

Visualising Change in the Tamar Valley: Participatory processes for generating 3D visual tools to communicate sea-level rise

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Publications arising from this research

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Abstract

This thesis introduces and analyses a unique approach which involved iteratively engaging with stakeholders to generate a film about sea-level rise at a heritage site. The project used fine-scale remote sensing techniques, including airborne and terrestrial laser scanning (TLS), to produce spatially accurate and realistic 3D digital visualisations of projected sea level rise at Cotehele Quay, a site on the River Tamar in Cornwall which is owned and managed by the National Trust. Area residents and stakeholders were involved in a series of focus groups which provided guidance on the integration of the spatial models into a short film. This thesis makes an original contribution to knowledge about how non-scientific audiences understand and interpret visual realism and spatial accuracy when engaged with the process of developing such a tool. Ultimately, the thesis proposes a new kind of visual realism based on this knowledge, known as 'participatory realism'. The main output of this research was a film, 'Changing Tides at Cotehele Quay', which is presently being used by the National Trust as part of their wider communication toolkit. In addition to reflecting on the production of the film, the thesis makes the argument that at present TLS is not being proactively used to engage wider audiences. The research explored how TLS and other spatial data can be used in settings which are more public-facing; the thesis analyses the results of this innovative practice and interrogates the way in which people interacted and responded in the course of their participation.

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Chapter 1

Introduction

1. Introduction

1.1. Framing the thesis

The significance of heritage sites as a cultural asset at risk from climate change has been increasingly recognised over the past 10 years, following on from resurgence of cultural and recreational interest in heritage more generally, that has taken place over the last 25 years (Watson and Waterton 2010). The importance of heritage as a cultural asset, providing recreation and tangible evidence of the past, has led to conflicting views over its future management. The dissonance that surrounds heritage management is longstanding and on-going (Tunbridge and Ashworth 1996; Waterton and Watson 2013). Most recently, one of the most pressing issues that has emerged concerns how heritage is managed in regards to the as yet unquantified site specific impacts of climate change. Recent studies have acknowledged that heritage sites embody qualities which engender place attachment (Brown and Raymond 2007). These studies have called for a new heritage management approach which includes lay knowledge in the protection, conservation, adaptation and management of heritage sites, particularly those at risk from climate change (Yung and Chan 2011). By actively choosing to take a more participatory approach to managing heritage, not only will there be more ownership and support for mitigation strategies protecting heritage from the impacts of climate change, but there is potential to have an impact on how people engage with and understand the impacts of climate change on heritage sites in the future. This research is driven by the need to develop strategies for integrating public opinions and insights in the future management of threatened sites.

This research project is framed around an applied understanding of climate change science; whilst not contributing new climate change data, it uses climate projections of sea-level rise to start conversations with and between communities, stakeholders and decision-makers to collaboratively develop novel tools for thinking about the impact of climate change. From an academic perspective, climate change is a phenomenon that is studied by both physical and social scientists. The scientific consensus about the anthropogenic contribution to carbon dioxide levels is growing, and there is increasing recognition that anthropogenic emissions of the greenhouse gases (GHG) will impact on the global climate system (Bertrand, Ypersele et al.

2002; Braganza, Karoly et al. 2004; Storch and Stehr 2006; Rosenzweig, Karoly et al. 2008). There is already evidence of the environmental impacts of climate change across the globe, including ecological impacts (Walther, Post et al. 2002) and rising sea levels (Miller and Douglas 2006), with potential future threats to livelihoods (Tol, Klein et al. 2008), economies (O'Brien and Leichenko 2000) and national security (Cinnamon Pinon 2008).

Climate impacts will not affect the Earth uniformly (IPCCa 2007); from what is known about climate change presently, in the UK the greatest future environmental threat is posed by rising sea levels. It has been some thirty years since the rate of sea level rise was attributed to climate change (Barth and Titus 1984). In the UK, sea-level rise is predicted to have one of the greatest impacts on the economies and livelihoods of people and businesses living and working at the coast (King 2004). The question now is not how sea level will be affected by a changing climate, but how much will relative sea level increase in the future (Miller and Douglas 2006; Rahmstorf 2007). The UK is still experiencing isostatic rebound from the end of the last glacial period (Varekamp, Thomas et al. 1992; Hansen 2007; Rick, Boykoff et al. 2010), and distinguishing between relative and absolute sea level adds complexity to the issue.

The broad issue of climate change frames the research presented in this thesis. As section 1.5 will outline in more detail, this research was initiated in recognition of sea-level rise posing a direct threat to both the physical and social landscape across the UK. The National Trust (section 1.3), who supported this research, have recognised a need to take early mitigation measures on a local level which will address the much broader threats posed by climate change and sea-level rise on the heritage assets in their care.

1.2. Research context

Heritage sites are culturally significant places, which encapsulate cultural and historic memories and actions (Soderland 2009). Over the last 25 years, public interest in heritage has experienced something of renaissance (Watson and Waterton 2010), in part due to changes in popular cultural activity and recreation (Brown 2005) and also due to an expanding media interest in the management of these sites (West 2010). This has resulted in a resurgence of public interest in the

way these spaces and places are managed and protected from future change (Harrison 2010; Watson and Waterton 2010).

Throughout the UK the management of heritage sites often rests with local authorities or trusts and foundations whose activity centres on maintaining and preserving heritage sites in the public's interest¹. These organisations face numerous economic, environmental and social challenges in the coming years. Climate change presents itself as one of the most uncertain future challenges, as scientists are still determining what the impacts will be (Brimblecombe, Grossi et al. 2006).

Climate change impacts on heritage are likely to be felt across the globe (Hassler 2006; Sabbioni, Cassar et al. 2006) in the form of increased erosion of historic structures (Smith, Gomez-Heras et al. 2008) and rising sea levels damaging and submerging low-lying heritage sites (Day and Lunn 2003). In the UK, various regional impacts are likely to be felt, including threats to coastal heritage sites from rising sea levels, and damage to buildings and other structures from extreme weather (Farrar and Vaze 2000; Cassar 2005).

The scientific uncertainty surrounding the impacts of climate change on heritage mean that scientific endeavour is being called upon to provide platforms in which data can be relayed to other audiences and non-scientists in a meaningful and engaging way if participation in management is deemed important (Grimwade and Carter 2000). The importance of undertaking this activity lies in disseminating and generating understanding about the impacts of climate change, as well as encouraging support for plans which mitigate for future impacts, rather than generating confusion and dissonance (Roussou 2006).

This shift in the output platforms of scientific information has led to increased political and public pressure on scientists to publish their research results using platforms that are accessible to a wider audience (O'Neill and Nicholson-Cole 2009), as well as being framed for both national and local audiences (Livingstone 2004). Recent misrepresentation and miscommunication in scientific data has led to the public asking for transparency in the scientific data that is presented to them

¹ For example the National Trust whose motto is 'for ever, for everyone'

(Maibach, Leiserowitz et al. 2012). It is therefore no surprise that scientific practice, methods and results have been called into question (Holliman 2011).

There has been an increase in the academic literature on science and public communication of climate change (Kua, Reder et al. 2004; Collins and Ison 2009; Metzner-Szigeth 2009; O'Neill and Nicholson-Cole 2009) guiding the way forward for scientists to disseminate their research in appropriate channels depending on the intended audience. Yet the *modus operandi* for science communication stems from the release of data to be *consumed* by public audiences, rather than being an interactive experience where the public are able to *engage and participate* with the collection and dissemination of scientific research (O'Neill and Hulme 2009). There is a missed opportunity in this potential engagement stage where important contextual information could be gathered and used by scientists to make the outcomes and deliverables more useful to society. The transition of the public's role in science communication from 'consumers' to 'informers', is discussed further in the literature review chapter of this thesis (Chapter 2).

Heritage sites present a particular challenge for science communication, as it is often not the scientist producing the data who engages with stakeholders; that responsibility falls with the managers of a site. It is these 'middle-man' positions which generate a grey area in the current science communication literature. Managers and decision-makers at heritage sites are well positioned to take advantage of local knowledge and interest in the future of heritage sites, yet lack the scientific knowledge to present reliable and trustworthy data to stakeholders (Bontchev 2009). Heritage managers are on the front line of engagement with local audiences well placed to act in the best interests of local communities and encourage participation in knowledge exchange for the future management of heritage. Engagement with local audiences regarding the generation of scientific data can also generate results which are meaningful to a wider audience, going beyond a local agenda (Treby and Clark 2004).

The National Trust is one such organisation which has an opportunity to engage wider audiences with scientific data. The majority of their sites are open to the public as either free or 'paid for' venues, offering built and natural landscapes to explore and enjoy [section 1.3]. The National Trust has outlined an approach for

adapting to climate impacts (NT 2005), which leaves room for each property to decide upon a strategy which best reflects the needs of the local stakeholders.

This research project stems from one particular National Trust heritage site, Cotehele Quay in the South West of the UK which has experienced severe flooding. The site has been identified as a complex site at risk from further flooding due to sea-level rise [a more complete explanation to the site is included in section 1.4]. At this site, conversations with the general manager identified a need to bridge the communication gap between science and the public in a way that was simultaneously rigorous, thorough, interactive, participatory and visually stimulating. The project used fine-scale remote sensing techniques including airborne and terrestrial laser scanning to produce spatially accurate and realistic 3D digital visualisations of projected sea level rise at Cotehele Quay.

1.3. The National Trust

The National Trust (NT) is a charitable organisation founded in 1895. It is responsible for maintaining public access to over 700 miles of coastline, 280,000ha of land and over 300 mansions and gardens (NT 2005). The NT has a commitment to preserving and maintaining the heritage assets in its care. The scale of their assets range from small man-made artefacts in stately homes, to protected wild habitats and secluded sites. Increasing membership numbers (NT 2012) demonstrate the popularity of the NT among the public, and non-member visitor numbers are increasing year on year. The challenge currently facing the NT is how it manages these sites in changing financial and environmental climates. The NT's ubiquitous motto 'for ever, for everyone' underpins a dual commitment to looking after the heritage assets for future generations and maintaining public access. This creates an underlying tension between doing what is right for the built and natural environment and keeping these assets open and accessible; it may not always be possible to do both. Of these two challenges, the first is complicated by uncertainty about how climate change will affect buildings and sites within NT care. There is a consensus that the climate is changing (Oreskes 2004), and whether this is due to anthropogenic influence (Rosenzweig, Karoly et al. 2008) or natural climate variability (Joshi, Shine et al. 2003), the NT need to be in a position in which they can best manage their heritage assets. This requires informed decision-making

taking into account the opinions and influences of a) building and environmental specialists and b) NT stakeholders, including staff and volunteers, local authorities and the local community.

To begin this process of management and decision-making, in 2005 the NT issued a Statement of Intent in response to the threat of impacts from climate change [Table 1]. This statement acts as guiding principles for how the NT will deal with decisions on climate change, but also introduce uncertainty in how sustainable it may be in the future to preserve their assets in perpetuity (statement number five).

Statement	
1	The Trust accepts that climate change is real and its causes need urgent action
2	We are committed to reducing our own emissions from all our activities; like energy use, land management etc.
3	The impacts of climate change need to be understood and integrated into decision-making
4	We recognise that we have to adapt to climate change and will seek to optimise the opportunities and minimise the risks arising
5	It will not always be possible to preserve our properties and contents entirely unchanged. Unless critical interests require intervention we should seek to work with the grain of natural processes
6	We should be innovative in our approach to adaptation, but should also be opportunistic and economical with resources
7	Climate change cannot be accurately predicted so we need to be both adaptable and vigilant
8	We will be proactive in raising awareness of causes and effects of climate change with members, visitors and the public; and inform people of Trust responses to it

Table 1 Statement of Intent and guiding principles [adapted from NT (2005)(NT 2005)(NT 2005)(NT 2005)]

Part of the NT's response to climate change was setting up a Climate Change Impacts Group (CCIG), which was put in place to raise awareness, both internally and externally, of the NT's approach and principles; provide guidance for property

managers and other staff on practical measures to minimise the risks of climate change; and identify priority properties where intervention may be more urgently needed (NT 2005). Through initial consultation they determined several themes:

- “The need to recognise that we can’t always conserve things exactly as we might once have. This goes for species, habitats, coasts, gardens or buildings
- We will have to make decisions about property management and projects which are ‘climate-resilient’ and allow flexibility in changing conditions
- There are opportunities to exploit as well as problems to deal with
- We need to inform our visitors and Trust members about how we are responding to new circumstances and why management sometimes needs to change”

[NT 2012:11]

These themes were echoed in the NT’s (2005) document, which outlined a strategy for dealing with climate change at coastal heritage sites, taking a long-term view of coping with change. *Shifting Shores* (2005) determined that long-term adaptive management which ‘works with nature’ (National Trust 2005) was the only way to balance future social, economic and environmental demands at many of their coastal properties. The adoption of this coastal management policy sits somewhat uneasily with the NT’s promise to protect the places in their care under their strapline, ‘for ever, for everyone’. Since 2005, the NT has been developing communication strategies that take into account emotional attachments to threatened places and help people to understand and adapt to projected changes to heritage environments. The *Shifting Shores* document mirrored the CCIG’s themes in that it also did not advocate the use of hard defences if these were unlikely to be sustainable. In 2010, the NT produced a coastal risk assessment identifying that 295 of the NT’s coastal sites were at risk from either erosion or tidal flooding (NT 2011) [Figure 1].



Priority Coastal Change Properties arising from CRA2

Scale: 1:2,500,000

Date: 29/06/2010

Heelis
Kemble Drive, Swindon SN2 2NA
Telephone 01793 817400

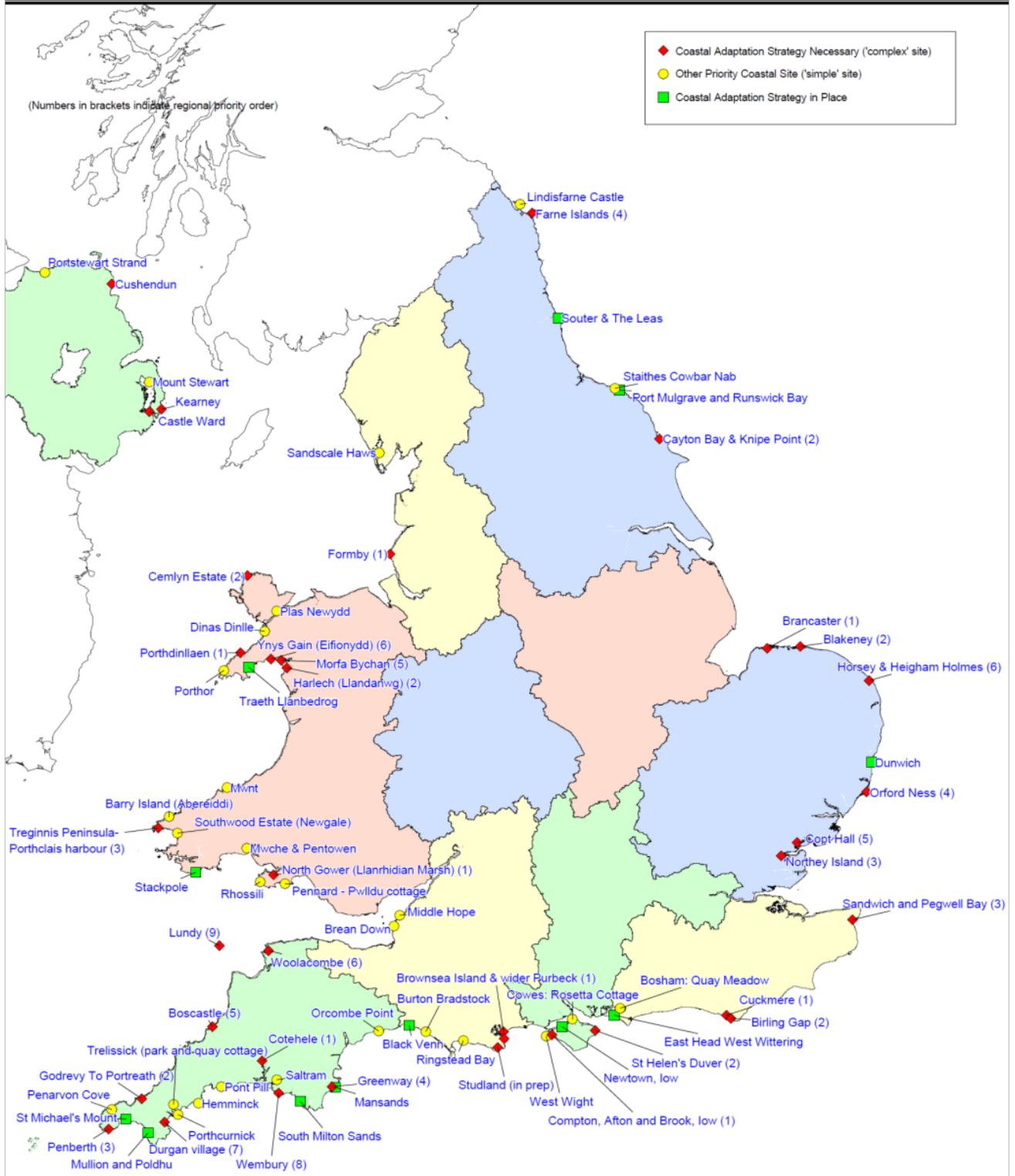


Figure 1 National Trust coastal risk assessment

The NT is currently using this knowledge (NT 2012), to develop and advise different coastal adaptation strategies for properties across the country (NT 2012). The risk map produced as part of the coastal risk assessment [Figure 1] is an indicator of the complexity and multiplicity of decision-making that needs to take place, with each location facing a different degree of urgency and severity of impact. The NT want to engage local stakeholders in the future of their sites, partly to foster understanding about the impacts of climate change, but more importantly to reach an adaptation or mitigation solution that is representative of more than just the NT's needs (Jarman 2005). Rob Jarman, Sustainability Director at the National Trust, said that sustainable heritage does not just mean "holding on to crumbling buildings" (Jarman 2006: 1); rather it means finding ways to protect tangible and intangible evidence from people and environments of the past. People have struggled to come to terms with the reality that these sites are under threat from climate change. Therefore, communicating about change is not purely a 'duty' but also needs to deal with emotional attachments to sites of heritage (Tunbridge and Ashworth 1996).

1.4. Site description

The Tamar Valley is situated on the border between Devon and Cornwall and is protected as an Area of Outstanding Natural Beauty (AONB). Natural England have identified the lower Tamar river and valley as requiring higher level stewardship (HLS), which further justifies its environmental value. Furthermore, Natural England highlighted significant value of this region for its coastal habitats, historic parklands and historic buildings ([AONB 2009](#)). Adaptation strategies vary at different locations, and in the Tamar Valley there are interactions between natural habitats and the historic built environment. For this reason, coastal adaptation strategies may not have dealt with the issues raised at this site.



Figure 2 Location of Cotehele Quay, South West, UK

Cotehele (located at N50° 29.6898, W004° 13.5487) is a National Trust site situated on the River Tamar. The NT site consists of two unique heritage features, Cotehele house and Cotehele Quay, the latter of which is the primary focus for this study. Cotehele house is situated at an elevation of 90 m above sea level and was built in 1485 by the Edgcombe family (NT 2010). Its elevated position means that it is not considered “at risk” from coastal change in the foreseeable future. In contrast, Cotehele quay is situated at 1.2 m above sea level, and lies adjacent to the river Tamar. The historic quayside was a busy port at the peak of the Cornish mining industry (circa 1850-1905) and is recognised as being of considerable heritage value due to its links to Cornish mining during the 18th and 19th centuries. The quay incorporates features of historic interest in the region including lime kilns, barns, maritime artefacts and the quay itself. Cornwall and Devon were inscribed to the World Heritage list in 2006 for their significance as influencing the mining world at large (WH 2010) and Cotehele received special recognition from the Cornwall Mining World Heritage Site for its significance as a port during the industrial revolution (CWDML 2012).

The quayside is composed of mixed-use buildings and properties all owned by the National Trust. This includes holiday rental properties, residential rented properties, and facilities for visitors, including toilets and a café [Figure 3]. When referred to later in the thesis [starting in Chapter 3], once the site has been digitised, each of these buildings is referred to as a separate 'component'. This refers to their state as digitally recorded objects, as opposed to their real life existence as individual buildings.



Figure 3 Plan view of Cotehele Quay and facilities

Due to the landscape and environmental value of the Tamar Valley, it continues to be a popular site for scientific research. Its proximity to local colleges and universities has meant that it has been frequented by environmental scientists looking to explore the flora and fauna (Percival 1929), soil composition (Davies 1983), and estuarine processes (Paterson, Crawford et al. 1990). Its historical significance as a mining landscape has meant that scientists continue to investigate the effect of residual mining chemicals and the impact of

mining processes (Howell, Achterberg et al. 2006). In addition to this, the significance of the heritage of Cotehele means that social and cultural studies have used Cotehele and the surrounding villages to situate research regarding the history of Cotehele House (Cordrey, Bullock et al. 2008; Busby, Hunt et al. 2009) and the cultural landscape of the Tamar Valley (Harkel, Gosden et al. 2012). Whilst there are specific historical investigations into Cotehele House and its contents (Johnson, Thomas et al. 1995; Busby, Hunt et al. 2009), these are not directly related to the research outlined here. As stated previously, there are several villages in the neighbouring parish to the Cotehele Estate. Although the Tamar Valley is a site of scientific interest, the surrounding villages are not as historically significant (relative to Cotehele Quay or the Tamar Valley) and therefore there is no research which investigates these locales in detail. For the purposes of the research methodology and as discussed later in this thesis (Chapter 3, Section 3), whilst Calstock was not under investigation in this research, many of the residents of this small village are frequent users of the river, and as such were targeted to take part in the research. This relates to further stakeholder engagement which is discussed in more detail in Chapter 3.

Part of the attraction for using Cotehele Quay for this particular piece of research was that it offered a chance to simultaneously investigate the scientific characteristics of the river, marrying this with the historical context of the site. Herring's (2007) research began to map the predominant historic characteristics of Cornwall, followed by Wainwright et al., (2012). In some respects this is the first foray into merging the historic and scientific characteristics of the site. A review of the existing literature demonstrates the complexity of interactions (environmental, social and historical) that take place at the site, highlighting its value as a site to study the interactions between these various concepts.

1.5. Project outline

This research used multi-disciplinary methods to go beyond science communication as a 'duty' and a tool for effecting behavioural change [Chapter 2]. This thesis presents the results of an innovative project which combined laser scanning and community engagement methods at a heritage site. A literature review provides an initial indication of the applicability and scope of visual tools for engaging audiences with scientific data (Chapter 2) with the succeeding research chapters detailing how laser scanning and 3D modelling can be used in practice. One of the outputs of this

research was a visualisation tool that can be used as part of a communication package for the NT at Cotehele Quay; addressing the multiple issues of flooding, emotional attachments to heritage and heritage management. The resulting tool was a nine minute mixed-media film incorporating short visualisations from the 3D model along with contextual data including photography. Beyond this one output, other results presented in this thesis include an analysis of the complexity of the mixed-method approach, addressing the appropriateness of laser scanning as a technique to model the site and the practice of conducting participatory research to inform the development of the 3D model.

The research project was initiated after a discussion with the General Manager at Cotehele. Once the NT had identified Cotehele Quay as a complex site for adaptation, the General Manager knew that a more sophisticated and integrated approach, incorporating public opinions about what to do at the site, would be necessary. This stemmed from a history of dissonance at the site relating to flooding. A group of local residents formed an opposition group, known locally as Save Our Dykes in the Tamar (SODITT). This group raised money in order to gain expert advice, conduct research and raise the profile of their opposition to flooding of a site down river from Cotehele, known locally as the Haye Marsh. The NT had submitted plans to flood low-lying grazing land in order to alleviate flooding upstream, particularly for the Cotehele site. SODITT were successful in their campaigning and after two failed planning applications withdrew from the process (SDPV 2012). The result of this exchange between the local community and the NT created a tension for both parties. The NT had failed to protect Cotehele Quay from future flooding and simultaneously alienated the local community from engaging in future conversations, and the local community were encouraged to be sceptical of future NT activity that would alter the landscape. This resulted in the need for a new approach for the NT which could overcome the existing relationship dynamic at the site between the NT and the local community. From the point of view of the General Manager, the main issue was finding a tool that could start conversations, rather than communicate decisions. But this tool also needed to address the social, economic and environmental challenges at the site [Figure 4].

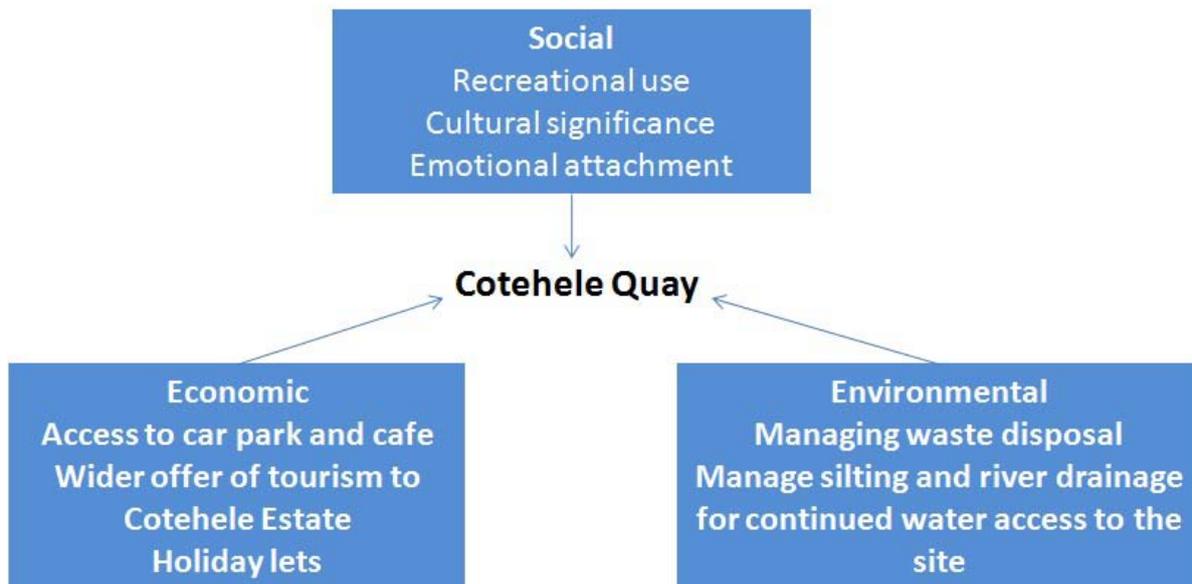


Figure 4 Economic, environmental and social interactions at Cotehele Quay
 [Source: Interview with Toby Fox, General Manager, Cotehele Quay, August 2008]

The interdisciplinary nature of this study required the mastery of two distinct, but inter-related sets of research. Firstly, spatial data capture methods were explored using terrestrial laser scanning methods. This provided data for creating 3D visualisations of the study site. Once these data had been processed, the second stage was to use these data to facilitate discussions with stakeholders, for development of visually stimulating, scientifically accurate and contextually realistic scenarios of change at Cotehele Quay. One of the challenges posed by this research was that these models had to reflect accurately the projected changes (driven by climate) whilst being relevant and engaging to a lay audience. Using terrestrial laser scanning for this purpose raised interesting technical and theoretical questions about the levels of realism and accuracy that are portrayed through digital displays of information. For the NT the main driver of the project was to engage the local community in open and non-committal conversations about how the NT at one of their sites could adapt to rising sea levels.

1.6. Research aims and objectives

This chapter has introduced the rationale for looking at heritage risks in a changing climate. It has explained how climate change as a global phenomenon will impact on sea level in the UK and how the NT are proactively responding to threats to the heritage in their care by seeking to engage local stakeholders in the management of

these sites. The rest of this section outlines the aims and objectives of the research project, specifically outlining how the objectives act as the structure on which the rest of this thesis is written.

This thesis is unusual in that it aims to merge very disparate fields of research to address an area which requires expertise from both technical and social sciences. The aims of this research are centred on outlining, developing and applying a new methodology for the use and application of terrestrial laser scan data to encourage participation in the management of heritage threatened by sea-level rise. In doing so, it questions current heritage management approaches and their applicability to emerging threats in the form of climate change. It contributes to the knowledge on the communication and engagement of stakeholders with data on sea-level rise, adapting existing engagement methods to create a process that evolves in partnership with input from stakeholders. One of the specific technical aims of the research is to demonstrate how terrestrial laser scanning can be used as more than simply a data capture method for the documentation of heritage. The research tested how terrestrial laser scanning can be used in an applied way to generate a visually realistic engagement tool.

In order to evaluate the success of this approach the aims address the technical and social elements individually, whilst also looking to demonstrate the impact of using a multi-disciplinary approach. The aims are:

- I. To develop 3D visualisations which can be used to engage diverse participants in an understanding of the projected effects of sea-level rise on a heritage site.
- II. To arrive at new means of critically analysing the information content of spatial models derived from (i) so that messages about future change, and uncertainties in the scientific understanding behind those messages can be effectively communicated to diverse audiences.

A set of objectives have been written which lead to the fulfilment of the aims. The structure of this thesis is such that the objectives of the research frame the content of the following chapters². The thesis is formed of three methodological/empirical chapters. For these, the objectives are:

² More on the thesis structure in Section 1.7

- [Chapter 2] To identify the characteristics of current engagement strategies in heritage and climate change and to critically appraise present-day methods (including 3D visualisation) for communicating change in heritage and climate change.
- [Chapter 3] To explore how terrestrial laser scan data can be used as a foundation to provide content for community engagement tools.
- [Chapter 3] To determine how to improve, adapt, modify or add to the terrestrial laser scan data to make it more engaging and useful, through consultation with focus groups and solicitation of other stakeholder input.
- [Chapter 4] To construct a digital story (or film) about Cotehele Quay and explore the use of contextual data to do this.
- [Chapter 5] To analyse the participatory process and the implications of engaging with a range of stakeholders in the development of the visualisations / film.

As this thesis predominantly explores the methods of developing a 3D visualisation tool, there is one analytical / evaluative chapter of this thesis which bridges the technical and social themes of this research. The objectives of this chapter are:

- [Chapter 6] To determine how realism and accuracy are interpreted in 3D visualisations, and to determine what characteristics and/or processes make the 3D visualisations appear more 'real'.
- [Chapter 6] To define the appropriateness and applicability of terrestrial laser scan data as a tool for communicating sea-level rise at a heritage site.
- [Chapter 6] To contribute to the knowledge and working practice of current engagement strategies for heritage management, with a specific focus on iterative engagement and 3D visualisations.

1.7. Thesis structure

The structure of this thesis is organised around a detailed breakdown of the methods used for technological exploration and application, complimented by rigorous qualitative data capture. This structure deviates from traditional theses as it

is a hybrid piece of work, combining social and technological sciences, and a narrative, chronological presentation is best able to express this integration.

The iterative nature of the project has led to results sections being included at the end of each methods section, capturing the outcomes of each stage to feed-in to the next. The structure of the report flows between a narrative of qualitative practice and a detailed breakdown of the scientific constituents of technical research. The structure accommodates and reflects the iterative process of data generation and feedback. Outputs of research engagement are presented and discussed and then it is demonstrated how these outputs fed back in to the research design.

Although the outputs can in themselves be seen as results (and would perhaps most traditionally sit within a separate results section), the necessity within the project to reflect on these results before the research could progress means that they *have* to be presented at the point in which they occurred to make sense within the research as a whole, thus making the thesis structure a chronology of events that took place.

The central activities of data collection, data processing, engagement and participation, analysis and feedback were each undertaken at least twice in the duration of the research. This is reflected in the chapter structure; Chapter 3 is the first iteration (stage one), Chapters 4 and 5 are the second iteration (stage two). These are stand-alone self-contained studies into the methodology for creating 3D tools.

Chapter 6 presents a discussion of the results from the research, showing how the technical and social elements overlap. The first half of this chapter primarily focuses on how realism and accuracy can become conflated terms when presenting data visually. It addresses how the epistemology of realism has always been somewhat confused, leading to artists and scientists building their own interpretations of realist theory. Contemporary digital graphic designers have been forced into defining realism by the technological processes it can render upon an image. It further discusses how realism when communicating scientific data can cause a misplaced faith in images, and how this played out in the research. Finally, these sections address the appropriateness of using terrestrial laser scanning as a dataset for making 3D visualisations for sea level rise communication.

The second half of the chapter addresses the participatory processes that were used in the research, looking at the effect that sustained engagement with the research project had on the participants own feelings about sea-level rise. By the end of the research, they were able to articulate their feelings about the threats posed to Cotehele. These sections also look at a new approach to participation in science communication, through digital storytelling. This section argues that although there is a degree of urgency in responding to the threats posed by climate change, participatory approaches can allow people the time and space to develop their own thoughts and feelings in regards to change (rather than being force-fed communication for behavioural change) have the potential to be as effective – if not more so – in creating genuine relationships between scientists, decision-makers and local communities.

Chapter 2

Literature Review

Objective

To identify the characteristics of current participation strategies in heritage and climate change and to critically appraise present-day methods (including 3D visualisation) for communicating change in heritage and climate change.

2. Literature review

2.1. Introduction

This literature review introduces the key themes of this research: heritage, climate change and 3D visualisation. The overall aim of this literature review is to critique the current literature on heritage, participation and engagement for climate change communication, and 3D visualisation tools and techniques. Each of these areas is approached independently, with the concluding sections of this literature review addressing how they overlap and are relevant as joint themes in this research.

The first part of this thesis looks at the significance of heritage sites, as places of cultural significance. It specifically looks at the literature which identifies heritage sites as places which engender strong emotional attachments. Following from this is a review of the dissonance that surrounds heritage. From poorly communicated management decisions leading to tensions between site management and the public, to the reactionary response that the public can have when presented with future site scenarios. The review of heritage literature culminates with a consideration of how climate change is likely to have an impact on heritage sites in the future, and how mitigation measures thus far have struggled with adequately engaging the public in discussions about change.

Having recognised that heritage is likely to be affected by climate change, the second part of the review introduces climate change as a phenomenon which will be felt across the globe and will impact on meaningful cultural landscapes, the review first considers the theoretical and historical significance of people's relationships with nature. These sections culminate in a critical analysis of how climate change communication is undertaken; what strategies and methods employ and use data in a way that is scientifically rigorous, honest, and open and accurately portrays the data, whilst also being easy to understand and engage with and visually appealing to a wide range of audiences.

The third part of this review will consider how the data captured by remote sensing technologies have been used to generate visual data. It will look specifically at the range of remote sensing technologies (satellite, airborne and terrestrial systems)

and then how variations in the spatial resolution of these data mean they can be used to visualise data on a range of spatial scales (from millimetres to kilometres).

The topics discussed in this literature review cross disciplinary boundaries; from heritage to public participation, climate science and remote sensing. To best articulate and demonstrate the interactions between these subjects, the sections offer a series of narrowing sub-headings which look at the detail and interactions of each overlapping theme. The nature and structure of this literature review is in line with the thesis of a whole in which a narrative is drawn that articulates the interactions and complications of addressing social, technical and physical themes.

2.2. Heritage

2.2.1. Place Attachment

For centuries there has been fascination and fear with wild landscapes. Throughout the Romantic era, this fascination grew into an evolving sense of the sacred, associations with core values of culture (Konijnendijk 2012). In the late 18th century, Edmund Burke referenced the wilderness as 'sublime', encapsulating both the fear and awe which are entrenched in natural landscapes (Cronan 1996). Historic landscape artists of the past, such as George Stubbs and Joseph Turner attempted to capture elements of nature that invigorate these senses and this is still something that is present in contemporary art and design (Hodgins and Thompson 2011). Present day cultural heritage sites often embody much of this sense of past wilderness and as such they have become sites which are sought after by the public looking to reengage with historic notions such as romanticism (Chhabra, Healy et al. 2003). People's attachment to landscapes and nature ultimately mean that there is an inherent desire to protect and retain the features of landscapes that generate these strong emotional responses (Kaplan and Kaplan 1989).

The rationale for including a slightly tangential thread within a literature review primarily centred on heritage, climate change and visualising data is that it frames the historic context for why people care about landscapes (going beyond the immediacy of economic impacts). There is a possibility that climate change could render some parts of the world unrecognisable from their present state, although this is unlikely to happen within the next 50-100 years from the time of study

(Mortreux and Barnett 2009). In any case, it is necessary to understand what impact climate change may have on landscapes and how the historic relationship between landscapes and people may affect the format and content of visually communicated data.

Place attachment is the formation of emotional and cognitive bonds with a place (Scannell and Gifford 2011), not necessarily constrained to sites of heritage or other culturally significant spaces. One study by Palmer (2009) used place attachment to heritage to study the epistemology of how knowledge is constructed through everyday experience of the world. She reasoned that a focus on heritage was instructive due to its importance in cultural associations with the notion of inheritance, something being handed down from generation to generation. As Kearney and Bradley (2009) explain, the constant historic re-making and contestation of places over time can create a sense of ownership or belonging, meaning that any new management approaches will have little choice but to take into consideration local knowledges (Agyeman, Devine-Wright et al. 2009). More often, new policy and regulation for mitigation of climate change effects on heritage will face contestation if planning policy processes are not seen to be taking local knowledge into consideration (Agyeman, Devine-Wright et al. 2009). By considering that place attachment builds strong emotional bonds it is easy to see why management decisions made by third parties for the futures of these sites may cause controversy.

Basso (1996) used the term 'inter-animation' to describe the way people actualise place through experience, memory and emotion. Emotional responses are often seen as strong triggers for positioning on an issue (Kearney and Bradley 2009), especially in heritage which are spaces of embodied emotion. Therefore when developing participatory exercises, place attachment should be seen as a tool for engaging new audiences rather than a barrier to engagement.

It would be unwise to disregard using place attachment as an emotional or political trigger to engage audiences with an issue, when drawing together participatory plans for heritage management (Kearney and Bradley 2009). In some cases even the simplest act of recognising that colloquial names for heritage may be important for local citizens, in transmitting a narrative about a place to children and visitors,

can make the difference between support for or rejection of a cause (Kearney and Bradley 2009). Applying this type of lay knowledge acceptance when approaching new audiences for participatory exercises, can alleviate problems from individuals who may feel more strongly about protecting their meaningful places (Scannell and Gifford 2011).

Heritage sites that will be potentially impacted by climate change are more likely to require a more structured approach to place attachment. Scannell and Gifford (2011) explore how strong connectedness to a place was important to climate change attitudes and behaviours because it can sometimes engender place-protective actions (such as opposition to planning and adaptation). In fact using place attachment as a means to engage audiences in participatory activities can serve to be counter-productive, especially in the case of climate change related examples (Devine-Wright and Howes 2010; Scannell and Gifford 2011). Communities may use their emotional attachments to oppose mitigation measures that may appear to have negative impacts on heritage (Devine-Wright and Howes 2010). In order to get round this issue it is necessary to use methods which are clear, concise and accepting of people's emotional attachments to culturally significant spaces (Palmer 2009).

2.2.2. Dissonance in Heritage Management

Tunbridge and Ashworth (1996) claimed that one of the characterising features of heritage was the dissonance that surrounds it (Tunbridge and Ashworth 1996). As has previously been mentioned, if the past 20 years has seen an increase in interest in heritage as a pastime and leisure interest (Cowell 2008) then why have issues of dissonance not yet been successfully addressed? Often the vulnerability of heritage can cause tension between groups, politically, economically or environmentally (Lillehammer 2009) as place attachment relationships draw people into social action against disagreeable mitigation options (Harrison 2010). These struggles are often caused by identity and values that go beyond the superficiality of heritage places but manifest themselves when cultural values are challenged.

Garden (2009) argues that heritage management is made more difficult due to a lack of understanding about what heritage sites 'do' and how they 'work'. As physical spaces they are easy to identify, but as cultural constructs they are highly

experiential spaces (Garden 2009). It may be the case that some people are unclear about heritage, yet for defined local communities and managers the role of heritage in the landscape may be clearly accepted but altogether intangible (Munjeri 2004). West (2010) draws distinctions between official heritage (recognised and protected by states and other local government) and unofficial heritage (sitting outside bureaucratic processes). Unofficial heritage is understood to be in the intangible expressions of traditional culture: such as craft, dance and song. To take this a stage further, it may be useful for decision-makers to realise that much dissonance of heritage management sits within the realm of cultural traditions; that actually this 'unofficial heritage' is what makes heritage so unique and that there is a need to bridge the gap between the processes for recognising and protecting heritage (in an official sense) whilst involving the cultural traditions that these sites encumber.

Drawing attention to contentious issues in heritage management highlights existing gaps between people and decision-makers; a grey area where the tangible and intangible are confused. There is a need for more engagement with those who may feel alienated from decision-making processes, but although the literature does not show many examples of this, there is to some degree a passive engagement with heritage (Cowell 2008). This passivity exists between individuals and groups who may engage with heritage in passive forms, such as site visits and through watching television. If a passive engagement approach has the potential to alleviate tension then more research should be carried out in this field.

2.2.3. Heritage and Climate Change

One sector of heritage that is closely affected by the confusions and complications of heritage dissonance is that affected (or which will be affected by) climate change. A consensus is building which supports the need for educating the public on the impact of climate change on this particular area of cultural heritage and the historic environment (Cassar 2005; Brenner, Dold et al. 2008). Sites especially at risk are those which historic monuments and artefacts are exposed to damage from changes along coastlines affected by climate change (Jarman 2006).

Considering the importance of heritage sites for recreation, education and as sites of cultural significance, there is a considerable lack of understanding about how

heritage structures have responded to climate over time from weathering (Flatman 2009). Flatman (2009) suggests that without further research into the risks posed by climate change we will not have time to manage and preserve heritage buildings; if indeed there is a need to 'preserve' at all. How preservation is undertaken is much debated (Drury 1996; Brown 2005; Brimblecombe, Grossi et al. 2006) with some studies using advanced technology to monitor degradation (Smith, Gomez-Heras et al. 2008; Crespo, Armesto et al. 2010). Management approaches tend to be reactive rather than proactive in responding to threats such as extreme events (Stratton and Taylor 1996). Heritage managers, however, are beginning to plan for an adaptive, extended response to climate change impacts which reflects that not all sites will be sustainable to maintain; having recognised the need for local level communication and consultation in this process (Tunbridge and Ashworth 1996). It is important to involve affected people in discussing a long-term view in planning and management (Sabbioni, Cassar et al. 2006). The need for local level involvement about future adaptation and management is seemingly a joint call from the public and decision-makers alike. The public are concerned about planning decisions that have rendered some stretches of the coast 'no active intervention' (DEFRA 2006); decision-makers are more aware that threats to heritage from the risks posed by climate change are increasingly shared in the public domain (Grimwade and Carter 2000).

2.3. Climate change

From an academic perspective, climate change is a topic that naturally draws on many disciplines, such as sociology, anthropology, and environmental management. This is largely due to the fact that the effects of climate change are likely to be felt on a global scale. The scientific consensus is that anthropogenic emissions of greenhouse gases will impact on the global environmental system (Bertrand, Ypersele et al. 2002; Braganza, Karoly et al. 2004; Storch and Stehr 2006; Rosenzweig, Karoly et al. 2008). There is already evidence of the environmental impacts of climate change such as ecological change (Walther, Post et al. 2002) and sea-level rise (Miller and Douglas 2006). Future threats include risks to livelihoods (Robert 2000), economies (Francesco, Roberto et al. 2008) and potentially national security (Cinnamon Pinon 2008).

Institutions across the globe are modelling the impacts of climate change in order to predict and manage future change (Joshi, Shine et al. 2003). The output of this research is used to inform local and national policy on mitigation measures. Currently, the most fine-scale climate modelling for the UK is produced by the UK's Met Office. The Met Office provides climate projections at regional grid squares of 25km²; each grid includes data on temperature and precipitation change, as well as sea-level rise data for coastal sites. It is more difficult to produce climate change models on small scales (less than 25km²) as often the data required to model the impacts are not available at a spatial frequency suitable for such low resolution models. This means the impacts of climate change on local landscapes are harder to determine; a greater understanding of local level impacts (Demeritt and Langdon 2004) and a reduction in the uncertainty of global projections (Tallacchini 2005; Schenk and Lensink 2007; Brown 2010) would contribute to improving climate models at <25km².

2.3.1. Sea-level rise

It has been almost thirty years since future climate change was identified as having an impact on sea level (Barth and Titus 1984). The question now is not how will sea level be affected by a changing climate, but how much will relative sea level increase in the future (Rahmstorf 2007). There is no one impact of climate change that will be felt unilaterally across the globe, and in the UK the threat of sea-level rise is likely to have one of the greatest impacts on the economies and livelihoods of people and businesses living and working at the coast (King 2004). For this reason, the following sections of the literature review deal more explicitly with understanding trends and rates in SLR and the potential impacts on the UK coastline.

An important point and one that is generally poorly communicated in public discussions about sea-level change is that the UK is still experiencing glacial isostatic adjustment since the end of the last glacial period (Varekamp, Thomas et al. 1992; Hansen 2007; Rick, Boykoff et al. 2010). This means that when communicating sea-level rise, the degree of change is referred to as either relative or absolute (Miller and Douglas 2006). Relative sea level is a calculation of mean sea level minus isostatic rebound, where the land mass is still rising from isostatic

adjustment (Milne, Shennan et al. 2006). Taking into consideration isostasy, relative sea levels in the north of the UK are increasing at a slower rate than in the south.

Trends in mean sea level are calculated using several decades of data, showing mean sea level observations collected from tide gauges around the world (Baker 1993). In the UK as a whole, mean sea levels are rising (Shennan In Press), looking at variations in the rate of SLR in more detail indicates fluctuations with an increased rate of SLR over the past 30 years (Wahl, Haigh et al. 2013).

A brief overview of mean sea-level trends for the UK, show that sea levels have been rising for the last century (Woodworth and Blackman 2002), but simply extrapolating these into the future may be too great an assumption (Gregory and Oerlemans 1998; Siddall, Stocker et al. 2009). Over the past 15 years there has been some confusion over the rate of UK SLR, leading to authors exercising caution about the use and applicability of historic tide gauge records. In particular, Woodworth et al., (1999) challenged the appropriateness of creating projections of sea level based on incomplete datasets³.

At present, there is no alternative to using past tidal records and proxies for historic sea level to make projections of future rises (IPCCa 2007; UKCIP09a 2009). How sea-level projections are translated to information that can be used for adaptation and mitigation strategies and communicated to lay audiences, is something that has largely been left to national and local government to decide (Nicholls and Mimura 1998) and therefore contains uncertainty and is often poorly communicated.

2.3.2. Communicating sea-level rise

There is a tendency for the national and international press to focus on sea-level rise as a linear issue that will affect the globe equally (Woodworth, Tsimplis et al. 1999; Connor 2013; Fears 2013; Harvey 2013). Often these press articles relate sea-level rise to loss of arctic sea ice which can have wide ranging impacts such as

³ A study Woodworth et al. (1999) showed increasing relative sea level trends for the south of the UK for the period 1901 – 1996, although they commented that the quality of some records should be questioned. In the 1999 study, records for Devonport tide gauge show a mean sea level trend of 3.04 ± 1.01 mm/yr compared to Newlyn at 1.69mm/yr and Portsmouth 1.45 ± 0.60 mm/yr; the Devonport result was deemed as anomalous and therefore discarded in long term trend analysis. An updated study by Woodworth et al., (2009) show revised results for the same tide gauges (Newlyn 1.70 ± 0.10 mm/yr, Portsmouth 1.58 ± 0.44 mm/yr and Devonport 2.55 ± 0.75 mm/yr).

impacts on global marine biodiversity and changing temperatures (Connor 2013) despite the fact that this is largely floating ice that does not contribute to sea-level change. Even though 10% of the world's population live on low lying coastal areas (McGranahan, Balk et al. 2007), and any increase in sea level is likely to affect a large number of people, there has been a lack of national news articles focusing on specific local threats to locations across the UK. Arguably the lack of local level stories in the national press is that this falls outside of their remit as press reporters, but in any case, there should be a more equal distribution of stories that communicate both global and local impacts of sea-level rise.

Of those articles which are focused solely on the UK, public awareness about the cause of sea-level rise is centred on isostatic adjustment rather than climate induced sea-level rise from greenhouse gas contribution to the world's oceans. Whether or not the rate of sea-level rise in the UK is enhanced by increases in CO₂ is arguably neither here nor there (Lorenzoni and Pidgeon 2006). Instead, communicating the risks of sea-level rise should take priority (Pidgeon and Fischhoff 2011) in whatever circumstances it is induced. At present there is a significant lack of clarity about the degree to which the public are able to make judgements and decisions about what information is relevant to them, and this has led to sea-level rise communication continually being targeted at a broad and confused public (Weingart, Engels et al. 2000).

Particular areas of confusion have centred on the regional variance, magnitude, and regularity of anticipated coastal flood events (Marcos, Woppelmann et al. 2007; Rick, Boykoff et al. 2010). These are very much issues which need addressing on a regional, if not, local scale (Merz, Thielen et al. 2007). At present, and in some ways to address the gap identified in regards to communicating to a non-targeted audience, local authorities and regionally-based organisations (such as the Environment Agency) have stepped in to help communities better understand the impacts of sea-level rise on their coastline. Unfortunately, at present, it is not the public who are pushing the communication agenda, and whilst the academic literature is able to monitor and comment on the frequency of news articles (Boykoff 2007; Boykoff and Boykoff 2007; Carvalho 2007; Rick, Boykoff et al. 2010) and alternative engagement strategies (DiBiase, MacEachren et al. 1992), in reality the structures and guidelines providing a framework for communicating both sea-level

rise and climate change more generally are embedded in European legislation (2008); having the greatest impact on the amount of communication being undertaken on a local level.

2.3.3. Communicating climate change

One of the ways to help frame thinking about sea-level rise communication is turning to the examples of climate change communication. In doing so, it is possible to identify emerging trends and narratives that are regularly used to communicate climate change and what, if any, other approaches have been taken to tackle communicating complex scientific data. This section does not intend to cover the wealth of literature on the subject, instead it focuses on contextualising the research amongst climate change communication and the evolving field of research that has begun to transition towards engagement approaches, such as upstream engagement.

When climate change first came to public awareness, much of the communication centred on science and policy implications (Boykoff 2008; Moser 2010), but over time, this shifted towards scaremongering tactics and as a result there remains in mass media, a perpetuating discourse of 'fear' (O'Neill and Nicholson-Cole 2009), as well as a lack of balanced reporting on the consensus of anthropogenic greenhouse gases (Boykoff 2007). This has somewhat hindered climate change communication, as publics are now seemingly more sceptical of climate change science, and as a result are less emotionally engaged with the subject (O'Neill and Nicholson-Cole 2009). In addition to this, unless there is direct suffering as a result of climate change, the urgency at which action needs to take place is difficult to communicate. Whilst, behavioural change is not always the intended outcome for communicating climate change, it often serves as the driving factor (Wolf and Moser 2011). This apparent 'need' to change individuals' behaviour, (although not particularly relevant to this thesis as it was not the intended outcome of the research), has driven other researchers to investigate the motivations for, and perceptions of, climate change communication.

One of the challenges that climate change communication faces, is the battle against the disconnect people face between themselves and the environment (Klepeis, Nelson et al. 2001), taking this into account, it is disconcerting that mass

media is the front line source of information about climate change for the general public (Boykoff and Boykoff 2007; Boykoff 2008). Ultimately this leads towards how climate change is framed either as a scientific matter or as environmental stewardship – which has proven to have more effect on people’s willingness to respond to an issue if they feel directly implicated (Wardekker, Petersen et al. 2008). Research suggests that in developed countries, climate change is seen as a distant threat (spatially and temporally) that is non-personal (Ohe and Ikeda 2005; Leiserowitz, Maibach et al. 2008). To counter this, academics have considered how non-environmental factors, such as social marketing (Corner and Randall 2011), and the ‘celebritization’ of climate change (Boykoff and Goodman 2009) could change the perpetuating discourse of climate change as something which is unlikely to have an effect on individuals.

Looking more specifically at individual responses to climate change communication, there has been a recent shift [in the climate change domain specifically], towards upstream engagement (Corner, Pidgeon et al. 2012). This is the process of involving “members of the public in constructive dialogue about emerging and potentially controversial areas of science at the earliest possible stage” (Corner et al. 2012:456). It emerged out of trials in nanotechnology (Pidgeon and Rogers-Hayden 2007; Kurath and Gisler 2009) and later in synthetic biology (Tait 2009). The value of upstream engagement is in generating and understanding the full spectrum of public opinion before the technology is launched. By involving the public in the testing and experimentation of new technology, the engagement builds up a two-way dialogue (Wynne 2006), based broadly on Fiorino’s (1990) four arguments presented in Section 2.5. of this thesis.

There has been a shift in the trajectory of climate change communication, from top down communication towards upstream engagement approaches. This process involves people in decision-making and ‘trial and error’ methods of creating communication and engagement tools. Whilst this does not solve how mass media portrayals of climate change affect public perceptions of the issue, it leads towards a new paradigm of public engagement which can help, in particular, climate change engagement approaches which are targeted at localised, groups of people.

2.3.4. Visual ways of communicating climate change

As discussed in the previous section, climate change communication has followed several trajectories. These trajectories have resulted in a shift in the way that regional and local climate change is shared, particularly due to an increasing reluctance to use 'communication' as a way to describe the sharing of scientific data (Jude, Jones et al. 2006). Whilst communication may still be the primary way of disseminating knowledge on a national and international level (particularly through traditional media channels), this is seemingly less effective for specific audiences who are more adverse to 'receiving' information about places they are familiar with.

However, transitioning to an alternative model of sharing climate change data on regional and local scales is fraught with complexity. Visual tools have emerged in the literature as one of the more effective ways of *engaging* people and they offer the opportunity to convey complex messages simply and clearly when used appropriately (Sheppard 2005).

Visual tools can be produced in many formats; from the digital (e.g. 3D visualisation) to the artistic (Van Kouwen, Dieperink et al. 2007). Artistic visual interpretations may lack the accuracy of computer generated models for showing change, but in some circumstances can provide a valuable new perspective on climate change and have a profound long-term impact on those involved in their creation. At two sites in the south-east of the UK the organisation Red Earth, in collaboration with the NT, engaged local community with coastal change (Lowenstein 2005). This approach involved the public forming a line to show one prediction for the future coastline [Figure 5] (Lowenstein 2005).



Figure 5 Birling Gap, East Sussex. Artistic representation of where the coast will be in 'years to come'

Red Earth's approach shows how artistic approaches are one response to research on coastal change. This artistic interpretation of the data, demonstrates how it is possible to engage a large number of people – predominantly from the surrounding communities – in interpreting scientific data. However, artistic methods are susceptible to subjective interpretation and therefore lack the clear and concise messaging available from other visual tools for share climate change data.

Three-dimensional data visualisation (3D visualisations) have emerged as another solution to combining artistic and scientific realms in data visualisation, particularly as two-dimensional visual tools are becoming redundant in a society whose everyday experiences are increasing technology-centric (Sheppard, Shaw et al. 2008). 3D visualisations have been used for many years in geographical information systems as a tool for visualising urban and rural landscape change, and therefore the accuracy and rigour at which data can be manipulated is well-recognised (Appleton and Lovett 2003; Dockerty, Lovett et al. 2005; Wang 2005). Similar tools are now being exploited as an alternative engagement tool.

Early attempts to improve public participation (Webler, Kastenholz et al. 1995) found electronic means were unable to capture the complexity of needs and requirements of public audiences to reach a state of democratic participation. There are still many complexities when using visual tools, for example Phipps et al.,

(2010) explain that it is not simply a case of removing the technical language, as if they are only understood or engaged with by those who contributed to its creation, they can become a constraint for novice users (Mokrech, Hanson et al. 2009; Phipps and Rowe 2010). Yet as outlined by Sheppard (2012), there are significant advantages to attempting 3D visual tools, these are often motivated by:

- Improving people's understanding of the future with climate change, by communicating complex scientific information clearly
- Conveying what it might be like to experience climate change in the context of specific communities, to help build climate literacy and preparedness
- Sparking the imagination, exploring solutions and inspiring action

[adapted from Sheppard 2012: 355]

There are two research institutions who are carving the path for 3D visualisations for climate change engagement; these are the Tyndall Centre, at the University of East Anglia, and the Collaborative for Advanced Landscape Planning at the University of British Columbia. The Tyndall Centre developed the 'Coastal Simulator' where the user could 'enter into' a coastal zone affected by climate change (Nicholson-Cole 2007). The final visualisation was developed at a time concurrent with review of the SMP procedure, so user feedback was largely influenced by the SMP process. The intention of the modelling results was not to develop specialist knowledge of coastal processes, but to achieve user recognition of the landscape. These allowed the user not only to position themselves spatially, but be aware of a temporal rate of change through cliff erosion. Brown et al. (2006) states that creating identifiable and associable 'nodes' within a visualisation may be a key point of success if users are to engage with abstract forms of science communication, and this is all the more important for small-scale sites where local communities recognise and share the coastline. The Coastal Simulator produced by the Tyndall Centre incorporates three types of visualisation 1) standard time series (lines representing cliff erosion) 2) 3D visualisation and 3) uncertainty representation (Nicholson-Cole 2007). The intention is for it to be used as a platform for knowledge transfer including communication and engagement with non-specialised stakeholders. The quality of realism⁴ used in the graphic displays of the

⁴ Realism is discussed in section 2.11.2.

Coastal Simulator needs further consideration and until user feedback is acquired this will struggle to be effective for lay audiences. Although there are an increasing number of studies looking to understand and visualise the effects of climate change [Figure 6] (Jude, Gardiner et al. 2007), how well these create ‘realistic’ looking models which engage people whilst being scientifically robust is an area that still needs considerable work.

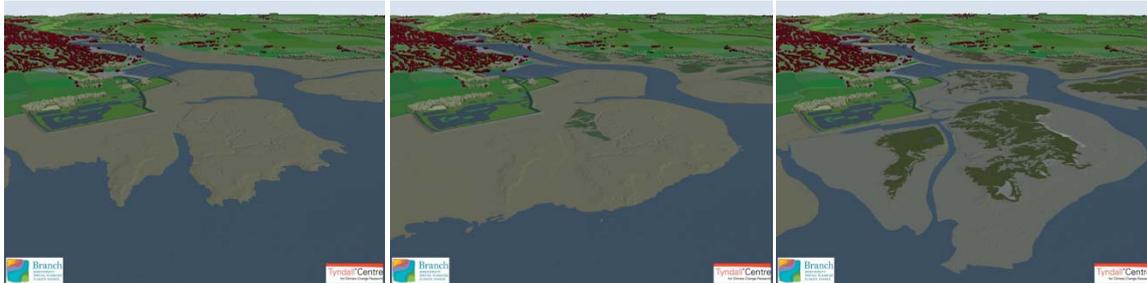


Figure 6 ‘Realistic’ visualisation Normandy Marshes; present day (left), 2080 medium low (centre) and 2080 high scenario (right) (Jude, Gardiner et al. 2007)

The CALP department initiated a Local Climate Change Visioning Project (Sheppard 2012), and conducted some of the most detailed exploration into landscape visualisation for climate change engagement, by any single organisation. Demonstrating the complexity of working on landscape visualisation, the project drew on resources from a number of different disciplines, including psychology, social marketing, landscape architecture, natural sciences and climate science (Sheppard 2012). The extensive research drew on an iterative visioning process with various stakeholders in order to “explore the implications of climate change impacts on their [the participants] region and explore linkages with other community priorities” (Sheppard 2012:406). The Project worked with two communities and developed bespoke 3D visualisations for both locations. As a result, the Project reported that both communities were more aware of climate change and felt that it was more ‘real’ and ‘urgent’. Participants also reported an increase in support for climate change policies.

2.3.4.1. **Feedback**

Perhaps a reflection on the stage of development of the technology, there is seemingly very little feedback about the success of the visualisation tools as a method of engaging people. Papers point towards areas in which audiences have

responded positively (for example the landscape ‘nodes’ as suggested by Brown et al., (2006)), but the overall success is proving difficult to measure. Having clearly defined goals for a visualisation would be an evaluative criterion, but this could undermine the exploratory nature of the tool in the first instance. One of the challenges of collecting feedback, is being able to assess the effectiveness of the tool, but also determining what changes to make to the visualisations themselves. Sheppard’s work with the Local Climate Change Visioning Project is one example of specific and detailed feedback on the visualisation to communicate climate change (for example, 29% of participants reported they had learnt a great deal about climate change), but more data is needed across a range of projects. Building in evaluative and assessment criteria into the visualisation development process, as demonstrated by Bruno et al., (2010) is another solution. If these tools are to develop into a serious alternative to other forms of sharing information, their effectiveness needs to be properly assessed (Tompkins, Few et al. 2008).

2.3.4.2. Where next with visual tools?

Advancing technological capabilities have led to increased experimentation with 3D visualisations as a possible engagement tool. This has aligned with a shift in emphasis from climate change communication, to climate change engagement, fuelling greater public participation in the creation of visual tools that can aid sharing knowledge.

The move away from traditional 2D visual tools is demonstrative of the complexity of trying to simultaneously combine complex scientific data in a form which is visually engaging. The advances in 3D visualisation are demonstrable in the defined motivations for following this route (e.g. from Sheppard 2012). The potential flexibility of these tools, which is really only starting to be exploited, shows promise with regard to their applicability to capturing the interest of diverse audiences. As experimentation with visual tools continue, researchers need to bear in mind both the audiences, but also the policy context in which visualisations are being developed; they are unlikely to ever stand alone in isolation.

2.4. Climate change policy and guidance

The Climate Change Act 2008 was the UK's first legally binding long-term commitment to tackling changes in the levels of greenhouse gases. The Climate Change Act's primary aim is reduce carbon emissions by regulation and monitoring, but included within this legislation were guidelines for more structured adaptation strategies that deal with climate change impacts. Notably:

1. A UK-wide Climate Change Risk Assessment (CCRA) that must be carried out every five years.
2. A National Adaptation Programme (NAP) which has to be reviewed every five years - setting out the Government's objectives, proposals and policies for responding to the risks identified in the CCRA.

Decisively, it is not solely the role of the government to be proactive about changing behaviour and attitudes towards carbon consumption. Yet, it has a responsibility to act as a facilitator of knowledge, to disseminate provision of support and guidance to help local authorities and other government funded agencies share this knowledge. The UK government have not taken any one climate impact in isolation when deciding policy. In fact it could be argued that the regulation of carbon emissions has been prioritised over the last 10 years.

In 2007 the European Union passed the EU Flood Directive (2007), outlining an EU-wide approach to dealing with the threat of flooding – included in this remit is tidal flooding. The Directive spawned a series of UK based laws focused on better management of flood prone areas of the UK, including: the Marine and Coastal Access Act 2009, Coastal Change Policy 2009 and the Flood and Water Management Act 2010. The most ambitious practice to be encouraged by the EU Directive was the support for Integrated Coastal Zone Management (ICZM). In theory, an ICZM approach brings together different policies and decision-making structures, fostering cohesion among coastal stakeholders to reach common goals (DEFRA 2008). In practice, ICZM has recognised economic and ecological benefits (Bower and Turner 1996; McGlashan and Firn 2003), most notably the ability to identify causal links across disciplines and geographical regions (Van Kouwen, Dieperink et al. 2007). Compared to individual efforts to manage our coastal assets, ICZM adopts an holistic approach where political, ecological and economic boundaries are crossed to create a “desirable mix of socially desirable products and

services” (Bower & Turner 1999:6). The limitations of an ICZM approach are that it fails to take into consideration social cultures along the coast; although not explicitly stated, the end goal of ICZM is to generate an economically successful coastline with less regard for existing cultural discourse. By neglecting to engage with the social dimensions of coastal areas, the ICZM tends to work on a model which is seen as reactionary rather than proactive (McGlashan 2002).

With regard to climate impacts on coastal sites, adaptation policies organised on principles of ICZM may not be the most effective approach for helping individuals and local communities deal with predicted impacts. The cross-boundary approach of ICZM may make policy and planning a less bureaucratic process, but it fails to address the emotional, social and financial constraints individuals have along the coast. Nicholls, Wong et al. (2007) argued that adaptation strategies should be integrated into ICZM and should not act as ‘stand-alone’ efforts. In some circumstances, in order to tackle individual needs there will need to be a breakdown of the coastal zone into geographic regions that have a similar purpose or role; in this way localised issues that arise can be addressed that find ways of adapting that are more localised and meet the needs of the local community, especially as new and uncertain futures are played out under climatic changes (Weinstein, Baird et al. 2007). Due to rapidly changing knowledge and understanding regarding climate change impacts, it is yet unclear if ICZM will have a long-term position as a coastal management strategy. Literature thus far shows little evidence that ICZM will shift towards incorporating social issues in its ‘holistic’ approach (Weinstein, Baird et al. 2007; Portman, Esteves et al. 2012).

2.4.1. Coastal adaptation: support and guidance

As part of the on-going effort to bridge the economic and social needs of coastal sites, planning policy and guidance has been receiving considerable attention in recent years. This includes round two of Shoreline Management Plans 2009-2010 (DEFRA 2006), and a Consultation on Coastal Change Policy (DEFRA 2009). Alongside the development of policy and guidance on the impacts of climate change, there was relatively little complementary support for exactly how (and who) should be engaging with the public to share these plans. To address this, DEFRA funded a Local Authority-led initiative aimed at improving understanding of how

coastal communities can adapt to coastal change (e.g. Pathfinder Projects) (DEFRA 2009). The Pathfinder Projects allowed local authorities the freedom to develop adaptation solutions that were more suitable to local issues and flooding concerns, through a process of engagement and communication with the public. Even though the Pathfinder Projects gave local authorities a degree of freedom in how exactly to communicate and decide on future plans for coastal sites, it has raised questions regarding the most effective method for communicating these changes. Dorset County Council received £376,000 for the generation of site specific coastal scenarios, using a range of visual media. An interview with Project Officer, Henry Aron (August 2010) who co-ordinated the development of these scenarios, explained that currently no precedent is in place for how these should be created and deciding scenarios will be a “collaborative decision between scientists and stakeholders” (Interview Henry Aron, Project Assistant, August 2010).

2.5. Community engagement

Arnstein (1969) attempted to conceptualise a model of participation with the ‘ladder of citizen participation’. Arnstein suggested that the partnership level (rung 6 on the ladder) enables the powerless to negotiate and engage in trade-offs with traditional power holders and is the first meaningful step towards citizen empowerment. Arnstein is sceptical about the motives for most participatory exercises, and assumes that any meetings which are initiated for participation can be turned into “vehicles for one-way communication” (Arnstein 1969: 219). It is further suggested that participation without the redistribution of power can be an empty and frustrating process.

This distrustful standpoint serves to undermine *any* attempt at participation and discourages rather than encourages participatory techniques. Collins and Ison’s (2009) critique of Arnstein’s ladder led them to suggest social learning as a new paradigm for participation in climate change adaptation. They believe that social learning involves a collective engagement process which assumes stakeholders are intelligent, responsible agents who are able to co-design their own adaptation policies (Collins and Ison 2009). They criticise Arnstein’s ladder for constraining the way we think about participation, particularly in a climate change context. Taking Collins and Ison’s (2009) argument further, there is still scope to questions how

power relations between stakeholders and academics could easily form between those who are knowledge-rich and knowledge-poor. In contrast to recent research (Kesby 2007), Collins and Ison's (2009) research does not intend on 'picking sides'; it is not about empowerment or power, but concentrates more concerted on a shared knowledge of the future. These ideas build on Burgess and Chilvers' (2006) work regarding the design and implementation of a framework for evaluating participatory methods. Rather than a 'ladder' in which there is a top and bottom (inciting negative connotations of 'top' being superior), they suggest engagement approaches are structured along a continuum, with one end being the provision of information, and the other the delegation of decision-making power (Burgess and Chilvers 2006). Ultimately their argument is that the purpose of participatory activity is to achieve agreement about the end result and its purpose.

This adds a positive dimension to an otherwise negative critique of participation. As Petts (2008) explains, trust can be built when specific elements of information can be traced to particular sources whose reliability can be tested. In a climate shrouded by uncertainty and constant debate about the future of carbon emissions and sea-level rise, the focus of participatory theory should shift to centre more effort on helping researchers and scientists understand how participation can be a tool to communicate and co-produce scientific findings; rather than used as a position of power in communicating scientific findings and developing trust for 'easy' decision-making (Few, Brown et al. 2007).

The need to build trust as intrinsic to the engagement process stems from people's increasing lack of control over the social dimensions that affect them (Fiorino 1990). Arguably, building trust through engagement mechanisms builds democratic skills in those involved as well as overcoming any feelings of powerlessness in the process (Fiorino 1990). Trust and engagement go hand in hand: the key to building trusting relationships is time. Building trust between participants can be difficult to create and maintain throughout engagement process (for example: SMP review, DEFRA Pathfinder Projects). Reed's (2008) research into stakeholder engagement draws on several studies which critique the appropriateness of engagement processes. In Reed's (2008) view, participation should not be approached as requiring a 'tool-kit', instead it should be viewed as a 'process'. By taking this approach when building long-term relationships between the public and decision-makers trust is established

as each party negotiates solutions. Reed (2008) suggests caveats to long-term, protracted, engagement particularly in regards to the philosophy and approach of the researcher and the emphasis that is placed on helping the participants to recognise and have genuine control with regard to shaping the outcome. Larsen and Gunnarson-Östling (2009) explore the term 'participatory service contract' as an alternative for participatory 'process'. This is a much more commercial and top down approach to participation and engagement as it suggests those involved are entering in to a binding contract which they are contractually obliged to fulfil. An alternative, and perhaps more applicable method to develop trust within a group could be a deliberative shift in the focus of a project from the output, to the process itself being open and diverse (Larsen and Gunnarsson-Östling 2009).

Running in parallel to power, the space in which engagement occurs should also be considered. Shifting strategies for engagement (as outlined in Burgess and Chilvers (2006)), have changed the need for spaces of engagement; moving toward social spaces in which participants feel able to share their views and experiences. Lefebvre suggested that social relations only exist in the spaces in which they are experienced (Lefebvre 1991), and that they have no reality outside their environment. Taking Lefebvre's argument, spaces for engagement are a unique environment which is unlikely to be created elsewhere. Therefore, 'participatory spaces' need not be bound by social constructions of power, rather should act as 'heterotopias' (Foucault 1995) where beliefs and ideals can be explored and debated without confinement to the laws of normal social dynamics. An interlinked dimension to how participatory spaces can be heterotopias is Cornwall's (2002) proposal that power, space and time are interlinked, suggesting that participatory spaces open up a socio-spatial arena governed by a set of discourses and practices quite unlike those that order everyday spaces and agency (Cornwall 2002). Jupp (2007) suggested that groups may respond differently to being involved in engagement activities if they are frequently invited into working groups or asked to participate in some form of engagement exercise. Those most frequently invited to engage in engagement are groups with either a little or a lot of contact with policy-makers (Jupp 2007). These groups may therefore be exposed more frequently to spaces where the boundaries of power are blurred.

Although both power and space remain a consideration within engagement strategies, this thesis looks to override a hierarchical approach. It is clear that when attempting engagement to aid decision-makers, the power relationship may lie with the 'gatekeepers' of knowledge, regardless of efforts made otherwise. Successful engagement strategies could arguably rest on two factors 1) ensuring that participants have the power to really influence the decision 2) ensure participants have the technical capability to engage effectively with the decision and the process (Reed 2008). Climate change data, from a general public's perspective can be confusing and misinterpreted (Nerlich, Koteyko et al. 2010). For this reason, following the two factors outlined by Reed become more significant in the context of climate change engagement approaches (Nerlich, Koteyko et al. 2010; Wolf and Moser 2011). This thesis will attempt to distribute power relations between the local community and managers by focusing on the means as well as process to produce visualisations rather than the end product (as proposed by Larsen and Gunnarsson-Östling 2009).

Fiorino (1990) developed a participation theory of evaluating risk, in response to a technocratic orientation which did not reflect citizen participation in risk decisions (or the democratic orientation). Participation theory is founded as a counter argument to the technocratic orientation, based on a substantive argument that lay knowledge is of equal value to that of experts, a normative argument that technocratic orientation does not align with democratic ideals, and finally, an instrumental argument that citizen participation legitimizes decisions. Fiorino (1990) proposed four criteria for evaluating risk which take into account the democratic values: direct participation of amateurs in decision, collective decision-making, structure for face-to-face discussion and an assessment of the opportunity it offers citizens in feeding in their knowledge. These criteria are based on the assumption that individuals have the capacity for collective decision-making and political awareness to contribute meaningful to risk decisions. Fiorino's (1990) argument was that by approaching risk evaluation using these participatory methods, citizens would be less likely to feel powerlessness and alienation and would ultimately contribute more to the political system.

For some time, the focus remained on public involvement for developing policy (i.e. decision-making). As theories of engagement and participation evolved, there was

an emergence of evaluation criteria to attempt to identify the 'quality' of the engagement methods (Walls et al. 2011, Rowe and Frewer 2000). Rowe and Frewer (2000) developed evaluation criteria broken down into two sub-categories: acceptance criteria and process criteria. Traditional engagement methods were then analysed against these criteria, demonstrating that a hybrid approach (using multiple methods of engagement) would work best in most cases, achieving the majority of criteria. The 'top-down' methods (e.g. public hearings), perform most poorly according to these criteria. Building on this work, Chilvers and Burgess (2008) developed an 'analytic-deliberative' process of appraisal. This approach further explores the relationship between scientific analysis and the engagement process. Chilvers and Burgess (2008) work critiqued the framing and construction of engagement processes, suggesting a move towards a constructive relationship between science and democracy would alleviate the tension that participation is becoming institutionalised. Both Chilvers and Burgess (2008) study and Wall et al.'s (2011) research contribute two notable findings which are relevant to this thesis: firstly that attaining measurable evaluation criteria should be built into informal and organic forms of engagement, and secondly that participants should be notified of the influence of their contributions.

2.6. Strategies for engagement

Engagement strategies for environmental decision-making existed before the need to communicate the effects of climate change (Few, Brown et al. 2007) and have been prevalent since the uptake of Principle 10 of the Rio Declaration in 1992 (van den Hove 2006). The focus of this section is how engagement is enacted in an environmental context, and the recent development of specific coastal change engagement strategies. In the UK, coastal managers and decision-makers are provided with empirical support for understanding the impact of coastal change in the form of Shoreline Management Plans (SMPs). The UK coastline is broken down into regions and then individual contractors are employed to conduct research into the effect climate change will have on that area of coastline. The guidance for SMP engagement (DEFRA 2006) involves two-way stakeholder engagement at stages 4 (public examination) & 5 (finalise plan) of the project. It explicitly states that in order for an effective dialogue to be generated more than one way of passing information

should be undertaken, otherwise the objectives of the SMP will not be met. Strategies for information sharing have included:

- Focus Groups
- Advisory Committees
- Workshops
- Round Table Discussions
- Questionnaires and Surveys
- Exhibitions and Road Shows
- Public Meetings
- Multi-media approaches to share information
- Structured Interviews
- Semi-Structured Interviews
- Forums

(DEFRA 2006)

The development of the SMP strategy evolves over several months and this gradual process benefits the involved parties or stakeholders as it develops and sustains relationships over this period (Satherley 2009). A criticism of the SMP engagement strategy is its approach to contacting and maintaining stakeholder interest. Although an initial advertising campaign is carried out to make the public aware that an SMP is being undertaken, later in the process no new interest is generated. A lack of continual engagement reinforces a top-down approach whereby information is presented and in theory should be accepted. Considering that future scenario planning involves uncertainty (which is, as previously discussed, complicated to communicate), it may well be that reducing the amount of public engagement in producing the SMPs is a strategy for limiting criticism. Satherley et al. (2009) found that sustained contact with a local interest group raised community awareness of the issue and developed trust and ongoing interest with participants. Increasing the amount of contact with participants has the potential to alleviate the pressure to arrive at a finite decision yet requires an intense engagement strategy. Unlike the SMP review, Satherley's study took place on a small scale, in a local community: there needs to be a compromise between national and local projects where a greater number of stakeholders are engaged and this is then sustained.

Arnstein's "Ladder of Participation" has since been explored and re-theorised by many researchers looking to redefine individual components of the ladder (Collins and Ison 2009). On a superficial level it is clear that elements of the SMP engagement strategy are merely an effort towards what Arnstein coined *tokenism*. This suggestion is derived from the fact that most engagement strategies are aimed at devising engagement strategies that aid in successful decision-making. For this reason, the end goal is to make adaptation policies more implementable at a management level and the focus is retained above the public sphere. Both in practice and reality there has been a lack of research into the benefits of public participation for engagement's sake, and rather a focus on engagement for successful decision-making (van den Hove 2006; Fletcher 2007; Milligan, O'Riordan et al. 2009). To address this, DEFRA established the Pathfinder Project in June 2009. This was the first collaborative scheme which encouraged local authorities (LAs) to engage local stakeholders in conversations about the impact of climate change and work with them to develop strategies for the future. Unfortunately many LAs lack a successful precedent for the development of engagement strategies and the SMP engagement strategy was poorly received. Meeting set objectives may help engagement strategies have more success, rather than just providing a 'box ticking' service. One Pathfinder Project, at Slapton in South Devon, has created a new participatory approach in order to communicate coastal change. This may have been a reactionary response when an access road was breached by a combination of high tides, low pressure and strong winds. Since this event, how the community and LA have responded has initiated a re-invigorated interest in successful engagement (Trudgill 2009). As Larsen et al. (2009) suggest the idea is to stimulate processes open to different possible scenarios without experts steering the process too much, something which has seemingly been a success in the Slapton Sands example.

2.7. Tools for Monitoring Cultural Heritage

This PhD project is focusing on community engagement at a heritage site at Cotehele Quay in Cornwall and has so far established that heritage sites affected by climate change need effective communication strategies which engage the public in understanding the impacts, whilst also being mindful of people's attachment to such places, and in some cases, using this as a tool to foster enhanced engagement.

This section looks at the application of spatial data as a tool for visualising heritage landscapes. Firstly comparing airborne and terrestrial laser data capture methods and then looking at how this data can be visualised to convey a message.

2.8. Spatial Data

The scope of this section is to review how remotely sensed data have been used to create visual representations of reality which can then be used in community engagement. Spatial data is thus called for the 'spatial' element, as these data each have a geographical reference (Haining 2003). Three dimensional (3D) visualisations will require data that are spatially distributed, conveying information on the location, shape, size, height and texture of the object/s under observation. Such spatial data can be captured using a variety of technological tools, including satellite remote sensing (e.g. optical or RADAR imaging) (Tatem, Goetz et al. 2008), airborne data capture (e.g. optical or thermal videography, laser scanning (LiDAR), and hyperspectral scanning) (Flood 2001; French 2003), ground based surveying (e.g. differential GPS surveys, ground-based laser scanning, field mapping (Tarchi, Rudolf et al. 2000; Patias, Grussenmeyer et al. 2008; Zhilin, Chen et al. 2008). The range of technological options for the capture and visualisation of spatial data for public participation exercises means that each have advantages over another for specific purposes. Each method is able to capture data with different resolution characteristics (spectral, spatial and temporal resolutions) but each method provides data at different resolutions and these differ between the types of remote sensing system selected, thus each is required to 'trade off' its ability to capture one resolution in order to enhance another. A comparison of different systems is shown in Table 1. Greater geographic coverage (extent) can be met with satellite and airborne methods; however these offer reduced spatial resolution compared to ground-based methods. If recording and observing environmental change is necessary then the regularity and reliability of satellite data can provide datasets of change over long timescales, where this may be difficult with manual recording (such is the case with DGPS). This table demonstrates that it depends on the requirements of the research what resolution the data needs to be collected at, and that this may be constrained with the availability (frequency of capture) of data or financial cost of collection.

<i>Type of data</i>	<i>Spatial resolution (m)</i>	<i>Spectral resolution</i>	<i>Coverage extent (swath) /</i>	<i>Temporal resolution</i>	<i>Orbital distance</i>	<i>Data cost</i>	<i>Reported spatial accuracy (in x,y domain)</i>	<i>Indicative reference</i>
Satellite regional, optical (e.g. Advanced Very High Resolution Radiometer)	1000	4 bands, VNIR	2,500km	Twice daily	833 or 870km	high	Undefined for AVHRR (Friedl, Woodcock et al. 2000)	(Ehrlich, Estes et al. 1994; Stathopoulou, Cartalis et al. 2004)
Satellite multispectral (e.g. Landsat, Advanced Land Imager)	30	7 bands covering VNIR and TIR	185km	revisit time = 20 days	705 +/- 5 km (at the equator) sun-synchronous	medium	±20m	(Goward, Masek et al. 2001)
Satellite hyperspectral (e.g. Hyperion)	30	10nm	7.75km	revisit time = 16 days	705km	high	6% absolute radiometric accuracy / observed 3.4%	(Pengra, Johnston et al. 2007)
Satellite: active microwave i.e. RADAR (e.g. CloudSat)	>1km	4 bands	2.5km	revisit time = 16 days	705km	high	Undefined	(Stephens, Vane et al. 2002)
Airborne light detection and ranging (LiDAR)	Up to 25 cm	One band, usually green or NIR	~2km depends on flying height	As often as you can afford to fly	1000m up to ~10000m	high	~15cm	(Lan, Martin et al. In press)
Ground-based DGPS surveys	User defined	N/A	User defined	As often as required	N/A	low	1 – 100mm (McCoy 2005)	(Teatini, Tosi et al. 2005)
Ground-based laser scanning	0.02 – 1000	Dependent on scan system, usually one band: green	Range dependent on model (0 – 1000m)	As often as required	N/A	Low (excl equipment cost)	Dependent on scanner. Leica HDS 3000 Target accuracy 1.5mm (Leica 2010)	(Lemmens 2009)

Table 2 Systems for capturing spatial data of landscape features: a comparison

2.9. Terrestrial Laser Scanning vs. Airborne Laser Scanning

2.9.1. Terrestrial Laser Scanning

Terrestrial laser scanning (TLS) as a method in remote sensing data capture is still in its infancy when compared to aerial LiDAR systems, and currently there is no consensus on a 'best practice' (Hodge 2010). Therefore when choosing TLS as a survey tool, one must carefully consider the capabilities of a wide range of systems. Numerous studies have attempted to do this (Huisug and Perierira 1998; Lemmens 2007), yet few have been successful in realising the potential in specific applications (e.g. documenting cultural heritage), instead focusing on general comparisons in accuracy and precision. A TLS system is "any ground based device that uses a laser to measure the three-dimensional coordinates of a given region of an object's surface automatically, in a systematic order at a high rate in (near) real time" (Barber et al., 2003: 622). The data collected is more commonly known as a point cloud, which is a common co-ordinate system where each data point has an X,Y,Z value as well as an intensity value (Barber 2003).

TLS has applications in many fields of research (Jones, McCaffrey et al. 2009), and the choice and availability of different scan systems means there is a scan model capable of capturing data on almost any scale. TLS systems are optimised for fine-scale, detailed analyses of localised patches of landscape and would not be useful for extents of greater than a few 100 metres by a few 100 metres, therefore it is not possible to gather regional or global extent data with these systems. Table 3 shows a comparison of some of the most popular scanners used in the documentation and study of cultural artefacts. For cultural heritage documentation there has been a focus on using close-range laser scanners as these use the technique of triangulation for data registration. Triangulation is preferred in this context as it guarantees both high accuracy and fine spatial resolution (<2mm) for

small and detailed artefacts (Boehler, Heinz et al. 2001). An alternative principle for data capture is time-of-flight, which is primarily used for larger scenes as increasing the distance range of the laser beam decreases the recorded accuracy using the triangulation method (Boehler, Heinz et al. 2001).

	System	Measurement	Frequency	Range	Performance
Leica	HDS 3000	Pulse	1000 Hz	>100m	A: 6 mm @50
Mensi	GS 200	Pulse	5000 Hz	700 m	R:3 mm @100
Optech	IL-RIS 3D	Pulse	2000 Hz	800 m	\bar{A} :3mm <100 m
Riegel	LMS Z 360	Pulse	8000 Hz	800 m	R: 5 mm
Riegel	LPM-25HA	Pulse	1000 Hz	2 – 60 m	R: 1 mm

Table 3 Comparison of laser scanning operating models (A: Accuracy at known distance, R: Finest spatial resolution achievable)

Buckley et al. (2008) explained that longer range instruments use a higher power laser in frequencies such as infrared, however there is a trade-off in that the laser diverges at greater distances resulting in lower positional accuracy. Close-range scanners have traditionally been more popular for cultural archiving as a lower powered laser may have a limited range (<100m) but the shape of the beam stays stable; leading to higher accuracy and available spatial resolution (Buckley, Howell et al. 2008). It should be noted that due to the range of scan models, testing accuracy will need to be carried out prior to each project on the model used in a particular study (e.g.Boehler, Heinz et al. 2001).

Although close-range scanning is popular for digital recording of small objects, one of the advantages of using a laser source is that the laser light is extremely bright and highly focused (Pavlidis et al., 2007), suggesting that the opportunity to use this on larger scales should not be overlooked. Interdisciplinary studies which look at landscape scale heritage sites are less common, although beginning to be undertaken (Zheng and Wang 2007; Entwistle, McCaffrey et al. 2009). Entwistle et al's (2009) covers an area of 60x40m, which is a useful comparative study considering the site

observed in this thesis is approximately 100x40m. Entwistle et al's (2009) study suggests that TLS produces enhanced spatial resolution and improved vertical accuracy, and is much cheaper to implement, without the need for airborne surveys. The popularity of TLS is increasing and much work on documenting heritage (artefacts or buildings) is demonstrated on the Cyark website (Cyark 2010). Cyark is an organisation which aims to capture, using TLS, sites of global heritage importance and provides a portal for the dissemination of surveying work undertaken. The advantage of using laser capture for heritage is that these sites are potentially remote or protected areas where close-range scanning may not be possible and aerial LiDAR does not provide sufficient detail at a high enough spatial resolution. Whilst digitally documenting heritage (artefacts and landscapes) using TLS creates a digital record, often these digital archives go little further than providing educational tools and sources and data for research and are infrequently applied proactively in other situations.

Use of hybrid techniques, namely TLS and photogrammetry, has been widely documented (Ahmon 2004; Boochs, Heinz et al. 2006; Pesci, Fabris et al. 2007; Yastikli ; Boochs, Huxhagen et al. 2008) especially for cultural heritage recording. This data combination has advantages for recording cultural artefacts as digital photography can capture the spectral qualities of a surface which aids when developing visualisations; something which many terrestrial laser scan models lack (Boochs, Heinz et al. 2006). The additional time implications of including more than one dataset have been highlighted (Boehler and Marbs 2004), but Boehler et al. (2004) argue that increasing the amount of data can only benefit the final model.

An alternative to TLS and photogrammetry is the use of aerial LiDAR to make landscape scale models. This combination has been less well studied (Buckley, Howell et al. 2008) which is no doubt due to the large datasets generated from scanning and the physical constraints of using laser scanning, such as the cost of acquiring a suitable model, weight for transportation and travel, and the range of environmental conditions that

prohibit survey work (Entwistle, McCaffrey et al. 2009). Dransch (2000) argued that “the visualisation of spatial data is not restricted any longer by technical constraints” (Dransch 2000:5) the lack of research into visualisations of landscapes using fine scale data suggests otherwise. The ability to combine datasets collected at varying spatial scales can be an important part for contextualising a study and an appreciation of cultural sites can best be achieved by viewing them in context and combining TLS with aerial LiDAR datasets can achieve this, something which current heritage digitising omits (Cyark 2010). There is a continuing quest to get higher spatial resolutions on a landscape scale (centimetre resolution over metres) (Smith, Chandler et al. 2009). Whilst a higher resolution provides a more detailed image of the landscape, there is a lack of technology which allows these data to be visualised (Dekeyser, Gaspard et al. 2002). As is the case with much TLS data, it is frequently observed that not all the data recorded is required. This is a frustrating dimension of TLS as it increases the processing time spent dealing with millions of points, which ultimately may be redundant.

2.9.2. Airborne Light Detection and Ranging (LiDAR)

Aerial data acquisition has advantages over its ground-based alternatives in that one is able to acquire information about landscape features of a greater extent (Guenther, Cunningham et al. 2000; Jude, Jones et al. 2006), as well as providing a more spatially efficient method for collecting data of broader geographic coverage (Booth, Cox et al. 2008).

The coverage extent of LiDAR (km scale) and spatial resolution (~2m+) has proved popular for archaeological purposes (McCoy and Ladefoged 2009) and recent research has been in feature detection of archaeological sites (Devereux, Amable et al. 2008; Hesse 2010). For both Devereux et al. (2008) and Hesse (2010) 2.5 metre resolution has been sufficient for the detection of many slight archaeological landscape features [Figure 7]. McCoy et al. (2009) suggest this is still not fine enough and can be a limiting factor to detailed archaeological surveying. One study had to

exaggerate the scale of the DEM generated from LiDAR data 20 times in an effort to portray subtle features of the landscape (Hesse 2010). Although this thesis is not looking to 'discover' or survey archaeological sites, the distortion generated by exaggerating the scale of the data by this amount will hinder the ability of the visualisations to appear 'realistic'.

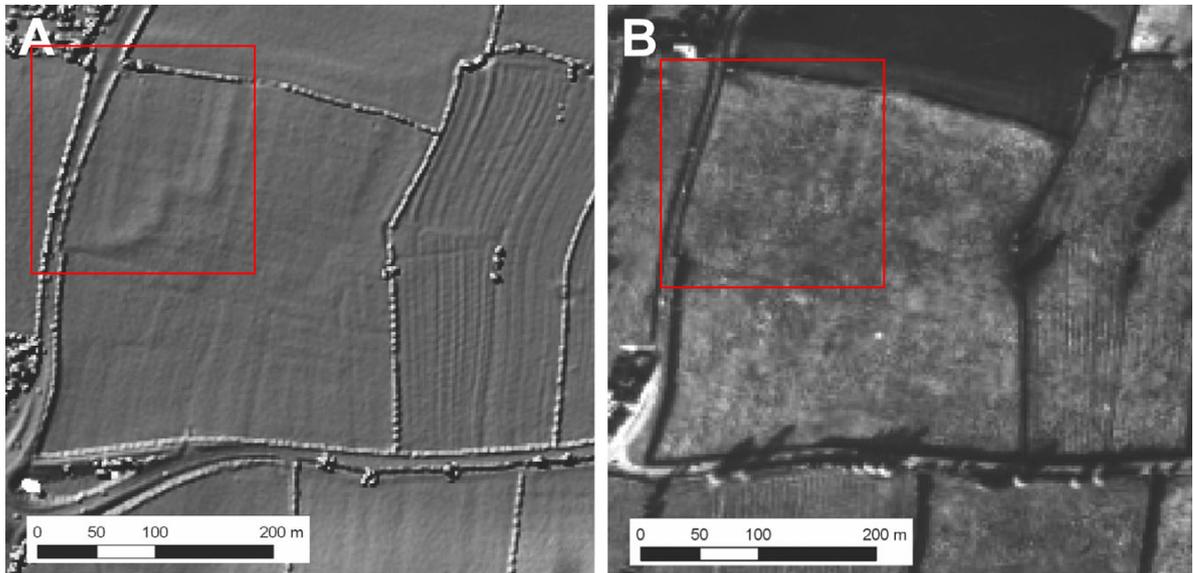


Figure 6 Examples of earthwork features which were detected by LiDAR analysis (a), but which are not visible on the aerial photography (b) (Challis, Kokalj et al. 2008)

The elevation accuracy reported by the HDS 3000 laser scanner is significantly higher (6mm) than the elevation accuracy from LiDAR data. Hodgson (2004) studied the accuracy of the reflected laser beam over different surface topographies and found that on the smoothest surface (pavement) an error of 14.9cm was observed in the LiDAR data, increasing over complex topographical structures to 20.3cm in deciduous forests. Palamara et al. (2007) suggested that by combining elevation data from two separate remote sensing techniques it is possible to show error and gauge the accuracy of the data. Unless the two datasets are derived from the same source it may not be possible to accurately compare the error of elevation between two datasets without resulting in a relative data precision for the two instruments used.

Another area of advance for the use of LiDAR technologies is the development of full-waveform LiDAR. Waveform capture presents

interesting opportunities for remote sensing scientists in that compared to simply receiving the time-of-flight from the laser pulse, the entire return waveform from the laser pulse is collected, and in that manner detailed information on the entire vertical structure within the laser footprint is gathered (Flood 2001). Although this contributes significantly to the observation of landscape features beneath forest canopies (Persson, Soderman et al. 2005; Sittler, Weinacker et al. 2007; Doneus, Briese et al. 2008), its applications in the field of cultural heritage are yet to be explored and it could be argued that its relevance to the development of 3D displays is limited as it is currently more of an exploratory spatial analysis tool.

As the context of this thesis is climate induced change, the responsiveness of a particular dataset to change must be taken into consideration. TLS data, although captured remotely, requires the user to be within a certain range (100m for the Leica HDS 3000 used in this study). The frequency of data collection is dependent upon the user's ability to visit a site. For applications in disaster response and monitoring TLS is relatively useless in the immediate aftermath. The frequency of LiDAR data acquisition can provide a rapid and thorough way of gathering data in an emergency (Stoker, Tyler et al. 2009) as well as being able to generate rapid acquisition of new landscapes. However, one of the barriers to more extensive use of LiDAR is the expense of conducting an aerial survey, which can cost upwards of £10,000.

2.10. 3D Visualisation and Communication

Scientific visualisations often stand alone as a tool for communicating scientific results, yet this review has so far revealed that although visualisations can be useful engagement tools they are not independent from broader social interactions (Bruno, Bruno et al. 2009). In participatory exercises a visualisation should not be placed as a stand-alone effort to inform, rather one step towards an holistic communicative process. Therefore how spatial data is visualised is crucial to how it is applied in a social context and needs careful consideration. There has been recognition that scenarios using spatial data are not well suited to dealing with local

landscapes (Munday, Jones et al. 2010) and visualising a regional perspective is required (Entwistle, McCaffrey et al. 2009). But there is still a lack of studies which deal with this in three dimensions (Whitworth and Hunt 2004; Munday, Jones et al. 2010). Data captured from both airborne and terrestrial remote sensing technologies can be transformed into 3D visual displays, but the available data formats for online publication may not be compatible with an intended user's available technology (Guney and Celik 2004). Intended public users of visualisations frequently do not have access to computers with sufficient computer memory, nor the same software used to create visualisations. Visualisation 'pop-up' stations have been explored as one way to present visual data to users (Bruno and Bruno 2010).

The online publication of point cloud data produced from laser scanning is becoming more frequent. Websites such as those produced by Cyark (2010) have attempted to showcase the scope of data collection possible when using ground-based scanners, although little has been done to disseminate Cyark's work any further as at present its remit is to act as a conservation and repository. Cyark use the raw point data in order to document and archive heritage sites for preservation purposes. Although important, in order to be more widely acknowledged the point clouds need to be transformed to something people can identify with in a real world context (Dursun, Sagir et al. 2008). The purpose of Cyark is to create virtual archives of heritage sites and for that purpose it may not be necessary to move beyond the raw point data. Especially since these data can be used to analyse the spatial characteristics of a site for architectural and engineering applications (Pieraccini, Fratini et al. 2009). There is though, potential for these data to be useful as a visualisation tool, and for this the raw data requires further manipulation.

Few researchers have attempted to create realistic looking models from the raw point cloud data and this is probably due to lack of access to software and high time investments for the collection and processing of the data (Entwistle, McCaffrey et al. 2009; Bruno and Bruno 2010). The study by Bruno et al. (2010) stressed the complications of capturing and visualising spatial data of this kind, optical limits of the hardware when scanning black,

white or highly reflective surfaces and scanner definition too poor to map texture. The conclusions of this work found that although processing the data was time-consuming, the end-goal of sharing this data with the public was achievable as the format worked in several computer software packages and the visualisation screen set-up was easily transferable to other sites. Regrettably, only informal user-feedback was collected thus limiting the extent to how future studies can improve on these methods.

Early papers highlighted the challenges faced by geographers and cartographers in mixing geographical data with animation and 3D visualisation (Dorling 1993) and a research paper by Flood (2001) suggested that within five years, the emergence of reliable software tools for the visualisation of LiDAR data would be a significant area of growth within the commercial sector. It could be argued that this predicted 'growth' has not occurred at this anticipated rate, as GIS software is still the principal choice for LiDAR visualisation (Alexander, Smith-Voysey et al. 2009) and alternatives are costly. Evidence suggests a move towards practical applications, as there is a shift towards mainstream users and commercial interest (Beraldin 2004). The desire for a 'digital Earth' means that laser scanning could be the beginning of a paradigmatic shift in the way that data are captured for public and commercial uses (Yilmaz, Yakar et al. 2007; Boyd 2009).

Currently, most models that exist as a public resource are primarily used in their role for field mapping and reconnaissance by the public (Smith and Pain 2009), however there is a requirement and call among the research community for more work which looks at the outreach dimensions of visualisation of scanning technology (Smith and Pain 2009). The methodology for producing a working visualisation in promoting heritage objects and structures has been little explored, although some effort has been made to engage the public with visualisation tools (Al-Kodmany 2002). Al-Kodmany (2002) used a mixture of photographs and digital images to create a mixture of different visualisation tools. He found that although new resources in visualisation media were emerging, traditional methods should not be discarded and could be incorporated into any future workings. Future

studies on developing 3D visualisations should remember that heritage sites are places which have a historical value and putting too much emphasis on modern approaches may intimidate supporters of a traditional approach to communication and engagement efforts.

Geographical Information Systems (GIS) offer the potential to be used not only as a visualisation tool, but have the ability to geo-reference, carry out exploratory spatial data analysis and include supporting information (Burrough 2001). GIS offers the possibility to fuse data of differing spatial and temporal resolutions into one model. This was successfully undertaken by Brown et al. (2006) who initially took cliff erosion rates in a vector file, creating a sample polyline to match the co-ordinated rates of erosion along a cliff face. A 2D representation of rates of erosion was developed. High resolution LiDAR altimetry data in 2km tiles each with a data grid at 2m horizontal resolution were combined with the spatial database of coastal erosion rates to create a 3D model. This was one of the first papers to focus on attempting to communicate coastal change to the public and it highlights the need for multivariate and multiscale datasets in order to achieve the final result of focus on their potential role as awareness-raising tools. It may not always be appropriate to focus on one method for visualising data, such as in the case of Brown et al., (2006) as there are limitations to focusing on one kind of software over another (Entwistle, McCaffrey et al. 2009). The results of Brown et al. (2006) highlight that coastal decision-makers are in need for communicative tools that not only make visual representations of planning proposals, but are also able to offer communities a chance to share in understanding the future. Although how to achieve this using terrestrial laser scan data is yet to be identified, there is potential to produce even more localised, realistic and engaging visualisations.

2.11. Realism and Accuracy in Digital Data

It is indisputable that climate change will affect cultural landscapes (Sabbioni, Cassar et al. 2006) so establishing how best to share expected impacts is critical not only to aid managers, but also to help local communities deal with the emotional attachments to sites of heritage. Using

spatial data to create 3D displays of information can provide a rapid method to generate and share information. At this juncture there is a socio-technical barrier between determining a sufficient level of accuracy and providing adequate realism to create engaging visualisations.

This barrier is a product of the relationship between accuracy as a feature of the data, and realism, which is how data accuracy is handled by the user.

2.11.1. Data accuracy

Accuracy in data can be defined as being the sum of [un]bias and precision (Foody and Atkinson 2002), and accurate data are therefore those that closely represent the “truth” (closeness to the true value). Bias can most easily be described as an expectation of over or under prediction, generally from a range of measurements. Systematic errors increase bias, therefore an assumption can be made that if calibration of a laser scanner has not been undertaken, any intrinsic biases will propagate as scanning continues. This is not only the case for scanning but also needs to be considered during location decisions for survey work and during subsequent pre-processing where registration of scans could lead to propagation of bias. Precision can be defined as an expectation of the spread of errors around a mean error (Foody and Atkinson 2002) and in a measurement sense, relates to the spread of data values if a constant is measured. Precision tells us about the reliability with which an instrument can record data points of the same measurand. Accurate data of a fixed measurand would therefore be tightly clustered around a mean value which closely represented the “truth”.

Returning to Table 3 we can see that the scanners range in their accuracy between 1 – 6mm but this varies across range; the Mensi GS 200 maintains a higher accuracy level at a larger range compared to the HDS 3000. Due to the range of scan models, testing accuracy need to be carried out using the model in a particular study (Boehler, Heinz et al. 2001; Schulz and Ingensand 2004). Where the data is used in applied architectural and structural surveying the fluctuations in mm accuracy may be important. For the visualisation of heritage, accuracy is not always the predominant

demand (Boehler and Marbs 2005; Devereux, Amable et al. 2008). If this is the case, then it raises questions about the expectations of lay audiences in regards to accuracy. At present there is no research which addresses how lay audiences perceive the accuracy of terrestrial laser scanning datasets.

For TLS, the accuracy of a measured point is to an extent controlled by the support of the laser points (“an n-dimensional volume, within which average values of a variable may be computed” Dungan et al. 2002: 627). Changing the spatial resolution across a dataset will affect the accuracy of the registered data and furthermore spatial resolution provides a limit to the scale of spatial variation that is detectable (Foody and Atkinson 2002). Calculating accuracy as a measure of [un]bias + precision to produce a quantitative result is not significant if the level of realism in the displays does not engage an audience. There needs to be a consideration of the wider application of these models in order to communicate a robust empirical grounding. By losing the ‘true value’ (point in relative x,y,z space) and accuracy of the original dataset a risk presents itself of achieving too much realism while sacrificing the true values of data. Creating a misplaced faith in realistic displays also termed ‘naive realism’. What is currently lacking clear guidelines, is the effect on the trust and validity of datasets where the data have been manipulated to achieve a degree of realism. It is impossible to avoid all error and inaccuracies in data collection, but this thesis is concerned with the inaccuracies generated during processing of the original data.

A significant problem when discussing accuracy is that error can propagate as the data are processed, and although initial scanning at a dense spatial resolution may appear to provide a more complete dataset, this can be problematic further in the workflow. This is significantly so if the data is to be meshed in order to generate a digital elevation model (DEM). As Pieraccini et al. (2001) explained, a noisy point cloud can disrupt the mesh creating larger inaccuracies in the dataset than previously captured. This is clearly dependent on the size and framework of the mesh. Increasing the number of triangles or polygons which construct a mesh is normally advantageous, however this may reduce/improve data accuracy. Reduce accuracy from

increased interpolation between data points, if the ratio of spatial resolution covering an area is not equal to the number of triangles/polygons meshing a surface b) improve accuracy as fewer extremes are generated from outlying data. In most cases increasing the density of the mesh will provide a more realistic texture to a surface, but these examples tend to be close-range scanning of artefacts (Dekeyser, Gaspard et al. 2002). Although Dekeyser et al. (2002) argue for accuracy in the field of cultural heritage documentation, the focus on digitising heritage for conservation work may not require the same consideration as that for providing visualisations based on projections of climate change, especially for the use of TLS on landscapes. A solution to communicating the inaccuracies in the dataset could be to share this information via the 3D model, however in the context of this thesis it could confuse rather than clarify a distinction between data accuracy and climatic uncertainty and therefore requires further consideration.

2.11.2. Realism

Realism is a notably broad and subjective concept when applied to data visualisation. As Chapter 6 will look at in more detail, individual perceptions of realism are prone to subjective interpretation (Feigenson 2006). In the case of realism in data visualisation, there is an added level of complexity in that realism can be mis-interpreted as data accuracy and mislead audiences.

For spatial data, there are essentially two dimensions to any visualisation, i) current real-world conditions and ii) the virtual interpretation of this / the desired model (Addison and Gaiani 2000). Recognising these is an important step in developing the workflow in order to consider cost and time implications of processing the data to balance the current real world situation with the visual representation of a site. Realism in 3D visualisation is complicated to convey as it is largely determined by the viewer's perception of what is 'realistic'. Sheppard (2005) suggests that increasing the recognisable content of the visualisation contributes to what people will find 'realistic', such as following recognised footpaths along a coastal trail or

placing benches which are recognisable to those who frequent these places.

An interesting dimension to realism in 3D visualisation was proposed by Roussou (2006) who explained that computer visualisations “had the ability to engender fascination far beyond its commercial prospects and practical limitations, even before it had the opportunity to undergo [...] a process of maturation” (Roussou 2006: 265). The public may have expectations which exceed the capabilities of the form in which information is presented to them, creating confusion when trying to interpret visual data. Sheppard (2005) sees the ultimate aim of visualisations to their use in effecting a response to climate change (in reducing emissions). Although this could be seen as scare tactics, Sheppard argues that by improving the realism of the display, the response from viewers will be close to real world responses. Whilst Sheppard’s approach has the potential to be effectual, it is still closely aligned with more traditional forms of communication for behaviour change (as discussed in earlier sections of this literature review). An alternative view and the approach that is taken in this research project, is that visualisations can be used as tools to support conversations about change. Rather than being a catalyst for behaviour change, they can be used to initiate a dialogue between the NT and communities, helping the NT manage the emotional response that losing heritage may have.

2.11.3. Realism vs. Accuracy

There exist contrasting views over the importance of the level of photo-realism for 3D displays and some have argued that this is a deciding factor in the success or failure of visualisations (Roussou and Drettakis 2003), whilst others such as Zuk et al., (2005) argue that presenting a photo-realistic visualisation may not be the most effective tool in communicating results if the user perceives accuracy through photo-realism, or that realism was achieved through good rendering of the 3D model (Rossi, Marini et al. 2004).

A display of the raw data geo-rectified to the national grid may suggest ‘realism’, yet what users perceive to be ‘real’ may not be the same as what

constitutes realism for spatial data applications. Jude et al. (2006) found that people knew what they wanted in terms of realism, although major concern was shown over the perceived definitive-ness of the visualisations: “one particular concern was that the visualisations provide an air of certainty over uncertain coastal processes” (Jude et al., 2006: 1536).

To create a 3D model which clearly shares and offers access to scientific information, requires a thorough consideration of how important both accuracy and realism are to those viewing and creating the models. The ultimate aim of many visualisations is to achieve an appearance of reality, known as photo-realism (Ervin 2001). The constraints of the available technology may make this a difficult process, as data may be limiting in terms of quality or spatial resolution. It is also important to consider that the user’s perception of what reality is will differ from person-to-person. The accuracy of the underlying data set which provides the foundations for the 3D display may be taken in a different context when the data is used for public interaction.

When moving beyond the initial data there could be a shift from looking at the accuracy of the data to the content of the visualisation and in this respect there could be a distortion between accuracy and representation (Roussou 2006). Ultimately Roussou argues that accuracy in the representation of heritage can be inter-changeable with authenticity “the quality of being genuine, not being corrupted from the original”; placing the viewer in a context that is as close to the real-world as possible. This suggestion highlights the divide between a researcher who captures spatial data for use in heritage studies and sees accuracy as a semi-quantitative representation of a measure produced from the recording device, and the creator of a 3D model of this data. Between each, the boundaries of representation and accuracy are blurred. Developing a visualisation tool which is flexible to the needs of researchers, decision-makers and the public, can initiate a debate as to what these mean to different users and help to define what ‘realism’ and ‘accuracy’ are for future studies.

2.12. Conclusions

This review has attempted to look at a spectrum of research covering the relationship between climate change data, communicating and adaptation and then practical approaches to creating scientific visualisations.

This review tells us that although there is plenty of research into how best to communicate climate change, there is a discourse of fear within the media. This discourse stems from communicating the global impacts of climate change, rather than focusing on local issues. Local impacts of climate change vary globally, and it is not the case that increases in temperature, precipitation and sea-level rise will cause negative impacts in every case. Communication attempts need to focus on addressing local impacts of climate change (Dockerty, Lovett et al. 2005), and early research suggests that using storytelling narratives and visual tools may be one way to do this.

Using spatial data to make an accurate and realistic model of a site is seemingly one way to achieve the site specific focus required; the range of remote sensing tools available for landscape visualisation is vast. Choosing the most appropriate spatial resolution depends on the application of the data, but in the case of showing projected sea levels the spatial resolution and accuracy of the data are paramount. Combining terrestrial laser scanning and aerial LiDAR datasets allows for varying spatial resolutions to produce an accurate and realistic interpretation of a landscape.

The application of TLS data in cultural heritage is not new, but using it for the communication of sea-level change has yet to be explored. Combining the flexibility of using TLS in 3D digital design software and storytelling for community engagement with climate science information may pave the way forward in creating long-lasting, original and engaging approaches to communicating climate change.

Chapter 3

Project Inception and the First Visualisations

Objectives

To explore how terrestrial laser scan data can be used as a foundation to provide content for community engagement tools.

To determine how to improve, adapt, modify or add to the terrestrial laser scan data to make it more engaging and useful, through consultation with focus groups and solicitation of other stakeholder input.

3. Project Inception and the First Visualisations

3.1. Introduction

This chapter is the first in a series which chart the chronology of the research from data collection through to the production of the final film. The chapter deliberately integrates discussions of methods and results, in order to draw out the implications of decisions made and how these decisions have impacted on the research. This approach is best suited to reporting of a research project where the development methodological approach is as much as part of the research brief as the findings from the methods.

Figure 8 shows the breakdown of the chapter structure of the methodological chapters of this thesis (Chapters 3-5) and provides an overview the technical and engagement activity that took place over a three year period. This includes the initial fieldwork, followed by modelling the data and then iterations of engagement and model development. Three groups were engaged with, focus groups consisting of members of the local community and NT staff and volunteers, a working group [section 3.7] made of industry experts from the environmental sector and members of the public for a public viewing [see Chapter 5, section 5.9]. Each of these activities fed in to the overall development of the final nine minute film.

Due to the structure of activity and its iterative nature, some results are presented particularly early on; for example the results of the first round of working groups [section 3.8]. Analysis of the working group meeting was undertaken immediately after it was held and the results fed back into the research design. By allowing the structure of the chapter to accommodate the integration of results, the report better demonstrates the impact of the participatory process and iterative development of the visualisations [Figure 8].

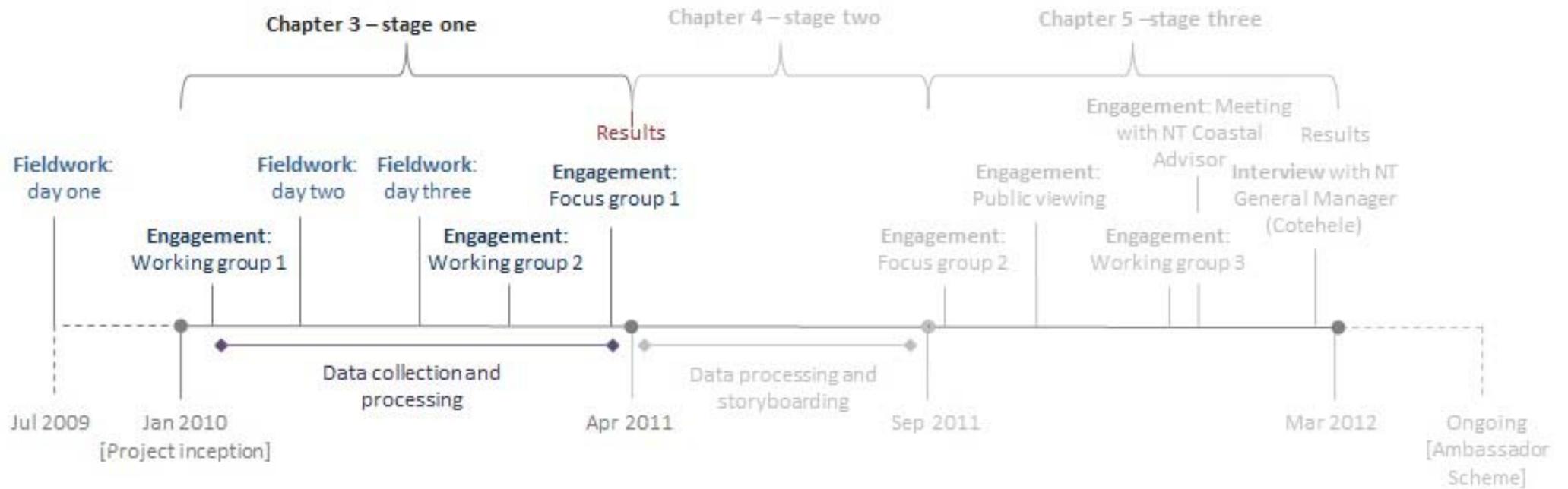


Figure 7 Structure of methodological chapters

A large proportion of this chapter is dedicated to outlining in detail the methods for collecting and processing data needed to make a 3D model. What these sections demonstrate is that there is an underlying tension between presenting a realistic model vs. a spatially accurate one, when using spatial datasets which are traditionally used for the examination of landscape characteristics and environmental change, in order to process them to make them visually appealing. There is little guidance on how best to achieve a realistic 3D model, as each approach is unique. The visual appearance of the 3D model is controlled by tweaking and fine-tuning the software rather than understanding the characteristics of the data and how they are manipulated. This chapter charts the spatial accuracy of the data through the processing stages [Figure 9]. Whilst the raw data are not changed during processing, the accuracy of the resultant model is, therefore the spatial accuracy and the realism both apply to the model.

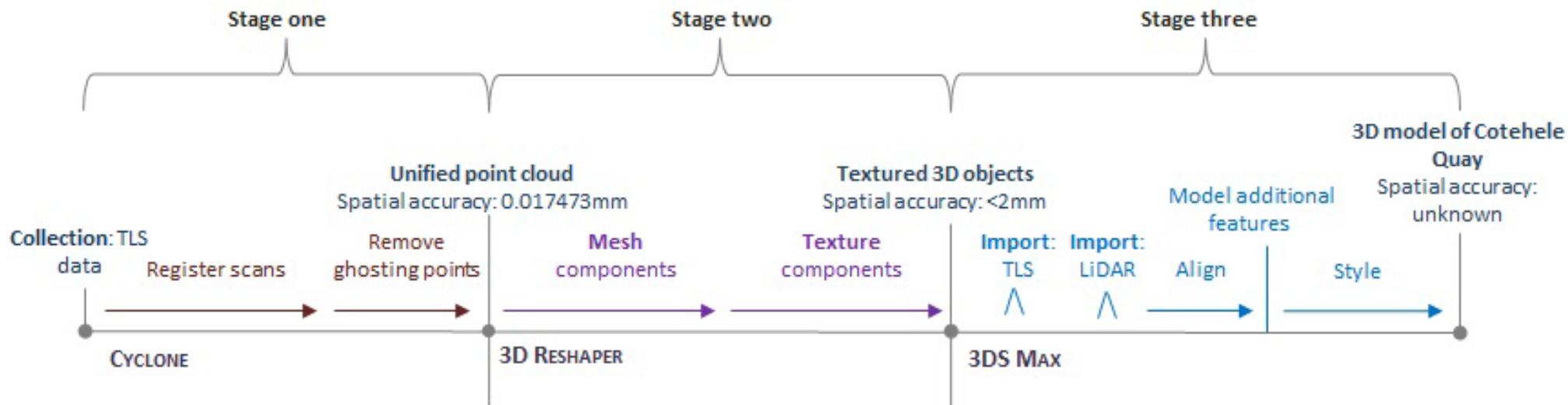


Figure 8 From data collection to 3D model: the three processing stages

The main focus of this chapter is to demonstrate how the first iterations of the visualisations were received by various groups who had been invited to take part in the research; in response to this feedback the visualisations were improved and developed. Early meetings with the working groups [section 3.7] established a network of individuals with a vested interest in the seeing the project progress.

3.2. Introduction to chapter structure

This chapter sets the foundation for the working methodology as a whole, and as such presents a combination of qualitative and quantitative data collection. The chapter is written as a series of chronological actions and processes, communicating not only the methods used, but also demonstrating how each decision fed into the development of the research as a whole. It is not conventional to present some results of the research so soon in the research, but this structure is essential to share an understanding about how the research progressed. The chapter starts by outlining the position of the researcher in the project as a whole, thereby justifying the chronological ordering of a combined methodology and results chapter. This is followed by an introduction to the working relationships with the NT and with industry professionals.

The first meeting that took place was with the working group; this discussion informed how the research was approached, so the outcomes of this meeting are discussed in detail. Having gained some insight into how the visualisations were likely to develop, fieldwork took place over three non-consecutive days. This chapter presents how the terrestrial laser scan data were captured and the factors affecting the data's accuracy. The following sections introduce the additional spatial data that were collected and processed; this is followed by discussion of how this fed into the development of the first iteration of a 3D model, presented at the second working group meeting.

The second half of this chapter discusses how the participatory process was initiated with the second iteration of the visualisations; these were shown to a core group from the local community as well as the NT staff and volunteers. The final part of this chapter considers results from the focus group meetings and first iteration of the visualisations, introducing the following chapter which demonstrates how the results from this chapter fed in to improving and refining the 3D model.

3.3. Role as a Researcher

As is the case with much community engagement around climate change, it is somewhat difficult to step aside from an advocacy role when engaging a group of people in thinking about change (i.e. when the researchers believe that climate change is taking place it is difficult to act unbiased and not to act in the interests of climate change mitigation) (Nisbet 2009; Ockwell, Whitmarsh et al. 2009). This research takes an independent set of data and uses this to share information on sea level rise at a specific location; this meant that it was difficult to create space between the role as a researcher and as person acting with some degree of advocacy. Research that focuses on social issues leans towards advocacy as the researcher will likely have a strong attachment to a particular issue (Graddol, Maybin et al. 1994). Deliberate or otherwise, placing oneself in an advocacy role may mean providing a voice for these participants, raising their consciousness, or advancing an agenda for change to improve the lives of the participants (Kemmis & Wilkinson 1998).

Kemmis & Wilkinson (1998) suggested particular attributes of researchers acting in an advocacy role, particularly those engaging participants as active collaborators in the research. It would go too far to suggest that as a researcher at Cotehele the intention was to be an advocate for changing perceptions of climate change, but it is not unreasonable to assume some degree of advocacy for changing perceptions about the impacts of sea level rise. Whatever tangible advocacy changes are manifested as outcomes of this research may not be attributable to the project, but are nonetheless a factor of the research having taken place.

The paradigmatic shift in attitudes towards research approaches led researchers to realise the impact of triangulating qualitative and quantitative methods to validate research (Jick 1979; Blaikie 1991). Triangulation was defined as: “the combination of methodologies in the study of the same phenomena” (Denzin 1978:291), and although the methodological approach used in this research is not triangulation as such, it can be argued that the root of combining datasets stems from an exploration of mixed-methods dating back some 30 years.

Evolving research methods deal with the complexities of combining qualitative and quantitative techniques including: concurrent triangulation strategy, sequential exploratory strategy and sequential transformative strategy (Flick 2009). One of the distinctions between these strategies is that only the latter has a theoretical perspective to guide the study (Flick 2007). The aim of this theoretical perspective has a role in guiding the research in an advocacy role that goes beyond the use of the methods alone. In some respects it could be argued that the researcher was acting as an advocate on behalf of the NT for public relations exercises and box-ticking when it comes to community engagement; yet the research approach is heavily focused on developing unique digital tools to engage communities and therefore presents as more than advocacy on behalf of the research participants. It presents a way of interpreting digital data that gives it purpose in digital forums for change communication and engagement. The qualitative methods used in this study reflect the need to include multiple perspectives in the research design. Focus groups were the predominant qualitative research method used throughout the project; further introduction to their application in this project is given in later sections. Other qualitative research methods included secondary archival research into the history of flooding in the Tamar Valley and semi-structured interviews.

One of the tensions that Creswell (2007) highlights is the need to ‘prioritise’ one type of research over another (qualitative over quantitative or vice versa), this being dependent on the audience and/or the emphasis of the study; using the terms ‘dominant’ and ‘less dominant’ to express priority of

one research method over another. This research uses both qualitative and quantitative at different stages and it is easy to see how Creswell's (2007) idea of having one dominant strand can become entrenched. However the iterative processing of data means that it is less likely that one strand will dominate over the other. As this chapter continues to demonstrate, each method ran sequentially, as one dataset was dependant on the results feeding into the next stage.

The question over advocacy and concern for helping the participants to understand the research was also experienced by (Bondi 2007) who struggled to communicate with interviewees that she had no influence over decisions made regarding the closure of primary schools in a British city. She felt guilt that she was in some way leading on these people who at some level might have felt that she had some persuasive effect on the outcome. The complexity of the role of a researcher when engaging with people on a sensitive issue is summarised nicely as:

“The emotions expected of researchers thus range from the passionate immersion associated with the ‘drive’ needed to conduct research, to the cool contemplation associated with the capacity to ‘stand back’ and reflect critically on one’s own ideas” (Bondi 2007:p233)

3.4. Critical reflection on the research process

Throughout the course of my PhD I engaged with and connected with numerous local residents, stakeholders, industry professionals as well as informally sharing my research and methods with other academics and technical support staff. The most straightforward way to address this, is to think of the work chronologically. Similar to many research projects, the general methodology and approach to participation and engagement was mapped from the outset. This meant that whilst the people who I was hoping to involve were yet to be contacted, I knew that I wanted to engage numerous times with the same stakeholder group.

The first attempt at recruiting focus group participants fell flat, gaining no responses from sending pre-paid postcards and short information packets to selected stakeholders. Following this, personal emails and calls were made to the same group.

It is likely that the people I was targeting to take part in the research were suffering from 'research fatigue' (Clark 2008), although an investigation was not conducted to identify if this was the case. Meaning that due to lots of research take, covering similar disciplines – changes to the river, the impact of climate change on biodiversity (see section 1.4 for an overview of other research that has taken place in the Tamar Valley) – then those who are recognised as the most likely to know the most about the river will often be repeating themselves. This is the case in urban areas research which targets specific groups or marginalised communities (Way 2013) and in rural communities where there are a limited number of people who can respond on a particular topic (Mandel 2003). In the Tamar Valley, some responses to the invitation to take part in the research were hostile. The ferryboat men were angry at repeatedly being asked to take part in research which, in their opinion, had little effect on them. As an academic it was upsetting and disheartening to get this response, particularly considering the motivations and processes in this research were more inclusive and would ultimately feedback to the communities. The hostility I encountered meant approaching different audiences to meaningfully engage in the project.

My second attempt at recruiting participants involved a visit to Cotehele Quay and the neighbouring town of Calstock. Calstock was where many of the primary stakeholders for my research lived; including landowners whose properties were at risk of regular flooding. I used this visit as an opportunity to explore who else could potentially be involved in the research project. I contacted the editor of the local newsletter. Like many other studies (such as Crowhurst and Kennedy-Macfoy 2013), it was finding this 'gatekeeper' which helped me to unlock contacts from the village who would be interested in taking part. This was the gatekeeper to those actively involved in the community, rather than engaged in activities on the water. Not only

did this mean that I was approaching people who were less likely to be suffering research fatigue, but I was also targeting people who were already taking an active interest in the community and were more likely to be a part of the research in the long-term. This challenged my own pre-conceptions about the role of 'gatekeepers', and made me realise that when conducting research into a specific subject, I shouldn't segregate the participants into silos.

As I researcher, I struggled to balance my inherent desire to be as inclusive as possible, whilst also inviting participants to the focus groups who would willingly and knowledgably contribute to the discussion. By meaningful, I mean that they would have the confidence and knowledge about the Tamar Valley to be able to take part in discussions. Whilst it was important that they were familiar with the river, it was not necessary for them to have any knowledge about climate change or river processes.

The resulting mix of people who took part in the research, was a cross between people from the campaign group SODITT, local residents and staff and volunteers from the NT. This mix is likely to have benefitted the research in so much that their thoughts and feelings were not repeated from previous conversations about similar issues (Clark 2008). For the majority of participants this was the first time they had talked through issues such as sea-level rise and climate change.

Whilst the research did attract those engaged in the climate change debate, for example the ex-Greenpeace activist who still takes an active interest in environmental issues, there were others who wouldn't attend such a meeting. This included the editor of the local newsletter, the programme manager for the local arts centre and a project office for a heritage site further up the river. One of the strengths of the approach, and it was communicated when they agreed to take part, was that this approach involved 3D digital images and I needed feedback on these. It is likely that participants choose to engage in something new that they hadn't experienced before (Peel et al. 2006).

I knew that one of the most important actions I could take was to ingratiate myself into the community (Cornwall 2010 – What is participatory research). In this case, I needed to get the balance right, between acting like an independent professional researcher, and demonstrating to the participants that I was sensitive to, and understood the context of changes in the Tamar Valley. In summary, this was not such a straightforward focus group exercise, particularly because I knew that I wanted the participants to be involved in more than one meeting.

3.4.1. Co-producing knowledge

My reflections on this process, and the participatory methods in which I engaged with, draw on an emerging body of literature on the co-production of knowledge (Pohl, Rist et al. 2010; Armitage, Berkes et al. 2011). This is defined as “the collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem and build an integrated or systems-orientated understanding of that problem” (Armitage 2011:996). Ideas behind the co-production of knowledge centre on helping individuals and groups to develop adaptive capacity to change (Armitage et al. 2011). The benefit of taking into consideration the ideas on co-production of knowledge, is that it addressed the need I faced with regard to taking into account scientific knowledge and other forms of knowledge when developing the 3D model. Considering my own reluctance to, and therefore the methodological approach to, employing top-down engagement strategies (based on a knowledge deficit model), co-producing knowledge assumes and challenges the researcher to balance their own position as a facilitator, intermediary and researcher (Pohl 2010). The strength of this approach is that it assumes that neither science nor other knowledge is sufficient on its own. As identified by Pohl (2010), the co-production of knowledge challenges both the researcher and the participants to manage their own expectations on: i. the role of power ii. shared understanding of other perspectives iii. normative context

For my point of view, I was not actively seeking to build the community’s adaptive capacity. Instead, I drew on the ideas and theories of the co-

production of knowledge, balancing my role as a researcher to involve gain feedback on the 3D model. Such was the nature of my research, and the open-ended question asking in the first iteration of the 3D visualisations, that participants' knowledge could feed in to the research stemming from their knowledge about Cotehele Quay from several different perspectives. For example, sea level rise and flooding at Cotehele Quay, knowledge about use and recreation on the quayside, specific details of the buildings and more. The final film directly demonstrated the blend of scientific knowledge and other knowledge, using the 3D model to show projections of sea-level rise, and incorporating participants and others experiences of flooding as text.

It is likely that participants developed adaptive capacity during the research; this was lightly demonstrated in the second focus groups as the conversation naturally shifted to mitigation (see section 5.11). Developing visual tools is a natural fit to explore the field of knowledge co-production further.

3.5. Assumptions of the National Trust

As was introduced in Chapter 1, this project was initiated due to questions posed by the National Trust in regards to the future management of Cotehele Quay. The idea behind this research was born out of a conversation between the General Manager at the NT and staff at the University of Exeter. A NT commitment to community engagement meant that staff at Cotehele Quay were increasingly looking to inform their own policies and strategies by listening to the local community. A conversation about exploratory approaches to do this led to the research project being formulated around ideas such as modelling sea-level rise in an engaging and realistic way.

This section identifies how the National Trust, as the institution framing the research, influenced the research methods and approaches that were undertaken. From the outset, there were no expectations about which research methods would be used to initiate a participatory process. Both the NT and the University were committed to trialling a new way of engaging

audiences with visual data and University were able to provide cutting edge technology in the form of a terrestrial laser scanner. An initial meeting with the General Manager at Cotehele, Toby Fox, made it clear that although the NT were financially supporting the research the NT staff wanted to take a backseat in the direction of the project and the production of visual material. The NT wanted the public to see this research project as a move away from traditional community participation for decision-making that had been carried out previously on site (i.e. planning proposals which had caused controversy amongst the local community).

3.6. Working with the NT

Two members of NT staff were involved in the project throughout; these were the General Manager, Toby Fox; and the Head Warden, Joe Lawrence. The relationship that grew out of this working format, between the NT and the researchers, was central to the success of the project. Their primary role was to guide and support the project and its progression, and secondly to help organise logistics during fieldwork. Toby had been General Manager since 2008, at the same time as the end of the fraught Haye Marsh project. Joe had lived and worked at Cotehele Quay for over 20 years and was familiar with both the social and environmental conditions of the site. Both Toby and Joe were able to offer insights and understandings into the people and situations at Cotehele Quay that would feature heavily throughout the research. Early recognition of the importance of Toby and Joe's knowledge of the site and their interest in the implications of the research on the wider population, led to the establishment of a working group including representatives from organisations outside of the NT.

3.7. Project inception: Working Group One

The role of the working group in the research was to represent professional opinion on the structure, content and methods used in the research. As the following chapters will demonstrate, the working group were consulted three times throughout the duration of the research, at key moments of the project. Feedback from the working group and focus groups were treated

with equal importance, even though the working group contained industry professionals, in other words, experience and knowledge of the site was given equal emphasis when deciding what feedback to include the feedback from experienced professionals. The invited participants were from relevant organisations including Natural England, the Environment Agency and the AONB. All participants of the working group were residents of the South West and therefore were familiar with the issues presented at Cotehele Quay. The participants represented a network of local organisations with interests in environmental planning, biodiversity, regional planning and Cotehele Quay.

The first working group meeting was held on 25th January 2010, at Cotehele Quay; six organisations were represented by 11 participants. This was the preliminary scoping meeting for the research project and was used as an opportunity to develop further plans for 3D visualisations of Cotehele Quay. Details of the meeting were recorded via note-taking and then meeting minutes were produced and returned to participants. The structure of the meeting was intended to be informal with short introductions by Toby Fox, General Manager at Cotehele and the project researcher followed by a discussion session chaired by the University with prepared questions.

Date / Time	25 th January 2010, 2-4pm
Location	The Edgcumbe, Cotehele Quay
Number of Participants	11
Organisations Present	National Trust Tamar Valley AONB Environment Agency Tamar Estuaries Consultative Forum Natural England University of Exeter

Table 4 Details of working group one

Before the meeting the participants were provided a brief introduction to the research aims and were informed it was hoped they would continue to be involved in the project over three years. As part of the iterative methodology, the outputs of these meetings were a series of recommendations that informed later stages of the project and the model. As this was the first meeting including participants outside of the NT, the main drivers were to:

- Gather information on previous research in the Tamar Valley
- Gather information on recent planning and mitigation
- Highlight any known issues and problem areas, both in the local community and in the environment
- Determine how the working group interpreted the needs of the local community
- Inform the shape and scope of the project

3.8. Outcomes: Working Group One

Analysis of the first working group had to be undertaken before the project could continue, as results were fed into the development of the first round of visualisations. One day of TLS data collection had been undertaken prior to the working group meeting, which meant that a preliminary dataset could be introduced and the benefits and potential limitations of the software were discussed. The participants supported the use of this technology and understood that this approach was exploratory. Aside from providing professional knowledge towards the project, the exact level of involvement the WG would have on the research was deliberately left open. Having completed an analysis of the results from this meeting, a summary of how the working group saw their involvement in the research developing was as shaping the project focus, contributing to the structure of the research design and affecting the content of the 3D visualisations.

The working group conversations went beyond making suggestions about the visualisations to more general discussions about the project focus. This suggests that from the outset they had an interest in the implications of the research, and more importantly, its potential applications outside of Cotehele Quay. Some participants requested that the model be used to visualise specific future adaptation and flooding mitigation options (based on both the Shoreline Management Plans and Coastal Change Policy 2007). The main contributions and suggestions for how the visualisations should be developed are summarised in [Table 5].

Key Outcomes

- Create links with existing project partners and/or consultation activities
- Focus on open-ended outcomes using the model to initiate conversations about change
- Split the focus groups (stakeholders) into two groups: NT staff and volunteers and the local community

Table 5 Key outcomes from Working Group meeting one

The participants felt strongly that although the raw dataset (a point cloud generated from the TLS) would be a useful tool for the NT to compile and conduct surveys and analysis of buildings on the quayside, this alone would not provide a new format in which to engage or present sea-level rise information. They explained that the EA had existing datasets (such as lower spatial resolution LiDAR data) which could be used to model SLR projections, so the unique element for this research would need to be transforming the raw data into a functioning tool which was more graphically engaging. Toby Fox commented “there is a value in coming from the ‘left field’” (TF, Cotehele Quay 25/01/10), stressing that the visualisations needed to utilise TLS data in a way that captured the imagination of all stakeholders involved, whilst creating links with existing consultation activities.

The participants felt that the NT’s lack of any concrete future adaptation strategy was an opportune time to present the community with open-ended scenarios of climate impacts; making a tool that could “spark conversations about change” (JL, Cotehele Quay 25/01/10) rather than present predetermined solutions to future flooding events. One participant disagreed, feeling that the visualisations should attempt to model planning and adaptation approaches outlined in the Coastal Change Policy (EA 2010) and Catchment Food Management Plans (CFMPs) (EA 2012).

The most significant contribution the working group made at the meeting was a suggestion to split the stakeholders involved in the focus groups into two groups: the NT staff and volunteers, and the general public. There was some concern over alienation if the focus groups mixed NT staff and volunteers with members of the local community as not all people would

have the same knowledge of the site. The first focus group would be required to provide a baseline of information about previous flooding events (further introduced in section 3.22).

3.9. Data collection: Overview

The focus for data collection and visualisation was Cotehele Quay on the River Tamar, a site which is located within a steeply sloping and heavily wooded valley. To capture the detail of the quayside and the surrounding area in sufficient detail for the visualisation, a multi-scale approach was used in both the data collection and processing stages. Three spatial datasets were utilised:

- Airborne digital photographs collected by Get Mapping (GM 2013) and obtained from Tamar Valley AONB. Spatial resolution = 25cm; Date of data collection = unknown; Spatial extent = 2km².
- Airborne LiDAR data collected by the UK Environment Agency (EA 2012) and obtained from Channel Coast Observatory. Spatial resolution = 2m; Date of data collection = Spring 2008; Spatial extent = 58km² (used in 3D model 44km²).
- Terrestrial laser scanning data collected by the authors using a line-of-sight Leica HDS 3000 model instrument. Nominal point spacing 25 mm at 50m range⁵; date of data collection 7th Jul 2009, 10th February and 26th May 2010; Spatial extent = 0.02km.

Airborne data (LiDAR and aerial photographs) were used to provide a perspective of the wider regional extent around the quay, and to describe the broader landscape components around the quayside. These data were at too coarse a spatial resolution to allow the details of the buildings and quayside features to be accurately captured. Resultantly, fine-scale TLS data were employed to capture the detail of the quayside such as the buildings and fine-scale features such as the brickwork on the water-facing

⁵ The point spacing of the TLS instrument is set by each user, and depends on the specific nature of the site and the application. The point spacing varies with range distance – points closer to the scanner will have a smaller separation and points further away will be more distantly separated. It was decided for this application that 25 mm spacing at a range of 50 m would give the optimal balance between scan times at each station and spatial resolution.

side of the quay. While the LiDAR data were readily available from the Channel Coast Observatory (CCO) website (<http://www.channelcoast.org/>) the TLS data were more specialised and a survey had to be carried out for this project by the author.

3.10. Terrestrial Laser Scanning

Terrestrial surveying technology has progressed and changed rapidly since the development of terrestrial laser scanning systems for ground based surveys in the late 90s (Heritage & Large 2009). In many cases, best practice for building surveying and modelling has moved from mapping using ground positioning systems, to collecting real-world 3D co-ordinates of objects at rapid and accurate speed (Heritage & Large 2009). This research focuses on the use of terrestrial scanning for capturing the 3D detail of a heritage site in the Tamar Valley. Having introduced the data collection methods at the working group and discussed the benefits and limitations of this approach, data collection went ahead. In total three days of scanning were required to collect data covering an area of approximately 100x40m². The Cotehele Estate includes Cotehele House and Mill but the quayside area is the only part of the Cotehele Estate that will be affected by tidal flooding and therefore is the only area of interest for this study. The quay at Cotehele is open year-round to the public, unlike the house which is closed in the winter months.

A Leica HDS 3000 terrestrial laser scanner was used, which is a pulse-based (time-of-flight) measuring device. This scanner is recognised for its appropriateness for cultural heritage applications (Worboys 1998), and was particularly well suited to capturing data at Cotehele Quay as its spatial accuracy range is $\leq 6\text{mm}$ within 100m range (Leica 2010)⁶. Laser scanners use two different principles to measure the distance between a sensor and the target: pulse based systems and phase based systems. Pulsed based systems are well suited to scanning heritage sites as they capture data at longer wavelengths and longer wavelengths are less affected by the atmosphere. Conversely shorter wavelengths, found in phased based scan

⁶ Further discussion of data accuracy is presented in section 3.9.1

systems can provide a smaller footprint (the size of the laser spot on a surface). The trade-off here is the divergence of the laser over greater distances, decreasing the spatial accuracy of the collected data point (Buckley, Howell et al. 2008). Due to the size of the area at Cotehele Quay, it was more important that as much data could be collected and the size of the site was well suited to using a pulse-based system.

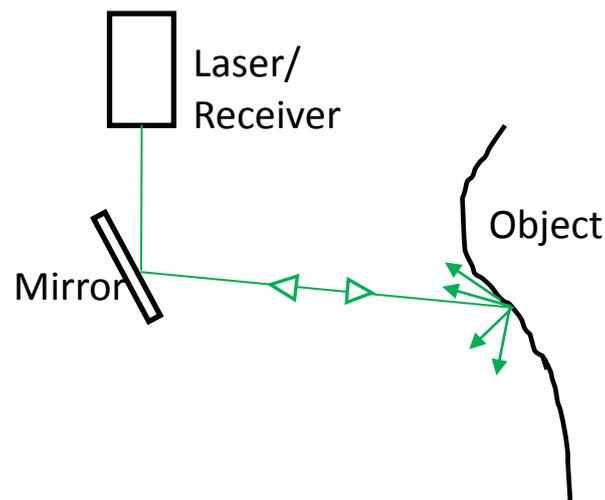


Figure 9 Time of flight (pulse-based) principle [adapted from Boehler and Marbs (2005)]

The spatial accuracy of an HDS 3000 is reported to be $\pm 6\text{mm}$ up to 100m; during field visits this distance was only deliberately exceeded once to capture data from an advantageous position across the river. The scanner field-of-view (FOV) reaches 270° in the vertical plane and a full 360° in the horizontal plane (full specifications in Appendix 1). Along with the x,y,z Cartesian coordinate collected by the laser scanner, the intensity of the received echo is registered as well. The scan system collects three observations about each point on an objects surface: the range (r) and two angles, (α) the horizontal angle and (β) the vertical angle. The scanner converts these from spherical coordinates into a Cartesian coordinate system [Figure 11] which enables these points to be mapped in the inbuilt scanner software as a 3D model and viewed immediately.

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = r \begin{pmatrix} \cos \alpha \cos \beta \\ \sin \alpha \cos \beta \\ \sin \beta \end{pmatrix}$$

Figure 10 Conversion from scanner coordinate system to Cartesian coordinate system [source: (Lichti, Gordon et al. 2005)]

The data were stored in a database as individual scanworlds using Leica software Cyclone (v 5.4, 2007). Cyclone is a virtual 3D database where each data point is stored and viewed as a 3D coordinate within the model space. Each point on a surface hit by the scanner is parameterised by three coordinates relative to the scanner: a horizontal angle, a vertical angle and a range (Lindenburgh, Pfeifer et al. 2005).

3.10.1. Precision of survey data

The precision of survey data collected is mainly dependent on two factors: instrument and environmental conditions. The demands of commercial applications of laser scanning (i.e. time constraints, requirements of rapid, accurate surveying) mean that the inbuilt calibration function of the HDS 3000 is recognised as being a reliable indicator of instrument precision (Lindenburgh, Pfeifer et al. 2005). Therefore, it is more important to be able to identify how external factors such as lighting and surface properties can affect the precision of the data collected as this is often the only variable affecting instrument precision that users are able to manage. Across an increasing range measurement (the distance from the laser to the observed object) the accuracy of the laser point depends upon the intensity of the reflected laser beam (Schulz and Ingensand 2004) [Table 6].

Accuracy of single measurement	
Position*	6mm
Distance*	4mm
Angle (horizontal/vertical)	60 microradians/60 microradians, one sigma
Modelled surface precision/noise	2mm, one sigma
Target acquisition	2mm std. Deviation

Table 6 Precision specifications for Leica HDS3000 scanner (Leica 2010)
*@ 1m – 50m range

Boehler and Marbs (2007) conducted tests on a number of laser scanning systems. They produced results on the differences between known and scanned spatial distances between two spheres. These results show that HDS 3000 produced the lowest standard deviation (in mm) of all scanners tested [Table 7].

	Close range <10m	Far range 10- 50m	Maximal absolute difference
Avg (2 tests)	1mm	0.85mm	2.15mm

Table 7 Standard deviation of difference between known and scanned distances using Leica HDS 3000 (adapted from Boehler and Marbs 2005)

3.10.2. Environmental factors affecting precision

Of the environmental factors which can affect the precision of the data, these can be further identified as surface properties and atmospheric conditions. As laser scanners have to rely on a signal reflected back to the laser scanner, the strength of the returned signal is affected by the reflective abilities of the surface; this is also known as the albedo. The reflectance qualities of the material or object under observation should always be considered before scanning takes place (Höfle and Pfeifer 2007). The two main factors affecting the reflectance characteristics of a laser are: colour and surface roughness. The effect of the colour of the surface does depend on the spectral characteristics of the laser (the HDS 3000 uses a green laser with a wavelength between 400nm and 700nm) but white surfaces yield the strongest reflections with black surfaces having weaker reflectance properties. (Boehler and Marbs 2005) carried out a series of tests on the

accuracy of the HDS 3000 laser scanning system, finding that in favourable environmental conditions (in a controlled environment, inside a building) meant no distance correction was needed for different coloured surfaces (white, grey, black); although this study does not take into account variations in surface roughness. The buildings at Cotehele Quay were scanned so that they were orientated towards the laser beam, reducing the orthogonal and shading possibilities and striving to achieve the highest spatial accuracy possible.

The atmospheric conditions which can affect the accuracy of the reflected laser pulse are how the speed of the returning beam is influenced by atmospheric conditions. These include a change in temperature of ± 1 °C a change in atmospheric pressure of +10mbar and a variation in relative humidity of 0% to 100% (Prokop 2008). In this study, as the fieldwork took place over three non-consecutive days, the greatest influence on the return pulse would come from the change in atmospheric pressure.

3.10.3. Spatial Resolution

Spatial resolution governs the detail that is captured by the laser scanner and can be decoupled into range and angular components. Range resolution is the ability of a rangefinder to resolve two objects on the same line of sight and is governed by pulse length for a pulsed system (Lichti and Jamtsho 2006:141). Angular resolution (resolving two objects on adjacent sight lines) is a function of spatial sampling interval and the laser beamwidth. The resolution of the landscape model needs to be at least an order of magnitude greater than the sampling density of the most detailed scan feature (Nagihara, Mulligan et al. 2004). Using a point cloud segmentation method, Lindenburgh et al., (2005) found that within one scan, the error generated can be between 2mm at 10m to 10mm at 50m however once registered scans from different scan positions result in a maximal systematic error of 2mm with a standard deviation of 6mm (Lindenburgh, Pfeifer et al. 2005).

How one sets the resolution of the scanning system depends on the scale of objects and features that are to be measured (Buckley, Howell et al.

2008). For day one of fieldwork, scans were carried out with settings of 10mm, 25mm and 100mm at 50mm range spatial resolution (in Cyclone, version 5.4, Leica Geosystems). This was done to capture detail on particular objects of interest. The completion of scanning at the site for the following two days of fieldwork was carried out at a point spacing of 25mm at an average range of 50m. This standardisation of the dataset was a result of the realisation that there was no need to capture data at a finer spatial scale. Between datasets, the field of view (FOV) for neighbouring scans created overlap regions, yielding multiple coverage of areas within the site. The overlap of scanworlds enabled accurate co-registration of scans using objects that appeared in >1 scanworld, and additionally produced a dataset with overall a more densely sampled point cloud than suggested by the 25mm spacing of a single scan, Leica's Cyclone software was used to register the 21 scanworlds together into a single TLS model of the entire quayside. Other datasets were then required in order to render this point cloud useable in a geographic sense. Lichti and Jamtsho (2006) explain that it is misleading to view a point cloud and assume it has a high spatial resolution if it has a fine sampling density and high point density. The detail within a scan (and the spatial resolution) can become blurred if the beamwidth of the laser is large relative to the sampling interval.

3.11. Deployment

Laser scanning of Cotehele Quay took place over three non-consecutive days [Table 8]. At any one time, the laser scanner needed to operate on fully charged batteries with a lifetime of approximately 6 hours. One of the advantages of laser scanning is that it allows data capture of complex landscapes (Prokop 2008), however the laser beam is only able to capture data about objects in its line of sight. Although the site at Cotehele does not cover a large area, the distribution of buildings around the quay meant that the scanner had to be manually moved from position to position to capture as much detail as possible of the roofs, doorways and windows. During scanning, the scan instrument is mounted on a tripod [Figure 12]



Figure 11 Scan set up on Cotehele Quay

Table 8 shows the conditions on each day of scanning. Two field days were undertaken outside the high season when fewer people are using the site for recreation and a third field day was undertaken to capture data of the car park. The following tables show the results of the of the scanning that took place, including: the number of points that were collected per scan, the minimum and maximum distance from scanner to object and the settings for the field of view from the scanner [Table 9, Table 10 & Table 11].

Date	Time	Weather	Other field notes
07/07/2009	10-3pm	Temperature 17° Cloudy and sunny	Quay was busy, Canoe Tamar were using the slipway and were captured in the dataset. Lots of movement from cars and people around the site. Weather was clear.
26/05/2010	8-2pm	Temperature 10° Cloudy	Early morning, site quiet and empty.
10/10/2010	10-3pm	Temperature 10° Cloudy	Site quiet Morning spring tide meant wet ground around the quay edges

Table 8 Fieldwork conditions

	# of points	Min distance	Max distance	Window Hz (degrees)	Window Vr (degrees)
Scanworld 1					
# of points					
117282	56171	5.43	58.48	4/50	-10/-30
Scan 1	61113	5.58	245.35	6/66	-9/8
Scan 2					
Scanworld 2					
# of points					
931806	555705	1.30	129.90	300/314	12/-25
Scan 1	377363	7.15	228.07	10.5/117	3/36
Scan 2					
Scanworld 3					
# of points					
250715	202380	2.91	47.87	3/90	3/-20
Scan 1	48335	27.05	203.35	250/319	1/-3
Scan 2					
Scanworld 4					
# of points					
751831	528282	16.50	198.55	284/51.5	3/-5
Scan 1	15551	73.92	202.93	325.5/330	2/5
Scan 2	207998	23.77	213.12	336/39.5	8/0
Scan 3					
Scanworld 5					
# of points					
469386	469386	1.71	53.93	312/132	0/-38.5
Scan 1					
Scanworld 6					
# of points					
201757	201757	9.92	231.41	320/90	0/-25
Scan 1					
Scanworld 7					
# of points					
209885	209885	8.04	100.98	358/112	-11/27.5
Scan 1					

Table 9 Information on data capture - field day one

10	# of points	Min distance	Max distance	Window Hz (degrees)	Window Vr (degrees)
Scanworld 1					
# of points					
539503	99901	1.16	28.21	0/220	15/-10
Scan 1	99951	2.68	14.39	0/220	15/-10
Scan 2	99412	2.48	145.21	0/220	15/-10
Scan 3	99197	6.02	109.83	0/220	15/-10
Scan 4	95095	5.59	140.38	0/220	15/-10
Scan 5	62265	19.29	189.99	0/220	15/-10
Scan 6					
Scanworld 2					
# of points					
85202	85202	7.21	10.14	340/20	15/-10
Scan 1					
Scanworld 3					
# of points					
371510	285601	8.23	166.46	0/220	-10/20
Scan 1	43369	2.15	49.86		
Scan 2	42540	8.30	50.08		
Scan 3					
Scanworld 4					
# of points					
603199	603199	3.04	107.79	350/75	-10/50
Scan 1					
Scanworld 5					
# of points					
164844	145733	6.69	187.63	350/65	20/-10
Scan 1	19111	3.22	234.54		
Scan 2					
Scanworld 6					
# of points					
201429	201429	6.44	14.56	350/70	-10/20
Scan 1					

Table 10 Information on data capture - field day two

	# of points	Min distance (m)	Max distance (m)	Window Hz (degrees)	Window Vr (degrees)
Scanworld 1					
# of points	1453515				
Scan 1	1291012	0.29	296.02	360	22/-33
Scan 2	20835	18.82	34.23	55.5/57	-3.5/-5.5
Scan 3	41324	10.78	16.19	76/78	-6/-9
Scan 4	32324	27.30	44.17	81/83	-1.5/-2.5
Scan 5	20904	38.30	39.26	114/115.5	0/1.5
Scan 6	47116	16.82	18.96	154/157	0/-2
Scanworld 2					
# of points	559785	8.33	213.10	0/180	-20/20
Scan 1					
Scanworld 3					
# of points	545071	6.20	229.48	104/280	20/-16
Scan 1	6708	14.87	16.79	217/218.4	-0.6/-1.4
Scan 2	6336	19.70	19.91	129.2/130	0.8/1.6
Scan 3					
Scanworld 4					
# of points	1134570	37.02	148.24	360	28/-15
Scan 1	1134570	37.02	148.24	360	28/-15
Scanworld 5					
# of points	397111	5.35	45.99	300/120	-15/10.5
Scan 1	397111	5.35	45.99	300/120	-15/10.5
Scanworld 6					
# of points	1585746	3.18	53.42	360	-30/22
Scan 1	1585746	3.18	53.42	360	-30/22

Table 11 Information on data capture - field day three

In total 10,591,729 data points were collected, with an average minimum distance of 12m and an average maximum distance of 116m.

3.12. Differential Global Positioning System (DGPS)

The next stage was to gather data in the field for registration of the point cloud data to the British National Grid. This converts the point cloud to provide an absolute coordinate transformation. To achieve this, a differential GPS base station was first set up at Cotehele (located at N50° 29.6898, W4° 13.5487, 2.542m) and left for 2 hours to collect data [Figure 13]. The location for the base station was determined as it provided line of sight to

much of the rest of the quayside area. The roving receiver used to survey other areas of the quayside had a range of approximately 50m in line of sight before losing connection with the base station. This was taken into consideration when deciding on the most appropriate location for the GPS base station. Using Receiver Independent Exchange format (RINEX) software, differential corrections were made using the nearest UK Ordnance Survey vector difference corrections, following the method described in Anderson et al (2010). The co-ordinate precision for these data were 0.004mE, 0.004mN and 0.007m AMSL. Upon returning to the site the base station was set up with the determined DGPS co-ordinates. A pole-mounted roving DGPS receiver (HiPER Pro, Topcon) was then used to survey the rest of the site against the determined base station position. The reported accuracies of the roving system were <10mm (horizontal) and <15mm (vertical; Topcon 2009 in Anderson et al, 2010). Key features describing the geometry of the site, such as corners of buildings and stone work were collected with the roving receiver. Around 80 individual co-ordinates were collected.

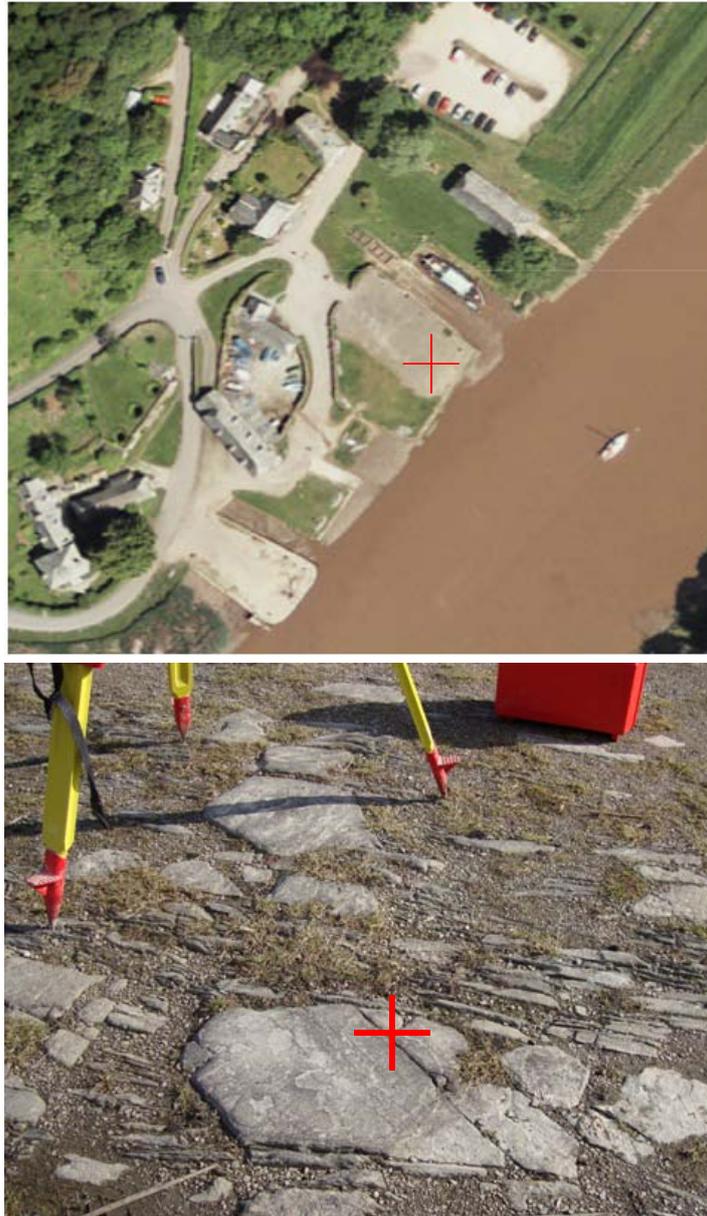


Figure 12 Location of GPS base station, [top] aerial view of Cotehele Quay, cross marks location of base station, [bottom] cross marks location over which base station was sited.

3.13. Light Detection and Ranging (LiDAR)

Airborne LiDAR data is remotely captured spatial data that derives geometric information in three dimensions. Collecting sequential laser range measurements, light is reflected from the surface and captured at decimetre accuracy (Hug 1997). Whilst the technique of capturing LiDAR data is somewhat similar to TLS, airborne LiDAR can capture data on much greater spatial scales. Airborne LiDAR can produce DSMs with a reported accuracy

of 0.2m horizontally (x,y) and 0.1m vertically (z) (Lohr 1998) but this is dependent on the exact technology specifications.

The raw data captured are presented as a Digital Surface Model (DSM), meaning that they display not only the elevation of the surface but also the surface features (Priestnall, Jaafar et al. 2000). Digital Elevation Models (DEMs) of the ground elevation can be derived from a DSM dataset as the surface properties of the terrain can be extracted (Priestnall, Jaafar et al. 2000; Poon, Fraser et al. 2005), this has led to DSMs becoming more frequently used by planners, insurance companies and urban designers whilst DEMs have been continually used in environmental modelling as often the detailed surface terrain is not needed (Xiaoye Liu 2008).

Where DSMs have emerged as particularly applicable is to mapping flood inundation and hazard zones (Mason, Horritt et al. 2007). DEMs rely upon a small contour interval and a large number of surveyed spot heights, DSMs represent the ground surface at finer resolutions and therefore flood modelling can be calculated more accurately (Marks and Bates 2000). This may explain why DSMs have been applied across the UK in flood mapping exercises led by the EA (Brown and Damery 2002; Merz, Thieken et al. 2007). The relative ease at which LiDAR data can now be accessed and the increasing precision of the equipment used to capture the data (Csanyi and Toth 2007), means that LiDAR remains the most popular source of data for flood modelling large spatial extents (Horritt and Bates 2001; Poulter and Halpin 2008).

The LiDAR data used in this research was captured by the EA in 2008 and provided as a freely accessible online resource from the Channel Coastal Observatory (CCO 2012). These data had a spatial resolution of 1m covering a spatial extent of 58km², with 44km² of this downloaded dataset being used in the 3D model. These data were at too coarse a spatial resolution to allow the details of the buildings and quayside features to be precisely captured and described because fine-grained details in building structures were not visible given their spatial resolution.

3.14. Aerial and Terrestrial Photography

Having collected data on a range of spatial scales (TLS to aerial LiDAR), any images that would be used to texture the data needed to match the scale of the data it was being applied to, so photographic images were collected from airborne and terrestrial positions. It was clear that some parts of the 3D model would require more careful visualisation than others (e.g. buildings on the quay would need to have clear features such as doorframes, whereas the surrounding hillsides were likely to feature only momentarily in the visualisation). Airborne photography was a rapid solution for texturing the surrounding valley, whereas individual photos were taken of the quay to be able to model the buildings and retain the detail.

Often when a LiDAR survey is commissioned, aerial photography is simultaneously captured (Riaño, Valladares et al. 2004). Aerial photography is widely used to aid the visualisation of spatial data and is geo-rectified as part of the processing of the data and this makes it easy to overlay on digital elevation and digital surface models (Mostafa and Schwarz 2000). Whilst this does not serve any function other than to make spatial data more visually engaging, it can aid people's perceptions of the extent of landscape changes (McClure and Griffiths 2002). Along with the LiDAR data, aerial photography of Cotehele Quay and the surrounding area were downloaded from the CCO repository as 1km² grids, covering an area of 4km² over Cotehele House and Quay, and the surrounding area. The images were extracts from the Millennium Map Project (©Getmapping PLC).

Over 300 images were taken onsite at Cotehele Quay, capturing the external facades of the buildings and also the maritime artefacts distributed around the site. Two digital cameras were used to document the site, one with 12 megapixel resolution and another with 20 megapixel resolution [Figure 14].



Figure 13 Left 20 megapixel image, right 12 megapixel image

3.15. Cyclone: registration

Once laser scan datasets have been collected, each existed as separate point clouds in a database in Leica's Cyclone software. To bring these into one unified coordinate system these have to be registered (or aligned) to one another in a process known as registration. To do this, tie-points between pairs have to be identified and then an inbuilt algorithm in Cyclone computes the 'best fit' for the pair of scans. Cyclone assigns one scan as the slave scan and another as the master and the slave scan is transformed onto the master by an Euclidean transform function, also known as shift and rotation or congruency (Pfeifer and Briese 2007). The resulting registrations generate 'cloud constraint diagnostics', or statistics which provide information regarding the accuracy of the cloud registration [Table 12]. Two factors can have a detrimental effect on achieving an accurate registration:

1. Lack of overlapping points in the scanworld datasets [Figure 15]
2. Large amount of noise in the dataset [Figure 16]

Cloud constraint variable name	diagnostic	Definition
Cloud / mesh		The name of the constraint
Translation		The translation vector for the registration of the second cloud onto the first
Rotation		The rotation axis and angle for the registration of the second cloud onto the first
Objective function value		The value of the overlap error function being minimised during registration
Overlap point count		The number of overlapping points between two scanworlds
RMS		The root mean square value of the absolute errors between overlapping points
Avg		The average value of the absolute errors between overlapping points
Max		The maximum value of absolute errors
Min		The minimum value of absolute errors between overlapping points
Std dev		The standard deviation of the absolute errors between overlapping points

Table 12 Cloud constraints diagnostics variables and definitions [Leica, Cyclone, version 5.4]

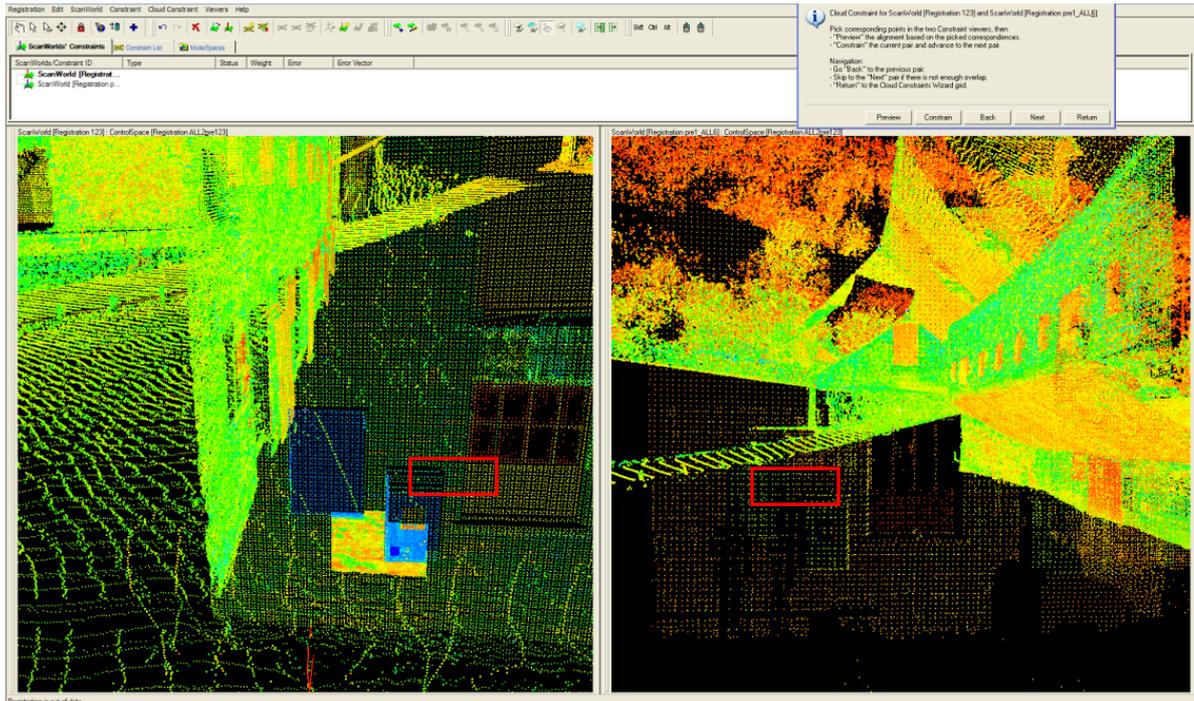


Figure 14 Comparison of two points captured in different scanworlds [left] with target [right] no target

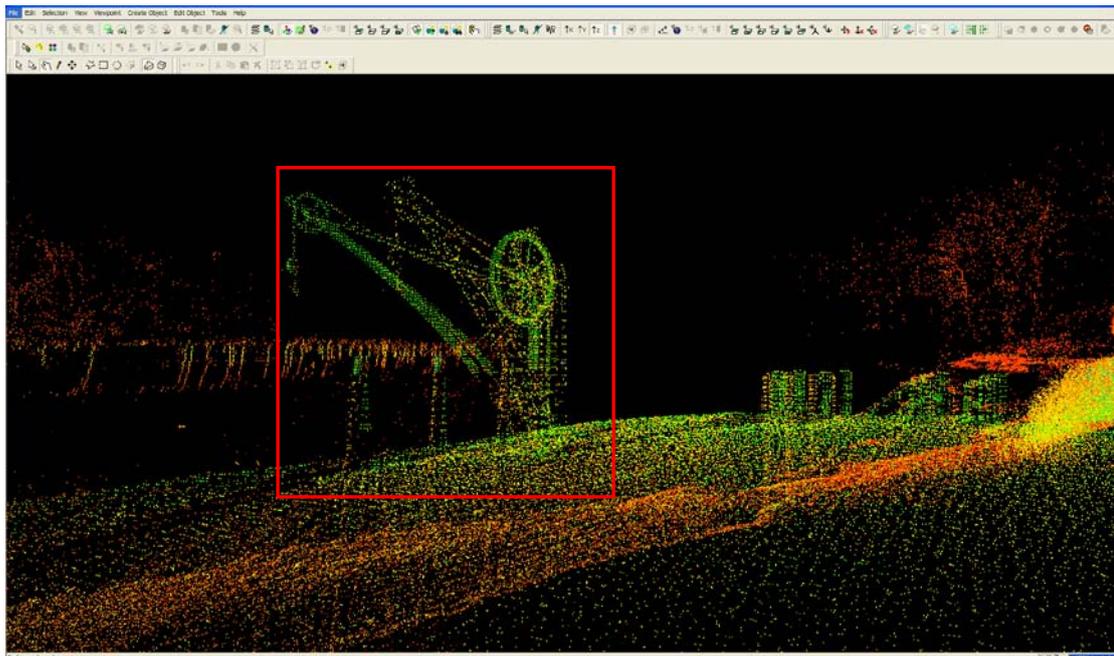


Figure 15 Overlapping scans reveal that the crane has been moved between scans and therefore noise has been generated in the dataset, also known as ghosting

There is no way to determine if the registration succeeded in finding the optimum alignment of the point clouds (within the accuracy limits of the data). Instead, the software providers suggest some alternative ways to

check the accuracy. Firstly looking at the RMS error of the registration: as reported by Leica, if the registration results in an RMS error of less than 6mm, than this is considered to be good. However for more complex geometry where the overlapping points may not be from the same source (e.g. in a field of grass) the RMS error will be higher.

The second and third suggestions rely heavily on the ability of the user to recognise and identify inaccurately registered point clouds. During the registration process an error histogram begins as a horizontal line and hopefully ends as a vertical bell-curve; a flat histogram indicates low registration accuracy [Figure 17].

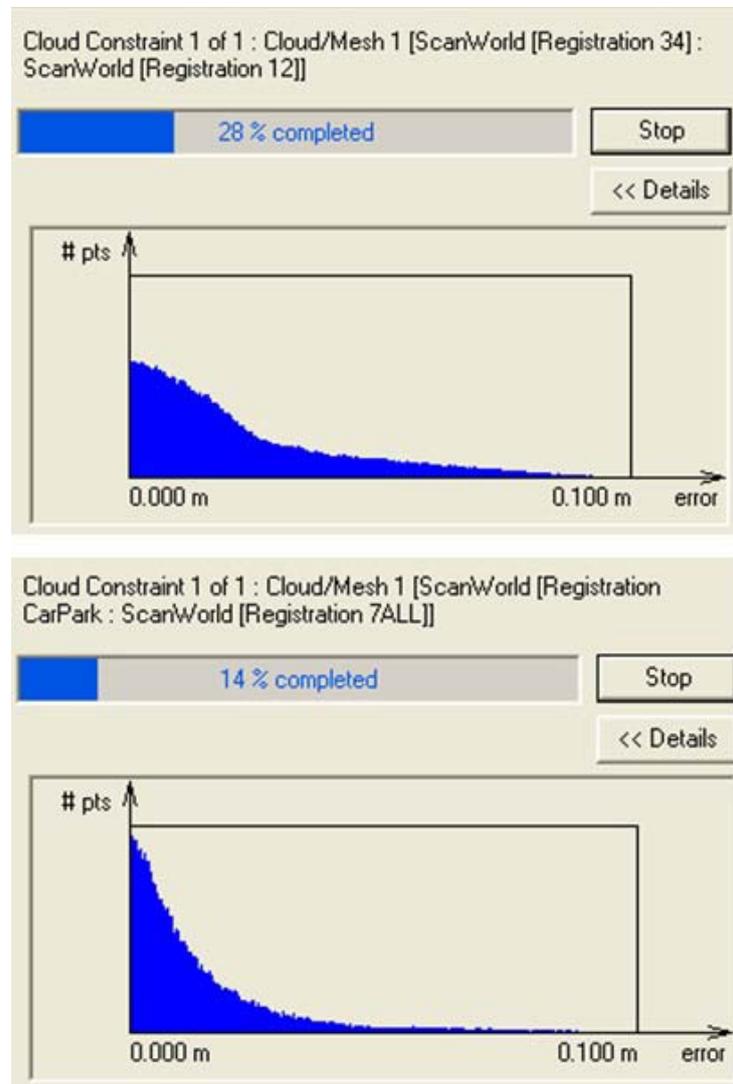


Figure 16 Example histograms during registration between point clouds. Higher vertical histograms represent more accurate spatial registrations

Finally, the third option is to carry out a manual check of the registration. If there are unaligned smooth surfaces this can signal poor registration [Figure 18].

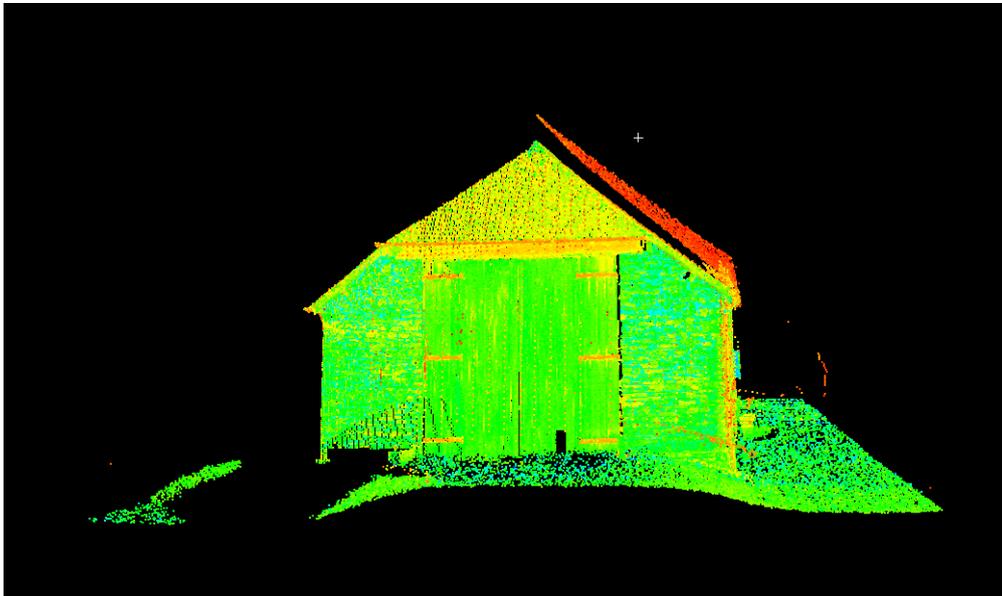


Figure 17 Poor alignment between two scans

Every effort was made to conduct the fieldwork for data capture when the conditions for laser scanning were favourable. The main contributory factor that generates noise in the dataset was movement that interrupted the laser beam from the object being surveyed. When objects move in front of the laser beam this create anomalous data also known as ‘ghosting points’ [Figure 16]. These points will then be stored in one scan but will not appear when the scanner is moved to another position. These anomalous points have little impact on the accuracy of the resulting registrations, as ghosting points are extremely unlikely to have matching tie points in another scan.

Although ghosting points are not detrimental to the accuracy of the registration, the few ghosting points that were captured as a result of cars and people moving around Cotehele Quay were removed before registration. Any further outliers that may have been overlooked were removed in 3D Reshaper [section 3.16].

3.16. 3D Reshaper: Meshing

The next stage of the process was to create a 3D surface of the points by completing a process known as 'meshing' [Figure 19]. Meshing is a process whereby point data is converted to a smooth surface by algorithms that interpolate between points and generate polygons that construct a solid surface. This is a process which has to be undertaken on the point data in order to render it useful for design and modelling applications. The complexity of algorithms used to generate a meshed surface has led to software programmes becoming expensive with little market competition. And whilst there are open source platforms offering users a simple alternative for converting points into meshes (e.g. MeshLab), these are more applicable for the documentation and preservation of small cultural artefacts rather than landscapes (Cignoni, Corsini et al. 2008). Refining meshing algorithms so they produce meshes which are more closely aligned with the original point dataset is an on-going interest for computer scientists (Bohm and Pateraki 2006; Woo and Dey 2006; Wang, Zhang et al. 2008). Researchers are beginning to address the exhaustive list of requirements for meshed surfaces; primarily balancing the speed of generating the mesh, against the ability of the mesh to capture the detail of the observed object.

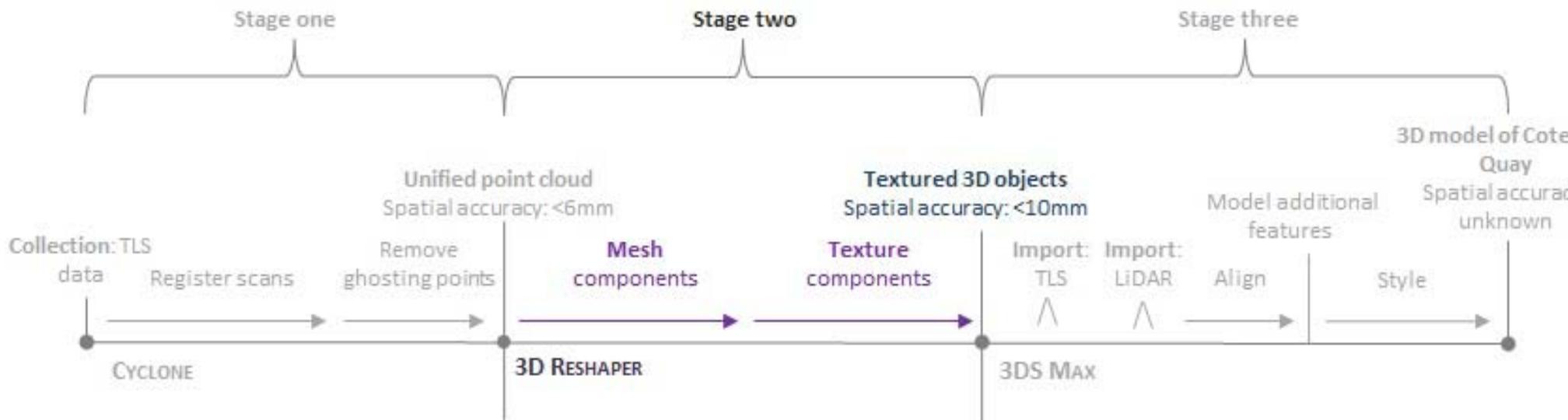


Figure 18 Diagram of processing stages: stage two

Having reached a stage where the point cloud has been registered, the next step was to convert the point data into an 'object' file (.obj)⁷ that can be used in design software. The point cloud was imported into 3D Reshaper, a programme that can be used to convert point clouds into meshed objects. After registration and geo-rectification, the accuracy of the point data is still <1cm accurate (relative to the original point cloud) but generating a mesh will alter this (Palamara, Nicholson et al. 2007). Increasing the number of polygons in the mesh improves accuracy by reducing the standard deviation of interpolated points (Landes, Grussenmeyer et al. 2007). Unfortunately the software (3D Reshaper) is limited to the number of polygons it can effectively handle without using all the available computer memory (200,000 polygons); however, smooth and planar surface fitting tools help to recognise smooth features where the number of polygons can be reduced to maintain detail and accuracy in other areas of the object.

To address the difficulty that the software has with dealing with large datasets, Zhang et al (2003) found that importing individual components from the scene one at a time was a solution to this problem. Each of the buildings and the terrain were therefore exported as point files (.pts) from Cyclone and then processed in 3D Reshaper [Figure 20].

⁷ An obj is a geometry definition file format used for representing 3D geometry.

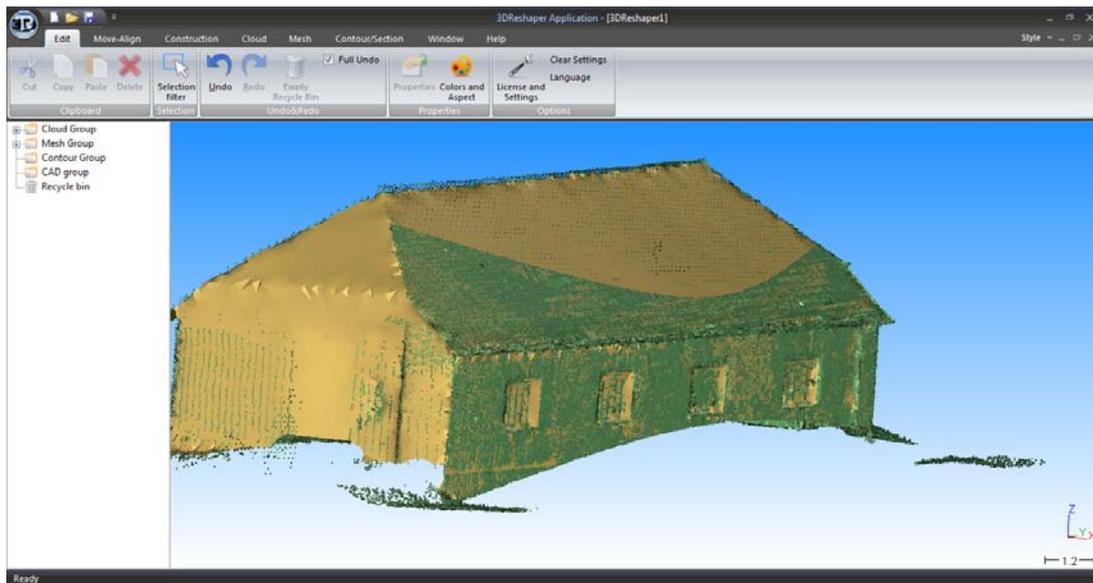


Figure 19 A mesh (yellow) of the workshop with the original point data (green)

The functions used for processing the components include: 3D meshing functions, texturing and mesh colouration, hole filling, noise elimination and surface smoothing (Technodigit 2012). As presented by (Buckley, Howell et al. 2008) the accuracy of the data can diminish during mesh generation particularly during hole filling, interpolation and smoothing. To avoid diminishing the accuracy as they highlight, hole filling and interpolation between points was only conducted on the windows and doors (i.e. not areas where the precision of the data is important). Meshing was the first of two stages of processing that were undertaken in 3D Reshaper, firstly each of the components were meshed, and secondly, these were then textured using the texturing and mesh coloration functions of the software. Each of the buildings were processed in broadly the same way, but throughout this stage of the processing it was necessary to make constant and on-going decisions regarding the level of detail that would remain for each of the buildings, how and why these decisions were made is discussed more in Chapter 8.

3.16.1. Texture Mapping

Using the mesh as a framework, the next stage was to apply images to the surface to create a realistic facade. There are various approaches to

achieve this in design environments; often architects use pre-existing stock imagery providing generic surface textures. This is suitable for conceptual designs, but is not always appropriate when modelling existing buildings. At Cotehele Quay the buildings are adorned with signs and markings that make them unique, providing character which make them familiar to the people who frequent the site. In order to visually represent the verisimilitude the most rapid approach is to use photography for texturing. In 3D Reshaper texturing is the process of applying photographs and digital images to create the appearance of textures on 3D digital surfaces. This is carried out by mapping the photograph onto to the object by selecting points between the building and the object.

A potentially contentious element to texturing the buildings in this way is that it can lead to visual misinterpretation of the height of the water up the side of the building; 3D Reshaper offers very little control over the precise application of images. Rather than decreasing the spatial accuracy of the dataset, this is more a misinterpretation of spatial positioning and has the potential to confuse or mislead the audience.

3.17. 3DS Max: overview

The final element of data processing involved using digital design software to create a realistic 3D model [Figure 21]. 3D Studio Max (3DS Max) was used to manipulate, model, render and create sequences and still images of flooding at Cotehele Quay. Much of the approach to using 3DS Max revolves around trial and error. A large proportion of research time went on learning and applying new methods to enhance the visual aesthetic and final content of the model of Cotehele Quay. The sections of this thesis which address the digital design of Cotehele Quay explain how modelling was carried out for Cotehele Quay. As there is no 'best practice' for 3D modelling these methods do not follow other studies which have used the same software. This should not undermine the rigour of this methodological approach; it is simply the case when creating entirely unique 3D environments using numerous spatial datasets.

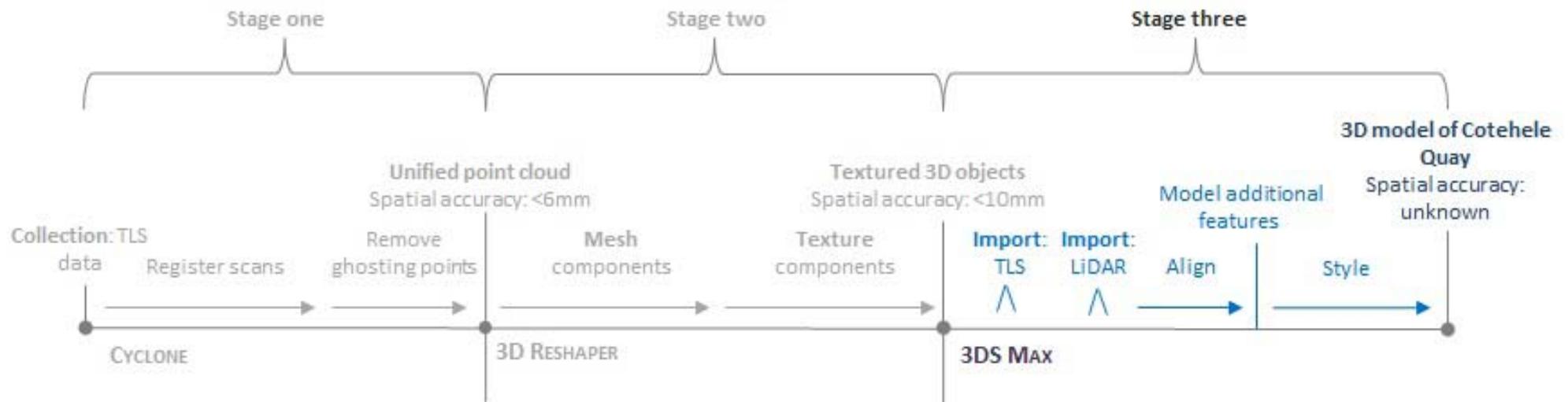


Figure 20 Diagram of processing stages: stage three

The iterative development of the model, meant returning 3DS Max to make modifications to the 3D model. Later in the research, improvements to the visual aesthetic of the model were made due to increased computer memory and processing power. This had significant and tangible (see focus groups results section 3.28) impacts on the portrayal of Cotehele Quay in the final film 'Changing Tides at Cotehele Quay'.

3DS Max is primarily a software programme for designing animations and characters (Matossian 2004), but it is well suited to designing landscape environments as it has the functionality to handle large datasets and file formats that capture the geometry of objects. The functionality of 3DS Max means that it played a dual role in this research. It was used to create, manipulate and modify the 3D data and it was also used to produce short video sequences of movement in the 3D model⁸. The visualisations were made in 3DS Max as the software is capable of handling large datasets, as well as providing the functions to create 3D environments and then render out frames to create films.

3.17.1. Texture Mapping

The process for adding texture in 3DS Max is different from that of 3D Reshaper. The design environment in 3DS Max is better suited to designing 3D textures from scratch, i.e. changing the qualities of a surface to create different textures. However for planar surfaces, bitmaps (photographic images e.g. jpegs) can be mapped onto surfaces using a function known as a UVW map. A UVW map is a function that assigns the image with 3D coordinates, which, when assigned to a surface can be manipulated to fit a 3D object (Matossian 2004). The majority of components of the 3D model had been textured in 3D Reshaper, but a test was carried out on one component to compare the quality of the texturing process. The Edgcumbe Arms [Figure 22] was modelled in 3DS Max and had not been through the meshing process. This resulted in this one building having a significantly

⁸ 3DS Max was also used to create the short visualisations, this part of the process is presented in section 1.16

lower number of polygons than any other component (250 faces). The flat surface and the lack of variation of the surface meant that the photograph of the Edgcumbe could easily be applied using the UVW function. The result of applying this image to the mesh did generate image distortion, but this is a compromise of appearance compared with using a mesh with a more complex structure which would use more computer memory to process.



Figure 21 Edgcumbe Arms in 3DS Max

3.17.2. Creating water

Within 3D environments, water is one of the most complex components to model (Iglesias 2004). The two most regularly modelled ways to display water are: 1. Flow - to create a separate boundless object which responds to other objects in the scene (it has the most similar characteristics to real water as if it comes in to contact with another object it will be stopped) and 2. Plane - to create a flat plane object and then to modify the surface properties of this object to make it appear like water; the latter approach was used in these visualisations. The simplicity of using a plane meant that the height of the water could be uniform across the model, rather than

responding, potentially unrealistically, to the objects in the scene. Additionally to this, a plane is only constructed of several 10s of polygons rather than 1000s, which would give the flow model its dynamism.

3DS Max allows the designer to limit the number of times that any object can reflect light; rather than this being an infinite quantity. The higher the number of iterations of reflectance, the more realistic a scene may appear as this creates shadows. The settings which characterise how light interacts with the surface area are what determines how realistic the water appears when rendered. Within the modelling interface it is possible to manipulate several characteristics of the object surface, including: surface reflectivity, transparency, glossiness and diffuse colour. Modifying each of these elements means adapting the way that light interacts with the object and therefore gives different visual results.

Light is the most demanding component of rendering a 3D scene in 3DS Max, as the software needs to have the capacity to compute thousands of rays of light in a scene. The more complex surfaces and interactions the light has to make, the more intensive rendering can become. For example, the setting in the render of 3DS Max can control how many times light is reflected off each surface e.g. each ray will hit three objects. Limited processing power offered by the computer meant that there were constraints on the options available to improve the level of the realism of the water. In particular, reflectivity and glossiness involved algorithms that went beyond the capabilities of the computer to process and therefore could not be applied to the surface. Using a 'bump' function, gives the plane an appearance of waves and/or ripples, in order to do this two contrasting colours need to be applied as the bump 'map' (the way in which the texture is applied to the surface), gives each pixel 2 faces with a different colour.

3.18. Working group two

Having reached a point in the research where the 3D model was taking shape and the constraints and possibilities of the software were beginning to be unveiled, it was decided that this was an appropriate time to re-engage with the working group. It had been explained to the participants at

the first meeting that it was hoped their involvement with the project would run for the duration of the research and that there would be at least one meeting per year. Table 13 shows who attended the second working group meeting.

Name	Affiliation	Attended WG1
Karen Anderson	UoE	Y
Caitlin Desilvey	UoE	Y
Chris Caseldine	UoE	Y
Kaja Curry	TECF	Y
Eloise Kane	AONB	Y
Joe Lawrence	NT	Y
Justin Ridgewell	Royal Haskoning	N
Toby Fox	NT	Y
Helen Vines (FG facilitator)	CEU Ltd	N

Table 13 Participants at working group 2

The first point to address at this meeting was the progress of the project, followed by a technical explanation of the processing that was involved in transitioning from separate datasets into a complete model [outlined in sections 3.9 to 3.17 of this chapter]. For the focus of the discussion of this meeting there were five main items to discuss:

- Setting the scene
- Scenarios planning – structure and content
- Focus and key themes
- Information inclusion
- Structure and form of public consultation

A deliberate decision was taken to show some initial rendered visualisations of the quay to the working group several months before the first focus group [screenshots of visualisations in Figure 23 & Figure 24, Visualisation in Appendix 2].



Figure 22 Still from the first iteration of visualisation 'Cotehele Quay West' from the 3D model

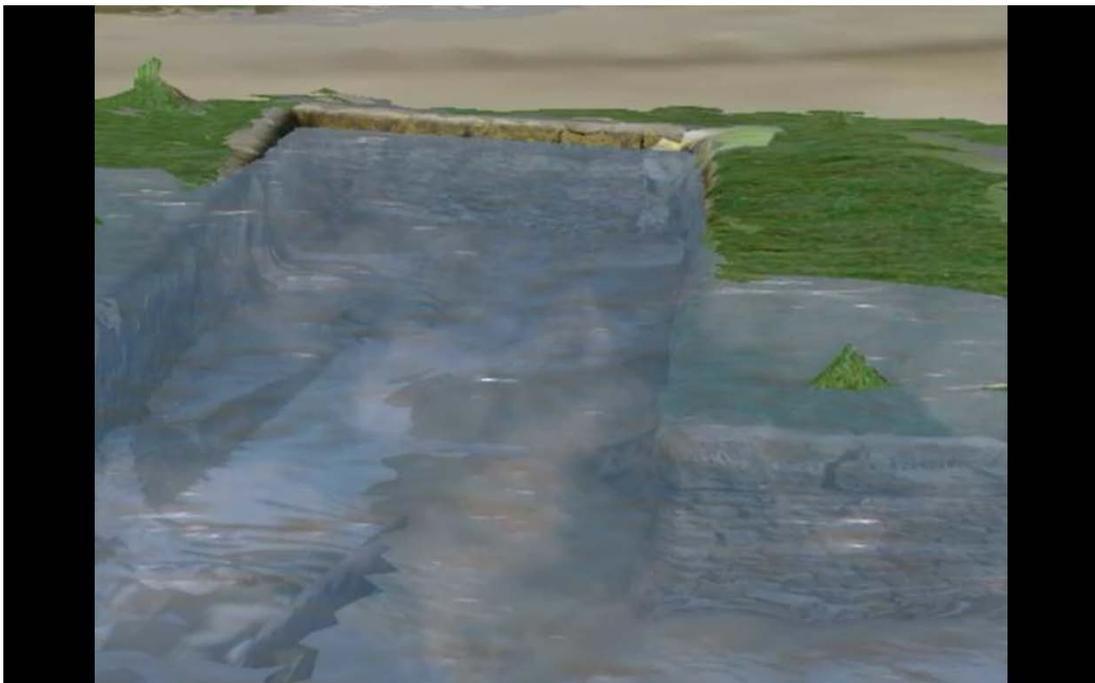


Figure 23 Still from the first iteration of visualisation 'rising water' from the 3D model

This allowed the style to be critiqued before reaching a public audience. Whilst it is important to note that the opinions of the working group were not seen as more important and influential than the focus groups, research suggests that if public focus groups are engaged with research that looks

unfinished they are less likely to contribute to the discussion (Bloor, Frankland et al. 2001).

3.19. Outcomes of working group two

The working group took place as planned on the 25/11/10 with 10 representatives from the NT, UoE, AONB, TECF and Royal Haskoning [full transcription in meeting Appendix 3]. At this point in the research it was clear that how the NT saw the visualisation being applied remained confused. Throughout the meeting the two NT staff members referenced different potential uses for the visualisations. On the one hand, the NT wanted the visualisations to remain driven by a need to start conversations about change at Cotehele, demonstrated by their eagerness to engage local communities. “How do we therefore engage the communities to sort of say this isn’t just about us and the impacts on us, but it’s about the valley and the impacts on all of us, so how do we need to think about this?” (TF, 25/11/10, Cotehele Quay). They also indicated a desire to have a tool which would allow them to make in-house management decisions about access and use of the site. Toby Fox summarised where the NT would like to be by the end of the research. “So we need to think about, if this area isn’t delivering public benefit because it is under water, then what are we going to do? What is our adaptation strategy?” (TF, 25/11/10, Cotehele Quay).

The group recognised that having the research conducted by an external party meant the NT were in a position of relative impartiality which they rarely get to experience. The same applies for other Quangos such as the EA who can be seen to be ‘forcing’ the issue. The NT staff felt that seeing the visualisations come from a third party might make the impacts ‘easier to bear’. So whilst the NT has a responsibility to protect heritage against environmental threats, and often facilitate conversations regarding decision-making, protecting individual’s property is outside of their remit, so they are able to position themselves in a different role.

Although the group recognised that expanding the visualisations beyond Cotehele Quay would demonstrate that this was not an inward-looking NT exercise, one participant highlighted that “you could well be opening up a

can of worms and find yourself in a very awkward situation, which you haven't necessarily got the support to be dealing with" (KC, 25/11/10, Cotehele Quay).

At this early stage, there was some disagreement about what scenarios should be considered for inclusion as a visualisation, with extreme events and future projections both mooted as alternative options. Part of the complexity in modelling extreme events is that it is still difficult to communicate probability. "We used to say it was 1 in 100 but now it's like 0.05% probability but people still have difficulty getting their heads round what that actually means" (JR, 25/11/10, Cotehele Quay).

High and low emissions scenarios were discussed as one alternative, but it was felt that these could be misleading. There was consensus that using projections from the UKCP09 report would validate the scenarios. One participant commented, "You don't get into trouble using figures generated by central government generally, because you just point the finger and say DEFRA said so" (JR, 25/11/10, Cotehele Quay).

Finally the working group discussed what the content of the visualisations should be placing particular emphasis on how they could be used to capture the attention of the audience and engage them emotionally, particularly the locals who frequent the quay. The general manager remarked, "throughout the course of the year, the little bench next to the shed, there are always people sitting there. This draws out the emotive factor" (TF, 25/11/10, Cotehele Quay).

3.20. Scenarios and Scene Setting

Responding to the working group feedback led on to the second iteration of visualisations in preparation for engagement with the focus groups. The purpose of engaging with the focus groups at this point was exploratory. It was clearly explained that at this stage the visualisations were at the start of the developmental process, and as such they were not a finished product. By explaining this, there was flexibility in what the visualisations demonstrated. The two central issues that the focus groups needed to

respond to were: a) how flooding is portrayed in the model, and b) how they perceived the realism of the buildings on the quay. At this point it was less important to show sea-level rise projections as they would have been misleading, considering the model had not been geo-rectified and was inaccurately aligned.

The second iteration of visualisations presented to the focus groups were somewhat different from the first in that they were both static. 'Visualisation One - tidal' lasted 35 seconds and showed the water level rising and falling, mimicking a tidal cycle. Although the model hadn't been geo-rectified, the measuring function in 3DS Max meant that the water could be raised to demonstrate an approximate 4.7m tide (an average neap tide). 'Visualisation two - flood' lasted 25 seconds and showed a flooding event on the quay. Both visualisations were static, which is a direct response to the feedback from the working group who criticised the 'jerky' motion of the camera. The first visualisation was deliberately a wider shot so the in the field of view is the quayside, the workshop and the Edgcumbe Arms. The first visualisation aimed to provoke a response to the realism of the buildings, whereas the second visualisation sought feedback on people's responses to the flood event.

The following section introduces how focus groups were used in this project as a participatory tool to offer feedback, and how the second iteration of the visualisations were utilised in an engagement setting.

3.21. Focus Groups as a Research Tool

Having analysed and improved the visualisations, the second iteration of visualisations were ready to be taken to the focus groups. Before discussing the outcome of this, the following section outlines the use of focus groups in this research and provides the rationale for using this method to gather feedback on the visualisations. The section begins by introducing focus groups as a research tool and justifies their appropriateness in this case, then follows the detail for how the first focus groups were conducted.

Focus groups were used as part of a longitudinal, iterative study during the research. Over the duration of the project, two sets of focus groups were conducted. The first pair of focus groups were held in March 2011, with one group representing the NT staff and volunteers and another comprised of members of the local community. These focus groups showcased the second iteration of visualisations (the methodology of production outlined in sections 3.10 to 3.17.2) in order to get feedback about modifications and improvements with the second set of focus groups were held in September 2011. By engaging with the same participants twice throughout the course of the year, a relationship was created opening up an opportunity to converse on subjects that went beyond flooding at Cotehele Quay.

Often longitudinal studies using focus groups are used as comparative indicators of change, whether that is a change in opinion, process or belief (Powell and Colin 2008; Forbat, Cayless et al. 2009); revisiting focus groups after a period of time can be used for retrospective analysis. The longitudinal design of the participatory process used focus groups in a somewhat unconventional way. Along with being a tool to gather feedback on the visualisations, the repeat contact with the same participants over an extended period meant that the nature of their involvement and engagement with the research over time could also be examined. There was interconnectedness between the iterative development of the visualisation and the relationship with the focus group participants, captured through this longitudinal research study. Over time, the focus groups acted as a mechanism bringing together stakeholders from the local community and industry professionals. (Bloor, Frankland et al. 2001) advocated that focus groups are an inherently social way of conducting research and are well suited to use in participatory research as they encourage social interactions (Pink 2006).

As the structure of the thesis follows a chronological trajectory, the rest of this chapter focuses solely on the first round of focus groups held in March 2011. From the outset, it was always planned that participation in this research would reach beyond the NT. The visualisations were intended to

be tools that could be used by the NT to initiate conversations about change with the local community.

Focus groups were used initially after World War II in market research and communication exercises (Templeton 1987). Market research activities still frequently use focus groups, particularly in an operational role for determining substantive matters (Bellenger, Bernhardt et al. 2011). However, over the last 20 years they have begun to emerge as a key methodological tool for opening up theoretical debates (Ding 2013). The theoretical applications for using focus groups at Cotehele Quay had a dual focus; the first stage of engagement (coinciding with the 2nd iteration of the visualisation) centred on gathering opinion and feedback, followed by the second stage orientated towards discourse and conversation analysis about flooding at Cotehele Quay and beyond.

Using focus groups as a tool for discussing and approaching issues that some participants may find difficult to talk about in a group setting has been something of a challenge for researchers for many years (Tonkiss 2004) although often overcome by researchers careful negotiation of sensitive topics (Kitzinger 1994). Rather than criticise the social aspect of focus groups as detrimental to the success of discussing sensitive subjects, (Kitzinger 1994) and Wilkinson (2004) have supported the use of focus groups as they can create spaces of comfort and reassurance. The impacts of climate change are one such topic which can engender uncomfortable tensions amongst groups affected, for although climate change is unlikely to have had (or have) a direct personal effect on those participating in the group (unlike other issues such as racism or gender stereotyping (Wilkinson 1998)) the many uncertainties and unknowns in regards to the impact of climate change can create tension amongst a group. The negativity which surrounds many of the media portrayals of climate change (O'Neill and Nicholson-Cole 2009) suggests that it is likely the participant will be attending with their own pre-constructed opinions about certain scientific issues. Well informed or not, this will impact on their contribution to the focus group and should not be overlooked. It is perhaps more important then, in this case, that the participants are familiar with one another as they

are then more likely to feel comfortable to share their thoughts and opinions, even though there may be conflicts. Morgan (1988) suggested that highlighting the participants 'commonality', or a sense of something shared, increases their willingness to contribute. It is less often that we experience focus groups that are asking questions about a very specific place. In this instance the common ground between all participants is a river.

The framing of the research encouraged participants of the focus groups to contest scientific facts and future projections. (Myers 1998) argued that it is more challenging to engage people in discussion about environmental issues as they lack interest in this area. Over the past 15 years, since Myers (1998) work was first published there have been changes in how people receive and engage with environmental debates. It is often now the case that people are more likely to want to be involved if the issues are local. Local knowledge has the potential to lead to interesting confrontations and shared understandings, where no one is likely to have 'nothing' to say on the matter. Being such a locally significant site, Cotehele Quay itself expounded a need for protection and contestation; something that manifests itself in the local community who when encouraged to talk about it, will no doubt have something to say.

The first round of focus groups were intended to be more perfunctory, looking to gather feedback on the style and content of the visualisations in a rather more superficial manner than later on in the research. A more thorough analysis of the results from these focus groups is presented later, but the point here is that the first focus groups avoided in depth discussion of climate impacts and were focused deliberately on reflecting on the visualisations shown to them.

3.22. Focus Group Details

The first round of focus groups took place in March 2011 over two days. The group was split between National Trust staff and volunteers, and local community members and businesses. As discussed in section 3.8 the working group suggested splitting the NT staff and volunteers and the local

community members during the focus groups. The previous dissonance surrounding the Hay Marsh site had caused tension between the NT and the public and some of the local members of 'Save Our Dykes in the Tamar' (SODITT) were attending the first meeting. The desire was to be as open and honest as possible and create a space that allowed participants to be frank about their feelings and feel less inhibited by past encounters. At this stage, there was no familiarity between the researchers and the participants of the focus groups, so no familiar ground had been established. The first meeting was used as an opportunity to establish relationships between researchers and participants, best done on neutral ground. Keeping the NT and public separate for this first meeting meant relationships could be formed between the researchers and participants in a neutral setting. Not having the NT at the meeting meant participants felt they were on a level playing field where they had the same knowledge as everyone else.

Focus group facilitation manages the group in order that participants' opinions and contributions are valued and encouraged, as well as moderating the conversation to stop certain participants from dominating. The aim was for participants to feel valued and to enjoy the experience enough that they would be willing to take part again in the future. Part of the challenge in encouraging repeat attendance to focus groups is that the meetings have to be designed and structured to demonstrate how the responses will be applied and what insight they bring to the researcher (Barbour 2005). Communicating the impact of the focus group may be unimportant for one-off activities, but demonstrating to participants that their contributions were taken on-board can be the deciding factor as to whether they take part again (Morgan 1993).

3.22.1. Structure and sampling

The first rounds of focus groups were carried out in March 2011 over two days. The length of the meetings was two hours (this is recognised as being a suitable length before participants begin to lose interest (Myers 1998)). The first iteration of the visualisations were shared at this meeting [Appendix 4]. The sessions were broken down with one meeting for the staff

and volunteers of the NT and another, evening session for members of the local communities. Each of these sessions were run with the same structure and agenda, with the same response sheet being given to each participant. The first two meetings were held in different locations; the first at a local Area of Outstanding Natural Beauty (AONB) centre and the second on site in a meeting room at Cotehele Quay. Folch-Lyon & Trost (1981) outline in their research a need for neutrality in spaces where focus groups are held. The experience of discussing flooding on Cotehele Quay could have been quite emotive, and it was therefore felt that those who worked or lived on the quay may be less likely to feel shocked at viewing this information in situ. For the community focus group, the AONB centre was a neutral space which participants associate formally with environmental issues, but not specifically Cotehele Quay or flooding.

By way of introduction the participants were each asked to introduce themselves and their affiliations and motivations for attending the session. This was followed by a short presentation about the work explaining the aims and objectives of the research. The introductory presentation conveyed to the group the participatory nature of the research and explained how it was hoped their involvement would continue. It was essential that the participants began to understand collectively they had some control and ownership over the outcomes of the project (Morgan 1993).

In regards to the meeting structure, each meeting was broken down into two sessions: an individual response session and a group discussion followed by presentation. By Morgan's (1996) classification this would be categorised as 'less structured', although there is no real evidence to suggest which meeting format is the most effective as it depends on the objectives of the work.

There were no applicable criteria which participants needed to meet (Rabiee 2004). For the NT meeting, an open invitation was extended to all staff and volunteers who may have had an interest in the future of the quay. It was anticipated that getting participation from within the NT would be

straightforward as they were more likely to have a vested interest in the future of the quay (several staff and volunteers had worked on the quay for over 20 years). It was rather more difficult to engage with potential participants for the community group. Initial invitations by post to local businesses who were located on or worked on the river went unanswered and follow up communications proved fruitless. Other invitees included representatives from the two local parish councils, the campaign group Save Our Dykes in the Tamar (who had been opposed to the Hays Marsh project) along with other locally based representatives. The final composition of those who attended the first meeting were people with a genuine interest, for themselves or for the local communities, in the future of the river. This included members of Calstock and St Dominic parish councils, an ex-member of Greenpeace, the editor of the local newsletter and representatives from local businesses.

3.22.2. Facilitation and Note Taking

As the subject of the meeting had the potential to provoke an uneasy response, a third party facilitator was brought in to facilitate the focus groups. Along with being one of the recommendations made in the first working group meeting, it was felt that demonstrating to the participants that this was being facilitated by a third party would alleviate some concerns about potential bias or inexperience (Flick 2007). The decision to involve a facilitator was largely based on the sensitivity of climate change issues, specifically at Cotehele Quay where the implications of sea-level rise are likely to affect not merely the visitors to the site, but also the residents of neighbouring villages along the river.

3.23. Data Collection

Data were collected via individual feedback sheets and group responses collated onto larger sheets of paper. Digital recordings of the meeting were not made at the first round of Focus Groups. This was deliberate and reflected the nature of the data that were being captured at this time. Feedback about the visualisations was generic and lacking discursive

content; it focused on specific aspects of the material presented (e.g. the colour of the water should be more realistic). The dynamics at the first round, and the separation of the Focus Groups into smaller units, meant collecting digital recordings was more challenging as the conversations were not facilitated and for the most part the groups were left to discuss the visualisations in an unstructured manner.

3.23.1. Individual Feedback Sheets

Focus groups are often digitally recorded for transcription at a later date, but this was not necessary for the first focus group meeting. This is a reflection of the aims of the meeting which centred on understanding which aspects of the visualisations needed to be improved. Two types of data were collected: in the first, individual feedback sheets captured participants' interpretations of the visualisations, whilst the individual thoughts were shared amongst the group providing group response sheets. The individual feedback sheets also asked participants in what context they could see the visualisations being used. A sample individual feedback sheet is attached in Appendix 5. The format and style of the form reflects traditional open ended survey techniques (Gomez and Jones 2010); the questions asked are shown in Table 14.

- | |
|--|
| <ul style="list-style-type: none">• How could the visualisations be improved to be relevant and useful to the wider community• Which local organisations would be interested to see these?• How long should they be, to be interesting and accessible?• What other situations / scenarios might it be useful to see, e.g. historic flooding events, mean high and low tides etc.?"• Any other relevant thoughts/reflections about the project and its potential? |
|--|

Table 14 Questions on Individual Feedback Sheet

The individual feedback sheets were collected before the facilitator moved on to opening the discussion up to group sessions from which the second

type of data were collected. The participants were broken into groups of four and prompted to discuss their thoughts on the visualisations. They were asked to think about what they thought of the visualisations, what they would like to see improved and any other content they would like to include. Each group summarised their thoughts on one side of flip chart paper and presented this to the other groups. Barbour (2007) highlighted the importance of triangulation when using Focus Groups, as this allows for cross comparison of results.

3.24. Data Analysis

To analyse the data from the individual feedback sheets and the group discussion sheets, qualitative content analysis was applied. This type of data analysis centres on summarising the content of data and systematically coding the data using codes generated from the data themselves (Sandelowski 2000). This form of data analysis works well for semi-survey style, open-ended responses where rapid coding can be undertaken. This style of analysis allows for clear definition and results with less interpretation required than with thematic analysis (Marks and Yardley 2004).

3.25. Results

After six months of activity, the first stage of data collection had taken place. This included collecting TLS data of Cotehele Quay, creating a 3D model and two visualisations, and conducting focus groups to gather feedback on the first set of visualisations. The reason for presenting the results at this point in the thesis is because it was the first stage of an iterative process. The iterative process was not just applied to the focus groups as a means to engagement; it was also applied to the TLS dataset to undertake a review of how this dataset was processed and what, if any, improvements could be made to the processing of the data to improve the spatial accuracy and/or realism. This meant that any flaws or inaccuracies in the dataset could be identified and rectified before it was returned to the user groups.

This section is structured thematically, with each section containing results and analysis from both the TLS dataset and the focus groups. The purpose of this approach is to demonstrate how the two strands of research were interwoven. In the same way that the research aims and objectives (as presented in section 1.6) can be broken down into an overarching theme and the technical and social components, at this stage in the research there were three rolling investigations, identified as:

- Understanding what elements of the model audiences wanted developing [overarching theme]
- Making modifications to the model based on feedback and research [technical strand]
- Engaging audiences with 3D visualisations [social strand]

3.26. Creating the 3D model: Cyclone

This chapter has demonstrated how a 3D model was constructed from the integration of two spatial datasets: TLS and LiDAR. To reach this point meant the processing of the data to transform the points generated in laser scanning to a solid object. The spatial accuracy of the data can be traced through the processing stages. Knowing that the precision of the instrument can capture data to an accuracy that is <6mm but once the data are processed this figure is subject to change. Figure 25 shows the registration relationship between different scanworlds (as defined by variable name); the result of this registration was an average Root Mean Square (RMS) error of 0.017473m and the average number of overlapping points to be 142327 (min: 32866, max: 832566); any correlation between these two variables is explored in greater detail in the results section of the Chapter [section 3.26]. The RMS statistic is calculated using the absolute errors between overlapping points and therefore says nothing about the relationship between the other data points or to the true position in reality.

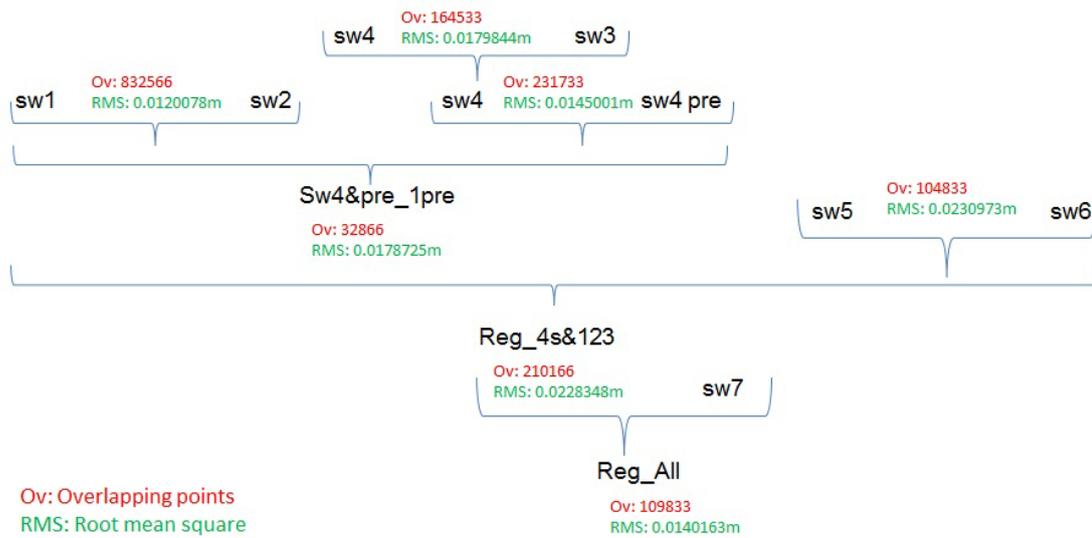


Figure 24 Conceptual diagram of registration and statistics

Rather than look at the resultant RMS figure for the final registration, this is a misleading figure of accuracy in the overall model, as it is only calculated for the absolute errors between overlapping points in the one registration, rather than how error has changed between registrations. A more precise figure of accuracy in the resulting modelling is to calculate the average accuracy across all registrations which results in a figure of 0.017473m [Table 15]. Whilst the laser scanner does not record the precision to this number of decimal places, stating this figure here will become relevant later in this thesis (Chapter 4) after a revision of the registration process is undertaken.

Registration #	Overlapping	RMS	Iterations	Min	Max
1.	32866	0.017873	79	5.22212	0.087816
2.	104833	0.023097	28	1.38805	0.09295
3.	109833	0.014016	75	3.80447	0.093225
4.	164533	0.017984	14	1.61099	0.096268
5.	210166	0.022835	24	1.46942	0.098142
6.	231733	0.0145	52	8.40364	0.096573
7.	832566	0.012008	65	2.3852	0.089597
Average	240933	0.017473	48	3.469127	0.09351

Table 15 Registration statistics

In order to explore the registration process in Cyclone more completely, one pair of scans were registered three times; each time the diagnostics of the

registration were captured. The results show large variation in each registration with RMS errors between 0.0095 and 0.0120 [Table 16].

	Registration one	Registration two	Registration three
RMS	0.00948593m	0.0100931	0.0120078
Iterations	31	98	65
Overlap count	195300	554166	832566
Average	0.00695778m	0.00685777	0.00815159

Table 16 Three identical registrations with different results

As Table 16 shows, there was a large variation in number of iterations, number of overlapping points and the RMS error between registrations conducted on the same data. To explore this further, analysis was carried out on the final registration statistics shown in Table 15 to see if there was a relationship between the variables of overlapping points or number of iterations on the resulting RMS statistic. The Root Mean Square Error of these data compares expected outcome with actual outcomes of the data. What Figure 26 shows is that there is a very weak relationship between the number of overlapping points between scans and the resulting RMS error statistic [Figure 26] ($R^2 = 0.2981$), whilst there is also weak relationship between the number of iterations during registration and the resulting RMS error ($R^2 = 0.4292$) [Figure 27]. It should be noted that the sample size of this dataset used to conduct this analysis is small, a more compelling result would need to expand on this.

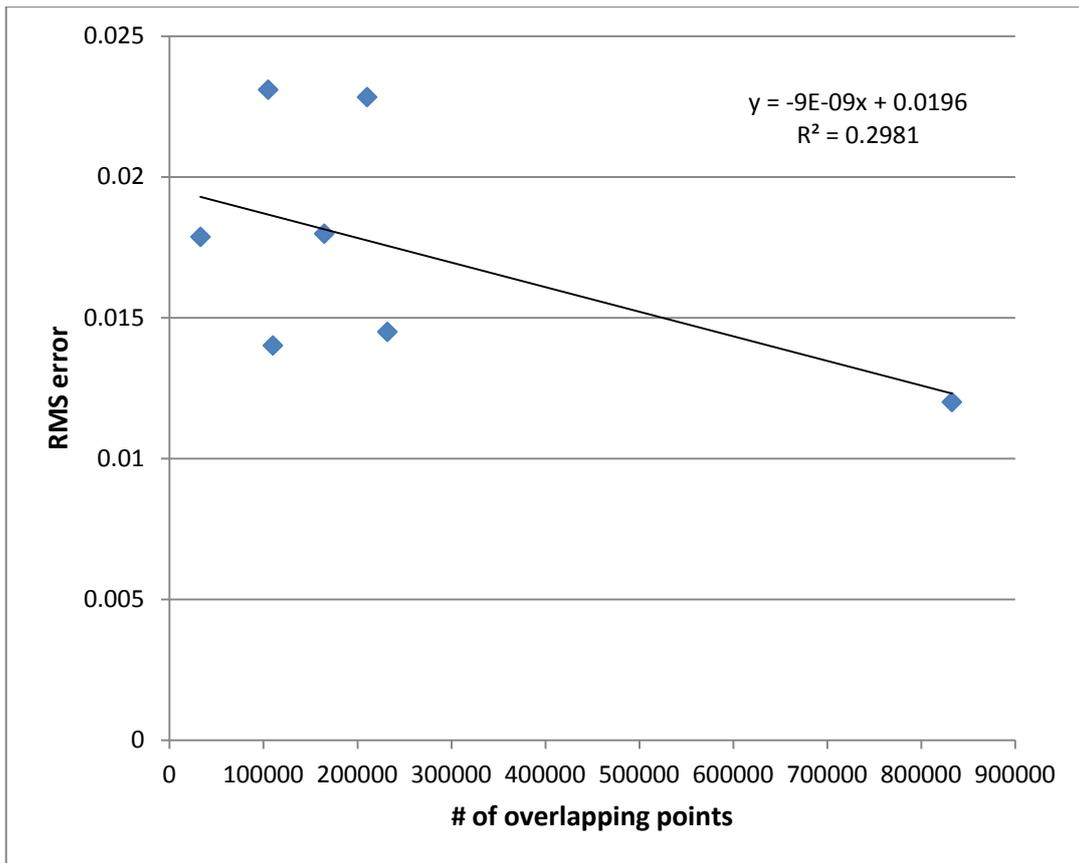


Figure 25 R^2 value calculated for the RMS error over the number of overlapping points between scan

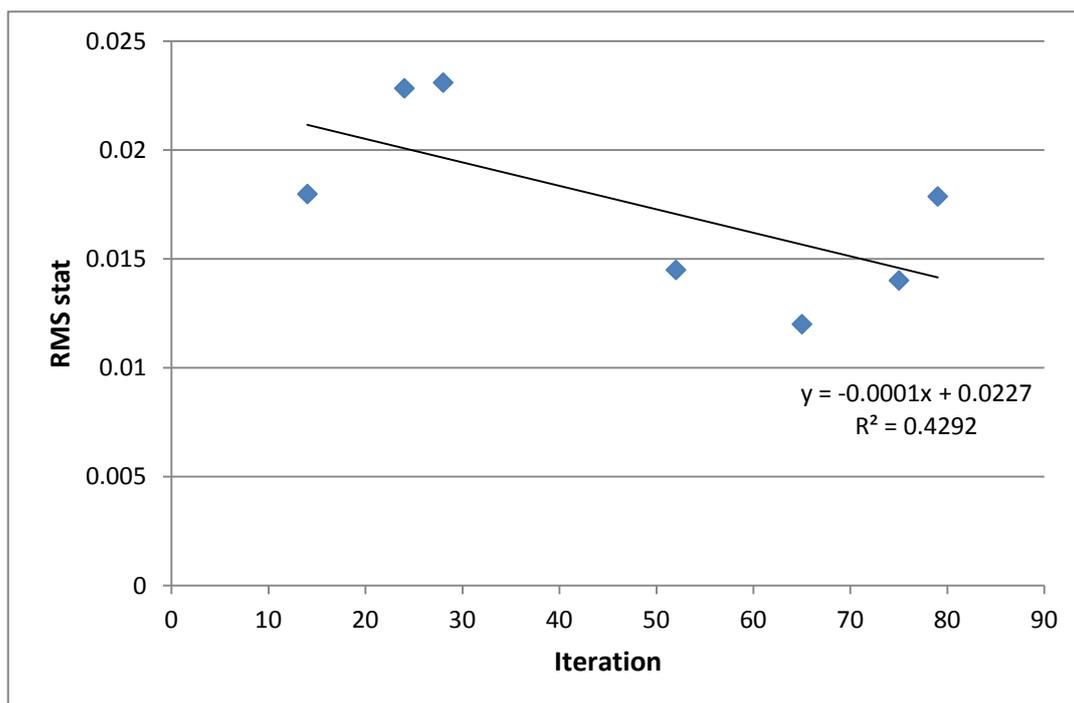


Figure 26 R^2 value calculated for the RMS error over the number of iterations during registration

These results suggest that manual control over improving the accuracy of the registration and the resulting accuracy of the spatial dataset is limited. And as Table 16 demonstrates it is possible to get largely varying results dependent on the registration that takes place. After the second set of focus groups this issue was revisited (see Chapter 4).

3.27. Creating the 3D model: 3D Reshaper and 3DS Max

There were several outputs from this stage of the research. The unified point cloud was exported as separate components and then meshed in 'object' files in 3D Reshaper. The level of detail that was captured was dependent on the number of faces (i.e. more face means a higher level of detailed captured). The number of faces any one object could have is infinite, but is actually constrained by the amount of processing power available. A 32-bit computer could adequately handle 300,000 faces but not more, and this meant a compromise on the detail of some of the buildings. As a result of this, the Edgumbe Arms was limited to 237 faces. Of all the

buildings on the quay, this one was only seen from one angle so it was the most appropriate to simplify. There is more discussion in Chapter 6 regarding the decision-making on how ‘real’ each building was going to look and what the deciding factors on this were.

Component	Vertices	Faces
Edgcumbe Arms	465	237
Toilet block	2780	4279
Terrain		
West	10420	17716
All	77530	133053
Discovery Centre	47421	125647
Workshop	6187	9009
Trees	8669	4967
Benches	284	584
Lime kiln	4469	8530
LiDAR	25438	49923
Car park	12587	19043
Garage	1273	2373
TOTAL	197,523	375,361

Table 17 Components in 3D model of Cotehele Quay - vertices and faces

The main output from the work in 3DS Max, was the production of four short visualisations at Cotehele Quay. The result of the participation of focus groups is presented in the following sections.



Figure 27 Screen shots from the second iterations of visualisations [left] tidal cycle [right] flood event

3.28. Participation

This section is structured based on the responses from the focus group participants, including the individual feedback sheets and the group discussions. The first focus groups were deliberately centred on gathering

feedback on the content and visual aesthetics of the 3D model. Where applicable, analysis is undertaken on how processes used in creating the model were applied and perceived by the focus groups, although this was not explicitly explained during the focus groups. The reality of engaging with focus groups at this point in the research means that three themes can be addressed which feedback to the aims and objectives of the research as a whole.

3.29. Reflections on dynamics: National Trust Staff and Volunteers (NT S&V)

Recruiting participants was more challenging than anticipated. The focus groups were advertised widely by the General Manager and other staff members but the majority of participants who took part in the focus groups were volunteers of ex staff of the site. Table 13 shows a breakdown of participant and affiliation.

Name	Role	Located
Jane Kiely	Volunteer	Off-site / Calstock
Cliff Lambert	Volunteer	Off-site / Calstock
James Robbins	Staff	Cotehele Quay
Jamie Laing	Staff	Cotehele Quay
Mike Bygrave	Ex-volunteer	Off-site
Anthea Whalley	Staff	Cotehele Quay
Roger Eley	Staff	Cotehele Quay
Joe Lawrence	Staff	Cotehele Quay

Table 18 Participants at the NT S&V FG

Those attending this focus group were already aware of previous flooding events that had occurred at Cotehele Quay and knew the extent and severity that an extreme flood event could cause. During the group discussion, the group were more likely to stray off topic into discussing the wider management issues of working at Cotehele Quay.

During the course of the meeting it transpired that one participant was unaware of the difference between neap and spring tides. This generated some discussion about the extent of flooding and when it occurred and participants shared and exchanged views and experiences about flooding at

the site. This built up some shared opinions about what they thought should be represented in the visualisations at Cotehele Quay.

3.30. Reflections on dynamics: Community and Business Group (C&B)

The C&B group engaged more eagerly in conversation than the NT group; most of the participants were already acquaintances [Table 19]. From an early point at the meeting the question of motivation behind the research was raised. Four participants were members of the group that formed during the NT's unsuccessful Hay Marsh planning proposal (SODITT). They expressed concern that this project was another attempt by the NT to push through controversial planning to alleviate flooding at Cotehele Quay. An explanation of the motivations behind the project, and how it was separate from on-going conversations regarding flooding elsewhere in the valley appeared to satisfy any concerns participants had.

Name	Role	Located
Julia Massey	Calstock Parish Council	Calstock
Norma Greenslade	Calstock Parish Council	Calstock
Diana Greene	St Dominic Parish Council	Halton Quay
Martin Smith	Calstock Hall	Calstock
Phil Hurley	Morwellham Quay	Gunnislake
Derek Scofield	SODITT	St Dominic
Mary Scofield	SODITT	St Dominic
Beverley Parke	Calstock News	Calstock
Drew Potter	St Dominic Parish Council	St Dominic
Pete Bouquet	Ex-Greenpeace	Calstock
Rita Hoile	Cotehele Quay Gig Club	Calstock
Gill Mannings-Cox	Cotehele Quay Gig Club	Calstock

Table 19 Participants for Community and Business focus group

The structure of the meeting worked well to engage the participants, though there were some comments that there was too much technical information provided. As the course of the meeting continued, the group's expectations grew as they discussed potential additions and modifications to the model. Although their comments and suggestions were extremely important to the development of the model, there was a need to manage expectations in regards to the scope of content and technical capabilities to achieve all of what they wanted to see happen. A positive reflection on this is that they

were actively engaged with the research, and wanted to contribute to its development.

3.31. Analysis of Individual Feedback Sheets

After watching the two visualisations [Appendices 4, 6 & 7], participants were asked to complete individual feedback sheets. The central point to asking for their reactions pre-group discussion was to have responses that had not been influenced by other people's ideas as well as:

- An indicative level of understanding of the research, depending on the level of detail in the response
- An indication of personal priority areas, derived from the order in which they listed their responses
- A more complete picture of individuals thoughts and perceptions about how/where the visualisations could be used

All participants completed the form in its entirety, although some questions were responded to in more detail than others. The following sections present the results of the first the NT Staff and Volunteers group followed by the Community and Business Group. The analysis of the individual feedback sheets is structured on the questions that were asked.

3.31.1. Individual feedback sheets: National Trust Staff and Volunteers

“How could the visualisations be improved to be relevant and useful to the wider community?”

The first question generated a wide range of responses, from ‘more detail’ to ‘show to as many organisations as possible’. Only two responses were repeated by more than one participant: ‘longer visualisations’ and a request for the model to show a greater extent of the Tamar Valley. The range of suggestions is not surprising given that the scope of the first meeting was to establish the foundations and directions for the visualisation to develop.

The group did not articulate exactly how they wanted the model improved (e.g. ‘more detail’, ‘more realistic’). This is interesting not least because it could be an indication of: a lack of emotional connection to the project

and/or visualisations, a lack of understanding regarding what they are required to input and feedback, an understanding but unwillingness to engage in greater depth with the project and/ or visualisation. At this stage it was unclear which, if any, were actually applicable.

“Which local organisations would be interested to see these?”

From the National Trust, the most frequent response to this questions was ‘rowing clubs’ (a third of participants mentioned them). After rowing clubs, national organisations were cited as being the next most likely to be interested in the visualisations, these include (in order of priority): the AONB, the NT and the EA.

A surprising result from this analysis was that Cornwall Council was only mentioned by one participant and this was allocated as a low priority. Mid-priority organisations were those who used the river for commercial purposes, such as Canoe Tamar and Tamar Ferries.

“How long should they be, to be interesting and accessible?”

There was no obvious consensus amongst participants how long they felt the visualisations should be. Responses ranged from ‘about three minutes’ to ‘no more than an hour’ with some comments at this point regarding the speed to the visualisations and movement through the scene. This was felt to be too fast for the viewer to understand what was happening and one participant requested it should be ‘slower rather than quicker’.

“What other situations/scenarios might it be useful to see, e.g. historic flooding events, mean high and low tides etc.?”

The NT participants were targeted in their responses to other scenarios and situations they would like to see. The two most commonly cited distinctions were between viewing average neap and spring tide events, and showing historic flooding events. Another request by two participants was to visualise the effect of SLR on the reed beds downstream. This response is unsurprising given the controversy in 2006 regarding the Hay Marsh site.

“Any other relevant thoughts/reflections about the project and its potential?”

Responses to this question focused on a concern for the future management of the site. Including showing building use during flooding scenarios and how the site would manage visitors and function as a public attraction if it is flooded more regularly than at present.

3.31.2. Individual Feedback Sheets: Community and Business Focus Groups

Across all questions the community and business focus group gave a much wider spread of responses to the questions, focusing more on the detail of the visualisations in comparison to the NT staff and volunteers group. There were fewer generalised responses.

“How could the visualisations be improved to be relevant and useful to the wider community?”

The responses to this question by the participants showed an interest in a high level of detail for the visualisations. Only four comments were cited more than once out of 21 different suggestions:

- show a greater extent of the area – 4
- improve realism: benches, mooring blocks and chains – 2
- indicate the speed of the tide – 2
- include photos – 2

The majority of responses to this question were additions to the content and context of the visualisations to make them more realistic, the second most common theme was a request to show different meteorological events that may occur in the future, with a comparison to the present day [Table 20].

Theme	Response
Meteorological events	Predicting conditions for events Visualisation of high tide 2020 Comparison of high tides 2020 / 2050 Present day data for comparison
Additions to content and context	Include photos of the site Show land use change Include 3D model Calstock Include Cotehele Quay car park and Boar's Bridge Show the whole of Cotehele Quay Include a commentary providing more detail of the project Show future access for commercial and leisure boat activity

Table 20 Responses from both focus groups to survey grouped into two themes

None of the participants mentioned visioning possible planning options for mitigating flooding at the site. The only landscape related suggestion was to show what repairing the quayside would do to flooding.

“Which local organisations would be interested to see these?”

This question proved to be much more divisive amongst the group, generating many different suggestions. The most common response was local councils, followed by local residents. Unlike the NT staff and volunteers participants, the community and business group stuck more closely to the question and were targeted more specifically at local groups. The NT were only mentioned once and other national organisations that were popular responses amongst the NT staff and volunteers group (such as the AONB and the EA) were minority responses; the EA were not mentioned at all. The most common and top priority responses to who would find the visualisations interesting were people who use the river for recreation and employment as well as schools and sports clubs. The discussion session held after individual feedback sheets had been collected shed some light on the reason why schools may be interested. Participants felt that the visualisations could be used as an educational tool to communicate sea level rise.

“How long should they be, to be interesting and accessible?”

There was more of a consensus among the community and business group that the visualisations should be between 1-5 minutes. Their perception of the visualisation was different from the NT staff and volunteers group as they were able to see the visualisations as stand alone pieces of information and did not respond to this question assuming they could be part of a larger story. This might correlate with their perception of the visualisations as an educational tool which, with each scenario acting as a stand alone piece of information.

“What other situations/scenarios might it be useful to see, e.g. historic flooding events, mean high and low tides etc?”

The community and business group had similar responses to the NT staff and volunteers group in that they also wanted to see historic flood events or sea levels, although for this group this was the priority with over half of the respondents asking for an historic perspective. Other requests were for future flooding scenarios and to see what would happen if the river silted up.

“Any other relevant thoughts/reflections about the project and its potential?”

Similar to the responses to the question regarding scenarios, participants of the community and business group did not respond with specific, targeted suggestions. There was a repeat emphasis on the inclusion of future scenarios and historic imagery. Some more general observations centred around the use of the visualisations to show long term change and future river use and access. One participant commented that “the data needs to be ‘correct’ and persuade people” and that the final visualisation should be shown in the local village hall.

3.32. Analysis of Group Discussion

Once individual feedback sheets were collected, participants were asked to discuss their thoughts in small groups and note down the main themes from their discussions. These were then presented to the group as formal suggestions for improvements to the model. The driving factor behind asking the participants to summarise their thoughts as a group, rather than

retaining their responses as individuals, was to clarify the most pertinent and pressing themes that were commonly shared amongst the group, rather than being a series of individual views that may not be representative of a wider audience. Each group were asked to respond to the individual feedback sheet questions and respond as a group with five points, each one detailing their key contribution to this question.

3.32.1. National Trust Staff and Volunteers

Responses from the NT were demonstrative of the difference in agenda and required outputs, compared to the community and business focus group. The NT group were less interested in long overly complicated visualisations (>1hr), and instead the majority requested a shorter, more directly informative visualisation that would answer specific questions about future flooding at the site. From this analysis, a distinction emerged between what was required for the needs of people working on the site (short and concise) and those whose interests are more recreational (longer storytelling).

The NT group were quick to identify flaws in the representation of the speed of the ebb and flood tidal cycle. There was also greater discussion regarding the impact of different processes on tides. There was generally a consensus that this was something they would like the model to demonstrate. The NT group were knowledgeable about past extreme flood events and showed a positive interest in having these reconstructed as short visualisations. There was no direct reason given for why these would benefit the NT, but there were some comments suggesting that including visualisations of historic events would give some credibility to the visualisations.

3.32.2. Community and Business

Much of what was communicated in the group discussion session had been recorded on the individual feedback sheets, the main difference being the highlighting of areas of most significance. Surprisingly there was little comment in relation to the realism of the buildings, as what drew the most attention was the colour of the water and the shape of some of the ground

surfaces. One participant had commented that “the water isn’t that blue” (G.M-C, 2011).

Heavy emphasis was placed on expanding the extent of the area included in the visualisation, and the scope of the content; thus demonstrating the complexity of the history of the site and the cultural context of change. Two other sites were noted for inclusion: Boar’s Bridge and Morwellham Quay. Whether or not flooding could be accurately modelled at these sites was yet to be determined [Table 21].

Group 1	Group 2	Group 3
<ul style="list-style-type: none"> • Cover larger area i.e. include car park and Boar’s Bridge • Extend duration of visualisations to 2/3 minutes and slow down • Exclude technical detail, include better explanation of the concept and emphasis its innovative approach 	<ul style="list-style-type: none"> • Putting Cotehele in wider context 	<ul style="list-style-type: none"> • Visuals plus photos or artists impressions • Predicting conditions for events, use of land, repairing quaysides, access for boats, access along roads, commercial sites
<ul style="list-style-type: none"> • Village Hall committee, Rowing Club, AONB 	<ul style="list-style-type: none"> • Local community and river users 	<ul style="list-style-type: none"> • Local orgs – AONB, Calstock PC, NT, boatyard, football club, Tamar Inn
<ul style="list-style-type: none"> • Longer and slow 	<ul style="list-style-type: none"> • Total 30 mins – segments and scenarios (approximately 5 mins each) 	<ul style="list-style-type: none"> • 30 seconds to 1 minute 15
<ul style="list-style-type: none"> • Past flood levels to be visualised • Indicators of the benchmark and historic flood levels • Indicators of future flood levels 	<ul style="list-style-type: none"> • Historic flood event 	<ul style="list-style-type: none"> • Historic events to temper the average and attract interest away from global warming e.g. Morwellham Quay 1979 – 1991 • Other climate conditions, rainwater catchment area, pressure and wind
<ul style="list-style-type: none"> • Showing of final programme at Calstock Village Hall for the community 	<ul style="list-style-type: none"> • Present day data 	<ul style="list-style-type: none"> • Extrapolation – future in visuals, river defences, actions against silting. Transport silt back upstream for agriculture

Table 21 Summary of group response sheets

In regards to the scope of the visualisations, the community and business group were particularly interested in seeing historic flooding scenarios,

including the use of narrative and photography to give a sense of what the situation was in the past and to show extreme events that had occurred. They were further interested to see how the regularity of flooding on spring and neap tides will change in the future.

Finally, the discussion session formed a consensus that the visualisations needed to be longer and slower; either having one to two minute 'snappy' visualisations or a longer film which could be shared amongst the local community. The participants felt that having an event night in Calstock to premier the film would work well to draw attention to it, and this could be longer and incorporate commentary, pictures and scenarios.

Although both of the animated sequences showed current or future tidal and flooding events, focus group participants expressed a strong interest in the inclusion of historic information about sea levels and flooding, as a point of comparison for anticipated future change. Research by DeSilvey (2012) has touched on the importance of acknowledging historical events and processes in conversations about future climate change, through the practice of 'anticipatory history'. The response from the focus group participants suggests that people actively seek historical perspectives to help them understand and adapt to change, though most scenario-based engagement approaches tend to focus exclusively on future projections (Nicholson-Cole 2005; Mansergh, Lau et al. 2008).

3.33. Summary of cross-cutting narratives

On the whole the feedback from the focus groups was very positive, and participants seemed genuinely interested in contributing to the development of the visualisations; this is not to say they were not critical of them in their current state. In general there seemed to be more honesty on the individual feedback sheets than in the focus group discussion, with one participant writing 'caramel fudge' with an arrow to an image of the quayside. This comment adds a layer of complexity to how users perceive realism, as the image had been textured using high-resolution aerial photograph of the quay. It was surprising to hear the community and business groups enthusiasm to see Calstock flooding, even though the implications of this

could affect livelihoods (and insurance premiums!). This was encouraging at this point in the process, as it suggested that they already had some confidence in the model.

In both the community and business and NT staff and volunteers focus groups, participants were able to respond with concise and clearly communicated responses to the questions presented on the individual feedback sheets. The community and business group were more targeted at providing responses which would benefit the local community and showed more interest in understanding how changes in fluvial dynamics would impact on recreational working use of the river. They also saw more applications for the visualisations as educational tools amongst the local community. The NT staff and volunteers group displayed a wider interest in seeing the visualisations used and engaged by national organisations who often conduct their own flood mapping exercises (such as the EA). The key areas that both groups wanted to see included were:

Greater extent: Both groups shared an interest in seeing a greater extent of the surrounding area modelled: more of the valley, as well as another site – namely Calstock. There was particular interest in comparative and historic perspectives, seeing how flood events would have affected the site in the past and visualising past water levels.

Detail: Both groups took an interest in commenting on the minutiae of detail that should be visualised in order to make the visualisation appear more realistic. This included modelling the mooring blocks and benches and improving the appearance of the ground surface so this more accurately reflected what it is like.

Tidal cycles: There were comments from both groups on the accuracy of the speed of the tidal cycle portrayed in one of the visualisations. As people who live and work next to the river, it was felt important that this was realistically interpreted within the model. Amongst both groups, someone had taken the time to explain the speed and breakdown of the rule of twelfths applying to tidal cycles. The complexity of modelling landscape and meteorological conditions with any degree of accuracy is beyond the scope

of the research; helping people to understand this without compromising their interpretations of the model was important. Part of the challenge was to help people see the visualisations as a valuable tool although it may not be able to address all of their personal concerns or questions.

3.33.1. Reflections on ‘culture’

A result of the first focus group, it became clear that developing the visual identity of the modelled site, meant adding the cultural assets. Looking back over the findings from the first focus groups, throughout the responses, the participants heavily relied on their own instincts and perceptions of heritage and culture to inform their contributions to the discussion. This was demonstrated in the requests for the Shamrock and the maritime artefacts to be modelled. In this thesis, culture is considered in relation to the cultural heritage of the site, where culture is defined as “the custom, civilization and achievements of a particular time or people” (Ahmed 2006: 27). Cultural heritage is a term frequently used in laser scanning, relating to the cultural objects under observation (Pieraccini, Guidi et al. 2001; Yastikli 2007; Yilmaz, Yakar et al. 2007), so its use in this context is not unusual. It relates specifically to the relationship between people and objects, and their presence in a digital space.

It should be noted, that unknowingly, people’s expectations about what the model would deliver also included elements of intangible cultural heritage. An example of this was several participants requests for the bench to be modelled allowing them to imagine themselves in that space, playing out every day experiences of the place in a way that is familiar to them (Kurin 2004). This interacts with how people experience the model and the level of perceived authenticity of the ‘cultural heritage’ experience (McIntosh 1999), discussed in more detail in Chapter 6.

3.33.2. Managing expectations

The community and business group in particular placed high technical expectations on the model, hoping that it would be able to show what the river would look like and how accessible the upstream areas would be if

silting occurred in the future. The complexity of creating a hydrological flood model that would be able to accurately measure this goes beyond the scope of the project: communicating and re-iterating the limitations of this technology was identified as a priority for the second meeting.

Aside from the requests to show complex landscape changes, there were few other requests which pushed the boundaries of the technology, specifically because much of the focus was on the contextual detail (i.e. showing historic flooding using images and photographs and communicating how the model was made).

3.33.3. Informing the Next Stage

The next stage of the research involved using these outputs to inform and develop the visualisations. In the same way that the working group contributed to the development of the model (section 3.8), the focus group input was absolutely fundamental to the project moving forward; their input helped determine the scope of the research. Until the analysis of these results had been carried out, the shape, content, and output for the visualisation remained undecided. It is at this point that the research demonstrated the unique capacity of the methods to inform the project. Individual feedback sheets and group discussions were analysed to narrow define the key contributions from the focus groups. These priority areas were:

- Include future flooding scenarios
- Improve detail of the quayside (to the built and natural landscapes) to improve realism
- Include comparative historic and present-day data
- Include context about climate change, sea-level rise and the flooding in the Tamar Valley

In order to address each of these areas, a reappraisal of the project methods and scope was undertaken. It was anticipated that a review of the approach would be necessary after the first focus groups, but the exact methods and data required were unknown. At this juncture, time was given

to reflect on the feedback from the participants. By reflecting on the outputs of the focus groups, the necessary amendments to the research process could be identified. Three main revisions to the research methods were identified:

- Develop a new approach to include narrative and storytelling
- Carry out a considerable amount of additional research to capture the context of the site, beyond 3D visualisations
- Re-consider and re-focus the working processes involved in the 3D modelling process to improve the detail and realism of the site

The focus groups wanted these visualisations to become part of a larger story about Cotehele Quay. This was never explicitly stated by the participants, but the requests for more contextual information, including comparative past flood events and historic photography could be most aptly addressed by constructing a flowing narrative of the site rather than staccato visualisations. A series of short visualisations, each showing a different flood event, may serve to act as a stand alone educational tool, but would not offer the scope to capture the rich contextual history and future of the site that was apparently desired through the requests of the focus groups. To provide a narrative structure for the visualisations a storytelling approach was decided upon (Chapter 4, section 4.8).

It was made apparent that ‘additionality’ was a factor of the visualisation’s content. The participants wanted to see more than abstract flooding scenarios; they wanted to know what Cotehele Quay looked like in the past, what flood events had occurred, what sea-level rise was and how that translated to the quay flooding more frequently. As stated above, this required a narrative approach, but it also required additional research that was not previously anticipated. To address the suggestions offered by the focus groups more contextual content was needed. Potential sources identified included:

- Oral history recordings
- Archival photography of flooding events

- Scientific data research about sea-level rise

The following chapter describes the process of re-fashioning the visualisations to address the findings from the first stage of the project. In doing so, it introduces some new methods to the project in a sequential fashion.

3.34. Conclusions

This chapter has addressed a complex and integrated methodological process; from data collection and processing through to the first stage of the participatory process. While this may cover a lot of ground, it communicates the complexity and decision-making involved in making a 3D model that people want to engage with. On the one hand, the collection and processing of terrestrial laser scan data seems far removed from the resulting 3D model, but to reach a stage whereby the model can be shown to the public with some degree of confidence meant looking closely at the interactions and changes in the dataset as it was manipulated from point cloud to 3D object.

The project was initiated from a conversation with the NT that identified a need for a visualisation that would help the NT engage the local community in thinking about the future of the site. Although the intention to create something that would allow them to work alongside the local community was clear, the NT also wanted a tool that could inform their decision-making in-house. In the early stages of the project, the development of the visualisations was led by processing the data to reach a stage where a baseline 3D model could be interacted with and responded to. At this point it was less important what the final application would be as there needed to be a spatial model capable showing sea-level rise projections. During the working group meetings, the group established themselves as not only directing the content of the visualisations but also taking a role in the future applications of the visualisations.

As will be discussed in a later chapter (Chapter 6), the spatial accuracy of the TLS data (for both the LiDAR and the TLS data) is known when it is in

the form of a point cloud, but is harder to measure when the point data is converted in 3D objects. The pre-registration and editing of the point cloud can improve the spatial accuracy after registration as outliers and noise in the dataset are manually removed. By the end of the registration process, the spatial accuracy of the dataset (measured by the overlapping points) was 0.017473m. Knowing whether or not this result is good, relative to the capabilities of the laser scanner is largely dependent on the factors that affect the quality of the registration. Personal communication with Steve Ramset, Senior Leica Technician, noted that he would expect to see a spatial accuracy of <2mm for a dataset of over nine million points. The spatial accuracy of the dataset after data capture is determined by the success of a good registration. As the spatial accuracy in Cyclone is determined by the RMS error of the data is calculated by the overlapping points, an analysis of the data was carried out that looked at the relationship between the RMS statistic generated for that registration and the number of iterations that the model used to carry out the registration. Linear regression analysis was conducted on the (notably small) sample of data and found that the R^2 value for this data was $R^2 = 0.4292$. A further relationship was explored between the RMS statistic generated for that registration and the number of overlapping points. For this the resulting R^2 value was 0.2981 demonstrating an even weaker relationship. What this establishes is that although the spatial accuracy for the registered point cloud as a whole is low there are few variables within the registration process which can be manually edited to improve this further. Beyond the terrestrial laser scan software, measuring spatial accuracy in software primarily manufactured for design rather than engineering purposes is more challenging. (Buckley, Howell et al. 2008) found that some of the processes that can be applied to the newly generated mesh can reduce the spatial accuracy of the data. Therefore these techniques: hole-filling, interpolation and smoothing were avoided on the data of Cotehele and only applied on the window frames and roofs where the flood waters will not reach therefore if the data of these parts is less accurate it will not affect the truth of the visualisations.

The result of this data processing was a 3D model with an estimated spatial accuracy of <2mm. The model was used to create the first iteration of visualisations and these were taken to the working group's second meeting. The meeting provided integral feedback into the structure and content of the visualisations. Some of the stylistic elements of the model needed refining (such as the movement of the camera), but the working group also commented on the possible applications of the tool now that the capabilities of the software were clearer. The most prominent challenge for the research that emerged from this meeting was a tension between what the NT wanted to offer the public – regarding a tool for conversations – and what they needed to be able to manage the site. There was no clear answer at this stage as to how the visualisations could be developed to meet both of these expectations.

The visualisations were refined and two short visualisations were created that showed the potential of the technology; these were taken to two focus groups. Feedback from the focus groups was positive but contained much critical comment. Participants wanted to see longer, slower visualisations which offered more insight into the history of flooding on the river; namely in the form of historic visualisations. The NT staff and volunteers group paid more specific attention to how the visualisations could help them to manage the site in the future. Apart from the comments on the water and surface terrain there was a notable lack of attention in regards to the realism of the buildings; the cause for this could either be because they felt they were sufficiently realistic, or there were other more pressing areas to address. In any case, both groups requested to see a greater extent of the quayside and the rest of valley, particularly Calstock and up towards Boar's Bridge. It is hard to determine at this stage how much trust the groups had in the visualisations, but that they asked to see Calstock in the model demonstrates early signs that they trusted what was being shown to them. In the following stage of development, careful expectation management needed to be exercised as both groups expressed an interest in seeing what the impact of landscape processes would have on the river (e.g. silting).

Chapter 4

Storyboarding and Making a Film

Objective

To construct a digital story (or film) about Cotehele Quay and explore the use of contextual data to do this.

4. Storyboarding

4.1. Introduction

The results of the first stage methodology chapter identified that stand alone visualisations were potentially problematic as a tool for communicating sea-level change, as they failed to help the audience understand the wider contextual issues about flooding at Cotehele Quay. The visualisations lacked the content which would provide the viewer with an overall sense of the history of the site and the consequences and impacts of future rises in sea level. The results of the first stage of engagement were explicit in that the participants wanted to see:

- Future flooding scenarios [using an accurate interpretation of a tidal cycle]
 - Comparisons of past and present events
 - 2050 scenario
 - Other future scenarios
- Improved detail of the quayside (to the built and natural landscapes)
 - Realism of water
 - Shape of the levee
- Comparative historic and present-day data
- Information about climate change, sea-level rise and flooding in the Tamar Valley

To address some of these suggestions meant re-appraising the initial investigations which used TLS as the key tool for modelling Cotehele Quay. The project inception meeting identified that there would need to be an additional level of data collection to provide some more contextual information to the project. Yet it was only clear how much additional work would need to be done after the first round of focus group and working group meetings. This meant that the results of the first meetings had a great impact on the overall structure and focus of the research. What this chapter demonstrates is the progression of the visualisations, from a series of unrelated scenarios, into a narrative structure that would eventually form the foundation for a nine minute mixed-media film.

This chapter documents the mechanisms and approaches used to design and articulate a narrative structure, and introduces the relevant data that were gathered to achieve this.

This chapter thus charts the second ‘developmental’ stage that moved the visualisations of Cotehele Quay forward. In doing so, it explores the ways in which embedding the visualisations within a narrative structure served to connect the audience with the visualisations. This chapter addresses how the visualisations had to be incorporated with other data to reflect the participants’ own knowledge and experiences about flooding. This meant that not only were the qualitative data important to provide context for the visualisations, but they also needed to act as the trigger to connect on an emotional level⁹.

4.2. Introduction to chapter structure

The main aim of this chapter is to demonstrate how the visualisations were incorporated into a film. This chapter outlines what new contextual data were collected, and provides the justification for doing so. It also outlines the decision-making that went in to including the information that was shown in the film ‘Changing Tides at Cotehele Quay’. The content of this chapter frames the research as a whole, because it shows the transition from a scientific engagement tool, to a cultural product which is responsive and inclusive of different viewpoints. Compared to previous chapters, this chapter charts a much greater change in the focus and content of the visualisations, and branches out from purely focusing on the technical aspects of the 3D model.

The iterative engagement process adopted in this study allowed people to express at a very early stage their expectations and perceptions about how scientific data about landscape change could be best presented, and these early insights were critical in the process of storyboarding the digital content for the benefit of other audiences. This chapter is dedicated to demonstrating all of the decisions that were made and justifies why some of

⁹ How the research was used as a tool to engage with audiences on an emotional level is discussed in chapter seven.

the contributions from the participants were left out of the final film. This is important as a significant amount of time was dedicated to processing data that were not included in the ensuing stages of the research. The inclusion of these explanations becomes all the more important as a contribution to the wider research aims which are about the appropriateness for using this technology; a discussion of this is found in Chapter 6.

In analysis of results from the first set of focus groups, it became clear that the response to the visual presentation of climate data was based on underlying (if not fully articulated) assumptions about realism (perceived likeness of model to real life) and accuracy (the physical closeness of the data to the truth), underpinned by other concepts, issues and feelings such as clarity, ambiguity, uncertainty, and trust.

4.3. Returning to the TLS data

One of the fundamental problems with the 3D model shown during the first engagement stage was that it had not been geo-rectified to the national grid which had been caused by an error in registration. Whilst this is visually insignificant, it had implications for the capacity of the 3D model to accurately show sea-level rise. To rectify this meant returning to the point cloud data collected two years previously, generating a new registration, and then registering that to the National Grid. Further justification for the additional and repetitive processing of the TLS dataset was a result of some comments from the focus group participants, who commented that parts of the modelled quay lacked verisimilitude; in particular the levee protecting the car park from flooding.

4.4. Final registration

Returning to repeat the initial processing of the point cloud data, the final registration of the dataset took place in April 2011 shortly after the first focus group meetings. The Cyclone database was cleared and each scanworld was (re)-registered, this time using a slightly different approach which in theory reduces the error propagating through the model. This alternative registration is shown conceptually in Figure 29. In principle,

rather than each of the scanworlds being registered in a hierarchical nature, the alternative approach allowed tie-points to be identified in all of the scanworlds before any registration took place. This meant that only one registration simultaneously tied all the scanworlds together which stopped error propagating each time a new registration between two models was completed.

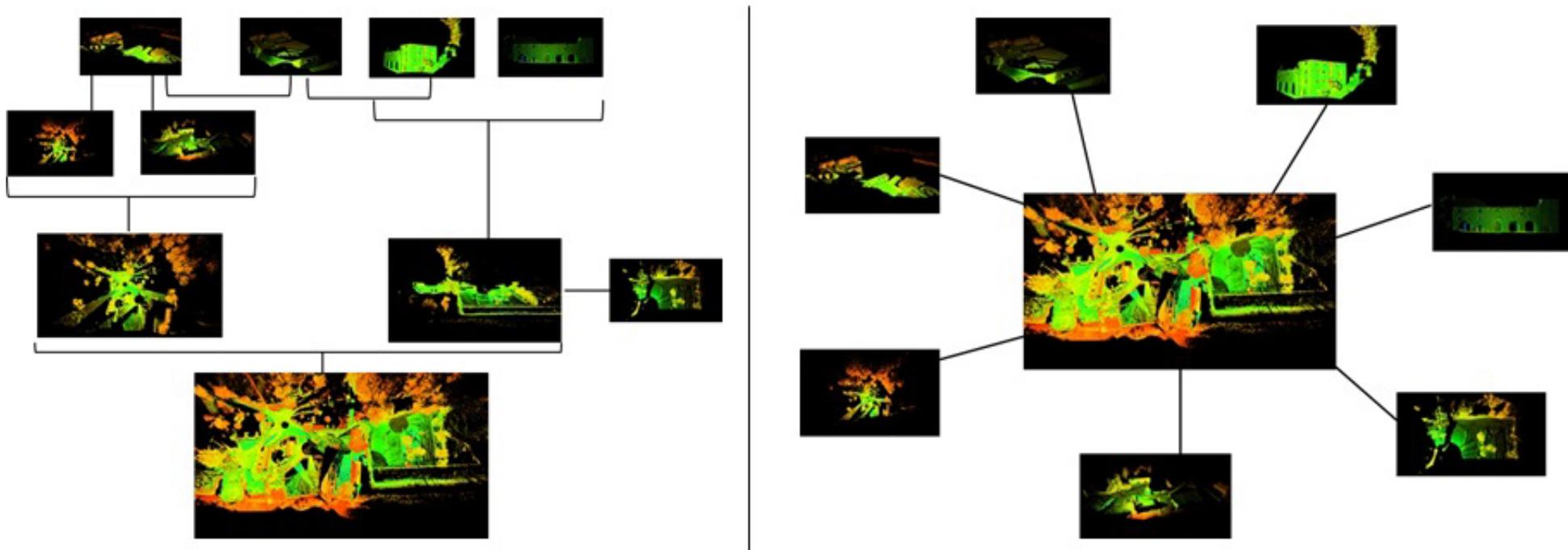


Figure 28 Conceptual diagram of registrations [left] hierarchical [right] non-hierarchical

The resulting point cloud registration is shown in Figure 30 from plan view. It is notable that a lack of overlapping points between the car park and the buildings on the quay meant that this part of the model was not registered to the rest. A lack of tie points between scans has been presented as one of the a drawbacks for TLS post-processing procedures, particularly in environmental and geological applications when the terrain can lack the geometry of urban environments (Barber 2003). The implications of these missing data are discussed later in Chapter Six, but at this stage in the development of the 3D model the missing data were not detrimental to the exploration of how the model was to appear visually realistic [section 4.10]. Figure 31 shows the registration relationship between different scanworlds (as defined by variable name), the results of this registration was an average RMS error of 0.017447 (min: 0.010065, max: 0.027485) and the average number of overlapping points to be 107784 (min: 16200, max: 352833).

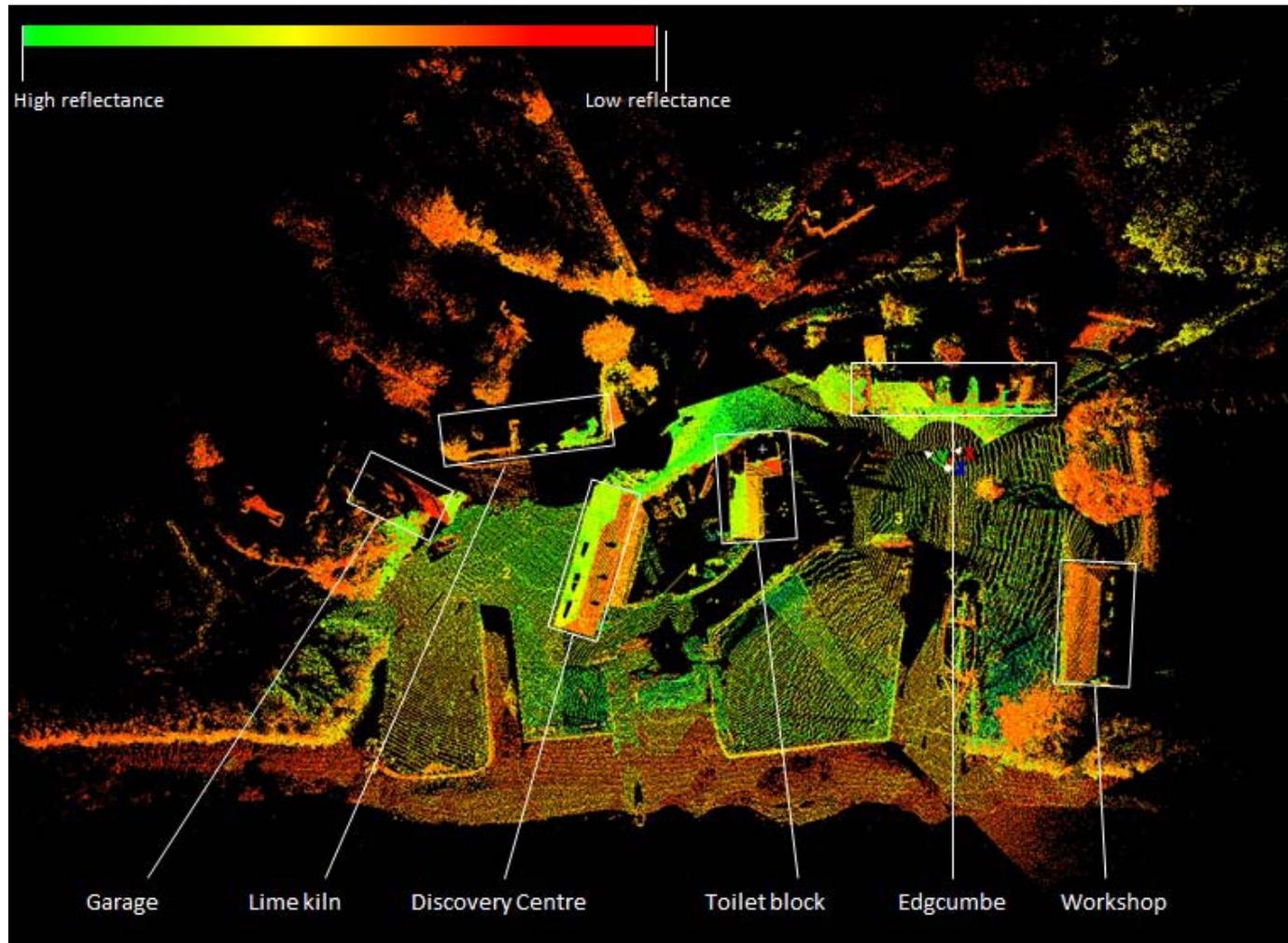


Figure 29 Final registration of the point cloud of Cotehele Quay in plan view

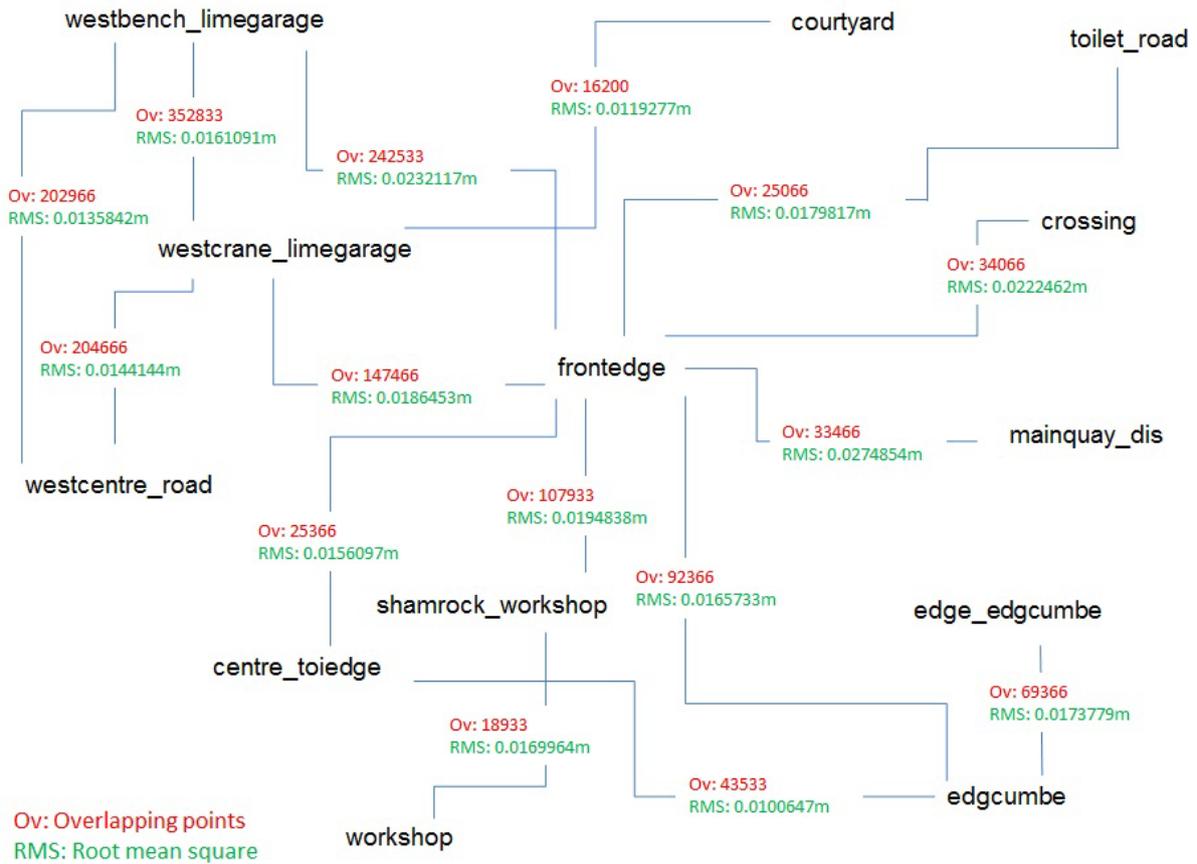


Figure 30 Conceptual diagram of the registration between different scanworlds (as variable name), with number of overlapping points between registration, and the RMS error generated during registration

Further analysis of these data show that there is a very weak relationship between the number of overlapping points between scans and the resulting RMS error statistic ($R^2 = 0.0004$) [Figure 32], whilst there is a positive weak relationship between the number of iterations during registration and the resulting RMS error ($R^2 = 0.1369$) [Figure 33]. It should be noted that the sample size of this dataset used to conduct this analysis is small (seven data points) and therefore any further analysis should look to increase this.

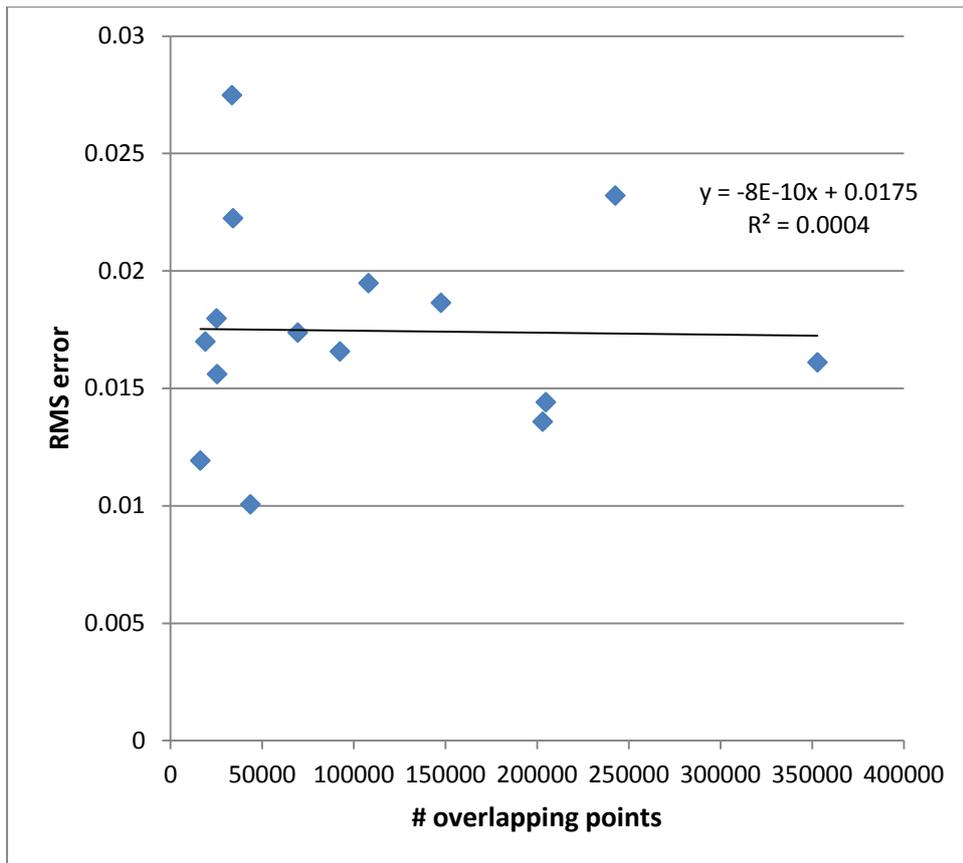


Figure 31 R^2 value calculated for the RMS error over the number of overlapping points between scan

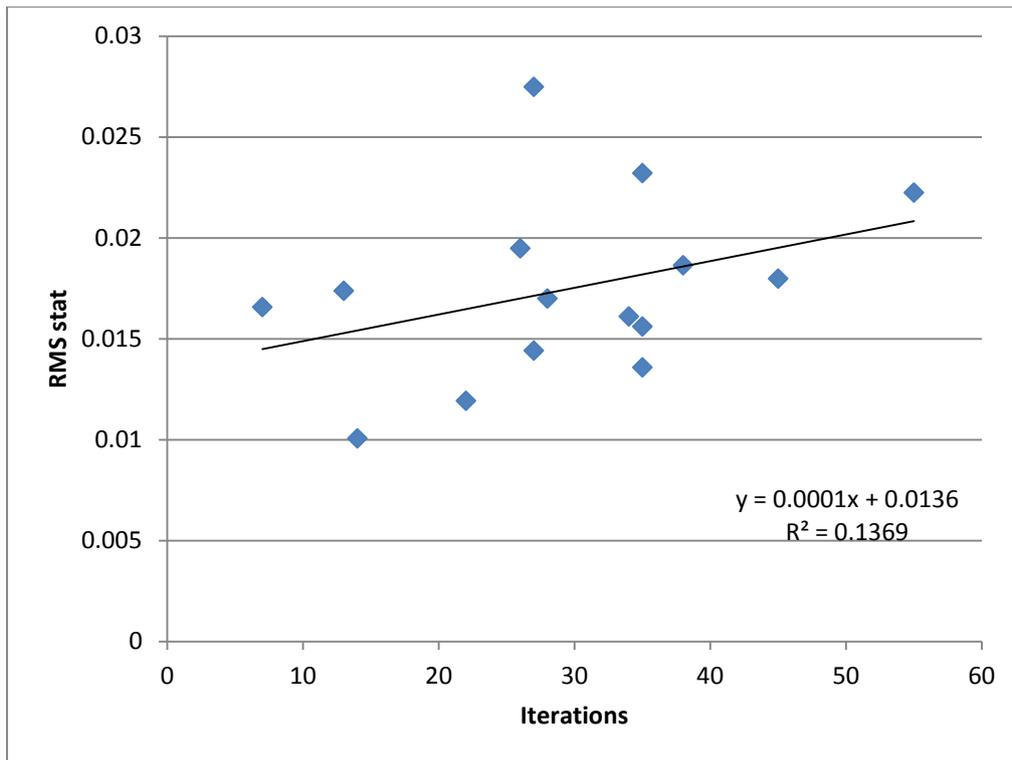


Figure 32 R^2 value calculated for the RMS error over the number of iterations during registration

4.5. Geo-referencing the model

At this stage, the point cloud had no “absolute” geographic co-ordinates and the next stage was therefore to geo-reference these data to the British National Grid co-ordinate system so as to allow them to be positioned correctly in relation to their true location on the British National Grid and, most importantly in terms of their height above mean sea level. This process of geo-referencing would also be important in later stages when the 3D model was imported to 3DS Max software, as the software is able to recognise assigned coordinates and automatically aligns the TLS and LiDAR data in 3D space. Geo-referencing was achieved using ground control points that had been independently surveyed using a differential Global Positioning System dataset (collected by Nettley. A, June 2010) which could pinpoint the location of objects on the quayside to a documented spatial accuracy of 1 cm in x and y and to 1.5 cm in z (reported in Anderson et al. (2010)). Overall three objects on the quayside (including stone pillars and natural geometry including the cornerstone on the quayside) were used to perform the geo-referencing of the data.

4.6. From TLS to 3D model

Having produced a geo-referenced point cloud the model was meshed and textured in the same way as described in Chapter 3, sections 3.16 to 3.17.2. The one difference to the first point cloud was that the car park of Cotehele Quay had not been registered to the main point cloud. This part of the model was textured using the same methods but when it was imported into 3DS Max it was aligned with the edge of the TLS dataset and the LiDAR data. Unfortunately, this meant that sea level could not be modelled against it as the alignment with the LiDAR was likely to include an offset of 0-50cm (although once in 3DS Max this was impossible to quantify exactly). Using a piece of design software to model the quay highlights the difficulties encountered when accurately measuring spatial datasets; they are not designed in order to work with spatial data [Table 22].

Component	Vertices	Faces
Edgcumbe	465	237
Toilet block	2780	4279
Terrain		
West	10420	17716
All	77530	133053
Discovery Centre		
Westside	47421	82094
Door	25	32
Side	25	32
Workshop	6187	9009
Trees	8669	4967
Benches	284	584
Lime kiln	4469	8530
LiDAR	25438	49923
Car park	12587	19043
Garage	1273	2373
TOTAL	197,573	331,872

Table 22 Number of vertices and faces used to construct the 3D mesh of each component part of the building at Cotehele Quay

4.7. Re-evaluating the role of visualisations

Taking into account the conversations that took place with the different groups during the first stage of participation, there were more obvious motivations for producing the film. From these conversations, it was clear that contrary to many other scenarios the motivations for the film were much less prescribed than comparative ‘scenario-building’ exercises (especially in so much that the NT did not want to propose or suggest a particular scenario).

Alcamo (2001:29) usefully suggests that the development of scenarios should be “tailored to the goals of the scenarios and the situation under which they are being developed”. Deciding on the goal of the visualisation was a useful starting point to think about how the visualisations would make a transition to a film. The goal of the film could be determined as to share with all audiences the history of flooding at Cotehele Quay and in the Tamar Valley, and to share projections of sea level that may possibly affect Cotehele Quay in the future which draws on the feedback from the first stage of engagement.

4.8. Stories and storyboarding

Taking into account the additional data that were going to be collected, meant thinking about the mechanisms for collecting and organising the data. At this point in the research, the visualisations that were produced in the first stage, whilst being developed and modified in their own right, were now looking to become a contribution to a much more involved story about change at Cotehele Quay. The following section addresses how the visualisations got subsumed into a narrative structure and why the decision was made to use storytelling rather than more traditional science visualisation approaches to communicate change at Cotehele Quay. The first step was to consider what the contributing factors to a successful story, followed by looking at how films, in particular documentary films, use storyboards as a tool to facilitate the collation of different media (Hart 1999; Denning 2001).

4.8.1. Stories for multi-media communications

Stories have been used for centuries as a vehicle to communicate messages (Ochs and Capps 2001) and whether they are told once or repeated, the strength of storytelling lies in the way that a successful story can engage audiences and proliferate through generations and across geographical space (Denning 2001). Stories have the capacity to be ‘natural’, ‘entertaining’, ‘easy’ and ‘energising’ (Denning 2001:15) and it is these intrinsic qualities which give them the flexibility to help people understand complex situations (Heugens 2002).

Stories have helped people weave together complex sequences of actions and experiences and the intention of stories is that they enable the revelation of hidden

aspects of the situation and create a new dilemma which calls for thoughts, actions or both (Ricoeur 1984). Given that one of the strengths of storytelling lies in how it transcends prior knowledge and understanding, it is not a surprise that the power to input words or images in to the minds of others has grown to become a form of organisational capital (Heugens 2002) particularly in regards to marketing (Fog, Budtz et al. 2005). Stories are not only used for personal gain; awareness campaigns have begun to harness the power of storytelling to raise awareness of a cause (Schaffer and Smith 2004). Stories have the power to convince outside audiences that the environmental concern or cause is worth supporting.

The strength of storytelling is a double-edged sword, and the control they can exert over audiences is not to be taken lightly. Climate science is certainly one such field which is greatly affected by storytelling and the power of opposing ideas (Smith 2005). The on-going and frustrating coverage of climate science in mainstream media shows how one story can overpower another even if one story tells more has more scientific supporting evidence (Boykoff 2007; Boykoff and Boykoff 2007).

Only over the last five years have science communicators really started to exploit the power of storytelling (Moser 2010), however this continues to be primarily focused on engaging and affecting responses to climate change (O'Neill and Hulme 2009). This has been driven by a concern that science communication started to be reduced (in the aim of simplified and clear communication) to analytical models (Sametz and Maydoney 2003), as a reaction to the difficulty of communicating scientific data in numerical formats¹⁰.

As the applications for storytelling grow in science communication, there is a parallel growth in the ability of digital technologies to offer ways to tell these stories, founded on traditions in documentary film making (Hearne 2006). The tension of science communication is its struggle to adhere to the traditional structures of what good storytelling is. Over the years scholars have each contributed their own interpretations of what constitutes a good story structure (Hart 1999; Denning 2001;

¹⁰ Infographics are a response to the call for engaging ways to present numerical data by combining text and graphics in static images. A good introduction to the pros and cons of this can be found in Cairo, A. (2012). The Functional Art: An introduction to information graphics and visualization, Pearson Education.

Heugens 2002; Sametz and Maydoney 2003; Fog, Budtz et al. 2005); what these all share are: messages, characters and a plot.

Often the strength of stories is determined by the strength of each of these components to tell the collective story. Where storytelling for science communication has arguably fallen down is that scientific data lacks the characterisation of good storytelling. And whilst this should not stop science communication from using a storytelling approach, it does mean that scientific data should look for more nuanced ways of adapting traditional storytelling structures.

The practices used in documentary-filmmaking are a useful framework to begin shaping a new structure. Although documentaries draw on similar modes for the structure, they are differentiated from stories, as they are often driven by the rhetorical or aesthetic functions attributable to them. As defined by Renov (1993:21-25) they are: 'to record, reveal or preserve, to persuade or promote, to analyse or interrogate and to express'. What this points towards are the different motivations behind documentary filmmaking compared to traditional storytelling, allowing the motivations to dominate the structure and justifying a shift towards less 'person-centric' storytelling. The working definition of storytelling that is used in this research is as defined by (Polkinghorne 1988):

"[A story] serves as a lens through which the apparently independent and disconnected elements of existence are seen as related parts of a whole"
(Polkinghorne 1988:36)

4.8.2. An emerging field: digital storytelling

At this point it should be noted that much of the preparation of material for the film 'Changing Tides' could be considered a contribution to the practice of digital storytelling; an emerging field of research whereby mixed media are used for creating a digital narrative about an issue or topic (McClellan 2007). A digital story is similar to a film, in that it contains a variety of media sources (Lothe 2000), however the term digital story is better suited to describe not only the content but also the construction of digital sequences incorporating short, informative pieces of data. It is likely too early to pronounce 'Changing Tides' as a digital story, especially since there are somewhat conflicting views about what a digital story should be defined as,

hence why throughout the methodological chapters the mixed media approach is presented as a 'film'. Yet the possibilities and opportunities for building on this concept in future studies are important and therefore discussed in more detail in Chapter 6.

4.8.3. Storyboards in film-making

The storyboard does not tell the story; it acts as a tool to facilitate bringing the story together. Storyboards are a useful tool as they help to plan the scope and sequence of audio, images and text in a film (Palmer and Lee 2012) whilst pre-planning the content of a film, anchoring the focus of the production (Hofer, Owings et al. 2010). One of the challenging aspects of constructing the storyboard was finding a middle-ground which balanced the present realistic and engaging visual content with the need to present robust and rigorous scientific information. The storyboarding process broke down each element of the digital story into its various components: model visualisation sequences, text quotations, historic photographs of past flooding events, and an overlay audio narrative. The process took into consideration the need to sequence visual and textual information carefully, to allow viewers to process information effectively (Jamieson 2007).

Using the results of the feedback a storyboard was constructed that was broken down into sections containing information on: script, shot, time and image. Using this format, it was easier to construct a flowing narrative.

4.9. Contextual data

Having identified that the visualisations alone were not an adequate tool on their own to demonstrate flooding at Cotehele Quay, the research looked to other sources of data to be included in the generation of a story about Cotehele Quay; this began with a review of the possible data sources and supplementary qualitative research techniques [Table 23].

	Data sources	References
Evidence of change at Cotehele Quay	Oral histories Historic photography Archived transcripts of flooding events	(Brennen and Hardt 1999; Errante 2000; Boschma, Yonge et al. 2003; Mannik 2011)
Explanations about sea-level rise	UKCP09 report (2009), IPCC Working Group I Report(2007)	(IPCCa 2007; UKCIP09a 2009; UKCIP09b 2009)
Sea-level rise scenarios	UKCP (2009)	(UKCIP09a 2009; Nicholls, Marinova et al. 2011; Bamber and Aspinall 2013)

Table 23 Additional data included in the film

What made this part of the research more challenging was that whilst undertaking research for secondary data, the development of the 3D model was on-going. The storyboard was acting as the framework to bring the contextual data and the visualisations together [see section 4.8]. The complexity of working simultaneously with multiple research methods is discussed more in Chapter 6. To manage the multiple datasets the storyboard acted as the framework to bring together the contextual data and the visualisations. This meant a juggling act as both the secondary data and the visualisations needed to work together to tell a coherent story. Essentially, any one element of the storyboard would not work without the others.¹¹

4.9.1. Archived research

The nearest local archive to Cotehele Quay is the Calstock Parish Archive located at the AONB offices in Gunnislake in the Tamar Valley. The archive houses written and photographic records, as well as maps and plans of local buildings. In 2000 the archive began electronically cataloguing its database (CPA 2012). To conduct the research, two search terms were used 'flood' and 'flooding'. This drew a mixture of results from historic photography to interview transcripts of flood events. The earliest record was a letter dated 1423 which noted 'the constant flood of Calstock', although it is unclear if this is related to tidal or fluvial flooding. Each of the results from the search were considered for inclusion based on the content of the image or text and relevance to tidal flooding at Cotehele Quay.

4.9.2. Historic photography

¹¹ This is demonstrable in the use of a flood event from 1866 that was uncovered in archival research. This event was linked to a visualisation that used 1866 as the base for showing historic water levels.

Since the invention of the camera, people have used these devices to capture events from the mundane to the extraordinary (Rosenblum 2007). Local archives are a rich source of historic photographic material, capturing many aspects of daily life throughout the past century. These photos inadvertently document societal ways of life and cultural norms that may otherwise be forgotten (Rose 2000), and they often capture unique events that occur during people's lives. Historic photography is frequently used in film-making to add historic context to a story (Brennen and Hardt 1999).

Photo-elicitation has long been a method used in visual sociological studies as a way of drawing an emotional response from participants of research (Harper 2002), particularly in interviews where eliciting an emotional response can generate a more complete response to the questions being asked (Collier and Collier 1986; Mannik 2011). Using photography helps interviewers sustain a narrative by eliciting nostalgic memories. They can facilitate relationships between the interviewer and the interviewee as they allow a joint exploration of meaning, emotion and memory (Mannik 2011).

Outside of using historic imagery in sociological studies, photography is often included in documentary film, where the subject matter covers historic events that have not been recorded on film (Harper 1998). This application of historic photography is more closely aligned with the uses presented in this research, but there is still some transition between the application of photography for purely emotive purposes as discussed in Harper (1998) and how photography was introduced in the film about Cotehele Quay. One critique of using photography is that it can act as a form of reactionary voyeurism, and Harper (1998) argues that this is the greatest threat to documentary film. This post-modern critique sits very much outside what the research was intended to do, but nonetheless is deserving of more attention and is discussed in more detail in Chapter 6.

Where the real strengths of photo elicitation truly lies, are in the ability of photos to redefine the relationship between subject and researcher, providing a platform for some form of collaboration in research (Harper 2002) which does not rely on power based relationships (Luke 1991). The primary driver for the inclusion of historic photography as part of the story at Cotehele Quay was a request from the

participants (which is a positive step towards engagement in research – see Chapter 6), but once included in the film the photography offered context and emotional gravitas to support the future sea level visualisations. By displaying historic photography in the film, Harper (2002) suggests that it allows the research participants to take the lead in deciding how emotionally involved they are.

From the archive search, seven photos were found which showed flooding on the River Tamar and two of the Shamrock (the barge now permanently located at Cotehele Quay). The exact year that these photos were taken is unknown, but they are assumed to have been taken in the 1970s; this is corroborated by oral history accounts of a large flood event that occurred in 1972. Of these seven images, four were used in the final film [shown in Figure 34, Figure 35, Figure 36 and Figure 37], selected as they showed the impact of tidal flooding rather than fluvial.



Figure 33 A view over the football field in Calstock circa 1970

Perhaps one of the most significant contributions the historic images made to the film were that they were the only images that included people. Once again, this builds on the emotional connection between the audience and the content, but more importantly they remind the audience that flooding is real and has been experienced throughout history, drawing on the powerful experiences of memory and history as a mechanism for thinking about the future.



Figure 34 Flooding at Calstock Quay circa 1970

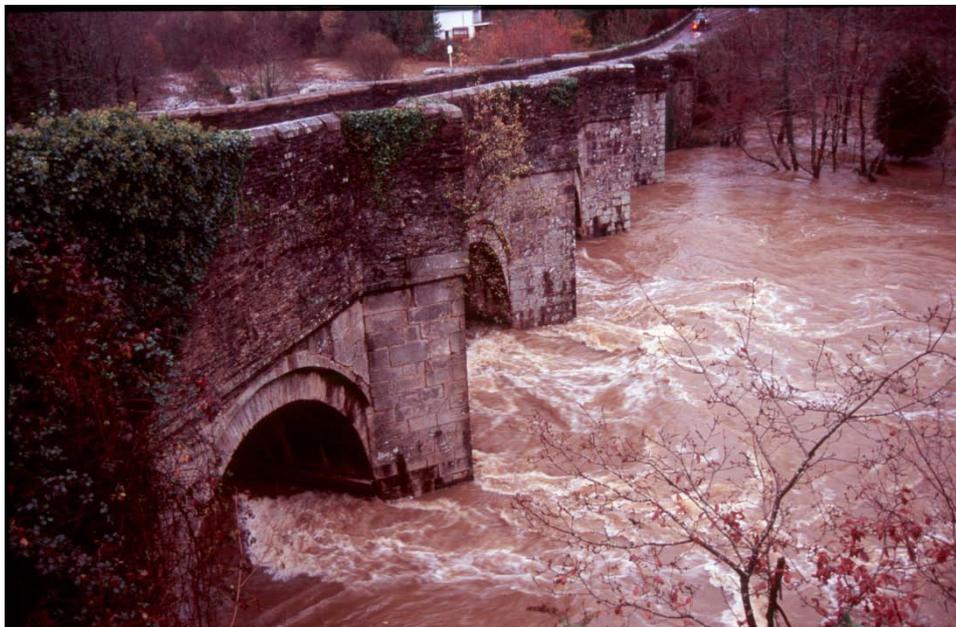


Figure 35 Flooding under Gunnislake Bridge circa 1970s



Figure 36 A 1970s Austin 1100 stranded at Calstock Quay

4.9.3. Historic interview transcripts

A secondary data source that was collected from the archive were transcribed interviews from local residents who recollected past flood events. The earliest memoir was from 1886, with the interviewee recounting several dramatic moments in one flood event which were both tragic and comedic.

“Water would be coming around, the tide would be flooded right out over all the hedges of the field. The cows would be simply swimming over the tops of the hedges.”

[Hawken (1987)]

The infrequency of these events make the recollections stand out. In a similar way to the historic photography, the personal memoirs of flooding were supporting historic evidence to the 20th century events. But as well as contextual data, the 1866 flood event would have a later influence on the scenario visualisations shown in the film [see section 4.11].

4.9.4. Oral histories

Oral histories are personal narratives which are subjective records of how men and women have experienced their lives, work or historical events (Boschma, Yonge et al. 2003), particularly well defined by Ritchie (2003) as “collecting memories and personal commentaries of historical significance through recorded interviews” (Ritchie 2003:19). Often oral histories are archived for future reference, or kept anonymous (Alexander 2006), rarely are they used in the way projected in this research. Storytelling is rooted in oral traditions, growing from tales of lived experiences, showing broader relationships between people (Banks-Wallace 2002), uncovering otherwise unknown relationships. Bearing in mind the role of storytelling that has emerged as central to the framing of flooding within the Tamar Valley and the ability of personal stories to engage audiences (Riley and Harvey 2005), to have overlooked the use of oral histories would have been imprudent. Using oral histories as personal narratives within this research added a novel dimension to the digital storytelling form, serving to refine a story as well as share common characteristics (Errante 2000; Banks-Wallace 2002).

Traditionally, oral histories were collected and then archived as a record for future generations’, it is far less common for textual narratives of the past to be included in visual media (Ritchie 2003), primarily as oral histories lack the visual dimension which translates to film and therefore needs to be juxtaposed with other media to be used in films (Kwan 2008). Sharing oral histories among a community can have beneficial effects on the communities’ collective sense of ownership over an issue (Ritchie 2003). In one study examined by Ritchie (2003), the community’s sense of shared heritage was low, so they were engaged with the oral histories of other residents. There was some apprehension over the degree to which sharing oral histories could convince the community to reconsider the importance of their shared heritage. Over time, and with repeat visits from researchers, the community began to see how they were perceived by the outside. It is not always the case that groups will experience similar positive experiences to the example in Ritchie’s study, but there is evidence that sharing personal experiences, based on shared or common values will engender trust and community cohesion (Errante 2000).

4.9.5. Application of oral histories in the film

To contribute to the growing story about flooding at Cotehele Quay, extracts were taken from a larger project being carried out simultaneously at the quayside by a Masters student at the University of Exeter. The aims of this complementary research study were to explore and analyse local experiences of flooding and other weather-related events and provide a legacy for the NT to use in engaging the public on issues around climate change (Goldthorpe 2011).

The oral histories captured during this piece of work provided some contemporary reflections on recent flood events as well as past flood events within living memory. Seven interviews were conducted with people who had worked on the river for around 20 years. The interviews took place between March and June 2011 and lasted approximately an hour. The interviews were transcribed and presented by Mark Goldthorpe, as part of a report focusing on memories of flooding and weather-related events on the River Tamar.

The decision to use oral histories quotes was due to the fact that this personal evidence of past flooding addressed two parts of the focus group participant requests: primarily, a desire to understand the historic context of flooding at the Quay, and secondly recognition of an emotional attachment and a sentimental understanding of the situation. The 41 pages of transcribed interviews yielded pages of examples of flooding throughout the 20th century of flooding on the quay, many of which would have been suitable for use in the film. The strategy for selecting quotes that appeared in the film was based on the desire to communicate experience and a lay knowledge about how the river responds to high tides (and often high levels of precipitation). The quotes in Table 24 were selected as they best conveyed these qualities. These quotes conveyed two aspects of flooding that the community were unlikely to be conscious of experiencing: surprise at floods occurring, and knowledge about the impact when they do [Table 24].

Interviewee	Quote	
Joe Lawrence, Head Warden	“In the early 1800s they started putting defence banks up along the river... Before then you still had these areas like we’ve got between the quay and the chapel, and then opposite Calstock – which would have allowed the water to spread out. But by putting the defence banks up, as soon as it finds a gap to go in it’s in there with some force.”	Vulnerability Lay knowledge
Peter Allington, Workshop Manager	“I came down that particular night to check on Shamrock, and I nearly walked straight into a lake! I come down past tea rooms and all I could see was water”	Experience

Table 24 Quotations used in the film

Joe is Head Warden at Cotehele and has lived on the site for over 20 years; similarly Peter had been a resident of the neighbouring village of Calstock his whole life and had spent the majority of his life working on the Quay at Cotehele. Both people are well respected members of the community and were recognised by the focus group participants.

4.10. 3D Visualisations: style and positioning

Before deciding on the projections of sea level for the visualisations, some decisions needed to be made regarding the style of the visualisations. The stylistic components of the model include lighting, depiction of flooding and movement of the camera through the model. The stylistic elements of the visualisations affect the realism of the final product i.e. the lighting in the scene can vastly affect how ‘real’ a model appears.

The focus and working groups had raised an important stylistic element, requesting a more accurate representation of a tidal cycle. This is a stylistic function rather than a scenario, as the primary concern for the visualisation was the height of the tide rather than the speed at which it reaches this level. Nevertheless, it was important to the audiences that this was shown to be truly representative of what happens at the quay.

The first visualisations that were generated and presented to the working group included a moving camera shot around the quay. The intention of moving the camera

through the scene was to demonstrate the scale of the site and the effect flooding would have. Unfortunately, in the first iteration of the film, the camera movement through the model was not effective at clearly showing the full extent of the model area. As was discussed in Chapter 3, part of the reason behind this was that at this stage the model was not geo-referenced to the national grid, unlike the LiDAR data to which it was aligned. Out of shot of the camera were areas which were clearly a poor alignment between the TLS and LiDAR data and therefore showing flooding of these areas would have been misleading.

4.10.1. Accurate tidal cycles

At the first focus group, the visualisation depicted an ebb and flood cycle at Cotehele Quay. There was general agreement amongst both the NT and community focus groups that the speed of the tide was not accurately portrayed, detrimentally affecting the realism of the visualisation. Responding to this criticism, the factors affecting tidal systems and the speed of the ebb and flood cycle were examined in more detail.

Tidal systems on the south coast of the UK are semi-diurnal (i.e. there are two high and low waters in a 24 hour period) in response to astronomical forcings and follow a Rule of Twelfths system (RoT). Other meteorological conditions have an impact on the dynamics of tidal processes along the coast and estuaries of the UK (Pugh 2004) but these are dependent on meteorological forcings and extremely hard to both predict or model due to the number of unknown circumstances which can affect the severity of impact.

In the six hours between low and high water the hourly depth changes are related to the tidal range [Table 25]. The tide moves most rapidly during the third and fourth hours of a changing tide as the water is flooding and ebbing half of its total range. The distance of the rise and fall of the tide is not uniform; the variations in tidal ranges are recorded in admiralty charts for 230 ports across the UK. The nearest tide gauge to Cotehele Quay is Devonport in Plymouth [Table 25].

1st hour	1/12 tidal range
2nd hour	2/12 tidal range
3rd hour	3/12 tidal range
4th hour	3/12 tidal range
5th hour	2/12 tidal range
6th hour	1/12 tidal range

Table 25 Explanation of Rule of Twelfths

The boundary level between the marine and coastal environments is known as tidal datum. Tidal datum are used as the sounding and depiction on all nautical charts (Hicks 1985). Of this tidal datum, the most commonly referenced are mean high water (MHW) and mean low water (MLW). Mean high water is the average high water level recorded each day by the nearest tide gauge, whilst mean low water is the lowest point of the tide each day. Another name for mean low water is chart datum, and this can be measured as 0cm above sea level (Woodworth, Tsimplis et al. 1999). The level for chart datum varies across the UK, at Devonport (Plymouth) chart datum is 3.22m (-3.22) below Ordnance Datum Newlyn (ODN). At Cotehele Quay chart datum is 2.13m below ODN [Table 26].

Station name	Latitude	Longitude	Country	Datum ref (ACD = Admiralty Chart Datum)
Devonport	50° 22' N	04° 11' W	England	ACD = ODN -3.22m
Cotehele Quay	50° 29' N	04° 13' W	England	ACD = ODN -2.13m

Table 26 Tide gauge information for Devonport and Cotehele Quay

Data for actual recorded tides (gathered every 15 minutes) can be accessed for the past 20 years for Devonport. At Devonport the lowest tide occurs one hour and 50 minutes before Cotehele Quay. Actual observed tides at Cotehele Quay have not been recorded although an estimation of the difference between the MLW level and MHW level between Devonport and Cotehele Quay are 0.8m and 0.58m respectively.

In order to calculate the level of the tide at Cotehele Quay, it is necessary to use predicted tidal levels using past data gathered from the Devonport tidal gauge. The UK Hydrographics Office produce charts of predicted and actual tidal levels for Devonport. The residuals generated from the observed tides at Devonport varied with the average difference between predicted and observed data being between -0.2 and 0.6m.

Having introduced the processes that are involved in semi-diurnal tidal cycles, this information was used to calculate the height of the water for each hour within two periods of high and low water a day. Calculating the height of the water throughout the tidal cycle was a rather exploratory process, as at this stage it was unknown if the water would be represented in this way in the visualisations. Two dates in the recent past were used as templates for calculating the water heights. The first (9th September 2009) was a spring high event where photographic evidence was recorded showing the extent of flooding, the second (28th September 2009) was a neap tidal cycle. Table 27 shows the conversion from the predicted tide levels in chart datum converted to ordnance datum (-2.13). Ordnance format can be used in the 3D geo-rectified model where ODN co-ordinates already exist [Table 27].

Time (24hrs)	Chart Datum (m)	Ordnance Datum Newlyn (m)
<i>Spring Tide 9th September 2010</i>		
0148	0.1	-2.03
0722	4.8	2.67
1409	0.1	-2.03
1939	5.1	2.97
<i>Neap Tide 28th September 2010</i>		
0345	0.8	-1.33
0916	4.3	2.17
1558	0.9	-1.23
2130	4.1	1.97

Table 27 Conversion of tide data from chart datum to ordnance datum Newlyn

3DS Max software recognises coordinate systems and the 3D model imported as an object retains the geographical coordinates attributed to the dataset when it was a point cloud. What this means for this calculation of tide heights is that the level needed to be converted from chart datum (m) into Ordnance Data Newlyn (ODN). The difference between these two measurements at Cotehele Quay is -2.13m. Building on Table 27, the next stage was to calculate the exact height of sea level based on the rule of twelfths [Table 28 and Table 29], for the six hour period between high and low water. The result of this calculation is 19 tide levels beginning at low tide and ending at the second high water period of the day.

Time (24hrs)	Calculated RoT (ODN)				
0148 Low Water	-2.03				
0248	-1.64	0822	2.28	1500	-1.61
0348	-0.89	0935	1.5	1550	-0.77
0448	0.28	1035	0.33	1650	0.49
0548	1.45	1130	-0.84	1755	1.75
0648	2.23	1230	-1.62	1855	2.59
0722 High Water	2.67 (2.62)	1409 Low Water	-2.03 (-2.01)	1939 High Water	2.97 (3.01)

Table 28 Spring Tide 9th September 2010

Time (24hrs)	Calculated RoT (ODN)				
0345 Low Water	-1.33				
0430	-1.04	1016	1.89	1658	-0.96
0530	-0.46	1116	1.33	1758	-0.42
0630	0.41	1216	0.49	1858	0.39
0735	1.28	1316	-0.35	1958	1.2
0835	1.86	1416	-0.91	2058	1.74
0916 High Water	2.17 (2.15)	1558 Low Water	-1.23 (-1.19)	2130 High Water	1.97 (2.01)

Table 29 Neap Tide 28th September 2010

Taking the hourly tide height and modelling rising water in 3DS Max meant setting key frames for each time period and then setting the water level. Whilst showing the rising water was technically feasible it was also technically complicated as each time needed to have multiple key frames for water level and time. Moreover, the resulting rising water levels distracted from the intended purpose of the visualisations, which were to show sea levels not to show tidal cycles.

4.10.2. Cultural and maritime artefacts

Although maritime artefacts had been modelled in the first stage of visualisations (including the mooring blocks and benches), due to the camera angle these were not visible in the first visualisations. The participants asked for these to be included (which actually meant positioning the camera in a different place). The largest maritime object that had been omitted from the first visualisations was the barge 'Shamrock' which is now permanently located on the quay.

Originally built as a Ketch rigged sailing barge in 1899, she is now the only remaining working barge on the River Tamar. The barge is jointly owned by the National Maritime Museums (Greenwich) and the NT who acquired her in 1973 and restored her to working condition (NMM 2012). Having been located at the quay for 40 years,

the Shamrock has become both a tourist attraction and an integral part of the daily life for several volunteers on the quay (NT 2012). For many people who visit the quay regularly, the Shamrock has been at Cotehele since they began visiting the site as is as much a part of Cotehele Quay as the other buildings and artefacts.

To model the barge from scratch in 3DS Max would have been complicated and time-consuming without expert guidance. An alternative and rapid way to model objects in 3DS Max is to use 'Google Warehouse', an open source database of thousands of objects that can be downloaded in .obj format ready to be used in 3DS Max¹². A sample barge was downloaded as an .obj and the colours modified in 3DS Max material editor to match the colours of the barge at Cotehele [Figure 38].



Figure 37 [left] Shamrock as modelled in 3DS Max [right] Shamrock at in situ at Cotehele Quay

Similarly to the Shamrock, the modelling of the crane on the quayside was outsourced to an experienced modeller in 3DS Max [Figure 39].

¹² Google Warehouse was primarily developed as a database for Google's 3D SketchUp software, but has evolved to an open source platform that shares .obj formats digital files.



Figure 38 [left] the crane as modelled in 3DS Max [right] the crane at in situ at Cotehele Quay

Unlike the terrain and landscape surfaces that were modelled on the TLS data, the primary function of the maritime artefacts that were included in the scene was to engage the audience and act as reference points for the viewers, therefore the fact that they were not to scale was not detrimental to overall accuracy of the sea level projections.

4.10.3. Camera angles and movement

The LiDAR data had been draped with aerial photography and both the LiDAR tiles and photographic images were 1km x 1km meaning that the visual representation of land use appeared digitally similar to the real thing. The LiDAR data has to be represented in two-dimensions rather than three as including more detail on the LiDAR would slow the rendering time and not contribute to the overall photo-realistic appearance that was strived to attain, as the LiDAR was not the focus for the sea-level rise projections. This meant that the level of detail between the modelled TLS data and the LiDAR was significantly different. Any camera angles had to be sympathetic to the fact that the LiDAR was not as visually detailed as the TLS landscape [Figure 40].

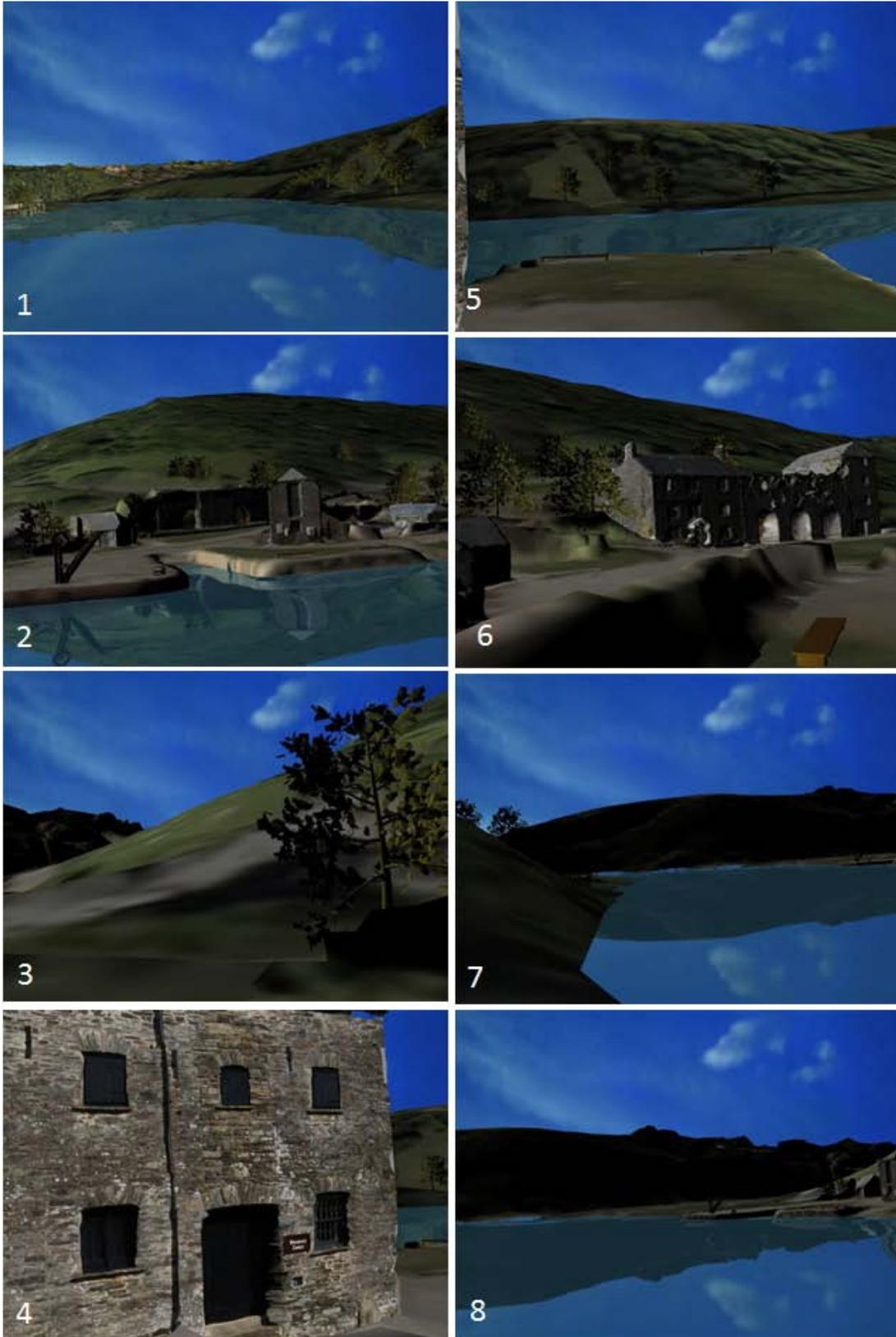


Figure 39 Test visualisation for path of camera showing. Images show technical difficulty of generating correct field of view [numbers show sequence of images in video sequence].

The second complication with using a moving camera in the scene was that it was technically very challenging to create a smooth and focused path for the camera that would not result in jerky motions or shots that were not too close to objects. There needed to be some consistency throughout all of the modelled visualisations and using a camera moving in the model seemed confusing. Finally, due to the nature of processing two datasets at different spatial resolutions, there were areas of the model where the boundary between the two datasets was apparent [Figure 41].



Figure 40 Poorly designed 3D modelling of boundary between LiDAR and TLS data

Ultimately the decision was taken to keep the height of the camera static whilst slowly panning in front of the quay. From this angle, most of the Cotehele site could be viewed, including useful reference points for scale such as the Discovery Centre and the crane. More importantly, this simple motion means that every rendered visualisation of varying sea-levels could be used as a comparative shot (i.e. present day to future 2050 scenario).

Only two visualisations deviated from this camera movement: the initial long sequence, where the camera starts further down river and then crosses the Hay

Marsh site to Cotehele [Figure 42,a], and the second visualisation which shows the whole Cotehele site [Figure 42,b]. This was deliberate and in direct response to what was requested at the focus and working groups. These audiences wanted to see Cotehele Quay in the wider context of the Tamar Valley. Whilst it was not appropriate to show flooding on this scale [as discussed in Chapter 3], it was possible to show an average neap tide throughout the valley. The first visualisation that appears in the film demonstrates this by moving up the river, and the second visualisation hints towards what is happening upstream as the river meanders towards Calstock [just in view].



Figure 41 [left: a] A still from the first visualisation [right: b] a still from the second visualisation shown in the film

4.10.4. Water and lighting

One of the priority areas for improvements on the visual aesthetics of the film lay in the water. One comment from a focus group participant was the water was much muddier than it appeared in the first round of visualisations. Changing the visual appearance of the water is straightforward in design terms; and involves changing a few settings to make the surface appear more uneven (waves) and darker / lighter to look like a sediment filled river. The challenge however, was to make an object that had the visual appearance of the Tamar, but didn't have the reflectance properties that would require computer processing power that would exceed the capabilities of the hardware available. In 3DS Max, changing the surface properties i.e. the noise (creating waves), transparency and reflectance characteristics of the plane, simultaneously increases the surface area of the plane. This has a knock on effect

on the rendering time and processing power to create one image. At first, and building on what was accomplished in the first series of visualisations, an attempt was made to improve the realism of the water by changing the properties of the surface using the materials editor in the 3DS Max software. Unfortunately it is not possible to show the trial and error attempts to make a 'realistic' looking water surface using only the variables in the material editor¹³. Looking for an alternative approach, which was less 'render-intensive', meant looking at existing photographic images of the River and trying to identify which characteristics were most likely to make the water in the model look 'real'. What was realised was that by using a simple plane and applying reflective properties to it in the material editor, it would mirror the opposite surfaces. Until the image is rendered, the plane appears to be dull, but during the rendering process light is put in the scene and bounces around mimicking a real world environment. In a 3D environment, light is artificially positioned in the desired location, but it reflects off every surface; in the model of Cotehele, this meant that the light was reflecting off the land surfaces (the buildings and quayside of Cotehele) as well as any background images that were added to the scene. Initial trials to mimic real world lighting using lights positioning around the scene (as above) did not create a water surface that appeared visually realistic. So, by using the knowledge about the effect of adding a background image to the model, the plane would reflect the surrounding landscape and therefore have one of the characteristics of waters' surface. Using a Google search of the term 'sky', several images were selected and tested in the model [Figure 43]. This approach resulted in a realistic looking water surface without being processing intensive at the rendering stage.

¹³ This is due to the software crashing when the processing power was insufficient to render an image and therefore the file had to be deleted and no image could be taken.

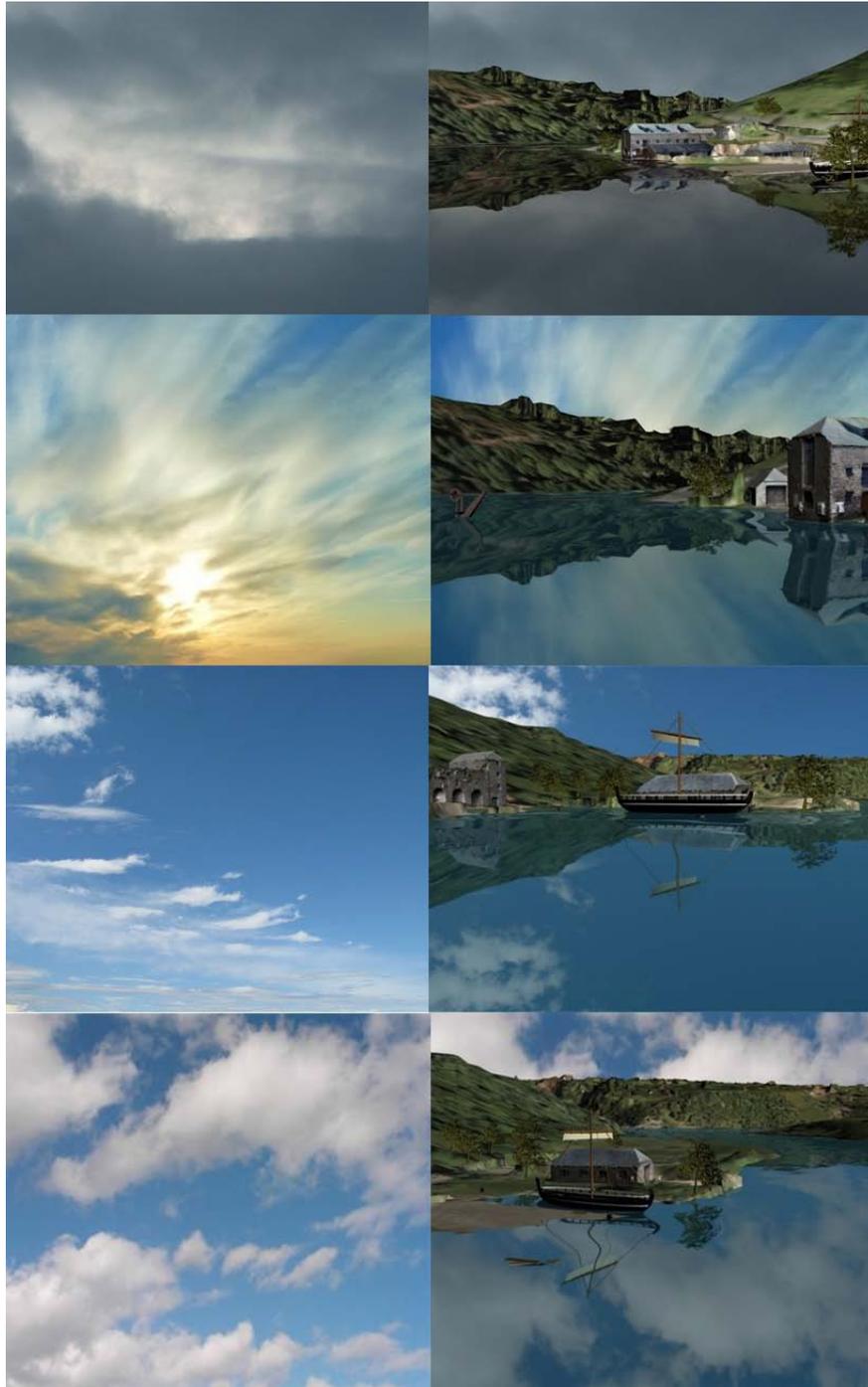


Figure 42 Examples of 'Sky' images modelled in 3DS Max

Depending on the bitmap properties of each image, darker images would reflect less light than bright images; resulting in a variation in the brightness of the overall image [Figure 43).

4.10.5. Conclusion: style and positioning

These preceding sections demonstrate how the 3D model was prepared in 3DS Max, in response to participant feedback, before the scenarios were created. The preparation of the 3D model centred on making simple changes to the aesthetic appearance of the water, as well as deciding on the camera angle that the visualisation would use in the film.

Some of the realism of the visualisations can be derived from the aesthetics of buildings and landscape, therefore spending time dedicated to improving these elements in the model was time well spent¹⁴. The focus and working groups requested specifically that the realism of the water be improved and this was addressed by changing the reflective properties of the surface. The only limiting factor which inhibited further improvements to the level of realism of the water was the processing power of the computer used to render the images.

What section 4.10.1 concluded was that attempting to accurately model a tidal cycle in 3DS Max would be technically difficult to demonstrate with any true likeness to real events. And whilst this did rule out its application in the model, showing the scenarios as tidal cycles actually offers very little in regards to communicating the future sea levels. Having decided that the visualisations were going to be placed adjacent to one another for comparative purposes, using a tidal cycle showing the high tides in the future would further complicate the scene with more moving images. The core purpose of the visualisations was to show the height of the sea level in the future, therefore a tidal cycle would be a stylistic component rather than a necessity for the visualisations.

Having reached the conclusion that each of the visualisations needed to be consistent with one another in the film, this was easily achieved by setting the camera angle the same in each shot so that only the water level changed in the model, thus making it much easier to compare present and future scenarios in the film. Reaching decisions on some of the stylistic parts of the film was the final action required before the sea level projections could be inputted and the visualisations

¹⁴ Realism of the visualisations is also informed by the authenticity of the scene and other contextual information. This is discussed further in Chapter 6.

made. At this point, the 3D model was put to one side and the scenarios that were to be included explored.

4.11. 3D visualisations: scenarios

Having reached a point [at the end of section 4.10] whereby the 3D model in 3DS Max was completed, the next stage was to decide on the scenarios and sea level rise projections that would be shown in the model. The projections had to connect to the historic data that had been collected and fit in with the wider story being told about Cotehele Quay. These considerations led to the production of five scenarios [Table 30], as well as two other visualisations.

Year(s) shown	Style of shot	Event	Tide height shown	SRES scenario used in UKCP09
1886 / 2011	Moving comparison	Mean high water	4.51m / 4.8m	N/A
2011 / 2011	Static comparison	4.8m modelled / 5.1m flood event	4.8m / 5.1m	N/A
2050	Moving	Mean high water	4.91m	B1
2050	Moving	Extreme event	5.91m	Public contribution (+1m)
2100	Moving	Mean high water	5.76m	A1 F1

Table 30 Scenarios shown in the film, version one

This section explores the decisions and the processes which contributed to selected visualisations being shown in the final film, as it was not the case that these visualisations were decided and implemented without trialling alternatives. Deciding which scenarios to use was dependent on two main contributing factors, including: relevance to the story being told, and ability to accurately model sea level in the 3D model.

These two factors highlight the unique methodological contribution of this research, in that although part of the focus was on accurately visualising sea-level rise, the science behind the sea-level rise projections was actually the most straightforward and uncomplicated element to the research. The most thought-provoking part of the research was the decision-making process that took place concerning how to model and display each scenario, and the resulting iterative process that ensued. The starting point for deciding on which scenarios to include was a reflection on the

feedback from the focus groups. Using this as a starting point, the following sections show how research and development (and growing understanding of the capabilities of the software) involved a trial and error process to reach the final output. The first step towards deciding on the visualisations was to take a look at what the focus and working groups had requested in way of scenarios they would like to see. These were:

1. Comparison of 2020/2050 high tides
2. 2050, 2100 projections
3. Present day
4. High and low tidal information from the past

The level of participant engagement dictated to some degree how much expectation there was to respond directly to each of the requests by the focus groups. The first decision was which sea-level rise projections to use, followed by a decision-making process of which scenario and probability from this needed to be included in the film.

4.11.1. Scenario vs. visualisations

The literature review (Chapter 2) has already explored the definition and applications of scientific visualisations; but it is important to reiterate at this point in the thesis the distinctions and important overlapping themes between scenarios and visualisations. As used in the IPCC reports, a scenario is defined as:

“A coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold. A projection may serve as the raw material for a scenario, but scenarios often require additional information (e.g., about baseline conditions). A set of scenarios is often adopted to reflect, as well as possible, the range of uncertainty in projections.” (IPCCc 2007)

The difference between visualisations and scenarios is that visualisations as applied in this research are sequences of video made from a 3D model showing changes in sea level. The visualisations are based on data derived from different scenarios, but not in themselves their own scenarios. The structure of the visualisations follows what Alcamo (2001) describes as ‘exploratory scenarios’. Exploratory scenarios are

those which begin in the present and explore trends into the future, in other words it is a sequence of emerging events.

Using an exploratory visualisation approach suits this research as it required less speculation than any 'anticipatory' alternatives. This approach allowed the structure of the visualisations to follow a chronological ordering of events. The exploratory structure has also been shown to be easier for lay audiences to follow, as it fits with people's experiences of events in chronological time (Andrienko and Andrienko 1999).

This research selected existing climate projection scenarios (those of the SRES scenarios developed by the IPCC and used by the UKCP09 – see following section), and then used these to produce locally applicable scenarios for Cotehele Quay, thus creating visualisation of sea-level rise.

Looking to previous studies which have attempted to visualise future climate change scenarios, it is clear a range of different methods have been used to generate statistically accurate representations of change. The scenarios selected are dependent on the temporal and spatial objectives of the research (Meitner, Sheppard et al. 2005). Meitner et al., (2005) pointed out that inputting feedback from land managers and ecologists to create landscape scale visualisations of change is complicated because it involves simplifying high-level policy decisions. A concern that arises from studies which are attempting to combine input from many different ecosystem managers is that 'expert' opinions in disciplines are favoured over those of the local population who may have a more clear sense of landscape response to different environmental impacts. The difficulty in quantifying knowledges of this kind is a likely reason for their lack of representation in the development of climate change visualisations. The focus group feedback revealed a contrast between visualisations of future scenarios suggested by the managers at Cotehele and those suggested by the public.

4.11.2. Climate projections

The focus groups had not been explicit in suggesting which scenarios they wanted to see; future scenario suggestions were 2020, 2050 and 2100. The evidence suggests that people find it easier to understand scenarios which are likely to play out in their

lifetimes (Dessai, Hulme et al. 2009). Often when scenarios are designed to engage the public they use projections which people can relate to their own lives. Whilst using short timescales is suitable for communicating some of the effects of climate change, visual images of climate impacts alters the scope of what can be communicated effectively. Visual images can often have more impact if they depict future projections that go beyond the lifetime of most people; this is primarily as visual images are able to communicate the impacts directly, often with little need for further interpretation (Sheppard 2005).

Sea-level rise projections were downloaded from the UK Climate Projections User Interface (<http://ukclimateprojections.defra.gov.uk/>) which allows users to select projections for sea level rise for areas covering 25km (UKCIP09b 2009) for three defined anthropogenic emissions scenarios [Table 32].

Scenario	Characterised by:
B1 (low emissions)	Rapid economic growth, changes towards services and information economy, transition to clean technologies and global solution for stability
A1B (medium emissions)	Emphasis on use of all energy sources
A1FI (high emissions)	Emphasis on fossil fuels

Table 31 Adapted from IPCC (2007)

These projections cover a timescale from 1990 to 2100 with low, medium and high scenarios and probabilities based upon the 5th, 50th and 95th percentiles. All projections from the low medium and high emissions scenarios (B1, A1B and A1FI respectively) were downloaded in .csv format from the UKCP09 user interface website for the grid square ID 25923, (latitude 50.4601, longitude -4.2435).

Often several emissions scenarios are used when showing the potential impacts of climate change (O'Neill and Hulme 2009). This research was no different, yet it was restricted by time constraints of modelling several scenarios. B1 and A1FI scenarios were chosen as these presented the extremes in the projections from the UKCP09 report. Table 32 shows the scenarios that were modelled and incorporated in the final version of the digital story.

Scenario	Year	Water level ODN (chart datum)
Historic MHWS	1866	4.51m (4.8 - 0.29)
Present average MHWS	2011	4.8m
B1 – 5th percentile	2050	4.91m (0.11 + 4.8)
B1 – 5th percentile (extreme event)	2050	5.91m (1.11 + 4.8)
A1FI – 95th percentile	2100	5.72m (4.8 + 0.92)
A1FI – 95th percentile (extreme event)	2100	6.72m (4.8 + 1.92)

Table 32 Scenarios modelled for Cotehele Quay

Following good practice undertaken in O'Neill & Hulme (2009), an assumption was made of no adaptation to climate change. This includes adaptation to prevent flooding from sea-level rise on a local level as well as global, other than what was set out in the emissions scenarios. The assumption of no adaptation was made as it is a baseline condition which can easily be projected for all the time series.

Because of the range of uncertainty and low, medium and high emissions scenarios the decision was made to include scenarios of the most probable low emissions scenario and the least likely high emissions scenarios. This selection is subject to scrutiny and may need to be adjusted to more greatly reflect the level of complexity in climate projections.

4.12. Returning to the storyboard: scripting

“The narrator speaks the word, and the online, film, or radio audience watches and/or listens to the narrator speak the word – mediated, of course, by the interviewer, recorder and editor / producer, but nonetheless providing a far more direct experience than when the audience is left to conjure up in mind’s ear and eye the original audio or visual performance based on the written approximation of what appears on the page”.

(Hardy & Dean 2008:269)

Hardy & Dean’s reference to the importance of narration to connect directly with an audience, draws the storyboarding process to its conclusion. Once the visualisations

were completed, the final step was to return to the storyboard, using that as a framework, to create the script that would eventually become a film. Having worked up a complete storyboard, incorporating all the different components, the last step was to record the audio narration for the film. This was done using a Zoom Recorder (Model H4, Zoom Corporation, 2011) in a recording booth based in Falmouth University. The device captures stereo sound and was exported in .mp4 format (Zoom 2012).

While a story is the overarching discourse of a series of events, containing a message and plot, the narrative is the oral discourse that pulls the story together (Genette 1980). Documentary films are almost always complemented by an audio narrative (Hearne 2006) which holds key additional information. One of the benefits of the storyboarding process was that it created a framework and digital space to re-work and modify the script that accompanied the visual imagery. Numerous minor changes were made to the script over the course of the second developmental stage which is documented in a succession of storyboards [Figure 44]. For *Changing Tides*, the narrative [as spoken, script when on the page] was the vehicle holding information about the scientific data, including data about the accuracy of the model and collection of the TLS data.

Script	In Vision	Time (minutes)	Image
1 [This visualisation has been developed as part of PhD study at the University of Exeter]	Logos University of Exeter European Social Fund National Trust	0:10	THE NATIONAL TRUST UNIVERSITY OF EXETER
2 [CONTEXT CREATION] "Located in the South West of the UK, north of Plymouth, Cotehele Quay is part of the larger Edgcombe Estate owned and maintained by the National Trust. It was used as a port during the mining era of the late 19 th century. To this day the site is reminiscent of this period. There are still mooring blocks and a crane on the quayside with lime kilns and the Discovery Centre all relics of the sites' historic importance".	[MAPS OF THE SOUTH WEST]		
3 "Cotehele Quay has a history of being affected by flooding events. Most people who have experienced or witnessed it, describe it as 'extreme'. There are several extreme events in living memory".			
4 "A combination of high sea levels and high tides, has been known to occur at Cotehele but at other sites."			

• All to appear at once
• Include new image 'title image' behind text
• Changing Tides at Cotehele Quay

All text font Arial

Frame	Left (seconds)	Left (mpg)	Right (seconds)	Right (mpg)	Narration	Narration edit	Edits
	2	2					• Prefer black background
	2	2					
	5/0	5/0					
	6	6			Cotehele Quay is located in the south west of the UK, in the Tamar Valley on the Cornish coast. During the nineteenth century the quay was used for the transport of agricultural and mining-related goods up and down the River Tamar, to Plymouth and beyond. The National Trust now owns and maintains the quay and its historic features, which include mooring blocks, cranes, former sheds and warehouses, lime kilns and an inn.		
	7	7					

Figure 43 Succession of storyboards used to collate different media for the film

As the storyboard developed iteratively, and new content was added, the resulting structure of the story developed from the data that were collected. The structure was almost equally distributed between different elements: an introduction to the site, the history of flooding, and the science behind sea-level rise and future projections. The narration tied all the images and visualisations together to tell one coherent story. Although it is difficult to assert that any one component of the storyboard is more 'important' than another, audio narration of the script directly conveys an explicit message to the viewer, compared to images which are deliberately open to interpretation.

4.13. Results

The conceptual storyboard was created using video editing software Adobe Premier Pro (version CS4, 2009). The software is designed to accommodate the amalgamation of different media files for editing and can export video formats of varying quality, size and compression depending on the intended application.

'Changing Tides' was exported at H.264 standard, meaning the most popular format for distribution of high definition videos; the properties of the exported film as shown in Table 33. See accompanying USB file [filename: Changing Tides_Version 1] for a copy of the film that was produced.

Property	Result
Length (time)	07:08 minutes
Frame width	1920
Frame height	1080
Frame rate	29 frames/second
Size	642 MB

Table 33 Properties of exported film version one

The film 'Changing Tides at Cotehele Quay' was the main output of this methodological process, but there are further results generated from processing the data to reach the film [the script for this version of the film is in Appendix 8]. Some of the results have already been presented in this chapter as this was crucial to moving on to the next stage of development with the film. Results from an analysis of the registration of the point clouds was carried out to explore if there was a way to lower the registration error generated during registration. Two variables were tested, iteration number and number overlapping points. Correlation analysis on the statistics of the registered point cloud shows that:

- There is a low correlation between the number of iterations of the registration and the RMS error (correlation coefficient = 0.37)
- There is no or very little correlation between the RMS error and the number of overlapping points (correlation coefficient = 0.37)

4.14. Conclusions

This chapter has shown the methodological outline for transitioning the visualisations into a film. In doing so it has introduced several new sources of data: oral histories and archived data. These were collected and their appropriateness for inclusion in the film was assessed. The chapter introduced and discussed the decision-making process that identified information that would satisfy both the needs of the audience, and the needs of a scientifically rigorous film. From the outset, and running consistently throughout this research, the methods and approaches used have had

to uphold two competing but equally significant roles, that of scientific rigour, and public engagement.

The content of this chapter and the transition from visualisation to film acknowledges the degree to which participant feedback is fundamental to making a successful film. Section 4.8, which discussed the significance of storytelling and narrative, identifies why this form of engagement is so powerful. The film that was produced through this project is probably not the most commonly recognised version of a story – in particular because there is no one protagonist or character running throughout the film, neither does it use a multi-plot script. Instead it takes the fundamental structure and components of a story and applies them to a landscape setting, where the lead protagonist is Cotehele Quay and the plot is flooding.

By using a similar approach to script theory (Schank and Abelson 1977), the raw material collected as contextual data were analysed for relevance to the film and then included or discarded as necessary. The most challenging aspect of bringing the script together was producing the narrative audio to underpin the visual images on screen. The audio narrative was the main body of information included in the film, and contained much of the information regarding the purpose of the film and how it was made. It also included a detailed explanation of the significance of climate change and how global climate change will have an impact on Cotehele Quay (i.e. at a local level). The role of the audio was more than a conduit for information. What was said and the importance of including this information was central to the engagement of the audience with the film. It includes a justification for the methods as well as an explanation of the scenarios chosen.

What this chapter has tried to demonstrate, is that making a film with the potential function of an engagement tool requires a constant and unrelenting process of decision-making. Each and every decision about the content of the film was considered in depth and this had to be fully expressed in the audio narrative in the film, as this level of detail would be an undesirable addition to the visual content of the film. This went beyond what would normally be considered the baseline for most storytelling activity which centres on a plot (or plots) that reach a conclusion. The film that was made during this stage in the research is not a traditional story. It contains multiple media formats, and one simple plot with imagined consequences. However

that is not to say it does not closely align itself with storytelling; it uses many of the same approaches as storytelling, namely a protagonist, plot and narrative. Fundamentally the final cut of the film at this stage matches Polkinghorne's (1988: 36) definition of a story as "a lens through which the [...] independent and disconnected elements of existence are seen as related parts of the whole".

Having addressed the contextual issues that arose in the focus group and working group meetings, the second half of this chapter addressed the technical and visual aesthetics of the model. This process was much less about decision-making and more deterministic in that each of the requests was either possible to accommodate or not. As the research itself needed to justify the engagement agenda by attempting to complete all the suggestions, the chapter included some of the processing stages that were not fully developed or included in the final film. One example of this is the daily tidal cycle at Cotehele. This was calculated and explained, but when it came to applying it to the 3D model, it was not possible. By demonstrating the working process, this explores and achieves two of the broader research aims of this thesis: one, to explore the use of terrestrial laser scanning and multi-scale datasets in the application of an engagement tool and two, to share direction and design with participants of the working and focus groups, to the extents possible given the constraints of the medium¹⁵.

Perhaps what should be drawn out in the conclusion here is that this chapter draws through the concurrent theme from Chapter 3 in that it has identified, and then responded to the challenges presented at the end of the first methodological stage. Chapter 7 of this thesis looks in more detail at the significance of approaching the project from an engagement perspective, but it is easy to identify throughout this chapter, that engagement is not something that can be applied and then ignored when working on more deeply technological functions of the research. The engagement needs to sit alongside the technology and prompt the researcher to ask questions of its relevance and applicability. The addition of new contextual data showed that the technology cannot stand alone when other data is included; there needs to be some way of providing an overarching narrative which shows the flow of connections between the contextual information and the 3D model. The flexibility of

¹⁵ The reasons that every decision needs to be justified is discussed more in Chapter 7 of this thesis

the 3D model is articulated in this chapter, as it is clear that the scenarios depicted directly relate to available contextual information (in the case of the 1866 flood event and the flood event on the 9th September). The 3D model was made responsive to user-driven demands, even if that includes prompting by external influence (such as other forms of data). Having reached a critical point, at which all feedback from the first stage had been addressed, the next step was to share the film with the audiences who contributed to its development and to record how it was received and what conversations it prompted.

Chapter 5

Changing Tides at Cotehele Quay

Objective

To analyse the participatory process and outcomes of engaging with a range of stakeholders in the development of the visualisations / film.

5. Changing Tides at Cotehele Quay

5.1. Introduction

The final of the self-contained study presents the second and final stage of engagement, including an additional outreach and feedback gathering exercise in the form of a public viewing of the film at Cotehele Quay and a post-completion meeting with the Cotehele General Manager.

The preceding chapter culminated with a first iteration of the film 'Changing Tides at Cotehele Quay'. Throughout this chapter the complex relationships between scientific data and the contextual (often cultural) data were examined. The chapter demonstrated how using storyboarding approaches can serve to tie different data together. Whilst the chapter used theoretical and applied evidence to justify storyboarding the film for Cotehele Quay, the final self-contained study examines in more detail how the film was received by various audiences, and the final edits made in response to feedback.

As well as being the final opportunity for suggestions to be collected about improvements to the film and visualisations, the chapter presents how these moments of participation were also an opportunity to explore some as yet unexamined questions, predominantly: how people perceive the threat of sea-level rise in the Tamar Valley, and also how people see the film being applied outside of the research agenda, especially reaching wider audiences.

This chapter draws to a close the participatory processes running throughout the project and introduces the next stages of dissemination (i.e. Ambassador Scheme) beyond the scope of the research timescale.

5.2. Introduction to chapter structure

The third methodological chapter focuses primarily on the second stage of engagement with focus groups, working groups and the public. Following a brief introduction to how each of these meetings were convened and undertaken, (with any changes to the procedures from the first stage explained) the body of this chapter analyses the results of each of these participatory events. The presentation of the results as the core to the chapter may seem somewhat unusual, but

presenting the results at the mid-point allows remaining sections to demonstrate how the development of the film reached its conclusion.

After presentation of the results of the meetings, the remaining sections show how the suggested amendments were fed back into the final development of the film, including an assessment of the major changes to some of the components of the storyboard, namely the audio narrative and explanation of the key concepts of laser scanning and sea-level rise.

Finally, section 5.18 of this chapter presents the results of an interview with Toby Fox, General Manager for Cotehele Quay. The interview was undertaken after the completion of the project research, and once the training for an Ambassador Scheme had been completed. The interview centres on a critical reflection about how the project fitted with the NT's own objectives, as well as any particular project successes and potential improvements to take into account in future collaborative research. The final stages of this research is summarised in Figure 45.

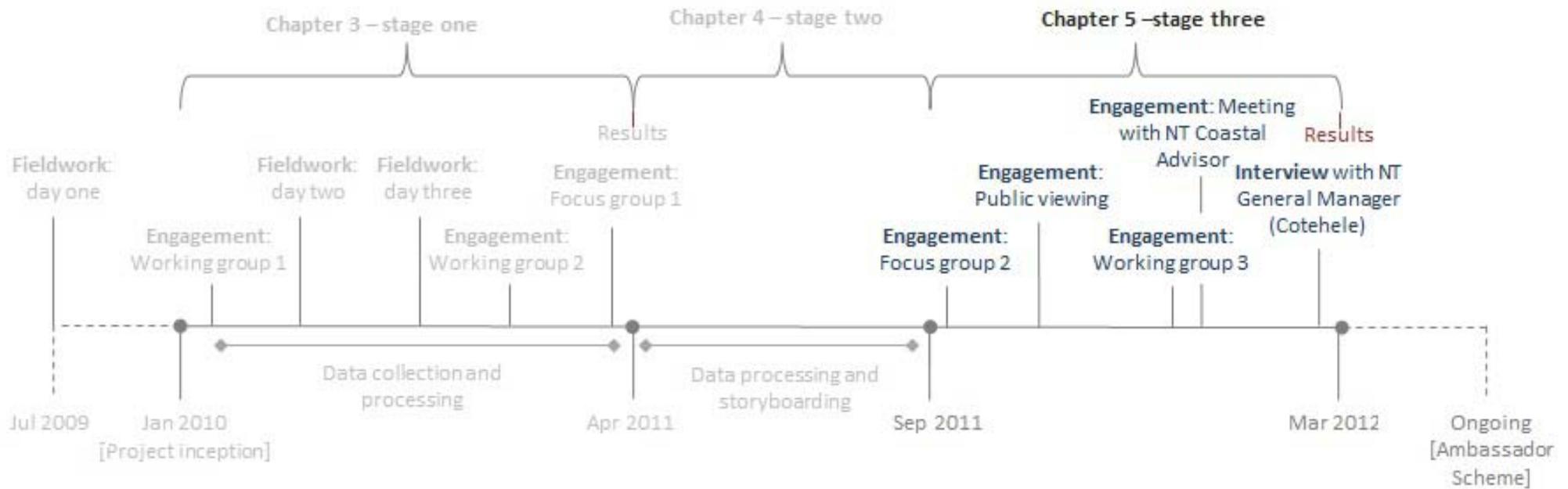


Figure 44 Diagram showing the structure of the methodological chapters

5.3. Focus Groups

An important consideration for the iterative, participatory process was to involve the same participants who had been involved at the first meeting in the second stage focus groups. All of the same participants were contacted and the second round of focus groups took place at Cotehele Quay on September 6th 2011.

Unlike the first meeting, the second round of meetings was less centred on collecting feedback on the model, instead it was interested in soliciting more open responses from the participants. Participation in the second NT focus group was open to any interested staff and volunteers: particularly those who had lived on the quay or worked there regularly. This approach meant that both managers at Cotehele and volunteers could contribute simultaneously to conversations about flooding at the site. This approach allowed the managers at Cotehele to learn more about how people experience flooding on an everyday level. Mixing the staff and the volunteers was not seen to be detrimental to the data gathering as there was familiarity amongst participants. This time, the groups were not divided between NT staff and volunteers, and were instead offered to sign up to a time that suited their schedule. It was anticipated that the NT staff were more likely to accept places at the day time sessions. For the second focus group meetings, both the meetings took place at The Edgcumbe Arms, Cotehele Quay.

Recruitment for the second round of focus groups consisted of contacting all the participants from both the NT and community and business groups and offering them a place. Not all of them were available to attend and if not they were asked to suggest an alternative person to go in their place. In the interim period between focus group meetings, two people got in touch about the research and showed an interest in attending the next meeting. Clare and Mike both had strong links to Cotehele Quay and a personal interest in sea level rise [Table 34].

Wednesday 6th Sep, 10am-12pm	Affiliation	Wednesday 6th Sep 6pm- 8pm	Affiliation
James Robbins	NT Staff	Beverley Parke	Calstock News
Jamie Laing	NT Staff	Julia Massey	Calstock Parish Council
Mike Bygrave	Ex NT volunteer and local resident	Derek Schofield	SODITT and local landowner
Dorigen Couchman	Local resident	Jane Kiely	NT volunteer and local resident
Pete Bouquet	Ex-Greenpeace member and local resident		
Simon Bates	AONB Cordiale project		
Clare Sanders	Local resident		

Table 34 Participant and affiliation / interest

For the second focus groups meetings, the groups were mixed between NT and staff and local community members. All the NT staff on the quay were encouraged to attend, as were the directors of departments within the larger Cotehele Estate. This had a surprisingly low turnout and it was disappointing that not more NT staff were able, or willing, to attend the meeting.

For the second meeting, there was also a somewhat disappointingly low interest in attending from the NT, reasons and indications for why this may have been will be discussed later in the thesis (see Chapter 6). The General Manager heavily encouraged his team to attend the session, but it failed to entice those who did not work on the quay to attend.

Throughout, there remained a high level of interest from the general public in regards to seeing the progress of the visualisations¹⁶, although the councillors from St Dominic who attend the first meeting did not return; again there are some assumptions about why they did not return and these are discussed further in Chapter 6.

5.4. Structure

The meeting was structured to make the most efficient use of the time and to get the participants thinking critically about the engagement with scientific data. This was done through the use of a short series of questions at the beginning of the meeting.

¹⁶ At this stage, the participants were not aware that the visualisations were now part of a wider story about flooding at Cotehele, in the form of a film.

The second part of the meeting included a viewing of the film in a cinema style setting. The third part of the meeting was centred on a discussion of the film. In the same vein as the first meeting, the second focus group utilised a trained facilitator to conduct the focus groups. The facilitator led the discussion, initially through a series of questions regarding the film, followed by a more general discussion about the participants' feelings about sea level rise in the Tamar Valley.

5.5. Pre-tasking exercise

Pre-tasking exercises are sometimes employed in studies using focus groups as a means to critically engage a group before they undertake the actual focus group (Bloor, Frankland et al. 2001). They are employed when the aim of the focus group is to engage the group in a discussion and the task is used as a tool to initiate critical thinking (Ibid.). In order to be effective they have to be carefully constructed to gently introduce the themes and messages of the session, without generating conflict or confusion (Marmion 2012). Pre-tasking exercises have only recently become more commonly used in focus groups and are not seen in traditional sources for outlining the processes for conducting focus groups (Morgan 1993; Kitzinger 1994; Krueger 1994; Morgan 1996). The likelihood of pre-tasking exercises becoming a tool used in every focus group session is unlikely as they can threaten to detract from the core purpose of the session (Marmion 2012). Pre-tasking exercises are designed around the needs of the focus group and therefore there is no precedent for the exact style of the tasks set.

The purpose of this first task was to get the participants thinking more critically about their engagement with scientific information, in particular to encourage the participants to realise that whilst SLR data is freely accessible it is challenging to find data presented in a format that is targeted to their location or their level of expertise. A secondary purpose of the task was for the participants to be more aware of the challenges facing scientists when communicating the data. The participants were not informed of the duality of the objectives of the pre-tasking exercise, but they were told that it was about 'getting them to think about how they engage with scientific data'.

5.6. The Exercise

The exercise involved splitting into two groups and using information and resources provided to answer five short questions; they were allocated 15 minutes to complete the exercise. They were asked to write down the answers and then had to present them to the group. Rather than asking the participants to conduct this task as individuals, they were asked to complete it in small groups, meaning that no one person was responsible for the answers they gave, right or wrong. The questions were derived from data that would later be shown in the film, but participants were not aware of this when carrying out the task.

The activity involved a task using several reports which included data about sea-level rise. The reports included the IPCC Working Group I report, the UKCP 09 sea-level rise projections for Cotehele Quay and an article about the Tamar River in New Zealand, as a red herring. From these reports the groups were required to answer set questions about the rate of past sea-level rise and projections for the future. Using this method is a similar approach to that of Lonsdale et al., (2008) who used role-playing to engage their participants; in this case the participants were the researchers. It was unimportant as to whether they answered correctly but the goal of the task was to initiate a thought process about how they receive information.

5.7. Data Collection

Data collection mirrored the first stage of focus groups, as participants were asked to complete individual feedback sheets immediately after viewing the film. These response sheets were collected and analysed. Compared to the first meeting, which was deliberately targeted to generate specific audience feedback about the visualisations, the second half of the meeting (the 'discussion session') was primarily aimed at generating discussion about flooding in the Tamar Valley without a focus on Cotehele Quay. For this reason, separating the focus groups into breakout groups to produce a sheet representing their collective recommendations would not have elicited the detailed response that was required at this stage in the research. Instead, the focus groups were engaged in group discussions, led by a facilitator [full transcription in Appendix 11 & 12]. The facilitator led with open ended rhetorical questions. This approach helps the researcher to see process and variation in the

analysis, which can lead to making connections among concepts (Strauss and Corbin 1998).

5.8. Data Analysis

Data collection at the second meeting included digital audio files of the discussion. There are multiple methods for analysing qualitative data of this kind: content analysis, thematic analysis and discourse analysis (Wetherell 1998; Willig 2001). Each approach provides a unique way to interpret and make sense of the data. Transcribed focus group discussions were analysed using thematic analysis to identify the key themes from the discussion relating to participants' opinions on the film, their interpretation of the data and their thoughts, feelings and experiences of flood events. Using a thematic analysis allows the researcher to deconstruct the text into emergent themes and then re-contextualise this information (Attride-Stirling 2001; Forbat, Cayless et al. 2009). It was a useful method for the initial analysis of the data for this research because the results of this analysis had separate functions. The discussion between focus group participants not only fed into the research questions as a whole, but specific comments about the digital story needed to be addressed as a functional critique of the film before the final edit.

During the first reading of the transcripts, an inductive approach allowed the researcher to identify and note the major themes that were embedded in the data. A second reading allows micro analysis of the data and produced a coding structure using symbols and categorisation.

5.9. Public Viewing

In early meetings with the NT [see section 3.7], there was an interest expressed in showing the visualisations (at this early stage they were visualisations rather than a film) to the public in the Discovery Centre on Cotehele Quay. Considering that at this stage the final cut of the film had not been made and there was one more round of anticipated amendments and modifications to the film, it was decided to show the film to the public at Cotehele Quay in an environment where feedback could be gathered. Although the NT did not want to be seen to have controlled the direction and content of the film, one of the aims of the research was that it would initiate

conversations about change at the quay, and one of the most effective ways to do this was to take it to the public.

Posters advertising the day of the public viewing were posted in local stores and at notice boards at the Cotehele Estate. A short survey was prepared to capture peoples' thoughts about the film after viewing it. There was no expectation that anyone attending the public viewing would have knowledge about either flooding in general or experience of flooding at Cotehele Quay.

5.9.1. Setting and data collection

The projector was set up at the rear of the museum, in an unobtrusive space that would not intimidate or hinder the public from moving through the museum [Figure 46]. It was put on repeat, so members of the public were free to sit and watch the film if they chose to. There was no obligation to stay and watch the film and no incentives were used. There was no selection process for who could view the film; anyone passing through the Discovery Centre was welcome to stop and watch the film.



Figure 45 Public viewing in the Discovery Centre [credit: Caitlin DeSilvey]

Once the film was finished, the audiences were asked to fill in a short survey about the film [attached in Appendix 13]. This survey tested their opinions of the film and how much they trusted the science that was presented to them. Showing the film at Cotehele Quay meant that the film could explore questions of interest for both the researchers and the NT.

5.10. Working Group Three and Meeting with the NT Coastal Advisor

The final working group meetings took place in early December 2011. Over the course of the project (3yrs), members of the working group had changed and only two of the original members of the group remained (not including members from the NT). The WG meeting took place in the Edgcumbe Arms at Cotehele Quay and lasted an hour and a half. The aims of the meeting were: to gather feedback about the film and discuss the next stages of the film, including the ambassador scheme and future ideas for the film.

Another meeting, this time with the Coastal Advisor for the NT and experts from the UoE, took place on the 11th December. Attending the meeting were: Phil Dyke (Coastal Advisor, NT), Chris Caseldine (UoE), Caitlin DeSilvey (UoE) and Karen Anderson (UoE). The agenda for this meeting was the same as the WG meeting held a few days previously.

5.11. Overview of outcomes: engagement stage 2

For the second round of engagement, the manner of and objectives for engaging with each of the groups varied. Each of the engaged groups (focus groups, public view audiences, working groups) were asked for feedback on the film and content, but they also had their own distinct role in the engagement process as a whole. The focus groups were engaged in a more wide reaching discussion about change at Cotehele Quay. The facilitator led the discussion with prepared questions, but they were allowed to deviate away from the film. The public viewing was an opportunity for the film to be shown to the public and to get their responses to the film. The response sheets distributed at the public viewing deliberately focused on capturing some of the bigger themes of the research, such as how they, as an audience, perceived realism and how much they trusted the science in the film. In regards to the research as a whole it was important to capture and analyse responses to similar questions asked to those at the focus groups – where the participants had had a much more sustained and involved engagement with the film. The analysis and discussion of these responses is explored more fully in Chapter 6. Finally, the working group meetings were an opportunity to capture some of the possible applications of the film that would lead to it being used more widely than at Cotehele Quay. This would also lead to the scope of the research being extended.

5.12. Focus Groups

The second focus groups were an opportunity to engage the same participants in another meeting about sea level rise at Cotehele Quay. The repeat engagement of the same participants was a critical part of the research agenda and every effort was made to encourage participants to return a second time. All of the same participants from the first meeting were contacted; however not all were interested in participating

and some were not contactable. Four new participants joined the research at this stage of the project having heard about the research via word of mouth.

Some general observations on the second focus groups were that there were distinct differences between the morning and evening groups. The evening meeting was much less formal than the morning meeting. This group was smaller than anticipated, with only four participants (one participant sent her apologies), and they all knew each other. Due to the small group size, and the provision of an evening meal, there was less formal structure to the arrival of the group. The earlier meeting was attended by some local residents, but also the NT staff and a member of the local AONB office possibly placing a more formal emphasis on the meeting [Table 34 p212].

As Table 34 shows, the morning group included several participants who were likely to be much more informed about climate change and sea-level rise; this may have had an impact on the discussion that took place after viewing the film. It was clear to everyone at the earlier meeting that they were well informed about these issues. One participant commented “I felt comfortable because you presented the range of possibilities, and extreme possibilities and least worse. I know that there is the range that is given by the climate projections and you were playing that back to us” (SB, Cotehele Quay, 06/09/11)

It would be interesting to know how the honesty and openness of the afternoon session would have been affected had they been mixed with participants of the morning group. The afternoon participants openly diverted to much more wide ranging issues other than sea level rise at Cotehele Quay. These issues included their consciousness of wider pro-environmental behaviour. One person said “Well I do my bit, recycling, you’re conscious about things [...]” (JM, Cotehele Quay, 06/09/11).

Regardless of the perceived levels of knowledge about climate change and sea level rise, all of the participants had expressed an interest in the future of Cotehele Quay and therefore all their contributions were valid, irrespective of if they were well informed. The following sections are an analysis of the results of the discussion session held after the participants watched the film. Thematic analysis was used to

investigate the transcribed recordings of the discussions, whilst the individual feedback sheets were analysed as separate documents.

5.12.1. Individual feedback sheets

As in the first round of focus groups, the results of the individual feedback sheets are presented as separate from the wider discussion. Responses to the film overall were very positive, but unlike the numerous suggestion for improvements to the model in the first meeting, the results from the second meetings showed homogeneity across themes [example individual feedback sheet in Appendix 10].

In comparison with the first meetings, participants had much less to contribute regarding suggestions for improving the realism of the model. The facilitator of the meeting deliberately did not define how realism should be interpreted. Only one comment (from a NT staff member) suggested the addition of trees to make the visualisation more real. Other comments included to 'stop the flickering', show the measurements on the buildings and to zoom in on the building to see where the flooding reached. The participants had clear opinions on the presentation of science in the film. Comments such as "[The] film has an appropriate balance, not too complicated for the lay person" addressed the balance between climate science and historic data. Other participants commented that the projections shown "rationally presents a set of data and sensibly doesn't dwell on the different models available or the vagaries of projections" (CS, 06/09/13, Cotehele Quay).

All of the participants who had attended the first meeting felt that their concerns had been addressed, even though some participants couldn't remember what suggestions they had made. The addition of contextual data prompted some participants to justify their trust in the film and the visualisations, for example "The balance between historical fact, transitioning to recent history and this into a projection leads the mind from fact to the future in a believable way" (CS, 06/09/13, Cotehele Quay). When asked if she trusted the information, one participant responded with "Yes, as it was backed by scientific info and personal recall from local residents, I liked the inclusion of this" (BP, 06/11/13, Cotehele Quay).

All participants expressed that they would feel comfortable engaging in a conversation about change at an event specifically focused on the issues presented

in the film, although some participants were uncertain about their ability to do so effectively (“I’d give it a go!” JR, Cotehele Quay, 06/09/11). One participant highlighted that their ability to engage in conversation about flooding at Cotehele Quay was enhanced by what he had learnt at the first focus group meeting. What presented itself as the most contentious issue was the fact that the film failed to offer any solutions to the flooding nor did it explicitly state what the impacts of flooding would be and on which buildings.

This was always a deliberate move when deciding on the focus and message of the film (by both the NT and the researcher). And even though this was highlighted as something the participants would have liked to see expanded, the discussion session of the meeting allowed them the space to consider the impacts and draw their own interpretations of the consequences.

5.12.2. Group discussions

The first theme that was apparent across both focus group discussions, was of a concern about the future of flooding and what protection was in place to stop more damage to the site occurring. There was a degree of confusion about which defences along the river were recent and which had been in place for many years. Participants seemed to be more inclined to support the removal of flood defences (and therefore allow flood-prone areas to flood naturally) if there was an historic precedent to this occurring. One participant commented“... opposite Calstock, there’s a bank, all the way down around the sharp corner in the river, did they leave those places to flood before or did they just accept they were going to flood?” (PB, 06/09/11, Cotehele Quay).

The participants launched into a convoluted and complicated discussion about when exactly the flood banks were installed and it was obvious that there was no definitive answer to this question. One participant raised the issue of the consequence of flood banks going up and how this can affect other sites along the river, stating, “I’m interested in the fact that people need to consider the consequences of their actions, so when you were talking about the flood defences going up that just channels the water into different places, and therefore it increased the flooding in different areas” (CS, 06/09/11, Cotehele Quay). Ultimately, both groups were resigned to the fact

that large scale, intrusive flood protection would be detrimental to the aesthetics of the Valley and furthermore it ultimately wouldn't stop 'nature' from taking its course.

JM: *"I think there's a limit, it's not a local thing, it's not a national thing, it's a global thing"*

BP: *"you can't stop nature"*

JM: *"no you can't"*

What the focus groups displayed, was an understanding that flood defences may not be the solution to rising sea levels affecting the quay, particularly as they could be intrusive in the landscape and had the potential to exacerbate flooding at other sites. Considering that the group were able to openly discuss the impact and future of flooding at the quay, there was no negativity regarding the content of the film. Instead participants were fascinated at the historic content and praised the progress that the research had made, one participant commented that he felt pleased "as I think this is a very challenging piece of work technically, socially and I was thinking that was a good job" (SB, 06/09/11, Cotehele Quay).

As an outcome of the longitudinal engagement approach, several participants expressed pride in what had been achieved in regards to improving the visualisations and the content. All the participants who had attended one of the first meetings commented that the film was a vast improvement on the visualisations in the first stage: "Talking of the visual, which I thought were extremely good and hugely improved, I thought the water was beautiful" (BP, 06/09/11, Cotehele Quay). Another noted "... the end feeling at the end was well done really, because by comparison to the last time it's a great improvement" (DS, 06/09/11, Cotehele Quay).

It was expected that the participants would find the composition of historic data with future scenarios much easier to engage with and understand and this was expressed by the participants. One suggested that she felt it easier to understand than previously, "a lot easier which I was pleased for you, you know I understood it a little bit more, or at least think I did. There was more interest in it than last time, I really didn't know what it was about last time. You've improved it tremendously [...]" (JM, 06/09/11, Cotehele Quay).

Very much at the forefront of interest, the historic content was seemingly the most intriguing part of the film. But beyond the content, the participants complimented the 'balance' of the film; how the film managed to balance the technical and scientific detail with the social history perspective. One of the participants who represented the AONB noted that "[...] it's challenging to get the balance right, the right amount of information, in plain English, it's a real challenge, it is difficult to do." (SB, 06/09/11, Cotehele Quay). With another participant commenting that "it was an inspired idea to include personal testaments and local knowledge, because in with the technical data it was a nice balance [...]. The vocabulary of the people and the quotes that you used were really excellent" (BP, 06/09/11, Cotehele Quay).

Although the balance of information was praised, this led to the audience asking for more time to take all the information in. There was a consensus amongst all groups that the text and images were not on screen long enough, and that the salient moments (particularly the historic photography and interview transcripts) were deserving of more attention. This reflects that rather than needing to simplify the data further, there was instead a need to allow people the time to reflect on and absorb the information presented to them. Two participants joked that this may have had more to do with age than anything else, and although these comments were light-hearted, they indicate to a potentially more challenging task in engagement – reaching different demographic groups. Some of the participants commented on their age as a factor which prohibited them from following the film as it was presented to them, with one suggesting that as the researcher was younger they had the ability to 'take things in'. Another commented "Yes perhaps there was too much information in a short time, for our poor little brains to cope" (JK, 06/09/11, Cotehele Quay).

The participants demonstrated a willingness to engage in with the scientific data but expressed that this was somewhat challenging considering their existing emotional ties to the river and their own experiences of flooding. One of the members of the former campaign group SODITT noted "we're too close to take in the scientific bit" (DS, 06/09/11, Cotehele Quay).

Even though the participants conceded that they had noticed a change in sea levels over the past 20 years or so, they struggled to apply the sea level rise to their everyday experiences, exclaiming that "perhaps someone who wasn't so familiar to

the area would be more objective about the scientific bits than we were” (JM, 06/09/11, Cotehele Quay)

As the conversation progressed it became clear that their difficulty to attribute the scientific projections to their everyday lives was in part a reflection of a changing threat: “... I was well aware of SLR, we’ve lived by the sea for 21 years, closer to the sea than I am now, on the river, we were always concerned about the breach now we’re concerned about our reed bed” (DS, 06/09/11, Cotehele Quay).

Through the transition of the visualisations to a film, one of the most obvious impacts was a new connection between the audiences and the film, leading on to an interpretation of the film that was based on their own personal experiences. This new connection with the content of the film actually overshadowed some of the climate change issues that were portrayed in the film. Several participants reported that they enjoyed seeing the historic imagery more than anything else with on commenting “I thought it was a good film, but I was more interested in the point of view of it’s my area and seeing places familiar to me than I was about the rivers rising” (JM, 06/09/11, Cotehele Quay).

One of the participants commented that if she were to have seen it playing in the Discovery Centre she would have stayed to watch it all the way through as it captures interest. It was clear that the historic imagery encouraged the audience to think about water levels in a different way. They were prompted to realise that past flooding had had a great impact on the landscape and buildings and that it could have been more extensive in the past than they realised. The demonstrable relationship between the participants and the film encouraged and provoked participants into sharing experiences of flooding:

JM: “It would have been pre the flood bank. I can remember going down in the train and looking across the football pitch, I can remember that used to flood quite regularly”

JM: “I think the Tamar Inn has been flooded”

JK: “well we’ve had to take all the reeds that come over with it and go all over the roads”

JL: *"I think there have been 3 breaches of the levee in my time down here"*

The nostalgia that the participants shared did not contain fear or concern; rather their experiences of flooding events were filled with anecdotes of amusing activities that took place during flood events. One participant recollected an event in 2008, noting "when the car park and field flooded, and we walked along the levee and you couldn't tell which bit was ... and that time when we gathered down here for the highest tide of the whole spring series and people were rowing between what is now the kiosk and the discovery centre, you could get in a boat and row down there" (JR, 06/09/11, Cotehele Quay). Another contributed a story she had heard about an event in the 1970s when "the whole of town farm flooded, which is the area from the village hall all the way up around those big flat fields. That was flooded, because that's when my house flooded. I know the people who lived there and they got canoes out and were boating around" (DG, Cotehele Quay, 06/09/11).

Aside from the content of the film, the participants were asked how they felt about their involvement in the development of the film. As was noted previously, feedback was extremely positive, and this ran alongside a sense of achievement that included their perception of the project overall. Several participants expressed pride in being able to take part in the research and expressed appreciation that their suggestions from the first meeting had been acted on. In particular there was a general consensus among both groups that the inclusion of their opinions about what should be included was something they wouldn't normally experience and this made a big difference to how they received the information about flooding. One of the NT volunteers felt it was wise to get their opinion as it "would have been very easy to have just ignored anybody who lived round here and just carried on with it as so many people do" (JK, 06/09/11, Cotehele Quay).

The trust that the participants had in the film because of their involvement in the decision-making, meant that they had no concerns suggesting groups and organisations who may have been interested in watching the film. This ranged from local riverside landowners to Plymouth Boats, but with particular emphasis on the villagers of Calstock, with one participant suggesting the villagers of Calstock, "I think the village hall community should have a viewing cos the village hall in Calstock is very low along with the Tamar, they're the two buildings that would be able to float

away, knowing their foundations aren't terribly sound.” (BP, Cotehele Quay, 06/09/11).

As anticipated, during the discussion session the participants discussed other issues surrounding the issue of climate change and flooding at Cotehele. What was raised was an insight to the themes and issues people associate with climate change and the broader implications of engaging people on these issues. At the start of the session the conversation centred on a concern for others, with comments like “...but your house would have been under I imagine? Have you got steps going up to it?” (BP, 06/09/11, Cotehele Quay), however by the end of the session this became much more about regional issues to do with climate change and adaptation, demonstrated by one participant’s observation about how much coastline Cornwall has.

It was discussed that generally there was little the Council could do to alleviate flooding and some degree of disagreement about who was responsible for flood protection and even if this was necessary. This caused tension among the group as it was suggested that the parish council (who had a representative at the meeting) should be seen to be taking a more public facing approach to communicating the impacts of future sea level rise. Even with the uncertainty concerning the future impact the group felt that it was still important to communicate ‘what is happening’ as widely as possible; more importantly the group demonstrated an understanding of the needs of simple communication tools to start conversations about change with one participant (an ex member of Greenpeace) commenting “unless you make a film about all the different data on climate change. You’ve got to start somewhere” (PB, 06/09/11, Cotehele Quay).

5.13. Public Viewing

In total, 24 response sheets were collected from viewers of the film with 29 respondents (some people collated their responses on to the same forms) [results from the survey in Appendix 14]. This includes people from across the UK [Figure 47] and also tourists from America and Australia. One woman who came on the day had seen a poster in a St Dominick shop; she was surprised that the film hadn’t generated more interest from local people. She was curious to see how the area would be affected and didn’t feel at present she was well informed on the possible

impacts of sea level rise. Apart from two people, everyone who watched the film had no knowledge that it was being shown on the day and were visiting Cotehele from outside the local area. They were happy and willing to contribute to a study and seemingly willing to learn more about the place they were visiting. One person explained that they had visited the site several years ago and was returning for the first time, she said it was interesting to see what would be happening in the future but did express concern about the future of the site.



Figure 46 Distribution of respondents to public viewing survey

There was a largely positive reaction to the film with 100% of the audience reporting that they enjoyed watching the film. Of the 23 response sheets collected, 88% reported trusting the scientific information that was shown to them whilst the remaining 11% (2 persons) were unsure if they trusted the information or not **Table 35**. The participants who reported being unsure about whether they trusted the information or not did not expand on their answers further, although one had added in response to this “mention of where the data / info comes from gives validation” (Participant, 01/10/11, Cotehele Quay).

	Yes	Don't know	No	Base respondent
Enjoyed watching the film	100%			23
Trusted the information presented in the film	83%	17%		23
Improved understanding of impacts of SLR at Cotehele Quay	88%	2%		18
Felt comfortable to engage in conversation	78%	17%	6%	18

Table 35 Summary of results from public viewing

The results demonstrate a degree of uncertainty about how comfortable they feel engaging in conversation about sea-level rise at Cotehele. It is further interesting to see that few people expanded on the question when prompted. The open answer questions showed some difference between UK based, and international audiences in regards to their perceptions of the film. International audiences seemed to be more alarmed by the film than UK based viewers, commenting “Disturbing – what needs to be done?” and “Good but worrisome” (Participants, 01/10/11, Cotehele Quay).

Whereas the UK based audience comments on the general content of the film indicated they found the film interesting and informative, for example “interesting, scary about the pictures of the area” and “very informative - makes you think about the consequences of climate change” (Participants, 01/10/11, Cotehele Quay). Amongst the participants there was a general feeling of frustration that climate change was not a high enough environmental priority, one participant commented “this has been well known for a good while, but not necessarily believed – unfortunately” (Participant, 01/10/11, Cotehele Quay).

When asked to give their thoughts on the general content of the film, the audience felt that the visualisations were realistic and well researched, although they only offered brief insights into how much they trusted the film, two participants commented “Appears well researched” and “I imagine they are accurate” (Participants, 01/10/11, Cotehele Quay).

One person self-validated the projections against their own knowledge and understanding of past flooding by commenting “Accurate history and reasonable projections”, whilst another viewer commented on the inclusion of data to validate the projections shown. Other participants were inclined to expand on their own

thoughts and feelings about climate change, with several participants remarking proactively about how to respond to climate change. One local resident who viewed the film remarked: "The flooding is going to increase and we need to adapt to nature and if we want to be close to and use the river positive action is needed to preserve what we can" (Participant, 01/10/11, Cotehele Quay). Amongst those who viewed the film, there was some acknowledgement about the fact that the climate is changing and a feeling that it should be more widely accepted. Upon watching the film, one participant from the USA commented "Why don't some people accept the fact that there is global warming? Unbelievable" (Participant, 01/10/11, Cotehele Quay).

Two of the international viewers felt slightly confused by the science behind the visualisations, with one commenting that it may be slightly difficult to understand for 'Mr Average' and another respondent from Australia stating "I would need more time and data to get a confident feeling" (Participant, 01/10/11, Cotehele Quay)

Conducting a cross reference analysis of responses, a correlation emerges between those with personal experience of a flooding event and their responses to the film (something similarly experienced by Whitmarsh 2011). Those who have personal experience of flooding had answered questions on the survey more fully than those without any personal experience of a flooding event. In particular, they were more likely to provide some form of critical comment on the film compared to people without personal experience of flooding [Table 36].

Experience of flooding	Thoughts on content	Thoughts on science
“High spring tides at home and tidal stitches”	“Very educational / quite alarming”	“Perhaps a little complicated for Mr Average”
“Higher spring tides and flooding local to me”	“Interesting – some images went by too quickly”	“This has been known for a good while, but not believed – unfortunately”
“Recently in September, the water was over the road. Shamrock appeared to be more in the River not in the dock. Next morning, thick mud over banks and road”	“Was ok, but a bit skimpy. Would like to see more detail and less data perhaps. But overall informative to me”	“The flooding is going to increase and we need to adapt to nature and if we want to be close to and use the river positive action is needed to preserve what we can”
“4.8m tide and various recent events”	“Good - could show a more recent event than 1866”	“Accurate history and reasonable projections”
“The surprise at high tides when they happen - as days like today make it something not considered will happen”	“It did what it was supposed to. It got people talking”	“Good - most people realise the future will bring a change to the climate, but have to get 'material' response till it happens”

Table 36 Responses from those with experience of flood events and comments on the film

Those without personal experience of flooding events were less able to articulate critically how they interpreted the science that was demonstrated in the film [Table 37], although there was support and trust in what was portrayed as demonstrated by the high response rate to this question on the survey [Table 35].

Experience of flooding	Thoughts on content	Thoughts on science
None	“Very informative - makes you think about the consequences of climate change”	“Excellent”
None	“Very thought-provoking and well presented”	“Appears well researched”
None	“Very interesting”	“Speculative”
None	“Very interesting”	“Feasible”

Table 37 Responses from people without personal experience of flooding and thoughts on the content of the film

These results suggest, but are not conclusive due to the small sample size, that people who have experienced a similar event in their lifetime as able to more engage more fully with the scientific detail of the film, the impact of this is discussed in more detail in Chapter 7.

Feedback from Toby Fox (General Manager) and Joe Lawrence (Head Warden) at this stage was limited [see section 5.18 for more complete feedback on their thoughts] but both expressed surprise about how far the film had progressed from the first iteration of the visualisations. The content of the film had changed dramatically from what had been expressed in early meetings with the NT and Toby explained that he understood that it was difficult to meet the expectations of his requirements and that it was useful for him to see the answers from the public about what is happening at Cotehele Quay.

5.14. Working group meeting three and meeting with NT Coastal Advisor

The working group participants (including the NT Coastal Advisor meeting group) were asked for their feedback on the film at a separate event on 11th Dec 2011. Many of their suggestions for improvement corroborated what had already been gleaned from the focus group participants. In particular:

- Slow down the historic imagery so people had time to take it in
- Highlight the interesting paragraphs from the other historic data
- Modelling a 5.1m tide height to provide a more realistic comparison to the event captured in the photograph

Overall there was praise for the film, in particular for the approach that it took in regards to showing both local and global climate change. One participant commented on the comparison between local and global climate change, stating “I liked that you were able to zoom out to the global stuff and then the text and the narrative brought it neatly back in to Cotehele” (PD, 11/12/11, Penryn).

As the participants of the working group meetings had more scientific knowledge than the focus groups, they were able to give more targeted feedback in regards to the scientific data and in particular the sea-level rise projections shown in the model. One participant felt that the visualisations should focus on *either* average high tide events *or* extreme events but not both as this may be confusing to the audience.

Another issue that was discussed at the meetings was which tide gauge to use to show the rise in sea levels. The participants at the first working group meeting

expressed concern that the tide gauge nearest to Cotehele (Devonport) was not being used; arguing that if it was, this would engender trust. When this issue was raised at the second working group meeting with the NT Coastal Advisor, it was expressed that the Newlyn tide record is much more complete than Devonport and as such offers a more comprehensive view of historic sea-level rise than the Devonport tide gauge.

One of the more salient issues was how to engage people with past and future sea-level rise in a way that was neither patronising nor too distant (geographically) and therefore they were not able to connect with it on a local level. There was some division amongst the working group participants regarding the best approach to take. The NT coastal advisor suggested that using examples of submerged forests and field boundaries around the South West coast could help people to understand that sea-level rise really has been occurring. But another participant felt that this would confuse participants and cause them to question when there is concern about future sea levels if it has risen anyway throughout history.

Much of the discussion for the working group participants was centred on what the film would be used for outside of the research and how this would be organised. Many of the ideas for the ambassador scheme [section5.17] originated from the third working group meetings. To note here:

- A 'Things to Think About' sheet
- Q&A for NT staff and volunteers who are showing the film
- Online resources e.g. Facebook group
- A local 'keeper' of the film, or lead ambassador

One participant expressed concern about taking the film much further afield than Cotehele as she did not feel there were the resources or structures in place to "deal with this at other locations" (KC, Cotehele Quay, 01/12/11).

Compared to the focus groups, the working group participants were more interested in using the film to model flooding scenarios that can draw on coastal planning policy. Suggestions were offered in regards to potential collaborators for taking the film forward and other research that could feed in the development of a film which is

more 'planning' orientated (this was a constant theme throughout the engagement with the WG and is therefore discussed more in Chapter 7).

5.15. Summary of final recommendations

Having collated and analysed all of the feedback and discussions for the focus groups and working groups, a summary of final recommendations were drawn together. These were based on the specific, film-focused suggestions rather than the discursive conversations that also took place. Not all the suggestions made from the groups were able to be applied, either because they were conflicting (e.g. Devonport vs. Newlyn for sea level rise) or because the suggestions did not fit within the theme of the film as a whole (e.g. show an image after the final shot of a message from Toby Fox). Taken from the feedback, the final modifications were:

- Slow down all images and text [hold on screen for longer]
- Highlight the text in the interview transcriptions
- Add a link to the NT Cotehele page
- Show a comparison shot of water levels
- Zoom in on a building to show water levels
- Simplify the climate data spoken and shown on screen

The final developmental stage for the film was bringing together the final edits and making the final cut.

5.16. Final cut

The final stage in all the film making and modelling was to respond to the third working group meeting, the public viewing and the second focus groups. Having drawn together all the responses to the film throughout this process, a new storyboard was pulled together bringing together all the feedback to make the final amendments to the film.

While making changes to the content of the film, the audio narrative was also revised. There were two main changes to the audio; primarily to make it clearer to the audience how the data from the 3D model was derived, and secondly to simplify the climate change and sea level rise explanation. Figure 48 shows a comparison between two sections of text from the audio narrative that accompanies the film.

Feedback from the focus groups suggested that some of the technical detail was too complicated. By comparison, people find visual messages easier to understand than verbal ones (Brown 2009). What was realised when revising the audio narrative was that the technical detail of making the model was primarily relevant to those who had been involved in contributing towards the making of the film. Therefore verbally communicating some of the technical detail would be overcomplicating the core message for audiences outside of the research. The message behind the section of text essentially needed to demonstrate the rigour behind the capture and processing of the data and this could be shared in less technical detail than initially anticipated. Often non expert audiences are offered limited technical detail when reviewing scientific data, frequently because they are not seen to have the knowledge or experience to understand complex data. Instead, what this research demonstrates is that the technical detail can be avoided as a simpler explanation would communicate the core message and this would suffice.

“One way of understanding and comparing how past and future flood events affect the site at Cotehele, is to create a virtual model which allows us to reconstruct past water levels and enables us to imagine what projected increases in tidal heights would look like.

The model that you will see in this video sequence has been generated using advanced surveying techniques that allow us to capture the three dimensional nature of the site. The resulting model seeks to find a balance between spatial accuracy and visual realism.

Using laser scanning technology, data have been gathered of the buildings and quayside at Cotehele. This dataset is precise to 5mm, meaning that the relative positions of objects such as windows and doors on the buildings are geometrically correct and appear true to life. When registered to Ordnance Survey mapping co-ordinates, the model is accurate to within 10cm of the actual ground surface position.”

Version One – laser scanning explanation

“To help us understand past and future tidal flooding at Cotehele, we have created the first virtual model of the site. This three dimensional model has been produced using state of the art technology and computer software. In the model, tidal conditions can be adjusted to reflect past, present and future levels. This allows us to visualise what past tidal conditions were like and perhaps more importantly, show projected increases in sea-level to understand the possible impacts of future sea level rise on the quay.

Specialist surveying equipment, including a laser scanning device, was used at the quay to capture data about the height, shape and arrangement of buildings and surrounding terrain. This detailed survey comprises millions of laser scanned data points. We used design software to transform the data points into a three dimensional digital model. This model balances spatial accuracy with a desire for visual realism.”

Version Two – laser scanning explanation

Figure 47 Comparison of laser scanning description. [top] Used in the first version of the film, [bottom] clearer explanation and justification in second version of the film

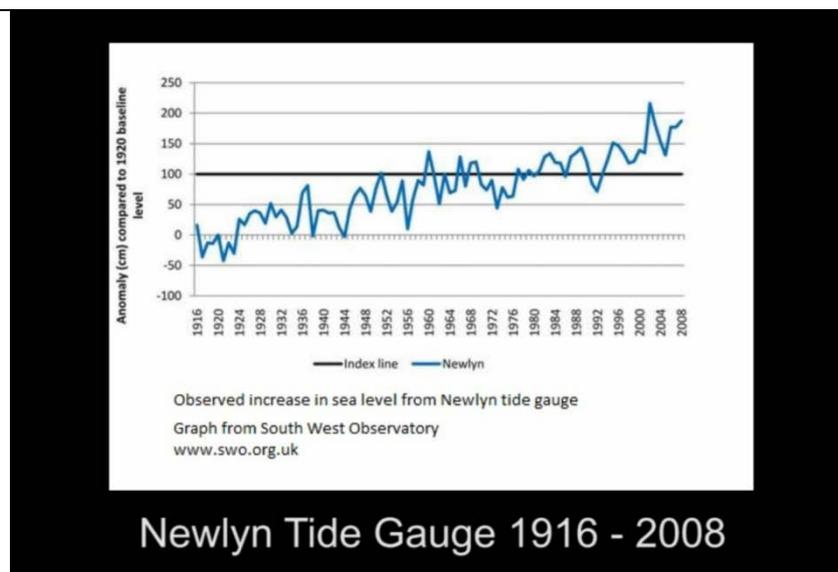
In addition to communicating the complexity of capturing and processing the laser scan data, the second theme of the film, which needed verbal explanation, was that of climate change. Phil Dyke, Coastal Advisor for the NT suggested that a more local interpretation of sea level would help people associate themselves with the changes (although this opinion was contested by the climate scientist at the interim working

group meeting). Added to this, feedback from the third working group meeting was a suggestion that the tide gauge at Devonport was a more appropriate record to use due to its proximity to Cotehele Quay. After some discussion at the additional meeting with Phil Dyke, and a review of the tidal records at Devonport, it was decided to uphold including Newlyn as the depiction of rising sea levels. This had to be justified to the audience and the most effective way of doing this was to explain that this was the nearest long term tide gauge to Cotehele. Devonport’s record began in 1961 whereas Newlyn’s began in 1915 (BODC 2013).

“Records show that globally the sea level has been rising for many years, due to glaciers melting at the end of the late glacial maximum, about 12,000 years ago.

In the south west sea level has been rising by approximately 2mm a year. To add to this background trend, within the last 50 years accelerated glacial melting and thermal expansion of the oceans have begun to increase the rate of sea-level rise.”

Version One – sea level rise explanation



Newlyn Tide Gauge 1916 - 2008

Figure 48 Image that accompanied commentary for version one

“Scientists believe that sea-level rise in the UK has been occurring since glaciers started melting at the end of the last ice age. There is evidence of historic sea-level rise at several coastal sites on the Cornish coastline, including the drowned forest at Marazion and underwater field boundaries on the Scilly Isles.

The nearest long-term tide gauge to Cotehele is at Newlyn, Cornwall. Newlyn’s records show that over the 20th century there has been an average increase in mean sea level of one point seven to two millimetres a year. Over the last 50 years or so the rate of sea-level rise in the South West has increased to approximately three millimetres a year. There is some evidence that this rate is increasing. This increase has been attributed in part to thermal expansion of the oceans, due to higher atmospheric levels of the greenhouse gas, Carbon Dioxide. The 2009 UK Climate Projections Report anticipates that the rate of sea-level rise will continue to accelerate.”

Version Two – sea level rise explanation

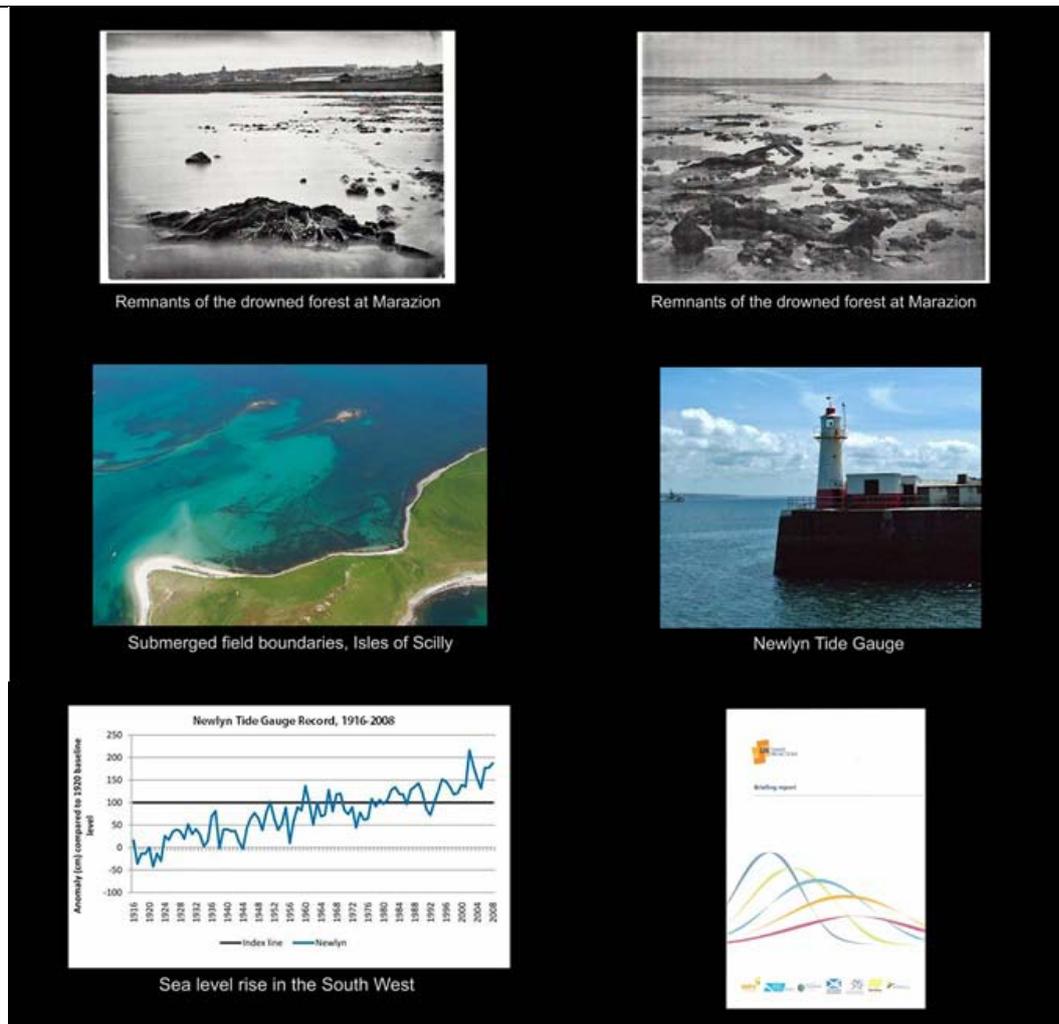


Figure 49 Images used to accompany commentary as shown in version two (starting clockwise from top left)

The final cut of the film was made in Adobe Premier Pro [the full script is in Appendix 15]. The final version can be viewed online at the University of Exeter's YouTube channel (http://www.youtube.com/watch?v=KybyfqV_dgk) and is also provided on a USB in Appendix 16.

5.17. Dissemination: Ambassadorial Scheme

For the NT, one of the desired outcomes of the research project was to gain a tool that they could use to engage with the local community about flooding at Cotehele Quay. To this end, once the film had been completed, an ambassadorial scheme was established which intended on disseminating the film more widely.

The aims of the scheme were to continue the engagement with participants of the focus group, making them ambassadors of the film. As they had provided input into the film, they were able to say with confidence that they understand the process that contributed to making the film and could be advocates for its wider dissemination. All of the focus group participants were invited to a training event that was held at Cotehele Quay. At present, two viewings of Changing Tides have taken place and the NT have the film and will remain promoting it as they continue engaging with the future securing the site from future dissonance.

As part of the Ambassador Scheme, a pack of information is provided to each ambassador containing: a 'Things to Think About' sheet, a FAQs sheet and a sheet with links if audiences are interested in getting more information [see appendices 15-18 for Ambassador Pack].

5.18. Post-project reflection: an interview with the General Manager

Once the fieldwork and engagement had been completed, a final interview was carried out with the NT manager of the Cotehele Estate. This interview was scheduled six months after the initiation of the ambassador training. The interview lasted 45 minutes and took place at Cotehele House.

The initial call for this research came from an identified need by the NT for a tool to initiate conversations about change at Cotehele Quay. Exactly how this was to be completed was left open to interpretation. The rationale behind holding an interview

at the very end of the research was to build a picture of how the NT feel the project went. More specifically, the researcher sought to explore the NT perspective on the engagement process with the local community, thoughts on the realism and representation of Cotehele Quay in the visualisations, the issues that heritage management presents, how the research has helped to address some of these and, finally, what the NT learnt from being involved in the process.

What was made very clear from the interview was that from a NT perspective the research was very successful as a piece of research which offered engagement opportunities with the local community, but also a chance for the NT to reconcile their concerns about the future of the site. Toby Fox, Cotehele General Manager took up his post shortly after the incident with the flooding of the Hay Marsh. He explained that there was a general feeling that people locally had had no control over the whole process and that they did not feel like they were dealing with Cotehele but with the NT. It was very important that this research project was seen as being driven by research aims and with heavy involvement from local audiences. Toby revealed in the interview that he was pleased with the way in which the 'tool' helps open up the debate. "We've got something tangible that is based on proper evidence, proper forecasting on what we think is going to happen over time and historical evidence about what we think has happened as well" [TF, 27/07/12, Cotehele House]

One of his concerns was that even though the NT deliberately wanted to stay at arm's length of the research, at times he felt concerned that as an organisation they weren't providing enough support, leading to feelings that he was just an end user of the film. Irrespective of whether he would have preferred to be more involved in the research, he felt comfortable that both the researcher and the NT staff had the same motives and therefore concerns about the project direction were limited. Had there been more time and resources, Toby would have liked to see other areas included in the visualisations, particularly Halton Quay and Calstock. From his point of view this would have demonstrated to the public that the NT were not only interested in their own properties, although using a heritage site owned by them did mean that they take more risks when looking at sea-level rise.

On reflection, Toby felt that more people should have been alerted to the project taking place, particularly Cornwall Council, but complimented the engagement with parish councils as he stressed that normally they wouldn't get involved in something like this. "I wondered if we should have taken a billing on a parish council meeting to show it, to help them encourage debate." [TF, 27/07/12, Cotehele House]

Toby did recognise that there were limits to the engagement and the number of people who would be interested in the research; he referred to this interest as people's 'appetite' for the topic. But this was countered by a realisation that the number of people involved in the research was actually manageable rather than overwhelming; had many more people been asked to contribute it would have been much more challenging to reach decisions on how the film should look and what content to include. Further, the use of an external facilitator to manage these meetings alleviated concerns from those involved regarding bias.

Toby made some pertinent comments about how people engage with scenarios, commenting that from his experience people often struggle to come up with solutions themselves, but when presented with options will often react negatively. He said that often if people are asked open-ended questions (i.e. 'what do you think?') it is hard to engage the public, whereas scenarios provoke a response. He drew one comparative situation which he felt would have generated more interest in the project: "If we'd done a visualisation that had a 10ft wall around the quay, I guarantee we'd have had a shed load more interest in it" [TF, 27/07/12, Cotehele House]

When asked what parts of the model Toby felt make the visualisations seem real, he commented that it was the mixture between natural and built environment being shown and the context to it that worked. In particular he emphasised that "by the time [the 3D model is] done the detail will be become less relevant. You're more interested in the context" [Toby Fox, 27/07/12, Cotehele House]

He feels that man-made heritage landscapes generate such strong emotional ties because for many people they are unchanging as the natural landscape, emphasising that "people have got so used to [the buildings on the Quay] and they haven't seen it change in their lifetimes and then it could change. It has an inherently

strong impact on them; emotionally that changes things quite radically” [TF, 27/07/12, Cotehele House]

Finally, what rests as the most important issue for the NT, is for the film to demonstrate credibility amongst its audiences. Toby believes that the credibility and thoroughness of the data mean that the same approach could be applied at many sites across the country. It fits the NT strategic approach to managing heritage, and from Toby’s perspective the financial barriers to applying it at other sites are limited. When using a tool that hasn’t been manufactured by the NT, Toby felt that it was important to demonstrate the depth of data that went into it in order to ‘not look stupid’. Toby stressed that “it’s a much more useful tool for us to use with anybody. The good thing is you know that it is based on good information. There’s no way we’d even think about putting it on a screen [in the Discovery Centre] if it had been ‘photoshopped’!” [TF, 27/07/12, Cotehele House]

5.19. Conclusions

This chapter has shown the final engagement stage of the research, including two further mixed focus groups and two working group meetings including an additional meeting with the NT Coastal Advisor. The overall aim of this chapter has been to present the final engagement activities with an analysis of the results of the meetings. As this was the second and final engagement stage¹⁷, the discussions that took place were allowed to take on more discursive style and this was encouraged. The research was interested to see how participants’ views had changed over time and through being part of a longitudinal study.

The first half of this chapter introduced the groups that were engaged: focus groups, working groups and the public. The feedback that was gathered from each group played a slightly different role in its contribution to the on-going research. With the focus groups, along with gathering feedback on final amendments to the film, a discussion session channelled their thoughts about the film to thinking about flooding more widely. What the results of discussion show is that the focus group participants felt more confident and more able to talk about sea level rise having taken part in this research. Further, they engaged in conversations about flooding in the Tamar Valley

¹⁷ Further engagement took place as part of the Ambassador Scheme, but conducting research into the impact of this was not part of this thesis.

and smoothly transitioned to discussing what they could do to mitigate the impacts and what procedures and prevention measures were already in place. Considering the film did not offer the viewers any solutions, the participants were able to recall what flood protection was in place, whilst questioning what should be done in the future. The participants further expressed satisfaction and pride having taken part in the research, complimenting the progress of the research as a whole and the responsiveness of the model and research to accommodate the suggestions from the first meeting. By far the most striking response to the film was the participants' responses to the historic images of flooding at Cotehele Quay. Several of the participants mentioned a desire to see more of the images and commented that it struck them to see the extent of historic events; even though some of them had witnessed similar events in their lifetimes.

For the working groups, they were asked about possible applications for the model as well and how possible structures for the dissemination of the film via the Ambassador Scheme. Pre-tasking exercises have been shown to increase the responsiveness of focus group participants (Bloor, Frankland et al. 2001) and this chapter identified the appropriateness of undertaking a pre-tasking exercise to engage participants in critical thinking about sea level rise communication.

Overall, the General Manager of Cotehele was pleased with the film and how it was used to engage with the local community; particularly praising the engagement with local parish councils who he did not feel would usually get involved in research projects of this kind. He explained that from his point of view, he had confidence in the film to portray the future for Cotehele Quay and this was important as the NT has acted with a deliberately 'hands off' approach. He commented that he struggled to manage the NT engagement with the project simultaneously feeling that the NT should be more involved in the decision-making but knowing that their involvement had the potential to undermine the focus group participants' trust in the process.

Building on the results and conclusions presented in this chapter, the following empirical chapters discuss in more detail the findings from the project as a whole, reflecting on the three core methodological chapters as well as the wider literature to explore the relationships between the technological modelling and the interactions with research participants. In particular the chapter explores the relationship between

spatial accuracy and visual realism and how this affected the participants' relationship with the project. The second thread of the empirical chapter looks at how participatory processes were used to test the appropriateness for terrestrial laser scanning as a technology for creating tools to start conversations about sea level rise at a heritage site. The concluding remarks of the chapter consider how realism, accuracy and participation can be holistically approached to generate meaningful engagement tools.

Chapter 6

Realism, Accuracy and Participatory Processes

Objectives

To determine how realism and accuracy are interpreted in 3D visualisations, and to determine what characteristics and/or processes make the 3D visualisations appear more real.

To define the appropriateness and applicability of terrestrial laser scan data as a tool for communicating sea-level rise at a heritage site.

To contribute to knowledge and working practice of current engagement strategies with specific focus on iterative engagement and 3D visualisations.

6. Realism, accuracy and participatory process

6.1. Introduction

Whilst constructing and sharing the film 'Changing Tides at Cotehele Quay', several key themes arose. Background questions regarding accuracy and realism remained central to the engagement process, and significantly influenced the design and production of the film. But throughout the research other themes emerged which became intermixed with questions of accuracy and realism. From the outset this research was not intended to be about participation and engagement, rather it was framed as an exploratory piece of research which set out to use spatial technologies as a tool for further research. However, using spatial technologies simultaneously allowed the opportunity to explore how participatory processes can affect the development of a 3D visualisation tool.

During the period of this research, there have been some great shifts in how the research has interpreted, and how the public and stakeholders have responded, in regards to perceptions of realism and accuracy. But to separate the participatory processes of involving various stakeholders in contributing to and deciding on key features of the 3D visualisations from the themes of accuracy and realism of the spatial data, only serves to encourage a widening gap between the technological and cultural dimensions of 3D visualisation and engagement. What this chapter does is to merge two concepts that have seemingly not yet been viewed as mutually inclusive in the wider literature, but as is demonstrated throughout this research, are seemingly so. This chapter demonstrates new ways of thinking about how these themes are available to offer insight into developing more robust ways of integrating spatial data into 3D visualisations and also how involving people in the development of these 3D tools can serve to be an effective method for climate change engagement that goes beyond an existing discourse of climate change communication for affecting behavioural change.

The first half of this chapter addresses realism and accuracy as two themes which have been conflicting throughout the project. To articulate how these two themes came to be conflicting requires an epistemological understanding of visual realism and how this idea has been interpreted and re-interpreted through a succession of

developmental improvements in computer graphics. One of the arguments of this chapter is that as visual realism has developed as a technological pursuit, data accuracy (in a scientific sense) has been pushed to the side in favour of enhancing realism. The beginning of this chapter argues that there is no one definition of realism, instead realism is perceived, understood and experienced depending on the context in which it is encountered. Where computer scientists and digital designers have tried to carve a path for realism, which sits outside of the traditional artistic understandings, they have used the technical characteristics of the modelling environment to do so, unwittingly ignoring the cultural dimensions of their own personal interpretations of realism, and the cultural context in which the visual images will be received. This chapter takes a targeted look at the role of TLS in contributing to the development of a 3D model and how the data from TLS feeds in to the over-arching debate on accuracy and realism.

The second half of this chapter builds a picture about how participatory processes changed how people engaged with the visual media and engaged with the issues explored in the visualisations. The participatory processes undertaken took place over the course of a year and three different demographic groups fed in to the research: industry professionals, the NT staff and volunteers and the local community. The moments they were engaged was largely determined by the development schedule for the 3D model. What the second half of this chapter does is to expand on the issues of realism and accuracy and identify how and why the participants engaged in the way they did with the visualisations and, ultimately, the film and what means for the use of spatial data for 3D landscape visualisation.

6.2. Introduction to realism

Building on the work of Smallman & John (2005), the following sections examine the notion of naïve realism; in other words a “misplaced faith in realistic displays”. However the focus here is specifically on how audiences and viewers discern accuracy and realism and perceptions of both (rather than looking at a wider spectrum of characteristics). The accuracy of the TLS data is a central theme throughout this research, but what the preceding chapters have shown is that as other data have been introduced, continuing to monitor the accuracy becomes a. more challenging and b. less important to audiences. One of the challenges that

visualisations face is that many of the qualities of the data, such as accuracy can be perceived in the same manner as the visually aesthetic qualities like realism. Unlike realism, which is experienced, perceived and understood based on the receivers understanding, knowledge and preferences, accuracy is distinguished as a characteristic that is attributed the moment that data are collected. Therefore, in theory, accuracy should not be something which is susceptible to perception; it is an intrinsic quality of the data and should be explicitly stated (where possible) alongside the visualisation. Unfortunately increasing interest in 3D landscape visualisation suggests that realism and accuracy are increasingly being conflated (Lewis, Casello et al. 2012). The lack of subjectivity with the attribution of accuracy figures to the dataset is what underpins the confusion with realism, simultaneously making it more important to distinguish between the two terms for audiences. Literature on the separate themes of accuracy and realism suggest that the conflation of terms is something unique to 3D modelling, where the base data are derived from a hyper-accurate data source – further compounded when data on other spatial scales is integrated. Being able to discern the two concepts of realism and accuracy is critical to the future applications of laser scanning technology as it begins to branch beyond documentation and archival purposes in cultural heritage documentation. At present the biggest commercial selling point for laser scanning is the precision of the technology that can capture accurate data. Yet as a relatively ‘young’ technology, the audiences for the datasets will change, and as they do accuracy may no longer be the unique selling point as realism of design takes its place; therefore refining the characteristics for attaining realism in practice becomes all the more important.

The following sections will discuss the development of defining realism for visual imagery, interpreting which definition of realism is the closest fit with the 3D landscape modelling. It will then continue by looking at how audiences interpreted realism during the term of the research, in comparison with measures of the accuracy of the dataset. What these sections seek to achieve is a new consideration of how realism and accuracy are produced within visual displays of information through specific encounters between people and spatial data. From a scientific perspective accuracy should be an attribute of the data that is intrinsic, but when juxtaposed with cultural contextual data this starts to become less significant. The chapter argues that striving to achieve realism and accuracy can hinge on the way in

which the images are communicated to the audience and that the context for engagement is the cornerstone on which understanding about accuracy and realism rests.

Ultimately this chapter proposes a new definition of realism in the context of engagement, known as 'participatory realism'. This idea offers a new way to conceptualise and practically apply ideas of realism in visual imagery, whilst taking into account the epistemological foundations of artistic realism as verisimilitude and veracity, cultural understandings contained within an image and the technological practicalities of generating an image or model which contains these characteristics and attributes.

6.3. Re-defining realism: contributing the cultural

The starting point for this chapter is an analysis of where we stand in regards to reaching a coherent definition of realism. It seems that this concept is quite some way from being fully developed. In 1922 Rene Magritte's famous series of paintings entitled 'the Treason of Images', he taunted and provoked wide debate in the philosophical underpinnings of how we perceive visual realism [Figure 51].



Figure 50 Rene Magritte's The Treason of Images 'Ceci n'est pas une pipe'

What Magritte was drawing attention to was that although the image has the characteristics of something real, it is not the same as the real thing. At the same

time as Magritte's painting was produced, scientific realism (the view that "what science reveals – entities, objects, relations, mechanisms and so forth – is reality itself" (Herrnstein Smith 2005:80)) was prevailing. The fact that there exists a prolonged and on-going debate in regards to what scientific realism is, led to (Magnus and Callender 2007) arguing that the situation was unresolvable. Realism in art has a similarly long and discursive history, and Roman Jakobson (1971) stressed that realism in art has always been what artists strive to achieve, regardless of whether this is intentional or not (Jakobson 1971; Langkjar 2002). From Jakobson's perspective, realism in art has been proclaimed as having the "maximum verisimilitude as the guiding motto to their artistic program" (Jakobson 1971:39). The idea of visual realism in computer graphics is a much more recent construct and at present centred on changing the technical characteristics of the software.

It seems that the genre of film has taken its own approach to realism, and it is here that the most coherent definitions of realism lie. Jakobson (1971) characterised five ways to make sense of realism: 1) as artistic intention, 2) as perceived, 3) as referring to specific periods in art history, 4) as defined by narrative techniques and 5) defined by the way it motivates style or narrative. Looking further into realism from the perspective of film, (Langkjar 2002) proposes four levels of realism:

- Perceptual realism
- Realism of style
- Narrative realism
- Recognition, whether social, psychological, cultural or otherwise

What Langkjar (2002) offers, is an opportunity for the construction of realism that fits one or more of these levels of realism, rather than attaining to meeting all of the set criteria for defining realism. What Langkjar offers is the curator of 'realistic' images an opportunity to fit within one or several of these categories of realism.

Generating photo-realistic 3D models of real scenes is a two tonged problem. On the one hand, computer and visual effects specialists argue that creating 'realism' can be achieved by advanced knowledge of computer vision and graphics (Chow and Chan 2009; Slater, Khanna et al. 2009) however, culturally there is a need to question the epistemological values that are attributed to 'realism' and find a

definition for realism in computer generated images that recognises the cultural context in which these digital images are produced.

6.4. Realism and accuracy manifested in 3D models

So far this chapter has looked to examine the foundations of realism, and reveal that realism is something that is and always has been centred on viewer perception and affixed with meaning through interpretation. The following sections address how realism has become the defining characteristic for visual information. One of the constant conflicts throughout this research has been the tension between finding a level of realism that audiences are able to engage with, and meeting levels of accuracy that would stand up to the scrutiny of a scientific audience.

The results of the research are interesting in that they suggest that the use of a collaborative, iterative approach changes the focus of the work, and the measure of success. Smallman and John (2005) propose the concept of 'naive realism' as a useful way of exploring how realism and accuracy can be conflated when something appears visually 'true to life'. While this term is helpful, the understanding of realism in this thesis is more nuanced. Perceptions of 'realism' changed over the course of the research: while it seemed to be important for the models to appear 'realistic' during the initial stages of the research project, similar visual content was received in an entirely different way when it was embedded in a broader context and presented in relation to other media. In this project, the participants who were involved in the focus groups clearly also felt some ownership over the final presentation of the digital story. Their sense of ownership and investment in the project inevitably affected their response to the content presented, and may have led them to further adjust their perceptions of relative authenticity and realism.

When modelling landscape for science communication it is hard to overlook the style and realism of the data, especially if it will be shared in the public realm. The unavoidable tension is how to simultaneously demonstrate the accuracy of the data without misleading viewers of the information. The concept of naive realism is not particularly new (Smallman and John 2005), but yet how it plays out in science communication has received notably low attention in the academic literature. This is likely to be because research seeks to attain to the gold standard in accuracy *or* realism, rather than seeing the two concepts as equally important. Part of this

struggle stems from the often implicit understanding among scientists about data accuracy; whereas this unspoken understanding of accuracy is often not understood or obvious to non-scientific audiences (Smallman and John 2005).

When interpreting realism in cultural heritage documentation, this requires a different viewpoint. Cultural heritage is documented on a range of spatial scales, from small artefacts to landscapes meaning that the level of spatial accuracy of the data and the realism of the modelled object(s) often require approaches to realism and spatial accuracy that are quite different from one another. One example of this is the documentation and archiving of small cultural artefacts. In this example the spatial accuracy may be more important than how 'real' the item appears as the focus lies in archival and preservation purposes, so there is less pressure on practitioners to balance accuracy and realism. For this reason, these sections examine how realism and spatial accuracy have been demonstrated and communicated for spatial datasets on landscape scales, rather than taking a targeted look at cultural heritage.

In addition to this, there seems to have been a lackadaisical approach by academics when approaching realism in environmental studies. Sheppard (2005) used recognisable objects to make the scene appear 'real'. It is easy to contest the manner in which Sheppard uses terms such as realism, critiquing this simplified use by arguing that adding objects makes the scene more authentic and therefore more believable but does not make the scene more realistic, particularly in a technological sense. There is a difference between making something realistic and making something believable. Fundamentally, the definitions of realism and believability are distinctly different, and the intrinsic qualities of each lie in separate domains. To make something believable there needs to be an element of trust. Does the viewer trust that what is being shown to them is truthful to the actual situation; from their own experience, are they aware that the situation or scenarios that are being presented to them could be possible in real life situations? This is inherently much more complex than simply presenting visual information. There is a much deeper cognitive understanding about what is believable, based on individual knowledge and understanding. This goes far beyond a more traditional view of whether or not something appears to be visually 'real'. This research is well placed to examine this issue, as all the participants had a fair knowledge about the setting of the film. They all lived or worked within five miles of the site. Although the depth of their

understanding varied (with some participants not being aware of the difference between spring and neap tides), they had a much better shared knowledge about the topic than many other focus groups, particularly those that are based on gathering opinions for market research.

It is surprising that more studies into visual communication tools have not explored the relationship between realism and perceptions of authenticity, particularly since it was cited by Roussou in 2006 that the representation of heritage can be interchangeable with authenticity. This study has shown that there is need from audiences to take them on a journey through cultural experiences, going beyond just a representation of heritage. In actual fact, representation of a scene does not offer audiences enough cultural context, in this case, the gold standard is verisimilitude [expand on in Section 6.7]. This was demonstrated by the focus groups requirement of adding the Shamrock to the model. If another model of boat or barge had been added, this would not have satisfied the needs of the group; they wanted to see that the film best represented their own understandings of the site and this meant replicating the precise objects on the quay. This is backed up by the benches, which were modelled on benches that exist on the quay. These were requested in the first focus groups, with one person commenting “I have my lunch on that bench every day”. It is not just about making objects and placing them in the scene, it is about making objects and placing them in the scene in the correct place so that people can envisage themselves in that setting. Much of the authenticity and the believability of the scene is generated when people are able to imagine their own position in the scene. If they are able to imagine themselves in the scene they are more likely to trust and believe the information contained in the film.

Individuals interpret authenticity differently, so there will always be a degree of subjectivity in how the model sequences and the digital story are perceived (Smallman and John 2005). All of the people who offered comment and feedback on the various visualisations iterations had the cultural capacity to make informed decisions about the level of realism required. Ultimately the decision lies with the creator of the model and digital story whose sense of realism is reflected in the final product (Macdonald 2007). As the results showed, participants were most interested in the inclusion of cultural artefacts at the site, suggesting that distinctions between perceptions of realism and authenticity are drawn in the cultural dimension. The

audience's sense of the authenticity of the visual content was grounded in their cultural understanding of the site, while their sense of visual realism was based on their lived everyday experiences and interactions with the site, their lay knowledge.

For this reason, abstract images have been less successful at engaging audiences according to Brown (2006), especially in regards to planners and decision makers who do not expect to work with abstract visual imagery. Whilst Brown's study highlights the difference audience needs of images, the particular reference in this study is more of relevance to content rather than abstraction. In the research presented here, the working group were more explicit in their expectations from the outset; they hoped to have determined answers to questions regarding the precise height and extent of flooding in the future, attributable to particular flooding events and occurrences. Their knowledge of planning procedures and possible mitigation strategies meant they were able to articulate exactly what might realistically happen in regards to future management of the river. This is one of the reasons that they were treated separately to the focus groups and the discussion was managed in a different way. The demands and expectations of each group, specifically in regards to realism and accuracy were not that dissimilar, regardless of their personal and professional affiliations. The second working group meeting demonstrated this, when the participants explained how they each would use the film and the purpose they saw it serving, rather than being a point of discussion to generate interest and build a picture of the future, the film to them, was a functional tool that needed to play a role.

An altogether more challenging component to the existing questions that are presented here regarding definitions of realism for visual imagery, is when one considers the implications of using a subject matter which 'matters' to people. Heritage is recognised globally as being a cultural resource, and moreover, a tangible part of people's memories and traditions. Chapter 3 has already considered the importance of heritage sites as spaces and places which provoke strong emotional responses (Kaplan and Kaplan 1989) as well as the actions of stakeholders if heritage is considered to be under threat (Agyeman, Devine-Wright et al. 2009). Nationally, there is a sense of collective ownership of heritage and a pride in the history that heritage sites represent. Although public interest in heritage sites positively supports their protection and conservation, this is often accompanied by a protective attitude which can in fact impede management strategies aimed at doing

what is best for heritage. The real challenge from a 3D modelling perspective, is that whilst it is possible to model heritage in 3D space, there is no evidence that suggests that people who have existing access to these sites, actually want to experience heritage in another way. The level of emotional connection to heritage, challenges the 3D modeller to produce something which is of satisfactory quality.

6.5. Accuracy and realism

Having considered the importance of making an image appear visually real, and the significance of demonstrating how the image shows the verisimilitude to the actual location, when this image is constructed from a spatial accurate 3D model, one also needs to consider how spatial accuracy is conveyed. This was not straightforward, as conventional measures of accuracy were not entirely relevant or applicable in such an open, consultative process. The TLS could capture data at 5 mm spatial accuracy, and for the purposes of showing sea-level rise of a few centimetres, having spatially accurate data was a necessity in the development of the 3D model. Capturing the spatial characteristics of cultural artefacts often centres on an order of magnitude of a few millimetres, unlike environmental and landscape spatial data where the spatial accuracy ranges from millimetres to metres depending on the method of data collection. Whilst the integration of spatial datasets on multiple spatial scales makes this research somewhat unique, it also presents an interesting tension between TLS and LiDAR regarding issues of realism. Creating a mesh from the original TLS dataset meant changing the spatial resolution of the dataset and thus, its spatial accuracy is likely to have been reduced to a value worse than the instrument's accuracy of 5 mm suggests. However the meshing process applied to the TLS data meant that accuracy could be optimised in areas of the model where it was most needed. In general the mesh represents the structures on the quayside as a series of triangles where more triangles per unit area means that the original dataset is more accurately represented (El-Hakim, Brenner et al. 1998). In the final model the building with the densest mesh (and therefore the most accurate representation of the original TLS data) was the Discovery Centre, yet interestingly no comment by the focus groups in regards to this appearing more 'realistic' than any other building. Perhaps more useful in building trust in the model was the inclusion of the regional perspective from airborne LiDAR (also generalised using a mesh-based approach). This multi-scale approach allowed both the detailed view of

the quayside and its components to be embedded within a coarser resolution (and less accurate) landscape representation. In the second focus groups, the distinction between TLS and LiDAR datasets and how these were shown in the film was not explicitly discussed, yet the impact of including fine scale data with the coarse LiDAR meant that participants naturally began to think about the impacts outside of Cotehele Quay.

As this research demonstrates, one of the advantages to using a 3D model incorporated in a film, is that it allows for an accompanying narrative to communicate the spatial accuracy of the dataset. Two-dimensional images lack the same format of narrative and therefore, spatial accuracy and data uncertainty is communicated on the image (Ehlschlaeger, Shortridge et al. 1997; Schenk and Lensink 2007; Chilvers 2008; Brown 2010). One of the challenges with attempting to display all the information on the screen at any one time is that it can often be overwhelming for the audience. What 3D visualisation, used as part of a longer film, allows for is individual scenarios to be selected and shared as part of a longer narrative containing a clear message or opening up a dialogue.

Before the first iteration of engagement with the focus groups and working groups, it was believed that realism was based on the aesthetics of the 3D model, for example when texturing the buildings and adding water and lighting to a scene. However this was uncovered to be less important, as many of the comments from the focus groups centred on adding in the detailed cultural artefacts on the site, rather than accurately representing the granularity of the workshops walls. What this demonstrates is that ensuring the perceived authenticity of the visualisation lies in creating a sense of place, something supported by the work of Orange (2011), integrating a greater extent of the landscape, and adding in the small architectural features that provide the historical heritage context for Cotehele. Ironically, the 'place making' elements of the model, the crane, barge and other incidental quayside features, were not parts of the terrestrial laser-scanned dataset, and were modelled in response to feedback from the first focus group about the absence of recognisable objects at the site. Creating an authentic and realistic visualisation of landscape change is an interpretive process for the creator of the model. Engagement activity and consultation can significantly enhance the levels of trust and acceptance in

relation to the final product, as individual observations about realism and authenticity are integrated into a collective representation in the final product.

6.6. The applicability of TLS as a communication tool: a help or a hindrance

The preceding sections have outlined some more definitive ideas about the construction and control of realism and accuracy. This section takes a targeted look at the role of TLS in contributing to the development of a 3D model and analyses how the data from TLS feed in to the over-arching debate on accuracy and realism. One of the principal objectives of this research was to explore how terrestrial laser scan data can be used as a foundation to provide content for community engagement tools. This section takes a more detailed look at the role TLS played in making a 3D model of heritage, and whether or not its application for this purpose is either a help or a hindrance. As with the structure of this thesis as a whole, it is easy to discuss the role of TLS as a tool in a chronological way. This makes sense, not least because there were clear stages in the collection and processing of data, but more importantly because through throughout the collection and processing of the data, the relationship that the audience had, and their understandings of how the data were portrayed and understood had an impact on the final film.

Terrestrial laser scanning has been hailed as a remote sensing technology which allows for rapid data acquisition (Schulz and Ingensand 2004). Along with being rapid, laser scanners are able to capture data with precision, providing data with levels of spatial accuracy not offered from other forms of ground surveying¹⁸. The pertinent issue here is to understand how rapid data capture is beneficial when post processing is more time consuming than other options. What are the relative trade-offs of TLS compared to CPS surveying (which would result in lower accuracy but be more flexible)?

As the preceding sections to this chapter demonstrate, this discussion has demonstrated that technology is embedded in the relationship between people and visual realism. The following discussion looks specifically at the role of technology in 'controlling' the realism of the 3D model. Considering that one of the aims of this

¹⁸ See Chapter 2 for an outline of the data and what it offers.

thesis was to explore the use and applicability of TLS the following sections centre on this technology.

In the early chapters of this thesis, TLS was identified as a popular technology for digitally preserving and documenting cultural artefacts. The evidence for realism and TLS on a small scale is demonstrable throughout the literature, however realism for TLS on landscapes has been overlooked as it is often LiDAR data which is used to generate images on greater spatial scales. The research presented in this thesis can be used to discuss the appropriateness of using TLS, rather than LiDAR, to make realistic models of landscapes. Considering that the bar has been set high (with millions of euros spent on enhancing the realism of cultural sites and artefacts). First and foremost, it is necessary to address how the accuracy of the data that were collected contributed to making the 3D model more realistic. Working with data which had a precision of 6mm (<100m range) was fundamental to its use for sea-level rise communication, as at Cotehele Quay even a few centimetres of additional sea-level rise could have a large impact.

One of the challenges faced when using TLS is that the data are not visually realistic in its raw format. As Chapter 3 discussed, the original TLS data needs to be processed using design software to make the transition into a format which can begin to appear realistic. What is problematic here is that as the data are converted from its original point format to a meshed grid, the spatial accuracy cannot be measured, only approximated. It is possible to drape photography over the point cloud, thereby giving it a realistic appearance (or at least the colour characteristics of the real environment). However the dataset will retain its dataset composed of millions of points, thus rendering itself too large a file size to be used in any other software (beyond that owned by the laser scanner manufacturers). It is therefore difficult to avoid converting the data into more manageable formats.

Ultimately, being able to definitively determine the spatial accuracy of the spatial dataset when it is processed beyond a point cloud is frustrating, particularly as (when coupled for public use as a tool to explain climate change), the public are generally already aware of the uncertainties of climate data (Smith 2005; Zuk, Carpendale et al. 2005), so ideally, the tools used would not add an additional layer of complexity.

As the research methods were exploratory, in the early stages of data processing every effort was made to collect accurate spatial data. The second round of registrations (Chapter 4) saw an alternative registration technique used which only resulted in an improvement of the accuracy by 0.04mm. At the second stage, the car park at Cotehele Quay was not included in the registration as it was impacting on the spatial accuracy. Once the registration had been completed, the point cloud was geo-rectified. The purpose of geo-rectifying the data was so that it could be integrated with other spatial datasets. Geo-rectifying the dataset does have an impact on the spatial accuracy of the TLS (Chapter 4) but even so, it was still carried out as the focus groups had requested to see a greater extent of the Tamar Valley. Throughout the second round of processing it was necessary to weigh up the balance between retaining spatial accuracy and meeting the needs of the focus groups. In the second working group meeting one of the participants had suggested the visualisations could be used to show flood depths and aid planning for emergency services. If this would have been the use of the dataset, then geo-rectifying the data may not have been a priority, as small areas could be modelled and flooded without the need to integrate with other spatial data. As the unsuccessful first attempt to geo-rectify the point cloud demonstrated, without geo-rectifying it is not possible to accurately align spatial data on different scales.

What this discussion draws to is how important spatial accuracy is relative to the time spent processing the raw data as to retain this figure. After all processing stages have been undertaken the spatial accuracy of the raw TLS data can only be approximated. Juxtaposing this with the knowledge that the cultural context was the area in which participants responded to most strongly, asks what the balance of time and effort should be between maintaining spatial accuracy and focusing on design and content. Or if the iterative and participatory manner in which the model and film were generated were trusted to the degree that participants felt comfortable not to address this aspect.

6.7. A new approach to realism: Participatory realism

The start of this chapter introduced the many ways in which realism has been interpreted throughout history. More recent technological advances have seen the introduction of more computer-centred realism definitions, often focusing entirely on

the functionality of software to enhance the realistic attributes of 3D models and other photo-realistic scenes. This chapter has demonstrated how realism manifests itself when used in a participatory study. The argument here is that Langkor's (2002) presentation of realism that can be interpreted in four ways is a useful and overarching way to define realism in visual information, this research has identified that the definition of realism cannot be based on 'selecting' parts of a definition for realism. Based on the research, this thesis offers a new conceptualisation of realism, called 'participatory realism'. Participatory realism acknowledges that all interpretations of realism are based on certain criteria, namely 1) existing knowledge of the subject area, 2) setting and context of display and 3) social and cultural background of audience. These three categories will influence how visual information is received. What is unique about participatory realism is that it recognises that perceptions of realism are produced through engagement with a group of people. Ultimately this will mean that the viewers are more likely to trust and believe what they are being shown and then for those people, the realism is enhanced. This is essentially the top level of an hierarchical approach to understanding realism [Figure 51].

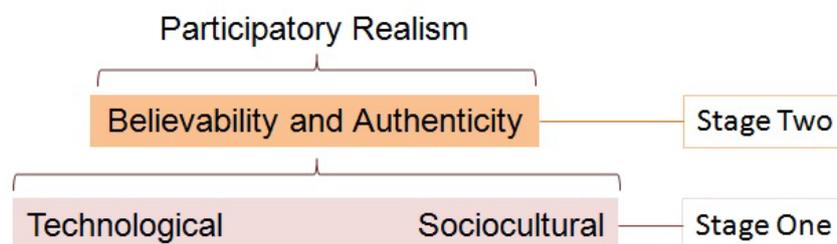


Figure 51 Conceptual diagram demonstrating how to reach participatory realism
 Figure 52 is a conceptual diagram of how realism is built by those viewing the images, the foundations of which are distinguished between the technological and the participatory approach (sociocultural). What this structure allows is an holistic approach to defining realism that can take into account both the technical and cultural / social aspects which Langjkar (2002) lacks.

This approach lays down a set of process and characteristics which, when undertaken in a participatory context, generate images that can reach a level of participatory realism. Crucially, this does not mean that the images have to appear

'photo-real'. This approach allows flexibility in the interpretation of visual realism, in so much that it is defined by the participants of the study and reached by mutual agreement. The *realistic* component of the image, lays in the creation of the image in equal measure as to the final output.

This approach to realism moves away from the emerging literature on realism as a result of improved digital capabilities and returns to theoretical perceptions of what realism is. For participatory realism to be achieved, the process hinges on engagement with the public or stakeholders who are involved at every stage. This approach has emerged over the period of the research undertaken. As this thesis has demonstrated, particularly through the interdisciplinary nature of the study, it is necessary to take into account numerous viewpoints and knowledges when making a visual tool – and participatory realism addresses the particular visual element of engagement.

The first stage, shown in Figure 52, is to establish the socio-cultural context and the technological capabilities. Often these two areas are seen as distinct i.e. one will come after the other. Yet, this approach assumes that one cannot progress further without these two working together. Part of this process addresses participants' expectations about the feasibility of the certain methods to achieve what their suggestions. The first stage should be a research base on which to develop a relationship with the participants. The success of participatory realism centres on communicating and involving participants in the research process, and therefore findings from this initial phase would be fed back to participants.

The second stage focuses on softer engagement with the participants; particularly with regard to responding to feedback captured in stage one. This stage involves re-working the image or video to capture authenticity as suggested by participants. Only when participants have been able to respond at this second stage, can participatory realism be reached.

The concept of participatory realism is still nascent, and needs further refinement. But it is a useful contribution to the thinking on one of the main questions presented in this thesis – that is balancing spatial accuracy and visual realism. As the research has demonstrated, participants seem to de-prioritise spatial accuracy in response to increased commitment, and inclusion. That suggests that, as participatory realism

introduces, if participants are engaged in the technical detail and rigour from the beginning of the process, the approach will generate a potentially more useful tool as a final product; one that truly reflects the participants desires but is also trusted.

The argument for creating visual images that are believable and authentic is widely supported in the literature on authentic cultural experiences (Chhabra, Healy et al. 2003). This literature primarily focuses on the tourism industry, but the strive to achieve 'photo-realism' suggests that people expect similar levels of verisimilitude in images as they do in everyday cultural experiences.

What remains to be identified is who the intended audience is, however as Brown (2006) attests, in a climate change context, even industry professionals (i.e. decision-makers) will struggle to interpret scientific data if presented in a format which is too abstract; therefore it could be argued that striving for some degree of realism would always be preferred.

6.8. Introduction to participatory process

As introduced earlier, the second half of this chapter addresses the length to which the participants of the research engaged with the process as a whole and how they engaged with the 3D visualisations which were part of the film about Cotehele Quay. So far, this chapter has reached clarification about how realism can be defined by the processes that manifest the images, and that spatial accuracy of the TLS dataset is important to communicate in the early stages of a longitudinal research study in order to contribute to but not overshadow the accuracy of the data. By the end of the research process, participants inherently accept that the data are spatially accurate; the next stage is to consider how the participants engaged with the visualisations.

Without deliberate emphasis, much of the project was about control and ownership. The NT wanted the participants to feel that they had a hand in creating something that would impact on future management at Cotehele Quay. An important part of the research in the second stage of engagement was about feeding back to the participants about the influence that their contributions had made. Other climate-change related community engagement activities are able to offer more ownership over the end product than was available here (Dockerty, Lovett et al. 2005). This is largely determined by access and ability to manipulate design software to generate

the visualisations. It was important that the focus group participants felt that they had ownership of the project, that to some degree they were able to control the final content of the film, but it was not possible to grant them overriding access in producing content for the final film. For the participants, ownership of the film was granted in the form of feeding back comments on how to improve the visualisations. Comments from the second round of focus groups demonstrated that participants were pleased that their comments had been acted on. The literature acknowledges that much of the communication when addressing the impacts of climate change is done in one direction (Moser 2010; Somerville and Hassol 2011), but other studies have begun to acknowledge the appropriateness for involving third party feedback (Edelenbos and Klijn 2006; Larsen and Gunnarsson-Östling 2009; Reed, Kenter et al. 2013).

6.8.1. The early stages of participation

The participants demonstrated high levels of interest in the impacts of flooding from the very early stages of the project. At the first focus group meeting participants asked to see other areas of the river flooded, in particular Halton Quay and Calstock. Considering the furore over the Environment Agency flood maps (Merz, Thieken et al. 2007), and the seemingly obvious public concern about the relationship between insurance premiums and flood maps, it is somewhat surprising that they were so open to visualising flooding that has implications which go beyond the research study. It is difficult to find a comparable research study that has demonstrated a community's willingness to understand local effects.

Throughout, although the NT staff and volunteers focus group was initially separate, both the NT staff and volunteers group and the community group were asked the same questions and saw the same visualisations. Yet their engagement with the research demonstrates the challenges that arise when engaging with different groups. It is well documented that participation strategies need to be targeted at specific groups to be effective (Bondi 2007), which is one of the many challenges faced by climate change communicators (Ockwell, Whitmarsh et al. 2009; Johnson 2011). However this research demonstrates that in practice if the message is targeted to a local audience, it is actually how the message is received which makes the difference to the audience. At the first focus group meetings, both the NT staff

and volunteers and the community and business group understood the visualisations, but their responses to this information demonstrated their different agendas.

At the second working group meeting the AONB officer was not convinced that what would be produced would be more than a management tool. Her feelings were that whatever guise this was shrouded in, it will continue to be a management tool rather than something which engages with people. She was more satisfied only when it was explained to her the flexibility of the tool in that the initial 3D visualisations acted as baseline for data and that the model will be responsive to collective construction to make something that is meaningful to them, that she was placated. When it was explained that the tool (in whatever format it was later to arrive at) was intended to be responsive, she voiced some concern about promising too much in regards to possibilities of engagement, noting *“I just think at this stage then that you wouldn’t want to go too far down this route”* (EK, Cotehele Quay, 25/01/11).

One of the more disappointing outcomes of this process was the realisation that caution had to be extended when engaging with other communities. This was something that was recognised from the outset and one of the few downsides of using terrestrial laser scan data. We knew that the accuracy would hold more validity with the local community and therefore we knew we could not include all areas as we would have hoped. We did not want to raise concerns in the same way that the Environment Agency flood maps had done and the Shoreline Management Plan review. This was not about scientifically stating the level of flooding, it was about testing an approach. Throughout the working group meetings concerns about the applicability at other sites was raised. This is one of the most obvious and yet difficult challenges that science communication needs to tackle: how to communicate specific climate impacts at numerous site with limited resources (Demeritt and Langdon 2004). How this research has contributed to that, is in offering a responsive tool which can incorporate different types of media, as well as a model for thinking about how to build to trust and accountability into this approach. These same approaches can be applied on a larger scale than just Cotehele Quay.

However, although the NT saw the value in using the data and the visualisations to branch out to other areas and engage with other groups, they remained unsure

about the skills, expertise and capacity needed to undertake such activity. This again highlights the 'grey area' in science communication and engagement, in that it is often not the scientists who are sharing their data, but the decision-makers who are attempting to interpret it for other audiences (Tompkins, Few et al. 2008).

It did emerge very early on how much the NT cared about involving other groups outside of the NT in deciding on future management plans for the quayside, partly as it was in response to the failed Hays Marsh application, and partly and that they knew it was something they wanted to do right from the beginning. In the initial setting up of the meetings for the focus groups, it was difficult to get some of the key stakeholders on board; in particular, the ferrymen and the landlord of the pub on the quayside in Calstock. Both these stakeholders have an economic interest in the future of the river but were seemingly uninterested in being a part of the process.

The villages surrounding Cotehele, namely St Dominick and Calstock are often targeted as 'interest groups' for research that is carried out about flooding in the Tamar Valley as they are the nearest populated sites to the River Tamar and are villages which also experience fluvial flood events. One of the particular issues that the research was aware of was that participatory engagement activity can often neglect any sense of a longer term relationship between the research and the participants (Few, Brown et al. 2007). It is likely that members of the communities' local to Cotehele Quay have grown weary of being asked to be a part of scientific research particularly because they don't see or experience the outputs or outcomes even though they commit time and effort.

6.8.2. The later stages of participation

As it was anticipated that those being invited to partake in the research may have been approached before for other research, it was made clear from the outset that this research approach would be different, in that their participating was intended to be sustained, further the open nature of discussion at the meetings meant there was no intention for the visualisations to act as tool to facilitate behavioural change, although some comments suggest it has the potential to provoke such a response "...recycling, all those things. I think that's the whole point of it really, all these individuals who come together will make a whole." (JM, 2011, Focus Group, 6/9/11).

This points perhaps towards a larger role outside of initiating conversations about change that visual tools can play when communicating climate change.

Something that was avoided throughout the engagement process was sensationalising the film and over-dramatising events that are predicted to take place in the future. It was the steering group in the second round of engagement who suggested using tabloid headings as a place holder during the film. Throughout the film, the intention was to present regional sea level projections at a local level, with the deliberate intention that there would be limited affiliation to *global* climate change as this was felt to be too distant to what was happening at Cotehele Quay. This is supported by science communicators who highlight the power of local stories to communicate local change, rather than global (Lawrence 1997).

The film produced was much less about climate change, and instead centred on showing sea-level rise in an accurate and visually appealing way. The quantity of 'global' input into the film would have confused the viewer about the purpose of the film. Not all of the participants of the focus groups were ready and willing to engage with the film in the manner that was intended. One of the oldest participants who was also a member of the Haye Marsh opposition group SODITT commented that "And that was the way I felt, it was not about the information, because the information felt quite familiar to me" (DS, Cotehele Quay, 06/09/11)

It is unclear if these were his honest feelings about the film, but his determination to demonstrate existing understanding of the consequences highlights how lay knowledge can contribute to these activities and also how not including these experiences and opinions can generate ill-feeling (Brace and Geoghegan 2011). Whilst some of the participants were comfortable with the technical detail, others found the experience to change how they saw the Tamar Valley. One participant had commented that she would have been just as happy to see the historic photography. What this demonstrate is that although participants may have knowledge and experience to contribute in one area or strand of the topic being discussed, it cannot be assumed that they will always make suggestions which fit with the story being told and some cautious selection should be made; something that has been slightly overlooked in the campaigning to include lay knowledges in climate change communication.

The feelings of this participant, in regards to seeing the historic imagery were shared amongst the group, with a general feeling that the historic images were one of the most interesting parts of the film. This falls in line with the literature which ascertains that people struggle to imagine futures but are willing to reflect on the past (DeSilvey 2012). It further points towards a need to engage people with their histories and exploit this knowledge before moving on more abstract (possibly future) issues.

Even the industry professionals struggled to determine which scenarios should be produced as a tool that would be meaningful to the public. Throughout the research, the working groups tended to feedback a desire for more policy-aligned visualisations and even at the final meeting one participant asked “I still don’t understand the point of this” and then promptly got into an argument with another participant regarding what measures were in place to mitigate the impacts of climate change in the Tamar Valley – at which point this was pointed out to her that this was the point of the film, and it was working. It often assumed that policy practitioners and decision-makers are already aware of the need to develop community specific tools.

6.9. Lessons on participatory approaches

“There are huge parameters within which all this discussion takes place. And there aren’t rights or wrongs, there are just questions that people need to get a hold of themselves” [Phil Dyke, Coastal and Marine Advisor, National Trust]

As the quote by Phil Dyke suggests, there were no right or wrong conversations to be had during the meetings. At times the participants were expected to feed back into the development of the 3D model, but one strand of the research project was about opening up the lines of communication between the NT and the local community. Getting the support of the local community was fundamental to the success of the research and each group assumed a slightly different role in the participatory process. The working group were the ‘expert’ advisory body and the focus groups the ‘expert’ local audience. It seemed to act quite organically that each group assumed these roles. Throughout the project the working group remained much more focused on the bigger picture – what were the visualisations for and what role were they assuming. Whereas the focus group had a dual role: firstly to assume a position as an informant to the development of the visualisation (in much the same

way as the working group) and secondly, and less directly, to engage with the process in offering insight into how this type of participatory approach manifests. It was not just about engagement with people, but also with the technology. The terrestrial laser scan data became something that was iteratively engaged with and the engagement informed the final presentation. Most research does not have such an ingrained relationship with the data source.

Compared to similar studies using a participatory approach (Reed, Kenter et al. 2013), there was a degree of openness in regards to stakeholder engagement. For the most part, and certainly from the point of the researcher, the boundaries set were mainly established by the limitations of the technology rather than being defined by the researcher. This contributes to the discussion on trust and ownership as well as responsiveness.

What this project has identified, is that 'engagement' when using mixed media to make a story and involving various audiences, works on both the macro and micro levels. On the one hand, there is the overall process of 'engagement', which sits comfortably within the most frequently applied 'engagement' strategies. On the other hand, this form of 'engagement' is the one that (should) receive the most criticism, because it is engagement at the macro level which is often influenced by power relationships. From an academic perspective, it is frustrating to read Rowe and Fewer's (2005) theory for 'public engagement' as a general term for several different approaches. What this demonstrates is that engagement is not about the people who are being engaged, rather the mechanism by which the engagement is carried out. This begs the question as to which is the real priority – the mechanism used or the output of the application of engagement.

The methods and approaches in this research have allowed fresh insight into the micro relationships that audiences have with mixed media. One of the observations that is unique to this research is that 'engagement' took place within all levels of the project. The people who were involved throughout this study did not only engage in the process as a whole, but they engaged as individuals with the content of the film. This means that they engaged with each individual type of media contained in the film: the historic photography, the oral histories, the interview transcripts, with each other, with the visualisations etc. The list of micro engagement that took place is

something that is particularly unique to engagement of this kind. There is no research which deals explicitly with micro level engagement with different media (i.e. one can study the engagement between people and imagery or the engagement between scientific visualisation and people but not look at what the end product is of these smaller engagements as part of a larger whole). People's engagement with climate change information is particularly guilty of overlooking some of the micro relationships that people encounter, but this is perhaps due to the limited – but increasing – number of studies which analyse peoples' interactions with digital media.

One of the continuing assumptions about engagement between the public and climate change is that there is a need for behavioural change (McCrum, Blackstock et al. 2009), demonstrated in engagement mechanisms which are often top-down. What climate change public engagement needs, and this stems from years of (somewhat unsuccessful albeit contributory) research into engagement with climate change for behavioural change or changing understandings, is a long term view to engagement which engages issues in a manner which is exploratory rather than prescriptive. This has been initiated by a shift in climate change communication towards upstream engagement, and the digital tools developed in this research build on responsive and flexible tools that encourages people to think about climate change in a different way.

One of the challenges in upstream engagement is the time it takes to 'do' the engagement, when there is a need for action to mitigate and adapt to climate change. Ineffectual government regulation does not encourage the use of low carbon technologies so the pace of change towards a more sustainable economy is both slow and lacking in driving people's motivation for change. So we are in a dichotomous relationship where there is no time to truly 'engage' with people and to have conversations about climate change, there is the frustrating and urgent agenda which has driven engagement with climate change to be something more aggressive and impenetrable.

What this research suggests is that perhaps participation in climate change debates should not be approached from the same starting point as other topics as people need a different conversation before 'changing behaviour'. People need the time and

space, as well as the presentation of the impacts that climate change will have on them, in order to have the time to understand and consider the impacts of climate change. What climate change engagement has done is jump ahead of itself in the rush to address the urgency of climate change. Scientists have overlooked the fact that whilst research into climate change is on-going, the communication side of climate change (which is well documented and wide in scope) has struggled to find a comfortable narrative for communication; swinging between scaremongering and balanced appraisal of the impacts – neither of which are seemingly effective at engaging people in long term conversations about change.

Until now, the social sciences have offered many more opportunities for the public to engage in thinking about climate change rather than affecting any actual change. Digital technologies have been the conduit for this communication but have not provided the tools which allow for open thinking on these subjects. In the long term, social and physical scientists need to decide what is more important: forcing people to adapt rapidly to climate change or taking a long term view of communication and engagement which can be led by interactive digital technologies. These have the scope and potential to go way beyond what has been utilised so far.

It seems that as progressively more scientific evidence for the impacts of climate change is gathered, the tools and methods that researchers use to communicate and engage with other audiences in regards to these findings is not progressing at the same pace. What has seemingly occurred is to look to more traditional engagement methods and apply them, whilst failing to respond to the growing availability of digital technologies to help communicate and share scientific findings. One of the challenges of the situation is that the impact of climate change can still only be inferred and is not certain, yet poses threats to the environmental and economic livelihoods of millions of people. What this demonstrates is that there is no precedent for this change and therefore no evidence to suggest which way to disseminate information has had the greatest impact, and little evidence to support how climate change communication and engagement methods have worked on communities actually affected by change.

6.10. Digital storytelling

Perhaps this is an area into which approaching digital storytelling can contribute; by establishing forms of engagement which are not just about the macro relationships, but also about the micro relationships between different media. Many scientific visualisations are all or nothing in regards to containing information (i.e. merely the bare minimum information to communicate the message, or everything). In the search for scientific rigour, science communicators have lost their way between 'simple and clear' messages and messages that are simple and clear but also interesting and contextualised for the audience. This is actually less about engagement, and more about an understanding of audience needs. Admittedly this approach may only work truly effectively with a local audience, but it does not mean to say that it should not be looked at in more detail.

The approach adopted in the coastal change study at Cotehele Quay drew on work in the emerging field of digital storytelling. Digital storytelling involves the use of mixed media for creating a digital narrative about an issue or topic (McClean 2007). A digital story is similar to a film, in that it contains a variety of media sources (Lothe 2000), however the term digital story is better suited to describe not only the content but also the construction of digital sequences incorporating short, informative pieces of data. Digital storytelling has its foundations in studies of agency in the classroom (Connelly and Clandinin 1990; Bers and Cassell 1998; Robin 2008), and more recently it has been recognised as responsive tool for community engagement around contested or complex topics (Ryan 2004; Lambert 2009). McWilliam (2009) outlines three roles for digital storytelling in community projects: historical, aspirational and recuperative. Historical roles of those which collect public histories of community or place, aspirational those which empower storytellers, and thirdly recuperative which help storytellers to overcome adversity. For the purposes of initiating a dialogue about climate change, a combination of all three roles is necessary. There are applied examples of digital (Nerlich, Koteyko et al. 2010) storytelling in practice (Project Aspect 2011) but little published research outside literature on gaming and education (Alexander 2011). The concept of computer-based visualisation and storytelling is still relatively new and currently lacking guidelines and frameworks for appropriate use (Nerlich, Koteyko et al. 2010) and so most work in this area is still carving its niche. Nevertheless an argument can be made for digital storytelling to provide a useful model of practice for research that

aims to generate visual representations of landscape change through iterative, participatory methods because it recognises the value of representing multiple voices and perspectives, and integrates different types of media in novel and engaging formats.

6.11. Conclusions

What this chapter has presented are the challenges faced when reaching a useful definition for realism. Realism exists for different experiences and this has led to an unclear typology for how to determine what realism is. As technology advances there has been a shift to focus on the technical capabilities for improving realism rather than focusing on the needs of the audience.

Separately, both strands of realism contribute to understanding on realism, and Langkjar's (2002) definition bridges the technological and social elements of realism. However even this definition overlooks how these can overlap to contribute to an idea of realism that takes into account the technical and the social. This chapter discussed how this research uncovered how characteristics of engaging in the process built trust and believability with the 3D model and how this was evidenced to enhance their perceptions of realism. What was most clear from this discussion was the role of the cultural context in contributing to the overall realism of the visual images. Throughout the research, participants made few comments about the realism of the buildings, instead it was the cultural artefacts they were interested in. It would be easy and misleading to assume that authenticity lies in the cultural realm whilst realism sits aside, created by technology. What this chapter has proposed is a new way of approaching realism which can be seen as addressing the dichotomy between technical and social realms. This conceptual notion of realism facilitates the creation of realistic images when generated using participatory methods; therefore it has been coined 'participatory realism'.

Having reached a clearer idea on what realism is, this chapter follows on by examining the relationship between spatial accuracy and realism. The concept of naive realism is a growing concern for practitioners working in science communication, and one that is particularly relevant when using spatial data for visual images and film. What this chapter has discussed is how whilst there was a commitment to maintaining spatial accuracy throughout processing, there is little

evidence to suggest that this was significantly important to the participants. It is suggested that the reason participants did not question the accuracy of the data, was due to the engagement approach and their participation in the creation of the model and the film. This built trust and led to less scepticism regarding the validity of the data and the scenarios.

This chapter has tried to describe how the participation and engagement techniques used throughout this research represent a new approach to thinking about how people can be engaged with climate change information. This departs from an understanding of climate change communication and engagement which is largely driven by a need to see changes in behaviour. What this chapter has discussed is how people engage with climate change data when engaged in an iterative participation approach and are asked to contribute ideas to the formulation of a film, incorporating flooding scenarios, rather than be recipients of pre-defined scenarios.

What this chapter demonstrates is that people's relationship to the data and their perceptions and engagement with it, changed over time. From the early stages, when it was seen as a functional tool for both the focus groups and the working groups, to the later stages when conversation flowed on subjects that went beyond the scope of the research, such as the local parish councils mitigation strategy for dealing with flooding. These conversations demonstrated a shift in how the participants had engaged with the research.

Even by the final stages there was some remaining confusion about the wider climate impacts, and participants began to confuse the impacts of climate change in the Tamar Valley with issues around consumption and waste. What this suggests is that regardless of the messages communicated to the public, it is challenging to communicate every message that is *entangled* in climate change.

Ultimately, the discussion here points towards a positive shift in how people engage in conversations about climate change, generated because of the conversation that had opened up during the research project and unlikely to have happened sooner had it not taken place. Practitioners who manage sites at risk are slowly realising, due to their own experiences, that driving straight towards adaptation strategies can often fail as people struggle to connect and understand the science and decision-making process.

Chapter 7

Conclusions

7. Conclusions

7.1. Main findings from research

This research was initiated in response to climate change studies which identify that coastal sites across the world will be affected by rising sea levels in the next 20 years, and as such will require a proactive approach to managing these sites. One data type that has often been used to explore scenarios within fluvial or coastal settings is that of spatial data derived from laser scanning (airborne and terrestrial). These data are often used within scientific settings, but rarely used to engage the public with ideas about future change and to initiate conversations with local stakeholders about change, many of whom have emotional attachments to these coastal sites. The main barrier to using spatial data derived from laser scanning is the inaccessibility and complexity of the raw data, which can be hard for the layperson to understand and digest. However, there is a great potential to integrate spatial data into visually realistic virtual models to be used to better communicate stories and scenarios of future change. This research has sought to achieve a new model for integrating such spatial data into an iterative communication process.

Chapter 3 identified climate change as a potential threat to coastal landscapes across the world, with projected tangible impacts on cultural resources and artefacts. However, it was argued that decision-making about future management of affected landscapes was not being supported by tools that would adequately allow managers to take into consideration the opinions and knowledge of other audiences, in particular local community members who have a vested interest in the future of these sites.

Added to this was an acknowledgement that whilst managers are trying to identify the best methods and approaches for sharing scientific data, climate data are constantly being updated as more research is conducted. This requires that any resulting communication tool be flexible, in so much that the content can change in response to input from different audiences and updated information sources. What was identified at this stage, was that despite the continuous generation of new scientific data, communication tools had not developed at the same pace, resulting in the perpetuation of top down styles of climate change communication. A new approach was needed which would allow managers of sites likely to be affected by

climate change a chance to engage those who care about these places to think more proactively, with the space to consider different scenarios of change.

Early on in this project, laser scanning was identified as one technique to capture spatially accurate data, with the potential to be used for sharing information about environmental change. Whilst use of these data was not particularly new in coastal landscape monitoring, there had been a limited amount of work which specifically looked at the balance between generating spatially accurate and simultaneously visually realistic information based on these data, particularly for community engagement purposes. The rest of this chapter addresses the conclusions of the research against the original stated aims of this research project.

Aim: To develop 3D visualisations which can be used to engage diverse participants in an understanding of the projected effects of sea-level rise on a heritage site

The key finding of this thesis is the recognition that when transforming technical datasets into content that is deemed meaningful to a wider audience, the realism of the 3D model is as much defined by the cultural articulation of realism as by the visual aesthetics of objects in the scene. In other words, what is absent or included in the film, and the relation of these objects or scenes to the viewer, can significantly affect the user experience. What has been determined is that user experience and perceived realism is much more about the cultural context of the film than was initially anticipated, and this is true regardless of the type of media included. After the first focus group meetings, a point was reached where the initial visualisations were not sufficiently engaging to be effective communication tools for the local community. The focus group participants directly contributed to identifying the content which would later be included in the film.

Although the exact imagery, text and narrative was ultimately decided by the researcher of this thesis, the focus group feedback was the catalyst that meant the scope of the tool had to change. The use of an iterative and participatory approach required the researchers to engage in constant decision-making and adjustment, something that was not necessarily considered at the beginning of this research. This was largely due to the fact that whilst the film had a relatively simple narrative structure, the inclusion of spatially accurate data, and numerous formats of media

files meant that behind the 'plot' and narrative, were a more complicated set of decisions. These decisions were in some cases forced by technical constraints, or alternatively prompted by suggestions from feedback. The key finding was that the development of the digital tool could not be separated from the researcher's evolving relationship with the participants.

A significant finding of this research has been determining the appropriateness of using spatial data, in particular those derived from TLS and airborne LiDAR. Whilst TLS offered a rapid means of capturing data, the computing resources and time needed to process the dataset were found to be a major challenge to the generation of the visualisations. As Chapter 3 identifies there are alternative spatial datasets available which can also be used to generate a 3D model (e.g. GPS surveying). This research has shown that the spatial accuracy of the data captured using TLS has particular advantages over alternatives, although it is necessary to consider the wider implications of using this method. Data capture using TLS required onsite field visits, meaning that the researcher became familiar with the site and the people using and working there. This ultimately benefited the relationship between the researcher and the participants of the research, as the researcher knew the site well as was able to better understand the emotional connections that participants had with the site. This would not necessarily have been the case if other methods had been used (particularly the case for aerially captured spatial data). In truly interdisciplinary fashion, the fact that TLS meant that a rapport could be built between the researcher and the participants, highlights that the trade-off of time and computing power were necessary to build the meaningful relationship between different involved parties. Ultimately TLS was determined to be an appropriate method, irrespective of its drawbacks.

Aim: To arrive at new means of critically analysing the information content and response to spatial models derived from (i) so that messages about future change, and uncertainties in the scientific understanding behind those messages can be effectively communicated to diverse audiences.

The concept of participatory realism explored through this thesis is an original contribution to knowledge, and offers a new way to approach the contentious issue of balancing spatial accuracy with visual realism. Chapter 6 demonstrates that there

are many ways in which to approach realism when working with digital imagery, and no particularly clear definitions about how visual realism is constructed, as the perception of realism is a subjective judgement made by the person viewing the image. It was recognised early in the research that the analysis would need to demonstrate the accuracy of the spatial data to focus group participants and the eventual audience. But it was only after consultation with the working group that it became clear how other factors might inform the presentation of the data. The research found that many of the elements of the 3D model that participants commented made the scene 'real' (i.e. the Shamrock, benches and crane), were in fact the cultural artefacts and historic components of the site, which allowed participants to imagine themselves in that space. While this suggests that spatial accuracy could be regarded as less important by the participants, this is unlikely to be the case, primarily as the use of iterative participation meant that the participants were already well acquainted with the data used in the model and knew the reliability of the source of the data and the rigour with which it was collected and processed. This is where the strength of participatory realism lies, in establishing trust and creating an open platform for discussion early on in the development of the communication tool, so that the finished model or image acknowledges the cultural dimensions of the issue and fosters an understanding about the data presented; all of which appeared to generate a feeling of perceived realism in the model.

One of the main challenges of the research was making a tool which could ultimately be used to engage with a wider audience. For the creation of the film, two audiences were engaged, those from the community, and industry professionals. It was clear from the outset that the working group were interested in seeing flooding scenarios to determine the potential effect of mitigation strategies and policy responses to sea-level rise; whereas the community and business group were more open-minded. Ultimately, it was not possible to deliver a tool that accurately modelled spatial distributed hydrological flooding, therefore the result did not necessarily meet the expectations of that audience. The implication of this is that more still needs to be done to balance the needs and requirements of multiple audiences (if in fact this is deemed as a necessity in the first instance).

7.2. Implications and areas for further investigation

Having drawn together the conclusions from this thesis, a final statement can be made regarding further work that could be generated as a result of the above findings. The ideas for further investigation were generated continuously throughout the duration of the PhD, rather than being a result of the conclusions. These suggestions emerged during the project and stem from both the technological and social dimensions, including areas where the overlap has provoked an interesting result.

The literature on climate change communication shows that the emerging use of digital tools for communication and engagement is still a relatively niche subject matter. Often digital datasets are being used and developed within disciplines of surveying and remote sensing but are rarely picked up outside this area due to complexities with handling the data and equipment. Those who are using these data in other settings are still learning to do so in appropriate and meaningful ways. In reality, 'digital' is threatened with becoming as ambiguous as 'sustainability' in regards to its use in everyday settings, which will only serve to cause more confusion. There is a need for research to actively address the role of digital tools in climate change communication and other engagement and participatory processes. The capacity for digital resources to be used to respond flexibly to diverse sets of opinions and forms of input means that they should be used more widely to encourage participation from a number of groups, be they managers, decision-makers, local governments or communities; and as such, the application of such tools requires more attention in academic literature.

The field of digital storytelling is another area for further consideration. As Chapter 7 showed, digital storytelling involves the recording of personal narratives with the intention that they be shared digitally, and the process allows people to shape and tell their own stories. Although the principle of digital storytelling has existed for many years, the concept is not particularly advanced in regards to how it is used when targeting a specific issue, at least not in the academic literature. Moreover, digital storytelling can be constrained to one type of media (i.e. personal narrative to screen) when, as this research has demonstrated, a story can be more compelling if drawing on more than one source of media. Digital storytelling has the advantage of being able to draw on social and technical research and to present scientific data in visually engaging ways; coupled with personal narratives, there is scope for digital

storytelling to become an interactive, responsive and participatory tool with applications in many fields of research.

As digital tools are increasingly used to encourage engagement and communication with scientific data, there will be a need for clearer guidance and best practice for how to balance data accuracy and visual realism. The commercialisation of laser scanning as (1) a product for digital documentation in the cultural heritage sector and (2) a measurement tool for engineers and surveyors, has led to the creation of a 'black box' in regards to processing and tracking spatial accuracy once outside of the scanning software. The visual output of laser scanning data (often in the form of a point cloud) does not show the spatial uncertainty of the data and this can be misleading. Although cultural heritage applications have long used laser scanning to reconstruct artefacts, and therefore do cross the artistic boundary between technology and science, the amount of work produced on the spatial accuracy of the model when in a digital designed environment is still somewhat lacking and would be an interesting area to explore in more depth.

This work was centred around the use of terrestrial laser scanning as a tool for collecting quantitative 'ranging' data with an aim of describing the structure and arrangement of heritage objects in the landscape. The thesis highlights the applicability of data collected from laser scanning as appropriate to many different applications, but the main current limitation regards the high level of computing power needed to process the data; this is a barrier to further community participatory projects and limits experimentation with the application of laser scanning data in similar situations to the one demonstrated in this research. The workflow demonstrated throughout this thesis shows that complex computing methods are required to turn the raw data into an information product; therefore the uptake of this technology by others is often limited to technically experienced users. As the processes become less complicated the barriers to using this data will be removed and there is scope to explore the use of laser scanning data for further participatory study, not only limited to starting conversations about climate change. Where this research was limited, was in the offer for participants to curate their own scenarios. This is as much a knowledge barrier regarding use of the technology as it is an example of how this research was exploratory in its use of technology for participatory engagement in the first instance.

Appendices

Appendix 1

Product Specification for Leica HDS3000

System performance	
Single point accuracy (@ 1-50m range)	
Position	6mm
Distance	4mm
Angle (horizontal)	60 micro-radians
Angle (vertical)	60 micro-radians
Modelled surface precision (subject to modelling methodology)	2mm
Target acquisition accuracy	1.5mm
Data integrity monitoring	Periodic accuracy self-checking during operation and at startup
Laser scanning system	
Type	Pulsed (time-of-flight)
Colour	Green
Optimal effective range	1m-100m
Scan rate	Up to 1800 points/second (dependent on scan resolution and selected field-of-view)
Scan density	
Spot size	≤6mm from 0-50m
Selectability	Independently selectable vertical and horizontal Point-to-point measurement spacing
Point spacing	1.2mm
Maximum sampling density	
Field-of-view	
Horizontal	360°
Vertical	270°
Environmental	
Operating temperature	0°C to 40°C
Storage temperature	-25°C to 65°C
Lighting	Fully operational between bright sunlight and complete darkness
Humidity	Non-condensing atmosphere

(adapted from Leica 2004)

Appendix 2

[Visualisations shown at Working Group 2 – on USB]

Appendix 3

Working Group Two (25/11/10) - Transcript

Present

Amy: AN Joe: JL
Karen: KA Justin: JR
Caitlin: CD Helen: HV
Chris Caseldine: CC Eloise: EM
Kaja: KC Toby: TF

A: yeah it's the rendering that takes the time

Ka: but once you've done it, once you've created it, can you not save it as something simpler in terms of a video, like you can with jpeg, like once you've done your Photoshop you turn it into a uhh jpeg or whatever

AN: the what as in the...

KC: so that it's easier to actually you know if you wanted to make it online available

AN: yeah that's what it is, the film itself, well this isn't complicated, you could put this on YouTube really easily, it wouldn't take

JL: (over A) it's like a quick time movie

AN: yeah exactly, we've got, you can do this, I've got this same thing in like 5 different formats and you can use them for different things they all kind of work in the same way. The thing that takes time is the individual rendering, putting the light in the scene, so that's the thing that takes the time. So yeah, when it's all together it's a lot smaller.

CC: the balance of storage of computer power is the construction of it so when you're asking the questions about mentioning things like that it's the, its the, you've got to make it clear what the tradeoffs are to improve something against something else which will not be, well you'll see it in the end product, but it's not really a final product

JR: and that's automatically the question that I sort of think, like, you're saying what's the importance of having true colouring and all this effort that goes into rendering and making the scene really realistic [A: yep] and I can totally see it's really important when you're, when you're talking about site specific consultation and so forth. I'd sort of think that if you're working on, umm, a limited budget say, and you've got time constraints, what else could the technology allow you to achieve with the data that might provide a more quantitative answer to what, to a problem say if you prioritised your time and money and say ok, we're not actually going to be able to produce a realistic looking scene, but we're actually going to end up with more data about say tide heights at a certain point in time, uhh, at a certain location within the scene that we've created because I mean, obviously you know as soon as your umm, animating a rising tide then that, that has umm, applications to consultation with coastal settlements when you're trying to uhh, get across the, the impacts of a, a one metre higher spring tide in a hundred years and that sort of thing so...

AN: yeah I see what you mean, I think that's why we've split it down into the dynamic elements and the static elements because, that was why the scene. I have done a lot more than you can see in this but it's not all at the same sort of, uhh quality and level and that's why it's not all been shown but once that's done, that's the baseline and I think that's when we get to play around with the quantitative elements of this. So that, I don't think by focusing on trying to make this look realistic we're sacrificing any opportunity to do that. Umm,

because that's kind of why I want to get that done by February and, uhh, you know if not any sooner, I don't know when I can do it for but you know, the latest February, umm,

CC: yeah but the point is we're quite broad on, Karen and I were just talking about which is, and it goes back to your, what are you producing it for? If you're producing it for the public, just to look at and get an idea what it might look like, then it doesn't matter if it's fully geo-referenced. But if you want it as a real tool for detailed policy and detailed, then you'd need to keep that, and... and is it possible to do both? Such that you can create a workflow which allows you to effectively produce something which is effective for both purposes and rather than going off down one road, instead of going down another one or is there a point at which you diverge it, and you say, the public really want us to think, the public really want this sort of thing which means you've got to lose some of your geo-referencing or whatever. Whereas for the NT, they would like something which is a real management policy, structure... detailed plan which they can work on.

JR: and that's right, if you start to think about the wider applications, and that's partly why I'm here, isn't it, to think of it, you know, wider use and commercial use and sorry, think of the use we do with the EA to begin with the emergency services partners. They want to know where, where umm, during a flooding event where the flows are going to be deepest. And how they're going to manifest themselves through the built topography. Part of a real issue is that, so that it's quite exciting that you've got, if you've got like a very accurate surface model that's accurate to what? Within... what's the uhh centimetres [A: 10 cm, probably less than that] well I mean instantly you can go in and you can get a very accurate idea of what the flood depths are going to be like within the built topog, environment, within the built topography, at a certain stage of a ermm, theoretical ermm, extreme tide height. So I mean, that's a very powerful tool, and if you can, and I can imagine, you know yourself sit down and, you might be talking about flood risk at Perranporth then you'll have a table of people like this and you'll sit down and have a representative from the fire brigade, from the police, and if you've got this and say, well this is how it happens it comes down this street, forth street first, then its flooding in the car park, and then its running up the, the bolinge channel and then the perrancombe channel and, I mean that's got, that's really, really, really useful. But if you can go in and measure, and use it to actually measure depths and use it to have that quantitative answer so sort of say, how deep is it going to be..

AN: ok, yeah, yeah, well I see what you mean

JR: you know that's huge, that's hugely useful

AN: hmmm (agreement)

CD: this model would be able to do that, wouldn't it?

AN: yeah yeah, you could, I could, all you could is literally is a tape measure function so you can do that.

KA:so this is flooding from the sea, from sea-level rise won't it? It won't do any, it won't do fluvial flooding or surface

AN: no, no it's just, it will just simulate tidal flooding [K: yeah] because it's not an actual flood model, it's not responsive to the landscape at all or changes to that in any way.

JR: and of course it's going to give you depths, it's not going to give you flow pathways or, or velocity is it?

KA: or the interaction with water coming, you won't know what will happen with water coming down from, surfaces

CD: You can, feed these in with other models, like the EA models and that kind of thing and then say well with that scenario this is what will be like. But the amazing thing is that making the water rise is one of the simplest things that you do isn't it? Basically, pushing a button. So, once you have the model built making that happen is, is easy. It's actually getting the

models to the point where it has all the data that it needs in order to do that accurately, as I understand it. So that's not a big ask, as far as the...

AN: I think that. Yeah, I think that's what I failed to say in my first response was that, that, that's quite easy to do, once you've got the model there and ready.

CD: Amy can I just ask, you made a point about, umm, pulling in other information, do you imagine that being sort of little text boxes that would pop up in the video or kind of... how do you see that?

AN: Kind of yeah, that's kind of what I thought, because it's quite, otherwise were not really saying what's going on or why is this significant to, not just to the focus group but to everyone else, so I don't know what people think about that idea? But I don't know how it would be incorporated, but may be interesting to have that in some way.

CD: But it would be simple to do that? In the video? [A: yeah]where you could have.... so you could start way out, with, at the bottom of the river, below Halton Quay and then have a little story that starts, that then brings you in [A: yep] with frames of text? Ok. And you could even make the video so it sort of paused and moved you through, you can more sophisticated versions of this?

TF: So you could make little pop-up boxes which identifies location, because people will be interested in terms of, this is where I live and I want to see that, but it is trying to get that broader idea of...

AN: I actually made, I don't know someone might be familiar with Google Earth, and that's really good and I made like a short fly-through just to see what it would look like, because I can include, I can incorporate, I can include Google Earth, so I could zoom in from out of space, but it might be a little bit dramatic [laughter] to the UK, but I did this, and then thought no that's probably a bit overkill of the zooming and the flying and, but they've got in that software, because I can use that to use, just to do before we reach the LiDAR data which is at umm, umm, Plymouth and then in that you can put text boxes that appear and node point like Halton Quay I had a marker for and Cotehele and then I went up to Calstock and then around to Morwellham, and I think it's a really nice idea to have points like that, and then you know go up to Morwellham and it says this is a, you know because you've got several sites along this river which are really nice and quite significant and so it would be nice to pick those out.

TF: and I think ultimately it helps us engage with umm, visitors coming into the valley as well so from that perspective, people coming in might you know, if they know blimey, that's tourist attraction Cotehele, that's tourist attraction Morwellham, well wherever it might be then they can actually visualise it and think ok, I can I can I didn't realise this was the impact which it's going to have upon these particular areas and it's easier to give feedback and to sort of say, I, these are my views on this so we shouldn't be necessarily directly engaging local communities but it's also that broader view of more people coming into the valley. So it'd help that I think.

EM: What do you ultimately want the local communities to be doing with the information? That's what I'm wondering. Cos it's all like, it's good to show them, but you have to have a long view of what you actually want, how you envisage them reacting or what.

AN: Well I think that's what we've been discussing this morning, is that my project is about getting them to get involved in this project and getting them to think about what is happening at this site. Umm... but the long term vision is you I think, it's going to be up to the NT what they use this for. Umm.. and I think that's something you might need to ask Toby... to deflect that question.

TF: I think more than anything, what, where this kind of came from, from us was that we did a few years ago a coastal risk assessment where, we did it throughout, well the whole of the country umm, and they picked out hotspots of where we're going to have major problems in

the future, and Cotehele was one of those, in a high risk area. Umm, and what we found ourselves starting to do was to think, we've got to work out what is our strategy to change these areas, if these areas are going to be flooded on a regular basis, what are we going to do about it? And actually we decided to take more of a step back and learning from our Haymarsh experience as well about actually should we be creating adaptation strategies now or should we actually be saying what will it look like? And how do we therefore engage the communities to sort of say this isn't just about us and the impacts us but it's about the valley and the impacts on all of us, so how do we need to think about this? Let's start that conversation of what is it going to look like in 20, 30, 50, 100 years and therefore do we need to collectively think about it? We were trying to come from an angle of, right guys, lets kind of go on this journey together, rather than us, say what we're going to do, you're alright with that aren't you?! Umm.. it should be a let's start the journey and say what do we think we need to do? Cos a lot of, our core purpose is about delivering public benefit, so this type of model, I agree with Chris, is useful to have it from the management planning and policy making decision perspective to have that detail, but at the same time it does need to, you know your first question about 'what's it for?' my answer is actually both because it should be about engaging people in the conversation because actually the Trust is about providing public benefit at the end of the day. So we do need to think about, if this area isn't delivering public benefit, because it is under water then what are we going to do? What is our adaptation strategy?

EM: and so you want people, local communities to inform the policy and planning? So you can't really separate out the two then if that's the case

AN: Well I don't think it's just about, well I don't know what, what they want but I think, what I've seen and this is more about my research in general is that a lot of what is generated in terms of visualisations is just for planning and policy and I think people are getting a bit annoyed that all they keep hearing about is 'we've made this to show you, to, so that you understand why we're doing this' which is kind of, you know, like, this whole approach of we're telling you this so you understand so you don't get annoyed at us when we do something later on. Whereas this is more about opening up a discussion about this, getting people thinking, it's not about saying we're doing and we're doing this so later on it's less hassle for us.

EM: but it is still you want this, from your point of view, you want them to help you decide what to do about this isn't it. Even, even if that's do nothing that's still a management policy. [T: yeah absolutely]

TF: but it's starting form a baseline of rather than us saying well these are all of our options and we want you to help us pick one of them we sort of saying well look, this is what the impact is likely to be, it's opening up that debate to say what do you think we should do about this?

EM: I, I, I just think it is still, effectively [T: it's not trying to force a decision], in the long game, no but it is obviously, as an organisation you need to have a management strategy in place, now how you get there would be local engagement, but ultimately, the end game really is, this is going to happen, we will need to deal with it at some point but we need the local community to help us decide. [T: yeah, yeah]

CD: but also I think there is an opportunity here for whatever the local community is to say actually I don't, I really want to see what's going to happen using the LidAR data up here as I think it's really important for us to take this view, or I want the movie to, to go, you know I want it to show these three different scenarios working a hundred years out. So there's nothing fixed about what that model gets used for and I think that's a really important point is that the answer to that question umm, what is the function of the model in the long run is partly going to come out of this consultation process because people will offer their own umm, their own opinions about that, and everyone will have different ideas maybe about what they want to see happening but it's about a collective construction of the tool as well as

an application of it, I think and that's the role Amy has here which she can take it and say umm, you know it's not the sky's the limit but there are certain things which she can make it do that makes it quite responsive.

EM: I just think at this stage then that would you want to go too far down wither route

AN: well yeah, no, that's why is this working up this base model kind of thing as in that way it can be as flexible as possible to the first meeting, to what you say now and to what I hear in February

KA: I mean if you get asked to do a community consultation, including Calstock for example which has very clear issues, individuals, houses, in the fairly short term future, you could well be opening up a can of worms and find yourself in a very awkward and uncomfortable situation, which you haven't necessarily got the support to be dealing with the issues that are going to be raised.

[TF: send Jo in] [laughter] [EM: Jo's very good at diffusing personality]

CD: I think that's part of the reason why we've re-jigged part of the shape of this project

KA: It's a shame the EA aren't here in order to inform some of that

CD: I mean if you think about that...

KA: you must be finding that with the SMP in Cornwall aren't you around here? The fact that it's a bit of a political hot potato but also that it's raising immediate fears about people's major investment, their house.

JR: oh yeah absolutely, we got a lot of comments saying, well that's it, you've blighted my house, so I can't get insurance, I can't sell it [KA: well yes it's your fault] and you think well it's serious, but there there [K: for showing it in a picture] and it's a massive picture about how we represent these things in, in, in public documents. I mean but it's information we've been paid to model recession of the cliff line

KC: well it may be but that hasn't not gone public yet purely for that reason

JR: yeah, but it is going public, it's available for everyone to see, I mean I've

KC: it may be available but it has not been taken to the communities that are going to be affected is it at the moment

JR: well yeah it has been we've done a full engagement, with the whole, with, with, all of the public we've been to, we've been to places like Donderry that's very affected by erosion, we've been to their village hall and I put up maps on a screen showing how much I think their coastline is going to erode, and which houses will be lost. So we took the decision to go and do that. Because there is a wider project called the National erosion, national coastal erosion mapping project which was being done by DEFRA and Halcrow and other consultants, and they have, initially it was planned that it would show erosion risk for the whole of coast of England and Wales and they would show lines on maps, but they've backed away and backed away and backed away. And now they're not going to show any maps, it's all too political, we can't show these, and well we've said this is ridiculous because the SMP, because they're all coming out and they're all going to show lines on maps, well they're going to show bands of erosion risk. But people's houses are still going to fall within a band, even if not saying this is, because of course we can't say the coast is definitely going to erode in this position, because the biggest thing we're dealing with is uncertainty and how we, how we deal with that uncertainty is a real issue as well within what we're trying to show because we don't definitely want to say it's going to erode to here because we could end up blighting properties unnecessarily. But at the same time we have got to sort of try and present not necessarily the very worst case scenario but you know a low and a high scenario, is what we've got within Cornwall and we create a band of erosion risk based upon a low and a high scenario.

KC: so given that do you think I'd be safe for this just to be confined to areas like the NT, places maybe like Morwellham, and other places like that, where you haven't got all those concerns about the other communities and the way that the...

JR: well the communities will want to know, and in some cases

KC: they might well do, but that's not the role of this project

AN: for that reason we deliberately stepped away from scanning Calstock, we talked about it originally, and obviously it's not NT, you know and you wanted it to be broader and that's why we used the LiDAR because you know we're not going to flood anyone's homes essentially, and what I was really surprised about at the Charmouth meeting was that they used the scenarios and they sort of said, and I was expecting everyone to be like 'oh my god my house is going to fall off a cliff' which is essentially what they're saying is going to happen. But because they were already aware of it they were just thinking, alright so what do we do about this? There was no panic and I think, I don't know, I think it kind of depends on the community and if they're aware of it already. You know if it comes as a shock then yeah there are going to be some problems but they...

KC: well at Charmouth they are aren't they because it's a pathfinder project

AN: yeah exactly, but I know Calstock floods, it does flood, you know I don't know how regularly but fairly frequently, frequently enough that people are aware of it. So I don't think it's going to come as a surprise. And even if we're talking of this site, then they might think oh god we might flood a little bit more I don't know, I think that's why Helens really important to have in this project because...

TF: well they should have been consulted through the south Devon and Dorset SMP because that's where the community of Calstock will fall within that SMP

KC: well on paper I think they had the opportunity, but I don't think anyone took up the opportunity to go to any of the meetings

JR: I don't think it could be the place of this project to try and start... you would just be going waaaay off the beaten track if you were trying to do that wouldn't be fair on...

CD: that conversation

KC: so we are focusing just on here then? Cos there other sites that have been discussed

CD: well that was the decision not to scan in any detail any other sites partly around these, in a conversation with Ros actually months ago, but I think I mean one thing that could happen is these 6 movies, scenarios that Amy develops that are finished this summer out of the consultation with these groups of people could, just go up on YouTube and then any group that wanted to go look at that could draw it down. They could look at it in Parish Council meetings in an AONB, I mean this is just here, we can do with it what we will, and it's actually our responsibility to use this to visualise the future but there's no one leading us on this, it's not really owned by at that point, and that actually might be more appropriate than having, the Trust could display it here in the discovery centre and it could be there as a resource and that's something that we've gone back and forth about it we're not quite sure whether people will need more context for it, but in some ways as long as they're as good and accurate as they can be that might be the most appropriate thing to do with them, just release them. And see what people make of them, see there are a lot of people....

EM: you could always write to the Parish councils as well just to say this is here

CD: well they probably be involved in the focus groups anyway but I think in some ways, that democratic like, alright we did this there are a lot of different things you can apply it in and actually you could probably come back to Amy and say we want a different scenario, you could put it on YouTube. You know, actually, I'd like to see this version.

TF: do you think the great thing here is that it could easily be viewed as independent data? So it's not the EA saying to communities 'right this is what is going to happen to you' this is actually completely independent, so it's not somebody forcing the issue from that perspective, it's ahh. I don't know, is it just easier to bear? In a weird sort of way.

CD: if you have a meeting in the value, someone has got to run the meeting

JR: it should be, you know the Trust has quite a unique position really, in that you can present that independently, with that independent face and you can say well this is, well we're just saying it how it is. We're showing it how it is. You don't have any responsibility to protect anyone's homes from flooding, you've got a responsibility nationally in terms of you know, making sure that that dialogue takes place, as to how you know we manage the heritage and so forth, but when it comes down to individual communities and individual householders you're removed from that sort of umm umm.. responsibility aren't you. So you can just present things and say this is some research we've been doing. And part of what you're doing is trying to demonstrate the power of the data that you're using, and the software as a technique and a workflow. And that, by definition you need to have a very site specific focus to sort of do that adequately I think if you're trying to get into different places.

KC: with 6 films then, what are we talking about, 6 different locations? We talking about 6 diff [A: one location] 6 versions of Cotehele

CD: but the stretched out landscape does run from Morwellham past Halton so the coarser grained detail is in a much larger scale, so you could watch water come up and down in that... it doesn't just have to happen here.

KC: so those 6 scenarios would also apply for the LiDAR down there?

CD: they could yeah, well Amy can make her camera wherever

AN: I could yeah, we could do that, but I would be slightly more reluctant to do that, because I think you could show it because I wouldn't really want to focus on doing it for the whole of the Tamar just because the resolution of the mesh isn't as good and you know you don't want to start losing the detail because it's not as accurate and I just don't want to necessarily say to people it's going to flood here or whatever on a LiDAR scale

K: so you talk about scenarios then, what sort of scenarios do you mean?

AN: so, literally I was thinking this is very open to suggestion but having, like, one scenario for example, which is an extreme event that occurs in 2050 or something

CC: I think you ought to keep the dates out, I think if you just say the scale of the event, I'm slightly worried about the legal side of this too in the sense that it's quite easy to say 'if we had an event of' this magnitude this is what would happen, and not say this is predicted to happen by 2050 because then you go into issues which are

JR: but I think the most powerful of representation, scenarios that you've got is just modelling mean high water, so to say this is mean high water for spring, and you do have to use a date and this is mean high water spring in 2080. So this is going to happen twice a month and show it in that way, but you do have to say, you do have to apply a temporal resolution to it then, because you're applying a climate change factor by saying, we've increased mean sea-level by... 72cm of whatever depending on the date you've picked. Because of course its impressive when you, umm, represent an extreme event, a one in 100 year event or 1 in 200 but it is difficult getting across the fact that this is a probability and that's the thing we always have difficulty with, because we always used to be, we used to say it was a 1 in 100, but now it's like a 0.05% probability or its a 1% probability or a 20% probability, but people still have difficulty getting their heads round what that means. Whereas you can just say that's what high tide is going to be 2050 or 2100. I think that's the most powerful representation you can get because then there's no arguing with that.

Obviously there is still uncertainty because it's still based on future predictions of sea-level rise but

AN: so for example our little scenario one little film would be, would be that, would be showing that that is what the tide is going to be in the future, so that would be one. And the way I was thinking of doing it would be set a camera up running from above the site, and have a whole day so you see the water go up and down throughout the course of a day and showing what it is now and then what it will be and I think that would be one scenario and we'd think of a couple of others [K: such as..] such as extreme events [K: such as an extreme event of 50 years time] so exactly, I know when I came up the other week, I was talking to Jo and another chap, Peter about how when there is heavy rain, I know my model cannot respond to the landscape but I can make an interpretation of what happens, and I know that the levee, it breaches the levee and the car park floods, and this kind of thing. I can show that, what it's like now and I know they measured it and it was 5 inches above the corner of the workshop and I can say, well if this happens again in the future, this is going to, with anticipated rise in sea-level, and perhaps increased precipitation, but I don't know whether or not I can be able to do that yet. You know we can say it's going to increase by this much. I think that's something else I could look at doing a scenario of that kind of scale.

JL: you've got historical events too Amy that went on, you know you go back x number of years and there were some very high tides you've seen one or two of the markers about, I mean another one just to chuck in there is the difference as an educational thing is the difference between neaps and springs, do people actually understand the difference between a neap and a spring? And you could quite easily show the difference between the neaps and the springs, within a scenario like this. So it has a very visual and fixed understanding. And I would have thought that the idea of prediction I can understand, and I must admit that this wasn't a side that even crossed my mind about, wow, the sort of political areas you could delve into with one of these things, but surely though you must be able to show that, the figures we have at the moment show the tide rising a level of so and so, and this is what it's going to look like. That doesn't get you into trouble does it?

[general chat 'it depends what figures you use']

JR: then you just use the DEFRA figures for it, based on the UKCIP, but then that's their sort of nationally recognised. They've built in a bit of a precaution because they're kind of based, well they're aimed at engineers designing defences. So there's a bit of free port built into those. Well you can explain that anyway to people, these are precautionary and they have a bit added in for that reason. So you're towards the higher end of the scenario rather than the lower end of the scenario, but that's easily explained. And you don't get into trouble using figures generated by central government generally, because you just point the finger and say DEFRA they said so, well that's what we say. If people come up to me, then I say, well we're using DEFRA figures, that's what we're asked to use. Makes sense because then there's consistency, they're probably not the most scientifically accurate figures out there, values out there but they have a basis on designing new defences, so it makes sense to use those. Umm, and you're always going to get someone who will argue, but as long as you've got that sound basis and you bear in mind why you've used them then I think you're on pretty firm ground.

AN: That would be something to include in the models and I don't know where but that explanation of how we have decided this because obviously the focus group are going to know because we're going to talk about it, but how we actually, if we put it on YouTube it'd be great but people are going to be like 'that's great but...' where's there a greater explanation of this, and I don't know if there is potential to put it on the NT website [C: put it on Joe's countryside blog]

CD: can I just throw some options, because Amy can remove buildings, so you could run a scenario that didn't have the discovery centre in or a scenario that didn't have the levee in it.

JL: we tend to get hitched up because we're based on the river so we're suddenly talking about the tide all the time, you know I can see other benefits from it as a fly-through pointing out specific parts about the quay. So... talk about limestone burning, this is where the Shamrock would come up and be tied, or not the shamrock, but a barge and tie up. This area would have coal dumped on it, this area would have... because these are quite specific things that can be pinpointed quite easily so similar to what you were saying, a fly-through where the animation stops, text boxes pop up just to explain that little bit you know and point at different parts of the quay. Saying this is what was involved in limestone burning...

[31.18] CC: could you have it so that a nice sort of gentle, this is what it is nice little technique that shows you. And you do that with the tide going up and down as it is [general chat] and in 50 years time this is what it's going to look like. And that's a nice gentle introduction to oh god what are we going to do? That might be quite an effective tool, by just doing that.

[31.42] JL: because you see these guys who worked on this quay 150 years ago would have been affected by the tide greatly, they would have had to organise their life around the tide so you know you wouldn't have been able to dump coal there or something at certain times of the year.

[32.04] CD: one of the things we talked about in the upgrade panel was actually that people have a lot of memories of extreme events and all kinds of things that happen that there is a way you could make one little movie that was just about capturing these memories. So you could have, stop at different points along and have, I don't know if we could have audio but you could include a sort of voice over where you have a short interview with somebody saying in 1998 I saw the tide come up to here and we could stop in the movie there and move on. So capture some of these ephemeral things which, that are more really about the community making a narrative that makes sense for themselves about it.

JL: you see when you talk about local community; you see this is well used quay by people from Callington, people from some of the other villages, all coming down. They would congregate; they would talk, with all the various products going down the river. There's a little story to tell in there as well.

[Ch brings the conversation back to focus on what should be expected from my PhD project]

TF: I'm wondering whether there is something really important there about what Joe said about people connecting to heritage in a very broad way to sort of have those narratives of people from the local community that probably have lived here for 60-80 years doing there bit of, well actually in the past, that then makes it kind of a different emotional response when they see this is actually the impact. This may broaden the conversation or eases the conversation, or makes it bloody hard. I don't know whether that actually feeds into that next bit quite well.

CD: you could use those focus groups to do that, there's no reason you can't collect those stories at those groups.

[34.43] JL: but it raised again on a point you said about Amy and the PhD and obviously we mustn't lose sight of that [laughter], but it raises the question of ownership of all of this and where does it sit? Is there a possibility that that basic model can be given and we find the expertise and software but you are there to advise and talk it through and that sort of thing. [coming up with scenarios is easy – it could be made available]

AN: [that's a nice suggestion actually, shows how it can be applicable to other sites]

CD: How feasible would it be to deliver a package to use itself?

JL: getting software as a charity.....

AN: getting to grips with the software is more difficult, it is feasible. Getting someone to give you the model

CD: [suggestion of using the MSc]

KA: that would be the next step, assessment of the value of this tool being used by MSc students

[chat about MSc students]

TF: from my side of things, this is really powerful tool, and getting back to your point needing to use it, because if it's a toolkit that can be used, for the Trust its massive, considering the number of sites that can be used

KC: presumably this can be used as a catalyst for sites that will be affected, and particularly if we lose that car park how do you feel about the car park moving will we use these bits.

TF: with the shifting shores document that we had done. And if we're being mercenary about this we've got to think about the financial impact of this, and if we don't and we go belly up with have a tremendous liability.

K: so what would need in what Amy does to start a dialogue with the Las, DEFRA, SMP budget etc.. a hidden agenda for what this work could do. Amongst decision-makers.

TF: well I think we're going down the right route at the moment, in my view we want something that informs policy, but it needs to have a certain amount of emotive factor into it. For me it will naturally be an emotive topic, in terms of the detail, my view is it should have asset level of detail, for tcc.. if you can capture the bench near the wall. Doesn't have to be all of them

JL: you only need the key points, picking up on the things people will miss

TF: throughout the course of the year the little bench next to the shed there are always people sitting there. This draws out the emotive response. Questions of how often will this happen, this starts the broader dialogue

JR: this is what will take the time at the other sites, [the emotive factor] could put a Manuel together for how to do this, most sites will have liar and you'd have to decide what aspects of a site you can do quickly. If you can actually represent the surface in x, y z you're almost most of the way there. And orthophotography can drape it on a surface model and that program (CCO) has just got more funding.

KC: there are number of observatory (CCO), Plymouth Uni they handle the data from the SW.

[chat about CCO]

47.20

A: what do you want to see? [discussion about features]

TF: wouldn't be worried about features

JL: most people would look at that [the model] and recognise it anyway

CC: and its having the recognisable features for rising water

TF: like the steps up the discovery centre, in terms of detail on buildings, I wouldn't worry too much

JL: little things like the tyres look good

CD: this is relatively grainy but it doesn't need to be changed much

AN: the buildings need to be there

KC: people who aren't familiar with the site, there are no reference points so you wouldn't know how high things are

AN: there will be a bench in the picture

KC: the granite bollards would be a useful marker

KA: and the ladder

AN: I hadn't thought about showing the scale

[chat about scale]

53.49

CC: something else you raised was the length of time for the animation, depending on how you'll use it

JL: but if you're running a fly-through with stopping it's not going to take as long a time. You could end up with a 5 minute video with 3.5 minutes text and 1.5 minutes of animation

AN: is a minute and half too long

CD: people should be able to pause them

TF: one good idea is to re-design a historic flooding event goes over a tidal cycle. If you can accurately represent this in 4 minutes then that would keep people satisfied. That may remove cynicism

KA: you could pick up a photo from that time

[CD: MSc student may be willing to collect the lay knowledge aspect of this]

TF: [Joe is key player in the community]

JL: haymarsh flooding, people around who remember that. There are people around.

JL: the NT staff and volunteers would be interested, that would bring another side to things, and I think they'd be really interested to get thinking. They good feedback into this.

HV: [limit numbers] quality facilitation

JL: I was thinking about a special thing for Cotehele people

TF: I think we'd get a lot of interest here [200 volunteers] do we do 4 over the course of the day

Appendix 4

[Visualisations shown at Focus Group 1 – on USB]

Appendix 5

Individual feedback sheet (FGs)

Community and Business Focus Group

3D Visualisation at Cotehele Quay – 23rd March 2011

On your own and then in groups, please consider the following:

- How could the visualisations be improved to be relevant and useful to the wider community?
- What local organisations do you think would be interested to see these?
- How long should they be to be interesting and accessible?
- What other situation / scenarios might be useful to see, e.g. historic flooding events, mean high water and low tides, etc?.
- Any other relevant thoughts / reflections about the project and its potential.

Name and contact (optional)

Thank you!

Appendix 6

Handout, Visualisation One

Visualisation #1

Regular Tidal Cycle for the 14th March 2011



1. Tidal cycle 23rd February 2011

Duration: 35 seconds

Temporal Context: 9 hours (0700-1600)

Tidal Cycle:

Low: 0344 0.3m

High: 0921 4.5m

Appendix 7

Handout, Visualisation Two

Visualisation #2

Example Extreme High Tide Event



2. Example extreme high tide event

Duration: 25 seconds

Temporal Context: static

Tidal Cycle: No tidal cycle

Extent: Up to a 6m tide (2x annual event)

Appendix 8

Version One - Full script: 'Changing Tides at Cotehele Quay'

Shown at – Focus group two, public viewing, working group three

Cotehele Quay is located in the South West of the UK, in the Tamar Valley on the Cotehele Estate. During the nineteenth century the quay was used for the transport of agricultural and mining-related goods up and down the River Tamar, to Plymouth and beyond. The National Trust now owns and maintains the quay and its historic features, which include mooring blocks, cranes, former sheds and warehouses, lime kilns and an inn.

Cotehele Quay has a history of being affected by both tidal and fluvial flooding. Changes have been made over the years to protect the site from periods of extreme high water.

Most people who live or work on the River Tamar will have experienced a flood event during their lifetimes

The highest tides occur twice a month on the full and new moon—these are called spring tides. When adverse meteorological conditions coincide with high spring tides the likelihood of flooding in the Tamar Valley increases. At the moment, high tidal waters overtop the quay almost monthly. People who live on the river often document high water levels with photographs.

Cotehele has suffered many extreme flood events, both during the quay's hey-day in the mining era and throughout the 20th and 21st centuries. Many of these historic flood events have been well documented, and records can be found in the Calstock Parish Archives. A flood in 1866 was particularly well recorded, as well as major river and tidal flooding throughout the latter half of the 20th century.

Although we can't know exactly how the site was affected during the flood event in 1866, we do know that similar events have had an impact on the quayside and other sites along the river since then.

One way of understanding and comparing how past and future flood events affect the site at Cotehele, is to create a virtual model which allows us to reconstruct past water levels and enables us to imagine what projected increases in tidal heights would look like.

The model that you will see in this video sequence has been generated using advanced surveying techniques that allow us to capture the three dimensional nature of the site. The resulting model seeks to find a balance between spatial accuracy and visual realism.

Using laser scanning technology, data have been gathered of the buildings and quayside at Cotehele. This dataset is precise to 5mm, meaning that the relative positions of objects such as windows and doors on the buildings are geometrically correct and appear true to life. When registered to Ordnance Survey mapping co-ordinates, the model is accurate to within 10cm of the actual ground surface position.

This three dimensional model has been designed as a tool for facilitating conversations about past and future change on the quay

Extreme events such as flooding can generate strong emotional responses and have a dramatic impact on the landscape. However, it's perhaps the everyday tidal cycles which will have more frequent and noticeable impact on Cotehele Quay in the future

Records show that globally the sea level has been rising for many years. Due to glaciers melting at the end of the late glacial maximum, about 12,000 years ago.

In the south west sea level has been rising by approximately 2mm a year. To add to this background trend, within the last 50 years accelerated glacial melting and thermal expansion of the oceans have begun to increase the rate of sea-level rise.

The impact of accelerated sea level rise on Cotehele Quay will be most obvious with the change in average levels of spring tides. We can calculate that in 1866 when the dramatic flood event occurred the mean sea level was 29cm lower than the present day

Tide heights are measured against chart datum, which can also be described as the lowest possible level of the tide. At Cotehele Quay, an average spring high tide looks like this, measured at 4.8m above chart datum. To compare the model to a real world situation the image on the right was a predicted tide height of 5.1m.

By 2050 an average spring high tide not affected by other meteorological forcing's could be 11 centimetres higher than it is today. This estimate is based on the most conservative possible reading of SLR projections, drawing on findings from the UK Climate Projections report produced in 2009.

People familiar with the river's cycles suggest that increased rainfall and low pressure systems can add up to a metre of water on top the high spring tide levels.

Life on the river will need to adapt to these new circumstances...

There is some debate about the magnitude of SLR in the more distant future. Some studies suggest a worst case scenario in which sea levels could rise by almost a metre by 2100. This means the level of water inundating the quayside at Cotehele could increase to as high as 6m on an average spring high tide. This means the quay could potentially flood several times each month, limiting access to some areas of the site and damaging buildings and artefacts. An extreme event with an additional metre at high water would have potentially greater consequences

Appendix 9

[Visualisations shown at Focus Group 2 – on USB]

Appendix 10

Individual feedback sheets (FGs 2)

Individual Feedback Sheet

(Responses on individual feedback will be kept confidential)

What are your initial thoughts on:

The general content of the film?

.....
.....
.....

The realism of the visualisation?

.....
.....
.....

The science behind of the flooding scenarios shown?

.....
.....
.....

Perceptions of the film:

What changes to the visualisations can you notice from the first meeting? (if applicable)

.....
.....
.....

Do you feel your comments on the first visualisation were addressed? Explain.

.....
.....
.....

Do you trust the information presented to you in the film?

Which events that were shown in the film can you relate to your own experience?

After watching this...

Do you feel you have an improved understanding of the potential impacts of sea level rise at Cotehele Quay?

Would you feel comfortable to engage in a conversation about flooding at Cotehele after having watched this film?

Other thoughts

Do you have any other comments to make?

Appendix 11

Transcript for FG2 (morning)

Morning Session

Helen Vines HV

Dorigen Couchman DC

James Robbins JR

Jamie Lang JL

Mike Bygrave MB

Clare Sanders CS

Simon Bates SB

Pete Bouquet PB

Name	Transcription
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HV	What do you remember from the film?
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PB	mainly I remember the old pictures from the flooding and id have liked to have seen the pictures for a bit longer, it's just personal preference
----	--

MB	I remember the projections of what the effects are going to be, and how high up the sides of the buildings a really serious high tide will come.
----	--

CS	they could have been a bit longer, I suspect you're very familiar with these, if you're not as familiar that makes the juxtaposition between existing high tide and projecting high tide, takes some time to sink in. but you know, it's important.
----	---

DG	When there's a 4.8m tide, is it always as flooded as that? Or does it vary a lot?
----	---

AN	These guys can probably tell you better than I can, but I think it varies quite a
----	---

lot dependant on the other weather conditions. [explanation of reasoning behind choice of 4.8]

DG well there was a 5.1 the other day and I was wondering if this was as flooded then. It would be interesting to know the variation

To see you know, if every time there's a 4.8 is it as flooded as that.

AN Well you guys probably know that better than I do.

JL you probably have to show a bit more of the area to do that, you have to go up into the meadow and look at the car park. I don't think it quite honed in on that. That's the most dramatic when it gets flooded and it breaks the levee.

CS well how often does that happen?

JL Well Mikes been here a long time. Well since I've been working down here in this department, about 4 times its breached the banks in the last 10 months

MB I think you have to be careful about the car park Jamie, because in fact the level of the water is below sea level and when you get a high tide in the river I'm told and I can see what happens, the weight of water in the river presses water down and it comes up as squirts in the car park, and that's not quite the same as flooding. I've seen that many times. [recollection of mending a post] this is the same as the reed beds. It's amazing.

JL I think there have been 3 breaches of the levee in my time down here.

MB they had to close the footpath

JR was in 2008 when the car park and field flooded, and we walked along the levee and you couldn't tell which bit was ...

and that time when we gathered down here for the highest tie of the whole spring series and people were rowing between what is now the quiosk and the discovery centre, you could get in a boat and row down there.

JL yeah like mike was saying, the posts in the car park do go up and down you do get that.

HV ok, so anybody else, images, words that you remember, that stuck in your head

SB I was, perhaps because it's something I'm interested in, but the fact that

you've got some information from the parish archive stuck with me, the flood event, the fact that there was someone there to record it

AN well actually, the reason I went there was because of the first meeting, people said, these things have happened before, we'd love you to research this, so that's why I went and did that. No there's a lot of data. [comment on 13th flooding event] you have all these records going back hundreds of years.

SB that is interesting, because someone was telling me that the duke of Bedford estate on the Devon side there's a lot of documentation there about events, wind storms and also things like mining dust affecting the value of his timber. Because it's an estate everything's documented and I didn't think that might be the case on this side. but it sounds like it might be.

AN that's not the only archive either, I just was only able to visit that one.

Pause

HV so any particular new pieces of information that stuck out

DG I didn't know that the quay flooded

PB I think it was good, because at the first one I was concerned, well not concerned, but it wasn't put into context, as so much now. You've done that now, I mean globally.

AN do you think that's important?

PB oh yeah, for me it is

AN do you think we could take that further, or is it ok as it is?

PB depends what you want to do really, what the ultimate aim of your project is. For me it's important that that message is spread as widely as possible. What's happening with climate change.

CS what do you imagine your audience to be?

HV well that's what we're going to talk to you about a little bit later on, anything else people learnt from the visuals of narrative

PB Well again, what was shown historically, I didn't think it was as extensive as that in the past. And there was pictures with the viaduct in the background, that was quite impressive.

what has been done there

SB what date was that image? The one with the car?

AN there weren't dates for any of them, I think that was the 1970s

SB so the flood banks were in position then?

AN well there was a big event in 1979 that that might have been related to. I think the flood defences went up early 80s

DG how the EA been involved in your project at all?

AN I had another meeting with people who are involved with organisations that deal with flood data and a representative from the EA has come to previous meetings, but it's been quite similar to this in that I've asked their opinions and on what they think, but the last time I saw them was back in January, which was actually before I created this.

CS I'm interested in the fact that people need to considering the consequences of their actions, so when you were talking about the flood defences going up that just channels the water into different places, and therefore it increased the flooding in different areas. I think that's important if you want the focus to be on impacts and consequences, because it then leads into projects about the reed beds and how you actually manage what this potential increase is going to be.

PB because opposite Calstock, there's a bank, all the way down around the sharp corner in the river, do they leave those places to flood before?

or did they just accept that they were going to flood?

BP well that banks been there a long time, it's been there about 100 years.

DG well I know that in the 70s, the whole of town farm flooded, which is the area from the village hall all the way up around those big flat fields. That was flooded, because that's when my house flooded. I know the people who lived there and they got canoes out and were boating around

AN so are you quite aware of the fact that you're being defended? Do you feel quite well protected from things that are happening?

DG I know it's there I know t has flooded before

CS at the moment it seems to be working and where it isn't is by the boatyard and that's when the water comes up. I'm also quite glad I'm not actually living right on the water front

MB I know Jamie and James will remember a few years ago when there was all this eruption about the NT wanting to flood the plains down here, and there have been several quite immanent people who have said well just wait a few years and the rising sea levels will do it for you. I don't know, they're artificial banks, because that used to be a floodplain down there anyway. which is why the grazing down there is second rate, because there is still a certain amount of salt in the ground, the grass doesn't grow too well. for those who don't know, the NT wanted to knock all that bank down and flood the whole lot, eventually they withdrew, mainly because they found out the information they were getting wasn't quite accurate. that probably will flood anyway.

PB Why did the NT want to flood it?

MB it was when we were trying to get otters up here. Otters need water voles to prey on and water voles need so many km² of reed beds in which to breed, and that was the whole idea - am I right?

JL I think there weren't actually target species, it was the habitat and hopefully they could have had bitterns and it would have been the biggest reed bed in Cornwall and just have everything else, with the loss of reed beds it would have been, you could increase it again. and also the flooding aspect of it as well. but the reason the NT pulled out of it in the end was because the accretion rate was going to be a lot slower so it would have been a lot longer to return to reed beds than they thought so it would have been mudflats for a longer period of time and that is what a lot of local people objected to. a few people making a lot of noise. they made themselves known. they also realised that they would have had to build structures. they are thinking of a slightly watered down project now that may make lakes and things within it, but obviously now, with the SODITT input they have to be really careful where they tread, but NE are going to be involved with it with the farmer. NT are stepping back, they've had a consultation day up there about a month ago.

HV Having seen the film, how did you feel at the end of the film? Excited, depressed, asleep?

JL	aware
JR	knowledgeable
SB	I felt pleased I think, as someone who doesn't live here, but please for Amy as I think this is a very challenging piece of work technically, socially and I was thinking that was a good job.
HV	Simon when you say challenging, do you mean as well as the technical stuff, do you mean the content?
SB	no not in that respect, its challenging to get the balance right, the right amount of information, in plain English, it's a real challenge, it's difficult to do. Because my notes here on first viewing I thought, it needed more about the background on why the sea is rising, of course on the second viewing you realise that you have talked about that, but it has the graphs in the background and I think I was distracted by the graphs, I didn't actually hear the explanation.
CS	I don't want too much of the this or that, background to the data because I think there are a lot of people who do a lot of studies with data and analysed at statistics and if you look too closely then you get confused. I thought it was quite balanced view, but you didn't major on any of the vagaries of the data, so the impression that I got was that this is going to happen and to do something about it so it was successful to me in inspiring me to think that I really should find out, does the village have a flood action plan, what are we thinking of doing what are the options and consequences.
HV	Anyone else?
PB	yeah I was pleased because, yeah, you don't want to hear all the in's and out's of the science, a point of a mm or you know all the rest of it. You just want someone to shift it through that and tell you that right, this is best thing that we can believe from all this data because for everything you read, you can read something else as well, so you have to start from a position from either believing it or no. so I think that, people who perhaps don't believe it, although I don't know if there are people who don't believe it, well you know on a local level, people can look at it and say you know well yeah.
AN	how do you feel about me picking what you see?

PB well there's no other way of doing it is there really? Unless you make a film about all the different data on climate change. You've got to start somewhere.

CS it depends on your objective as well, if your objective is to make a visualisation that talks about the inevitability of rising sea levels and what you're going to do about it, then it's perfect, if your objective was to put the Tamar Valley in historical context then you would've included different information, so to some extent you have to trust any journalist to look at what they're trying to do and pick out the information that they need.

SB I felt comfortable because you presented the range of possibilities, and extreme possibilities and least worse. I know that there is now the range that is given by the climate projections and you were playing that back to us.

CS What's the difference between now and the 13th century though, if it's been doing it for all these centuries.

AN fluvial flooding has been happening for centuries but now the water will be higher.

MB there is just one thing that confuses me about the whole subject and that is that. There have been periods of climate change since history began and we've gone through extreme cold periods, we're going through a warm period. Nobody knows why these happened, are we able to project what the climate is able to do forgetting man made CO₂, we can't even forecast the weather next week. that's what confuses me and perhaps you could have introduced a small piece about that. I see films about Alan Titchmarsh standing on a mountain saying 50 million years ago this was underwater, fine, but can we also include a form of climate change projections. is it possible to show climate change?

AN well actually the ipcc reports which you looked at they do actually have projections of future temperature change and CO₂ increase, with the anthropogenic, the man made input and without, and all of it is rising, so that climate variability that we're seeing, thousands of years, we see the climate changing. what we're seeing at the moment, which is what scientists are trying to show is that there's been an increase in the rate of everything. so increased CO₂ in the atmosphere, increased temperature rise, which we have seen for thousands of years, which is why there is the anomaly currently in these records. and it might mean that in 2000 years its nothing, but obviously we don't know right now, so we're going on this estimate that this isn't right,

because we have these records from thousands of years ago, but this doesn't fit in the pattern which we've seen.

MB the one thing that people often quote is that 150 years ago, is the Thames used to freeze over regularly is why we have it on our postcards, and that's not so long ago.

KA I think the key distinction, is that there is always an underlying change in the system and this is caused by things like sun spot cycles and changes in atmospheric CO2 which is driven by natural factors, but the key difference in the last 10 / 20 years is that the rate of change has been unprecedented in terms of the speed of which we've seen the number of years where summer temps have broken a record or the number of years we've seen rainfall increase year on year. and in terms of the kind of statistical significance of that, the last 20 years have been quite exceptional when you look back, against the last 200 years. maybe that needs more time given to it in the film.

MB Maybe a little more time given to it, because there are people asking these kind of questions.

KA some kind of context about the climate change and how we understand that it is happening in a more general sense

SM Which could be an additional chapter, which doesn't necessarily have to be in yours, I would suggest Amy, because there are probably plenty of really good, short presentations that you could use which sum that up nicely.

HV have any of you got burning issues with the film?

BP I think if they were that burning they would have come out by now

HV What happens next? Who do you think should be seeing this? What do you think should happen with this?

DG I think there are two specific groups, the NT and people who are specifically involved with the land around here. There's a huge wealth of information here, I presume project sponsors or at least people that you've worked with to actually look at the direct consequences, well changes and to pick it up and use the information to help influence decisions in the immediate vicinity, but my personal interest is the general populous of Calstock. let's say, look at this work that's been done at Cotehele Quay, think about the impacts on the village, what does that then mean, have we lost the shop? probably not, have

we lost the shop. where are those defences good enough, so it's actually to raise awareness of the broader local community.

BP and presumably of people just visiting here, it's something you could have running in one of the rooms down here

MB well we already have a film show for our visitors, in the film room. Maybe this could be attached to that, but I think it could give it a much wider spreads, because we get visitors from all over the world at this estate. They're directed to see the film first before they start looking at the house. a 5 minute thing, might be a good idea.

BP but wouldn't it be better to see it down here?

MB well it would be, but we don't have any facilities down here

JL they have one at the mill running all the time, similar to that really. A lot of people who visit the quay don't necessarily visit the house.

KA we were thinking a nice thing to do with it would be to have a public viewing. That way everyone who has been involved with it can come along and view it in an informal atmosphere perhaps when Amy has implemented the changes she needs to.

PB I think it would be useful for students in Callington School as well.

BP What are plans for next year Amy?

AN I don't really know yet.

KA I like the idea of showing Calstock, but we decided that that might be a sensitive issue. How do you think it would be received?

CS I think you'd get the people who are interested in this sort of thing coming along, but not the people that weren't. it would be hard to get the message across. We've had various films... there is an interest in things like this. Maybe you're right, having it about the quay is slightly more objective.

PB Does the AONB know anything about this.

AN yeah [names]

SB [introduction]

PB see there are people who live in the village I live in, who are several metres higher up and this wouldn't affect our village at all, but we have an interest down here many people who live in my village - harrowbarrow, come down here regularly. Dog walking if nothing else.

SB there are a couple of things in my mind, it is very specific to the quay, there aren't visuals of Calstock, so I would run it down here and invite people to come down and view it and then perhaps have some of the flooding experts point out some of the things you could do right now. for example sand bags, and just to go through some of the techniques that you could exercise right now in the event of a flooding.

DG one of the things I'm interested in, is what is the equivalent impact on the village, if you take your same data set, would the existing flood defences in Calstock cope with the same dataset or not, and that's where I would like to take it. Assuming that you've done all the research to get your baseline set, if you could take that and the current village dataset and say, would the defences cope? that's where the village might get interested.

SB would a walk and talk, you need to bring everyone up to a similar level of understanding, how were the banks created, who maintains them, a little bit about the previous flood events, so everyone understands how the system works.

PB that aspect of it, and the global climate change that happening, this is what would happen at the Cotehele, these are the defences we have now, these are what were here in the past, you could make a whole evening out of it and that film would be useful to focus people in on, that's happening in Africa, but well it's happening here.

SB to people's knowledge, have the EA done walks, raised people's awareness of what you can do in a flood event. They do encourage people to sign up to their floodline.

DG there are people along from us who do get the phone calls, but you have to go and search that out. But there's never been anyone coming and giving advice on potential situation

Appendix 12

Transcript for FG2 (afternoon)

Evening Session

Derek Schofield DS

Julia Massey JS

Jane Kiely JK

Beverley Parke BP

Helen Vines HV

Amy Nettley AN

HV What do you remember?

JK for me the flooding in Calstock

BP because it's personal to us

JM the goalposts were there, you've got something to relate it to

AN [explanation of years]

JM It would have been pre the flood bank. I can remember going down in the train and looking across the football pitch, I can remember that used to flood quite regularly

BP I remember people telling us when we moved here, but your house would have been under I imagine? Have you got steps going up to it?

JK well the quay actually rises slightly, well no it wasn't

JM I think the Tamar [Inn] and that has been flooded

HV So the photographs of Calstock stick in your mind. What else? Any particular words? Any other images?

JK	for me, also the quay here, because I do see it reasonably flooded when I come ere
JM	well vie been down at high tides and seen it
BP	I never actually seen it go over the road like that, but vie heard it does that frequently too
JK	well we've had to take all the reeds that come over with it and go all over the roads
DS	the thing that stuck in my mind in the whole thing , was my inability to read everything in the time [general agreement]
	whether it's a document or other wording, wasn't on screen long enough, but you don't only need to read it, you need to absorb it
BP	and I like to read things like that quite slowly in my head, to really take in what's been said, just a few seconds would have been enough I think
JM	The bits that you have from the archive, I mean unless you've got several minutes, you're not going to be able to read them. And it might have been better to highlight a few things.
BP	or just have a mass of documents that you're not supposed to read
JM	because I wanted to read them and then they were gone
DS	the same with the end of the sequences, you could have had, hold the relevant scene at the end, as a still
BP	yes, they went away a bit quickly
DS	especially as a comparison
JK	to compare as well, because you needed that comparison
HV	Any particular pieces of information?
BP	Over and above the obvious level? Which is the actual thing?
HV	Did you spot any of the answers to the questions?

BP	Oh lord I wasn't even thinking about that
HV	all the same answers were we asked were in there
JM	I was conscious that there was information there, but I wasn't sure I absorbed that information
AN	Was that because it was too fast?
	[too fast agreement]
BP	I thought it was very good the way you narrated it, the speed, the pitch and the intonation were very good. It may be a little bit left for you to take in what you were seeing of what you were saying, so a little bit longer, it's the pacing of it really.
DS	Is this an age thing? Not so much us being slow, but Amy being younger and faster. In viewing things.
JK	I think the youngsters speak much more quickly now, than even we did
BP	Do you think she speak too fast in the narration then?
JK	some of it
DS	No I thought it was very clear, but I think the whole thing goes through too fast overall. If we're the target too fast
HV	some of what you're saying was reflected in the feedback this morning in terms of how long quotes were on etc...
JK	yes perhaps there was too much information in a short time, for our poor little brains to cope
BP	well I think it's because you are, when you're listening to something and seeing something, although they're directly related you kind of, you do need that extra time to take it all in. and if you are concentrating on the narration you may miss some of the visuals, and vice versa.
JK	perhaps you need to have a few more spaces in-between, what you're saying and before you go on to the next bit
BP	yes I think that's all it needs
DS	do you watch the international news a lot Amy? [discuss of international news]

BP just in-between paragraphs leave 3 or 4 seconds when there is a visual on that you want people to really take it and quiet for a little while. Talking of the visual, which I thought were extremely good [emphasis] and hugely improved, I thought the water was beautiful, but is there any possibility, I did find myself, as it changed or faded away, not only did I want a little bit longer with that image, but I wanted it to be a little bit closer. is there any way of zooming in? Cos I wanted to see how far up the walls of the Discovery Centre is it going to come. Making more of all the hours you must have spent creating that. Make more of it.

DS I think there's a much better and a well done in there somewhere.

HV thinking about the whole presentation then, was there anything in there that particularly challenged you?

JK probably the things we've been talking about

HV what about in terms of the content? Anything that made you uncomfortable?

DS it's not new, we all live by the river and we all understand that it is going to rise. We'll happily accept that it's presented to us. So no, it wasn't uncomfortable, it just confirmed things we already knew.

JM no it wasn't uncomfortable, I don't know about confirming things we already know, confirming things we are being told, whether you believe that is right or not, I don't know. It doesn't worry to be honest.

HV how did you feel at the end of the presentation?

JM I thought it was a good film, but I was more interested in the point of view of it's my area and seeing places familiar to me than I was about the rivers rising.

JK so in fact if there weren't any images, you would have just liked to see the photographs?!

[laughter]

JM it was an interesting film about my patch

DS we're too close to it to take in the scientific bit

[agreement]

BP that's probably why, because I know Jane lives down there and I wonder would she be affected.

DS	I live down river and I thought 'oh', but no you haven't gone that far down river.
BP	so when you were panning round the buildings here, I know the people that live in the first house round the corner and I was just waiting for that. Stopped short, all these personal things, I suppose that's just inevitable isn't it. But perhaps faced with these we should have more to feel, more alert to the scientific side
JM	perhaps someone who wasn't so familiar to the area would be more objective about the scientific bits than we were
AN	[local may get distracted by other local interest topics]
JM	when asked about what struck us in the film, well it was the football pitch.
BP	and I remember our first meeting, one of our first questions was 'why didn't you do Calstock?' and the first question when someone sat down was why did you choose Cotehele Quay?
JK	why did you choose Cotehele?
AN	[explanation of Shifting Shores]
JK	I wonder if most people bury their heads in the sand and think well this isn't going to happen.
BP	there is a lot of denial isn't there
DS	it's not going to happen in my lifetime so... that's a lot of attitude
BP	well one hopes it isn't
JK	tide was very high the other week though [agreement]
BP	well I was going to say earlier every time there is a high tide, you're kind of looking and thinking, have I seen it up to there before, I'm sure it's even higher than usual. It is worrying. I feel as well that ok its people's homes and that's the most important thing, but how would it affect all the wildlife as well. some would benefit, others it wouldn't make much difference, but it would in certain areas, not necessarily here...
DS	well the otter that I saw the night would be very happy. I was sat up in bed looking out my window and there was an otter on the bank. It couldn't have been anything else, I saw him only for a fraction of a second and this movement. No

doubt in my mind.

BP it's my hope that one day I will see a wild otter.

JM it might be a blinkered view, but why worry about something I can't personally change and I think that's probably what a lot of people feel too.

JK well don't you think we can and that we've set in motion already by the way we...

JM as a country yes, but personally...]

BP but there are lots of things, like everybody, that help towards what you consume, what you drive, how..

JK recycling, all those things. I think that's the whole point of it really, all these individuals who come together will make a whole.

AN you have to have that sense of being part of something don't. if you feel like no one else is making that effort then you feel like..

JM well yeah I do my bit, recycling, you're conscious about things, but it doesn't worry...

JK does it annoy you, the people that don't recycle?

[annoys everyone]

HV how did you feel at the end of the presentation?

BP no we didn't there was a big silence. It's a difficult question I find, because it wasn't emotive, well it was emotive in that it was personal to us, but...

no I thought it was intriguing and very interesting and my answer to the first general question was interesting scenarios, well shown clearly explained and held interest well. Umm.. How do I feel though, it's a lot of mixed emotions, I actually do feel worried for the future, for the world not only Calstock and this area, I think it's disgraceful the way humans are treating it, so this will help me to understand the science behind what may and probably will happen in this area and I think it did that very well. so it raised my consciousness. so when you ask me how I feel, apart from what we've already said, that I do feel angry about people trashing this planet and all the rest of it, it brought that to my mind, if that's any help at all.

JK	I don't know how I felt, I felt it was a lot easier to understand than it was last time, a lot easier which I was please for you, you know I understood it a little bit more, or at least I did. There was more interest in it than last time, I really didn't know what it was all about before. you've improved it tremendously, but as to how I feel about it well done you've done so much work on it! and I can appreciate how long it's taken you. especially as it's not really your area, but you've also got involved with it, and you understand it very well.
HV	is there anything in there you learnt or that you weren't aware of before?
BP	the specifics, I think for me of the heights
AN	we you aware of how much lower the sea levels were years ago?
JK	well I've never lived by a river before so I think living here you can see the water levels are very different, that you are much more aware of it than if you live inland.
JM	not in terms of actual figures, I mean yes you here it on the telly, SLR what have you, but you know, doing that little exercise and looking at the film, you've got a bit of data and illustrate what...
DS	yes, I was well aware SLR, we've lived by the sea for 21 years closer to the sea than I am now on the river, we were always concerned about the beach now we're concerned about our reed bed. I don't think I was worried, and then I thought, the end feeling at the end was well done really, because by comparison to the last time it's a great improvement. and that was the way I felt, it wasn't about the information, because the information felt quite familiar to me.
AN	how do you feel about the fact you saw that, you were involved in the first round, did you feel you understood this a bit more? You knew where I was coming from?
	[yes, yes all]
JM	it was very technical [the first round]
AN	how would you feel if you hadn't been to that first meeting?
BP	very accomplished I would have thought
JK	you went to great lengths to explain how the program worked which I think got a lot of criticism

DS	that was the reason I came! I was the odd one out, I wanted to see the technical bit
JK	no I think if I'd seen that and nothing else I would understand what you were getting at.
BP	if for example that was being shown in the DC it would hook you and you would stick around and stay till the end, that...
HV	What do you think would be the best use of this?
JM	I think its um... it can be understand by the lay person... it's perhaps schools
JK	AONB office, Discovery Centre
DS	yeah, but how many local Wis have you got? That you could present it? And get paid for it. How many, there's a Tuesday club in St Dominic, lot of old fogies like me, but they might take it in, if it was longer, slower and you know...
JK	and even if they live on the top of the hill
JM	do you mean on a local sort of basis, or would you be looking to sort of illustrate SLR in a wider...
BP	to raise people's awareness
	[national]
AN	currently with this one, locally, but it depends if there is a site specific place where this could be applied, because the modelling of the buildings is what took most of the time and making it look like it did.
JK	would you be prepared for instance to go and give talks about this? To give lectures. Because I arrange talks for Friends of the Tamar Valley up at the AONB Centre and I think they would be very interested in this. If it was longer and a bit slower.
BP	with the person who made it there, to answer questions.
AN	[this is flexible tool]
BP	so you could illustrate this even further and with more detail
AN	as a separate project then yes

DS	this is the way to pay your debt
BP	would you be in a position to sell it perhaps
	because up at the Centre, they have an ongoing slide show of the Tamar Valley in the hall
	also in the education room
DS	it's only got to go on a DVD and you can take it anywhere
JK	for those sort of places do you want to be fairly concise, for a lecture you would want to make it longer.
BP	but you could couldn't you, you could relate it to this is a local example
JK	I think one thing I found interesting, I don't know if it's possible to put more in, is the comparison of the two. The real photograph and your visualisation of what it could be.
DS	thinking back to that scenario we had, discussion at Shifting Shores, the NT could well be a customer for you in all their sites, the number of sites they have.... What is the point of learning all this technical stuff, if you're not going to use it later??
JK	it must be what happens with so many PhDs isn't it
BP	what are you hoping to go into Amy may I ask?
AN	I have no idea
HV	are there other people in the valley whose work or lives are going to be affected by these potential changes who need to be up to speed.
BP	aside from the inhabitants? Who live close to the river or the farmers who have land that a but the river
JK	Plymouth Boats
BP	clubs, ride higher on the water I guess
JK	all the infrastructure, it might not be there to land at
DS	if you think about Saltash and there's a great stretch of grass and parkland but then there's houses, you get that one metre rise and then they will be at risk.

	And the road
JM	presumably, if it rises by 1m you've got the weir, is the weir, at Gunnislake, would it go beyond the weir, when you think of big structure
DS	you need to get yourself a tide table and go for a walk at the right time and see...
JM	there was a picture of Gunnislake there [in the film] and I was thinking that really high flood water, would it affect further up river
DS	yeah because you have the SLR up there and it stops the water coming down the weir, it holds it there and you get more and more coming down
BP	the significance if that bridge couldn't be crossed would be enormous
DS	you know we get flooding at Halton Quay its not from the river it's the surface water that can't get away at high tide, which would be the same at the weir.
JK	the surface water sits on top of the tide coming in and that's always frightening I find, do you know that? If you've got water coming down from the hills its going out, and the tide is coming in and I've actually seen it and its frightening, the tide underneath and of course everything is rising because there's nowhere for it to go and that's when you get a real problem.
	its affected by the hills around here, with all the water that's coming down.
JM	so if that's affecting Gunnislake, everybody's livelihood will be affected
JK	up until the Tamar Bridge was put in in Saltash that was the main road in
JM	1961, yes
JK	I always came in that way, that was the only way through
JM	what we used to do on a Saturday, where my parents lived was looking over towards Gulworthy, was how far the cars were queued back. Because they would queue almost all the way back to Tavistock. And the same up the other side, because we've only got one lane of traffic across the bridge. you used to have traffic lights on the bridge in the summer.
JK	it took me a couple of years of coming down here before realising this is where I used come, because there was no other way in. there was no road around Launceston at that time was there. It was a long way round.

BP	other chat about access in]
JK	what about the wildlife? The trout and salmon?
DS	I think going up the river it would be a lot easier for them!
HV	are there any actions you feel inspired to take having seen this film?
DS	I might make my flood barrier a little higher
	[laughter]
DS	and I'd put one on the north side of the house as well
BP	I think the village hall community should have a viewing cos the village hall in Calstock is very low along with the Tamar, they're the two buildings that would be able to float away, knowing their foundations aren't terribly sound.
JM	you might seem fit to move!
HV	what are some things that could help now?
DS	Cornwall has obviously got problems because it's got so much coastline, but there'll be focused on coastline, they made need their eyes opening to the rivers.
JK	knowing how long things take to eventually get done if there are suggestions or actions people feel be taken, its well to start to earlier rather than later.
JM	I just think what good would it do, what action can anybody take, alright yes you can do your bit, but what are they going to do, it's...
BP	you don't want great big levees built all along the river
HV	but some people might!
DS	I've got an existing levee...
HV	does everyone share your view, it's going to happen so let it happen
JM	I think there's a limit, it's not a local thing, it's not a national thing, it's a global thing and...
BP	you can't stop nature
JK	no you can't

HV how do you adapt to it on your doorstep - that's the discussion..

DS if you want to get home buy a boat!!

JM I don't think you need to adapt really because things evolve don't they really, and it won't be that one day it's this and then the next day's it's that, its gradual and that's how communities grow up, they evolve. Things will evolve and adapt to the circumstances

BP I think you're absolutely right actually

JK so therefore is there no point in making people aware of it?

JM I think it's an interesting film, but I don't think there is any point in lobbying people like Cornwall council and that because I don't think there is anything they can do, especially the way Cornwall Council is, they're not going to do anything.

JK but I think that's going to happen anyway if you take it up a level the government haven't got any money to do anything either

DS If you think of those bridges that were washed away up country, and you're talking about Newbridge, if they were made aware of what could happen and the amount of water coming down is going to change and therefore all the bridges are at risk, should they not have some plan or other. Just in a back room somewhere, where they can pull it out if something happens, and if you make them aware of it then they would do that. Because they won't do it otherwise, or they could do that.

JK presumably all these agencies have disaster plans,

JM there is emergency plan department in CC, but they would think its perhaps beyond what their capable of, I don't know if CC plan on this sort of scale

DS is it not the, what is PCs responsibility, it's responsibility to its Parish, if you can see something that might go wrong, might happen, should you not be telling your clerk to write to the county and say 'what if'

it's not going to happen tomorrow Have you a plan? Because as a Parish you can see a problem at the moment you have no way of gauging...

JM well I don't know, I think a lot of people to be think it was scaremongering I think that a lot of people don't accept that this will happen

DS well that's the job of the Parish council to overcome the general public's worry about scaremongering

JM No I don't think it is, I don't think that is the job of the PC. I think the PC will take on issues that concern the people and I don't think

DS well lack of supplies over Newtonbridge will be of great concern

JM it's not going to happen tomorrow is it

DS no, no, that's why you ask the question now

JM But then I think it's not going to happen next week, or next year or the next 10 years...

DS So if they've got a plan in place...

JK well there's got to be some sort of a plan

BP well I agree there should be some sort of contingency to recognise that if that were to happen, and it will at some point in the future, there should be a means of quite rapidly, when it happens, even if it's not happening quickly, as the level rises, year on year on, the bridge you've got left

DS the longer the tidal flow, in and out, the more its going change that structure, it's going to wash that structure away in places where it wasn't designed to be washed out

BP so before that happens, the thing should be strengthened but I think there should be somewhere a contingency plan for raising that road

DS get a surveyor out there to survey the bridge would help

JM The surveyor would tell you that the bridge was not designed....

no no it will say that it's a lot stronger than all the bridges, because when they had to do the strengthening work on the bridges to take the extra weight, well Gunnislake / Newbridge did not need any work at all, and these new modern bridges that they had to strengthen

DS Well you've got that reassurance, but I didn't know that. If you hadn't got that reassurance, that's what I thought the PC should have done to ask

JM I can't see the Parish or the county looking at things so far ahead

JK they're not proactive like that are they

JM well no, because yes they might in terms of recycling and minimising pollution and waste, yes, but I can't see them planning ahead that far because their transport plans and the plans for roads, are only 10 15 years ahead so they plan 50 years ahead

DS but it's the job of the county to do that, but the county are prompted from below
it's the same as you'd be prompted

JM Anything like that would have to come nationally first, it'd have to come from government to tell councils to plan for this. I don't think CC have the will or the money to do that. It's more of a national thing. They won't look at it in isolation

DS you've just made my argument for me, because if the county haven't got the wit and the Parish should be concerned about the people, then you SHOULD be doing this - ill leave it at that

BP I want to add to what I said earlier that it was an inspired idea to include personal testimonials and local knowledge, because in with the technical data it was a nice balance, a nice compliment so it wasn't all. The vocabulary of the people and the quotes that you used were really excellent

AN Do you feel being a part of this process was beneficial to have you involved in the first meeting?

[agreement 'yes']

JK I think you were wise to discuss and get our personal knowledge. It would have been very easy to have just ignored anybody who lived round here and just carried on with it as so many people do, but no I agree with you I think that the balance of the film was very good because of that.

BP it's very personally satisfying to know that you've been a little bit a part of something like this, and that when you pointed me in the direction of that [the previous suggestions] and I thought oh yes we did bring this that and the other it wasn't my group but I remember thinking oh yes I wish I had thought of that. And you actually acted on everything, which was really nice for all of us.

[general agreement]

HV I think we were very keen to make sure that was a loop, because I have so often been involved in projects where people's opinions are sought, and they give their

time and then they never hear from you again and I think that is very rude. It makes you less likely to contribute when asked. A huge amount of valuable suggestions came out from the last time we were very keen to present back to you what had been included and what hadn't, and if it hadn't been for what reason. They were largely technical reasons.

JK well the only one not able to address was only 1

AN [introduction of 1st October]

Appendix 13

Public viewing: survey

Individual Response Sheet

(Responses on individual feedback will be kept confidential)

In which village / town do you live?

Please specify:

.....

Postcode:

.....

Did you enjoy watching the film?

YES

NO

Can you give your thoughts on:

The general content of the film?

.....
.....

The realism of the visualisation?

.....
.....

The science behind of the flooding scenarios shown?

.....
.....

Perceptions of the film:

Do you trust the information presented to you in the film?

YES

NO

DON'T KNOW

Other:

Which events that were shown in the film can you relate to your own experience?

After watching this...

Do you feel you have an improved understanding of the potential impacts of sea level rise at Cotehele Quay?

YES NO DON'T KNOW

Comments:

Would you feel comfortable to engage in a conversation about flooding at Cotehele after having watched this film?

YES NO DON'T KNOW

Other thoughts

Do you have any other comments to make?

Appendix 14

Public viewing: results from the survey

Location	Enjoyed watching the film	Trusted the information	Improved understanding of impacts	Comfortable to engage in conversation
Cotehele Quay	Y	DK	Y	Y
Saltash	Y	Y		
Waterlooville	Y	Y	Y	DK
USA	Y	Y	Y	Y
St Dominick	Y	Y	Y	Y
St Dominick	Y	Y	Y	Y
Surrey	Y	Y	Y	Y
Eardisley	Y	Y		
Oxford	Y	Y	Y	N
Bewdley	Y	Y	Y	DK
Oxford	Y	Y		
Lincolnshire	Y	DK	Y	Y
Lincolnshire	Y	Y	Y	Y
Southampton	Y	Y	Y	Y
Southampton	Y	Y	Y	Y
Exeter	Y	Y	DK	Y
USA	Y	Y		
Broadwindsor	Y	DK	N/A	Y
USA	Y	Y	Y	Y
St Dominick	Y	Y	Y	Y
River Yealm	Y	DK	Y	DK
St Dominick	Y	Y	Y	Y
Australia	Y	Y		
Base:	23	23	18	18

Appendix 15

Version Two - Full script: 'Changing Tides at Cotehele Quay'

Shown at – Friends of the Tamar Valley, University of Exeter 'YouTube – UoE Research' page

Cotehele Quay is located in the South West of the UK, in the Tamar Valley on the National Trust's Cotehele Estate. During the nineteenth century the quay was used for the transport of agricultural and mining-related goods up and down the River Tamar, to Plymouth and beyond. The National Trust now owns and maintains the quay and its historic features, which include former sheds and warehouses, lime kilns, an inn, mooring blocks and cranes.

Cotehele Quay has a history of being affected by both tidal and fluvial flooding. Changes have been made over the years to protect the site from periods of extreme high water

"In the early 1800s they started putting defence banks up along the river... Before then you still had these areas like we've got between the quay and the chapel, and then opposite Calstock – which would have allowed the water to spread out. But by putting the defence banks up, as soon as it finds a gap to go in it's in there with some force."

The highest tides occur twice a month on the full and new moon—these are called spring tides. When adverse meteorological conditions coincide with high spring tides the likelihood of flooding in the Tamar Valley increases. At the moment, high tidal waters overtop the quay during most spring high tide events.

Most people who live or work on the River Tamar will have experienced a flood event during their lifetimes. People who live on the river often document high water levels with photographs.

Throughout its history, Cotehele Quay has suffered many extreme flood events, both during its hey-day in the mining era and throughout the 20th and 21st centuries. Many of these historic flood events have been well documented, and records can be found in the Calstock Parish Archives.

A flood in 1866 was well recorded in the archives. Although we can't know exactly how Cotehele Quay was affected during the 1866 flood, records comment on the fact that the river Tamar rose to a great height. Trees and other objects were carried off in a rush of flood waters, causing great damage to land in the vicinity of the river.

To help us understand past and future tidal flooding at Cotehele, we have created the first virtual model of the site. This three dimensional model has been produced using state of the art technology and computer software. In the model, tidal conditions can be adjusted to reflect past, present and future levels. This allows us to visualise what past tidal conditions were like and perhaps more importantly, show projected increases in sea-level to understand the possible impacts of future sea level rise on the quay.

Specialist surveying equipment, including a laser scanning device, was used at the quay to capture data about the height, shape and arrangement of buildings and surrounding terrain. This detailed survey comprises millions of laser scanned data points. We used design software to transform the data points into a three dimensional digital model. This model balances spatial accuracy with a desire for visual realism.

Throughout this film you will see short video sequences created using the virtual model.

The model can be used as a tool for initiating conversations about past and future change on the quay. These conversations will inform decision-making about adaptation at Cotehele.

Extreme events such as flooding can generate strong emotional responses and have a dramatic impact on the landscape. However, changes in everyday tidal cycles are likely to have a more frequent and noticeable impact on Cotehele Quay in the future.

Scientists believe that sea-level rise in the UK has been occurring since glaciers started melting at the end of the last ice age. There is evidence of historic sea-level rise at several coastal sites on the Cornish coastline, including the drowned forest at Marazion and underwater field boundaries on the Scilly Isles.

The nearest long-term tide gauge to Cotehele is at Newlyn, Cornwall. Newlyn's records show that over the 20th century there has been an average increase in mean sea level of one point seven to two millimetres a year. Over the last 50 years or so the rate of sea-level rise in the South West has increased to approximately three millimetres a year. There is some evidence that this rate is increasing. This increase has been attributed in part to thermal expansion of the oceans, due to higher atmospheric levels of the greenhouse gas, Carbon Dioxide. The 2009 UK Climate Projections Report anticipates that the rate of sea-level rise will continue to accelerate.

At the time of the 1866 flood event the mean high water level was 29cm lower than it is today.

Today an average spring high tide is 4.8m above chart datum. Chart datum is the lowest possible level of the tide, but is a level that varies across the country and is dependent on the range of the tide at a particular location.

On September 9th 2010 a spring high tide on the quay measured 5.1m, as shown in this comparison.

By 2050 we could be seeing an extra 11 centimetres on the top of an average spring high tide, bringing it to 4.91m above chart datum. This estimate is based on the most conservative possible reading of SLR projections, drawing on findings from the UK Climate Projections report.

People familiar with the river's cycles suggest that increased rainfall and low pressure systems can add up to a metre of water on top of the high spring tide levels. Such levels could limit access to some areas of the site and damaging buildings and artefacts

Life on the river will need to adapt to these new circumstances...

There is some debate about the magnitude of sea level rise in the more distant future beyond 2050. This is because the magnitude will vary depending on changes in atmospheric carbon dioxide in the next 50 years. Some studies suggest a worst case scenario in which sea levels will rise by almost a metre by 2100. This means we could expect to see an average spring high tide increase to 5.7m above chart datum. At these levels the quay could potentially flood several times each month. A low pressure system combined with heavy rainfall could add an additional metre of water, with potentially greater consequences.

Appendix 16

[Final film 'Changing Tides at Cotehele Quay – on CD]

Appendix 17

Ambassador Pack contents (Q&A)

Questions & Answers (for ambassadors)

Why has this film been made?

This film has been made as part of a PhD research project which used advanced surveying technologies to create visualisations of sea-level rise. The project developed tools to engage people with climate science and environmental change on the River Tamar.

What are you trying to show us?

The purpose of this film is to begin a conversation about sea level rise and possible future mitigation and adaptation scenarios. It does not present a definitive statement about the extent of future sea level rise, and does not advocate any particular response.

Who was involved in developing this film ?

The organisations involved in funding and carrying out this project were the University of Exeter, the National Trust and the European Social Fund. Other organisations which were involved in steering group meetings include the Environment Agency, Royal Haskoning, Natural England, Tamar Estuaries Consultative Forum and the Tamar Valley Area of Outstanding Natural Beauty (AONB).

Who was involved locally?

During the making of this film local residents and Parish Council representatives from both Calstock and St Dominck Parishes were invited to be a part of focus groups. Focus group participants gave input into the content and structure of the film. They worked together with staff and volunteers from the National Trust. Those involved in the FGs were initially invited as having an interest in the river. This included local business, local parish councils, and residents who may be affected by flooding.

Who is being shown the film?

This film is being shown to various community groups in the Tamar Valley as well as being presented at national conferences as part of an academic piece of work.

What sea-level rise projections were used to inform the models in the film?

The film shows projections of future sea-level from the UK Climate Projections Report 2009 (UKCP2009). The Sea-level projections used in the UKCP 09 report are derived from projections of absolute sea level from multiple global climate models. The focus of the UKCP09 report is to reflect *regional* variations in projections of sea-level rise. Sea-level rise projections are based on a range of scenarios which represent future levels of greenhouse gas emissions.

The sea level rise projection for the **2050** levels shown in this film were taken from the low emissions scenario, which projects an increase in mean sea-level of 11cm. The sea level rise projection for the **2100** levels shown in the film were taken from the high emissions scenario, which projects an increase in mean sea-level of 92cm. The sea level projections are not probabilistic but instead provide a frequency distribution of projections.

Where can I find these sea-level rise projections?

The SLR projections are an open resource provided on the UKCP09 website. Following the instructions on the user interface it is possible to select the data and region you are interested in and download data from that site.

Why not use Intergovernmental Panel on Climate Change (IPCC) or other data?

It was decided to use the UK Climate Projections 09 report for SLR projections because they are the most recent SLR projections for the UK. IPCC reports provide alternative sources of sea-level rise projections but it was felt that UK projections on regional scale would better suit the task at hand.

Why didn't you show sea-level rise at other sites along the river?

The research project focused on Cotehele Quay because of the recognised threat of future flooding and National Trust interest in generating broad discussion about management options for the site. The sea-level rise scenarios projected in the film for Cotehele Quay show future changes that will affect life up and down the river. Time and technical constraints prevented the inclusion of other sites in this project. Because of the accuracy of the data collected at Cotehele we can show to some degree how high the waters will rise given set meteorological conditions. Sea-level rise impacts will vary along the river and it is difficult to say with any certainty how specific sites will be affected. There are other sources of information available should you wish to find out more about the impacts on your own area.

What is being done now to prepare for future sea-level rise?

Nationally, the Shoreline Management Plans provide insight into future management of the coastline to help local agencies decide on the most suitable adaptation and mitigation strategies. These are developed with short (0-20 years), medium (20-50 years) and long term (50-100 years) timescales. This planning process been carried out for the Tamar Estuary but does not address the tidal reaches, which include Cotehele Quay.

The National Trust have carried out a risk assessment of all coastal properties in their care are in the process of developing Coastal Adaptation Strategies to address specific threats in each location. Cotehele has been identified as a site in need of a Coastal Adaptation Strategy, and NT staff will be developing this strategy in consultation with area residents and stakeholders over the next several years. Feedback from the film sessions and other engagement activities will inform what the NT decides to do at Cotehele Quay.

Who owns and manages the defences along the river?

Existing defences along the River Tamar are the responsibility of the Environment Agency but landowners are responsible for protecting their own land should no defences be in place. The most recent Shoreline Management Plan has declared the upper Tamar Estuary as an area of No Active Intervention.

I don't understand how the model was made, can you explain please?

A terrestrial laser scanner collected three-dimensional data of the buildings and quayside at Cotehele Quay. Aerial LiDAR (Light Detection And Ranging) data of the valley was sourced from the Environment Agency database. Once this data had been collected it was made into a 3D computer model and design software was used to apply textures and lighting to the scene to make the buildings and landscape look as realistic as possible. Aerial photography was used to colour the surrounding landscape and photographs taken from Cotehele were used to texture the buildings.

Other information was collected independently and integrated into the final film. Historic images and text were collected from Calstock Parish Archive. The interview quotes were recorded and transcribed by Mark Goldthorpe, another student at the University of Exeter, who kindly allowed them to be included in the film.

Who can I contact if I have questions?

If you have questions about how the model was made and the content of the film then get in touch with Amy Nettley on 01326 253707 or email a.j.nettley@exeter.ac.uk . If Amy is not available, contact Caitlin DeSilvey (c.o.desilvey@exeter.ac.uk) or Karen Anderson (karen.anderson@exeter.ac.uk).

I want to show this to some more people – is this possible?

We currently have 8 ambassadors for this film who are happy to come and show the film to interested groups and organisations. If you wish to share it with some more people contact the Lead Ambassador Joe Lawrence on joe.lawrence@nationaltrust.org.uk or on 01579 352720.

Where can I see it again?

The film is available online at <http://vimeo.com/37650554> or on youtube.com by searching for 'Changing Tides at Cotehele Quay'.

Focus Group Participants

*also film ambassador

Simon	Bates*	Cordiale Project, Tamar Valley AONB
Pete	Bouquet	Local resident
Mike	Bygrave*	Local resident / NT volunteer
Dorigen	Couchman	Local resident
Roger	Eley	NT staff
Diana	Greene	Chairman St Dominic PC
Norma	Greenslade	Councillor Calstock PC
Rita	Hoile	Club captain Cotehele Quay gig club
Phil	Hurley	Morwellham Museum
Jane	Kiely*	NT Volunteer
Cliff	Lambert*	NT volunteer
Jamie	Lang*	NT Warden
Joe	Lawrence*	NT Head Ranger
Gill	Mannings-Cox	Local resident
Julia	Massey	Clerk Calstock PC
Beverley	Parke	Calstock News
Drew	Potter	Councillor St Dominic PC
James	Robbins	NT Warden
Clare	Saunders	Local resident
Derek	Schofield	Local resident
Mary	Schofield	Local resident
Martin	Smith	Ex-Calstock Arts

Appendix 18

Ambassador Pack contents (info sheet)

Where to look for answers (for distribution at presentations)

UK Climate Impacts Program

The UK Climate Projections (UKCP09) provide climate information designed to help those needing to plan how they will adapt to a changing climate. The models shown in the film used UKCP2009 sea-level rise projections. The data is focussed on the UK, and is free of charge.

Website: <http://ukclimateprojections.defra.gov.uk/>

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). Assessment reports which detail global climate change projections are available on the IPCC website.

Website: <http://www.ipcc.ch/index.htm>

Environment Agency

The Environment Agency works with local authorities and internal drainage boards to carry out flood and coastal risk management schemes, and to generate flood risk maps. The 'Floodline' warning service can give you advance notice of when flooding from rivers and the sea is likely to happen and time to prepare.

Planning: <http://www.environment-agency.gov.uk/research/planning/118129.aspx>

Flood Maps: <http://www.environment-agency.gov.uk/homeandleisure/37837.aspx>

Floodline: <http://www.environment-agency.gov.uk/homeandleisure/floods/38289.aspx>

Shoreline Management Plans

Shoreline management plans (SMP) are large-scale reports, assessing the risks associated with coastal processes. They aim to help reduce erosion and coastal flooding risks to people, property and the historic and natural environment. In doing so, it is an important part of the Government's strategy for managing flooding and coastal erosion.

Durlston Head to Rame Head SMP: <http://www.sdadcag.org/SMP.html>

Queen's Harbour Master Plymouth

The Queen's Harbour Master is the harbour authority for the Dockyard Port of Plymouth, and operational and administrative management includes the River Tamar. All questions about the dredging, siltation and potential toxins in the river should be directed to the Queen's Harbour Master.

Website: <http://www.qhm.mod.uk/plymouth/>

National Trust

The National Trust is a charitable organisation that works to preserve and protect the coastline, countryside, buildings and natural heritage of England, Wales and Northern Ireland. They have produced reports on their strategy for dealing with future threats of climate change.

Energy and Climate Change Information:

http://www.nationaltrust.org.uk/main/w-chl/w-countryside_environment/w-climate_change.htm

Coastal Policy:

<http://www.nationaltrust.org.uk/servlet/file/store5/item349171/version2/UK%20shifting%20shorest.pdf>

Tamar Valley Area of Outstanding Natural Beauty

The Tamar Valley AONB is responsible for the Tamar Valley Heritage Sites and works on many projects from the Tamar Valley Mining Heritage Project, to smaller schemes working with schools and local community groups. Most recently, the Cordiale Project has been established which focuses on making landscapes and livelihoods more resilient to climate change.

Cordiale Project Website: <http://www.tamarvalley.org.uk/projects/cordiale/>

Tamar Estuaries Consultative Forum

The TECF provides the means for delivery of integrated coastal management for the Tamar Estuaries, including the implementation of Plymouth Sound and Estuaries European Marine Site management.

TECF website: <http://www.plymouth.gov.uk/tecf>

Department for Energy, Food and Rural Affairs (DEFRA)

DEFRA are the UK government department making policy and legislation that covers areas such as the natural environment, sustainable development and animal welfare.

DEFRA website: <http://www.defra.gov.uk/>

EasyTide

EasyTide is a service for collecting free tidal data for a 7 day forecast and a request service for historic tidal data (for a fee).

EasyTide website: <http://easytide.ukho.gov.uk/EasyTide/EasyTide/index.aspx>

Cornwall & Devon County Councils

County Councils work with other agencies to implement and develop planning and management strategies. When developing adaptation strategies for the Tamar Valley often both councils are involved.

Cornwall County Council: <http://www.cornwall.gov.uk/>

Devon County Council: <http://www.devon.gov.uk/index.htm>

Calstock Parish Archive

The Calstock Parish Archive is a local repository for local historical data about the parish of Calstock. Records include photographic, oral and written records, as well as information on the history of mining, agriculture, the river and the people.

Calstock Parish Archive website: <http://www.calstockhistory.org.uk/index.html>

Appendix 19

Ambassador Pack contents (prompt sheet)

Changing Tides on the Tamar – presentation prompt sheet.

*Your role: remember that **your role is to share the film** and the information within in, and to offer sources of further information, **and to stimulate a debate** about some of the issues in the film and what people think of them in terms of the Tamar. **Your role is to remain objective** and not be drawn into a discussion about your personal views on this topic!*

*Your role is **not** to be the expert, **nor** to have all the answers. If people want more information, where possible direct them to the information sheets and encourage them to find out more for themselves. If you volunteer to find something out, make sure you get back to them.*

What follows are a few prompt, not a script to be adhered to. Each ambassador will bring their own experience, knowledge and personality to the viewings you deliver.

Introduce self/selves and thanks for invite.

Ice breaker questions: *(could include the following, don't use more than 3)*

- ❖ Hands up who's been on or in the Tamar this week/month?
- ❖ Hands up who works or worked on the River?
- ❖ Hands up who can remember the Tamar flooding? *(this could lead into scene setting...)*

Explain how film came about and put together (factual information from Q&A sheet).
Mention context of NT Coastal Adaptation Strategy and NT keen to start a discussion.

“My/our role today is to share the film with you and give you an opportunity to discuss it together”. You could also say: “by the end of this session you should know more about predicted tidal change and its effects at Cotehele and the Tamar”.

Show film

“**Any questions?**” This may way lead into debate but if you want a more structured approach you could use the following format.

Framework for discussion.

Suggested questions to start you off *if you need them (don't use them all, and try and run through them in ORID order!)*.

Objective questions *(useful for reminding self and other of what it contained)*

What do you remember from the film?

Which scenes grabbed your attention?

What images do you remember?

What words or phrases caught your attention?

Reflective questions

What did you identify with in the film?

How did you feel at the end of the film?

Interpretive Questions

What were some of the key points made?

What came across as important for you?

What did you learn that you didn't know before?

Decisional Questions

Who do you feel needs to see this? Why?

What actions should we take in response to the content of the film?

What actions should the NT take in response to the content of the film?

Resources:

Remember to take/ensure:

- ❖ Digital projector, screen, laptop, dvd of film, speakers
- ❖ Ambassador feedback sheet
- ❖ Ambassador Q&A sheet
- ❖ 'Where to look for answers' resource sheet
- ❖ Film script
- ❖ Individuals feedback cards (*ensure everyone has these at the start, they might want to jot down notes*)
- ❖ Pens/pencils for people to use

You may want to use flipchart to chart ideas if available.

Please complete Ambassador feedback sheet and return to Joe Lawrence within fortnight of each film viewing.

Questions that arose during workshop session - 01/06/12

What equipment was used to collect data? SEE FILM/CRIB SHEET

What area is information covering, area of river expansion? SEE FILM/CRIB SHEET

Where do you get the background facts from? SEE FILM/CRIB SHEET

What is the probability of this happening? SEE CRIB SHEET

Where can we get more information from? SEE RESOURCE SHEET

This has happened before in history, so what makes you think it is anything to with man and not just a natural process? SEE FILM/CRIB SHEET and DISCUSSION

What am I expected to do about it? DISCUSSION

What are THEY doing about it? SEE CRIB SHEET

What can be done about it? DISCUSSION

What about the silt in the river, should it be dredged? What content of toxins still exist in the Tamar? REFER to Queens Harbour Master.

If we didn't have the effects of the weather would the height of the river change?
DISCUSSION

Should the defence banks be knocked down and let the river flood naturally? DISCUSSION

Who started this project off? SEE FILM/CRIB SHEET

Who was consulted locally regarding the project? SEE FILM/CRIB SHEET

Who is involved and why? SEE FILM/CRIB SHEET

Do we defend or let nature take its course? DISCUSSION

How long before it might happen? REF TO FILM

What is the government policy for managing defences and Who manages the banks and Quays and What is the Environment Agency's role in this? SEE RESOURCE SHEET

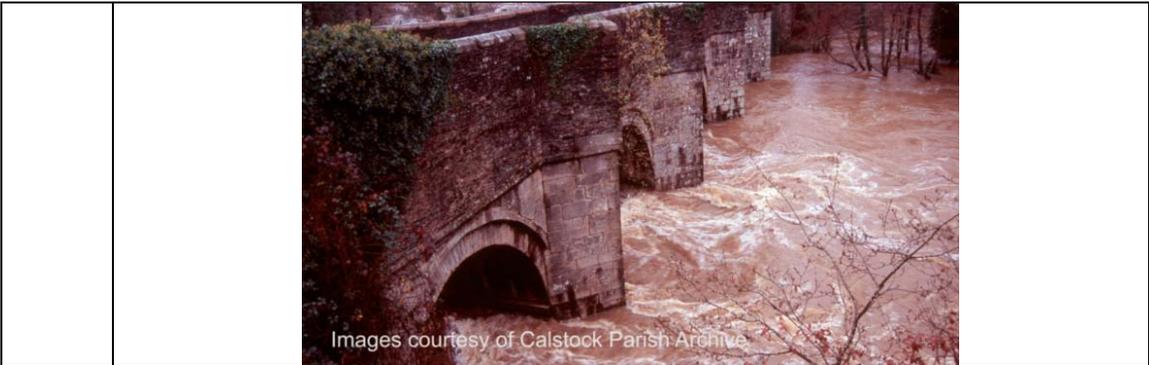
Appendix 20

Ambassador Pack contents (script)

'Changing Tides at Cotehele Quay' Script

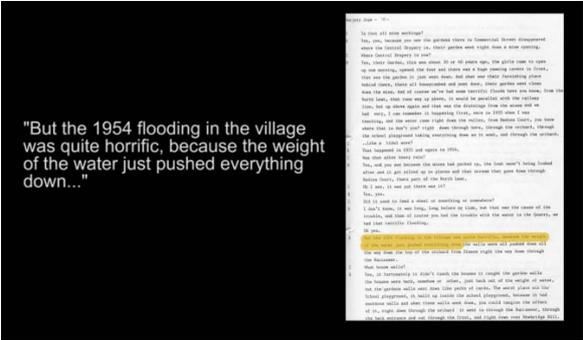
Time	Script
	Opening Slides
0.20	<p>Cotehele Quay is located in the South West of the UK, in the Tamar Valley on the National Trust's Cotehele Estate. During the nineteenth century the quay was used for the transport of agricultural and mining-related goods up and down the River Tamar, to Plymouth and beyond. The Trust now owns and maintains the quay and its historic features, which include former sheds and warehouses, lime kilns, an inn, mooring blocks and cranes.</p> 
0.48	<p>Cotehele Quay has a history of being affected by both tidal and fluvial flooding. Changes have been made over the years to protect the site from periods of extreme high water.</p> 
01.00	<p><i>"In the early 1800s they started putting defence banks up along the river... Before then you still had these areas like we've got between the quay and the chapel, and then opposite Calstock – which would have allowed the water to spread out. But by putting the defence banks up, as soon as it finds a gap to go in it's in there with some force."</i></p>

	<p>"It was in the early 1800s I think, they started putting the defence banks up along the river.... So any time before then you still had these areas - like we've got between the quay and the chapel, and then opposite Calstock - which would have allowed the water to spread out, so a lot of the force behind the water would have been spread out. But by putting the defence banks up, as soon as it finds a gap to go in it's in there with some force. So open quay areas are always going to be vulnerable"</p>  <p>Joe Lawrence Flooding in the Tamar Valley Interview with Mark Goldthorpe</p>
01.20	<p>The highest tides occur twice a month on the full and new moon—these are called spring tides. When adverse meteorological conditions coincide with spring high tides the likelihood of flooding in the Tamar Valley increases. At the moment, high tidal waters overtop the quay during most spring high tide events.</p> 
01.40	<p><i>"I came down that particular night to check on Shamrock and I nearly walked straight into a lake. I come down past the tea rooms but all I could see was water."</i></p>  <p>"I came down that particular night to check on Shamrock and I nearly walked straight into a lake. I come down past the tea rooms and all I could see was water"</p> <p>Peter Allington Recollection of 2008 flood event Interview with Mark Goldthorpe</p>
01.50	<p>Most people who live or work on the River Tamar will have experienced a flood event during their lifetimes. People who live on the river often document high water levels with photographs.</p>



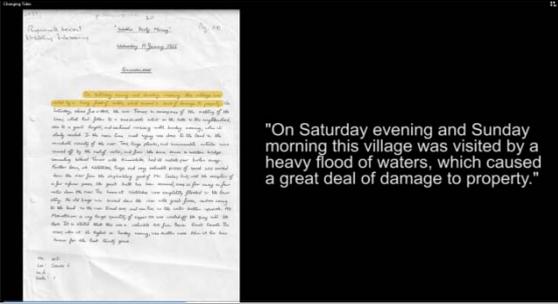
02.25

Throughout its history, Cotehele Quay has suffered many extreme flood events, both during its hey-day in the mining era and throughout the 20th and 21st centuries. Many of these historic flood events have been well documented, and records can be found in the Calstock Parish Archives.



02.53

A flood in 1866 was well recorded in the archives. Although we can't know exactly how Cotehele Quay was affected during this flood, records comment on the fact that the River Tamar rose to a great height. Trees and other objects were carried off in a rush of flood waters, causing great damage to land in the vicinity of the river.



03.13

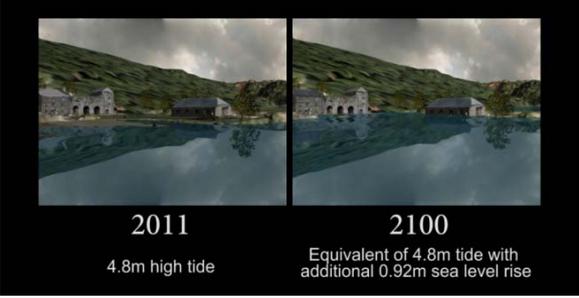
To help us understand past and future tidal flooding at Cotehele, we have created the first virtual model of the site. This three dimensional model has been produced using state of the art technology and computer software. In the model, tidal conditions can be adjusted to reflect past, present and future levels. This allows us to visualise what past tidal conditions were like, showing perhaps more importantly projected increases in sea-level to understand the possible impacts of future sea level rise on the quay.

Specialist surveying equipment, including a laser scanning device, was used at the quay to capture data about the height, shape and arrangement of buildings and surrounding terrain. This detailed survey comprises millions of

	<p>laser scanned data points. We used design software to transform the data points into a three dimensional digital model. This model balances spatial accuracy with a desire for visual realism.</p> <p>Throughout this film you will see short video sequences created using the virtual model.</p> <p>The model can be used as a tool for initiating conversations about past and future change on the quay. These conversations will inform decision-making about adaptation at Cotehele.</p> 
04.30	<p>Extreme events such as flooding can generate strong emotional responses and have a dramatic impact on the landscape. However, changes in everyday tidal cycles are likely to have a more frequent and noticeable impact on Cotehele Quay in the future.</p> 
04.46	<p>Scientists believe that sea-level rise in the UK has been occurring since glaciers started melting at the end of the last ice age. There is evidence of historic sea-level rise at several coastal sites on the Cornish coastline, including the drowned forest at Marazion and underwater field boundaries on the Scilly Isles.</p> <p>The nearest long-term tide gauge to Cotehele is at Newlyn, Cornwall. Newlyn's records show that over the 20th century there has been an average increase in mean sea level of about 1.7 to two millimetres a year. Over the last 50 years or so the rate of sea-level rise in the South West has increased to approximately three millimetres a year. There is some evidence that this rate is increasing. This increase has been attributed in part to thermal expansion of the oceans, due to higher atmospheric levels of the greenhouse gas, carbon dioxide. The 2009 UK Climate Projections Report anticipates that the rate of sea-level rise will continue to accelerate.</p>

	
05.51	<p>At the time of the 1866 flood event the mean high water level was 29cm lower than it is today.</p> 
06.07	<p>Today an average spring high tide is 4.8m above chart datum. Chart datum is the lowest possible level of the tide, but is a level that varies across the country and is dependent on the range of the tide at a particular location.</p> <p>On September 9th 2010 a spring high tide on the quay measured 5.1m, as shown in this comparison.</p> 
06.33	<p>By 2050 we could be seeing an extra 11 centimetres on the top of an average spring high tide, bringing it to 4.91m above chart datum. This estimate is based on the most conservative possible reading of sea level rise projections, drawing on findings from the UK Climate Projections report.</p>

	 <p style="text-align: center;">Spring High Tide 2050 4.8m + 0.11m</p>
06.55	<p>People familiar with the river's cycles suggest that increased rainfall and low pressure systems can add up to a metre of water on top of the high spring tide levels. Such levels could limit access to some areas of the site and damage buildings and artefacts.</p>  <p style="text-align: center;">Extreme Spring High Tide 2050 4.8m + 1.11m</p>
07.12	<p>Life on the river will need to adapt to these new circumstances...</p> 
07.20	<p>There is some debate about the magnitude of sea level rise in the more distant future beyond 2050. This is because the magnitude will vary depending on changes in atmospheric carbon dioxide in the next 50 years. Some studies suggest a worst case scenario in which sea levels will rise by almost a metre by 2100. This means we could expect to see an average spring high tide increase to 5.7m above chart datum. At these levels the quay could potentially flood several times each month. A low pressure system combined with heavy rainfall could add up to a metre of water, with potentially greater consequences.</p>

	 <p>The image shows two side-by-side photographs of a coastal town. The left photograph is labeled '2011' and '4.8m high tide', showing buildings partially submerged in water. The right photograph is labeled '2100' and 'Equivalent of 4.8m tide with additional 0.92m sea level rise', showing the same town with a significantly higher water level, indicating more extensive flooding.</p>
	<p>End and Credits</p>

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