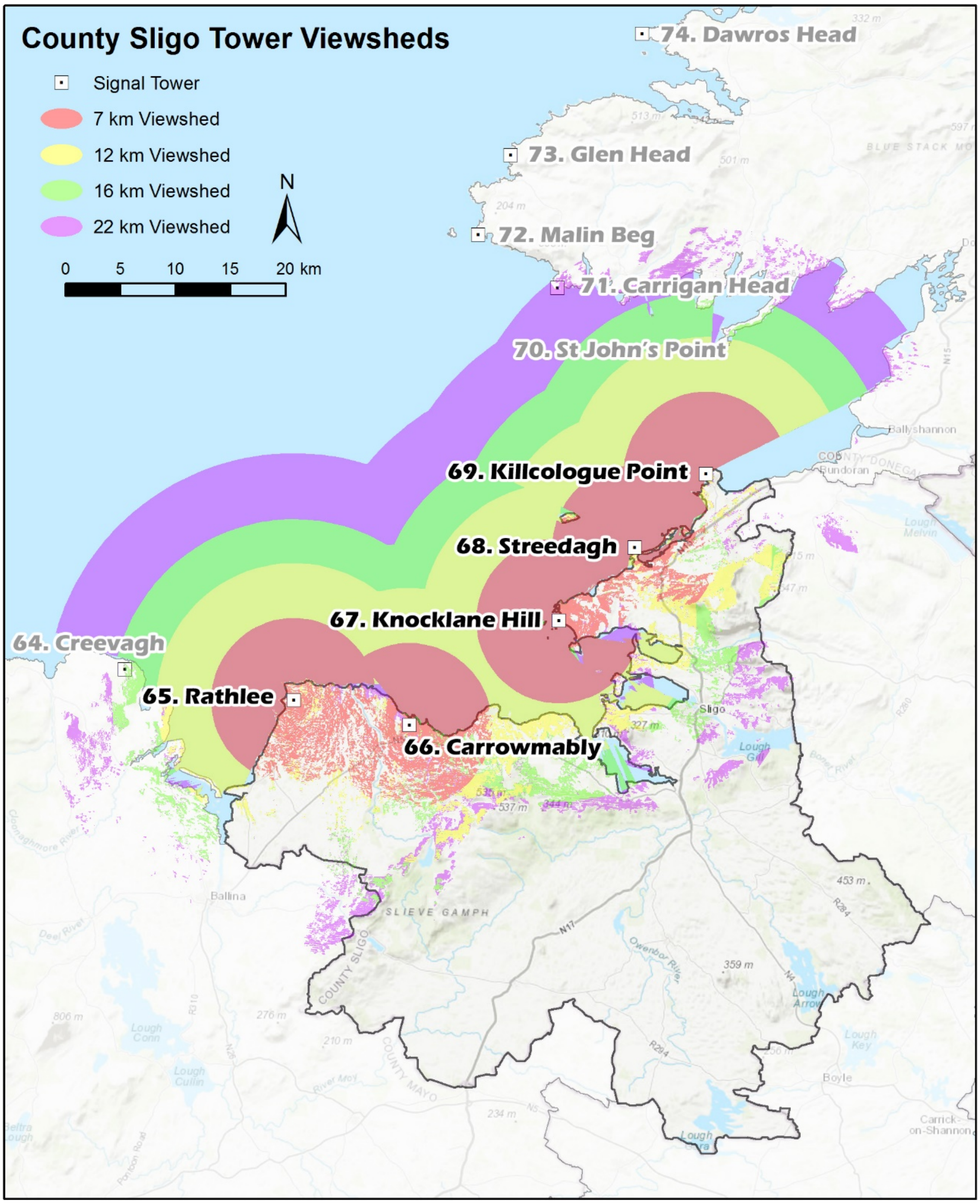


Figure 4.71. *ArcGIS* Viewsheds from the County Sligo Signal Stations.

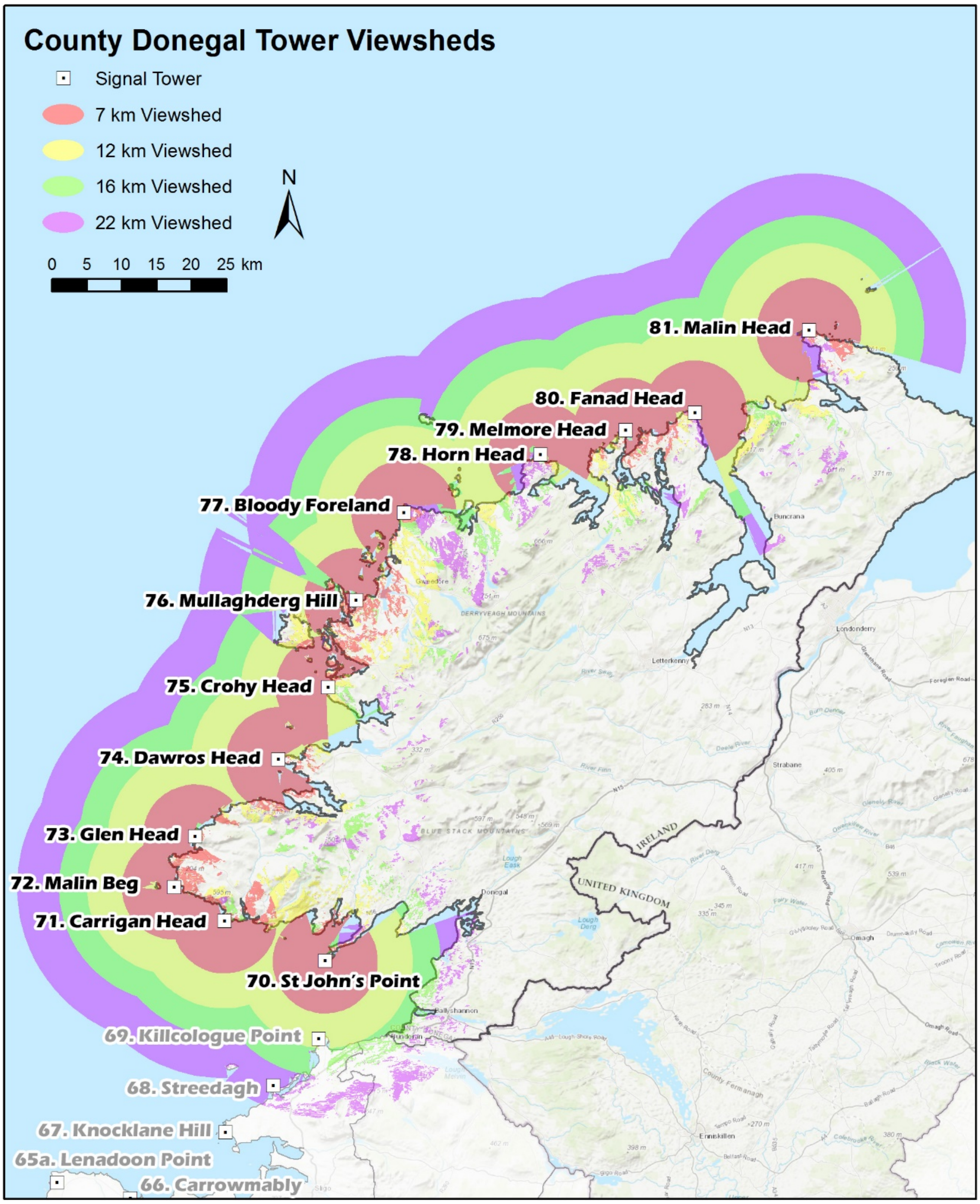


Figure 4.72. *ArcGIS* Viewsheds from the County Donegal Signal Stations.

### 4.13.3 Meteorological Data

Having established how different visibility ranges would have impaired the functionality of the signal stations, it was important to determine how frequently such conditions would have occurred. The historical data section of *Met Éireann's* (The Irish Meteorological Service) website contains hourly readings from various weather stations across Ireland. The service includes four weather stations located on the coast of the main study area, but only Belmullet, County Mayo, and Malin Head, County Donegal include hourly recordings of visibility levels (*Met Éireann* 2019). The hourly data is available from 1987 onwards and ten years of data, running hourly from 1 January 1987 through to 31 December 1996 was downloaded and analysed to provide a sample of accurate visibility data over a decade. The number of entries in each of the four visibility bands used in the ArcGIS viewshed analysis (7 km, 12 km, 16 km, 22 km) was tallied for each of the years, and these totals were then calculated as a percentage of the total number of readings per year. The results are presented in Table 4.8.

The data suggest that, based on 1980s-1990s climatic conditions, the signal stations in County Mayo would have been fully functional around 60% of the time, had limited functionality around 16% of the time and would have been dysfunctional around 24% of the time. The signal stations in County Donegal would have been fully functional around 68% of the time, had limited functionality around 10% of the time and would have been dysfunctional around 22% of the time. The functionality of the system as a whole is determined by the weakest components, so the combined totals given at the end of Table 4.8, are less relevant than the levels recorded for County Mayo, which had the lower levels of visibility.

The significance assigned to these particular results is dependent on how closely modern visibility levels are likely to reflect visibility levels in the early 19th century. Work assessing sunshine levels and cloud levels in Ireland between 1881 and 1998, principally based on measurements taken at Armagh Observatory, County Armagh, suggest that cloud cover levels have been increasing and sunshine levels have been decreasing since the late 19th century (Pallé & Butler 2001; Butler *et al* 2007). A more recent study has tentatively identified a long-term trend towards wetter and cloudier conditions in Ireland from the 1790s through to the present (Murphy *et al* 2018). Should these results be confirmed by further studies then the assessment of the level of functionality of the Irish Signal Stations based on visibility conditions would have to be revised upwards. Based on the proxy data from the 1980s-1990s, the signal stations are estimated to have been fully functional for around 60% of the time, partially functional for around 15% of the time, and only fully dysfunctional around 25% of the time.

| **Belmullet** | Number of Hourly Readings | | | | | |
|---|---|---|---|---|---|---|
| Year | 0-6.9 km | 7-11.9 km | 12-15.9 km | 16-21.9 km | **22 km +** | Total Number of Readings |
| 1987 | 822 | 891 | 662 | 943 | 5442 | 8760 |
| 1988 | 560 | 730 | 664 | 1228 | 5602 | 8784 |
| 1989 | 685 | 740 | 739 | 1322 | 5274 | 8760 |
| 1990 | 595 | 768 | 726 | 1185 | 5486 | 8760 |
| 1991 | 1078 | 833 | 796 | 1286 | 4767 | 8760 |
| 1992 | 750 | 771 | 693 | 1583 | 4987 | 8784 |
| 1993 | 689 | 819 | 725 | 1569 | 4958 | 8760 |
| 1994 | 628 | 694 | 588 | 1746 | 5104 | 8760 |
| 1995 | 567 | 769 | 613 | 1508 | 5255 | 8712 |
| 1996 | 559 | 752 | 468 | 1543 | 5462 | 8784 |
| Total | 6933 | 7767 | 6674 | 13913 | 52337 | 87624 |
| **Percent** | **7.9%** | **8.9%** | **7.6%** | **15.9%** | **59.7%** | |
| | | | | | | |
| **Malin Head** | Number of Hourly Readings | | | | | |
| Year | 0-6.9 km | 7-11.9 km | 12-15.9 km | 16-21.9 km | **22 km +** | Total Number of Readings |
| 1987 | 676 | 812 | 731 | 615 | 5926 | 8760 |
| 1988 | 412 | 684 | 821 | 767 | 6100 | 8784 |
| 1989 | 364 | 592 | 794 | 791 | 6219 | 8760 |
| 1990 | 268 | 552 | 810 | 999 | 6131 | 8760 |
| 1991 | 658 | 824 | 810 | 946 | 5522 | 8760 |
| 1992 | 372 | 627 | 782 | 1134 | 5869 | 8784 |
| 1993 | 572 | 816 | 878 | 975 | 5519 | 8760 |
| 1994 | 373 | 650 | 777 | 1054 | 5906 | 8760 |
| 1995 | 333 | 578 | 705 | 907 | 6237 | 8760 |
| 1996 | 399 | 624 | 677 | 853 | 6231 | 8784 |
| Total | 4427 | 6759 | 7785 | 9041 | 59660 | 87672 |
| **Percent** | **5%** | **7.7%** | **8.9%** | **10.3%** | **68.1%** | |
| | | | | | | |
| **Combined Results** | Number of Hourly Readings | | | | | |
| Year | 0-6.9 km | 7-11.9 km | 12-15.9 km | 16-21.9 km | **22 km +** | Total Number of Readings |
| Total | 11360 | 14526 | 14459 | 22954 | 111997 | 175296 |
| **Percent** | **6.5%** | **8.3%** | **8.2%** | **13.1%** | **63.9%** | |

**Table 4.8. Visibility levels in the main study area between 1987 and 1996. The table shows the number of hourly readings observed at Belmullet and Malin Head weather stations which fell into each visibility range over a ten-year span.**

### 4.13.4 Elevation Data

As the patterns within the ArcGIS viewshed analysis data became apparent, a question arose concerning possible correlations of the distances between signal stations and either the county they were located in, or the elevation they were situated at. In the first instance it was speculated that local political concerns or geographical factors might reflect a particular spacing pattern. In the second instance it was speculated that there might be a proportional relationship between the relative elevations of adjacent signal stations and the distance between them; potentially the visible distance between a high elevation site and a low elevation site could be greater than two adjacent sites at similar elevations. Table 4.9 shows the results of this investigation.

None of the counties demonstrate any noticeable preference for having signal stations spaced in particular distance ranges. Using a correlation coefficient analysis (*Data* Analysis tools in *Microsoft Excel*) a correlation of r = 0.2 was calculated for the relationship between relative elevation and the county each pair of stations was located in (the counties were each assigned a simple numerical value). This is a weak positive correlation between the two variables, and as such is likely insignificant (Akoglu 2018, Table 1).

Similarly, the relative elevation changes between adjacent stations did not seem to affect the spacing between the signal stations. The two adjacent signal stations with the third highest relative elevation changes between them, Malin Beg and Glen Head, County Donegal, had the shortest distance between them. Conversely the two adjacent signal stations with the greatest distance between them, Clare Island and Saddle Hill Signal Stations, County Mayo, have a relative elevation change of 52 m, which is one of the two median values within the overall range. A correlation coefficient of r = 0.084 was calculated for the relationship between relative elevation and distance, indicating a negligible positive correlation between the two variables (Akoglu 2018, Table 1).

| Span | Distance (km) | County | Relative Elevation Change (m) |
|---|---|---|---|
| Malin Beg to Glen Head | 7.84 | Donegal | 192 |
| Carrigan Head to Malin Beg | 8.71 | Donegal | 192 |
| Streedagh to Kilcologue Point | 9.33 | Sligo | 4 |
| Knocklane Hill to Streedagh | 9.56 | Sligo | 43 |
| Melmore Head to Fanad Head | 10.16 | Donegal | 33 |
| Rathlee to Carrowmably | 10.72 | Sligo | 22 |
| Inishturk to Clare Island | 11.15 | Mayo | 49 |
| Kilcologue Point to St John's Point | 11.3 | Sligo/Donegal | 15 |
| Tower Hill to Benwee Head | 11.31 | Mayo | 28 |
| Saddle Hill to Glash | 12.23 | Mayo | 139 |
| Inishmore to Golam Head | 12.24 | Galway | 97 |
| Golam Head to Cuileen Hill | 12.54 | Galway | 72 |
| Dawros Head to Crohy Head | 12.54 | Donegal | 37 |
| Horn Head to Melmore Head | 12.69 | Donegal | 139 |
| Crohy Head to Mullaghderg Hill | 13.13 | Donegal | 3 |
| Benwee Head to Glinsk | 13.83 | Mayo | 93 |
| Mullaghderg Hill to Bloody Foreland | 14.27 | Donegal | 6 |
| Inisheer to Inishmore | 14.3 | Galway | 61 |
| St John's Point to Carrigan Head | 15.51 | Donegal | 201 |
| Cleggan Hill to Inishturk | 15.54 | Galway/Mayo | 45 |
| Creevagh to Rathlee | 15.59 | Mayo/Sligo | 43 |
| Glen Head to Dawros Head | 16.27 | Donegal | 215 |
| Carrowmably to Knocklane Hill | 16.58 | Sligo | 25 |
| Bunowen Hill (Slyne Head) to Cleggan Hill | 17.1 | Galway | 82 |
| Cuileen Hill to Bunowen Hill | 19.88 | Galway | 36 |
| Glash to Tower Hill | 20.14 | Mayo | 76 |
| Fanad Head to Malin Head | 20.14 | Donegal | 54 |
| Bloody Foreland to Horn Head | 21.2 | Donegal | 129 |
| Glinsk to Creevagh | 21.94 | Mayo | 181 |
| Clare Island to Saddle Hill | 22.23 | Mayo | 52 |

**Table 4.9 Distances and relative elevation changes between signal stations.**

These results support the assertion that the primary factors in locating the signal stations were the identification of locations which offered consecutive inter-visibility, a view over the adjacent coast, and which were not in excess of the operational range of the signalling apparatus. Apparently at two sites, Benwee Head and Glinsk Signal Stations, County Mayo (Section 4.13.2), no location could be found which could satisfy all three of these criteria, and the view of the adjacent coastline was sacrificed at the expense of maintaining consecutive inter-visibility.

# Chapter 5. Discussion

The results of this project have not led to a revision of the fundamental details of the Irish signal stations. The broad research question defined in Section 1.2 asked how the Irish signal stations should be understood as a distinct monument class. The Irish signal stations can be briefly summarized as follows;

Approximately 80 signal stations were established around the coast in the wake of the failed rebellion of 1798. The signal stations were planned as part of a larger response to the 1798 rebellion which involved a substantial improvement in Ireland's coastal defences and internal military organisation. The plan to construct the signal stations was developed in 1803. Construction began in 1804 and was largely complete by 1806. Less than a decade later the signal stations were abandoned, their usefulness left untested in the absence of another invasion. A small number of signal stations were established at existing facilities or newly constructed Martello towers, but the vast majority were located at new purpose-built facilities. The purpose-built signal stations consisted of a two-storey stone-built signal tower that was constructed according to a standard design. The signal towers were sometimes set within small enclosures and may have been accompanied by a small number of additional buildings. Signalling between adjacent signal stations was achieved using a series of flags and canvas balls suspended from a signal mast in different combinations.

The brief description above could have been obtained from reading Kerrigan's work on the subject, or from any of the subsequent work that sourced information about the Irish signal stations wholly or largely from Kerrigan (Section 2.5). The following nine sections discuss the results of the project and presents a significant volume of new information that enhances our understanding of the Irish signal stations as a monument class.

## 5.1 Research Question 1. How many signal stations were constructed around the coast of Ireland?

Kerrigan proposed that 80 signal stations had been located around the coast of Ireland, and that one additional signal station, Hog Island in County Kerry, was planned but never constructed (Kerrigan 1995, 162). Extensive historical and cartographic research only resulted in the identification of one additional site, at Lenadoon Point in County Sligo, which seems to have been abandoned before it was completed in favour of the nearby site at Rathlee (Appendix C.65a & C.65). A thorough review of cartographic evidence and aerial photographs failed to identify any traces of a site on Hog Island (Appendix F.39). This study concurs with Kerrigan's tally; the first configuration of the signal station system consisted of 80 signal stations.

The four enclosed barracks in County Kerry appear to have been additions to the original signal station system, constructed around 1808 (Section 4.12.3; Appendix G). The four enclosed barracks are located in areas where the gaps between the original signal stations were large enough to have proved problematic for signalling (Section 4.12.3; Table 4.6). One of these sites, Bolus Head Enclosed Barracks, either replaced or supplemented the existing Bolus Head Signal Station, and therefore did not add to the overall number of signal stations in the system. The expanded version of the signal station system consisted of 83 signal stations.

What happened at each end of the chain of signal stations currently remains somewhat unclear. The signal station at Pigeon House Fort in Dublin seems to represent a terminal. However, the 12 Martello towers constructed north of Dublin, between Sutton Creek and Balbriggan, County Dublin, were equipped with flagstaffs, and were so closely spaced that communication between the sites would have been very feasible. The distance between Sutton Creek Martello Tower (Reg. No. 11366017) and Pigeon House Signal Station was a very manageable 7.3 km or 4.5 miles (Kerrigan 1995, 174-6; Hartnett McEnery 2006, 83-5). The short distance of around 13 km (8 miles) between the final Martello at Balbriggan (DU002-004----/Reg. No. 11305009) and Richmond Fort, the larger but related fortification at Drogheda, County Louth (LH024-041009-/Reg. No. 13622082), would have been feasible for optical signal communications, most practically via an additional signal post at Mornington on the south side of the mouth of the River Boyne, although no published sources mention this as having occurred. North of Drogheda the distances between the major fortifications at Carlingford and Carrickfergus were much greater. Between Drogheda and Carlingford there were 34 km (21 miles), and between Carlingford and Carrickfergus there were 77 km (48 miles) via the shortest overland route, or 116 km (72 miles) around the coast. These sites do not seem to have communicated via optical signals. There is no evidence that any attempt was made to continue the optical signal system eastwards from the final signal station at Malin Head in County Donegal. The contemporary opinion that the east coast was not vulnerable to invasion has been discussed above (Section 2.2.4), but O'Sullivan and Downey's comment regarding the prevailing view that defences were not required between Drogheda and Belfast is particularly pertinent (O'Sullivan and Downey 2012, 48).

## 5.2 Research Question 2. When were the signal stations constructed and when were they abandoned?

The Irish Signal Stations were a direct response to the 1978 invasion. As detailed in Section 2.2.4, a complicated sequence of personnel re-appointments, report preparation, and debate followed the invasion, and all but the most urgent responses were delayed for a number of years. By June 1803 Lord Lieutenant Hardwicke had determined a need for an early warning system to announce a future naval invasion (Clements 2013, 98). Initially this task was assigned to Lieutenant Colonel Benjamin Fisher of the Royal Engineers, who identified the need for fortified stone buildings to house the signal crews, given the additional threats they were likely to face in Ireland as opposed to England, where simple wooden buildings sufficed for this purpose (Kerrigan 1995, 157). The actual design of the signal towers to be used at the signal stations was created by Major Alexander Taylor of the Royal Engineers, and clearly follows Fischer's suggestion (NLI Mss 14, 917; letter dated 6 November 1803 from Admiral Whitshed to William Wickham). Rear Admiral James Whitshed was dispatched to Ireland in September 1803 to advise on the defence of the coast and raise the Sea Fencibles (Kerrigan 1995, 157; Hattendorf 2008). Responsibility for the signal stations was transferred to Whitshed, and he appears to have utilised Taylor's design that was, at the very least, already under development prior to his arrival in Ireland (Kerrigan 1995, 157). Construction of the signal stations commenced early in 1804 and they were completed by 1806 (Kerrigan 1995, 276-80). The successes of the British Navy in the early 19th century drastically reduced the likelihood of another French-led invasion of Ireland, although the threat would persist in theory for many years (Section 2.2.3). By 1808 the likelihood of a fourth invasion of Ireland was reduced to the extent that resources used to defend the coasts of Britain and Ireland began to be re-assigned, and the future of the Irish Signal Stations came under discussion (Kerrigan 1995, 165).

In September 1809 orders were issued to abandon large parts of the system, between Dalkey, County Dublin, and Fort Davis, County Cork, and between Inishmore, County Galway, and Horn Head, County Donegal. Two sections of the signal station system were preserved, one section from Robert's Head Signal Sation, County Cork, to Hag's Head Signal Station, County Clare, and a second section that protected the approach to Lough Swilly, and is assumed to have included just Melmore Head, Fanad Head, and Malin

Head Signal Stations, County Donegal (Kerrigan 1985, 165). In 1811, the likelihood of a conflict with America increased to the point that the British began to make preparations for the future conflict. Some of the previously abandoned signal stations were recommissioned prior to the American declaration of War, on 1 June 1812 (Kerrigan 1995, 163). It is not currently clear how many signal stations were brought back into operation during this period, and if they were limited to the western and southern coasts, or if they were more widely distributed. The signal stations are thought to have remained in operation until some point in 1815, with their final decommissioning either coincided with the ratification of a peace treaty by the government in Washington DC on 17 February 1815, or with final defeat of Napoleon at the Battle of Waterloo on 18 June 1815. It is not clear if the final decommissioning of the Irish signal stations was a piecemeal process, or if the entire system was closed at once. Clements states that the signal station system was completely out of service by 1816 (Clements 2013, 102).

It has been implied that the four enclosed barracks in County Kerry might be directly attributable to the 1812-1815 conflict with America (Mould 1994, 24; Kerrigan 1995, 162; Clements 2013, 102). The discussion of Rough Point Enclosed Barracks in state papers dating to 1812 indicates that at least one of the sites was operative at that point (Kerrigan 1995, 162-3). As highlighted in Section 4.12.3, the enclosed barracks are located in the area that had the largest gaps between the original signal stations. It is clear that the enclosed barracks were added as a functional necessity, in response to operational difficulties discovered after the initial signal stations were activated and any association with the War of 1812 may have been coincidental. Alternatively, they may have been added as part of the preparations for the War of 1812 in response to an acknowledged but unresolved flaw in the original system. The new design of the enclosed barracks may simply reflect the ongoing criticisms of the original signal towers as being unpleasant residences (Section 5.3). However, they appear to have been able to house a larger number of men, and the addition of bastions to the corners of the enclosures certainly would have improved the defensive capabilities of the sites. It is unclear if this represents additional defensive roles being assigned to the new sites. Wakefield makes a very brief mention of a signal station at Brandon Heights, County Kerry, that was “next” to Kerry Head Signal Station and had “never yet been used.“ His comment seems to indicate that the Brandon Heights Enclosed Barracks was newly constructed at the time of his visit in 18 October 1808, which strongly suggests that the enclosed barracks are several years older than has been previously assumed (Wakefield 1812b, 830).

## 5.3 Research Question 3. What did each signal station consist of?

The only wholly consistent element recorded at the purpose-built signal stations were the signal towers, which were present at every site with a small degree of variation. Each site would also have featured a signal mast, but evidence for these features was limited to a small number of possible mast mounts, and information that could be gathered from contemporary drawings and descriptions. Enclosures, small storage buildings, privies, lime kilns and roads were also used at some of the signal stations, in various combinations. An entry from Francis H. Tuckey's 'Cork Remembrancer' for the year 1804 includes a particularly important detail about the signal crews that manned the signal stations;

> *"March 28 [1804] – The establishment of signal posts along this coast was carried out with expedition: strong buildings, capable of lodging the naval officer and his assistants, as well as containing a detachment of armed men, were built in the most proper place contiguous to the signal posts."* (Tuckey 1837, 222-3).

The division of the signal crew into three distinct grades is also mentioned in a letter dated 30 August 1806, which mentions a lieutenant, a midshipman, and a number of privates (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). Although Tuckey mentions multiple "assistants" and Berrell mentions only a single "midshipman or second officer", there is general agreement between the two contemporary statements. This is taken to indicate that the signal crews were formally divided into three distinct tiers within the naval employment structure.

### 5.3.1 Signal Towers

The composition of the signal stations in the main study area of Connacht and Ulster were extremely similar, and almost identical designs for the signal towers were used. None of the signal stations in the main study area made use of existing buildings and it is believed that all of the sites originally featured square signal towers.

Most of the signal towers featured a similar arrangement of rooms:

- a semi-basement level, referred to in a contemporary document as a 'hold'
- a ground-floor room containing;
    - four small rectangular windows.
    - a fireplace flanked by two alcoves.
    - a split mezzanine floor level, consisting of two platforms set above the height of the windows, the alcoves, and the fireplace.
- a first-floor divided into two rooms (this division was not visible in the surviving masonry and is known only from historical descriptions) containing;
    - an external door opening into the smaller room, accessed via a retractable ladder.
    - four large rectangular windows.
    - a fireplace flanked by two alcoves located in the larger room.
- an attic level with no windows which was too low to stand upright in.
- a roof level with a parapet wall featuring;
    - two square shaped bartizans over the corners of the rear wall.
    - a rectangular machicolation over the doorway on the front wall.
    - a rectangular chimney stack in the centre of the rear wall.
    - Coping stones placed along the top of the parapet wall, with slight overhangs.

The design also featured a vertical drainage channel running down one of the interior corners of the rear wall, leading water from the roof level to the semi-basement or hold where it would be collected in casks (Section 4.2.2.3). As far as could be determined, given the signal towers variable states of survival, this design was present throughout County Galway, throughout Sligo, with one exception, and throughout County Donegal, with two exceptions. One of the signal towers in County Donegal, at Malin Beg Signal

Station, lacked clear evidence for the split mezzanine floors, but that signal tower had been modified, and it may originally have possessed this feature. The signal tower at Horn Head Signal Station, County Donegal, featured arched top ground-floor windows, and may have had other variations, but it was poorly preserved, and the upper parts of the structure were not intact. The single site in County Sligo which was a variant design, Rathlee Signal Station, was located at the far west of the county, and shared its variations with the sites in County Mayo.

The arrangement at the top of the towers is only briefly discussed by Kerrigan, who mentions the double row of joist holes at the top of the tower at the Old Head of Kinsale, County Cork, and notes it would have provided for “a particularly strong roof” (Kerrigan 1995, 158). Although White (2003, 177) repeats this information, it has not attracted proper analysis or commentary. Clearly the uppermost slot and the step in the wall supported the roof. The space between the uppermost slot and the slot that supported the ceiling of the first-floor room was between 0.6 m and 1.22 m (2’ and 4’) tall. Clearly this space cannot be considered to be a second-floor room in the proper sense, and it is identified here as a windowless attic level. Whether this space was actually used as an attic or if it was simply part of an arrangement that provided a strong and accessible roof is unclear. A two-stage arrangement with hatches/doors through the first-floor ceiling and through the roof could have allowed access to the roof level without exposing the interior of the tower to the elements.

In County Mayo a slightly different design was utilised. The general size and layout of the signal towers were the same, but most of the sites did not feature the split mezzanine levels, the vertical drainage channel, or the attic level, and they featured semi-rounded bartizans. The signal tower at Rathlee Signal Station, County Sligo, resembled the County Mayo examples, lacking the vertical drainage channel and the attic level. It featured a version of the split mezzanine level, but the floors sloped downwards into the interior of the tower suggesting a slightly different function than found elsewhere. The bartizans at Rathlee Signal Station were fully rounded. None of the well-preserved sites with this variant design featured intact coping stones around the tops of the walls, and it is unclear if they were ever a part of this design. Another minor variation restricted to sites in Counties Mayo and Sligo were horizontal or inclined chutes passing through the rear walls of signal towers into the semi-basement level or into the ground-floor alcoves. These features were identified at the signal towers at Inishturk, Saddle Hill, Glash, and Glinsk Signal Stations in County Mayo and at Lenadoon Point and Carrowmably Signal Stations in County Sligo.

Kerrigan states that groups of adjacent signal stations were built by specific contractors, under the supervision of Army officers (Kerrigan 1995, 161). The different style of the signal towers in County Mayo and at Rathlee, County Sligo, may be indicative of the work of a particular contractor. Unfortunately, the variable condition of the signal towers across the main study areas means it was not possible to delimit other groups designed by particular contractors. In County Galway the southern three signal stations, Inisheer, Inishmore, and Golam Head, appear to be extremely similar, suggesting they were the work of a single contractor. Because of their poor condition of the northern three signal stations in County Galway, Cuileen Hill, Bunowen Hill, and Cleggan Hill, were of the same design, suggesting the same contractor, or if they were of a different design, indicative of a different contractor. Only two sites in County Sligo featured well preserved signal towers, Rathlee and Carrowmably Signal Stations. Although the towers are clearly of different design, the very poor condition of the remaining sites meant it was not possible to identify groups of buildings constructed by specific contractors. Only four sites in County Donegal have signal towers that are well preserved enough to properly evaluate their similarities, Carrigan Head, Malin Beg, Glen Head, and Crohy Head Signal Stations. The signal towers are very similar and could be the work of a single contractor. Unfortunately, the poor condition of the remaining sites in the southern part of Donegal does not allow for a proper delineation of this group.

External and internal render was present at signal towers in each county in the main study area, suggesting the use of render was very widespread, and it seems likely that every signal tower had originally featured layers of internal and external render. Conversely weather-proof slates were only identified at the signal towers at Inisheer and Inishmore Signal Stations in County Galway, and at Mullaghderg Hill Signal Station, County Donegal. At the County Galway sites, impressions of the slates could be seen in the external render where the slate themselves were missing. The absence of in-situ weather-proof slates or the impressions of weather-proof slates in areas of external render may indicate that the use of weather-proof slates did not extend into Counties Mayo, Sligo. The presence of weather-proof slates at Mullaghderg Hill Signal Station in County Donegal may relate to the secondary use of the site by the Coast Guard and may not indicate that the County Donegal Signal Stations originally utilized weather-proof slates.

Admiral Whitshed's archive of letters contain numerous additional details about the signal towers and the signal stations which proved very informative. In a letter from the architect John Berrell to John Hughes Esquire written in 1806, Berrell appears to indicate that the application of "plaster" to the exterior walls was trialled at Inisheer, Inishmore, and Golam Head Signal Stations, County Galway. This "rough damping" successfully halted the ingress of damp, and Berrell suggests its use should be extended to the external walls and back of the parapet at the other signal towers in County Galway (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). For Galway, at least, the render, and thus the weather-proof slates, were secondary features added shortly after the main construction work was completed, added to combat the penetration of damp.

In a letter dated 22 November 1805, from James Lecky to Thomas Soden, Lecky described a number of alterations he had made or planned to make at the signal towers at Carrowmably, Knocklane Hill, Streedagh, and Kilcologue Point in County Sligo. The letter mentions making various holes from the exterior of the signal towers to the interior;

> *"To make the houses defensible, a pike hole should be cut in the front door and window shutters, and as there is no aperture in the back of the house, loop holes should be made in each of the recesses in the officers rooms and guard room in which latter place should also be made small pipe holes from whence the dirty water and slops from the kitchen may be thrown out, as nothing will conduce more to the health of the people than cleanliness. A hole is also necessary in the back of the wall through which the water casks may be filled – it being very troublesome to procure water by the common entrance…"* (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden).

Some of the features described by Lecky closely match the chutes observed at the signal towers in Counties Mayo and Sligo, they are tentatively identified as secondary additions used to allow water and waste to either enter or leave the buildings.

Berrell identifies the semi-basement area as the hold. He describes it as containing water vessels (Section 4.2.2.3) and states that it was accessed via a step ladder (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806).

The ground-floor room is identified by Berrell as the "Privates Room", and therefore must have been equipped to sleep between 4 and 6 men (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). Lecky implies that a kitchen was also located on the ground-floor, an important detail not repeated elsewhere (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden). Berrell refers to the need to widen the "platform" in the Privates Room, *or* to provide "fixed bedstead proper," which seems to refer to split level mezzanine features and indicate that they were used as sleeping places for some of the privates (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806).

Kerrigan states that the first-floor contained a room for the Lieutenant and a passageway, from which the roof could be accessed via a ladder (Kerrigan 1995, 160). Kerrigan seems to have based this description on Wakefield's brief contemporary account (Section 3.4.4) (Wakefield 1812b, 830). Berrell mentions a fourth internal space, the "Midshipman's Birth" adjacent to the door, and also mentions that adding a privy to the roof level would be "inconvenient… as the passage to it would be through the apartment of the midshipman or second officer" (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). To create a passage next to the door the dividing wall between the passageway and the Lieutenants room would presumably have ran parallel to the front wall, but no traces of these walls were identified on the side walls at any of the signal towers, so it is not clear how far away from the front wall it was located. The red line on Figure 4.19 indicates a possible location of this dividing wall.

The use of rain-water capture systems has not been previously discussed in relation to the Irish signal stations. Such systems are known from other contemporary military buildings, such as the Martello tower on Trinidad constructed in 1801, and in later buildings which were part of the same tradition, such as the Brehon Tower, a late Martello tower constructed on Guernsey in 1854 (Clements 2011, 149-50 & 163-4). This longevity presumably reflects their effectiveness.

In a letter from November 1805, Lecky appears to describe these features;

> *"As wooden pipes are by no means fit to secure the water from the roof leaden pipes should be inserted – for in the Houses of Rathlee and Creevagh I have been obliged to get the wooden pipes taken down and replaced by leaden ones"* (NLI Mss 14, 118; letter dated 22 November 1805 from James Lecky to Thomas Soden).

In the same letter Lecky mentions filling "casks" inside the signal towers with water. Berrell's letter to Hughes mentions the presence of "water vessels" in the semi-basement level of the signal towers in County Galway (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). A letter from Alexander Stewart to Major General Affleck regarding the problems of water inundation of the semi-basement levels at signal towers in Counties Sligo and Donegal describes the geology at St John's Point being such that the common flooding problems are not present, but that "it is necessary to build a complete sewer for fear of the worst in raining weather overflowing of the water casks" (NLI Mss, 14, 918; letter dated 4 May 1805 from Alexander Stewart to Major General Affleck). In combination these letters strongly indicate that casks were held in the semi-basement level and filled with water gathered from the roof. In dry weather Lecky seems to imply that the casks were topped up with water brought from outside sources (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden). The distances from the County Galway Signal Stations to "good water" were stated in Berrell's letter, indicating that bringing water to the sites was a task that had to be taken into consideration (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806).

## 5.3.2 Enclosures

Within the main study area, 16 signal stations featured stone walled enclosures. Of these enclosed sites, 12 examples occurred at elevated and exposed positions, and four examples, Glash, and Creevagh Signal Stations, County Mayo, Rathlee Signal Station, County Sligo, and St John's Point Signal Station, County Donegal, occurred at low-lying positions. Of these low-lying sites, Glash Signal Station, County Mayo, and St John's Point Signal Station, County Donegal, feature visible traces of the enclosure, the presence of enclosures at the other two low-lying sites is only known from historical sources (Section 4.3; Table 4.2). From the remaining 16 sites in the main study area, 15 do not seem to have featured purpose-built enclosures, even though four of them were categorised as being exposed sites. The status of one site, Fanad Head Signal Station in County Donegal, is currently unknown, having been demolished around 1814, prior to it being recorded by the Ordnance Survey. The ratio of enclosed to unenclosed signal stations in the main study area is either 16:16 or 15:17, depending on whether an enclosure was present at Fanad Head Signal Station.

A contemporary letter indicates that the enclosures in County Galway were secondary additions added to the signal stations shortly after the signal towers, and that their principal role was to provide shelter from the weather in the vicinity of the signal towers, rather than being primarily defensive features (Section 4.3; NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). A different contemporary letter describes Creevagh Signal Station, County Mayo, and Rathlee Signal Station, County Sligo, as having enclosures mentions that they were enclosed because they were felt vulnerable to sabotage, but this seems to be specific to those two low-lying sites (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden). Because no visible traces of the enclosures survive at Creevagh or Rathlee Signal Stations it is not known how the enclosing elements were constructed. Whilst the defensive properties of a stout wall should not be underestimated[13] the enclosures do not seem to have been considered to have been potential temporary redoubts for use during another invasion. The plans to defend Ireland from further

[13] the pre-eminent example of the defensibility of a simple walled enclosure during the early 19th century is surely *Hougoumont Chateaux*, Belgium, which was besieged by Napoleon's forces during the Battle of Waterloo. The successful British defence of the enclosed residence throughout the day is considered one of the defining actions of the battle (Cornwell 2014, 158-64, 175-6, 207-9)

military invasions involved intercepting the foreign army somewhere in the Irish Midlands, as they marched towards Dublin (Sections 2.2.4 & 2.2.5). The signal towers were the primary defensive features of the signal stations, designed to protect the signal crew from local forces at the start of another uprising or invasion, and an invading force would have had no reason to attack the signal stations after they had transmitted the announcement of a landing; as an army marched inland they would have quickly become invisible to the signal stations and they would have been unable to provide further useful information (Sections 4.13.1 & 4.13.2). It is worth noting that the locally recruited Yeomanry were assigned the role of protecting the signal stations, rather than the signal stations being designated as having a role in protecting the Yeomanry, which would have been the case if the enclosures were intended to be used as temporary redoubts (NLI Mss 14 917; letter from Admiral Whitshed to Sir E.B. Littlehales).

If the enclosures were considered to be primarily defensive features their absence might make sense at some unenclosed sites, such as Inishturk Signal Station, County Mayo, where the remote and inaccessible island location would have obviated the need for a defensive enclosure, whilst at other sites natural features would have provided a defensive aspect, for example the tidal channel that must be crossed to access Golam Head Signal Station, County Galway. However, there are a number of sites without enclosures which appear to be in extremely vulnerable low-lying positions, in particular the signal stations at Lenadoon Point and Streedagh in County Sligo, which are easily accessible and would have been obvious candidates to receive defensive enclosures.

Several passages in the 1806 letter from John Berrell to John Hughes regarding the County Galway Signal Stations discuss adding enclosures to the signal stations;

> "*These bounds must (in all the cases that have hitherto occurred to me) be formed of stone walls – which are essentially necessary for forming some shelter from the severe weather in all these situations.*" (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806).

The letter strongly suggests that, for County Galway at least, the enclosures were secondary additions to the signal stations, and that their purpose was primarily to provide a wind break rather than a defensive perimeter. This suggestion would accord with the absence of the enclosure from the early illustrations of Malin Head Signal

Station, County Donegal, where later cartographic sources indicate that the site was enclosed (Figures 1.3, 5.3 – 5.5).

Of the 18 sites categorised as being in exposed positions, 14 featured enclosures. The four exposed signal station sites without enclosures, Bunowen Hill Signal Station, County Galway, Inishturk Signal Station, County Mayo, and Glen Head and Mullaghderg Hill Signal Stations, County Donegal, were all located in positions where enclosures could conceivably have been constructed, but three featured later activity in their immediate vicinity which may have led to the removal of the enclosure walls. The fourth site, Glen Head, was accessible via a well-constructed road which could have allowed for the stones from an enclosure wall to have been removed from the area (see Appendix entries A.55, B.57, D.73 and D.77 for details).

In most cases, exposed upland sites have an enclosure and low-lying sites do not feature enclosures. Four low-lying sites also featured enclosures, Glash and Creevagh Signal Stations, County Mayo, Rathlee Signal Station, County Sligo, and St John’s Point Signal Station, County Donegal. The latter site is located at the end of a long low-lying peninsula which protrudes much further out into Donegal Bay then the adjacent headlands and therefore might reasonably be considered to be an exposed position despite its low elevation. The specific reasons for the enclosure of two sites, Creevagh Signal Station, County Mayo, and Rathlee Signal Station, County Sligo, are discussed below. Omitting these four less exposed sites from consideration, the results of the field survey support the suggestion that the enclosures were secondary additions provided to the signal stations which were found to be particularly exposed to the weather, shortly after they were first occupied.

Berrell provided a small plan of his proposed enclosures, which largely accords with the large rectangular enclosures that were constructed throughout the main study area (Figure 5.1). Berrell’s enclosure has dimensions of 72 m by 23 m (235’ by 75’) meaning his enclosure is both narrower and longer than the recorded examples.

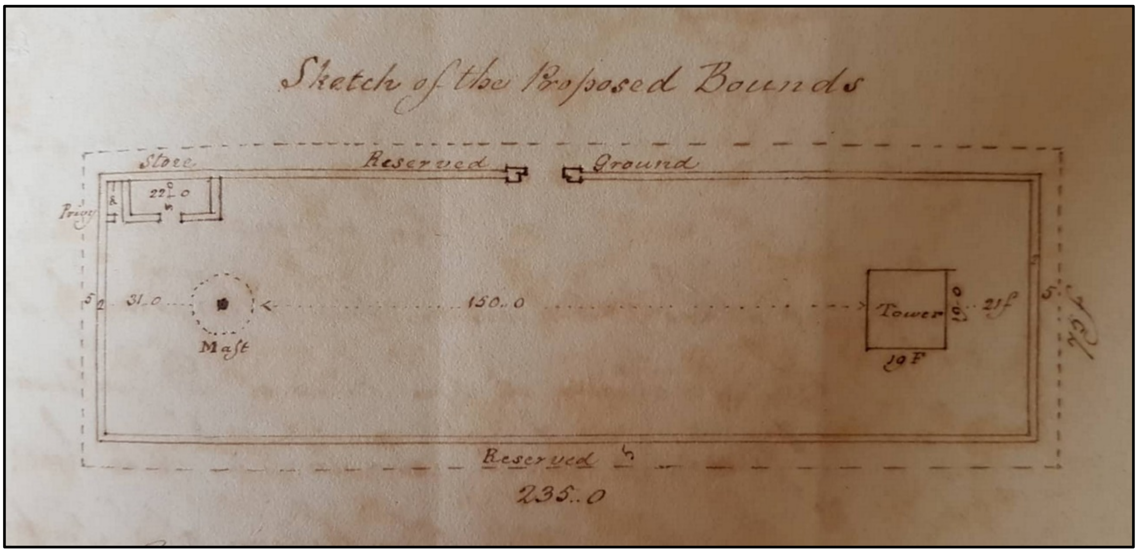

Figure 5.1. John Berrell's plan of his proposed enclosures to provide shelter at exposed signal stations. The storeroom and privy in the top left corner of the enclosure is discussed in Section 4.4.1 (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806).

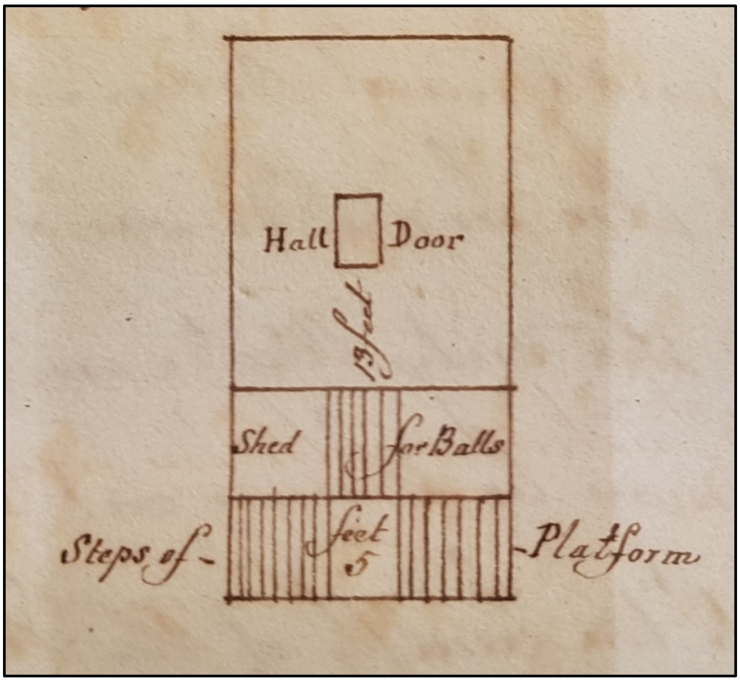

**Figure 5.2. Captain Lecky's plan of the enclosure he claims to have constructed at Creevagh Signal Station, County Mayo, and Rathlee Signal Station, County Sligo. The lower part of the illustrated enclosure appears to contain a shed for the signal balls and a 5' tall platform accessed via steps on which the signal mast may have been mounted (NLI Mss 14, 918; letter from James Lecky to Thomas Soden, dated 22 November 1805).**

Berrell's plan shows the position of the signal tower on the long axis, close to one end of the enclosure, the entrance at the midpoint along one of the long sides, the location of the mast on the long axis some distance from the signal tower, and the location of a small building in the corner of the enclosure, are all features which were observed with some regularity during the field surveys.

A more enigmatic drawing is included in Captain Lecky's letter to Soden (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden), describing the enclosures he claimed to have constructed at Creevagh Signal Station, County Mayo, and Rathlee Signal Station, County Sligo (Figure 5.2). In the accompanying letter Lecky describes providing a more secure storage for the signal balls and the plan appears to show a complex arrangement of a small shed and an elevated platform occupying one end of an enclosure, with the signal tower located on the central axis at the other end of the enclosure.

The enclosure drawn by Lecky lacks dimensions but its length to width ratio, and overall size, seem to more closely match the recorded enclosures than Berrell's longer and thinner design. Lecky describes the need for the enclosures as relating to possible sabotage of the signalling equipment, rather than for providing shelter from the elements, providing an explanation for why these two less exposed sites were selected for enclosure.  This rational may also apply to the low-lying enclosed signal stations at Glash, County Mayo, and St John's Point, County Donegal.

The association between the signal stations in the main study area and earlier fortifications, principally promontory forts, was described in Section 4.11. With the possible exception of Carrowmably Signal Station, County Sligo, which is located within a large prehistoric enclosure, none of the signal stations seems to have taken advantage of the pre-existing earthworks. It is currently unknown if any defensive value was ascribed to the large earthworks that encompass Carrowmably Signal Station. None of the signal stations in Leinster are known to be located within or in the vicinity of earlier fortifications. Only three of the signal stations in Munster have any association with earlier fortifications.  Island of Kane Signal Station, County Waterford, was located close to. But not within, the remains of a promontory fort (SMR WA026-036004-) (Appendix F.15). The promontory that makes up the Old Head of Kinsale, County Cork, features a series of defensive earthworks, and the remains of a tower house (SMR C0137-009001-) (Appendix F.25). The signal station is located to the north of these sites, although at a stretch it could be claimed to be 'behind' the ramparts. Finally, Hag's Head Signal Station, County Clare, is located within the remnants of a promontory fort (SMR CL014-010001-) (Appendix F.50). There are a very large number of promontory forts around the Irish coast, and the general avoidance of these sites reflects both the intention to position the sites for optimum intervisibility (Sections 4.13 & 5.7), and that old earthen defences designed to protect a coastal promontory from attacks from the inland direction did not offer anything of value to the designers of the signal stations.

### 5.3.3 Additional elements at the signal stations

Many of the enclosed and unenclosed signal stations in the main study area featured a small selection of other features, including external storage buildings and privies, lime kilns, and mounts for the signal masts (Section 4.4 & 4.5). The survival and visibility of these features varied from site to site, but examples of each were present in every county in the main study area, with the exception of visible mast mounts in County Galway, and visible mast mounts and contemporary storage buildings in County Sligo, although this is likely to be a factor of survivability and visibility.

Sir William Smith's illustrations of the signal stations at Malin Head and Fanad Head, County Donegal, are particularly important in this regard (Figures 1.3, 5.3 – 5.6; D.109. - D.115, D.129 - D.133) as they show small side gabled buildings adjacent to the signal mast, identified as barracks. The buildings are shown in images prior to the construction of the signal towers, and after their completion. The barrack buildings seemed to be clad in wooden boards and had two doors on one long wall, a window on at least one of the end walls, and a centrally located chimney projecting from the ridge line. The example at Malin Head had a shed roofed addition on one end wall. The remains of these building are not visible at the sites today and it is not known if they were set on timber or stone foundations, although the latter is a distinct possibility given the presence of low rectangular stone foundations at a number of other sites. In 1803 Whitshed twice mentions the potential use of sentry boxes to be used to house the men prior to the construction of proper accommodation, and these barrack buildings which clearly predated the construction of the signal towers may be a response to this idea (NLI Mss 14, 917; letter dated 6 November 1803 from Admiral Whitshed to William Wickham; NLI Mss 14, 917; letter dated 15 November 1803 from Admiral Whitshed to Lord Gardiner).

Four of the enclosed sites in the main study area featured traces of small rectangular buildings in one or more of the corners of the enclosures (Section 4.4.1) In terms of their plan, size, and position, these buildings bear a strong resemblance to a combined ball store and privy shown on Berrell's plan drawing (Figure 5.1) and mentioned in his letter to John Hughes;

> *The store for the balls and the privy should be placed in the angle most sheltered from the prevalent wind.*" (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806).

The example at Tower Hill Signal Station, County Mayo corresponds particularly well given that it was divided into two unequally sized rooms. The smaller room, adjacent to the corner of the enclosure, containing its own screened off entrance, could have been the privy, and the larger room to the north-east could have been the storeroom. The other examples of rectangular buildings located in the corners of the enclosures, Saddle Hill Signal Station, County Mayo, and Horn Head and Melmore Head Signal Stations, County Donegal, are likely to have been used for similar purposes. The 1st edition Ordnance Survey maps also shows a similar rectangular building in one of the corners of the enclosure at Glash Signal Station, County Mayo. Because the enclosures seem to have been additions to the signal stations, these buildings in the enclosure corners should also be considered additions, albeit ones that were added after only a short period of time had passed. Two of the unenclosed buildings have similarly sized rectangular buildings in their vicinities, Cleggan Hill Signal Station, County Galway, and Glen Head Signal Station, County Donegal. It has not yet been established that either of these buildings were contemporary elements of the signal stations, but the internal division of one of the two buildings at Glen Head Signal Station, County Donegal, is worth highlighting, especially given the small size of the smaller of the two rooms, which would have been suitably sized for use as a privy.

It would require excavation or geophysical investigation to determine if the six suspected examples of mast mounts have been correctly identified or if they had some other purpose, such as being small lime kilns (Section 4.5). The three examples in County Mayo and the example at Horn Head Signal Station, County Donegal, were all located along the long axis of their respective enclosures. This is the position that mast mounts are shown on Berrell's plan (Figure 5.1).

The association between the signal stations and small lime kilns has previously attracted little comment. Five of the sites in the main study area featured probable lime kilns and three signal stations in County Galway have lime kilns shown on the 1st edition maps which are no longer visible. In addition if some of the possible mast mounts were excavated they might be found to be infilled lime kilns. Although only approximately

25% of the sites in the main study area are associated with lime kilns, the utility of such structures during the construction process is clear, and the potential for many more of the sites to have also featured lime kilns would appear to be high.

## 5.3.4 Roads

Very few of the signal stations in the main study area seem to have been serviced by purpose-built roads, although a small number in more populated areas seem to have been accessed via existing roads. O'Sullivan and Downey's statement that "roads were an essential infrastructural element of signal stations" may have over emphasised their importance, at least in Connacht and Ulster (O'Sullivan & Downey 2012, 48). Similarly, Rynne's insistence that well engineered roads were an essential element of the signal stations may only reflect the situation in parts of Munster (Rynne 2006, 445).

A contemporary letter describes the County Galway Signal Stations as being accessed via boat, and this also seems to be the case for St John's Point Signal Station, County Donegal, which was located in an area only served by a small dock until the mid-19th century (Section 4.6).

Berrell notes that there was no road running to the signal tower on Inisheer, only a horse track running part of the way from the landing place, with the remaining two thirds of the journey being "over and among rocks, winding to the summit," clearly indicating the road was a later addition (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). Similarly, Berrell notes the absence of a road leading to the signal station on Inishmore, "At the village a confined horse way commences which is very rough, being partly rock, with many spots of bog – For the distance of about 1 ¼ miles…" (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). Wall building on the Aran Islands is believed to have peaked between 1839 and 1899, and Berrell's comments imply that the areas around the signal towers were not enclosed during the operational period of the signal stations (Whelan 2011a, 134).

Describing the rest of the County Galway Signal Stations, Berrell mentions either a total absence of roads (Golam Head and Cuileen Hill Signal Stations), or the presence of rough tracks and horse ways for only part of the journey (Bunowen Hill and Cleggan Hill Signal Stations). In all instances he refers to approaching the signal stations from "the usual landing places" suggesting that, for County Galway at least, travel to the active signal stations was largely by sea (NLI Mss 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806).

### 5.3.5 Signal Stations in Leinster

The poor survival of the eight purpose-built signal stations in Leinster severely limits the scope for any discussion (Table 4.4). The sole surviving signal tower in Leinster, at Dalkey Signal Station, County Dublin, has been heavily modified. Without having performed a detailed on-site examination of both the exterior and interior of the signal tower it is impossible to establish whether it is a modified example of the standard design, or if it was a variant form. Dalkey Signal Station, County Dublin, is shown as having an enclosure on the 1st edition Ordnance Survey Map (surveyed 1843), and the 2nd edition Ordnance Survey Map, surveyed 1871-1875, shows that the enclosure had been substantially expanded at some point in the mid-19th Century. The expanded enclosure is still present. The original enclosure was not rectangular, having a staggered side along the south-east side. By the time the 1st edition Ordnance Survey map was recorded the north-west side was defined by a cliff that marked the edge of Dalkey Quarry, but it is unclear if this cliff edge had encroached upon the enclosure after it was built, or if the enclosure originally utilised the cliff edge. Mizen Head Signal Station, County Wicklow, is shown as unenclosed on the 1st Edition Ordnance Survey map, surveyed 1838. Neither Dalkey Signal Station or Mizen Head Signal Station are shown on the 1st edition Ordnance Survey maps as being associated with additional buildings or structures, such as lime kilns, store buildings, or privies. The south-west side of the Dalkey Signal Station is connected to a road which leads to a carpark on the west side of Dalkey Hill. The road is not shown on any of the early Ordnance Survey maps, and must be a 20th century addition. The 1st edition Ordnance Survey map shows a road terminating approximately 200 m to the south-east of the signal station. The road runs off to the south, following the coast around until it turns north-west to run into Killiney. It is not known if the road was present when the signal station was operative. The site of Mizen Head Signal Station, County Wicklow, is not currently connected to a road, and none of the early Ordnance Survey maps show a road connecting to the site. Five signal stations in Leinster were established at existing facilities or newly constructed Martello towers. Of these sites, Fort Point Martello Tower, County Wexford, has been lost to coastal erosion, and Pigeon House Signal Station, County Dublin, has been heavily modified during the development of Dublin Port. The remaining sites are largely intact.

No physical components of these sites that can be directly related to the signal stations has been identified.

### 5.3.6 Signal Stations in Munster

The survivability of the sites in Munster was much higher than in Leinster, and a more detailed desk-based assessment was possible in that province (Table 4.5). Only one of the sites in Munster, Fort Davis Signal Station, County Cork, was established at an existing facility. As with the signal stations established at existing sites in Leinster, no features at Fort Davis could be directly related to the presence of the signal crews or the signal mast. Of the 35 purpose-built signal stations in Munster, ten (29%) had been entirely removed, leaving 25 examples available for examination. Based on an examination of their exterior features, signal towers utilising the standard design were identified at 21 (60%) of these sites, with only minor variations being noted. One site, Ardmore Signal Station, County Waterford, featured a heavily modified tower which might not have been of the standard design, although its original form was obscured by the alterations. Two sites, Robert's Head and Mizen Head Signal Stations, County Cork, featured large three-storey towers which may have been alternate signal tower designs, heavily modified standard design signal towers, or later replacements for the original signal towers. At a fourth site, Sybil Head Signal Station, County Kerry, the original signal tower had either been modified to the extent that its form was no longer recognisable, or it had been demolished and replaced (Section 4.12.2). Four enclosed barracks that were later additions to the signal station system were also located in Munster (Section 4.12.3). Two of these sites survived in good condition, one had largely collapsed, and one had been demolished (Section 4.12.3).

Without detailed field study, the interior features of most of the surviving signal towers in the secondary study area could not be assessed, and it is not known if the level of similarity demonstrated by the exteriors was repeated in the interiors of the signal towers. The interior features of the signal tower at the Old Head of Kinsale Signal Station, County Cork, (recorded prior to the tower's restoration in 2012) were similar to those recorded in the main study area, although the ground-floor alcoves continued above the height of the split mezzanine level, the first-floor alcoves extended from floor to ceiling, and there was no attic level (Hurley and Rynne 2012, 16-22; Appendix F.25). The interior face of the rear wall of the signal tower at Ballydavid Head Signal Station rear wall (seen in UAV-acquired imagery) featured the familiar pattern of alcoves flanking fireplaces on both floors, although the alcoves again extended through the full height of each floor (Appendix F.44).

It was not possible to determine how many of the five purpose-built signal stations in County Waterford that were lost to demolition or coastal erosion had been enclosed sites, and how many had been unenclosed sites (Section 4.12.2). There is no evidence of an enclosure at the sole surviving example in County Waterford, Ardmore Signal Station, in either aerial photographs of the site, or on the early Ordnance Survey maps.

All of the purpose-built signal stations in County Cork featured enclosures. Thirteen of the signal stations in County Cork featured distinctive enclosures with narrow rectangular forms that had an expanded end facing towards the sea. These enclosures had often been heavily modified, but their original forms were captured on a series of contemporary plans (Kerrigan 1995, 158; Kerrigan 2003, 38; Clements 2013, Figure 7.22; Section 4.12.2). Only two of the purpose-built sites in County Cork, Black Ball Head and Old Head of Kinsale Signal Stations, featured rectangular enclosures resembling those found in the main study area, although the latter site had a unique semi-circular protrusion on its seaward side. Two sites, Knockadoon and Ballynacotter Signal Stations, had smaller rectangular enclosures. Seven Heads Signal Station had a small square enclosure with a semi-circular enclosure extending from the seaward wall. The universal use of enclosures at the signal stations in County Cork is strikingly different to the situation in the main study area, where either 50% or 53% of the signal stations were enclosed, depending on whether Fanad Head Signal Station, County Donegal, was enclosed or not (Section 4.3). It is interesting that Hamilton’s plans of the sites which show the enclosures seem to date exclusively from 1806, the same year that enclosures were being added to sites in Counties Galway, Mayo, and Sligo (Section 5.3.2). This may imply that the enclosures at the County Cork Signal Stations were also secondary additions, although this suggestion needs to be investigated further.

County Kerry has a ratio of 5:1 enclosed to unenclosed signal stations. This ratio is more similar to the ratio recorded in County Cork, than the ratio recorded within the main study area (Section 5.3.2). Rectangular enclosures resembling those found in the main study area were identified at Bray Head, Sybil Head, and Ballydavid Head Signal Stations, in County Kerry. The irregular enclosures at Great Blasket and Kerry Head Signal Stations, County Kerry, appear to have been subject to repeated modification. The original form of those enclosures is uncertain, and it is not known if they were parts of the original design of the signal stations, or if they were secondary additions. Bolus Head Signal Station was the only signal station in County Kerry that did not feature an enclosure. It is not known if the enclosures at the County Kerry signal stations were original features, or if they were secondary additions. If the enclosures were secondary additions then the construction of the Bolus Head Enclosed Barrack site so close to Bolus Head Signal Station may have negated the need to add an enclosure to the original site, depending on when the enclosed barracks was constructed (Section 5.2).

In County Clare, rectangular enclosures were used at Loop Head Signal Station, Ballard Signal Station, and Mutton Island Signal Station (Section 4.12.2). It is not known if these enclosures were parts of the original design of the signal stations, or if they were secondary additions. The remaining two sites appear to have been unenclosed. County Clare has a ratio of enclosed to unenclosed signal stations of 3:2. This ratio is similar to the ratio recorded within the main study area (Section 5.3.2).

It is not known if any of the signal stations in Munster featured lime kilns, although the early Ordnance Survey maps identify lime kilns in the general vicinity of Robert's Head Signal Station, County Cork, and Loop Head Signal Station, County Clare (Appendices F.23 & F.46). Signal mast mounts were identified at two sites, Bere Island Signal Station, County Cork, and Great Blasket Signal Station, County Kerry, and a possible signal mast mount was also located at Sybil Head Signal Station, County Kerry (Appendices F.36, F.42 & F.43). Several of the signal stations in Munster were depicted on the 1st edition Ordnance Survey maps as being associated with small rectangular buildings that may be stores or privies; Ballynacotter, Seven Heads, Glandore, Ballylinchy Point, Mizen Head, Black Ball Head, Dursey Island Signal Stations, County Cork, Ballydavid Head Signal Station, County Kerry, Ballard, and Mutton Island Signal Stations, County Clare. However, given the amount of later re-use that occurred at the Munster Signal Stations these cartographic identifications must be treated with caution. John Hampton's 1806 site plans of the County Cork Signal Stations show that most of the signal stations featured rectangular buildings adjacent to, and in line with, the signal towers, although it is currently unclear how many of these original buildings are the same buildings that were later recorded on the early Ordnance Survey maps, or whether these are the same additions that are present at some sites today (Kerrigan 2003, 38).

John Hampton’s 1806 plans of the 18 purpose-built signal stations in Cork indicate that each site was intended to be connected to the local road network, but that at the point when he surveyed the sites this had yet to occur at six of the sites; the roads at Mizen Head and Sheep’s Head Signal Stations were not completed at the time of his 1806 surveys, and the roads at Brow Head, Bere Island, Black Ball Head, and Dursey Island Signal Stations were marked out but had not yet been laid (Kerrigan 2003, 38).

Wakefield’s 1808 account mentions the absence of a road connecting to Kerry Head Signal Station, County Kerry (Wakefield 1812b, 830) A road is shown as connecting to the site on the 1st edition Ordnance Survey map, surveyed 1841-1842, suggesting the road was built several years after the signal station, at the very earliest, exemplifying the problem of assuming a road shown on the 1st edition Ordnance Survey maps was present during the occupation of a signal station. The 1st edition Ordnance Survey maps show that by the mid-19th century all but one of the Munster signal stations were either connected to the local road network, or were located close to a part of it.

## 5.4 Research Question 4. What happened to each site following its abandonment?

It has been more than 200 years since the orders were issued that led to the abandonment of the Irish signal stations. In the intervening years the sites have variously been subject to neglect, decay, demolition, and, in some instances, re-use. The patterns of post-abandonment both complex and poorly understood. In addition, the patterns of post-abandonment activity exhibit considerable regional variation.

### 5.4.1 Decay and re-use of the Irish Signal Stations

Many of the signal station sites were permanently abandoned following the initial orders of abandonment in 1809, or the final decommissioning of the system in 1815. These abandoned sites were either cleared in the decades following their abandonment or left to slowly decay. Some sites were lost to coastal erosion, and some sites were subject to stone robbing after their buildings collapsed. The sites chosen for the signal stations offered extensive views of the adjacent coast, and this quality saw numerous sites being re-used for other maritime related purposes. At some sites this may have involved simply repairing the existing buildings and structures to allow for their re-use. At others, the existing buildings and structures were adapted, or new buildings and structures were added to the sites. It was not possible to fully understand the later periods of activities at the sites during this project, but some useful information was recorded during the surveys and uncovered through subsequent research. A strong pattern of regional variation was identified regarding the post-abandonment activity at the signal station sites, summarised below.

Of the 20 purpose-built signal stations in Connacht only three sites, Bunowen Hill Signal Station, County Donegal, Creevagh Signal Station, County Mayo, and Kilcologue Point Signal Station, County Sligo, have been entirely cleared, and none of the sites have been lost to coastal erosion. Cuileen Hill Signal Station, County Galway, Benwee Head Signal Station, County Mayo, and Knocklane Hill and Streedagh Signal Stations, County Galway, have been reduced to low ruins and large quantities of stones have been removed from the sites for re-use. Slievemore and Glinsk Signal Stations in County Mayo are low ruins, but the collapsed stone remains in situ. The remaining 13 sites feature either partially collapsed signal towers, or largely intact signal towers and have not been subject to stone removal. Inishmore Signal Station, County Galway, was converted into a lighthouse in the early 19th century. Inisheer Signal Station, County Galway was re-used as the site of a 19th century schoolhouse, the only recorded example of non-maritime related re-use in the main study area. During World War 2 LOPs were constructed in the immediate vicinity of Bunowen Hill Signal Station, County Galway, and Rathlee Signal Station, County Mayo.

Of the 12 purpose-built signal stations in Ulster two sites, Bloody Foreland Signal Station and Fanad Head Signal Station, County Donegal, have been cleared. The signal tower at St John’s Point Signal Station, County Donegal, has been cleared, but the associated enclosure is still in situ, although in poor condition. None of the sites in Donegal appear to have been lost through coastal erosion, although the final surviving parts of Dawros Head Signal Station, County Donegal, are likely to be lost to coastal erosion in the near future, and most of the stone from the site has likely already been removed by the sea. The remaining sites feature either partially collapsed signal towers, or largely intact signal towers and have not been subject to stone removal. A lighthouse was constructed close to St John’s Point Signal Sation, and a lighthouse was constructed over the position of the cleared Fanad Head Signal Station, County Donegal. A coast guard station was established adjacent to Mullaghderg Hill Signal Station, County Donegal, although it is not clear if any of the elements of the signal station were re-used. The signal tower at Malin Beg Signal Station, County Donegal, was reconfigured at some point in the 19th century. It is unclear when these modifications occurred, but it is possible that they could relate to the use of the site by the coast guard. Malin Head Signal Station, County Donegal, was renovated in the late 19th century and was used for a variety of communications purposes into the 20th century. During World War 2 LOPs were constructed in the immediate vicinity of Carrigan Head and Malin Head Signal Stations, County Donegal.

Of the eight purpose-built signal stations in Leinster, only one of the sites has any visible remains, Dalkey Signal Station, County Dublin. The signal tower at Dalkey Signal Station has been heavily modified and the enclosure is no longer in its original configuration. Two of the sites, Mizen Head Signal Station, County Wicklow, and Hill Castle Signal Station, County Wexford, have been deliberately cleared. The exact location of the remaining five purpose-built signal stations could not be established, and these sites have either been deliberately cleared or lost to coastal erosion (Section 4.12.1). The remaining five signal stations in Leinster were established at existing facilities or newly constructed Martello towers. Of these, Fort Point Martello Tower, County Wexford, has been lost to coastal erosion, and the remaining four sites survive. Pigeon House Fort in County Dublin has been heavily affected by the ongoing development of the Dublin Port. The lighthouse at Wicklow Head, County Wicklow, where a signal station was established still stands, but it was rendered obsolete in the 1820s when a second lighthouse was added to the site. Baginbun Martello Tower, County Wexford, where a signal station was established still stands, but it has been converted into a residence. The lighthouse at Hook Head, County Wicklow, where a signal station was established still stands, but it has undergone several periods of modification, addition, and renovation since the signal station was abandoned. During World War 2 an LOP was constructed at Hook Head Lighthouse.

Of the 35 purpose-built signal stations in Munster, nine sites have been either deliberately cleared or lost to coastal erosion, Brownstone Head, Island of Kane, Bunmahon Head, Ballyvoyle Head, and Ballynamona Signal Stations in County Waterford, Barry's Head and Glandore Head Siganal Stations in County Cork, and Kerry Head and Knocknagharoon Hill Signal Stations in County Kerry. Only one of these sites, Glandore Signal Station, County Cork, has been constructed over. At Loop Head Signal Station, the site has been demolished and the stone has been removed but both the position of the signal tower and the outline of the enclosure can still be identified as disturbances. Of the 25 purpose-built signal stations in Munster where parts of the signal stations survived, 17 had been subject to modification (69%), including the construction of small additions, conversion into residences, or through the construction of additional buildings in the immediate vicinity of the signal towers (Section 4.12.2). Cape Clear Signal Station, County Cork, was converted into a lighthouse in 1818, one year later than the first lighthouse replaced the signal station at Fanad Head, County Donegal, and just a few years before Inishmore Signal Station, County Glaway, was converted into a lighthouse and the second lighthouse was constructed at Wicklow Head, County Wicklow.

The modifications to the signal station sites in Munster seem to have mostly occurred during the 19th century, although there were some important exceptions; Brow Head Signal Station, County Cork, was converted into a coast guard station in the late 19th century, but a Marconi signal station was added to the site in 1901, and in 1917 the site was being used as a Lloyds signalling station (Hydrographic Office 1917, 54; Appendix F.33); two sites in County Kerry, Bray Head and Sybil Head Signal Stations, were re-used by the Royal Navy during World War 1, leading to the renovation of the signal tower at Bray Head Signal Station, and the modification or replacement of the signal tower at Sybil Head Signal Station (Appendices F.41 & F.43); Ballynacotter and Leamcon Signal Stations, County Cork, were incorporated into mid to late 20th century residences, and a late 20th century residence was constructed over the site of Glandore Signal Station, County Cork, although the site was cleared in the early 20th century (Appendices F.21, F28, & F.32). During World War 2 LOPs were constructed in the immediate vicinity of Brownstone Head Signal Station, County Waterford, Knockadoon, Toe Head, Ballylinchy Point, Mizen Head Signal Stations, County Cork, and Hag's Head Signal Station, County Clare. The only signal station in Munster that was established at an existing facility was the station at the still well well-preserved Fort Davis, on the eastern side of Cork harbour. Of the four enclosed barracks in County Kerry, two sites are largely intact, Hog's Head and Bolus Head Enclosed Barracks. Brandon Heights Enclosed Barracks is in a very collapsed state, but it does not seem to have had been subject to stone removal. The fourth site, Rough Point Enclosed Barracks, has been cleared and the site has been built over.

A major distinction between the signal stations in the secondary study area and those in the main study area was the increased level of clearance and loss through coastal erosion. In the main study area, 13% of the purpose-built signal stations had been entirely lost through demolition and clearance (Section 4.12.1), far lower than the corresponding rates of loss in Leinster (88%), and Munster (29%) (Sections 4.12.1 & 4.12.2). The differences in the levels of loss through coastal erosion, and demolition, and of the levels of intensive modification between the main study area and the secondary study area might relate to differences in topography, environment, and population density. In addition, there were two specific differences regarding how the coastal areas in the main study area and the secondary study area were utilised that required examination.

The topography of the coastal regions in both the main study area and the secondary study area is broadly similar. The coastal zones of Counties Wicklow, Cork, Kerry, Clare, Galway, Mayo, and Donegal largely consist of narrow coastal strips backed by low hills, with mountains located a little further inland. There is some variation, with parts of eastern Cork, northern Kerry, southern Clare, and north-western Mayo having less elevated ground (Aalen 2011b, Figure 5; O'Sullivan & Breen 2007, 16-7). The coastal zones of Counties Dublin, Wexford, Waterford and Sligo are generally at lower elevations, and any higher ground is noticeably further inland (Aalen 2011b, Figure 5).

The lower elevations of the coastal regions of Leinster and the eastern part of Munster necessitated the placement of signal stations on cliff edges and promontories in order to achieve inter-visibility. This may have made the sites more vulnerable to coastal erosion. It is unclear how many signal stations were actually lost to coastal erosion, which has only been confirmed for the signal station located at the Fort Point Martello Tower, County Wexford, and at the purpose-built Island of Kane Signal Station, County Waterford, where the signal station seems to have been cleared prior to the site being lost to coastal erosion (Section 4.12.1).

A common method of delineating the environmental zones across Ireland is to divide the country into three zones, with a drier region to the east, a damper area in the centre with large areas of raised bog, and a wetter Atlantic margin, characterised by large areas of blanket bog (Aalen 2011b, Figure 30). The coast of Leinster and the eastern parts of the coast of Munster lie in the drier and more fertile eastern zone, whilst the rest of the secondary study area, and the whole of the main study area, are firmly within the wetter Atlantic margin. This Atlantic margin is not homogenous, and the areas of blanket bogs are more extensive in Connacht and Ulster, in comparison to the western parts of Munster (Tomlinson 2011, Figure 2). It is noticeable that the counties where site loss is greatest lie within the drier eastern region of the country, but obviously lower rainfall levels and different vegetation types cannot be directly responsible for the loss of sites in the east and south-east.

Dr Alan Ferinhough has produced a series of population density maps of Ireland in ten-year intervals between 1841 and 2002. The maps demonstrate that the coastal zones, even in the low population counties of the west, generally supported much higher population densities than the inland areas (McGreevy 2019). Between 1841 and 1961, it is only the extremely marginal areas of the coast, the far west parts of Counties Cork and Kerry, the islands and north-west coast of County Mayo, and the southern part of the west coast of County Donegal, that illustrate dramatically lower population densities in comparison to the coastal zones in Leinster and the eastern part of Munster (Whelan 2011c, Figure 43; McGreevy 2019). After 1961 there is a much clearer differential in population density between the western coastal areas, which became depopulated, and their eastern equivalents. This well-known demographic shift happened long after most of the signal station sites were modified or lost (Whelan 2011a, 119 – 122; Sections 4.12). Again, population levels alone cannot explain the high loss of sites around the east and south-east coasts.

One crucial difference in the landscapes around the coast is the degree to which the land adjacent to the signal stations has been enclosed and improved. Of the 29 purpose-built signal stations in the secondary study area with known locations, a total of 21 (72%) were located within or immediately adjacent to enclosed and improved land, as depicted on the 1st edition Ordnance Survey map: all three of the purpose-built signal stations in Leinster, fifteen of the eighteen in County Cork, three of the six in County Kerry, and three of the five in County Clare. Interestingly this figure had not changed by the time the 3rd edition Ordnance Survey maps were prepared. This contrasts sharply with the main study area. Of the 32 purpose-built signal stations in the main study are, a total of 10 (31%) were located within or immediately adjacent to enclosed and improved land, as depicted on the 1st edition Ordnance Survey map: three of the six signal stations in County Galway, two of the eight in County Mayo, four of the six in County Sligo, and two of the twelve in County Donegal. By the time the 3rd editions of the Ordnance Survey maps had been prepared this figure had changed slightly, with 14 of the 32 signal stations (44%) being located within or immediately adjacent to enclosed and improved land.

Given these figures it becomes very clear that there was simply more intensive activity taking place in the areas adjacent to the signal towers in the secondary study area than was found in the areas adjacent to the signal towers in the main study area. This higher level of adjacent activity is thought to have had a strong influence over the rates at which the signal stations were subject to modification, demolition, and clearance. The level of activity adjacent to the signal stations in the secondary study area reflects the more amenable topography and climate that allowed local populations to undertake more intensive farming and other activities in the areas around the signal stations. In contrast, the signal stations in the main study area were typically located within open bog, only used for grazing livestock and peat extraction, where the signal stations were left to slowly decay and collapse in-situ.

Two additional factors which appear to be relevant to the higher levels of site modification along the southern coast have been identified. The first factor was the presence of the large Royal Naval base at Cork Harbour, which did not have an equivalent elsewhere in either of the study areas. The second factor was the presence of a major transatlantic shipping lane running past the southern coast of Ireland, which again did not have an equivalent elsewhere in either of the study areas.

Cork Harbour was home to the British South Atlantic Fleet until 1938 (Foster 1998, 554). The presence of such a large Royal Navy presence may have been responsible in some fashion for the re-use and modification of so many of the abandoned signal stations along the adjacent stretches of the coast. Identified periods during which the modifications may have taken place include: during the War of 1812 (Section 2.3.1); following the establishment of the coast guard in 1820; following the takeover of the coast guard by the British Admiralty in 1856; during World War 1 (Clements 2013, 102; Mayne 2017, 275-6). It certainly seems clear that the modifications to the signal towers at Bray Head and Sybil Head, County Kerry, date to their use as Naval War Signal Stations during World War 1. Clements states that alongside these two sites, the signal stations at Galley Head, Mizen Head, and Black Ball Head, County Cork, and Loop Head, County Clare, were also used as Naval War Signal Stations (Clements 2013, 102). Further research is required regarding these additional sites named by Clements. Galley Head, Mizen Head, and Loop Head all featured operational lighthouses during that time period, and the lighthouses may have been utilised, rather than the abandoned signal towers.

The important transatlantic mercantile shipping route along the southern coast of Ireland was initially developed between 1730 and 1780, and its importance continued well into the 20th century (Foster 1998, 202-4; Rynne 2006, 389-90). Cork Harbour and Waterford Harbour were the most important ports along the southern coast and saw the largest programs of improvement and modernisation throughout the 19th century (Rynne 2006, 390–404). To facilitate the safe travel of ships along the coast a tremendous number of navigation aids were added to the coast, with advancements in technology being rapidly adapted. A 1917 pilots guide to the Irish coast (published by the American Hydrographic Office under the authority of the Secretary of the Navy) reflects the importance of this route, listing the details of the coast between Mizen Head, County Cork, and Carnsore Point, County Wexford, prior to describing the rest of the coast of Ireland (Hydrographic Office 1917). The number of facilities to aid with shipping listed along this stretch of coast in the 1917 guide is extremely impressive. The southern coast featured lighthouses, fog signals, explosive signals, Lloyd's signal stations, Radiotelegraph stations, beacons, coast guards, rocket apparatus, life-saving apparatus, daymarks, clearing marks, buoys, and storm signals (Hydrographic Office 1917). The scale of shipping related activity along the coast is readily apparent, and 19th and 20th century shipping related activity could account for the modifications recorded at some of the signal stations sites. This is explicitly confirmed for one site, Brow Head Signal Station, County Cork, where the 1917 pilots guide states there was a Lloyd's signal station with signal flags and lamps, and a radiotelegraph operated by the General Post Office (Hydrographic Office 1917, 54). It is not currently known where these services were located. Whilst the old coast guard station and the abandoned Marconi station are the most likely candidates, it is possible that the signal tower was re-used in the same way that the signal tower at Malin Head, County Donegal, was re-used.

## 5.4.2 Lighthouses

One class of monument which occasionally occur in proximity to the signal stations, but which more frequently share the same general location in the landscape, are lighthouses. The oldest extant (and operational) lighthouse in Ireland is located on Hook Head, County Wexford (this site was utilised as a signal station; see Appendix E.13). Hook Head lighthouse was originally constructed in the early 13th century, some decades after the construction of the first lighthouse in Ireland, purported to be the late 12th century example at Youghal, County Cork, which was demolished in the 18th century (O'Sullivan & Downey 2013, 26). Simple 'cottage' style lighthouses were in use at a number of locations in the 16th and 17th centuries (O'Sullivan & Downey 2013, 28). An example was located close to the signal station site at the Old Head of Kinsale, County Cork (see Appendix F.25), which was constructed at the direction of Sir Thomas Reading who acquired a letter patent to construct a number of lighthouses in 1665. A later cottage lighthouse (CO137-001002-) on the Old Head of Kinsale survives in good condition. It is believed to be a replacement dating to the 18th century, whilst the adjacent ruin of a circular lighthouse (CO137-001003-) dates to 1805 (Rynne 2006, 405) and is therefore contemporary to the construction of the signal stations. The archetypal tall cylindrical lighthouse design originated in the 18th century, but they were constructed in the greatest quantity in the mid-19th century (Bathurst 1999; Rynne 2006, 407-410; O'Sullivan & Breen 2007, 233-4). It is this type most frequently associated with signal station locations. The still operational lighthouse at the southern tip of the Old Head of Kinsale (Reg. No. 20913710) is of this cylindrical design and was constructed in 1855.

In the main study area, there is a tendency for lighthouses to be located on small offshore islands, therefore avoiding the specific locations utilised by the signal stations. This arrangement is seen at Straw Island, Rock Island (located to the east and west of Inishmore, respectively), and Leap Island, County Galway, Inishgort, Achill Beg, Black Rock and Eagle Island, County Mayo, Blackrock and Oyster Island, County Sligo, and Rotten Island, Rathlin O'Birne, Ballagh Rocks, and Inishtrahull, County Donegal. Two of the lighthouses in County Donegal are located on larger islands, Arranmore and Tory Island, neither of which featured signal stations. The function of these lighthouses is clearly to mark the position of these islands and rocks which would have been a danger to shipping, and so their siting follows a quite different logic to that used to decide the location of the signal stations. The remaining lighthouses in Connacht and Ulster are located on dangerous headlands, Fardurris Point on Inisheer, County Galway, Blacksod and Broadhaven, County Mayo, and Dunree and Inishowen, County Donegal. Again, the logic behind their siting is different to that used to locate the signal stations. Given the position of the signal stations were selected specifically to provide expansive views it is unsurprising that most, but not all, of these lighthouses are visible from the nearest signal station locations. The only examples where the lighthouses are not visible from the nearest signal stations are those on Clare Island and Achill Beg in County Mayo where tall hills obstruct the view.

### 5.4.3 Look Out Posts

A second class of monument which occasionally occur in proximity to the signal stations, but which more frequently share the same general location in the landscape, are the World War 2 era Look Out Posts (LOPs). At least three of the Look Out Posts appear to have utilised early 20th century coast guard watch houses. It is noticeable that the total number of sites believed to be necessary to provide an adequate watch over the coast was found to be similar for both systems; 81 signal stations and 83 Look Out Posts (LOPs). The Look Out Post (LOP) system extended north from Dublin as far as Ballagan Point on the south-east tip of the Cooley Peninsula, and extended to the east of Malin Head, with sites located at Glengad Head, and Inishowen Head, which appears to have used an existing coast guard watch house. This means the Look Out Posts were slightly more spaced out than the signal stations, and this may reflect a functional difference between the two systems, in that the Look Out Posts (LOPs) did not have a requirement for intervisibility.

In the main study area five signal stations had Look Out Posts (LOPs) constructed in their immediate vicinity (16%). These sites were clearly re-used because they provided an expansive view of the adjacent area of the coast, and potentially because there was some value in the existing infrastructure.

Seven or eight signal stations (25%) had Look Out Posts (LOPs) located less than 2km (1.2 miles) away, depending on where the Look Out Post on Inishmore, County Galway, was actually located (Section 4.9). The Look Out Post (LOP) at Fanad Head, County Donegal, reused an early 20th Century coast guard watch house, negating the need for a new 137 block building. The watch house was located less than 2km away from the site where the Fanad Head Signal Station had been located. These locations were selected to observe the same areas of the coast that had been observed by the earlier signal stations, and the decision to choose a different specific location may have resulted from a number of considerations. The lack of a requirement for the Look Out Posts (LOP) to be intervisible may have allowed for sites with slightly better views of the coast to be selected. The Look Out Posts (LOPs) also did not require as much area for construction, and they needed smaller quantities of building materials, which may have allowed them to be sited in locations found unsuitable for the earlier signal station construction.

Twelve signal stations in the main study area have Look Out Posts (LOPs) located in the same area of the coast, within a range of between 2km and 7 km (1.2 and 4.4 miles). These sites did not observe the exact same part of the coast as the signal stations, and may not have had any overlap with the viewsheds available from the nearest signal station. This was certainly the case on Achill Island, where the re-used coast guard watch house (LOP 59) looked out to the north-west, west, and south, but the signal station observed the coast to the north and south and the view to the west was blocked by a mountain (Section 4.13.1). Seven of the signal station sites in the main study area did not have a Look Out Post (LOP) positioned within 7 km (4.4 miles) of them. Three of those signal stations were located on offshore islands (Inisheer Signal Station in County Galway, Inishturk and Clare Island Signal Stations in County Mayo) and these locations may have been avoided by the Coast Watch Service because the Look Out Posts were connected to G2 (Irish Military Intelligence) in the Curragh, County Kildare, by telephone lines (Kennedy 2008, 42-8). Whilst L.O.P. 51 was established on Lettertmullan Island, County Galway, and L.O.P. 75 was established on Arranmore Island, County Donegal, those islands were much closer to the mainland and it may have been possible to provide telephone connections to those sites. The four signal stations on the mainland that were not associated with Look Out Posts, Glinsk Signal Station, County Mayo, Streedagh Signal Station, County Sligo, and Mullaghderg Hill Signal Station, County Donegal, may simply not have offered a useful observation point in the mid-20th century when continuous inter-visibility between sites was not a requirement.

The two pre-existing coast guard watch houses in the main study area which were re-used as Look Out Posts (LOPs), Moyteogue Head on Achill Island, County Mayo, and Fanad Head, County Donegal, had an overall similarity to the later 137 block buildings (Figures 4.51 & 4.52). They were slightly larger and had more complex plans featuring multiple rooms. The key design elements, single-storey flat roofed buildings with a bay window facing out to sea, are so similar that it is possible that this building type provided some inspiration for the later design. A copy of a design drawing of the example at Moyteogue Head is in the possession of the owner of the adjacent coast guard station, Michael O'Connor. The design drawing is dated 1911, suggesting it was constructed in the second decade of the 20th century (M. O'Connor, pers. comm.). Both examples are surrounded by iron mounts secured in concrete foundations. The design drawing of Moyteouge Head watch house shows a telescopic signal lamp protruding through the building's roof, but examination of the interior suggests this was not included in the finished building. The adjacent mounts may therefore have supported a signal lamp on a tall mast, which means that in terms of optical signalling technology, the early 20th Century buildings were more technically advanced than the later buildings; the 1940s Look Out Posts were equipped with hand held signal lamps and signal flags. This class of early watch house has attracted little attention and it is not clear how common such designs may have been or if any other examples were located within the main study area (O'Sullivan & Downey 2014; McDonald 2016, 83). It is also worth noting that the two coast guard stations associated with these watch houses, the brick-built structure at Keem Bay, County Mayo, and the poured concrete structures at Fanad Head, County Donegal, appear to have been constructed from versions of the same architectural plans. Physical differences exhibited beyond the construction materials are extremely minimal (McDonald 2016, 82; M. O'Connor, pers. comm.).

An association between the signal stations in the secondary study areas and the World War 2 era Look Out Posts was also apparent (Sections 4.9, 4.12.1 & 4.12.2, Appendices E & F). The two light house sites in Leinster where signal stations were located, Wicklow Head, County Wicklow, and Hook Head, County Wexford, were the locations of LOP 9 and LOP 16 respectively. The location of LOP 7 was less than 900 m (0.6 miles) away from Dalkey Signal Station in County Dublin. Although the location of the signal stations at Kilmichael Point, Cahore Point and Forlorn Point, County Wexford, was not established, the areas feature LOP 10, LOP 11, and LOP 15 respectively, suggesting that the later sites would have observed the same areas of the coast as the earlier sites. In Munster, five signal stations sites, Ardmore Signal Station (LOP 20), County Waterford, Knockadoon (LOP 21), Toe Head (LOP 28) and Ballylinchy Point (LOP 29) Signal Stations County Cork, and Hag's Head Signal Station (LOP 47) in County Clare, have Look Out Posts (LOPs) in their immediate vicinities. The signal stations at Brownstone Head (LOP 17), County Waterford, Old Head of Kinsale (LOP 25) and Sheep's Head (LOP 31) Signal Stations, County Cork, all have Look Out Posts (LOPs) in their general vicinity, indicating that the Look Out Posts (LOPs) would have observed the same areas of the coast as the earlier sites. As with the main study area, the signal stations in Leinster and Munster have a frequent association with the later Look Out Posts (LOPs), either in the form of the reuse of the signal station sites (14%) or through both types of site observing the same part of the coast (16%).

Overall, it seems that the association between signal stations in Munster in Leinster with the Look Out Posts is slightly lower than in the main study area. 41% of Look Out Post (LOP) sites in the main study area either reused a signal station site or observed the same area of coast as a signal station. In Munster and Leinster this figure is reduced to 30% of Look Out Post (LOP) sites either reused a signal station site or observed the same area of coast as a signal station. This difference is not felt to be particularly meaningful, and around Ireland as a whole, 16% of Look Out Posts (LOPS) were constructed at signal station sites, and 34% of Look Out Posts (LOPs) either reused a signal station site or observed the same area of coast as a signal station.

### 5.4.4 Trigonometry Points

The role that the signal station sites had in 19th century mapping projects in Ireland has attracted little attention previously. The continuing association between the signal stations, trigonometry points, benchmarks and trigonometry pillars is a testament to their ongoing usefulness to cartographers and to how well the original surveyors had identified locations with optimal levels of visibility. Although beyond the scope of this project to properly investigate, a few points are worth noting.

The first cartographic use of the signal towers may have been during William Bald's survey of County Mayo in by William Bald between 1909 and 1916 (Section 3.4.1) (Bald 1830). Bald's published account of how he accomplished the survey makes clear that the signal towers were key to his triangulation (Bald 1825). William Larkin's surveys of Counties Waterford (1818), Galway (1819) and Mayo (1809-1817) mark the position of the signal station, but it is currently unclear if he made use of the sites during his mapping process. The absence of the signal stations from his map of County Sligo may indicate that although he recorded them in other counties, they were not part of his surveying method (Section 3.4.1). The high percentage of sites in the main study area that feature either trigonometry points or benchmarks on the early Ordnance Survey maps strongly suggests that the sites remained useful for cartographic survey throughout the 19th century (Section 4.8). The construction of concrete trigonometry pillars at four of the sites shows that this usefulness persisted well into the 20th century, given that the concrete pillars were erected in 1959 (Section 4.8).

The signal stations in Leinster and Munster seem to have been less useful for early cartographers, presumably because many of the areas featured other buildings that could be used for such purposes. Despite the existence of other options, particularly in Leinster and western Munster, the signal towers at Mizen Head Signal Station in County Wicklow, Galley Head, Leamcon, and Black Ball Head Signal Stations in County Cork, and Loop Head, Ballard, and Mutton Island Signal Stations, County Clare all feature trigonometry points on the 1st edition Ordnance Survey maps (Section 4.12). The only concrete trigonometry pillar associated with a signal station in Leinster or Munster was located at Old Head of Kinsale Signal Station, County Cork, (Appendix F.25).

## 5.5 Research Question 5. Was the design of the signal stations influenced by contemporary military architecture?

Martello towers were iconic features of the new defensive systems constructed by the British at the start of the 19th century. These buildings had antecedents in the Mediterranean; their design was heavily influenced by circular defensive towers observed and even combatted by Royal Navy personnel serving in the Mediterranean (Section 2.2.4.1) The antecedents of the signal towers used at the Irish signal stations have, however, attracted little discussion. O'Sullivan and Downey (2012, 48) believe that the signal towers "share a number of features with tower-house such as the vertical profile, the use of machicolations and the positioning of the doorway at first-floor level." The similarities between the signal towers and tower-houses of Ireland is superficial at best, limited to their general morphology and the presence of a small number of features that were common components of military architecture across many centuries (Sweetman 1999, 137-74).

The list of features shared by the two building types is outnumbered by the list of features they do not have in common (Table 5.1). Unlike the signal towers, tower houses have attracted a lot of research and are reasonably well understood. Given that these buildings date from roughly AD 1400 – 1650, and were built for a range of purposes, they are far from a homogenous group (i.e. Samuel 1998), making a full comparative analysis beyond the scope of this project. However, several points regarding the design and function of tower-houses are worth stating. Although there is an overlap between the size and complexity of the smallest tower-houses and the signal towers, the majority of tower-houses were larger and far more complex buildings, with bigger footprints, greater heights, more storeys, more rooms, and more windows. The tower-houses also frequently featured gun-loops and they incorporated complex architectural features such as vaulted ceilings, spiral staircases and intramural rooms and passages (Sweetman 1999, 137-74).

Despite some claims that tower-houses were principally defensive structures (Barry 1987, 180-190), there now seems to be a consensus that they were principally residential buildings which incorporated a range of defensive features, some of which would not have been particularly effective (McNeil 1997, 217-221; Sherlock 2011; Berryman 2011).

| **Attributes** | **Tower House** | **Signal Tower** | **Lascaris Tower** |
|---|---|---|---|
| Date Range | AD 1400 to 1650 | AD 1804 to 1806 | AD 1632 to 1662 |
| Plan | Rectangular or Circular (Uncommon) | Square | Square |
| Dimensions (L x W) | 20' x 16' to > 55' x 22' | 19' x 19' to 20' x 20' | 20' x 20' |
| Height | 40' to > 65’ | 32' to 40' | 36' |
| Storeys | 2 to 7 (typically 3 to 5) | 2 | 2 |
| Outward sloping walls | Frequent | Frequent | Y |
| Rooms | 3 to > 12 | 2 | 2 |
| Formal Hall | Frequent | N | N |
| Ground-Floor Entrance | Frequent | N | N |
| First-Floor Entrance | Occasional | Y | Y |
| Windows and Gun-loops | 12 to > 40 | 8 | N |
| Staircases | Y | N | N |
| Vaulted Ceilings | Y | N | N |
| Intramural Spaces | Frequent | N | N |
| Corner Towers | Frequent | N | N |
| Bartizans | Frequent | Y | N |
| Machicolations | Frequent | Y | N |
| Parapet Wall | Y | Y | Y |
| Roof Type | Pitched | Flat | Flat |
| Decorative Stonework | Frequent | N | N |
| Primary Function | Residential | Military | Military |

**Table 5.1. Comparisons between Irish tower-houses, Irish signal towers, and Maltese Lascaris towers.**

Sherlock has emphasized the hall as the most important room in a tower-house, and this is a room entirely missing from the signal towers (Sherlock 2011, 118-120). Berryman has demonstrated that the typical ground-floor entrance at most tower-houses are not effective defensive features (Berryman 2011, 262-7). Berryman notes that first-floor entrances were far more effective defensive features, but these have a restricted distribution, largely confined to parts of south-west Ireland (Berryman 2011, 267). Although many tower-houses utilised bartizans and machicolations, there is considerable variation between how these featured were incorporated into tower-houses, and they were not present at every site (Sweetman 1999, 137-74). The term tower-house denotes a style of building which was constructed over several hundred years, and which were not designed in response to a specific need. The variability of their design reflects different chronological and functional requirements, and this variability provides a sharp contrast to the signal towers which were created as a response to a single need, during a very short time span.

As discussed in depth in Section 2.3.4 the signal towers bear a strong resemblance to a series of coastal watch towers found in the western Mediterranean, which served a similar purpose. Details of the towers which most closely match the design of the Irish signal towers, the Lascaris towers from Malta, are included in Table 5.1. Comparing the information presented in the three columns of Table 5.1 illustrates that the Lascaris towers provide a much closer match to the signal towers than is provided by the Irish tower-houses. In brief, the mass and layout of the Lascaris towers is a very close match to the signal towers, and the few differences are confined to the lack of windows, bartizans and machicolations, and the more pronounced outward slope to the walls (which would have reduced the effectiveness of bartizans and machicolations). The de Redin towers, constructed on Malta immediately after the Lascaris towers, were also very similar in design to both the Irish signal towers and the Lascaris tower, but utilised vaulted ceilings (Section 2.3.4).

No previously published accounts have examined the possibility that the design of the Irish signal towers was influenced by existing Mediterranean watch towers. Unfortunately, none of the historical documents reviewed during this project discuss any connection between the Mediterranean watch towers and the design of the Irish signal towers, which might have provided independent corroboration of the proposed Mediterranean connection. The most important question that must be addressed is therefore whether a vector for the transmission of the architectural ideas between the Mediterranean coast and the Irish coast can be established. None of the key personnel involved in the design and construction of the signal towers in Ireland have a strong connection to the Mediterranean coast. Lord Lieutenant Hardwicke was not a naval officer, but he did undertake a 'grand tour' after graduating from Cambridge in 1776 (Richey 2009). Between 1777 and 1779 Hardwicke visited the Low Countries, Germany, Austria, Switzerland and Italy. It is possible that he could have observed some of the watch towers of the general type whilst in Italy, although more work would be required to establish which locations he visited (Goldsmith 2017, 66-7).

Admiral Whitshed only appears to have served in the Mediterranean for a brief period in 1799 and 1800. Whitshed was promoted to Rear Admiral in February 1799 whilst serving in the Channel Fleet. He took command of the ship of the line *Queen Charlotte* and was sent with a small squadron to support the Mediterranean Fleet under the command of Admiral John Jervis St Vincent (Hattendorf 2008, 6). On 2 June 1799 St Vincent relinquished command of the Mediterranean Fleet to Lord George Elphinstone Keith, due poor health. On the 14 June Keith took command of the *Queen Charlotte* and Whitshed took command of the *Barfleue*. The exchange took place off Cape de la Mola, Minorca (Clowes 1899, 384-5). Lord Keith's principal duties between 1799 and 1800 were to maintain the blockade of Malta, patrol the Italian Riviera, and support Austrian attempts to drive the French from Tuscany and Piedmont (Clowes 1899, 415; Stephenson 2004, 25-8). Whitshed returned to the English Channel by the end of 1799 or very early in 1800[2] (Clarke & McArthur 1800a, 155; Marshall 1823, 122; Hattendorf 2008, 6, 16). Full details of Whitshed's whereabouts during his brief time in the

[2] In 1799 the Naval Chronicle records Whitshed as being in Plymouth on the 1 February, Cawsand Bay on the 10 February and 6 May, and that he was spotted off Cape Finisterre on the 17 May (Clarke & McArthur 1799a, 258-9, 537; Clarke & McArthur 1799b, 79). In 1800 the Naval Chronicle records Whitshed as departing Plymouth bound for St Helens on 8 February, that he was in Torbay on the 22 February and back in Plymouth of the 30 June (Clarke & McArthur 1800a 155, Clarke & McArthur 1800b 235; 79). At the most then, Whitshed's total time in the Mediterranean could only have extended from late May 1799 through to early February 1800, a maximum span of around 8 months.

Mediterranean have not been published, but he would have had the opportunity to observe watch towers of the general type whilst he was off the coast of Spain and the Balearics, and if he sailed the Italian coast. If he accompanied Keith to Malta, he would have been able to observe the Lascaris and de Redin towers directly. Whitshed was obviously well acquainted with St Vincent and Keith, who would certainly have been familiar with both the general type of Mediterranean watch tower from their service in the Mediterranean, and the Lascaris towers and the de Redin towers, from their time spent blockading Malta (Gardiner 1997a, 68).

Whitshed himself states in a letter dated 6 November 1803 that the design of the tower was provided by the engineer Major Alexander Taylor of the Royal Engineers (NLI Mss 14, 917; letter dated 6 November 1803 from Admiral Whitshed to William Wickham). Taylor was one of three Scottish brothers who were trained as surveyors in the 1760s (Adams 1975, 55). Taylor worked in Scotland until the early 1780s, undertaking a number of land surveys. By 1783 he had moved to Ireland, where he remained for the rest of his career (Andrews 1966, 53-60; Adams 1975, 62; Dictionary of Irish Architects 2019). It seems unlikely that Taylor was ever on the continent. Adams claimed that Taylor's whereabouts remain unknown for several years prior to 1783, and it is possible that he had already enlisted in the British Army and was on active service somewhere during this period. However, the British Army was not active on the continent during that time-period, being engaged in conflicts in North America, the West Indies and the East Indies (Adams 1975, 62; Herman 2004, 310-19).

Taylor was assigned to the task of constructing the signal stations by Lieutenant Colonel Fisher of the Royal Engineers in 1803 (Kerrigan 1995, 157; Brown 2014, 6). Fisher arrived in Dublin in June 1801 to serve as the senior engineer in Ireland (Hartnett McEnery 2006, 57). Fisher had previously served in Canada, the West Indies, Jersey and on the south coast of England. Brown claims he was responsible for surveying and constructing Martello towers along the south coast of England, although Clements limits his involvement to Ireland (Hartnett McEnery 2006, 57; Clements 2011, 206-7; Brown 2014, 6).

Published sources do not indicate that Taylor had ever been in the Mediterranean, however Clements states that,

> "*Among the other engineer officers in Ireland serving under Fisher there were a number that had served previously in Minorca and there can be little doubt that the strong resemblance between the early Irish Martello towers and those built by the British on Minorca resulted from the previous experience of those officers on that island*" (Clements 2011, 14).

Clements named three of the officers with experience of Minorca as Captain Birch, Captain Cardew, and Lieutenant George Dyson, but their focus seems to have been entirely on the more complicated fortified sites, and neither Clements or Kerrigan mention these junior officers in association with the Irish signal stations (Clements 2013, 14, 22-7, 105).

The key personnel involved in designing the signal towers used at the Irish Signal Stations, Hardwicke, Whitshed, Taylor, and Fisher had no strong association with the Mediterranean. It seems that only Whitshed, and just possibly Hardwicke, could have viewed any of the Mediterranean watch towers in person. However, there had been a growing involvement of the Royal Navy and Army in the Mediterranean throughout the 17th and 18th centuries, beginning with the acquisition of Tangiers in North Africa in 1662 (Dietz 1994, 7-8). British occupation of Tangiers ended in 1683, but it was followed by the capture of Gibraltar in 1704, and Minorca in 1708 (Dietz 1994, 12-22; Herman 2004, 229-32). Minorca was taken by the French in 1756, ceded back to Britain in 1763 by one of the *Treatise of Paris,* and returned to Spain in 1783 by the next *Treaty of Paris* (Dietz 1994, 24; Herman 2004, 278). Gibraltar remains a British Overseas Territory (Gov.uk 2019). During the 18th and early 19th centuries the main ports used by the British Mediterranean Fleet were the freeport of *Livorno* (Leghorn) in north-west Italy, Palermo and Syracuse on Sicily, Valletta on Malta, Mahón on Minorca, and Gibraltar (Mahan 1893, 86-7). The use of these ports over such a long period would have led both Naval and Army personnel to develop a deep familiarity of the fortifications of the adjacent coast lines. Naval officers and army engineers were tasked with alternately attacking or defending ports and harbours around the western Mediterranean and are therefore likely to have paid close attention to their construction and operation.

It is argued here that the signal towers constructed in Ireland were at least indirectly influenced by a well-known and well-understood style of coastal watch tower that were common around the part of the Mediterranean which was most frequented by Royal

Navy officers of the Mediterranean Fleet, and by engineers attached to Army deployments. Drawing from a body of common knowledge when tasked with designing a defensible coastal signal tower for construction in Ireland, a style of building heavily reminiscent of these well-known structures in the Mediterranean would have been an obvious solution. That the design would have been instantly recognisable may be the reason that it attracted so little comment. That the design was not an exact replica of any particular example from the Mediterranean closely matches how the circular gun towers of the Mediterranean strongly influenced the design of the Martello towers, but did not provide an exact model on which they were based (Section 2.2.4.1).

The signal towers constructed in Ireland were adapted to both their chronological and geological position. Kerrigan's identification of the use of a Georgian style pattern of fenestration is an example of how stylistic elements reflected contemporary conceptions of how buildings should be constructed, and possibly even a concern for providing ventilation into the towers, given that health and hygiene had become important topics to the Navy by the turn of the 19th century (Smith 2018, 178). The addition of eight large windows was a clear deviation from the Mediterranean design (Section 2.3.4). Given that windows represent weak points in any defensive building, their provision may well reflect a low estimation of the military threat the towers were likely to be subjected to[14]. The reduction of the talus of the Mediterranean precursors to the slightest of batters present at the base of most of the signal towers in Ireland similarly marks a reduction of their defensive capability. For the main study area, at least, this is again likely a reflection of the estimated threat that Irish rebels were calculated to pose, and their geographical setting in remote upland and boggy positions, where they were highly unlikely to be attacked by cannon fire (Sections 4.3 & 4.13.4). Features such as rainwater capture systems, first-floor doorways accessed via

[14] The provision of windows may also reflect their use to observe the coast, but the windows may not have been designed for that purpose. Firstly, it was the front wall with the first-floor door that was most consistently positioned facing out to sea (Section 4.2.1.1), and certainly at some locations, for example Knocklane Hill Signal Station, County Sligo (Appendix C.67) and Mullaghderg Hill Signal Station, County Donegal (Appendix D.76) the windows would have provided very restricted views of the coast. It should also be noted that the small huts occupied by the crews of the signal posts on the coast of Britain were designed specifically so that the coast could not be observed from inside the building, much to the signal crew's chagrin, and the observations had to be taken from outside (Section 2.4.5.1). At the Irish signal stations, it is likely that the roof level was the designated observation point, at least in the minds of those who commissioned them.

retractable ladders, bartizans, and machicolations were all common parts of the military architecture of the time, but no specific building provides an obvious model which displays the exact combination and arrangement of these features consistently used at the signal towers built at the Irish signal stations. This strongly suggests the design was bespoke, probably envisioned by Taylor, created using appropriate elements from a common range of military architectural features, and with the core mass of the building reflecting a well-known building type which served a similar purpose, in a different location.

## 5.6 Research Question 6. What signalling technology was used at the signal stations?

The opening of Kerrigan's (1995) main narrative about the Irish Signal Stations begins with a brief description of Chappe's telegraph (1793) in France, and the subsequent introduction of shutter telegraphs across Southern England (1796). Kerrigan then describes the coastal signal post system constructed around the southern coast of England in 1794 (Section 2.4.5.1). He concludes his opening section by noting that the means of communication at the Irish signal stations was adapted from existing coastal signal posts first utilised by the British Admiralty in the 1790s (Kerrigan 1995, 156). Kerrigan does not clarify whether he thought there was a direct link between the Irish signal stations and either the French or English telegraph systems, and perhaps he was simply uncertain about whether the two late 18th century telegraph systems had influenced the design of the Irish signal stations, and if so, to what extent. In a later article Kerrigan states that the coastal signal posts in southern England could only communicate with passing ships, not with each other, and this misunderstanding of their ability to transmit signals along the line may explain his implied connection between the Irish signal stations and French and English overland telegraph systems (Kerrigan 2003, 39; Goodwin 2005, 35). The amalgamation of the separate naval signalling technologies, and long-distance overland telegraphy technology, can be argued to have occurred for the first time in England, with the development Admiral Sir Home Riggs Popham overland semaphore in 1816 (Section 2.4.7.6).

The comprehensive literature review (Section 2.4) indicated that there was no direct link between the Irish signal stations and the French and English telegraph technologies developed in the 1790s, either in terms of architecture or signalling technology. The Irish signal stations, at the time of their construction (1804-1806), had very little in common with the overland telegraph systems deployed across Europe, including the English shutter telegraph. The signalling system used at the Irish signal stations relates specifically to the naval signal post systems, first used by the Royal Navy in Jersey in 1792, two years prior to the establishment of Chappe's telegraph. The Jersey signal flag system derived from existing naval and mercantile ship-to-shore and ship-to-ship signalling systems that had been steadily increasing in complexity and functionality since the middle of the 18th century (Sections 2.4.4, 2.4.5 & 4.4.3). The appointment of

Lieutenant Colonel Benjamin Fisher of the Royal Engineers, as the senior engineer officer in Ireland in 1801, seems to have been of particular importance; prior to his posting to Ireland, Fisher had been stationed in Jersey (Hartnett McEnery 2006, 57). Although the Irish signal stations were commissioned and constructed by officers and engineers who had some familiarity with the English shutter telegraph system, the signalling equipment drew specifically from older naval practices. Both the signalling system and the defensible stations were substantially different to the equipment and buildings utilised by the English shutter telegraphs and the later semaphore telegraph systems (Sections 2.4.6 & 2.4.7). When the overland telegraph line connecting Dublin and Galway became operational in 1804, it was one Edgeworth's designs that was used, which he had first demonstrated in the 1760s, and which again had little connection to the English shutter telegraph (Sections 2.4.6.1, 2.4.6.4 & 2.4.7.5).

Unfortunately, the exact nature of the signal apparatus used at the Irish Signal Station could not be established. There are no material remains of the signal masts within either the main study area or the secondary study area that can be studied, aside from the possible mast mounting points at six of the sites in the main study area (Section 4.4.3), at Bere Heaven Signal Station, County Cork, and Great Blasket and Sybil Head Signal Stations, County Kerry (Appendices F.36, F.42 & F.43). Kerrigan describes the signal masts from the signal posts on the south coast of England (see Section 2.4.5.1);

> "*A rectangular flag, a blue pendant* [sic] *(narrow triangular flag) and four black balls made of hoops covered with canvas were hoisted in various arrangements to convey certain signals. The signal post consisted of an old topmast of fifty feet with a cap, cross trees, and fid (conical wooden pin) to secure the thirty-foot flagstaff, and a thirty-foot gaff or spar set at an angle from the mast, to which the canvas covered balls were hoisted*" (Kerrigan 1995, 156).

Kerrigan goes on to state that "this ball-and-flag system was the one introduced on the Irish coast in 1804," and Clements appears to repeat this idea without further interrogation (Kerrigan 1995, 156; Clements 2013, 98-9). Other authors have repeated this information without additional comment or analysis (White 2003, 178; Hurley & Rynne 2012, 1; O'Sullivan & Downey 2012, 49). The museum display within the Old Head of Kinsale Signal Station, County Cork, contains a display panel on the "flag-and-ball signalling system" and uses illustrations of the signal masts on Jersey (see Section

2.4.5.1). It is this design, with wider yards and complex rigging which is recreated in in the grounds of that signal station (Appendix F25; Figure F.12).

The most direct evidence for the nature of the signalling equipment is found in the contemporary drawings by Sir William Smith, which depict the signal masts at Fanad Head and Malin Head Signal Stations, County Donegal (Figures 1.3, 5.3 – 5.6; D.109 - D.114, D.129 -D.133). At both sites the mast is shown as a thin pole extending from a stout base section, with the mast supporting a short yard near its top. The mast at Malin Head is shown as being supported by three timber struts (Kerrigan 1995, 161). The method of supporting the mast at Fanad Head is not shown (Figures D.109 - D.114). It is clear from contemporary illustrations of the signal masts at Fanad Head and Malin Head Signal Stations, County Donegal (Figures 1.3, 5.3 – 5.6), that the equipment was similar but different to the navy signal posts utilised on Jersey, around the southern coast of England, and later by Wellington's forces in Portugal (Sections 2.4.5.1, 2.4.7.8 & 4.4.3). The use of a single mast supporting a short yard near the top, and some sort of mount at the tip, marks the form used in Ireland as different from those used in Jersey, around the coast of Britain by the Royal Navy, and in Portugal by the British Army. The collection of letters to, from, and forwarded to Admiral Whitshed contain frequent mention of the signal masts, typically in terms of their delayed arrival at the sites, but lack details about their form. Both Lecky and Berrell discuss the need to provide secure storage for the signalling equipment, and in each instance only signal balls are mentioned (NLI 14 118, letter dated 22 November 1805 from James Lecky to Thomas Soden; NLI Mss, 14, 918; letter from John Berrell to John Hughes, dated 30 August 1806). This could indicate that rather than the Jersey style flag and ball system it was the naval ball telegraph that was utilised, similar to the system used in Portugal (see Section 2.4.7.8). However, Whitshed makes repeated mentions of the erection of "flagstaffs" and the exact nature of the signal masts should be considered to be uncertain (NLI Mss 14, 917; letter dated 6 November 1803 from Admiral Whitshed to William Wickham; NLI Mss 14, 917; letter dated 15 November 1803 from Admiral Whitshed to Lord Gardiner).

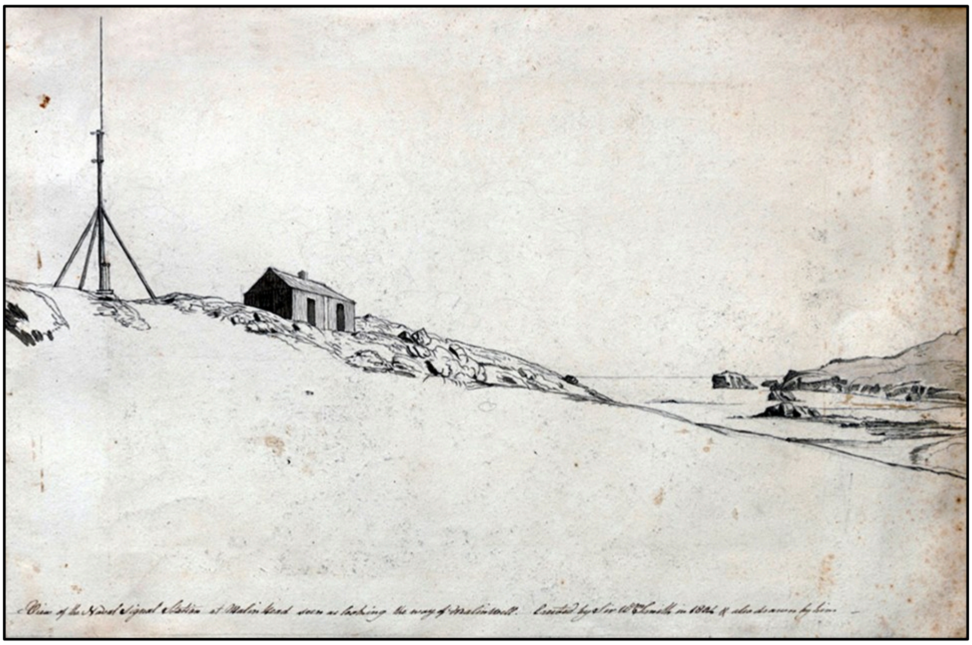

**Figure 5.3. "View of the Naval Signal Station at Malin Head seen looking the way of Malin Well erected by Sir William Smith in 1806 and also drawn by him" (TCD MS 942/1: 15).**

**Figure 5.4. "View of the Naval Signal Station at Malin Head designed built and drawn by Sir William Smith in 1806" (TCD MS 942/1: 16).**

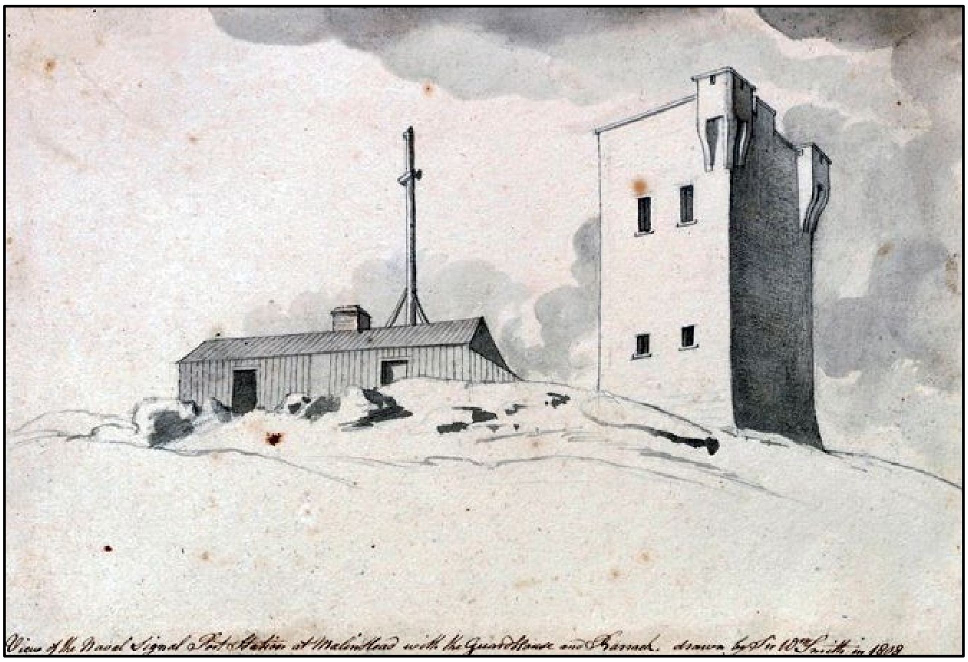

**Figure 5.5. "View of Naval Signal Port Station at Malin Head with the guardhouse and barrack drawn by Sir William Smith in 1808" (TCD MS 942/1: 23). Note that the shed roofed addition to the end wall of the barrack does not appear to be present in the 1806 illustrations.**

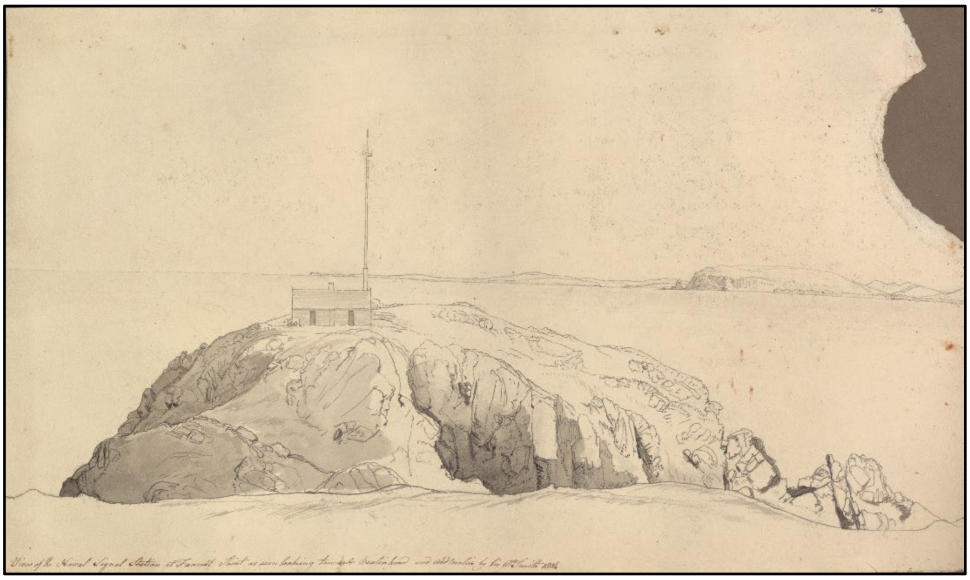

**Figure 5.6. "View of the Naval Signal Station at Fannat Point (sic) as seen looking towards Malin Head and Malin by Sir William Smith 1804" (TCD MS 942/1: 20). Note how closely the barracks building matches the example at the adjacent Malin Head Signal Station.**

The exact nature of the signal code could also not be established. No references indicating a specific code have been identified. In his 15 November letter to Lord Gardiner, Whitshed states, "I am very anxious to open an immediate communication with your Lordship and perhaps we might establish a small code of signals that might be of no small consequence…" suggesting that Whitshed only wished to utilise a code book with a limited scope (NLI Mss 14, 917; letter dated 15 November 1803 from Admiral Whitshed to Lord Gardiner). An 1803 edition of 'Sir Home Popham, Telegraphic Signals; or Marine Vocabulary' is part of the Whitshed archive held at the Naval Historical Collection, Newport, Rhode Island, USA (Hattendorf 2008, 20). This book would have been a standard item belonging to British Naval officers of the period (Section 2.4.5). Its possession does not necessarily indicate a connection to the Irish signal stations, although it was the current version used during the time frame when the Irish signal stations were being planned and constructed. Because the signal stations could also communicate from shore to ship, the signal code must have been comprehensible to passing ships (Kerrigan 2003, 39). It seems likely that either a full or reduced version of Popham's code was used by the Irish signal stations, or that a version of the 92-signal code developed by Admiral McBride for use at the English signal posts may have been used (Section 2.4.5.1). Lord Lieutenant Hardwicke is known to have requested information regarding McBride's code in 1803, whilst instigating the signal station system (Kerrigan 2003, 29).

Kerrigan also mentioned the possibility that a system of light signals may have been utilised to allow the signal stations to communicate at night, based on a brief remark by Arthur Wellesley relating to his examination of signal stations in County Kerry (Kerrigan 1995, 160). Clements claims that if weather conditions were poor fire beacons could be lit, in an emergency, but did not provide a source for this information (Clements 2013, 99). White states that a signal fire was located on the roof of the signal tower at the Old Head of Kinsale, County Cork, also without providing a source (White 2003, 178). A letter from Admiral William Wolesley (Commander of the Shannon District Sea Fencibles) to the Respective Officers of his Majesty's Ordnance appears to resolve the nature of this night time and poor weather signalling method, "Captain Godfrey having stated to me that there are fifty Blue Lights ready to be sent for the service of each of the signal stations now ready upon the coast of Ireland…" (NLI Mss 14, 919; letter dated 20 November 1805 from Admiral Wolesley to the Respective Officers of his Majesty's Ordnance). The Blue Lights in question were an early form of signal flare, widely used in the 18th and 19th centuries for naval signalling purposes, typically to indicate distress (Gray 1828, 499; United States Army 1850, 295; Goldenberg 1975). Various recipes for Blue Lights exist, but Benton's is particularly useful in that it describes the range at which the signal could be observed for the specific recipe;

> *"Blue-light. A very brilliant bluish light may be made of the following ingredients, viz: 14 Nitre, 3.7 Sulphur, 1 Regular, 1 mealed-powder. The brilliancy depends on the purity and thorough incorporation of the ingredients. The composition may be driven in a paper case, and afterward cut off to suit the required time of burning. Both ends of the case are closed with paper caps, and primed with quick match, in order that one or both ends may be lighted at pleasure. A light in which the composition is 1.5 inches in diameter can be easily distinguished at the distance of 15 miles" (Benton 1862, 369-70).*

Despite their name, Blue Lights typically burned with a bright white light and lasted for several minutes. The visible distance of 15 miles (24 km) stated by Benton is particularly important, in regard to the average distance between the signal stations and the typical levels of atmospheric visibility around the Irish Coast (Section 4.13). The discovery that the previously poorly understood night-time signalling method used by the Irish signal stations was based on Blue Lights is particularly important. Blue Lights were seemingly an exclusively naval method of signalling, which strengthens the argument that the signal system derived wholly from naval practices and was not directly connected to any of the various contemporary overland telegraph systems.

## 5.7 Research Question 7. Were the signal stations a successful communications system?

Clements (2013, 99-101) claimed that the rapid abandonment of the signal stations was due to their limited functionality given the poor visibility conditions around the Irish coast and the large distances between the signal stations. The viewshed analysis and review of meteorological conditions (Sections 4.13.2 & 4.13.3) indicate that the signal station system in the main study area would have been fully functional for approximately 60% of the time, partially functional for approximately 14% of the time and dysfunctional for approximately 24% of the time. If the 'blue light' signals were usable during poor day time weather conditions as well as at night, the frequency of dysfunctional periods may have been reduced. It is not clear if daytime use of the blue lights occurred at the signal stations, but signal lights were used by 19th century shipping in both day and night-time conditions, so it is a feasible suggestion (Kent 1993, 11). The contemporary letters reviewed during this project (Section 3.4.3) and by previous researchers, indicate there were considerable difficulties in constructing the signal stations, manning the signal stations, and subsequently ensuring they were kept fit for habitation and duty; no contemporary documents expressing concerns about the effectiveness of the signalling system have been identified to date. This is in stark contrast to the various signal systems in Britain which were frequently criticised for being rendered dysfunctional by heavy fog (Wilson 1976, 35-8; Kerrigan 1995, 157-61; Clements 2013, 99-101; Knight 2013, 235). A study in 1817 determined that the telegraph system then in use in England was fully functional approximately 56% of the time, was partially functional for approximately 17% of the time, and was dysfunctional for approximately 27% of the time (Longmate 2001, 269). These figures are slightly worse than the figures calculated here for the Irish signal station system. Given that the English telegraph and semaphore systems operated in various guises for over 20 years (Section 2.4.7.7), and similar commercial systems were operated for a further 30 years (Section 2.4.7.9), attributing the rapid abandonment of the Irish system wholly to poor performance is likely an over-simplification.

It is proposed that the signal station system was largely effective. The same visibility conditions which caused the system to become dysfunctional would have reduced the immediate threat of a hostile landing or sea voyage by foreign forces. This was aptly demonstrated by the failure of the French Fleet to land during bad weather conditions in 1776, despite being within Bantry Bay for a lengthy period (Section 2.2.1). The decision to retire the signal stations from active service in 1809 likely relates directly to the severe financial effects of the Napoleonic Wars, which saw the British economy badly hampered between 1803 and 1812. As the likelihood of another invasion reduced, the justification to continue funding the largely redundant, if operationally effective, Irish signal stations, could not be maintained (Best 1982, 138-43; Knight 2013, 302-3). The same financial considerations led to the closure of the shutter telegraphs in England shortly after the end of the conflicts in 1814 and the signing of the Treaty of Paris (Section 2.4.7.6). Comments such as those by Mould (1994, 24), Clements (2013, 99, 101), and the NIAH assessment of Galley Head Signal Station, County Cork[15], questioning the effectiveness of this optical signalling method in the Irish climate appear to be unfounded.

A final point to highlight here is the absence of Martello towers or other fortifications within the main study area. Between Galway Bay, County Galway, and Lough Swilly, County Donegal, there were no active coastal fortifications included in the defence program (Clements 2013, 49 – 73). This seems almost inexplicable given that two successful approaches of the coast were made in the Killala area of County Mayo in 1798; in August when the fleet carrying Humbolt and his forces landed nearby, and then in October when Savary's small fleet carrying reinforcements arrived apparently unopposed (Section 2.2.2). The Leinster and Munster signal stations were constructed along sections of the coast that featured regular coastal fortifications, either recently refurbished or recently constructed (Sections 2.2.4 & 2.2.5). The admiralty therefore must have placed considerable faith in the functionality of the signal towers, in the accuracy of their assumptions about where an invasion fleet would attempt to make a landing, and the ability of the gun boat squadrons to intervene and successfully delay or disrupt a large invasion fleet.

[15] The NIAH appraisal for the Galley Head Signal Station (Reg. No. 20914417) states that "the system was doomed to failure, as the British had not taken the wet and misty climate of the west coast into consideration, which obscured the signals," but offers no source for this information.

## 5.8 Research Question 8. Did the signal stations make a useful contribution to the defence of the Irish coast?

The program of coastal defence construction which occurred around the Irish coast between 1804 and 1809 enacted the first truly cohesive plan for the defence of Ireland (Section 2.2.4). This initial response to the threat of invasion was further improved by a second program which occurred between 1810 and 1817 (Section 2.2.5). The signal stations provided an important element in the first iteration of this system, but they were largely found to be redundant during the second iteration of the defensive system.

The early abandonment of the signal stations was symptomatic of the British Admiralty's attitude towards signal technology in general, and related to financial concerns rather than questions of effectiveness; all of the early 19th century signal systems used in England and Ireland seem to have operated satisfactorily, and similar levels of signalling technology were successfully replicated by commercially operations in the years following the abandonment of the military systems (Sections 2.4.5.1, 2.4.6.5, 2.4.7.6 & 2.4.7.9). Naval expenditure far outweighed the money spent on the army and cost cutting measures were always an imperative (Best 1982, 144; Knight 2013, 292). These fiscal concerns appear somewhat short sighted given how often a lack of good military intelligence is portrayed as being a determining factor in major conflicts during this period, for example; Nelson's long search for Napoleon's Fleet after it departed Toulon in May 1798, during which both Malta and Egypt were seized by the French (Keegan 2003, 34-65; Knight 2013, 128, 235; Section 2.3); the lengthy search for the French Mediterranean Fleet after it escaped into the Atlantic in 1805, which culminated in the Battle of Trafalgar (Gardiner 1997b, 120-144); the lack of information regarding the location of troops which negatively impacted Napoleon's plans during the days preceding and then during the Battle of Waterloo (Cornwell 2014). Regarding this apparent short sightedness, Best's categorisation of this period as one in which technological advancement was limited, and new technologies were of little interest to the "warlords" in charge seems relevant (Best 1982, 143). An attitude of almost complete indifference was certainly expressed by the Admiralty towards the numerous proposals to improve the effectiveness of signal technology that petitioners regularly submitted for their consideration (Wilson 1976, 112-9; Holzmann & Pehrson 2003, 192-3). As a counterpoint to this apparent oversight, Keegan's argument (2003, 321-49) that the importance of military intelligence during war time has been overstated may be particularly important.

Whilst the signal stations may have only had a short period of active military use, many of the other elements of the defensive system, gun batteries, quadrangular towers, and Martello towers, continued to be manned well into the second half of the 19th century, and in a few cases into the 20th century (Hartnett McEnery 2006, 117-171). Numerous sites saw their armaments repeatedly upgraded to keep up to date with changes in ballistic technologies, although the Irish sites were seldom, if ever, equipped with state of the art artillery (Hartnett McEnery 2006, 123). Ultimately changes in military technology rendered the 19th century styles of defences obsolete, and more modern fortifications are of a quite different nature (Herman 1992, 7).

The early 19th century defensive system can technically only be considered to have been successful in a deterrent role, having not been required to provide active resistance during the 19th century. The fortifications followed prevailing design paradigms, and so presumably if they been called upon during an invasion, they would have performed exactly as well as similar fortifications elsewhere (Section 2.3.3). The fortifications in Cork Harbour, Bere Haven, Lough Swilly and Belfast Lough were utilised extensively during World War 1, but not directly involved in any fighting (Hartnett McEnery 2006, 160-3). Richmond Fort, County Louth, Duncannon Fort, County Wexford and Charles Fort, County Cork, were similarly re-occupied during the Irish Civil War (1922-3). It was during this conflict that a part of the system finally come under direct attack; Richmond Fort was held by Irish Republicans and shelled by the Free State Army on 4 July 1922, causing considerable damage that would not be repaired until the year 2000 (Hartnett McEnry 2006, 166; Drogheda Museum 2019; NIAH 2019).

Published discussions of the fading French invasion threat typically make little or no mention of the French awareness or assessment of the new defensive system (Knight 2013, 222; Section 2.2.3). The strength of the English blockade of the English Channel, the low priority that Napoleon assigned to the capture of Ireland, and the removal of the *Grand Army* to the Danube in 1805, are typically cited as reasons why no further invasions of Ireland occurred after 1798 (Gardiner 1997b, 10-1, 92-98; Saunders 1989, 132).

By the end of 1805 most of the first phase of construction of the new defensive system had been completed, and this could conceivably have factored into the decision to de-prioritize another attempted invasion (Hartnett McEnery 2006, Table 6). Kerrigan briefly mentions that the decision to attempt a landing at Bantry Bay in 1796 was influenced by the presence of newly constructed defences in Cork Harbour, and that the new defences in Bantry Bay may have deterred an attempted invasion in 1811 (Kerrigan 1981, 5-6).

The appearance of the Irish coast to passing ships would have been considerably more intimidating after the work began, with so many headlands and harbours gaining modern fortifications. If the presence of these new works could be shown to have influenced the lessoning enthusiasm for another invasion, then the assessment of their effectiveness would have to be adjusted considerably. Despite their limited military functionality, the signal towers may have contributed, by dint of their size and number, to the visual impact of the new fortifications. Genuine fortifications were only present around restricted parts of the Irish coast (Figure 2.10). The regular spacing of signal towers would mean that any large enemy warship sailing along much of the coast at the contemporary average speed of 6-8 knots (11-15 kph) would have passed at least one or two signal stations every two hours (Table 4.9) (Whipple 1978, 12-18). Any enemy ship would likely always have been in sight of at least one signal tower if its course followed the shore (Section 4.13.2). The contribution that the signal stations, with their prominent and militaristic appearing signal towers, may have made to the overall deterrent nature of the new defensive system has previously been under-estimated or entirely overlooked.

## 5.9 Research Question 9. What level of legal protection is currently afforded to the signal stations?

As discussed in Section 1.1, legal protection offered to the signal stations around the coast of Ireland has been applied inconsistently, both between different counties, and in some instances, within the same county. Given the limited amount of data available for so many of the sites at the outset of the project, it was not possible to determine whether the existing legislative protection reflected the different levels of survival and integrity that the individual sites possessed. Having completed an assessment of all of the signal stations in the main study area (Section 4.1-4.11) and the secondary study area (Section 4.12), it is now possible to comment on this issue from an informed position. Table 5.2 lists the current legal status of the signal stations and the enclosed barracks, including whether each site is currently listed on the County SMR, whether each site is currently scheduled for inclusion in the next revision of the RMP, and whether each site is currently included in the NIAH (NIAH 2019). Table 5.2 also includes suggestions for which sites should be added to the County SMRs (and notes that the existing listings require updating to make them more uniform), which sites should be scheduled for inclusion in the next revision of the RMP, and which sites should be considered for inclusion in the NIAH. The suggestions are made based on the current treatment of the signal stations in County Cork, which have received the most cohesive and comprehensive legislative protection.

Of the 75 purpose-built signal stations around the Irish coast, 39 are currently listed on the County SMRs. Of these 39 sites, 29 are scheduled for inclusion in the next revision of the RMP. Of the four enclosed barrack sites in County Kerry, three are currently listed on the County SMR, and all three are scheduled for inclusion in the next revision of the RMP. It is suggested here that a further 25 purpose-built signal stations, and the site of the fourth enclosed barrack in County Kerry should be added to the County SMRs. Inclusion in the SMRs is suggested irrespective of the current condition of the site, an inclusive approach already applied in Counties Cork and Galway. The ten sites currently listed on the SMR which are not scheduled for inclusion in the next revision of the RMP, and all 25 of the sites which it is suggested should be added to the County SMRs, should be scheduled for inclusion in the next revision of the RMP. Again, this suggestion follows the precedents established by Counties Cork and Galway. Because the location of eleven sites in Counties Wicklow, Wexford, and Waterford, have not been established these sites cannot currently be added to the County SMRs.

Of the 75 purpose-built signal stations around the Irish coast, 25 sites have signal towers that are currently included on the NIAH (NIAH 2019). It is suggested that a further 16 sites have signal towers that should be considered for inclusion on the NIAH. The signal towers at the remaining 34 purpose-built signal station sites have either been destroyed or do not survive in a condition that would allow for their inclusion on the NIAH.

Of the six signal stations established at existing facilities or newly built Martello towers, only four are currently listed in their relevant County SMRs. None of their entries mention their use as signal stations, and the entries should be updated to include this information. Surprisingly one of these sites is the long-destroyed Martello tower at Fort Point (WX038-007002-), County Wexford, whose location in the waters off Wexford Harbour is marked. The other sites listed in the County SMRs are Pigeon House Signal Station (DU019-027----), County Dublin (listing for the 18th century Block House), Hook Head Lighthouse (WX054-010----), County Wexford, and Fort Davis (CO087-058----), County Cork. Three of these sites are scheduled for inclusion in the next revision of the RMP, the block house at Pigeon House Fort, Hook Head Lighthouse, and Fort Davis. The fourth site, Fort Point Martello Tower, is not currently scheduled for inclusion in the next revision of the RMP. The two unlisted sites, Wicklow Head Lighthouse, County Wicklow, and Baginbun Martello Tower, County Wexford, should be added to their respective County SMRs and scheduled for inclusion in the next revision of the RMP. Four of the existing facilities or Martello towers where signal stations were established are included on the NIAH, Wicklow Head Lighthouse (Reg. No. 16403102), Baginbun Martello Tower (Reg. No. 15705009), Hook Head Lighthouse (Reg. No. 15705414), and Fort Davis (Reg. No. 20908790). None of their entries mention their use as signal stations, and the entries should be updated to include this information. The Block House at Pigeon House Fort should be considered for inclusion on the NIAH, but the destroyed Martello tower at Fort Point, County Wexford, is not eligible for the NIAH as no part of the structure can be identified.

The SMR listings for three signal station sites in County Mayo require some revision. The signal station at Clare Island on Clare Island is recorded under two classes, *Kiln* –

*Lime* (MA084-001003-), and *Enclosure* (MA084-001002-). The signal tower is included in the description of the enclosure. This should be corrected to a single SMR number which would encompass, the signal tower, the enclosure, and the lime kiln, as they are clearly components of a singular site. The destroyed signal station at Creevagh (MA007-015002-) is listed on the SMR under the class *Building*. The site of Creevagh Signal Station should be reclassified under *Signal Tower*.

Two sites have been erroneously listed in their County SMRs under the class of *Signal Tower*, Doween (SMR CO143-0666----) in County Cork, and Stoove (DG013-010----/Reg No. 40901307) in Country Donegal. The Doween building is located halfway between Galley Head Signal Station (CO144-033001-) and Glandore Signal Station. It appears to be a later look out station with a flagstaff, associated with the coast guard station on the shore of Mill Cove to the west. The Stoove building is a look out station or watch house similar in form to the example at the Coast Guard Station at Fanad Head (Section 4.9). The structure was built in 1890 and modified for re-use as L.O.P. 82 during World War 2. Both buildings should be reclassified.

| No. | Signal Station | SMR Number | SMR Action | RMP Status | RMP Action | NIAH Number | NIAH Action |
|---|---|---|---|---|---|---|---|
| 1 | Pigeon House Signal Station (CF) | DU019-027---- | Update | Scheduled | - | - | Consider |
| 2 | Dalkey Signal Station | - | List | - | Schedule | - | Consider |
| 3 | Ballygannon Signal Station | - | - | - | Schedule | - | - |
| 4 | Wicklow Head Signal Station (LH) | - | List | - | Schedule | 16403102 | Update |
| 5 | Mizen Head Signal Station | WI036-022---- | Update | - | Schedule | - | - |
| 6 | Kilmichael Point Signal Station | - | - | - | - | - | - |
| 7 | Cahore Point Signal Station | - | - | - | - | - | - |
| 8 | Blackwater Signal Station | - | - | - | - | - | - |
| 9 | Fort Point Signal Station (MT) | WX038-007002- | Update | - | List | - | - |
| 10 | Hill Castle Signal Station | - | - | - | - | - | - |
| 11 | Forlorn Point Signal Station | - | - | - | - | - | - |
| 12 | Baginbun Signal Station (MT) | - | List | - | Schedule | 15705009 | Update |
| 13 | Hook Head Signal Station (LH) | WX054-010---- | Update | Scheduled | - | 15705414 | Update |
| 14 | Brownstone Head Signal Station | - | - | - | - | - | - |
| 15 | Island of Kane Signal Station | - | - | - | - | - | - |
| 16 | Bunmahon Head Signal Station | - | - | - | - | - | - |
| 17 | Ballyvoyle Head Signal Station | - | - | - | - | - | - |
| 18 | Ballynamona Signal Station | - | - | - | - | - | - |
| 19 | Ardmore Signal Station | WA040-024---- | Update | - | Schedule | 22904006 | - |
| 20 | Knockadoon Signal Station | CO078-015---- | Update | Scheduled | - | 20907820 | - |
| 21 | Ballynacotter Signal Station | CO089-048---- | Update | Scheduled | - | 20908931 | - |
| 22 | Fort Davis Signal Station (CF) | CO087-058---- | Update | Scheduled | - | 20908790 | Update |

**Table 5.2. Current legal status of the Irish signal stations and suggested revisions. (CF – Coastal Fort; LH – Lighthouse; MT – Martello Tower).**

| No. | Signal Station | SMR Number | SMR Action | RMP Status | RMP Action | NIAH Number | NIAH Action |
|---|---|---|---|---|---|---|---|
| 23 | Robert's Head Signal Station | CO113-015---- | Update | Scheduled | - | 20911312 | - |
| 24 | Barry's Head Signal Station | CO113-032---- | Update | Scheduled | - | - | - |
| 25 | Old Head of Kinsale Signal Station | CO137-008---- | Update | Scheduled | - | 20913706 | - |
| 26 | Seven Heads Signal Station | CO145-008---- | Update | Scheduled | - | 20914501 | - |
| 27 | Galley Head Signal Station | CO144-033001- | Update | Scheduled | - | 20914417 | - |
| 28 | Glandore Signal Station | CO143-086---- | Update | Scheduled | - | - | - |
| 29 | Toe Head Signal Station | CO151-041002- | Update | Scheduled | - | - | Consider |
| 30 | Ballylinchy Signal Station | CO150-042---- | Update | Scheduled | - | 20915015 | - |
| 31 | Cape Clear Signal Station | CO153-022002- | Update | Scheduled | - | 20915309 | - |
| 32 | Leamcon Signal Station | CO148-012---- | Update | Scheduled | - | 20914804 | - |
| 33 | Brow Head Signal Station | CO152-002---- | Update | Scheduled | - | 20915201 | - |
| 34 | Mizen Head Signal Station | CO152-001---- | Update | Scheduled | - | 20915202 | - |
| 35 | Sheep's Head Signal Station | CO138-001---- | Update | Scheduled | - | - | - |
| 36 | Bere Island Signal Station | CO128-013---- | Update | Scheduled | - | - | - |
| 37 | Black Ball Head Signal Station | CO127-028002- | Update | Scheduled | - | - | Consider |
| 38 | Dursey Island Signal Station | CO126-005---- | Update | Scheduled | - | 20912601 | - |
| 39 | Hog Island Signal Station | - | - | - | - | - | - |
| N/A | Hog’s Head Bastioned Enclosure | KE105-004---- | Update | Scheduled | - | - | Consider |
| 40 | Bolus Head Signal Station | - | List | - | Schedule | - | Consider |
| N/A | Bolus Head Bastioned Enclosure | KE104-001---- | Update | Scheduled | - | - | Consider |
| 41 | Bray Head Signal Station | - | List | - | Schedule | - | Consider |

**Table 5.2. continued. Current legal status of the Irish signal stations and suggested revisions. (CF – Coastal Fort; LH – Lighthouse; MT – Martello Tower).**

| No. | Signal Station | SMR Number | SMR Action | RMP Status | RMP Action | NIAH Number | NIAH Action |
|---|---|---|---|---|---|---|---|
| 42 | Great Blasket Signal Station | - | List | - | Schedule | - | - |
| 43 | Sybil Head Signal Station | - | List | - | Schedule | - | Consider |
| 44 | Ballydavid Head Signal Station | - | List | - | Schedule | - | Consider |
| N/A | Brandon Height Bastioned Enclosure | KE025-004---- | Update | Scheduled | - | - | - |
| N/A | Rough Point Bastioned Enclosure | - | List | - | Schedule | - | - |
| 45 | Kerry Head Signal Station | - | List | - | Schedule | - | - |
| 46 | Loop Head Signal Station | - | List | - | Schedule | - | - |
| 47 | Knocknagharoon Signal Station | CL065-006---- | Update | Scheduled | - | - | - |
| 48 | Ballard Signal Station | CL046-005---- | Update | Scheduled | - | - | - |
| 49 | Mutton Island Signal Station | - | List | - | Schedule | - | Consider |
| 50 | Hag's Head Signal Station | CL014-010002- | Update | - | Schedule | - | Consider |
| 51 | Inisheer Signal Station | GA120-016---- | Update | Scheduled | - | 30412008 | - |
| 52 | Inishmore Signal Station | GA110-133001- | Update | Scheduled | - | 30411019 | - |
| 53 | Golam Head | GA089-013---- | Update | Scheduled | - | - | Consider |
| 54 | Cuileen Hill Signal Station | GA076-006---- | Update | Scheduled | - | - | - |
| 55 | Bunowen Hill Signal Station | GA049-017002- | Update | Scheduled | - | - | - |
| 56 | Cleggan Hill Signal Station | GA009-007---- | Update | Scheduled | - | - | Consider |
| 57 | Inishturk Signal Station | - | List | - | Schedule | 31309401 | - |
| 58 | Clare Island Signal Station | MA084-001002- | Update | - | Schedule | 31308401 | - |
| 59 | Saddle Hill Signal Station | - | List | - | Schedule | 31304201 | - |
| 60 | Glash Signal Station | - | List | - | Schedule | 31302403 | - |
| 61 | Tower Hill Signal Station | - | List | - | Schedule | - | - |

**Table 5.2. continued. Current legal status of the Irish signal stations and suggested revisions. (CF – Coastal Fort; LH – Lighthouse; MT – Martello Tower).**

| No. | Signal Station | SMR Number | SMR Action | RMP Status | RMP Action | NIAH Number | NIAH Action |
|---|---|---|---|---|---|---|---|
| 62 | Benwee Head Signal Station | - | List | - | Schedule | - | - |
| 63 | Glinsk Signal Station | - | List | - | Schedule | - | - |
| 64 | Creevagh Signal Station | MA007-015002- | Update | - | Schedule | - | - |
| 65a | Lenadoon Point Signal Station | SL010-001002- | Update | - | Schedule | - | Consider |
| 65 | Rathlee Signal Station | SL011-025001- | Update | - | Schedule | - | Consider |
| 66 | Carrowmably Signal Station | SL012-008003- | Update | - | Schedule | 32401201 | - |
| 67 | Knocklane Hill Signal Station | - | List | - | Schedule | - | - |
| 68 | Streedagh Signal Station | - | List | - | Schedule | - | - |
| 69 | Kilcologue Point Signal Station | - | List | - | Schedule | - | - |
| 70 | St John's Point Signal Station | DG097-020---- | Update | - | Schedule | - | - |
| 71 | Carrigan Head Signal Station | - | List | - | Schedule | 40909601 | - |
| 72 | Malin Beg Signal Station | - | List | - | Schedule | 40908901 | - |
| 73 | Glen Head Signal Station | - | List | - | Schedule | 40908001 | - |
| 74 | Dawros Head Signal Station | DG064-001---- | Update | - | Schedule | - | - |
| 75 | Crohy Head Signal Station | | | | | | |
| 76 | Mullaghderg Hill Signal Station | | | | | | |
| 77 | Bloody Foreland Signal Station | DG023-003---- | Update | - | Schedule | - | - |
| 78 | Horn Head Signal Station | | | | | 40901510 | - |
| 79 | Melmore Head Signal Station | DG008-027---- | Update | - | Schedule | - | - |
| 80 | Fanad Head Signal Station | - | - | - | - | - | - |
| 81 | Malin Head Signal Station | DG001-006---- | Update | - | Schedule | 40900101 | - |

**Table 5.2. continued. Current legal status of the Irish signal stations and suggested revisions. (CF – Coastal Fort; LH – Lighthouse; MT – Martello Tower).**

# Chapter 6. Conclusion

The aim of this project was to answer the broad research question described in Section 1.2;

*How should the Irish signal stations be understood as a distinct class of monument?*

To answer this broad research question, a series of nine specific research questions were established. Chapter 5 discussed how the results of the project (Chapter 4) addressed the nine specific research questions. This chapter considers how well the broad research question has been answered and discusses some of the potential for future work on the Irish signal stations.

## 6.1. An improved understanding of the Irish signal stations

This study represents the first expansive study of the Irish signal stations. Previous work on the topic had described a general outline of the subject, and a small number of sites had been described at various levels of detail. The multi-faceted approach that was applied here has provided a wealth of new information about the Irish signal stations, a unique and important aspect of Ireland's heritage.

A comprehensive database of the entire system was created, which includes the precise location of all the extant signal station sites and over half of the demolished sites. Precise locations have not been established for ten demolished sites, confined to the south-east of the country. It was apparent at the outset of the project that many sites featured signal towers that were extremely similar, but it was not clear how much variation there was between the sites. It has been shown that all but four of the well-preserved signal towers were based on a standard design, with only quite minor variations between different examples. Many of the less well-preserved sites have been shown to exhibit enough similar design aspects that it could be assumed that they would have conformed to the standard design. The understanding of the standard signal tower design has been considerably improved, and many new details about the external and internal features, and about the arrangement of internal space, have been presented.

The signal stations featured other elements alongside the signal towers, such as enclosures, additional buildings, and mast mounts. A comprehensive account of the quantity and forms of these features was created, and several important questions about their function were resolved. The signal masts have left scant physical remains, but historical research has provided additional clarification regarding their physical form, and about how they were operated. The identification of the use of early chemical flares for night-time signalling was an important clarification of earlier suggestions that fire signals had been during night-time and day-time conditions with poor visibility. GIS analysis and meteorological data was used to assess the effectiveness of the signalling system, calculating that the system would have performed better than has been previously assumed. A new explanation for the rapid closure of the system was developed, focusing on fiscal concerns.

The extent to which the different parts of the system were subject to modification or clearance was documented. An area along the south coast was identified where the signal stations demonstrated extensive post-1809 use, modification, and clearance. The post-abandonment histories of the signal station had previously attracted little comment. It was argued that the alterations to the signal stations along the southern coast could be related to one of three causes; the lengthy presence of the Royal Naval in south-west Ireland; the support of commercial shipping along the south coast; the more intensive agricultural use of the coastal margin during the 19th century in comparison to the other parts of the Irish coast which featured signal stations.

A new historical context for the Irish signal stations was developed that attempted to assess the Irish signal stations at a number of scales, and from a number of perspectives. The internal politics of Ireland were assessed in order to confirm if the creation of the Irish signal stations related to the failed invasion of 1796 and the failed rebellion and invasion of 1798. The ongoing threat of rebellion into the early 19th century was considered, as were the various military responses to the threat of further internal unrest. At a larger scale, the lengthy period of warfare between European countries during which the signal stations were constructed and operated, was reviewed. This allowed for an understand of the creation of the signal stations against a backdrop of globe-spanning conflicts. The progress of the wider conflicts were shown to have influenced the assessment of the likelihood of another invasion of Ireland, and ultimately this assessment contributed to the abandonment of the Irish signal stations. Having developed a broad perspective on the creation of the Irish signal stations, a possible origin for the design of the signal towers was proposed, based on Mediterranean architecture which Royal Naval personal would have been familiar with. An earlier suggestion that the signal towers were an adaption of an existing indigenous design paradigm, the Irish tower-house, was refuted.

The development of communications technology in the 18th and 19th century was also reviewed, to clarify how the Irish signal stations related to contemporary technological advancements, and to determine what factors influenced the form of the signalling methodology used at the Irish signal stations. The previously implied links to the overland telegraphs being deployed across the world at the time of the construction of the Irish signal stations were rejected. It is argued that the signal system derived exclusively from existing naval flag signalling techniques, which underwent their own separate period of rapid development in the late 18th and early 19th centuries. Arguably it was the development of the overland semaphore system in England, beginning in 1816, which saw the two separate strands of communication technology combine for the first time, not the Irish signal stations, as was suggested by Kerrigan.

A blog detailing the results of the project was established at an early stage in the work and was subject to two substantial revisions (Section 1.3) (Rathbone & Bonsall 2017a). The final versions of the blog contain a detailed summary of the Irish signal stations, a discussion of the signalling technology that was used, detailed accounts of each signal station in the main study area, summary accounts of each signal station in the secondary study area, and a description of the methods that were used to record the signal stations. The blog has both a traditional index and an interactive map (Rathbone & Bonsall 2016b; 2017a), which allows the whole signal system to be examined, and which provides a second route to access information about each individual site. Important parts of the data presented on the blog were subsequently incorporated into a dedicated GIS layer on the *Heritage Council's* web mapping service *heritagemaps.ie* (heritagemaps.ie 2019). An extensive sequence of academic publication will be undertaken, beginning in 2022, presenting different parts of this thesis to the most relevant audiences.

Finally, the current legal protection level of each signal station site was established. An assessment was undertaken of how consistently legal protection has been applied to the individual signal station sites. An ideal application of legal protection was identified in two separate counties, and recommendations were made that this current best practice should be extended around the entire coast. During the final stages of the preparation of the final version of this thesis the National Monument Service were contacted to ask if they would be interested in receiving any of the data from this project. As a result of the enquiry, a small grant was awarded to cover the costs of editing each appendix entry into a new format, and these new accounts will be used to update the County SMR entries for each of the counties which feature signal stations.

## 6.2 Research outcomes

At the outset of the project 13 research outcomes were established that the project aimed to complete (Section 1.2). All 13 of the research outcomes were successfully completed (Chapters 3, 4, and 5). The submission of a detailed account of each individual signal station site and enclosed barracks site to the National Monument Service was an unplanned outcome. Each of the 85 individual submissions consists of a re-formatted version of the text included in each of the Appendix entries. For the sites that lay within the main study area the individual submissions was accompanied by full-resolution versions of each site plan, each external elevation drawing, each internal elevation drawing, and an extensive selection from the photographs taken during the field surveys. This represents a large and comprehensive archive of material relating to the signal stations. The transfer of this material to the National Monument Service ensures that the data gathered during the field surveys will be stored in a secure digital archive for long term curation. It is the intention of the National Monument Service that much of this material will soon be made publicly accessible via the *Historic Environment Viewer* web-service (T.J. O'Meara, pers. comm.)

A series of publications are planned to allow for the dissemination of the results of this project. An overview of the subject will be submitted to the *Journal of Irish Archaeology* or the *International Journal of Historical Archaeology*. A comparative paper discussing the Irish Signal Stations and the Mediterranean Watch Towers will be submitted to a journal specialising in Military architecture, potentially *Fort: The international Journal of Fortification and Military Architecture*. It is also intended that the viewshed and meteorological analysis of the functionality of the signal station system be published in a journal specialising in historical meteorological data, such as *History of Meteorology,* or in a journal dedicated to the history of technology, such as *History and Technology: An International Journal*. Finally, it is intended to produce a short article discussing the use of the Blue Lights chemical flares at the signal stations.

## 6.3 Future research

During the project several areas where additional research could be undertaken were identified. These avenues for future research can be divided into three groups, future field survey; future archaeological work, and future historical research. The potential for future research in these three areas is briefly discussed in this section.

### 6.3.1 Future Field Survey

The plans and elevations recorded for the signal stations in Connacht and Ulster represent an unusually comprehensive set of illustrations detailing a relatively minor monument class. The plans that were produced are undoubtedly simplistic but provide the first accurate plans known to be made of the sites in the main study area since the 3rd revisions of the Ordnance Survey maps were recorded in the early 20th century. Improved levels of detail could be obtained through any number of more high-tech methods; total station survey, high precision GPS survey, a low altitude UAV photographic survey, or an aircraft or UAV mounted Lidar survey (Andrews *et al* 2015; Historic England 2015; 2017; 2018a; 2018b). UAV survey would also provide images of the upper level of the signal towers and could thus provide information regarding currently unresolved issues about the construction of the roof and the nature of the interiors of the bartizans and machicolations. During the time frame of this project Dr James Bonsall undertook a UAV flyover of Ballydavid Head Signal Station, County Kerry. Images from this drone flyover proved extremely useful in the creation of the entry for the signal station included in the appendices (Appendix F.44). Sam Moore of IT Sligo also recently undertook a UAV flight over the enclosure at Carrowmably, in which the Carrowmably Signal Station is sited. The potential of UAV surveys for understanding the construction of the upper portions of the signal towers, and for better illustrating the position of signal stations in the landscape, were abundantly clear (Figures 6.1 & 6.2).

The external elevations prepared for the signal towers in Connacht and Ulster, represent a considerable increase in the level of detail and accuracy when compared to the site plans. Improved levels of detail could be obtained through the extensive use of 3D photogrammetry or ground based Lidar survey.

Figure 6.1. Drone photograph of the Carrowmably Signal Station, County Sligo, showing two concentric enclosures and the well-preserved signal tower, with the distinctive natural slope to the north (Photograph Courtesy of Sam Moore).

Figure 6.2. Drone photograph of the signal tower at Carrowmably Signal Station, County Sligo, showing details about the upper portion of the tower that would be difficult to observe directly from ground level (Photograph courtesy of Sam Moore).

These techniques have been used extensively in recent years to record a variety of watchtowers, circular gun towers, Martello towers and larger fortifications across the Mediterranean, and their usefulness has clearly been demonstrated (Murru 2015; Rodríguez-Navarro *et* al 2015; Altamura 2016; Baldi & Pucci 2016; Berciglia 2017; Campana 2017; Cowley *et al* 2017).

As discussed in Section 3.3.4 the level of accuracy of the internal elevations was hampered by the short distance between the camera position and the wall, and the steep angle required to photograph the upper portions of the walls. Use of a tripod may have allowed for the creation of panoramic shots of each interior wall with less distortion, but this was not attempted as the problem with the internal panoramic images was not identified until a late stage in the project. Some modern tilt-shift camera lenses such as the Canon TS-E 17 mm f/4L Tilt-Shift Lens offer in-built perspective correction features combined with very wide viewing angles (Carnathan 2019). In combination with a digital SLR camera and a tripod it is possible that such a camera rig might be able to take internal elevation shots in a manner that either the entire internal elevation could be captured in a single image with a low level of distortion, or that a panoramic series could be taken of each internal wall with a low level of distortion. Peter Horner has taken photographs and video of the interior of the signal tower at Malin Head Signal Station, County Donegal, from the first-floor doorway which he accessed via a ladder (Homer & Brown 2014b). Clearly a dangerous action that should not be repeated, the imagery does at least raise the possibility of safely accessing the doorway and first-floor windows from a mechanical lift or similar device and recording the interior of the tower from those vantage points.

Ultimately the success of the methods used during this project make it hard to argue for any urgency in undertaking more detailed recording at more than a small number of the best-preserved signal station sites in Connacht and Ulster. Conversely, the success of this project highlights the need for more detailed survey to occur at the sole surviving purpose-built signal station in Leinster, Dalkey Signal Station, County Dublin, and at the large number of well-preserved signal stations, and at three of the enclosed barracks sites, in Munster. Many questions raised during the desk-based assessments of the signal stations in Leinster and Munster could only be addressed through field survey. Any future field surveys in those provinces should match or improve on the levels of detail achieved at the Connacht and Ulster signal stations during this project. Of particular importance would be preparing detailed recordings of the sites where the signal towers have either been replaced or heavily modified.

### 6.3.2 Future archaeological work

During the project a number of areas where future archaeological research could be undertaken were identified. The most obvious targets for future archaeological work are those sites where the signal station locations are known with some degree of certainty, but where the signal stations have either been levelled or reduced to a series of low earthworks. In the main study area this specific situation occurs at Creevagh Signal Station, County Mayo, Kilcologue Point Signal Station, County Sligo, and Bloody Foreland Signal Station, County Donegal. Only one signal station site meets these criteria in Leinster, Mizen Head Signal Station, County Wicklow. Four signal stations in Munster meet these criteria; Barry's Head Signal Station, County Cork, Kerry Head Signal Station, County Kerry, and Loop Head and Knocknagharoon Hill Signal Stations, County Clare. Remote sensing techniques may be the only method available to try and re-locate the six signal stations in Leinster and the five signal stations in Munster whose positions are not currently known.

The locations of any of the better-preserved signal stations could also subject to geophysical survey and targeted excavations. Geophysical survey and targeted archaeological excavations could attempt to identify associated buildings and structures not currently visible at the sites, and to attempt to clarify the functions and dates of buildings, structures, and features suspected of being contemporary elements of the signal stations.

The semi-basement levels of any of the known signal towers would also make suitable targets for archaeological excavation, in order to better understand the use of the semi-basement levels, and to investigate if drains and sewers were present, and if so, were they additions to the building (Section 4.2 & 5.31). Two sites can be suggested where such excavation might best be undertaken, Knocklane Hill Signal Station and Streedagh Signal Station, both in County Sligo. In both instances, only the low remains of signal towers are present, reducing the health and safety concerns that would come with working inside the more complete signal towers, and the interiors do not feature large quantities of rubble which would have to be removed (Appendix C).

It is unlikely that detailed archaeological investigations of the six existing facilities or Martello towers where signal stations were established are likely to provide any information relating specifically to the signal stations. However, if archaeological work was to occur at any of these sites for different reasons, as has happened at Hook Head Lighthouse, County Wexford (Appendix E.13; Hayden 1999), it may be prove worthwhile to communicate with those projects about the possible meaning of artefacts that date specifically to the early 1800s, and the possibility of them finding structural remains that could be directly associated with the signal crews, most specifically mast-mounts.

A final field based survey that could potentially provide interesting new data would be a petrographic analysis of the cut stone elements used around the windows and doors of the signal towers, and around the top of the parapet wall. This might take the form of on-site analysis or through the recovery of small samples for analysis in a laboratory. If the likely source of the cut stone could be determined at a sufficient number of sites, such analysis could provide important information about the nature of the construction project, determining whether they were organised purely at a local level, or if more centralized sources were used for some of the more specialised building materials.

Finally, a similar viewshed analysis should be undertaken for the signal stations in Leinster and Munster using *ArcGIS*. This would allow the effectiveness of the system around the entire island to be assessed and would allow for any differences between the visibility ranges in Leinster and Munster and those in Connacht and Ulster to be identified.

### 6.3.3 Future historical research

The most informative historical sources used during this project proved to be Admiral Whitshed's collection of letters pertaining to the signal stations. It is likely that other relevant information is contained within similar collections of letters belonging to the other officers and politicians involved in the creation of the signal stations, principally Lord Hardwicke, Lieutenant Colonel Fisher and Major Taylor. Identifying the location of any such letters and reviewing their contents should be a research priority. An attempt should also be made to locate and review any papers associated with the junior officers who served under Lieutenant Colonel Fisher in Ireland (Section 5.5).

The location of Whitshed during his brief time in the Mediterranean is an important and unresolved issue. Fortunately, his logs for the period have survived (Hattendorf 2008, 15; NLI Mss 14, 922). Unfortunately, although copies of these logs were obtained during this project, their contents remained opaque; they are highly specialised documents and need to be examined by a specialist naval historian. The logs contain long lists of data which should reveal the location of ships, the movement of ships from one place to another, weather that the ships encountered, signals and orders given and received by the ships. They may also contain information tasks performed and carried out by ship's companies, disciplinary action carried out on board, and loss of or damage to stores on board (The National Archives 2019). The logbooks are written in a form of shorthand which would require considerable experience to interpret and plotting the positions of ships from the information contained would require a deep understanding of naval navigation procedures.

Sir William Smith's illustrations of the signal stations at Fanad Head and Malin Head in County Donegal were also of considerable use during this project. They are the only currently known pictorial views of any of the signal stations during their construction and operation. A comprehensive search for additional views by other officers and/or artists should be undertaken. In particular, Lieutenant Colonel Fisher is known to have been a talented landscape artist. Cooke states that he was tasked with drawing fortifications while stationed in Canada (Cooke 2003). His surviving body of work should be examined for any illustrations of Irish fortifications in general, and of the signal stations specifically.

The 1st edition Ordnance Survey maps proved particularly useful during this project, but the gap between the abandonment of the signal stations in 1815 and when the Ordnance Survey maps were recorded in the 1830s is not an insignificant length of time Several earlier cartographic sources proved useful during this study (3.4.1), but a more comprehensive review of early 19th century mapping may uncover further useful information. At a more localised scale, each of the signal stations in County Cork was mapped in detail shortly after they were completed, and the full set of these maps are part of the collection of the *National Library of Ireland*. Several of these maps were utilised during this study, but the remainder should be reviewed in detail.

Newspapers and periodicals of the early 19th century were not examined as part of this project, but certainly news of the completion of the signal stations might have been reported, and this possibility should be examined. If there were any formal ceremonies associated with the completion of the signal station system, these may have received coverage in the newspapers. Any reporting of test messages be transmitted along the chain, and any reporting of the speed at which transmissions occurred, would be extremely important details that might be found in newspaper articles.

Historical sources relating to mid and late 19th century shipping have the potential to provide information regarding secondary uses of the signal station sites. Admiralty navigation charts and pilot's guides are two sources that may be particularly useful, but any material regarding coastal navigation may be potentially valuable. The study of the architectural legacy of the Irish coast guards is not currently well developed, but preliminary work already undertaken indicates that further development of this subject could be very rewarding (Meide & Sikes 2014; Mayne 2017). The high degree of interaction between the Irish signal stations and the early coast guard stations has been established in this thesis (Section 5.4.1), but further research into the coast guards in general, and in their use of the signal station sites specifically, is likely to prove very enlightening. The identification of earlier lists of navigation features along the southern coast of Ireland would also likely provide important information regarding the re-use of the signal stations during the 19th century. A considerable amount of historical research needs to be undertaken to properly understand how the signal station sites were impacted by later military and mercantile ship-to-shore communications apparatus.

French publications and historical sources may mention the early 19th century fortifications that were constructed around the Irish coast in general, and the signal stations specifically. An understanding of the level of awareness the French military had of the new Irish fortifications and signalling system would be an important new source of information. A particularly interesting avenue of enquiry is whether the construction of the early 19th century fortification system (Section 5.8) can be shown to have played any role in dissuading further French invasion plans. If such an impact could be identified, it would contribute significantly to future assessments of the effectiveness of the effort that was expended in protecting the Irish coast.

Finally, the ‘hindcasting’ method utilised by Tyrell might be utilised to produce an account of the historical weather conditions throughout the period of the signal stations use. Tyrell identified a number of sources where meteorological observations were regularly recorded during this period and highlighted that British Naval ship logs provided the most useful information regarding weather conditions and visibility (Tyrell 2001, 4-13). Pallé and Butler, amongst others, have worked extensively with meteorological records from the Armagh Observatory, including providing a record of sunshine and cloud cover between 1881 and 1998 (Pallé & Butler 2001; Butler *et al* 2007). Murphy *et al* have recently compiled a 305 year long sequence of rain fall data for Ireland, covering the period 1711-2016 (Murphy *et al* 2018). Although a specialist task, it might prove possible to acquire an accurate account of visibility conditions around the Irish coast between 1804 and 1809 and, in combination with the results of the viewshed analysis, more accurately assess the functionality of the system.

## 6.4 Not the end

This thesis has focused on a small but important element of Ireland's archaeological and architectural heritage. The thesis built on a solid foundation laid down by Kerrigan several decades ago, but which had subsequently seen little development. The thesis utilised a fourfold approach to produce an analysis that operated at a number of different scales.

An extremely localised perspective was used to examine the individual sites, in particular the surviving signal towers which were quite literally examined stone by stone. This macroscopic approach to the individual buildings led to a number of new discoveries about how the buildings were constructed and functioned.

Contemporary letters, illustrations, and cartographic sources were utilised to support the results of the field surveys, explaining details identified during the examination of the buildings, providing details about the signal stations which lacked physical expressions that could be recovered through field work, and adding details about parts of sites and entire sites that have been lost over the last two centuries.

GIS analysis provided a regional scale analysis, examining how the individual sites were arranged in the landscape of the Irish coast. Once paired with historical meteorological data, the GIS analysis allowed for a robust assessment of how well the Irish signal stations would have functioned.

A very broad perspective was used to examine the subject as a whole. The Irish signal stations were located within the broader development of communications technology. A new origin of the architectural design that was employed was suggested, linked to British Naval involvement in the Mediterranean. The conflict which led to the creation of the Irish signal stations was reviewed, not just as a local, internal, rebellion with ineffective external support, but also as a relatively minor event that occurred during the first example of truly global warfare.

This thesis can only claim to present a comprehensive account of the individual signal stations in the main study area. It is now clear that the signal station sites in western Munster require a detailed field survey of their own, and the results from such a study would feature more variability than was discovered at the signal stations in Connacht and Ulster. A rather different approach would be needed to investigate the signal stations in Leinster and eastern Munster, where so many of the site locations remain unknown. Historical research, cartographic analysis and, eventually, geophysical survey or other remote sensing techniques may allow for the position of some of the currently unlocated signal stations to be identified. If any of the unlocated signal station sites in Leinster and eastern Munster were to be identified in the future, they would provide extremely compelling targets for archaeological excavation.

This study has also identified a complex sequence of post-abandonment use of many of the signal station sites, particularly in western Munster. Examining the nature and date of this post-abandonment activity in more detail is an exciting prospect. Currently the Irish signal stations have a rather isolated character, removed both geographically and functionally from other types of coastal archaeology. Through developing a better understanding of the post-signal station use of the sites, the Irish signal stations would become more deeply integrated into larger patterns of coastal activity. The interaction between the signal stations and the early coast guard stations created in the 1820s is an especially important area for future study.

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# Glossary

The terms presented in the following glossary are accompanied by an explanation of their meaning as used throughout this thesis.

Battery: A group of artillery pieces that operate as a unit. The term may be applied to mobile field pieces, to pieces located within a small fortification built specifically to house the unit, or to a unit within a larger fortification.

Bartizan: A small turret that projects from the corner of a building which allows defenders to enfilade attackers reaching the main wall of the building.

Bastioned Fort: A fortification that consists of an enclosure with numerous projecting bastions. The bastions provide fortified positions from which attackers can be subject to enfilading fire as they reach the main enclosure. Bastioned forts can be constructed from any combination of earth, timber, stone, and brick. Defensive lines may also feature projecting bastions which functioned in the same manner.

Battered walls: Walls which widen towards their base, giving the wall faces a sloping aspect. Battered walls add structural stability to a building. An over exaggerated wall batter may be added to a building as a defensive feature, in which case it is termed a talus wall.

Benchmarks: A location where a known height is indicated on a building or structure using a benchmark sign. Originally benchmarks only indicated height and did not record the position of the benchmark. In later uses the term has become inter-changeable with trigonometry points, and more recent benchmarks include positional information.

Booley: A seasonally occupied settlement or building used by cattle farmers during the summer months when cattle are taken to be fed on summer pastures away from the home farm or permanent village.

Cannon: A general term for artillery pieces. The term encompasses guns (commonly referred to as cannons), mortars, howitzers, carronades etc.

Cap: A horizontal plate attached to the top of a mast or flagstaff. A small extension called a truck may extend up from the cap that could be used to display an uppermost flag.

Celtic Revival: A nationalistic cultural movement of the late 19th century and early 20th century that promoted an interest in Celtic culture as an opposition to the dominating English culture. The Celtic Revival impacted on many different fields, and representations of Celtic culture varied widely between historically focused and more fanciful treatments.

Coping stones: Curved, triangular, or wedge-shaped stones which are used to cap a wall. Coping stones stop water ingress into the top of a wall.

Corbel: A masonry, wooden, or metal bracket embedded into the body of a wall. A corbel is used to support the weight of a structural element that projects out from the wall face, such as a mantel, a balcony, a floor, a bartizan, or a machicolation.

Corvette: A French term for a small warship smaller than a frigate and larger than a sloop. The British Navy did not adopt the term until the 1830s.

Cross-trees: Two short horizontal spars attached to the upper part of a mast or flagstaff used to attach the guy ropes that support the higher part of the mast or flagstaff.

De Redin towers: Thirteen small coastal watch towers constructed on Malta between 1657 and 1660, during the reign of Grand Master de Redin. The de Redin towers featured barrel vaulted roofs that could support the weight of a cannon.

Discharging arches: Blind arches built into the body of a wall over the top of a window or door opening. Discharging arches transfer downward force (super-incumbent weight) away from the opening.

Digital Elevation Model (DEM): A 3D computer representation of elevation data. Used in GIS programs to represent a landscape.

Enfilade: A volley of gunfire sent into the side of a military formation.

Fencibles: Irregular units of the British Army raised for self-defence. Intended to be temporary units, used for the duration of a specific threat. Fencibles were used to free up regular units of the British Army for more important assignments.

Fid or Fidd: A square bar of iron or wood, used to support the weight of the topmast when erected at the head of a mast or flagstaff.

Field piece: A cannon mounted to a carriage fitted with large wheels that allows the cannon to be moved long distances. Field pieces were gathered into an artillery train that accompanied a marching army.

Flagstaff: A vertical pole used to display a flag. Additional elements can be added to a flagstaff to allow for the display of multiple flags for use in an optical signalling system.

Floruit: The period of time when the career of a historical figure flourished. Stated as a start date and an end date.

Frigate: Fast single deck ships used as scouts of the battle fleet or as independent cruisers. At the start of the 19th century British frigates were equipped with between 32 and 40 guns (5th rate), or between 22 and 28 guns (6th rate).

Garrison carriages: A simple wooden carriage used to mount a cannon on a ship or at a fortification. Garrison Carriages were either fixed to the ground or equipped with small wheels.

Glacis slope: An artificial slope surrounding a fortification which is kept free of obstructions and which is designed to expose an attacking force to prolonged fire from the defenders of the fortification.

*Grande ciffre:* A complex substitution code utilised by the French court during the 18th century and early 19th century.

Gun: A direct fire artillery piece, with a long, smooth bore barrel.

Gunboat: A small undecked boat typically equipped with a single gun in the prow. Some gunboats were equipped with two cannons or sets of swivel guns. Capable of operating in shallow water such as rivers or lakes, or close to the shore and in small harbours.

Gun-loops: A narrow aperture in a wall to enable gun fire to be directed over a wide field whilst protecting the firer.

Head: One of the vertical elements of the frame of a door or window, that lines the top of the opening.

Heliographs: An optical signalling system that uses a mirror to create controlled flashes of reflected sunlight to convey messages.

Howitzers: An artillery piece with a medium length, smooth bore barrel. Can be adjusted to fire at various trajectories, and commonly used explosive shells.

Irish Militia: An irregular force founded in 1793 to replace the volunteer units which were raised during the American War of Independence.

Jambs: The vertical elements of the frame of a door or window, that line the sides of the opening.

Key stone: A wedge shaped stone used in the centre of a masonry arch or vault, which locks the unsupported stones into position, allowing the arch to bear weight.

Lascaris towers: Five small coastal watch towers constructed on Malta between 1636 and 1657, during the reign of Grand Master Lascaris.

Laser scanner: A device that uses a laser to take highly accurate measurements of an object, building, or landscape, that is used to generate an accurate 3D model of the subject.

Lidar: A laser scanning technique used to record buildings and landscapes.

Lime Kiln: A kiln in which limestone is heated until it undergoes calcination and is inverted into lime (quicklime) that is one of the key ingredients of mortar.

Lines of Torres Vedras: Constructed by Wellington’s engineers in Portugal in 1809, the Lines of Torres Vedras were a complex series of 150 fortifications that formed a series of four defensive lines.  During the winter of 1810 Wellington’s forces undertook a planned retreat to the Lines of Torres Vedras. Once the weather had improved in the spring of 1811, Wellington advanced from the Lines of Torres Vedras, following French forces who had been forced into retreat largely due to the effects of starvation.

Machicolation: A projecting element above a door or gate on a wall that allows defenders to protect the underlying entrance.

Martello towers: Circular or oval stone-built towers used to protect important locations along the coast, and along estuaries and rivers. The towers featured thick battered walls, bomb proof vaults, and could support cannons on their roofs. Constructed in considerable number throughout the British Empire during the late 18th century and into the mid 19th century.

Mezzanine floor: An intermediate floor located between the main floors of a building.

Mortar (artillery): An indirect fire artillery piece, with a short, smooth bore barrel.

Mortar (construction material): A paste that consists of a mix of sand, cement, lime, and water, that is used as a hard setting binder between masonry.

Naval War Signal Station: A series of ship to shore signal stations established by the British Navy in the approach to World War 1. Communications were achieved through a mixture of via flag signals, signal lamps, and wireless telegraphy.

Parapet: A wall around the edge of the roof of a building that provides protection to the defenders of the building.

Pennant: Long, narrow triangular flags used in flag signalling systems.

*Petits ciffres:* Simple substitution codes used by French institutions throughout the 18th century and the early 19th century.

Photogrammetry: A computer dependent technique that uses a series of overlapping photographs to create a lifelike 3D model of an object, building, or landscape.

Photo rectification: Various techniques that are used to correct distortions in photographs so that the photograph becomes an accurately scaled representation of the subject.

Plantation: The Plantation period involved a series of co-ordinated movements of British and Dutch settlers to different regions in Ireland throughout the 16th and 17th centuries. The Plantation period involved the displacement of indigenous Catholic populations.

Point cloud model: Various 3D surveying methods record locational data as a mass of points in a 3D space, called a point cloud. The point cloud model can then be draped with textures to create a realistic 3D model of the subject.

Powder ship: A ship tasked with storing gun powder. Typically, a powder ship was a ship that had been taken out of normal service due to damage or because its design was outdated.

Promontory fort: A common type of coastal site thought to date from the iron age or early medieval periods. A series of banks and ditches run across the neck of a promontory, effectively protecting the promontory from attackers coming from inland. A poorly understood monument class.

Protestant Ascendancy: An influential group of Protestant landowners, clergy, and professionals who exercised political, economic, and social control over Ireland between the late 17th century and the early 20th century. The membership was drawn from the Church of Ireland, and excluded other Protestant denominations, Catholics, and Jews.

Quadrangular towers: A narrow rectangular tower with thick battered walls and bomb proof arched ceilings. The quadrangular towers had multiple cannons mounted on their roofs and were often accompanied by enclosed gun batteries. The quadrangular towers were arranged with their broader side facing towards the potential line of attack.

Quoin stones: The stones that form the external angle of a wall. Various different patterns of quoin stones exist, and they often provide a location for architectural decoration.

Ranging rods: A simple piece of surveying equipment consisting of a pole with graduations marked in alternating colours, typically white and red. A ranging rod is used for sighting surveying equipment over long distances, and a number of other surveying tasks. Commonly used to provide scales in archaeological photographs.

Redoubt: An enclosed fortification which lies outside of major fortifications. Redoubts may be temporary or permanent structures. Redoubts may be located in isolation, as satellites surrounding major fortifications or fortified towns and cities, or along a defensive line largely consisting of smaller fortifications.

Render: A type of mortar that is applied to a wall as a thin layer to water-proof the wall.

Sea Fencibles: Fencible units organised by the British Admiralty and assigned to coastal protection (see Fencible). The Irish Sea Fencibles were tasked with manning the Martello towers, signal towers and gun boats.

Semaphore: An optical signalling system which uses an upright post with one or more rotating arms working in a vertical plane.

Ship of the line: Large warships. At the start of the 19th century, British ships of the line were categorized as 1st rate (100+ guns; 850 to 875 men; three decks), 2nd rate (80 to 99 guns; 700 to 750 men; three decks), and 3rd rate (64 to 79 guns; 500 to 650 men; two decks).

Sil: One of the vertical elements of the frame of a door or window, that lines the bottom of the opening.

Sloop: A small single deck warship. At the start of the 19th century British sloops carried up to 18 guns, which kept them bellow the rating system which began with 6th rate frigates with 20 guns.

Spot height: A point on a map where a known height is shown. Typically shown on the summits of hills or on the tops of buildings.

Star shaped fort: A fortification consisting of a series of bastions arranged in a regular pattern to enclose a protected area. Star shaped forts were first developed in the 15th century. They are a type of bastioned fort and are notable for the regularity of their frequently elaborate plans.

Surveyor's arrow: A metal pin used in surveying for marking taped measurements on the ground.

Talus wall: A steeply sloping section at the base of a wall that is used to deflect the impact of cannon fire.

Telegraph: An optical signalling system used to convey messages over long distances. Many different types of telegraph equipment have been developed. The electric telegraph adapted existing telegraphic transmission practices to convey messages along an electrical cable.

Total Station: An electronic surveying instrument that combines an electronic transit theodolite and an electronic distance measurement (EDM). Used for a variety of highly accurate 2D and 3D surveying tasks.

Traversing carriage: A cannon carriage that incorporates a vertical pivot allowing the cannon to be traversed from side to side independently of the carriage.

Trigonometry points: A location used by surveyors for triangulations. The position and the height of the trigonometry point is carefully measured when the point is established, and then it is available for future use. Often denoted by a permanent mark.

Trigonometry pillars: A concrete pillar with a trigonometry point mounted to the horizontal upper surface.

UAV: An Unmanned Aerial Vehicle. Can be equipped with a camera or a variety of other surveying equipment. The term covers radio-controlled drones, helicopters, and aeroplanes.

Viewshed Analysis: A GIS technique where lines of sites are calculated from a specific location within a Digital Elevation Model (DEM). Viewshed analysis is used to determine what can be seen from a specific position, and the extends from which a specific position can be viewed. The technique has a wider number of applications.

Viglae: A general term for coastal watchtowers found throughout the Mediterranean.

Yard: A large spar on a mast of flagstaff from which sails or flags are suspended.

Yeomanry: Volunteer regiments organized at a county level. Provided a military response in the event of civil unrest or invasion.

# List of Acronyms

The list of abbreviations presents the meaning of the various organisational and technical acronyms used throughout this thesis.

| | |
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| GIS | Geographic Information System |
| GPS | Global Positioning System |
| IHAI | Industrial Heritage Association of Ireland |
| IPMAG | Irish Post-Medieval Archaeology Group |
| ISIA | Irish Society for Industrial Archaeology |
| NIAH | National Inventory of Architectural Heritage |
| NLI | National Library of Ireland |
| NLI Mss | National Library of Ireland Manuscripts |
| NMS | National Monument Service |
| RMP | Record of Monuments and Places |
| SMR | Sites and Monuments Record |
| SPMA | Society of Post-Medieval Archaeology |