

Affective geographies of models and modelling

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Summary

With reference to three contexts of models and modelling practice (hydraulic models of environmental systems, model railways and miniature wargaming), this thesis asserts the importance of geography in understanding what models can be, what and how they can *do*, and how and why models may be made and engaged with. The thesis traces spatialities of models and modelling via conceptions of affect, emotion and feeling, alongside abstraction, the miniature and mimesis, in order to highlight how space is central to lived and embodied engagements with models and modelling. This thesis makes several contributions. Firstly, this thesis gives shape to five key interrelated ‘geographies of models and modelling’, these are; one: models and modelling can generate space-times, and in so doing, produce affective engagements with those space-times. Two: models, modelling and material and embodied affects can shape how spaces (including models) may be constituted, affected, encountered and engaged with. Three: practice can inform modelling as a representational practice and be important to models as representations. Four: modelling as a mimetic practice which, as well as model and modelling engagements, can involve embodied relations whether with places, landscapes, environments, events, people, materials, objects (including models), and temporalities of pasts, presents and futures. Finally, five: model and modelling engagements can be involved with the miniature and an ‘affirmative critique’ of abstraction. Through these geographies and the theoretical underpinnings of this thesis, the second core contribution: six broad lessons about models and modelling. These are; one: models and modelling and the absence and presence of possession. Two: modelling as a negotiated practice. Three: modelling as ‘drawing out elements of the world’. Four: models and modelling as connecting us with the world. Five: models and modelling and human and non-human relations. Finally, six: models and modelling and the more-than-representational.

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Dedication

This thesis is dedicated to my father Stuart MacKinnon who died from cancer at Christmas 2014. Dad, born in 1953, was an enthusiastic 'amateur' intellectual of the ancient world, particularly warfare and governance of the early Roman Empire. Supremely witty, charismatic, sharp in mind, principled and loving, dad experienced higher education in his mid-20s, gaining a BA in Egyptology from the University of Birmingham. Dad extolled the vital forces of learning, including the love of learning for its own sake. 'Down the pub' he would often assert 'knowledge is never wasted' and was always interested in academic debates, including hearing about geography ones. Dad had read parts of this thesis as conference presentations and even when gravely ill would make an effort to make several comments. He also drove me to interviewees on several occasions before I had a Sat Nav and bought me several miniature wargaming and model railway magazines. He had just turned to a new chapter in his life after remarrying the wonderful Wendy Clements in 2012.

My thoughts are also with my beloved 'nanny across the field', Dora Emma Cureton, a caring, thoroughly 'modern' and astute countrywoman. She also died from cancer before her time, aged 81 in 2009. On the day of writing this, my great-aunt Vera Pugh passed away from cancer, aged 90. She was a paragon of kindness, love, hope and compassion.

Contents

Chapter 1: Introduction	1
1.1: Introduction.....	1
1.2: Models and modelling: Associations, histories and geographies	1
1.3: Case study contexts and justifications.....	5
1.4: Thesis structure	19
Chapter 2: Theoretical and empirical positioning	21
2.1: Introduction.....	21
2.2: Doing geography with models	21
2.3: Models and modelling in cultural and historical geography and history of science...	24
2.4: Affect, emotion and feeling.....	27
2.4.1: <i>Affect</i>	28
2.4.2: <i>Emotion</i>	30
2.4.3: <i>Feeling</i>	32
2.5: The miniature and abstraction	33
2.5.1: <i>Embodied affordances of models: The miniature and abstraction</i>	34
2.5.2: <i>The miniature</i>	37
2.5.3: <i>Abstraction</i>	39
2.6: Modelling, models and mimesis: Contestation, negotiation and the more-than-representational.....	41
2.7: Conclusion	47
Chapter 3: Methods	49
3.1: Introduction.....	49
3.2: Choice of case studies	50
3.3: Internet research	55
3.4: Textual research	58
3.5: Interview research.....	61
3.6: Archival research.....	67
3.7: Conclusion	69
Chapter 4: Model railways	70
4.1: Introduction.....	70
4.2: Introducing model railways	71

4.3: The early years of model railways and introducing a mimetic politics to model, modelling and modeller	72
4.4: Nostalgia and love.....	78
4.5: Making a perfect world?.....	81
4.6: Research for a layout	88
4.7: Material affordance, material agency and mimesis	95
4.8: Affective atmosphere	103
4.9: Playing trains.....	110
4.10: Conclusion	114
Chapter 5: Hydraulic models.....	118
5.1: Introduction.....	118
5.2: Introducing hydraulic models	119
5.3: Intervening on uncertainty: Affordances of hydraulic models, government and the HRS.....	123
5.4: Precaution, watery affect and experiment	135
5.5: The Severn Barrage study: Mimesis, futures, affect, decision-making and questioning confidence	142
5.6: Knowing water worlds: Fieldwork practice, uncertainty, instrumental knowledge and the future	150
5.7: Scale effect and the negotiation of confidence.....	164
5.8: Inscriptions, limitations and predicting	168
5.9: Conclusion	179
Chapter 6: Miniature wargaming	183
6.1: Introduction.....	183
6.2: Introducing miniature wargaming.....	184
6.3: The emergence of miniature wargaming	185
6.4: Big and little war enthusiasm	191
6.5: Model soldiers: Imaginary spaces, the still and surfaces	200
6.6: Modelling war for the tabletop, part one: Teleplastic technologies, mimetic play and an embodied ontology to war.....	209
6.7: Modelling war for the tabletop, part two: Playability, abstraction, effect, elegance and imaginary spaces of the wargame.....	221
6.8: The violence of war and the wargame: Politics, identity, abstraction and an embodied ontology to war.....	224
6.9: Conclusion	234
Chapter 7: Conclusion	238

7.1: Introduction.....	238
7.2: Scholarship on models and modelling.....	238
7.3: Five cross-cutting themes and conceptual contributions.....	239
7.3.1: <i>Models and modelling can generate space-times and, in so doing, produce affective engagements with those space-times</i>	240
7.3.2: <i>Models, modelling and material and embodied affects can shape how spaces (including models) may be constituted, affected, encountered and engaged with</i>	242
7.3.3: <i>Practice can inform modelling as a representational practice and be important to models as representations</i>	244
7.3.4: <i>Modelling practice, as well as engagements with models and modelling, can involve embodied relations whether with places, landscapes, environments, events, people, objects (including models), materials, and temporalities of pasts, presents and futures</i>	246
7.3.5: <i>How model and modelling engagements can be involved with the miniature and an ‘affirmative critique’ of abstraction</i>	248
7.4: Six broad lessons and further contributions	251
7.4.1: <i>Models and modelling and the absence and presence of possession</i>	252
7.4.2: <i>Modelling as a negotiated practice/ Placing negotiation within mimesis</i>	253
7.4.3: <i>Modelling as ‘drawing out elements of the world’/ An ‘affirmative critique’ of abstraction</i>	255
7.4.4: <i>Models and modelling as connecting us with the world/ A critique of the ‘disappearance of the real’ after Baudrillard and Virilio</i>	256
7.4.5: <i>Models and modelling and human and non-human relations</i>	257
7.4.6: <i>Models and modelling and the more-than-representational</i>	259
7.5: Closing remarks.....	259
References.....	261

List of figures

1. A ‘basic’ model railway layout.....	7
2. ‘Clinkerford’, a model railway layout by the Glevum Area Group of the Scalefour Society.....	7
3. ‘Leeman Road’, a model railway layout by John Shaw.....	8
4. ‘Witney Euston’, a model railway layout by ‘mitziblue’	8
5. The ‘Bay [hydraulic] model’.....	9
6. Hydraulic model with moveable bed of the Oder River at Hohenwutzen.....	10
7. Hydraulic model for study concerning designs of an offshore breakwater	11
8. Hydraulic model for studying harbour designs	11
9. Hydraulic models from the 1930s (1/2).....	12
10. Hydraulic models from the 1930s (2/2).....	12
11. Hydraulic computer model in 2D simulating water velocity through bridge piers.....	13
12. 3D hydraulic computer model simulating water velocity in the delta of Lake Øyern.....	13
13. Napoleonic wargame underway with members of Army Group York wargames club.....	14
14. View of several Napoleonic era model soldiers in a wargames landscape.....	14
15. Several medieval soldiers	15
16. Wargames rulebook, ‘ <i>By Fire and Sword</i> ’.....	16
17. Wargame rulebooks, ‘ <i>Gaslight</i> ’ and ‘ <i>De Bellis Multitudinis</i> ’.....	16
18. Page from ‘ <i>De Bellis Multitudinis: Wargame rules for Ancient and Medieval battle</i> ’	17
19. Page from by ‘ <i>Force on Force: Modern wargaming rules</i> ’.....	18
20. Model railway layouts from the 1930s.....	75
21. Model railway scales.....	76
22. ‘St Marnock Engine Shed’, a model railway layout by Mike Bissett.	83
23. ‘Tetley Mills’, a model railway layout by David Shakespeare	84
24. ‘Maindee East Engine Shed’ c1964, a model railway layout by Steffan Lewis.	85
25. Page from ‘ <i>Creating realistic landscapes for model railways</i> ’ by Tony Hill.	97
26. Relative locations of infrastructures that many hydraulic model studies make present.....	120
27. Exterior to HRS ‘Main Hall’ c1956.....	133
28. Interior to HRS ‘Main Hall’ c1950s.....	133
29. Figure showing results of an experiment in relation to ‘Scheme 15’	140
30. Figure showing results of an experiment in relation to ‘Scheme 27’	141
31. Plate of the 1933 Severn Barrage model at Victoria University	144
32. Admiralty chart of Benfleet, Essex	153

33. Table of tides at Sharpness, volume of river flow at Bewdley and the amount of suspended solids near Avonmouth.....	154
34. Bed dune formation records, Humber Estuary.	155
35. Figures showing ‘fit’ between model and prototype behaviour	172
36. Figures showing ‘fit’ between model and prototype current velocities.....	173
37. Figures relating to the Thames Estuary: ‘Net excursions in model and prototype at various points on a cross section in Gravesend Reach’.	174
38. Figures relating to the Thames estuary: ‘Longitudinal salinity distribution in model and prototype’.	175
39. Several plates of ‘ <i>Little Wars</i> ’ being played in the garden.....	186
40. Illustration of H.G. Wells playing ‘ <i>Little Wars</i> ’	187
41. Page from Grant’s ‘ <i>Napoleonic Wargaming</i> ’ detailing the resolving of fire effect.	189

Abbreviations

AFV	Armoured Fighting Vehicle
BMSS	British Model Soldier Society
DSIR	Department of Scientific and Industrial Research
{f}	Forum research quote
FOW	Fog of War
GOI	Government of India
HMRS	Historical Model Railway Society
HRB	Hydraulics Research Board
HRW	Hydraulics Research Wallingford
HSC	Hydraulics Sub-Committee
ICE	Institute of Civil Engineers Proceedings
IHRSP	Irrigation and Hydrodynamics Research Station, Pune
IR	International Relations
MAF	Ministry of Agriculture and Fisheries
MFP	Ministry of Fuel and Power
MLGP	Ministry of Local Government and Planning
NEG	New Economic Geography
NPL	National Physical Laboratory
NLW	National Library of Wales
OED	Oxford English Dictionary
PBA	Port of Bristol Authority
S&D	Somerset and Dorset Joint Railway
SBAC	Severn Barrage Advisory Committee
SBMC	Severn Barrage Model Committee
SLAG	South London Area Group
TMP	The Miniatures Page
TNA	The National Archives
WES	Waterways Experiment Station

1: Introduction

1.1: Introduction

This chapter outlines the aims and scope of the thesis. The first section considers the associations, histories and geographies associated with models and modelling before then highlighting what this thesis intends to do. The chapter then moves to detail the case study contexts and justifications for them. It closes by outlining the thesis structure and with some comment about each of the forthcoming chapters.

1.2: Models and modelling: Associations, histories and geographies

'It's a model world', so begins the children's book of the same name by Hilton (1972). Her book attends to the diverse 'kinds' of 'scale model' (material, abstract and miniature), eulogising their affordances and narrating modelling efforts. Concluding, Hilton writes: 'There seems to be very little on earth – and above earth – that scale models cannot do. As long as man keeps thinking up projects, it looks as if scale models will be right in there pitching' (1972, p.120). A 'scale model' is just one kind of model that people identify, make and engage with. There are for instance; 'mathematical models' (including computer simulations), 'mental models' (ideas), 'disaster management models', 'material models', 'analogical models', 'business models', 'conceptual models' (e.g. the equilibrium model), 'abstract models', 'economic models', 'theoretical models', 'animal models' (animal testing), 'experimental models' and 'architectural models' (for taxonomies of models in the natural and social sciences see Müller (2008)). Morgan has asserted that '[m]odels are not easy objects [...] to define or, in general terms describe' (2012, p.21). For the purposes of this thesis we might think about what models and modelling are involved in doing; whether enabling the investigation of phenomena, making decisions, facilitating leisure and communication (teaching, showing etc.) or making predictions. Besides the above kinds of model, a person can be a model; a person might be a 'fashion model' or a 'role model' (see

Harré 2004). The value explicit in ‘role model’ can permeate how institutions, practices, spaces and places among other things might be accorded ‘model’. For instance, Francis Bacon’s (1937[1627]) utopian novel ‘*New Atlantis*’ was, for its publisher, a ‘[f]able my Lord devised, to the end that he might exhibit therein a model’ for a scientific society (Rawley 1937, np in Salzman 2002, p.43).

The term ‘model’ derives from the Latin for ‘modus’, meaning ‘measurement’. Following Müller (2008), derivatives of ‘modulus’ appeared in the French, German, Italian and English languages over the 11th to 14th centuries, including ‘pattern’ (worthy of imitation or the subject of imitation) and ‘paragon’ (having excellence, perfection), both of which can refer to the meaning of model expressed by Rawley on Bacon’s ‘*New Atlantis*’. By the Renaissance, model through ‘modello’ also referred to small physical representations, patterns important to the design and execution of architectural works (Morris 2006; Smith 2004). For Italian architect Martini writing in the 1480s: ‘Whereas it is difficult to demonstrate everything through drawings, nor is it at all possible to express many things in words [...], so it is necessary to make a model of nearly every object’ (Martini 1967, I, p.142 in Müller 2009, p.643). Over time, it was likely through the ability of a model to show architectural design and other design like invention to people in different places, divorced from particular contexts of practice, that model gained a meaning as a representation (see Müller 2008).

Of course, many representations are not considered models. Woodyer, in navigating how to approach what toys are, provides some help in thinking about how model has a ‘fluidity of meaning’:

‘In its broadest sense, ‘toy’ refers to a plaything, however, as Fleming (1996) notes, an object’s identity as a toy is not given, stable or intrinsically fixed in a unitary way. Rather, an object’s recognition as a toy depends upon its social and economic setting, culturally derived associations and representations in which it appears, and the prior experience of its user’ (2010, p.5).

The ‘fluidity of meaning’ of the term model, something this thesis works with, is complex and similar to ‘toy’ in many respects. An example can be found in Nyhart’s (2004) writing on the ‘natural history displays’ of German museums at the turn of the 20th century. Nyhart found it ‘remarkable’ that despite ‘artificial’ plankton being referred to as models, ‘German curators never wrote about their full-sized reconstructions of natural scenes [natural history displays] as ‘models’’ (2004, p.329). Nyhart considers this ‘suggests two important features of the values of natural history [...]; it indicates a powerful need among naturalists

to preserve authenticity as central to their practice of science and representation of nature and to divide it sharply from artifice' (ibid).

Historians of science have highlighted the formative role of models and modelling/modellers in the 'scientific enterprise' (Hopwood and Chadarevian 2004). Models, as Mazzolini (2004) and Schaffer (2004) have shown, were central to projects of the 'Age of Enlightenment'. For Schaffer in the context of ship and electric fish models: '[T]he great political debates of the age of reason concerned the legitimacy of applying to natural and social worlds the principles that had been demonstrated in mechanical models' (2004, p.97). Models could be found wherever 'commissioning, designing, making, exhibiting, awarding prizes and teaching' took place for Hopwood and de Chadarevian (2004, p.4). We can also include places of experimentation (see Harré 2009; Leggett 2013; Schaffer 2004) and research (see Harré 2009; Meinel 2004) and these were places where modelling happened as well.

By the mid-20th century, models became very important to the mathematical, social and physical sciences. Through theoretical physicist Ehrenfest, 'model' (which referred in physics to physical representations) came to permeate mathematics in the 1900s. Axioms, laws, formulas and equations relating to mathematical ideals/ideas and/or 'reality' began to be called models (see Morgan 2012; Schichl 2005). In the 1930s, the economist Tinbergen (and an assistant of Ehrenfest) called his new mathematical and statistical 'objects' models, and by the 1950s economists for Morgan were 'using the term as naturally as one might refer to domestic weed' (2012, p.12). As Barnes (2001a, 2001b, 2004, 2008, 2014) has detailed, human geography became caught up in a quantitative and positivist ascendancy in the late 1950s and early 1960s where, alongside computer power, mathematical models (including economic models) were 'star actors' in attempts at making 'relevant' interventions with, and 'truthful' conceptions of the world. Since the 1960s, mathematics, computer power and technologies of simulation and visualisation have pervaded or borne new kinds of model and modelling engagements (see Francoeur and Segal 2004; Turkle 2009), for example for O'Sullivan:

'Running the numbers' means 'asking a computer' what is likely to happen in the (virtual) world of a model, and acting in the (real) world as a result. This happens all the time, in all manner of ways from the banal (using weather forecasts to decide what to wear at the weekend), to the significant (using economic models to adjust interest rates), to the epoch-making (using climate change models to inform policy on carbon emissions; using war games to help decide whether or not to invade Iraq)' (2004, p.290).

An effect of the quantitative and positivist ascendancy on geography during the 1950s and 60s (the ‘quantitative revolution’) has been that today, modelling is an important epistemic practice and models important epistemic objects in human geography and physical geography, but especially the latter (see Cresswell 2014; Demeritt and Wainwright 2005). In recent years, cultural and historical geographers have studied several kinds and contexts of models and identifiable modelling practice, highlighting important engagements with models and modelling. However, given the pervasiveness of models and modelling in either historical or contemporary engagements with the world, the geographic literature is surprisingly light. In the context of classroom geography models (Ploszajska 1996) and model aircraft (Adey 2010, 2011), Adey and Ploszajska have each shown how physical models and modelling can be embroiled in the making of knowledgeable national subjects. Yarwood (2015) has recently dwelt a little on how miniature model soldiers can be objects of enchantment and work through play as ‘transitional objects’ helping to produce the imaginary spaces of the recreational wargame. Elsewhere, Koch (2010) has examined how physical architectural models can turn politically contentious projects into ‘objects of reverie’. More detail about this model literature in human geography is provided in 2.3.

This thesis seeks, with reference to three different contexts of models and modelling practice, to consider aspects of the importance of geography in understanding what models can be, what and how they can *do*, and how and why models may be made and engaged with. It traces spatialities of models and modelling via conceptions of affect, emotion and feeling, alongside abstraction, the miniature and mimesis. This opens up the conceptual space for the thesis to highlight the ways in which space can be central to lived and embodied engagements with models and modelling. Key to how geographies are traced in this thesis is affect, read after Spinney as ‘concerned with how emotions, sensations, atmospheres and feelings arise out of relational encounters between objects, spaces and people’ (2015, p.235).

This thesis gives shape to five key ‘geographies of models and modelling’ when considering aspects of the importance of geography in understanding what models can be, what and how they can *do*, and how and why models may be made and engaged with. The following cross-cutting themes *and* contributions are dwelt on; firstly, models and modelling can generate space-times and, in so doing, produce affective engagements with those space-times. Secondly, that models, modelling and material and embodied affects can shape how spaces (including models) may be constituted, affected, encountered and

engaged with. Thirdly, how practice can inform modelling as a representational practice and be important to models as representations. Fourthly, modelling as a mimetic practice which, as well as model and modelling engagements, can involve embodied relations whether with places, landscapes, environments, events, people, materials, objects (including models), and temporalities of pasts, presents and futures. Fifthly, how models and modelling engagements can be involved with the miniature and an ‘affirmative critique’ of abstraction.

Through the geographies of this thesis and its theoretical underpinnings, six broad lessons about models and modelling are also submitted. It is shown how these lessons are connected with contributions to several of the theoretical concepts this thesis has deployed (abstraction, the miniature, mimesis) and debates in geography concerning the human and non-human, the representational and the more-than-representational. To make clear, the six lessons are; one: models and modelling and the absence and presence of possession. Two: modelling as a negotiated practice/placing negotiation within mimesis. Three: modelling as ‘drawing out elements of the world’/an ‘affirmative critique’ of abstraction. Four: models and modelling as connecting us with the world/a critique of the ‘disappearance of the real’ after Baudrillard and Virilio. Five: models and modelling and human and non-human relations. Finally, six: models and modelling and the more-than-representational.

1.3: Case study contexts

From the outset, this PhD has been premised on an examination of several contexts of models and modelling practice. Such an approach has been deemed important because models are, and modelling is, differentiated (Demeritt and Wainwright 2005; Hopwood and Chadarevian 2004; Morgan 2012). Focusing on one context would have limited the scope and impact of the research, but the project would have also been different in character. This provides a brief introduction to each of the case studies; model railways, hydraulic models and miniature wargaming.

The model railway hobby, a practice emergent in Britain from the early 20th century, is one of several leisure activities associated with ‘railway enthusiasm’ (Carter 2008). The hobby involves making and engaging with a ‘layout’; a railway in its landscape and located usually on a baseboard at home, with model trains operated by electricity (see

figures 1-4, pp.7-8). The hobby is gendered, practised overwhelmingly by males from adults, teenagers to young children (Carter 2008; Yarwood and Shaw 2010). As far as can be judged from the research undertaken for this thesis, railway modelling is undertaken predominately by white males of diverse ages and social-economic backgrounds. This thesis engages with the model railway hobby through interview, internet and textual research.

Hydraulic models and modelling are important epistemic objects and practices respectively in the sense of knowing environmental and infrastructure/intervention futures, ensuring there are 'no bad surprises' (Anderson 2010). Models can be physical scale models, computer models or a mix of both (see figures 5-12, pp.9-13). Hydraulic modelling is a professional practice and emerged in Europe over the 19th century. It is concerned with shaping the capacities of water infrastructures/interventions to affect and be unaffected by 'water worlds' (Anderson and Peters 2014) in particular ways. The term 'water world/s' is used in this thesis to mean estuaries, rivers and coasts. This thesis concentrates on physical hydraulic models and a formative period of hydraulic modelling in the UK (1930s - 1950s) using archival material on the UK government's Hydraulics Research Station (HRS). Hydraulic modelling in the historical context this thesis examines is a male dominated practice, unsurprising given the societal expectations of women in 1950s Britain (see Holloway 2005).

The final case study concerns miniature wargaming which, like model railways, is predominantly a hobby practice and a gendered, male one too. Miniature wargaming developed in the UK and America during the 1950s and 60s. Miniature wargaming is a multifaceted practice involving wargames design and painting and gaming with miniature figures on a physical battlefield landscape (see figures 13-15, pp.14-15). In relation to wargames design, wargamers may compose or tinker with what is often called a 'warfare' or 'conflict model'. This is a textual document (a 'rulebook'), made up of rules and 'mechanisms' that represent combat practice and aim to negotiate play and enable particular feeling, emotional and imaginative states relating to other human bodies and space-times (see figures 16-19, pp.16-18). Unlike computer games, this 'model' (the representation of warfare/conflict) is 'external' (engaged with actively by the gamer) rather than 'internal' (models in computer games are also written in code). The hobby is engaged with through interview, internet and textual research.



Figure 1. A 'basic' model railway layout. Source: New Railway Modellers (2008).



Figure 2. A view of 'Clinkerford' (c1930s and a layout based on Cinderford station, Gloucestershire) by the Glevum Area Group of the Scalefour Society (The layout is on display at a model railway exhibition in the figure). Source: Combebarton (2010).



Figure 3. A view of 'Leeman Road' (York, c1962-1966), a layout by John Shaw. Source: Shaw (2015).



Figure 4. A view of 'Witney Euston' (East Midlands, 1910), a layout by 'mitziblue' (online forum name). Source: mitziblue (2010).



Figure 5. Panorama of the ‘Bay model’. This is a model of San Francisco Bay and Sacramento-San Joaquin River Delta. Built in 1957 by the Waterways Experiment Station to examine ‘impacts of the deepening of navigation channels, realignment of Delta channels (via a Peripheral Canal), and various flow arrangements on water quality’ (Wikipedia 2015, np). The model was operational until 2000. Source: Wikipedia (2015).



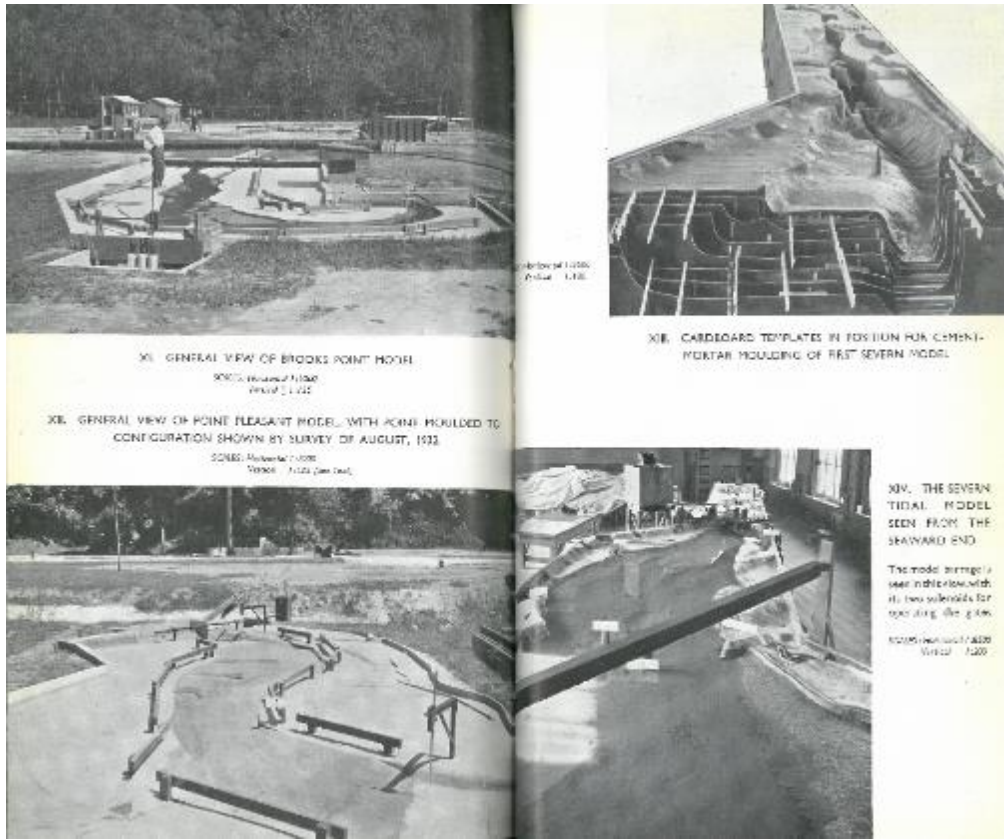
Figure 6. Model with moveable bed of the Oder River at Hohenwutzen, Germany. The model has been used for flood control designs. Source: Bundesanstalt für Wasserbau (2015).



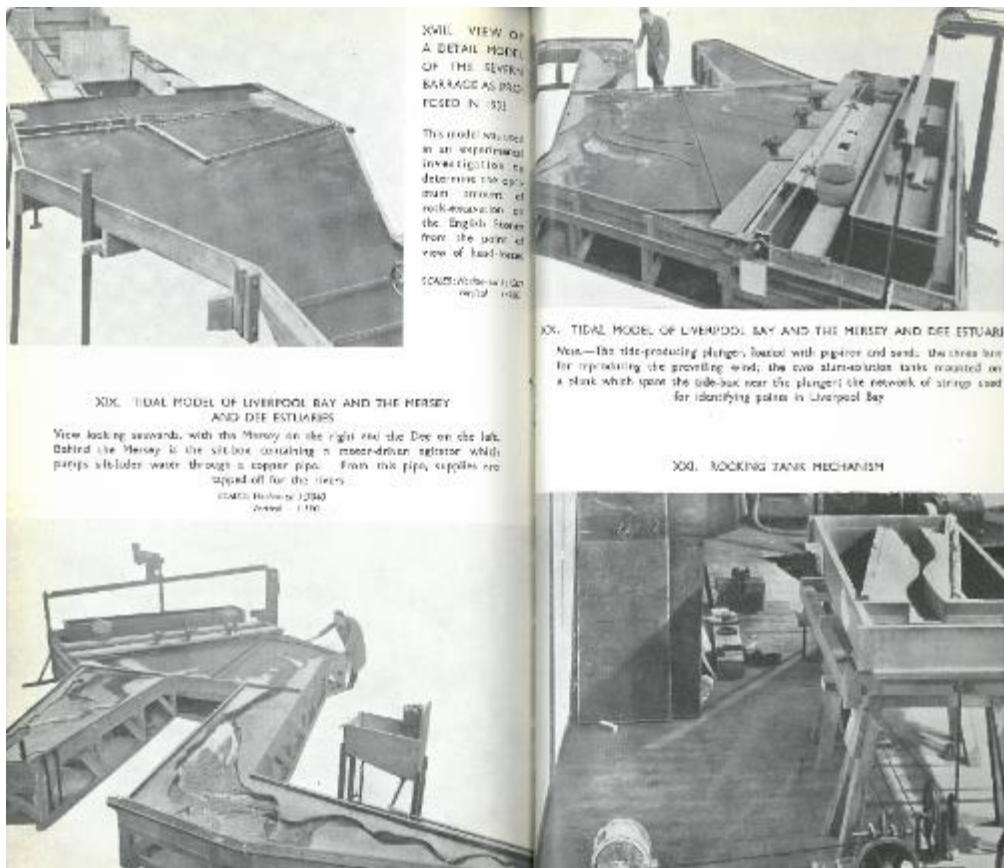
Figure 7. Model for study concerning designs of an offshore breakwater. The model is located in a ‘wave flume’. Source: Coasts, Deltas and Rivers International (2014).



Figure 8. Model for studying harbour designs. Source: R. Raviv Consulting Engineers (2013).



Figures 9 (above) and 10 (below). Hydraulic models from the 1930s. Source: Allen (1947).



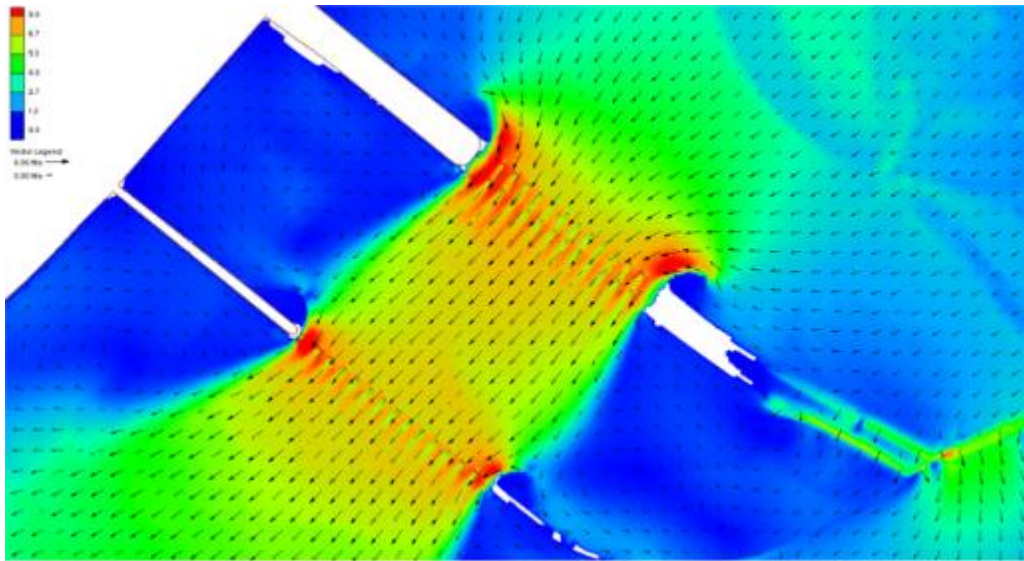


Figure 11. Screenshot of a hydraulic computer model in 2D simulating water velocity through bridge piers. Warmer colours mean higher velocity. Source: US Army Corps of Engineers (no date).

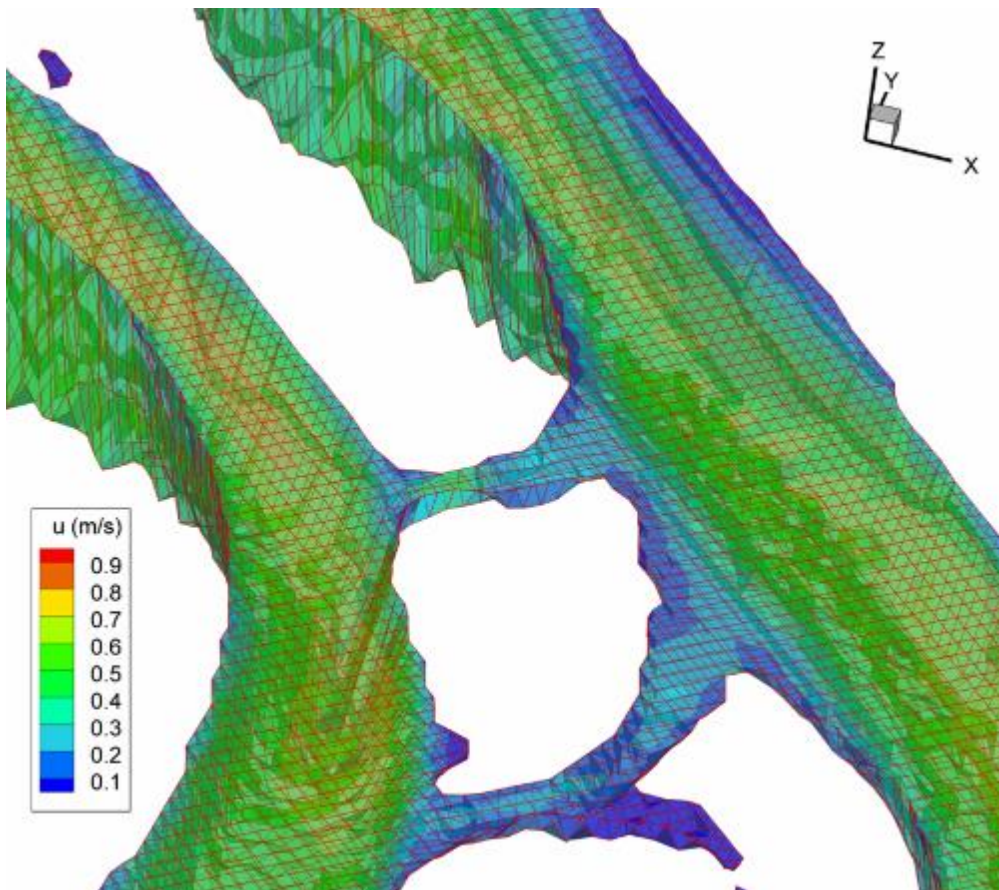


Figure 12. Screenshot of a 3D hydraulic computer model simulating water velocity in the delta of Lake Øyern, Norway. Warmer colours mean higher velocity. Source: Olsen (2011).



Figure 13. A Napoleonic wargame underway with members of Army Group York wargames club. Source: Army Group York (2015).



Figure 14. A view of several Napoleonic era wargames figures (the strip of grey in the foreground represents a road). Source: Army Group York (2015).



Figure 15. Several medieval wargames figures. Source: The World of Stelios (2015).



Figure 16. A wargames rulebook, *'By Fire and Sword'*. Source: Wargamer Company (no date).

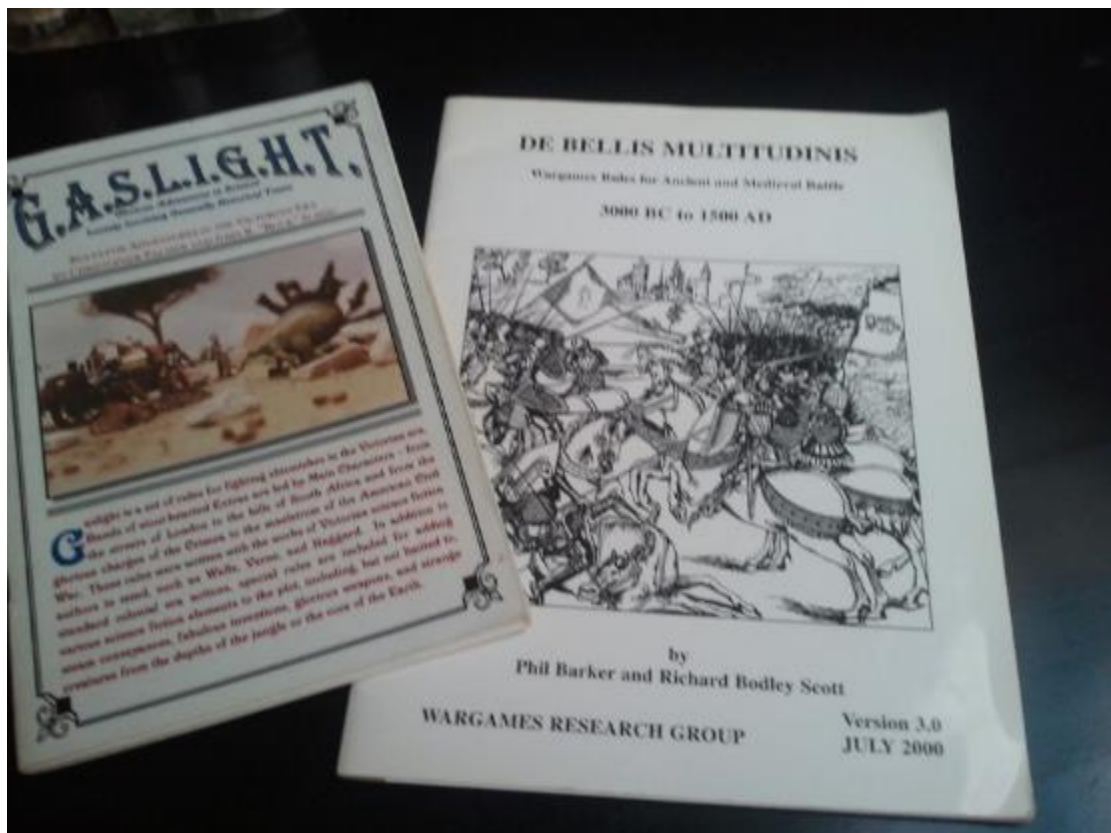


Figure 17. Several other examples of wargame rulebooks, *'Gaslight'* and *'De Bellis Multitudinis'*. Source: de Jong (2013).

Figure 18 redacted over copyright

Figure 19 redacted over copyright

1.4: Thesis structure

The thesis is composed of the following chapters:

Chapter 2: Empirical and theoretical positioning. After surveying the history of models in geography, and how cultural and historical geographers, philosophers of science and historians of science have considered models and modelling, this chapter provides initial details of the literatures worked with or taken forward through the empirical work of this thesis. Discussion pivots on readings of affect, emotion, feeling, abstraction, the miniature and finally mimesis.

Chapter 3: Methods. This chapter considers the choice of case studies and highlights how and why diverse spaces (virtual, material, textual, archival), networks (online forums, archives, texts), objects, collections, institutions and finally people (as screen-names, ‘in the flesh’ beings or dead) have been engaged with over the course of the research.

Chapter 4: Model railways. This chapter examines how model railway layouts afford and are made to produce particular affective engagements with loved, lost and/or enchanting space-times. Furthermore, modelling is considered here an embodied practice, one affected by and/or producing love, memory, atmosphere, place, landscape, enchantment, possession, matters of mimetic challenge with materials and a politics to models and modelling over matters of mimesis.

Chapter 5: Hydraulic models. This chapter explores how, at the heart of the impetus and enthusiasm for hydraulic models, are the agencies of water worlds and their uncertainties to humans and inherent changeability. Hydraulic models and modelling practices and knowledges are shown to make present, act on and present environmental futures and affected by and/or produce possession, threat, uncertainty, confidence, contestation, consternation, material and object agency in the contexts of water worlds, spatial imaginings, decision-making, scale, non-human affect and government-science relations.

Chapter 6: Miniature wargaming. This chapter considers how models and modelling are involved with war as a realm of experience. This is in relation to the spaces and places of war and also in the transformation, expansion and production of these through models.

Miniature wargaming models and modelling are shown to generate and be affected by war as a realm of experience in relation to feeling, emotional and imaginative states. On the generative aspect, for the most part this is through how models and modelling are related to other human bodies and/or space-times in the contexts of the military and battlespace (e.g. 'I feel like Napoleon at Waterloo').

Chapter 7: Conclusion. The final chapter begins by outlining how findings from this thesis give shape to five key 'geographies of models and modelling' when considering aspects of the importance of geography in understanding what models can be, what and how they can *do*, and how and why models may be made and engaged with. The chapter then moves beyond detailing relations between geography and models and modelling. It submits six broad lessons about models and modelling that can be identified from the findings of this thesis and which cut across and speak to all case studies.

2: Theoretical and empirical positioning

2.1 Introduction

This chapter considers the literatures engaged with in this thesis by providing initial details of how they are worked with or taken forward through the empirical work presented. The chapter is composed of seven sections. The first discussion section, 2.2, examines philosophical theories of models whilst also drawing attention to relations between human geography and models and modelling during and since the ‘quantitative revolution’ of the 1960s. In 2.3, scholarship on models and modelling in cultural and historical geography, as well as history of science, is highlighted. It is suggested there is much more potential to contemplate models and modelling conceptually through space. Conceptions of affect, emotion and feeling, alongside abstraction, the miniature and mimesis, are important in tracing the spatialities to models and modelling this thesis presents. How geographers and philosophers have considered affect, emotion and feeling is the subject of 2.4, and where it is shown how this thesis works with these concepts and, in the case of affect, how the thesis contributes to scholarship on affect. In 2.5 the miniature and abstraction are of interest and it is narrated how this thesis engages with and contributes to literatures respectively on these concepts. A sixth section, 2.6, attends to how this thesis works with several literatures and in the context of an overarching theoretical theme of mimesis. Mimesis is a concept this thesis also seeks to contribute conceptually towards.

2.2: Doing geography with models

Many geographers, past and present, physical and human, *do* geography with models and through modelling. Many geographers, therefore, have been/are intimate with models and modelling and with geography infused in these. As Ploszajska notes: ‘[H]istorians of geography most frequently associate the idea of model-building with post-1945 attempts

to establish the discipline as a spatial science' (1996, p.388). Mathematical models were crucial to the 'quantitative revolution' in physical, economic and urban geography during the 1960s although, as Barnes (2001a) has noted, geographers had been 'numerate' before, if there was any 'revolution' it was in theory. Many geographers, envious of economic and physical science, thought mathematical models and modelling in geography might afford enhanced professional and disciplinary status and more 'relevant' interventions with, and 'truthful' conceptions of, the world. Models and modelling, alongside computer power, were to help generate 'a radical transformation in the spirit and purpose' of geography for Burton (1963, p.151 in Barnes 2001, p.546). In the process of this 'radical transformation' within human geography, regional geography was being called 'to walk the plank' (Clarke and Wilson 1989, p.32). Physical geographers were also tempted by models and modelling, for Strahler:

'If geomorphology is to achieve full stature as a branch of geology [...] it must turn to the physical and engineering sciences and mathematics for the vitality it now lacks [...]. The establishment of [...] mathematical models may be regarded as the highest form of scientific achievement because the models are precise statements of fundamental truths' (1952, p.937 in Cresswell 2013, p.94).

Barnes (2001a 2001b, 2004a, 2008, 2014) has written extensively of how mathematical models were implicated within the practice of economic geography during the quantitative revolution, a period when 'both human and physical [geography] models [were] star actors often at the centre of the action' (Barnes 2008, p.5). Philosophy of science scholars Cartwright (1983, 1999), Hacking (1983), Hesse (1963), Morrison and Morgan (1999) and Pickering (1995) have all studied mathematical models in science. Barnes (2008), in his work on the relations between the military-industrial complex, mathematical modelling and the quantitative revolution, makes several important conceptual observations about mathematical models, drawing on these philosophy of science scholars. Several of these observations have applicability beyond mathematics and are important in conceptualising models for this thesis. Firstly, after Hesse (1963), models have agency: '[Models] do not simply describe the world, or help explain it [...], they also intervene, changing it [...]. The gravity model was used to change urban infrastructures and services on the ground [...], models produce material effects good and bad, big and small' (Barnes 2008, p.4). Secondly, for Morrison and Morgan, models can 'function as tools or instruments' (1999, p.11 in *ibid*), while Barnes suggests 'models [can be a] form of technology [...]. They are instruments to think about the world and instruments to alter it' (*ibid*). In relation to

Barnes's assertion, and also highlighting the affordances of models as abstract entities, Demeritt and Wainwright tell us that:

‘Models have assumed such prominence [in both physical and human geography] because they provide a method for understanding and predicting the operation of systems that either for practical and political reasons or because of complexity, spatio-temporal scale, or both, do not lend themselves to experimental methods of parameter or control group manipulation’ (2005, p. 206).

Thirdly and finally, the use of models and the practice of modelling can be about coming to terms with the ‘material agency’ of the world; ‘to try to get involved, to try to get a fix on it’ (Barnes 2008, p.7) after Pickering (1995).

For Badiou (2007 [1966]) models are ‘artificial’ entities and for Lévi-Strauss (1963) ‘constructed’ and ‘knocked together’. Furthermore, for Badiou (2007[1966]) in his exposition of a ‘materialist epistemology of mathematics’, models are only ever ‘partial representations’, and thus for Cantot and Luzeaux (2011) should be approached always with a ‘critical spirit’ in scientific practice. Models as partial representations and how, drawing upon Hesse (1963), Morrison and Morgan (1999) and Pickering (1995), they potentially affect and generate spaces, practices and conceptions about the world, can make modelling a highly fraught practice. Modellers may know and feel this and/or those people who are going to be affected by the result/prediction/conclusion that a model and modelling has helped produce (incidentally modelling *with* stakeholders (‘participatory modelling’) aims to ameliorate consternation (e.g. Dunn 2007; Voinov and Bousquet 2010; Voinov et al 2014)). At the height of the quantitative and positivist ascendancy in human geography, Haggett and Chorley appealed for ‘vigilance’ in ‘model building’ (1967, p.26), especially when there was so much enthusiasm for it and from other places such as government (which could mobilise enthusiasm within geographers). Haggett and Chorley suggested: ‘[S]implification might lead to ‘throwing the baby out with the bath water’; structuring to spurious correlation; suggestiveness to improper prediction; approximation to un-reality; and analogy to unjustifiable leaps into different domains’ (1967, p.26).

Positivism and the use of models in the practice of human geography came under critique from several new theoretical developments in the 1970s, namely Marxist political economy (Harvey 1973) and humanism (Tuan 1975). Since then, and with the ‘cultural turn’ (Bennett 1998) and attention to the ‘non-representational’ (Thrift 1996) (or the ‘more-than-representational’ (Lorimer 2005)), models and modelling have been marginalised in human geography, including economic geography. For Krugman, economic geography now ‘involves a rejection of abstract models in favour of ‘discursive

persuasion” (2011, p.3). Krugman writes that economic geographers have been ‘furious’ about economists and their ‘New Economic Geography’ (NEG) (ibid) where conceptualisation of space, place and history in models has been regarded by economic geographers as highly problematic (e.g. Garretsen and Martin 2010).¹ Johnston et al (2014) note an ‘antipathy’ towards quantitative methods within human geography generally, whilst for Woods ‘many rural geographers will be uneasy with the positivist or normative nature of [...] quantitative analysis and modelling’ (2012, p.131). However, models and modelling have a place in human geography (Cresswell 2014; Johnston et al 2014), especially when for Cresswell models are ‘less simplistic [...], informed by critical theory [...], more focused on ‘place’ and less positivist in its outlook’ (2014, p.54). The work of mobilities geographer Schwanen is an exemplar of such an approach. Schwanen’s work underscores how ‘quantitative methods can make important and unique contributions to critical geography’ (Schwanen et al 2014, p.63, also see Kwan and Schwanen 2009). Looking to the future, models and modelling in geography might be allied with ‘big data’, possibly leading ‘to a new scientific, positivist and quantitative turn in the social sciences [...], reducing the space for critical, qualitative and post-positivist research’ (Graham and Shelton 2013, p.257) (for discussion on ‘big data’ and geography see *Dialogues in Human Geography* 2013).

2.3: Models and modelling in cultural and historical geography and history of science

Today, models and modelling practice in the guise of mathematics and framed by positivism has lost its pre-eminence in human geography’s key tools, practices and interests, although remaining strong in physical geography. As Cresswell asserts: ‘The broad principles of positivism fit well within physical geography, [...] [a]lmost all physical geographers would subscribe to the [...] view that there is an external reality that is observable’ (2013, p.164). Physical geography could be said to adopt a philosophical stance of ‘critical rationalism’ (Inkpen and Wilson 2013).

Models are often involved in the writing of human geography in the sense of some kind of ‘formation’, whether a theoretical conception (Anderson et al 2012), a concept

¹ For Krugman though, NEG scholars are not looking for ‘realism’ but just ‘demonstrating that models of economic geography can be cute and fun’ (Krugman 1991, p.99 in Krugman 2011, p.3).

(Eden and Bear 2011), a canon (Powell 2015) or organisational network and/or structure (Wills 2012). Human geographers have also critically engaged with these kinds of models as mobilised 'out there' in the 'everyday' world and where they might be infused by 'ideal' and/or 'simplification'. Eden and Bear (2011) have illustrated how the equilibrium model, inherently problematic for its simplification and theory, is a powerful one within environmental education, affecting how environments are managed. Elsewhere, urban geographers have been interested in 'model cities' within the context of urban regeneration policy and practice, whether 'quasi-real entities' such as the 'Barcelona model' (see Blanco 2009; González 2011) or the controversial 'creative city' thesis of geographer Richard Florida (2005; Landry 2008) (see Leslie and Catungal 2012; McCann 2007; Miles 2005).

Over the past several decades or so, cultural and historical geographers have looked at several kinds and contexts of models and identifiable modelling practice, featuring particular engagements with models and modelling. Models as full of agency, being crafted three-dimensional objects and being a 'technology' or some kind of 'tool' permeates discussion of models. However, implicated within such discussion, cultural and historical geographers have also explored embodied engagements with models and modelling. Ploszajska (1996) and Adey (2010, 2011) have demonstrated how material models and modelling can be embroiled in the making of knowledgeable national subjects. Adey (2010, 2011) has described how Britain's Air Training Corps and Air Scouts in the 1930s and 40s believed the making of model aircraft (made up of diverse practices such as research, engaging with materials and experiment) developed an 'airmindedness', generative of 'model airmen', the pilots of tomorrow, in ways not possible by 'the eternal lecture and [the practice of] note-taking' (Air Training Corps Gazette 1941, p.5 in Adey 2011, p.77). Ploszajska (1996) has also looked at questions of materiality and the didactic, concentrating on knowing geography in the Victorian and Edwardian classroom. Making models and engaging with models made abstract concepts 'real' and the faraway places of the British Empire 'near'. For Ploszajska: '[M]odels [for the Royal Geographical Society, Geographical Association and Local Education Authorities] provided useful tools with which to sculpt British Imperial citizens' (1996, p.395). Elsewhere, Yarwood and Shaw (2010) have examined the hobby of railway modelling, drawing on Campbell's (2005) idea of the 'craft consumer' through which they emphasise 'the ways that commercial products and discourses are used, modified or ignored in the production of personal, model landscapes' (p. 427). Yarwood (2015) more recently has looked at the hobby of miniature wargaming and in a paper primarily concerned with how 'miniaturisation affects space' (p.654) has

dwelt a little on how model soldiers can be objects of enchantment and work through play as ‘transitional objects’, helping produce imaginary spaces of the wargame. Meanwhile, Koch (2010) has considered the use and display of physical architectural models by the Kazakhstan government in its elite city and nation building projects. Drawing upon Stewart’s (1993) theorisations of the miniature, Koch argues the qualities of the miniature architectural models make these projects into ‘objects of reverie outside the field of political contestation’ (p. 769).²

Given the centrality of many kinds of model in the history of scientific practice, from test-animals to observable ‘mole worlds’ (Harré 2009) and plastic anatomies to model ships (see Chadarevian and Hopwood 2004), historians of science have paid significant attention to models and modelling (see Chadarevian and Hopwood 2004; Knight 2014; Rossi 2010; Wintle 2009, 2014). Some historians of science have explicitly given prominence to the affectual possibilities/nature of models, how they may mobilise the imagination, certain feelings and emotions. For Jordanova, models can ‘provoke bodily reactions in their audiences’ (2004, p.449) or may ‘hold promises [of] delight’ and give ‘diverse pleasures’ (ibid, p.448) (also see Schnalke 2004).

The geographers whose work was detailed earlier have primarily dwelt on the embodied practices of modelling (Adey 2010, 2013; Ploszajska 1996; Yarwood and Shaw 2010) and/or embodied practices with models (Koch 2010; Yarwood 2015; Yarwood and Shaw 2010). Space is important to these discussions, but this thesis argues that there is much more potential to examine models and modelling conceptually through foregrounding space. Historians of science have not made space as present as geographers. With regard to modelling, historians of science have narrated the trials and tribulations, motivations, experiences, demands and sensibilities of modellers and mobilising materials, tools, embodied skills and techniques and questions of mimesis (see Chadarevian and Hopwood 2004; Rossi 2010; Wintle 2009). In essence, much more needs to be said about the spatialities that ensue in and around modelling as practice and models as entities.

As noted in 1.2, this thesis seeks to trace spatialities to models and modelling via the concepts of affect, emotion and feeling, alongside abstraction, the miniature and mimesis, opening up space, it is argued, to contemplate models and modelling from a particular perspective, one that emphasises the importance of space to lived and embodied engagements with models and modelling. Through this, the thesis aims to consider aspects

² Other cultural and historical geographers have dwelt more briefly on models, including Matless et al (2003), Merriman (2005a) and Robinson (2012, 2013).

of how models and modelling can matter to people. This is important because doing so highlights the importance of geography in understanding what models can be, what and how they can *do*, and how and why models may be made and engaged with.

2.4: Affect, emotion and feeling

The human body has been an important locus of geographic research for over several decades. The body has been pivotal to humanistic geography (Bale 1996; Tuan 1977, 1986), Marxist geography (Callard 1998; Harvey 1998) and feminist geography (Longhurst 1997; Rose 1993). The works just referenced focus on the meaning and/or identities of bodies. Since Rodaway's (1994) '*Sensuous geographies*', geographers have also turned to considering the body as a 'generative and expressive medium' (Harrison 2000 p.504), '[a] sensing, feeling body' (Hayes-Conroy and Hayes-Conroy 2010, p.1275) and particularly in relation to its 'intersensory unity with a world' (Doughty 2013, p.31). Doughty (*ibid*) writes:

[The body needs to be understood] as a medium for relations and as our human condition for action. We have learned from Merleau-Ponty's influential phenomenology of the flesh that the body is aimed at the world, directed towards it in its outreach, because as he writes [Merleau-Ponty [1962] 2002 p.155] 'to move one's body is to aim at things through it; it is to allow oneself to respond to their call, which is made upon it independently of any representation'.

Affect, emotion and feeling have been of intense interest to human geographers in recent years. This PhD project finds these important for mobilising particular spatialities to models and modelling. As will be evident over the course of this thesis, affects, emotions and feelings are pivotal to how we can think geographically about what models can be, what and how they can *do*, and how and why models may be made and engaged with. This section gives space to specifying understandings of affect, emotion and feeling. This section also highlights aspects of how the thesis works with affect, emotion and feeling and, in the case of affect, how this thesis contributes to geographical work on affect. Affect, emotion and feeling are each similar, but different at the same time. The section considers each concept individually in a dedicated sub-section primarily for ease and clarity of discussion.

2.4.1: *Affect*

Affect is a nebulous concept. For Hanlon affect is a ‘slippery and [rather unapparent]’ (2014, p.145), whilst for Lorimer (2008) it is hard to ‘grasp’. Nonetheless, affect like emotion has occupied many geographers in recent years. Spinoza, whether read through Massumi, Deleuze or not, has been important to geographic engagement with the concept. Thrift notes several diverse theories of affect, but finds them united by ‘a sense of push in the world’ (2004, p.64) or a ‘set of flows moving through the bodies of human and other beings’ (Thrift 2009, p.88). Thrift (2004) drew on Spinoza to suggest affect happens through its ability to cause change to the body and mind. For Spinoza: ‘By EMOTION (affectus) I understand the modifications of the body by which the power or action of the body is increased or diminished, aided or restrained, and at the same time the idea of these modifications’ (in Thrift 2004, p.62). Following Spinoza, affect lies with an encounter between other humans or non-humans. Relationality is an important aspect of where affects are and how they work in this reading, as Thrift explains: ‘[Affects] occur in an encounter between manifold things, and the outcome of each encounter depends upon what forms of composition these beings are able to enter in to’ (2007, p.179, also see Anderson 2004a 2004b, 2006b). Assemblages are made through affect (Deleuze and Guattari 1988; Fox 2015) and affects show up for Fox ‘only in terms of the capacities and desires they produce and the machines they engender’ (2015, p.306, after Deleuze and Guattari 1984, pp.1-8). The ‘showing up’ of affect emanates from changes to bodies. Fox provides examples to several typologies of affectual change:

‘[C]hanges wrought in bodies by affects may be physical (for instance, a kiss or a blow); psychological (such as a gain or loss in confidence or self-esteem); social (incorporation into a collectivity or a social institution such as marriage); emotional (a rush of fear, anger or pride); economic (acquisition of monetary resources), and so forth. But affects are also ‘projectiles’ that produce further affects within assemblages [...]; as one affect produces capacities of relations to do, desire or [...] feel, these capacities in turn create subsequent affective flows’ (2015, p.306).

Geographers have engaged with affect in several ways and contexts. Affect decentres the human and as Edensor notes ‘prompts us to think about how different configurations of objects, technologies, energies, non-human life forms, spaces, forms of knowledge and information combine to form ‘affective fields’ that are distributed across particular geographical settings’ (2010, p.236, also see Edensor 2012). Edensor is writing in the context of ‘affective atmosphere’, aerial tones of sensation, emotion, feeling or mood

produced by more-than-human relations. The literature on ‘affective atmosphere’ is now extensive and has particularly focused on the ‘engineering’ or production of atmosphere (see Bille 2014; Bissell 2010; Edensor 2014; Lin 2015; Watts 2008). Within the model railway chapter this thesis engages with atmosphere and furthers work on atmosphere by considering the ‘representation of the atmospheric’ (Kazig et al 2014), looking at the ‘ability’ to and practices of ‘(re)present[ing] atmospheres and ambiances’ (ibid, np); the production of atmosphere in a different medium from that which the atmosphere exists or is supposed to exist.

Because affects are contemplated as autonomous from bodies, several geographers after Thrift (2004) have seized on examining how diverse agents try to anticipate and ‘engineer’ affect for particular ends. Adey and Kraftl (Kraftl 2007; Kraftl and Adey 2008) have looked at architecture at airports and schools and others have dwelt on contexts involving atmospheres (see Bille 2014; Edensor 2014; Lin 2015). This literature is taken further in the hydraulic models chapter by figuring how humans try to come to terms with the non-human agency of water worlds via models and seek to shape the capacities of water infrastructures/interventions to affect and be unaffected by water worlds in particular ways. This contributes to a recent call from Ash to consider non-human affect and the particular ‘actors, objects and institutions that attempt to shape affect for their own ends and purposes’ (2014, p.2).

Affect is present in this thesis for the most part through its qualifications in humans as feelings, imaginations, atmospheres and emotions (including passions). These are all situated in, and generative of, the human subject (Dawney 2013) and practices. Taking account of affect makes us think about relations between things, an aspect Spinney makes clear when he says that ‘the [geographic] study of affect is concerned with how emotions, sensations, atmospheres and feelings arise out of relational encounters between objects, spaces and people’ (2015, p.234-235). Mobilising affect in this thesis enables particular spatialities to be figured with models and modelling, whether with play and imaginary spaces, the miniature, people and practice, economies, environments, events, places and spaces. As will be evident over the course of this thesis, affect is central to what and how models can *do*, and how and why models may be made and engaged with.

2.4.2: *Emotion*

Emotion has been of intense interest to human geographers over the past decade or more. For Bondi (2005) there has been an ‘emotional turn’ in geography and reaching beyond social and cultural geography to rural, political and time geographies among other sub-disciplines (see Convery et al 2005; McQuoid and Dijst 2012; Sultana 2011). Emotion for Geoghegan ‘is central to the way people experience the world [...], giving rise to relationships between places, people, things and events’ (2013, p.41). For Smith et al emotions ‘colour our experiential world such that we interpret and value aspects of it in particular ways’ (2009, p.7). Emotions, as made through individual feelings, are therefore intensely geographical. Emotions are performed and they engender action, performance and practice (Lees and Baxter 2011).

Spinoza’s writing has been important for how geographers have been thinking about emotion and particularly its relation with affect. For Watkins: ‘[A]ffect and emotion are different and similar at the same time’ (2011, p.142). Both emotion and affect are perhaps beyond intense theorisation (Young and Gilmore 2013; Johnson 2015), but Massumi renders them as bodily ‘intensities’, although with emotion a ‘sociolinguistic fixing [...] [or] qualification of affect’ (2002, p.28). An emotion is an ‘intensity owned and recognised’ (Massumi 2002, p.28) and for Curti ‘always present with memory’ (2008, p.106). Essentially, after Anderson (2006) and Pile (2010), emotions might be considered affects, but represented ones. Given that emotion is involved with practice, affects as emotions, as Fox suggests, ‘produce capacities in bodies (for example, ‘love’ may produce capacities for heroic action)’ (2015, p.307).

Whilst geographers have attended to an array of expressed emotions from guilt, despair, love, emotional pain to hope (see Pile 2010), some geographers, particularly of affect, have been wary of it (see Thien 2005). McCormack has warned against thinking that researching emotions get us ‘authentically’ proximate with ‘or capture[s] a sense of lived experience’ (2006, p.331). We are ‘condemned’, McCormack writes, ‘as we are to inhabit the moving and more-than-human materialities in which are implicated processes such as writing, speaking, thinking, eating, drinking and using keyboards. The affective authenticity of an emphatically human experience will always remain asymptotic – or a matter of faith’ (2006, p.331). Thinking, talking and writing about emotion, but also feeling, will always be mediated by practice. Furthermore, talking and writing about emotion and showing emotion might be suppressed in particular contexts and spaces (Moran 2015), although in social situations it can be difficult or impossible to ‘hide’ emotion. The social expression

of emotions (whether verbally, textually or bodily) might be monitored by prevalent or imagined social (including professional) norms, values and expectations. This is a matter of interest to this thesis when considering hydraulic modelling.

Pile has argued that emotional geographers need to be more critical about ‘why emotional geographies should be conducted in the first place’ (2010, p.17). Pile is concerned with geographers building up ‘an ever-expanding shopping list of expressed emotions that geographers should shop for – without ever reflecting on why’ (ibid). Pile’s critique in the context of this thesis can be addressed by the matter that if an emotional relation with models and/or modelling were extinguished for someone; they may not model and/or engage with models and modelling. As Jasper has argued: ‘[Not only are our emotions] part of our responses to events, they also – in the form of deep affective attachments – shape the goals of our actions’ (1998, p.398 in Fox 2015, p.302). Pile’s critique is similar to ones by Bondi (2005) and Sharp (2009) who both call for geographers not to ‘objectify’ emotions and instead think about what taking account of emotions opens us up to in thinking and finding.

This thesis particularly finds the following ‘emotional states’ mobilised when examining models and modelling: Love, including ‘object-love’ (Geoghegan and Hess 2014), loss and longing (can be nostalgia, after Boym (2001)), enthusiasm, boredom, pain (emotional), fear, anger, unhappiness, anxiety, guilt, shame, frustration, pleasure, worry, hope and finally wonder, delight and joy (these three together can be ‘enchantment’, after Bennett (2001)). Crucially, these emotional states are related in this thesis to models as geographical objects and whether in the sense of being abstracted objects of an ‘idea of reality’ (Nordstrom 2012), miniature objects and/or affective and powerful objects producing/co-producing space-times whether imaginary and/or real. Such emotional states are also related to modelling. Emotions are related to geography and modelling in this thesis through the practices, objects, attitudes, people, knowledges, events, spaces, places, landscapes and environments enrolled in, produced and/or affected by its practice.

2.4.3: Feeling

Emotions are feelings although feelings might not always be thought of as emotions. Munt writes that ‘feeling is affect made conscious, possessing an evaluative capacity [...], and emotion is [a] psychologically constructed, dramatized feeling’ (2008, p.5 in Roy 2014, p.42). ‘Feeling’ can mean embodied sensation and perception. Feeling might be associated

with physical touch, for instance, the sensation of a cat's fur may be perceived (felt) as soft or a fence-post strong. Equally, a sensation and perception may emanate from bodily change, such as feeling tired, pain, stressed or uneasy. Some of these, such as feeling uneasy or stressed, might be co-produced by 'affective forms of touch' (Tahhan 2013), sensations and perceptions related to a diversity of things and of various temporalities. For instance, Sheller has written how 'cars elicit a wide range of feelings: the pleasures of driving, the outburst of 'road rage', the thrill of speed, the security engendered by driving a 'safe' car and so on' (2004, p.221). Perhaps a final kind of feeling is a belief or attitude towards something (i.e. 'my feelings are that...'). Many of the aforementioned kinds of feelings may co-produce a belief or attitude. 'Touch' is important to a belief or attitude because touching is a perceiving and beliefs or attitudes will be perceptions of something.

As noted in 1.2, models can be representations. This thesis seeks to mobilise the more-than-representational qualities of models and recognising the entwining of representation and affect, practice and performance in complex and diverse ways (Merriman et al 2008). Indeed, McCormack has stated that '[representations need to be] reanimated as active and affective interventions in a world of relations and movements' (2005, p.22 in Griffin and Evans 2008, p.8). Attention to several of the 'kinds' of feelings noted above is vital to this quest besides of course emotions. This is done for instance by attending, in a similar way to Matless's work on moral geographies of landscape engagement (1995, 1997, 1998, 2000, 2005), to a politics of models and modelling in wargaming and model railways, with geography being important. Furthermore, in people's engagement with all of the model contexts described in thesis, the models as representations are performative. Firstly, in the sense of the models being made to enable particular 'feeling states' relating to other human bodies and/or space-times (e.g. 'I feel like Napoleon at Waterloo'), but we can also include emotional states too. Secondly, models and their contexts have embodied affects that may 'mobilise, animate, articulate or perform' (Merriman et al 2008, p.193) a diversity of kinds of spaces (from environments to landscapes) in many different ways.

This thesis mobilises feeling for how feelings, in the same way as described earlier with emotions, are related to modelling and geography. The points made earlier about moral geographies and feeling states work themselves in here. Feelings such as being uncertain, doubtful, annoyed, confident, and the making of feeling states, are related to geography and modelling through the practices, people, objects, attitudes, knowledges, events, spaces, places, landscapes and environments enrolled in and/or affected by

modelling practice. Meanwhile, models and the above feelings, but equally feelings such as feeling powerful, carefree and comfortable/uncomfortable among others, are related in this thesis to models as geographical objects and whether in the sense of being abstracted objects of an idea of reality, miniature objects and/or affective and powerful objects producing/co-producing spaces whether imaginary and/or real.

2.5: The miniature and abstraction

This section considers the miniature and abstraction. This thesis addresses these concepts because abstraction and the miniature are fundamental to thinking geographically about what models can be, what and how they can *do*, and how and why models may be made and engaged with. This section details how this thesis works with the miniature and abstraction and also contributes to and expands literatures respectively on these concepts. Discussion is split into three subsections. The first subsection takes an observation on the miniature from several scholars, and a reassessment of abstraction from McCormack (2012), to consider how these work through the case studies. In the ensuing discussion, diverse literatures each chapter engages are also discussed. A more focused and intense engagement with several writers on the miniature and McCormack's reassessment of abstraction follow in sections 2.5.2 and 2.5.3 respectively. In these sections, further contributions to the miniature and abstraction are highlighted through looking at how this thesis addresses models and modelling.

2.5.1: Embodied affordances of models: The miniature and abstraction

Baudrillard (1994), Debord (1984) and Eco (1995) have argued that engagement with the fake, copy, illusionary or artificial might be more desirous than engagement with the 'real'. For Best and Kellner, the simulation might be 'some-how better, sexier, more exciting' (1997, p.101). Eco feels that 'a museum diorama is more vivid and effective than the scene represented' (1988, p.41 in Bruner 1994, p.397). On the embodied affordances of the artificial, Olaquiaga (1998) has argued that kitsch objects are playfully situated within tensions of nostalgia and melancholy, tradition and modernity, the real and the artificial, and in this latter case where they are often intriguing and wonderful precisely for their 'sham' nature. Arguably at the opposite end of the mimetic spectrum, Mack (2007) and

King (1996) have highlighted the enthusiasm and beguilement with ‘detail’ and/or a feeling for ‘realism’ often found in making and encountering miniatures/models. King writes that for (some) modellers ‘[t]he recreated world must look very much like the real thing, [recognising] that beauty and effect lie [...] in a realism essentially photographic’ (1996, p27).

Baudrillard (1994) is concerned about the loss of ‘the real’ through ‘hyperreal’, mainly media based ‘simulacra’ (representations) which might produce for us an inability to distinguish reality from a simulation of reality.³ Hyperreality can occur within the simulacra (model) case studies of this thesis, but the contexts as practices and engagements do not stray into the hyperreal.⁴ This is because the artificial nature of the contexts is never elided or entirely elided, whether because of the practices of making and embodied and critical engagement and/or the differing temporalities engaged with (for instance pasts and memories, futures and ‘not yet’).⁵ The enthusiasm towards several of the models discussed in this thesis can lie with the difference as much as the similarity between the ‘model’ and that world by which the model ‘makes sense’ (model, following Jordanova, ‘an incomplete concept [...] implying the existence of something else, by virtue of which the model makes sense’ (2004, p.447)).

This sub-section is interested in how the miniature and abstraction may be involved with the embodied affordances of models. All the model contexts in this thesis can be recognised as abstractions, simplifications of something, and most of the models in this thesis can also be recognised as miniatures, small or scaled down things of something.

The miniature has been the subject of several important readings, particularly from Bachelard (1994), Haraway (1991), Lévi-Strauss (1962), Millhauser (1983) and Stewart (1993). All regard the miniature as imbued with power. Bachelard has remarked that ‘[t]he cleverer I am at miniaturising the world, the better I possess it’ (1994, p.169). For Lévi-Strauss: ‘[Q]uantitative transposition extends and diversifies our power over a homologue of the thing, and by means of it the latter can be grasped, assessed and apprehended at a

³ Whilst Baudrillard is not wrong to assert the performance of simulacra (and Deleuze writes on it (see Massumi 1987)) and is central to the thinking of ‘reality’ within the new cultural geography of the 1990s (Nayak and Jeffery 2013), his thesis has been critiqued as totalising, regarding people as passive and full of ‘methodological ineptitude and empirical misrepresentation’ (Hancock and Tyler 2001, p.30) (see also Best and Kellner 1991; Bruner 1995; Hayles 1991; Massumi 1987). Baudrillard’s work, despite several attempts by geographers (Smith 1997, 2003; Smith and Doel 2001), has on the whole elided geographical scholarship.

⁴ This thesis stays away from any discussion of hyperreality because it can soon dominate discussion and with discussion being very deconstructive (e.g. Kingsepp 2007).

⁵ An element of this argument is similar to one made by the philosopher Nelson Goodman: ‘The reader of a realist novel or a museum-goer looking at even the most realistic painting is well aware that he or she is dealing with a work of art’ (Goodman 1968, p.34-5 in Potolsky 2006, p.95).

glance' (1962, p.25). For Millhauser: 'We are teased out of the world of terror and death, and under the enchantment of the miniature we are invited to become God' (1983, p.135).

Bodies, landscapes, spaces, places and environments may, through the miniature, be made mobile (della Dora 2009), become less formidable and can be engaged with in diverse ways and towards embodied ends. Abstraction can do likewise though, and the miniature and abstraction can be closely related to the extent of working through each other. Lévi-Strauss (1962) has asserted that the miniature can be defined not only by a reduction in size, but as a product of this scaling down; abstraction - the loss of features and the making of the feigned (mimesis).

Abstraction, for Lefebvre (1991) and Marx (1973) in maintaining capitalism ('labour', 'commodity'), generates violence (Loftus 2015). For Baudrillard (1994) and Debord (1984), abstraction in the form of electronic media creates a society of passive spectators. Abstraction though is practiced, differentiated and constitutive of lived experience (McCormack 2012). Indeed, following an observation from McCormack on the diagram, abstraction may 'open up potential space-times rather than close them down [...], 'the unformed drawing [an] inventive rather than a representational device' (Manolopoulou 2005, p.520)' (2012, p.727). Abstraction as opening up potential space-times is a very important conceptual thread running through all three case studies of this thesis.

For della Dora a postcard 'creates an affective bond between a spatially and/or temporally removed place and the viewer – just as the smell, the dust and porosity of a nineteenth-century atlas take us back in time, perhaps to the classroom where it was used' (2009, p.340). Model railways can work in the same way as a postcard, but a model railway's spatial volume and possibility for play might offer a different, or maybe perhaps 'more' sensual and creative engagement than a produced image. Drawing upon the concepts of love (Geoghegan and Hess 2014), nostalgia (Boym 2001), intimacy (Valentine and Hughes 2012), enchantment (Bennett 2001) and affective atmosphere (Anderson 2009), this thesis finds how model railways via miniaturisation and abstraction might be made so as to afford particular affective engagements with loved, lost and/or enchanting space-times. These space-times might make model railway layouts and engagement with them therapeutic and comforting and deriving importance and meaning from discomfoting elsewheres and whens. Model railways, alongside practice, play and the imagination, 'bring' the affective constituents of particular space-times to the home and can be intimately engaged with, including affording mimetic play. Furthermore, via abstraction, forms of human and non-human action and power are elided, including (model) time.

The possessive and intimate affordances of the miniature and abstraction, but also abstraction as opening up space-times, are equally important to the embodied affordances of miniature wargaming, a practice ‘expanding’ the ‘spaces and places of war’ (Reich 2014, p.52) through producing them. Approaching war ‘as a realm of experience rather than a set of cause and correlates and abstract actors’ (Sylvester 2013, p.13), the thesis contemplates how wargame models (rulebooks (as the ‘warfare model’) and miniature model soldiers) offer particular embodied engagements with conflict and without the ‘lived body’ (Anderson and Wylie 2009) coming under threat. Drawing upon Caillois’s concepts of ‘teleplasty’ (2003) and ‘mimetic play’ (1961), it is shown how warfare models are made to enable particular feeling, emotional and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace. Enthusiasm, enchantment and love with aspects of war, but also war-as-game, from atmospheres to ‘terrain and tactics’, become *mobilised* through practice with abstract models (warfare models) and miniature models (model soldiers).

As noted earlier, enthusiasm towards several of the models discussed in this thesis can lie with the difference as much as the similarity between the ‘model’ and the world by which the model ‘makes sense’. Both wargaming and model railways might be understood as mediums and mediums delightful as such. Like scientific models more generally, engagements with hydraulic models are rather different. Whilst in hydraulics there may be pleasure derived from working on and/or engaging with physical models and/or computer models, movement between or a working with both rests not on sentiment, but pressure or impetus as to how best to ‘model’ a phenomenon or environment. This raises a question about the desire of abstraction, but as McCormack observes ‘abstraction is [...] crucial to the articulation and imagination of actionable futures’ (2012, p.728). Although abstraction can be problematic in hydraulics, and this thesis attends to this in relation to questions of scale and mimesis, it is often only through abstraction such a precautionary action as hydraulic modelling becomes possible and relevant.

Hydraulic model studies attempt to make futures ‘actionable’. In taking account of the embodied affordances of hydraulic models and relations with the miniature and abstraction, the following concepts are brought together: Uncertainty (Brown 2010), non-human affect (Ash 2014), threat, decision-making (McCormack and Schwanen 2011), material and object agency, government-science relations and finally futures (Anderson 2010a). It is shown how hydraulic models, alongside modelling practices and knowledges, try to intervene on uncertainty about possible infrastructures/interventions within water

worlds and threat to mobilities and capitalist accumulation, human life and to the intervention/infrastructure itself. At the heart of the impetus and enthusiasm for hydraulic models are the agencies of water worlds and their uncertainties to humans and inherent changeability. Hydraulic models and modelling practices and knowledges aim to possess futures; making them present, acting on and presenting them, giving modellers, politicians, civil engineers and various authorities inclinations of worlds to be, future worlds simulated and represented. Hydraulic models, from the perspective of diverse agents and modellers, can be encountered with a hopeful disposition around the potential via experiment to produce interventions and infrastructures that perform for a while at least, as desired by humans within the agencies of water worlds.

2.5.2: The miniature

This thesis seeks to contribute to thinking on the miniature. As noted earlier, the miniature has received attention from philosophers or essayists, notably Bachelard (1994), Lévi-Strauss (1962), Millhauser (1983) and Stewart (1993). Baudrillard (1988) and Virilio (1995) have also considered the miniature and several geographers have recently explicitly addressed it in the context of toys (Woodyer 2010), architectural models (Koch 2010) and miniature wargaming (Yarwood 2015).

As Pietrobruno notes, at base ‘the miniature compresses the large within the small’ (2011, p.175). The miniature, decided for Stewart ‘in the context of our [...] corporeal dimension’ (1993, p, 46), is usually associated with small physical things and representations (‘a miniature’), but following Baudrillard (1988) and Virilio (1995) is also present through and because of virtual technology (which miniaturise). Baudrillard writes how ‘time’, ‘space’ and ‘the human body’ have been shrunk to the minute sphere of the television and computer screen and equally to ‘the infinitesimal memory’ of digital technology’ (1988, p.17). This thesis works with the physical miniature although arguments from Baudrillard (1988) and Virilio (1995) will be important momentarily.

For Millhauser, the miniature ‘implies a relation, a discrepancy’, it ‘charms’ and where ‘the eye [...] will quickly tire if it does not perceive thoroughness of execution, richness of detail’ (1983, p.129). Millhauser evokes that ‘the miniature seizes the attention by the fact of discrepancy, and holds it by the quality of precision. The miniature strives toward the ideal of total imitation’ (ibid, p.132). This thesis queries this narrative in taking account of embodied effort, material agency, feelings and emotions, the making of

affective atmospheres and imaginary spaces. Both miniature wargaming and model railways are closely associated with the kind of miniature Millhauser has in mind (as opposed to hydraulic models and modelling where visual aesthetics is not important, object agency is).

Millhauser, but also Stewart (1993), regards the miniature as distant from us. Millhauser writes: 'And here is the farthest I can see into the mystery of the miniature; its separation from myself, its banishment of me [...], we are banished forever from the garden on the other side of the door' (1983, p.135). Equally, Stewart contends: 'All senses must be reduced to the visual, a sense which in its transcendence remains ironically and tragically remote' (1993, p.67). In another reading of the miniature Stewart suggests: '[T]he miniature offers a world clearly limited in space, but frozen and thereby both particularised and generalised in time' (ibid, p.68). This thesis challenges these readings in the model railway and miniature wargaming chapters. In response to the first reading, miniatures in this thesis are found to be emotionally powerful and objects of love and enchantment. On the matter of both readings it is detailed how the miniature can be enrolled in play, play following Woodyer 'productive or transformative of space, configuring imaginative, miniature, virtual and affective spaces' (2012, p.320 also see Woodyer 2010).

Whilst Millhauser and Stewart have deemed miniatures as representations of significant value for how they compress the large within the small, Baudrillard (1988) and Virilio (1995) have taken the opposite view. Baudrillard, for example, writes of the effect of miniaturisation and technology and its 'making objects miniature', and he argues that 'the disintegration of human scale through miniaturisation drives contemporary society toward a further disappearance of the real' (Pietrobruno 2011, p.175). Virilio, also having in mind the effects of the miniature and miniaturisation and technology, has a similar idea to Baudrillard when he says that 'the potential to connect to the world and other human beings at their veritable scale is being stripped away' (1995, p.62). Although mindful of the differing empirical context over the effects of the miniature and miniaturisation between this thesis and the writings of Baudrillard and Virilio, this thesis reads miniatures and miniaturisation in a positive light. Within all three case studies to this thesis the practices of miniature modelling and engagements with miniature models are found to create and are made through embodied relations with places, landscapes, environments, people, events, people, materials, objects and temporalities of pasts, presents and futures.⁶

⁶ Pietrobruno has argued that 'miniatures, such as Google Earth, can connect us to the actual world in a way that is not possible without the process of miniaturization created through the digital' (2009, p.14).

2.5.3: *Abstraction*

For McCormack: ‘Abstraction is the process by which simplification takes place, and abstractions are taken to be those representational forms through which this process is stabilised and through which its results circulate’ (2012, p.717). Abstraction and its involvement in the quantitative revolution has been roundly critiqued (e.g. Buttimer 1976). This is alongside other critiques of abstraction from geographers and other scholars such as how capitalism has ‘violent effects’ through its maintenance by abstractions such as ‘commodity’ or ‘labour’ (see Harvey 1985; Lefebvre 1991; Loftus 2015). McCormack (2012) has recently provided a significant overview of the treatment of abstraction within geography and has argued that the nature of the debate on abstraction needs to change; geographers need to be more critically open to abstraction.

This thesis is receptive to McCormack’s argument, like several recent papers (see Engelmann 2015; Gerlach 2015; Marshall and Staeheli 2015). Abstraction has become something of a ‘straw figure’ within geography. McCormack asserts (and acknowledging that abstraction *can be* ‘universalising’, ‘alienating’, reductive and ‘distancing’) that:

[I]t may well be the case that geographers run the risk of missing opportunities for attending to the surprising ways in which abstraction can participate in how we think through and become involved in lived space-times. That is, a taken-for-granted sense of abstraction can never be a secure platform for critique, but must itself be continuously subject to an affirmative style of critique in which the question of how abstraction works and comes to make a difference remains an open one’ (2012, p.716).

In staking out his call for an ‘affirmative critique’ of abstraction by developing a new reading of Lefebvre (1991) and drawing on several writers and philosophers (among others Whitehead (1967, 1978)), McCormack (2012) makes three ‘propositions’. Two are important for this thesis. The first is that abstraction is ‘differentiated: there are more ways than one of being and becoming abstract, and abstraction participates differentially in processes of thinking, feeling, and perceiving’ (p.726-7). Following from this, whilst abstraction can mean a distancing, ‘[e]qually, if we accept that the world is already withdrawn from us, then abstraction provides a way of drawing out elements of the world that make them thinkable and sense-able’ (p.727). The second proposition of interest from McCormack is that ‘rather than a static representation, abstraction is a process practised in context-specific ways. So rather than identifying – or indeed dismissing – generalisable

abstractions, an affirmative critique is concerned with the ‘localised and risky emergence of abstractions’ (Toscano 2008, p.65)’ (2012, p.727).

Abstraction ‘is experiential, not artefact’ as Gerlach (2015, p.280) notes in the context of engagements with ‘OpenStreetMap’, a participatory web application where registered users can ‘edit worlds’ (create and edit maps). ‘Editing the world’, Gerlach finds, is ‘a processual, ongoing exercise of abstraction, of cartographic experiences in the making [...], lines, icons and maps are conjured and edited through experiences and via movement and encountering’ (2015, p.280). This thesis is interested in how abstraction in modelling worlds is practiced and experienced and as noted in 2.5.1 finds abstraction as a process ‘provisional and prospective, intended to open up potential space-times rather than close them down’ (McCormack 2012, p.724).

This thesis firstly finds how abstraction as ‘drawing out elements of the world’, besides how it is linked to what has been detailed in 2.5.1, is related also to an array of modelling techniques and practices, materials, attitudes and ‘technologies of abstraction’ (scientific instruments and inscriptions). In the hydraulic models chapter, it is shown how water worlds, including model water worlds, are made thinkable and sense-able (but also become potentially contestable spaces), through measurement instruments and practice with these. Engagement with measurement instruments is infused with a hopeful disposition over their prospective potential. In the same chapter, developing Latour’s (1999) concept of ‘inscriptions’ (charts, diagrams, tables and graphs), water world and model inscriptions as abstract entities are illustrated to have prospective potential in enabling the exploration of spatial relationships, helping to give hydraulic models affective power and making them epistemic objects. In the model railway chapter, it is detailed how abstraction is involved in how railway modellers think through and produce affective atmospheres. Furthermore, in the miniature wargaming chapter it is highlighted how abstraction in wargame models is important to designers and players for enabling what is called ‘playability’ and, therefore, imaginary spaces through mimetic play.

2.6: Modelling, models and mimesis: Contestation, negotiation and the more-than-representational

This section considers modelling, models and mimesis, describing how this thesis works with particular literatures and within an overarching theoretical theme of mimesis. Mimesis is important to this thesis because its ‘denotation of imitation, representation and portrayal’ (Puetz 2002, np), intensely geographical qualities, can relate to aspects of what models can be, what and how they can *do*, and how and why models may be made and engaged with. This thesis builds on the mimetic literature by contemplating how negotiation is involved in the practice of mimesis.

As Gregory and Walford have written: ‘[O]ur texts are not mirrors which we hold up to the world [without distortion] they are, instead, creatures of our own making, though their making is not entirely of our own choosing’ (1989, p.2 in Barnes and Duncan (1992, p.2). In other words, ‘representations construct, as much as they claim to explain, the person, place, or thing to which they refer’ (Jackson 2010, p.644). The ‘cultural turn’ in human geography during the late 1980s and early 90s saw a re-evaluation and new critical posture towards representation. With the advent of non-representational theory, we should see representation and practice, performance and affect as co-productive of each other (Merriman et al 2008; Nash 2000; Scott 2004), something this thesis works with as noted in 2.4.3. Relatedly, Griffin and Evans have pointed out that:

‘Non-representational theory does not equate to a critique of representations in themselves, but rather a critique of the types of Cartesian-Platonic approaches that would have us believe that representations are static mirrors of reality rather than active assemblages which are informed by, and in turn intervene with, everyday embodied practices’ (2008, p.12).

The ‘cultural turn’ was closely related to the ‘crisis of representation’; an ‘attack on mimesis and the ‘natural attitude’ which underlines it [...], a product of the Enlightenment project’ (Barnett 1997, p.35). The questioning of positivism and models inherent in the human geography of the 1970s was a first ‘critique’ of mimesis for Duncan and Ley (1993). The critique proper, in the cultural theory influenced cultural geography of the 1980s, revolved around description. For Lukinbeal: ‘This crisis [questioned] the mimetic belief, or the idea that researchers could achieve absolute realism through representation’ (2010, p.1111). Complete mimesis was (and is) impossible in writing geography. For Barnes and

Duncan, the ‘point is that when we ‘tell it like it is’ we are also ‘telling it like we are’ (1992, p.3), this notion of representation as a ‘partial truth’ (Myers et al 2005) was the *sine qua non* of the ‘cultural turn’.

Mimesis is a pervasive, lucid and theoretically elusive concept and one geographers have long worked with since Ptolemy considered the *-graphy* in geography as ‘*mimesis-dia-graphes*’ (Olwig 2008, p.1845, emphasis original). For Potolsky: ‘Mimesis is among the oldest terms in literary and artistic theory [...]. Mimesis describes things such as artworks as well as actions, such as imitating another person’ (2006, p.1-2). For Plato, the ‘success or failure’ of mimesis lies with comparing ‘work and world’ (Potolsky 2006), with ‘work’ (poetics and art) conceived as a ‘static [mirror] of reality’ (Griffin and Evans 2008, p.12). Aristotle offered a different position, whereby the ‘mirror is implicitly turned to the spectator and his or her beliefs’ (Potolsky 2006, p.4). With the contexts of drama, poetics and art in mind, Aristotle regarded that mimesis is not necessarily performed with a view to ‘mirror’ the world, but often to give ‘a persuasive, or ‘lifelike’ simulation of it’ (Potolsky 2006, p.4) and where ‘[w]e should judge the success or failure of mimesis only in terms of its proper aims and methods, and not by comparison with something else’ (ibid, p.37). As will be argued later in this section, Aristotle’s reading of mimesis involves the more-than-representational.

Both Plato and Aristotle’s assessments of mimesis remain foundational to contemporary scholarly engagements with mimesis. Within the humanities, mimesis has been central to post-colonial studies where, involved in social practice, mimesis has been linked with empire-building, indigenous resistance and identity and alterity (see Bhabha 1984; Taussig 1993, and for overview Roque 2015). Questions of mimesis and social practice has been the concern of several 20th century philosophers, particularly Adorno and Horkheimer (1972 [1944]) and Benjamin (1986[1933]). These thinkers have moved discussion of mimesis away from of debates on depiction with objects and performance and instead have emphasised mimesis within social practice and particularly the ‘communicative correspondence between the subject and object’ (Kang 2014, p.45), essentially mimesis as an embodied ‘assimilation’ to the imitated subject. Caillois’s (1961) concept of ‘mimetic play’, which is important to this thesis in all the case studies, borrows in part from Benjamin, Adorno and Horkheimer and where ‘the distinction between the self and other becomes porous and flexible. [...], mimesis as mimicry opens up a tactile experience of the world in which the Cartesian categories of subject and object are not firm, but rather malleable’ (Puetz 2002, np).

Models as representations may be readily identified with the mimetic and alongside the miniature and abstraction mimesis can be involved with the embodied affordances of models. Of interest to this thesis, models and modelling may be divisive and contested. Passions and actions can be mobilised because of what modelling/a model *does*, not a model's existence *per se* or the practice of modelling likewise. Models, through modelling, may be powerful representations, with the potential to influence ways and styles of thinking (Eden and Bear 2011), produce new spatialities and influenced and/or actioned by potentially powerful agents. These agents can include government, but, and also thinking beyond human geography, equally modellers themselves and who might perform and be accorded an 'expert' status, particularly historically and as 'scientist'.

Climate models and hydraulic models, dealing with futures, are important to address from a mimetic perspective because these models, alongside modelling knowledge and practice, are meant to present futures under particular conditions. These models are meant to generate, or rather give modellers inclinations of, worlds to be; future worlds simulated and represented. Drawing upon Caillois's (1961) concept of 'mimetic play' where 'the distinction between the self and other becomes porous and flexible', climate and hydraulic models as epistemic objects for knowing futures (ensuring there are no 'bad surprises' (Anderson 2010a after Derrida 2003)) might not only be considered through modelling practice and knowledge to represent the other, but also be *the* other, its future 'drawn down into the present as [an] object of action and intervention' (McCormack 2012, p.728).

As noted earlier, models and modelling may be contested. This thesis considers how and why, and mimesis is fundamental here. With regard to environmental futures and models, such models and the modellers and modelling practices relating to them may be critiqued by modelling practitioners, particular agencies and interested/affected publics over a notion that modelled futures are wrong. Hydraulic models are feigns of water worlds and yet infrastructures and interventions *become* on the basis of model studies. Hydraulic model studies have material affects and therefore models, modellers and modelling practices and knowledges can become ripe for critique. Within the hydraulic model chapter, the critique of model futures is examined with reference to one particular modelling study contested by affected stakeholders and drawing upon geographical work on decision-making (McCormack and Schwanen 2011) and futures (Anderson 2010a; Anderson and Adey 2012; Holloway 2014). In taking account of the critique of model futures, emotion and feeling and relations with models, modellers, modelling and places,

landscapes and environments, are found as especially important in how critiques of models come to matter, including politically.

The contestation of models, and also involving mimesis, emotion, feeling and relations with models, modellers, modelling and geography, is also considered in the model railway and wargaming chapters. Geography, whether through place, landscape and/or atmosphere, is central to a mimetic politics within the model railway hobby over 'authentic' space-times, a politics not only produced by, but also affecting railway modellers and models in spatial ways. Within the wargaming chapter, it is detailed how a mimetic politics concerning surfaces and attitudes (poses) of model soldiers is tied to imaginary spaces through mimetic play, affecting how some wargamers practice or are able to practice the hobby. Space is important to the affects of this mimetic politics because wargaming is usually a social practice undertaken with a club. Feelings are crucial in making these mimetic politics in railway modelling and wargaming and are omnipresent in textual and social spaces. As a point of note on 'politics', politics following Paulson et al is approached in this thesis as 'practices and processes through which power, in its multiple forms, is wielded and negotiated' (2003, p.209 in Zografos and Mart 2009, p.1729). Such an understanding 'goes beyond institutions of governance' (Zografos and Mart 2009, p.1729) to 'encompass struggles over human practice, meaning, and representation' (Paulson et al 2003, p.213 in *ibid*). As with the geography debates on landscape in the 1980s and 90s, models and engagements with models and modelling practice can be productive of and produced by these 'struggles' over meaning, practice and representation (on landscape debates see Cosgrove 1984; Daniels 1989; Matless 1998).

The anthropologist Taussig has described mimesis as being the 'compulsion' 'to copy, imitate, make models, explore difference, yield into and become other' (1993, p. xiii). For McAllister, in this 'urge to copy' 'resides the magical power of replication' (2008, p.577), 'the image affecting what it is an image of, wherein the representation shares in or takes power from the represented' (Taussig 1993, p.2). It involves 'a palpable, sensuous, connection between the very body of the perceiver and the perceived' (*ibid*). Some desires of modelling and affective 'doings' of models that this thesis details have been sketched out in 2.5.1. Questions can be asked however about the embodied experiences of mimesis as a practice (or modelling) and the place of negotiation within mimesis. Mimesis is considered in this thesis as more-than 'original' and 'copy' and 'subject' and 'object', relations upon which the work of Taussig (1993), Adorno and Horkheimer (1972 [1944]), Benjamin (1986[1933]), Caillois (1961) and Aristotle and Plato have focused. This thesis

considers negotiation in mimesis in several contexts; contestation, non-human agency and finally representation and practice.

In recent years, non-human agency has been of increasing interest to human geographers (Tolia-Kelly 2013).⁷ Human geographers have been particularly attentive to the agencies of water worlds (for instance see Gibbs 2014; Peters 2012; Revill 2007). Whilst hydraulic model studies can be an attempt at coming to terms with, and shaping the agencies of water worlds as noted in 2.5.1, it is detailed how hydraulic modelling practice is also affected by these agencies and negotiating the epistemic potentials of models for the HRS. Water worlds and including pasts and futures need to be known and the chapter highlights what a fraught, difficult and impossible a practice this can be, water worlds often becoming spaces of consternation over the feeling state of ‘uncertainty’ (Brown 2004, 2010). Furthermore, within the model railway chapter, alongside non-human agency, the archaeologist Knappett’s (2004) writing on ‘affordances’ of materials is mobilised in tracing relations between modeller and material in the context of how railway modellers negotiate material agency in a practice of mimesis. The place of negotiation in railway modelling is often an affirming one, despite generating frustration and visceral pain, it can mobilise enthusiasm and fun.

Within the hydraulic models chapter, it is detailed how consternation outside of and within modelling practice over questions of mimesis came to be of concern to the British government in the 1940s. Historical geographers of science have been interested in the spatialities and materialities to scientific practice and knowledge production (Livingstone 1995, 2003; Naylor 2005; Offen 2012). Withers writes in the context of the work of 19th century British geographers that ‘[s]cience would come to depend upon the correspondence between instruments, inscription and the real worlds they measured’ (2013, p.172), whilst for Naylor: ‘[P]lace plays a major role in the development of particular sorts of science, not to mention the development of particular sorts of scientist’ (2005, p.3). It is shown how the British government sought to generate a feeling state of confidence in and around hydraulic modelling for reasons of national economic and political importance and through the making, financing and therefore technological supporting of a particular spatialised ‘community of practice’ of hydraulic modellers (the HRS).

⁷ Inspired by Jane Bennett’s (2004, 2010) work on ‘things’, Harman’s (2002, 2005) Object Orientated Philosophy and Latour’s (2005) Actor Network Theory.

This section closes on mimesis, modelling and the more-than-representational. Aristotle's formulation of mimesis is important for his assertion of the more-than-representational. Aristotle thought contra Plato that, in the words of Potolsky: '[T]he realism of a work is intellectual [...], mimesis matches our innate or conventional ways of knowing the world. Realism occurs in the interaction of work and viewer [...] and not of work and world' (2006, p.97). After James (1984), we might regard 'realism', but equally the 'authentic' (concepts emergent in the wargaming and model railway chapters), as a feeling and like affective atmosphere or landscape belonging to neither subject or object (on this matter in affective atmosphere see Anderson 2009, and on landscape see Wylie 2005, 2006, 2007). Impressionist painting is one pertinent example of Aristotle's mimesis, where the aim was/is to generate a 'sensation in the eye that views the subject, rather than delineating the details of the subject' (Divers 2004, p.348). This 'sensation' incidentally, can be an affective atmosphere. Aristotle's mimesis could be said to judge representations as 'active assemblages which are informed by, and in turn intervene with, everyday embodied practices' (Griffin and Evans 2008, p.12).

Affective 'doings' of models have been sketched in 2.5.1, but as with impressionist painting, embodied practice may inform modelling as a mimetic practice and be important to models as representations. In the model railway chapter, an 'impressionist' sensibility and technique to modelling is examined where affective atmosphere and abstraction can inform modelling practice, making present 'a palpable, sensuous, connection between the very body of the perceiver and the perceived' (Taussig 1993, p.2) (the modeller to the 'modelled'). Modellers here, like impressionist painters, try to generate a 'sensation in the eye that views the subject, rather than delineating the details of the subject' (Divers 2004, p.348). Within the miniature wargaming chapter, embodied practice is also demonstrated to inform how wargame designers model warfare within their rulesets. It is detailed how designers grapple with an 'embodied ontology to war' (McSorley 2012) for generating imaginary spaces through mimetic play with the model, including breaking down distinctions after Caillois (1961) between self and other (e.g. 'I feel like Napoleon at Waterloo').

2.7: Conclusion

This chapter has considered the literatures engaged with in this thesis as well as providing initial details of how the thesis works with or takes forward salient literatures through the empirical work presented.

The chapter has taken account of the place of models in the doing of human geography over the past half century and has also drew attention to several philosophical theories of models from philosophers of science, particularly over how models can potentially generate spaces, practices and conceptions about the world. Models and modelling in the guise of mathematics came to prominence with geography's 'quantitative revolution' of the 1960s, but with several theoretical developments since, attitudes towards and applicability of models and modelling within human geography have changed.

From geographers as modellers and/or mobilising models for research, to geographers studying models and modelling *as research*, the chapter addressed the limited although important literature cultural and historical geographers, but also historians of science have occasioned with several kinds and contexts of models and modelling practice. It is argued that there is much more potential to contemplate models and modelling conceptually by taking greater account of space.

This thesis mobilises its geographies of models and modelling through several concepts. The chapter firstly contemplated affect, emotion and feeling and how readings of these are important in generating the geographies of this thesis. Affect, emotions and feelings are vital to how life is lived and are made through relational encounters.

Also important here are readings of the miniature and abstraction. In thinking about abstraction, this thesis finds McCormack's (2012) reassessment of abstraction pertinent, where abstraction can be about 'drawing out elements of the world' and 'opening up' potential space-times rather than closing them down. The chapter contemplated how abstraction, alongside the miniature and its relation to power, plays a generative role in the embodied relations that models in this thesis are regarded and experienced as affording. In the context of such a discussion, diverse literatures each chapter engages with were also highlighted. A close look at writings on the miniature and McCormack's (2012) reassessment of abstraction followed, sketching further contributions this thesis makes to these important concepts, besides of course enabling here a thinking through of models and modelling in particular ways.

The final key concept this chapter examined was mimesis. Mimesis is important because like the other pivotal concepts worked with it can relate to aspects of what models can be, what and how they can *do*, and how and why models may be made and engaged with. Drawing upon several philosophers and writers on mimesis, the chapter showed how mimesis is made especially present in this thesis through mimetic play and how models and modelling may be contested and modelling a negotiated practice, in the latter case extending debates on mimesis. Several geographical and other literatures were also introduced and discussion on mimesis closed on its relations with the more-than-representational, drawing on Aristotle to highlight how this thesis finds embodied practice may inform modelling as a mimetic practice and be important to models as representations.

3: Methods

3.1: Introduction

The diverse research methods (textual, internet, archival and interview) undertaken for the completion of this thesis are related by the primacy of language, whether spoken or in text. Non-representational theories and new methodologies such as video recordings, try to access ‘somewheres’ ‘beyond words’ (Evans 2008; Merriman 2014). However, as Deleuze and Guattari (1988) remind us, there are relations between language and practice and for Evans ‘language use [...] can embody an immediate sensual coping with the world (language as tool) rather than something that only involves a cold description of the world (language as text)’ (2008, p.49-50). With the notion that language can be related to the concerns of non-representational theories, Merriman has queried an idea among some mobilities scholars that particular ‘performative and participative methods’ might ‘more successfully and accurately apprehend or represent certain meanings, feelings, emotions and kinaesthetic sensibilities’ (2014, p.175) than so-called ‘conventional’ methods (interviews, archival research etc.). For Merriman: ‘I do not see why video recordings or autobiographical reflections on being in a physical environment are more effective at portraying, capturing or representing some-thing, some feeling about a situation, event or environment, than a written or verbal record’ (2014, p.176). Merriman provides an example of how:

‘Driving is characterised by highly distinctive, kinaesthetic, proprioceptive, haptic, spatial and visual sensibilities that are difficult to describe and are rarely reflected upon, but this does not mean that motorists are unable to present or describe their embodied experiences, and indeed, the novelty and intensity of these affects and sensations led many early motorists to talk and write about the sensations, feelings and emotions which emerged when driving or being passengers in motor cars’ (ibid, p.180).

Whilst new performance based methods have been developed (and are continually developing) as part of a ‘tool-kit’ of methods to practice non-representational geographies (see Latham 2003; Patchett 2014; Simpson 2011), interview methodologies, textual and archival research, differentiated and themselves developing practices, should be and are important too. Indeed, whilst in the early 2000s there were concerns about the future of

historical geography with a non-representational inflected cultural geography (Griffin and Evans 2008), many historical geographers soon began to exercise what for Gagen et al were 'creative ways to engage with existing 'representational' sources as conveyors of historical 'performance' in its immediacy and evanescence' (2007, p.7) (see Cant 2006; DeSilvey 2007; Evans 2008; Gagen 2004; Lorimer 2003; Merriman 2005a, 2005b; Naylor 2002).

This thesis draws upon online and interview research as well as textual and archival research to consider spatialities to lived and embodied engagements with models and modelling. Research encounters (with texts and through speech with people) were negotiated by a sensibility on my part towards tracing, however partially, the non-representational, the 'fleeting, viscous, lively, embodied, material, more than human [and] precognitive' (Vannini 2014, p.317).

This chapter is split into five sections, four of which relate to the respective research methods, detailing how, over the course of the research, I have engaged with spaces, networks, objects, collections, institutions and finally people (as screen-names, 'in the flesh' beings, or dead).

3.2: Choice of case studies

There are many potential 'geographies' to models and modelling. This thesis crafts a particular narrative of geography and models and modelling by focusing on embodied relations and how space (through embodied relations) is involved in what models can be, what and how models can *do*, and how and why models may be made and engaged with.

Rather than focusing, for instance, on the biographies and mobilities of models ('follow the thing' research (Cook 2004; DeLyser and Greenstein 2015)) and how modelling is involved in these, the thesis concentrates on the representational and more-than-representational qualities of models and relatedly how modelling is involved here. Each case study offers similar yet different sightlines on how space is central to lived and embodied engagements with models and modelling. The case studies were each selected for three reasons; how space is important; the potentials to work with and contribute towards key geographical and wider scholarly debates and themes; and finally, matters of 'reskilling' (Forsyth 2012). This section turns now to address the conceptual attractions of the case studies. Questions of 'reskilling' are considered later.

All the case studies comprising this thesis are about, at heart, the generation of, and engagement with space-times. The space-times models and modelling can generate in this thesis are significant in embodied ways and with models and modelling becoming important, affective objects and practices respectively in relation to these.

The space-times models and modelling can generate and engagements with them were an important factor in the choosing of each case study. Model railways involve loved, lost and/or enchanting places, landscapes and affective atmospheres and enabling conceptual engagement with models and modelling and matters of nostalgia (Boym 2001), love (Valentine 2008; Valentine and Hughes 2012), utopia (Anderson 2006a), affective atmospheres (Anderson 2009) and enchantment (Bennett 2001). Hydraulic models meanwhile are implicated with water worlds, threat, uncertainty and futures; facilitating conceptual engagement with models and modelling and these spaces (Anderson and Peters 2014), temporalities (Anderson 2010a) and feeling states (Brown 2010). Miniature wargames on the other hand implicate feelings, and emotional and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace; enabling conceptual engagement with models and modelling and questions of 'teleplasty' (Ash 2010; Caillois 2003), an 'embodied ontology to war' (McSorley 2012) and play (Woodyer 2012).

As noted in chapter 1, from the outset this PhD has been premised on an examination of several contexts of models and modelling practice. Such an approach has been deemed important because models are, and modelling is, differentiated (Demeritt and Wainwright 2005; Hopwood and Chadarevian 2004; Morgan 2012). Focusing on one context would have limited the scope and impact of the research, but the project would have also been different in character. An important factor in the choice of case studies lay with how each could offer perspectives on different yet pervasive model and modelling contexts.

As epistemic and experimental objects and practices within science, hydraulic models and modelling are about enabling enquiry, like a number of models in the engineering or environmental sciences 'developed for the purposes of producing, controlling, or preventing some properties of materials or behaviour of processes and devices' (Knuuttila and Boon 2011, p.311). Models in the sense of enabling enquiry are imperative to such practices as geomorphology (Lane et al 2011), applied geochemistry (Nordstrom, 2012), climatology (Neelin 2011) as well as economics (Morgan, 2012) and economic geography (Garretsen and Martin 2010).

From scientific enquiry on physical processes/environments to leisure and craft practice with landscapes and affective atmospheres, several key practices in model railways – from diorama display, memory, material craft to idealism – find relevance with the geographies of a number of other contexts of models and modelling. These contexts include, and which scholars have examined in several ways; model ships (Fenner 2014), architectural/urban planning models (Koch 2010; Morris 2006; Smith 2004) and miniature model villages for tourists (Davies 1996; Kersel and Brown 2012).

The final case study, miniature wargames, has much in common with model railways, especially in terms of it being a leisure practice. Nevertheless, the ‘teleplastic’ quality of miniature wargame warfare models (an enabling ‘becoming other’, relating to other human bodies and space-times in the contexts of the military and battlespace) resonates with diverse genre videogames and the models which seek to produce a ‘game-world’ (Perla 1990; Sabin 2012). In modelling situational human practice, the warfare models in miniature wargaming have relations with not only many kinds of games, but agent based models (ABMs) and more particularly recent efforts to ‘model [...] human emotional dynamics’ (Belhaj et al 2014). Finally, the transitional potential of miniature wargame model figures finds relevance with many contexts of model engagement where models configure and are engaged with through ‘imaginary spaces of play’ (Woodyer 2010), including model railways, model aircraft (Adey 2010) and the doll’s house (Woodyer 2010).

Besides questions about the potential for each case study to offer different perspectives on the space-times that models and modelling can generate – and as just detailed, how each could offer perspectives on alternate yet pervasive model and modelling contexts – choices about the case studies were made in relation to other factors as well. Many of these relate to the remaining four of five ‘cross-cutting themes and conceptual contributions’ comprising this thesis.

Just as it is an aim of this PhD to consider what models and modelling can do from a geographical perspective, it is equally the aim here to research the geographies inherent in modelling as a *practice*. Theme four identifies the embodied relations within modelling as a practice. Each case study offers a diverse array of spatial contexts with which modelling is practiced: from places, landscapes, environments, events, people, objects (including models), and materials, to temporalities of pasts, presents and futures. More specifically, model railways mobilise relations between modeller and material at the worktop, and loved, lost and/or enchanting places, landscapes and affective atmospheres. The case study on hydraulic models meanwhile offers a consideration of the relations between modeller and

a dynamic and uncertain environment and with relations infused with futures. Finally, the miniature wargaming case study was chosen because it can provide an understanding of how embodied practice (in the context of military bodies and battlespace) may inform modelling as a practice. This particular idea also permeates the model railway chapter when considering the representation of the ‘atmospheric’.

As this research project progressed, the matter of how embodied practice may inform modelling as a practice became increasingly important, theoretically informed and, associated with a desire to clearly highlight the importance of practice to models as representations, gave rise to the third crosscutting theme; how practice can inform modelling as a representational practice and be important to models as representations.

The part subject of the fifth theme, the question of how model and modelling engagements can be involved with the miniature, did not influence the choice of each case study. As described in the previous chapter, the miniature can be a fundamental quality of model and modelling contexts, involved in and/or productive of diverse embodied relations with models and modelling. With this in mind, the question of how model and modelling engagements can be involved with the miniature were to come through the chosen qualities of each case study in relation to themes one and four.

The fifth theme considers, besides the miniature, how model and modelling engagements can be implicated with an ‘affirmative critique’ of abstraction. The importance of this critique to thinking about models and modelling did not influence the choice of *two* of the three case studies; hydraulic models and model railways. This was because awareness of McCormack’s (2012) reassessment of abstraction was realised towards the end of the first year of the PhD. Model railways and hydraulic models had been firmly settled on as case studies, but the context of a third had yet to be decided. The importance of abstraction as a way of coming to terms with the violent realities of war, making warfare approachable for people, was felt especially pertinent in the context of debates not only on abstraction, but war and representational media and became a factor in the choice of the miniature wargaming case study.

This is not to suggest though that discussion on how model and modelling engagements can be involved with an affirmative critique of abstraction could be any better addressed without hydraulic models and model railways as case studies. As described in the previous chapter, abstraction is a fundamental quality of model and modelling contexts, it also often works with the miniature and like the miniature is involved in and/or productive of diverse embodied relations with models and modelling. Bearing this in mind,

the chosen qualities of the model railway and hydraulic model case studies in relation to themes one, three and four (and which discussion of abstraction in the context of miniature wargaming is also tied to) offers diverse scaffolding with which to consider how models and modelling can be implicated with an affirmative critique of abstraction.

Finally, the place of theme two in the choice of case studies. Theme two is about how models, modelling and material and embodied affects shape how spaces (including models) can be constituted, affected, encountered and engaged with. This theme, which, like all the others has considerable links to each, only became apparent and cogent towards the end of this PhD research, thus not impacting the choice of case studies.

Besides the conceptual attractions of the case studies, reskilling also affected the choice of case studies. Personally, a PhD project on models and modelling was going to pose several reskilling challenges, especially in exploring the scientific, computational and mathematical elements to some key and pervasive modelling practices. Mathematical models and modelling, but also computer modelling, were held by me to pose too much of a reskilling challenge with the limited time available. With regard to computer (or virtual) models and modelling (for instance their use in architecture, animation, hydraulics and computer games), the affordances and engagements with virtual space could have been important in the context of debates about the virtual as a model and modelling medium (see Francoeur and Segal 2004; Griesemer 2004; Turkle 2009). As will be seen in the wargaming and model railway case studies, the physicality of models matters to people. Although the hydraulic case study focuses on physical models, many key points from that chapter equally apply to engagements with computer models in hydraulics and environmental modelling more generally. Virtual models and modelling could be an avenue for future research on geographies of models and modelling.

Finally, the undertaking of a historical rather than contemporary study on hydraulic models relates to two reasons; firstly, my own enthusiasm for archival work and secondly the period under study was a formative one for hydraulic modelling in the UK (1930s - 1950s).

3.3: Internet research

For Kinsley, online environments like discussion forums and social media are increasingly becoming ‘an integral part of everyday life’ for many people (2013, p.540). Since the millennium, online environments have been of some interest for geographers in the sense of research on them (see Crang and Graham 2007; Holloway and Valentine 2001; Longhurst 2009) and/or as a source of empirics (see Ding and Schuermans 2012; Fox 2006; Nelson 2010), the latter is how online environments are employed in this thesis. Being online is for many railway modellers and wargamers integral to the practice of their hobby. Both hobbies have a number of internet discussion forums where, after signing-up to become a member, hobbyists can post and discuss topics on conceptual, attitudinal, lived and practiced aspects to their pastime. In a similar way to Parr and Davidson’s observation on mental health internet discussion forums and biomedicine, forums can ‘open-up’ railway modelling/model railways to ‘embodied talk and situated knowledges’ (2008, p.39). In so doing, these forums can help make a ‘community of practice’. In the model railway community, one of the UK’s most popular internet forums is ‘RMweb’. RMweb began in 2005 and by mid-2015 it had some 26,000 members, mostly UK based and 1.9 million message board posts (RMweb 2015). The UK miniatures wargaming community has a much larger online forum called ‘The Miniatures Page’ (TMP). This has worldwide but mainly North American appeal: 4,000 *topics* are posted per month as an average (2001-2015) and with 220,000 user visits per month, again as an average (The Miniatures Page 2015).

The ethics of doing research online has been carefully considered by geographers in recent years (see Dwyer and Davies 2007, 2010; Kinsley 2013; Madge 2007) and several points from these discussions are mobilised in this section in the context of how the internet research for this thesis was conducted.

Several internet forums have been engaged with beyond TMP and RMweb although these are the principal forums from which much of the online forum empirics have been drawn. Online research for model railways began in mid-2012 and continued intermittently up until mid-2014. The equivalent online research for miniature wargaming began later, mid-2013 and continued intermittently up until mid-2015. Forum content was all publically accessible, but I had to become a member to post topics (questions), something I wanted to do because I wanted to do more than ‘lurk’ (Chen et al 2004). This method was

revealing, however. Reading forum content early in the research, whether involving motivations, attitudes or experiences, enabled me to learn about the hobbies and prepare interview questions.

Forums are somewhat anonymous, but I identified myself by my real name, made explicit my position as a postgraduate researcher, presented aspects of my research and posted forum topics for discussion intermittently. My research project attracted an overwhelmingly positive response, although several queried the relevance of the project. Consent was sought where possible from forum owners/moderators about how I intended to use the forums in this way. In all cases, a positive reaction was received. For one forum owner, it was thought my research was interesting and potentially important in promoting the hobby (via dissemination in university teaching and research) and also developing interesting conceptual issues for forum members to engage in.

The vast majority of railway modellers and miniature wargamers on the forums to some extent shield their 'offline identity' (or 'corporeal identity' (Deakin and Wakefield 2013)), most obviously in the sense of 'name' (i.e. 'olddudders') and 'location' (i.e. 'up a Welsh mountain'), although this shielding will often breakdown or disappear in the member-spaces of private communication. Anonymity in the forums engaged with could be said to 'lead people to a frankness they rarely show in face-to-face encounters' (Hine 2011, p.2; also see Jackson and Valentine 2014; Kinsley 2013; Rodham and Gavin 2006). However, I would argue on some forums frankness may well be negotiated by the need to maintain a forum identity to other members. It was in realisation and anticipation of this issue that I welcomed members to privately message or e-mail me on my message board questions since content would be visible to the forum community but also those beyond it. Over the three years of the intermittent online research no one did this, although incidentally some empirics were gathered from those enthused in helping in my research through forum messages and/or university e-mail.

As Kinsley asserts: 'The ability to bend and alter representations and performances of identity through mediated communication is [...] often treated as problematic' (2013, p.546). 'Online interactions' should be recognised as '*performed*' (ibid, p.547, emphasis original). For the sociologist Hookway however: '[D]oes it really matter [about the 'trustworthiness'] [...], how can the truth be ensured in any research scenario?' (2008, p.97). In an argument I sympathise with, Hookway regards such concerns about the validity of online ethnography as resting on an 'exaggerated vision of online identity play' and the idea that 'the only path to individual 'authenticity' is through the face-to-face interview' (2008,

p.98). I have found that forum posts are often personally revealing (about feelings, emotions and practices) and very well-constructed and adroit. Unlike in face-to-face interviews, much more time can be taken to present thoughts (Jackson and Valentine 2014).

Online research throws up debates about privacy and questions of public/private (Eynon et al 2009; Hookway 2008; Madge 2007). One argument goes that researchers need to attend to whether people perceive their online (public) interactions as a private or public act (Barnes, S.B. 2004), that researchers should not conflate the public accessibility of particular online spaces with ideas as to the publicness of the interactions. An opposite argument is a 'fair game-public domain' position (Hookway 2008, p.105). This is perhaps too simplistic a standpoint in an increasingly complex cyberspace (Hardey 2011), but the underlying idea I consider pertinent if used with care (see Convery and Cox 2012). Both arguments have their merits although the geographer Madge (2007) has argued that in 'open access forums' informed consent need not always be required, needing in effect a 'delicacy of concern' and 'reflexivity' (Moore 2010). In geography research using online forums for empirics, from abortion to public art, it is not clear what position researchers have taken (see for instance Ding and Schuermans 2012; Fox 2006; Jackson and Valentine 2014; Nelson 2010). Bearing in mind Madge's (2007) assertion described earlier, with the very likely 'low-risk' nature of the research project to unaware participants (and aware) and most importantly that the vast majority make their 'offline' identity anonymous, I ascribed to the 'fair game-public domain' position. This would be easier than having to negotiate my research (including writing) by waiting on permissions from many hundreds of people over the several years of this research project; 'time-consuming' 'cumbersome' and in the case of old forum posts where members have long left, 'impractical' (Hair and Clark, 2007, see also Convery and Cox 2012).

As emphasised earlier, the vast majority of railway modellers/wargamers on the forums to some extent shield their 'offline identity', particularly name (i.e. olddudders') and in some cases by giving a vague location (i.e. 'up a Welsh mountain'). For reasons of an easy read to the thesis I have decided to give 'conventional' names (i.e. Derek, Gareth etc.) to these online identities, mirroring the interview research. However, if distinguishing between forum and interview content is of interest, forum content is marked after the particular quote by this symbol: {f}. All forum content used in this thesis is able to be traceable, via the internet, to its 'real' author. In those cases, where it seems like online

names correspond to offline ones, these have been anonymised as a precaution, although as noted, all content ultimately has traceability in cyberspace.

Wargames player and designer blogs were a particularly important research resource for this thesis. These blogs are rarely anonymous (certainly with regard to designer blogs) and compared with online forum postings by bloggers are arguably more clear-cut as a consciously public act of content production. In this thesis, blog posts are referenced in the usual way (by author) and in a few cases where the blog author cannot be found the title of the blog site is used instead.

3.4: Textual research

Various printed texts such as magazines and books are involved in the practices of model railways and miniature wargaming in diverse ways and help make a ‘community of practice’. Magazines and books have been an important source of research for this thesis and have also helped draw out questions for the interviews. Books for Keighren ‘mirror and inform the societies in which they are produced and consumed’ (2013, p.745), although we can also include texts like magazines. Books, as well as other kinds of printed texts, might be seen as ‘tool[s] of communication and knowledge exchange – and as materially and socially constructed objects, situated within complex spatial contexts’ (Keighren 2013, p.747).

Online forums and printed texts do quite similar things within the miniature wargaming and model railway hobbies, particularly with regard to knowledge exchange around conceptual, lived and practiced aspects. However, there are differences between online forums and printed texts. Hobby magazines contain *articles*. Articles, which are usually much longer than forum posts, might be authored by staff writers for the magazine, usually reviewing products (whether model trains, soldiers or rulesets), but there are also editorials. Articles might also be authored by invited writers or those who have proposed a topic. Articles might discuss, for instance, how the author made their railway layout, how the author worked with materials to create a particular model, or how the author created a particular wargame ruleset. Hobby books are usually single authored texts and often take the form of ‘how-to’ guides, whether relating to making a layout, how to wargame, or more specifically making model buildings or wargaming the Napoleonic wars. A few hobby books are autobiographies of the author’s participation in the hobby, whilst others are

stories of the trials and tribulations involved in making of a particular layout in the case of model railways, written usually, if a communal club activity, as a club.

Geographers have been particularly keen on examining the production, dissemination and consumption of printed texts and involving editors, authors, and audiences (for overview see Keighren 2013). There has been some comment as to a rift between these focuses (Ogborn 2005-2006), although geographers have been interested in the interrelations (see Merriman 2005b, 2005c; Withers and Keighren 2011). This thesis has approached the texts, like the online forums, as spaces where lived and embodied engagements with models and modelling might be told. However, it soon became apparent that many of the texts and their mobility were important to my research, this was in the sense of involving relations between authors (and editors) and audiences over a matter of a geographically infused politics to railway modelling and, to a lesser extent, wargaming. Relations between authors, audiences, printed texts and a politics has been emphasised in the context of the English countryside, where geographers have examined the moral geographies of experiencing the English landscape (see Brace 2000; Brady and Palmer 2007; Matless 1997).

In 2012, I purchased via Amazon and eBay about 40 model railway books and in 2013 about 20 wargaming books. These dated for the most part from the last 30 years and relate to the kinds of books mentioned earlier; 'how-to' guides, autobiographies of hobby participation to stories about the trials and tribulations involved in making of a particular layout. 'How to' guides were of interest because of the potential to consider a mimetic politics in both of the hobbies, affective atmosphere and materiality and craft in the context of model railways and, especially in miniature wargaming, the opportunity to reskill through these texts. In both hobbies, autobiographies of hobby participation were chosen for the potential to consider especially personal narratives of the hobbies and relations with the conceptual themes of interest (as considered in 3.2) which also mobilised the purchase of model railway story books detailing the trials and tribulations involved in making a particular layout. Incidentally, The National Library of Wales (NLW), a legal deposit library in Aberystwyth, holds a sizeable collection of wargaming and model railway books and these were consulted as well.

The NLW also has a collection of commercial magazine titles on model railways. The NLW has four titles (Model Rail, British Railway Modelling, Railway Modeller, Model Railway Journal), all published in the UK and purchasable on the high-street (in passing, there are five commercial UK titles). Nearly all the titles are not older than 30 years and

each has occupied or developed a niche in the hobby, whether concentrating on modelling techniques (Model Rail), a particular community of practice (Model Railway Journal), new modellers (Hornby Magazine) or seeking to try to do bits of everything (to be 'mainstream'; British Railway Modelling, Railway Modeller). In many ways, these commercial magazines have similar kinds of content to the hobby books, with articles on model making, layout making and often personal narratives on the hobby. Particularly significant features of the magazines are letter pages, spaces of (controlled) dialogue and debate on particular issues.

In mid-2012, over the course of several days at the NLW, I browsed through several hundred back issues of the model railway magazines. Monthly back issues since the millennium were consulted, such a strategy effected by my desire for contemporariness. One magazine, the Model Railway Journal, is quarterly and the NLW only had copies of the magazine from its inception in 1985 up to 2000. A significant magazine, it was decided to examine all the issues.

When looking through these magazines, the same themes negotiated my engagement as did the hobby books. For a start, I was looking for evidence of the space-times railway models and modelling can generate and engagements with them, with particular themes around loved, lost and/or enchanting places, landscapes and affective atmospheres. Articles in which modellers wrote about their layouts were especially pertinent towards this aim. Also important were the geographies inherent in railway modelling as a *practice*. Here I was interested in a mimetic politics within the hobby, relations between modeller and material at the worktop and loved, lost and/or enchanting places, landscapes and affective atmospheres. Relations between modeller and material at the worktop could be found in 'how to' articles 'showing making', like making trees or creating effects of water, and also in articles where modellers described making their layouts. Relations between modeller and loved, lost and/or enchanting places, landscapes and affective atmospheres could be garnered within the latter kind of article as well and equally in 'how to' articles involving affective atmosphere. This kind of article would sometimes be shot through with a mimetic politics, present also within letters pages, opinion pieces and editorials.

The NLW has only one magazine title relating towards miniature wargaming (Wargames Soldiers and Strategy) there are several other important commercial and non-commercial titles (Miniature Wargames, Slingshot, Wargames Illustrated). Although back issues of the particular magazine were looked at in mid-2013, most of the articles, to me as an 'embodied researcher', were 'dry' 'battle reports'. Arguably, collections of several

other magazines could have been located (for instance at the British Library), although bearing in mind expenses and travel, I considered interview and internet research could provide more than enough empirics for what I wanted to do.

3.5: Interview research

19 substantial interviews, each partly semi-structured and partly quasi-unstructured in design, have been undertaken with UK railway modellers, either in Wales (mid and west Wales) or England (primarily the West Midlands region). These interviews were conducted between October 2012 and February 2013 and were on average around two hours in duration, with the shortest at one hour and longer ones at three or four hours. Seven relatively unstructured and short (c10-30 minutes) interviews took place with modellers at a club exhibition, although one was not recorded by accident. Of the substantial interviews, a majority of participants (13) were recruited through an advert placed in the news or advert section of several of the major commercial hobby magazines. Others (six) were recruited through a similar appeal to clubs or societies.

In the context of miniature wargaming, 10 substantial interviews, each semi-structured in design, have been undertaken with UK miniature wargamers. These interviews were conducted between September and November 2013 and were on average around one and a half hours in duration, although the longest was five hours. Appeals for interviews were sent out in November 2012 to a number of clubs in the English West Midlands region, alongside the possibility of participant observation.⁸ Appeals for interviews were sent to several commercial miniature wargaming magazines, one of which printed my appeal. One interview was garnered via the club appeals, three through my attendance at a wargames club meet and six via the magazine. I became worried about the relatively low number of participants (8) and so in early 2013 I managed to get an appeal in a society journal, which attracted two more. At the same time, I judged that I ought to talk with wargame designers. None of my appeals considered the design of wargames

⁸ Participant observation was considered within the wargaming case study in 2012 because I was interested in the wargame as a gaming event. By the time I came to undertake the wargames research in 2013 I considered that the event of the game would not be important to my research. Nevertheless, I undertook one participant observation session with a wargames club in the West Midlands. This was with an intention of learning about the hobby although also meeting and potentially recruiting club members for research interviews.

because I had thought warfare models would disrupt a 'scale model' theme to the PhD. Thankfully, four of my participants had practiced wargames design.

All interview participants in this PhD study were white and male, over twenty years of age and many were retired. Some interviewees had practiced their hobby for decades, others for a few years. I was interested in what motivated my participants to take part in my study. Motivations are always complex and generally speaking were presented to me as one or several of the following: Chance to discuss enthusiasm and/or show work; opportunity to have a voice in a potentially important project within and/or outside the model railway/wargaming community; interest in academic research (five possessed PhD's, four of these either worked or had worked in academia), and finally an opportunity to help someone.

Interviews were recorded by a dictaphone unless requested otherwise (this did not happen). Anonymity through a pseudonym was a central tenet to the ethics statement for this research project. Although many miniature wargamers and railway modellers liked the ability to remain anonymous and no one questioned this either, I think I should have offered the opportunity to be recognised in the research (Woodyer 2010).

For several participants, concerns about burglary of monetarily and/or emotionally valuable models prompted requests not to give away location (one wargames participant had c300k model soldiers, worth many millions of pounds). Among railway modellers, the layout name and place names were asked to be changed occasionally because these could reveal identity. So as to ensure anonymity for all interview participants, all model locations and placenames were changed and equally club names and locations.

The substantial interviews took place at the participant's home. Emplacing the research at home was key for several reasons; convenience for the participant and also a familiar and possibly comforting space for them. Most importantly, for nearly all model railway participants (17) their layouts and diverse modelling texts, objects and materials were located here. Equally, for all wargaming participants the home contained a collection of model soldiers and various research and gaming texts.

As Horton reminds us: '[R]esearchers and research participants are vulnerable, fallible, *emotional*, moody, *embodied* beings' (2008, p.376, emphases original). However, certain emotions and feelings might be important in affording particular research encounters such as enthusiasm, whether for participants towards miniature wargaming or me towards the PhD project. Nevertheless, as Horton (2008) seems to imply, certain emotions and feelings might be rendered problematic. The initial encounter, prior to the

interview with the participant, was often a nervous one for me and it seemed so for some participants too. However, 'ice breaking' conversations on university experiences, the house/flat/garden/ornaments, hobbies and so on over coffee, tea, even lunch, enabled us/me/them to relax more. On several occasions, 'problematic' emotions and feelings completely overwhelmed the research encounter. One participant was in a state of shock for several minutes when we found his cat had smashed his beloved layout. He decided not to 'terminate' the interview, but he was flustered and he became terse as his mind was elsewhere. I felt sorry for him and felt awkward asking such now seemingly inconsequential questions. After several minutes, I drew the interview to an end. He was relieved; he had been too polite to tell me to go. On another occasion, during my last wargames interview, I received a phone call. Stuart (my father) was in a life-threatening condition in hospital, he might not survive. I was inconsolable, my tears blurred my vision and I was in complete shock. My participant was uncomfortable and I quickly rushed out the house, gathering myself together in the car so as to be able to drive home.

My interview schedules for the two case studies sought to explore the geographically related motivations, attitudes and experiences participants had with models and modelling. In the context of the model railway case study, I firstly wanted to ascertain how my participants became interested in model railways, why they model railways and what their model/s and modelling practice affords and means to them. These questions were created from, and related to, cross-cutting themes one (the space-times models and modelling can generate and engagements with them), four (embodied relations within modelling as a practice (part of theme four)) and five (the miniature and abstraction). In addressing these questions, and which were informed by my scoping research and more formal research in the first year utilising hobby magazines, books, blogs and internet forums, I sought, for a start, to identify the thing/things mobilising my participants' enthusiasm (such as possession, the 'machine assemble' of the railway, its place within landscape, nostalgia). I also attempted to understand how modellers relate themselves to modelling practice and how modellers identify with their models and the affordances of the miniature and abstraction. All the questions were considered imperative to ask from a potential range of questions that could be related to themes one and/or four and/or five. This is because they enable the opportunity of investigating the geographies that impel and enable railway modellers to model and the ways in which model railways afford and are made to produce particular embodied engagements with spaces and space-times. These research intentions

permeated later questions and themes to consider in my model railway interview schedules, as will be evident momentarily.

Through my scoping and more formal research, utilising hobby magazines and books, it appeared that geography, whether through place, landscape and/or atmosphere, mobilised a mimetic politics in the hobby, generated by and affecting railway modellers and models in spatial ways. This realisation gave rise to the first inklings of the second theme of this thesis (Models, modelling and material and embodied affects can shape how spaces (including models) may be constituted, affected, encountered and engaged with), but at the time the issue described was pertinent for its relations to the first theme. This is because a mimetic politics is related to the space-times models and modelling can generate and engagements with them. A geographically infused mimetic politics was considered particularly crucial in addressing the diverse engagements with the space-times models and modelling can generate. After considering the research questions considered in the previous paragraph, several interview schedule questions sought to unfurl a mimetic politics from the perspective of my participants. Firstly, participants were asked for their perspective on the arguments of several model railway writers and commentators, these being on relations between (affective) atmosphere and qualities of models and modellers. Secondly, questions were placed regarding participants and the displaying of their models at model railway shows (or exhibitions). Intent here was to explore their experiences and perspectives of modelling work for a show, with the idea of gauging whether a mimetic politics affected their modelling practice (such as research and engagement with landscapes and spaces (including models)) and the wider performance of the hobby (namely, whether they feel confident displaying their layouts publically or where they display their layouts).

After a hitherto semi-structured interview schedule design, the remaining part of my model railway interview schedules were 'quasi-unstructured' in form. This change was necessitated by placing the participant's model railway layout/s in material form at the centre of the interview's performance. Inspired by the methodology mobilised by the geographer Riley (2010) in his work with farmers on past farming practices (also Riley and Harvey 2007), layouts were to become 'prompts to discussion and recollection' (Riley 2010, p.658) for both myself and research participants. Interviews were also to usually change in emplacement; from the living room to the space/s of modelling, the railway layout. Participants often seemed itching to show me their layouts during the interviews.

Placing the participant's model railway layout/s at the centre of the performance of the interview relates to the kinds of research questions and themes I sought to consider.

These could be better confronted and more easily grappled with by the layout being materially present in the research encounter.

My research encounter with the layout/s and the research participant was predicated on addressing a research theme of ‘making’; looking at the ‘representation of the atmospheric’ (Kazig et al 2014), embodied relations between modeller and material and also embodied relations between modeller, material and things, spaces and places. Through my scoping research with the hobby’s books, magazines, blogs and internet forums these issues became pertinent to this study in connection with part of theme four. The issues were considered vital to address in relation to theme four because for nearly all railway modellers their modelling involves embodied relations with materials and many have an expressed desire to represent an affective atmosphere.

When encountering the layout, participants were asked if they could describe to me how they built it and the decisions involved. This question sought to shape discussion of the layout in the direction of addressing the research theme of making. Both guiding and important to this discussion were themes and questions of how my participants made things, what they found difficult/painstaking/enjoyable/frustrating to make and what they are most satisfied/least satisfied with. These questions and themes were to explore embodied relations with materials, and materials things, spaces and places. With regard to affective atmosphere, this research issue was addressed by a theme of, and questions pivoting on, how affective atmosphere had been achieved (if it has been)? More specifically, what modelling sensibilities, techniques and decisions have been involved?

In the context of the miniature wargaming schedules, I firstly wanted to discern how my participants became interested in miniature wargames, why they play and/or model wargames and what their model/s, modelling practice and playing miniature wargames affords and means to them. These questions were generated from, and related to, cross-cutting themes four, five and one. In mobilising these questions, and which were informed by my scoping and more formal research in the first year, I sought to ascertain the thing/things mobilising my participants’ enthusiasm (such as the spectacle of miniatures, becoming a General, possession, remembrance), how wargamers relate themselves to modelling practice and wargames play and how wargamers identify with their models and the affordances of the miniature and abstraction. The questions were believed necessary to ask from a manifold range of questions that could be linked to themes one and/or four and/or five. This is for the reason that they allow the chance of investigating the geographies that motivate and enable miniature wargamers to model and play and the ways

in which models (as figures and rulesets) afford and are made and engaged with to produce particular embodied engagements with space-times. These research intentions imbued later questions and themes to examine in my miniature wargames interview schedules, as will become evident.

Participants were then asked a variety of questions about warfare models (rulesets) with questions focused on design and their 'teleplastic' nature (as a reminder, teleplastic meaning an enabling 'becoming other', relating to other human bodies and space-times, here in the contexts of the military and battlespace). For participants who made these warfare models (besides engaging with the models through play), questions were placed to them about the modelling techniques, sensibilities, decisions, tensions and aims present in their modelling. For all participants (including those who did not model warfare, but engaged with them through play), questions were included that sought to draw out their sensibilities and experiences with warfare models, for instance; most favourite/least favourite ruleset and why? All these questions addressing the design and the teleplastic nature of warfare models were developed from my scoping and more formal research via the hobby's books, blogs and online forums and links made through this research with theme four. The design and teleplastic character of warfare models were considered imperative to address in relation to theme four because wargames play depends upon engagement with warfare models.

For some people outside the hobby, miniature wargaming is a contentious practice and in relation to the miniature, abstraction, game and play. Through my scoping and more formal research, particularly via the hobby's books, it became noticeable that some wargamers were self-conscious over this issue, including influencing how some perform their identity in particular social contexts and domestic spaces (through display of model soldiers, texts etc.). Interviews offered the opportunity to explore this matter further, a matter considered relevant because of its relations with themes four, five and two (at the time, two was an inkling of its eventual form, as has been noted elsewhere). Questions pivoted on how miniature wargamers (if they do) negotiate their hobby identity socially and spatially in relation to negative attitudes towards relations between war, the miniature, abstraction and play. This research thread was considered important to address because the 'geographies of models' involved constitute a lived reality for a number of wargamers.

On the matter of interview transcription for this PhD research, transcriptions of my wargaming interviews, undertaken intermittently over November 2013, were very partial because I was so pressed for time. I transcribed only what I felt would be very

important to my research. Admittedly, this generated later frustration because as new issues crept up, there were no complete transcripts to quickly browse through. Instead, the audio files were studied, taking significantly longer. Some e-mail dialogue was maintained with a few of my participants throughout the study, consulting them on new issues as they emerged. Transcription of model railway interviews occurred over March 2013 and these were done personally and almost in full.

3.6: Archival research

This thesis engages with archives in the context of hydraulic modelling. In recent years, historical geographers have come to regard the archive as a 'subject', besides a 'source' (Ashmore et al 2012, p.82). Archives and the doing of archival research has been the subject of lively and serious thought within historical geography (for an overview see Mills 2013). This section draws upon several challenges dwelt on by geographers in their engagement with archives when describing how I experienced and negotiated my archival work.

Archival research on hydraulic modelling began at The National Archives in Kew (TNA) in the summer of 2012. Several 'pilot' visits were made with the idea of getting a 'feel' for whether an archival project on hydraulic modelling might be feasible. TNA holds about 130 files, some large, some small, on the HRS between 1945 and 1957. Whilst there are files after 1957 relating specifically to the HRS via its parent organisation the Department for Scientific and Industrial Research (DSIR), these are different. AY holdings contain, in places, fairly rich correspondence and reports (internal and external) about model studies and modelling practice which just does not exist after 1957 in any quantity. Particular 'stories' I found apparent in the HY files I traced through what Lorimer (2007) might call 'systematic quarrying' to other TNA government files. Files relating to the Ministry of Power and DSIR are very important to the hydraulic modelling chapter. After several initial visits, in September 2012 I spent 10 days at TNA looking through promising files. Over the next year, I visited TNA on several more occasions to examine other files, including those related to the DSIR and the Ministry of Power.

Archives, as geographers and historians have stressed, provide only a 'fragmented' view of the past (Baker 1997; Mills 2013). This reality might be frustrating, illuminating (given the political nature of archives over inclusion and exclusion) and even alluring and

enchanting. The fragmented nature of the archive became frustrating over the ensuing five months I spent with the material I had collected at TNA. More on fragments soon, but the challenge of the archival research was made more difficult by my having to come to terms with hydraulic modelling practice. Having no background in physical geography, for some time I felt intellectually distant from certain reports and correspondence; ‘what *is* he talking about’ or ‘how did he come to that decision?’ My experiences here mirrored those of Forsyth (2012) and her archival PhD work when she writes she had to ‘re[skill] [...] to read and understand camouflage, [making] at times [...] the archive a tricky and disorientating place’ (p.82).

The fragmented reality of the archive became particularly frustrating for the matter that the people ‘animated’ in the archive were overwhelmingly considerably ‘powerful’; board members of the HRS, the Director and his Assistant Director. Whilst recognising the ‘richness’ of the past can never be ‘fully recovered’ (Stanford 1994) and that, as DeSilvey (2006) has argued, historical geography can actually find its ‘force’ through absence and partiality, the fragmented reality of the archive had an impact on the extent to which I could trace spatialities to lived and embodied engagements with models and modelling. Although internal/external letters and notes, board meeting minutes among other material records relating to this ‘hydraulic elite’ were either mobilised by and/or contained embodied spatialities involving models and modelling, the embodied engagements of HRS’s ‘experimental officers’ or its ‘surveying team’ were obscure within the archive. Their trials and tribulations with technologies, materials, environments and non-human agencies were, however, narrated to an extent within progress reports on model studies or end of year reports, intended for DSIR or HRS Board study. Forsyth (2012) writes about how she had to find alternative archives to be able to account for the ‘corporeal experiences’ of WWII camoufleurs beyond ‘official reports and documentation’ (p.81). Geographers have been creative in recent years as to where to look to ‘fill in’ absences, from material objects and landscapes (Edensor 2005) to oral history (Cameron 2001; Lorimer 2006). Arguably I could have turned to oral history since a few modellers from the 1950s might be alive. If my research on hydraulic modelling were to develop along a historical trajectory, oral history as a research method would be considered.

My archival research was complemented by digital archives. *The Times* via The Times Digital Archives as well as Hansard were analysed in relation to a particular modelling project as well as the HRS more generally. The archive of Pathé News on YouTube had several 1960s newsreels about the HRS. The commentaries and visuals were interesting

from the point of view of how hydraulic modellers were presented to the British public. The YouTube archive of Pathé News supposedly contains all Pathé's newsreels and unused footage between 1910 and 1970 (90k films). Incidentally, this extensive virtual archive was an important resource in research for my model railway and wargaming case studies. Also helping to enrich my archival study on hydraulic models were electronic journal articles relating to work done by the HRS. Exciting for their insightfulness on modelling debates were 'discussion' publications in the journal *'Institute of Civil Engineers Proceedings: Engineering Divisions'*.

Finally, YouTube itself might be considered an archive. Important to the model railway and miniature wargaming research are television programs about the respective hobbies as well as 'vlogs' (video-blogs) from modellers and gamers among several other media on YouTube.

3.7: Conclusion

This chapter has highlighted the reasoning behind the choice of case studies and how, over the course of the research, diverse spaces (virtual, material, textual, archival), networks (online forums, archives, texts), objects, collections, institutions and finally people (as screen-names, 'in the flesh' beings, or dead) have been engaged with. Among other aspects, this chapter has shown how online research ethics was negotiated. It was considered that in virtual space questions of public/private are often unclear, making research here a particularly fraught practice and requiring a 'delicacy of concern' and 'reflexivity' (Moore 2010) on the part of the researcher. The chapter closed on how the fragmented reality of the archive had an impact on the extent to which spatialities to lived and embodied engagements with models and modelling could be figured.

4: Model railways

4.1: Introduction

This chapter considers how model railway layouts afford and are made to produce particular affective engagements with loved, lost and/or enchanting space-times. Railway modelling is examined here as an embodied practice, one affected by and/or producing love, memory, atmosphere, place, landscape, enchantment, possession, matters of mimetic challenge with materials and a mimetic politics to models and modelling.

This chapter's discussion on model railways is composed of seven empirical sections each pivoting around particular concepts and model and modelling engagements. After an introduction on model railways in 4.2, the first empirical section, 4.3, details the early history of model railways at the same time as introducing a mimetic politics within the hobby around model, modelling and modeller. Such a politics infuses later discussions in this chapter. Nostalgia and love are the subject of 4.4 where it is shown how railway models and modelling are imbued with these emotions, whilst 4.5 queries an idea that model railways are about making 'ideal worlds', opening up space for several conceptual discussions. The focus of 4.6 is on matters of research in railway modelling. The section firstly looks at the doing of research and then explores how research can be imbued with a mimetic politics. What takes place on the modeller's workbench is the subject of 4.7; the section contemplates embodied relations between modeller and material. Affective atmosphere is the concern of 4.8. Atmosphere permeates nearly all the preceding sections, but here atmosphere is looked at in some depth conceptually and empirically, with the second half considering the practice of modelling atmosphere. The empirical sections are closed by 4.9, concerned with play and the model railway layout. Salient points from this chapter are the subject of 4.10, the conclusion.

4.2: Introducing model railways

What is ‘railway modelling?’ as one modeller, Stuart, suggests: ‘[I]ts pretty crucial I think to recognise how wide the range of activities covered by the loose term ‘railway modelling’ really is. It’s probably a wider range than almost any other hobby’. The model railway author Simmons’s suggestion that ‘railway modelling is the art of creating in miniature a working replica of a full-size railway’ (1998, p.10) is a partial account and a politicised one. Tony (below) provides a nuanced understanding of how railway modelling may be differently practiced within the hobbyist ‘model railway community’:

‘Many people seem to favour one aspect of the hobby above others. There are folk that do superb scenery, but don’t worry too much about the trains; a simple track running through their countryside is enough. There are others who build superb trains/carriages/wagons and will happily run them on set track with ready to plant buildings. There are others who will get their pleasure out of recreating the operation of the real railway. The whole layout may be RTR [Ready To Run, i.e. commercial products], but they will have a timetable, working signals, maybe block bells and they will become totally absorbed in a running session’ {f}.

The railway is an ‘infrastructure’, ‘enabl[ing] the movement of other matter’ (Larkin 2013, p.329). However, the railway is more than a technical object facilitating the ‘move[ment] [of] people, parcels and products from place to place’ (Freezer 1993, p.13). As Larkin suggests: ‘[R]oads and railways [...] operate on the level of fantasy and desire [...] that stand as filters through which the object is seen’ (2013, p.329). For instance, for Wickham: “[W]hat is the fascination of the railway?’ It can be felt, but it is almost impossible to convey it in words’ (1949, p.5). What unites many railway modellers is an enthusiasm inflicted with enchantment, fantasy and desire for ‘the railway’ and usually its past rather than the present or an imaginary future. Railway enthusiasm may be produced by objects associated with the railway, the technological assemblage of the railway, its place in a landscape and/or its place in personal memory. Moreover, there is often a desire to produce an ‘affective atmosphere’ with regard to the railway and landscape. ‘Affective atmosphere’ is made through ‘feelings and moods that circulate through particular spaces’ (Ash 2013, p.22).

Railway modelling, a practice emergent from the early 20th century, is one of several popular activities associated with ‘railway enthusiasm’. Others include railway preservation (see Halsall 2001; Rhoden et al 2009; Wallace 2006), train spotting and railwayana collecting

(see Carter 2008). Enthusiasm for the hobby might be generated from and/or infused with these activities, but equally enthusiasm for such activities might spark from the hobby. The hobby is gendered, practised overwhelmingly by males from adults, teenagers to young children (Carter 2008; Yarwood and Shaw 2010). As far as can be judged from the research undertaken for this thesis, railway modelling is an enthusiasm predominately of white males and of diverse ages and social-economic backgrounds, although for Wells 'the ethnicity and gender of modellers is becoming [increasingly] diverse' (2015, np). Some modellers have had a lifelong enthusiasm for model railways, practicing the hobby for most of their lives, whilst others might have stopped practicing the hobby for a while because of work, family and space (at home) commitments. Retirement is an opportunity for many people to practice the hobby and many younger modellers leave the hobby during their teenage years, but may come back later (Yarwood and Shaw 2010).

The hobby is predominately practiced in the house as home and the model railway can 'make' home, which is to say give meaning to home. Regular home spaces for the hobby's practice include loft, garage, shed, basement and spare bedroom, although shared family space such as living, hobby or dining room might be utilised instead or as well. The home and family negotiates modelling practice. However, modellers do not necessarily have any desire for making the largest layout possible within the potentials of a space or the home. As model railway author Rice (1990) identifies, 'money', 'time' and 'satisfaction' can influence how much of available space is used. Whereas modellers at home will usually make layouts made by themselves, club modellers will communally make layouts (see Carter 2008; South London Area Group 2010; Waterman 2009). Modellers, whether at home or at a club, may find making enjoyable and many will spend months, even years making a layout and after completion start making another or the making of one is always in a state of continual coming-into-being. Modellers may take their club or personal layouts to model railway shows. At these shows, modellers can show and experience layouts and meet traders and producers of model railway products.⁹

⁹ Model railway shows are primarily about display. They function like other kinds of exhibitions, whether those 'displaying the nation' as with the Great Exhibition (1851) (Auerbach 1999), the future as with the Festival of Britain (1951) (Hornsey 2008), urban planning futures (Larkham and Lilley 2012) or farming at agricultural shows (Holloway 2004).

4.3: The early years of model railways and introducing a mimetic politics to model, modelling and modeller

The UK television personality and self-identified ‘train-set’ enthusiast James May, writing in his book accompanying the 2009 BBC TV series *James May’s Toy Stories*, proffered: ‘I use the phrase ‘train set’ advisedly: I’m not talking about model railways. Train sets are about trains, while model railways concentrate far too much on everything else’ (2009, p.92). The ‘everything else’ May refers to is the diversity of things, beyond trains, that make a ‘world’, from worn down steps, to pot-holes and ‘smoke blackened alleyways’ (Norman 1993, p.2). A model of a train has arguably been around longer than an actual train (early 19th century) bearing in mind models can be things to guide making and to present invention (Baker 2004; Ellis 1962; Smith 2004). Model railways have a relatively recent history, a genesis located in the first few decades of 20th century Britain.

Model railways branched out of a practice of ‘model engineering’. As Harrington has noted: ‘[M]odel engineering was a significant social and cultural presence in Victorian and Edwardian Britain, in trains and hobbies, education and juvenile literature’ (2012, p.21). Gelber asserts that by the 1930s ‘the English [...] had almost a century of experience [...] with [...] ‘model engineering’ [...], working models of powered boats, trains and farm machinery’ (1999, p.231). The model trains were powered by steam just like their referents. Through the edited periodical *Model Railways and Locomotives*, two major personalities in the hobby of model train engineering, Henry Greenly and Bassett-Lowke, sought to enthuse model train engineers to consider the railway as an environment, an operational system and its place within landscape.

At the time of Greenly and Bassett-Lowke’s writing (1909 to the early 1920s), the model scale was very large compared with those scales popular today, meaning the young hobby was costly and spatially consuming. Because of this, the hobby was practiced by a wealthy minority in their estate parkland or salubrious garden rather than loft or spare bedroom (Ellis 1962; Essery 2000). Better democratic access and a greater sense of realism were felt facilitated by miniaturisation, the power of home electricity and also the affordances of an indoor rather than outdoor environment. The toy producer Bing (quickly followed by others such as Bassett-Lowke) established the model railway scale ‘00’ (pronounced ‘double o’ and 1:76). Running on electricity, ‘00’ is today the most popular of indoor model railway scales, enabling for eminent model engineer Percival Marshall ‘the

owner of a small house, or even a flat, to put down a most attractive miniature railway system in a comparatively small space and to get all the thrills and interesting complications of a larger railway' (1935, p.5) (see figures 20-21, pp.75-76).

In reading through the hobby's early texts, it is not difficult to get a sense that some writers were feeling insecure and defensive about the new hobby. This was because of the use of the term 'toy' by some to refer to the new small model trains. A model was not a toy Binstead made clear to his readers: 'Those who carelessly speak of grown men playing with toy trains do not appreciate the fascination of a true scale model railway, nor do they appreciate its power of instruction' (1943, p.vii). For Craven, writing in the 1970s: 'There are some places in the world [...] where you run the risk of being lynched if you suggest that model railways are nothing but toy trains' (1979, p.1). In a similar fashion to presentations of making model aircraft (Adey 2010, 2011), school geography models (Barker 1954; Ploszajska 1996), history models (Bayley 1950) or 'amateur' naturalism (Withers and Finnegan 2003), railway modelling was to afford 'plenty of scope for a high order of intelligence and for the exercise of much practical skill and knowledge' in the opinion of an editorial in *Model Railway News* (1929, p.162). The editorial went on to propound: '[T]he fact that a model railway is necessarily diminutive in size does not make it a 'toy,' and while the hobby undoubtedly has great recreative value, it involves so much technical knowledge and ability that it is far removed from what is normally understood as the province of 'toys' (ibid).

Railway modelling was portrayed in the hobby's texts as a serious and noble endeavour. Attitudes of what a 'model', 'modeller' and a 'model railway' *was not*, soon began to permeate through the many books, magazines and articles constituting spaces for dialogue over the practice of the hobby. *Model Railway News* asserted about itself that 'it brings you in touch with hundreds of other enthusiasts and places their knowledge and experience at your service' (1927, np). Like many of the books, one by Beal (1935) sought to inform the reader how to make and 'operate' a model railway. For budding hobbyists, taking note from Beal's book according to Marshall (1935, p.6) would 'make your 'miniature railway not only pleasingly spectacular in appearance, but admirably representative of the real railway world'.

Magazines included adverts from new producers who saw a market for ready-made objects. Modellers would buy and/or build from scratch (alternatively called 'scratchbuilding'). A sentiment among some modellers was that the 'true' railway modeller was a craftsman and displaying, for one letter writer under the pseudonym 'Great Eastern',

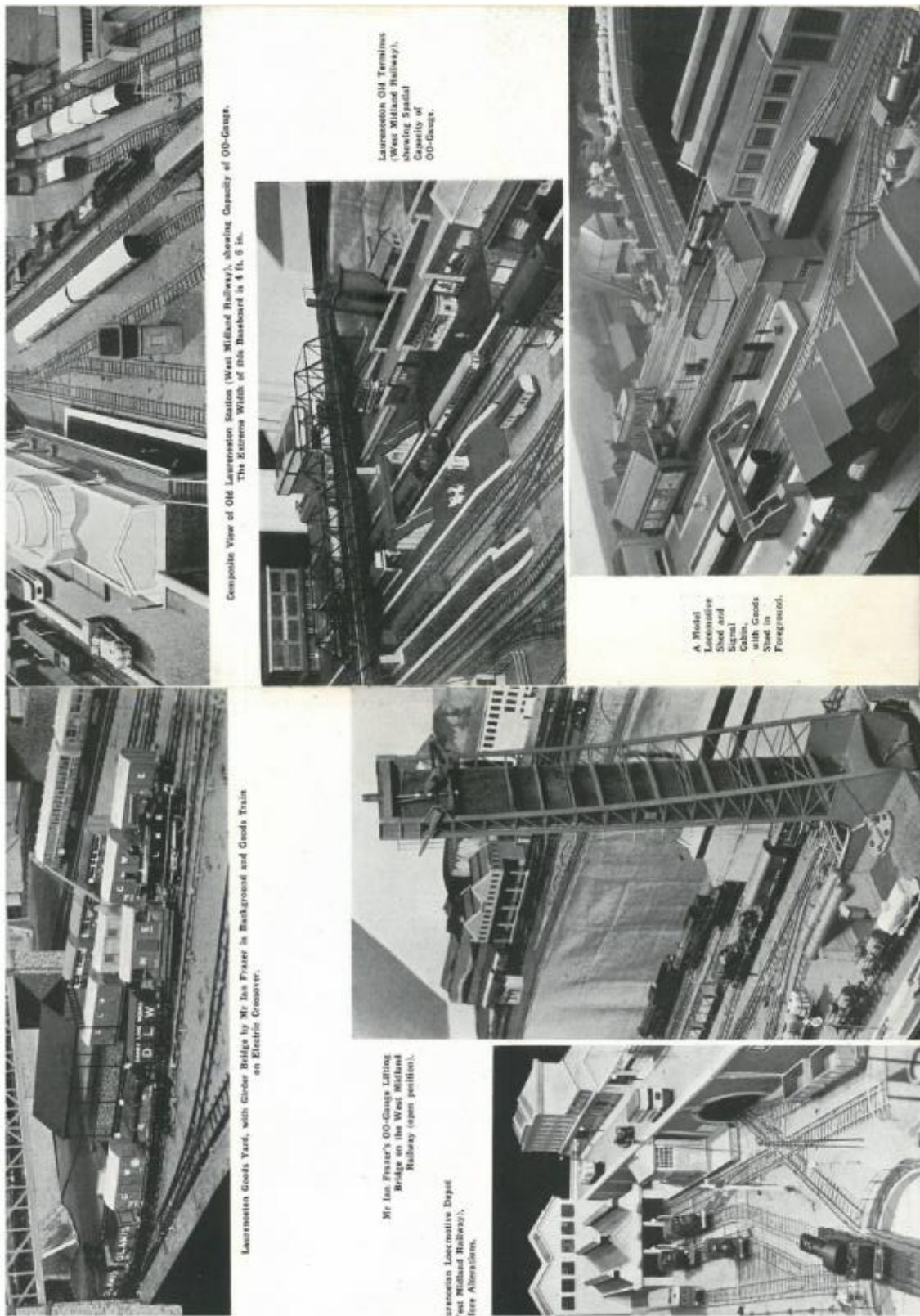


Figure 20. Plates of model railway layouts from the 1930s. Source: Beal (1935).



Figure 21. Relative size of model railway scales (name of scales displayed on front of table).
Source: Bob Symes's Model World (1975).

(1938, p. 273): '[L]ove of craftsmanship for its own sake, inborn skill or semi-skill in the use of tools'. Distaste was for the modeller who buys everything, creative power remaining latent. Constructions of 'modeller/not modeller' around 'passivity in leisure' (Snape and Pussard 2013) and the affective 'power of making' (Gauntlett 2011) are not so textually present today, although particularly among modellers who extensively scratch-build there are those who do harbour such conviction. For instance, Derek suggests: 'I do consider myself doing something very different from say someone just buying everything. We are both interested in trains, but that's about where it finishes [...]. I actually model'.

Toy – model relations in the construction of a politics to model or model railway come back into the picture when we think about more constructions of the ideal modeller. *Model Railway Constructor* asked of its readers: 'What is the object and aim of your model railway system? [...] is it a meaningless jumble of 'runs' with numerous stations and sharp curves, the like of which has never been seen on a real railway?' (1935, p.80). A model railway had to have an 'object and aim', the argument was that real railways were not planned with little forethought so why that which purports to model it. Explicit in *Model Railway Constructor's* question and anticipatory answer was an idea that a modeller ought to be striving for realism. Harrington (2012, p.36), paraphrasing *Model Railway News* (1931, p.65):

'Too often [...] modellers began with a prescribed space and created a track plan that would fill it with as many railway features as possible. Such a layout was 'bound to be of nondescript character', for 'it is not based on any particular service requirements, it bears no relation to geographical or countryside difficulties, it carries no well-defined passenger and goods traffic, and it resembles no known prototype' [...]. In this way the modeller would 'produce [...] a toy model railway'.

The underlying concern for *Model Railway News* was that a model railway ought to have a highly plausible relation with the railway and landscape past or present.

Making an observation on the hobby today, whilst all interview participants and seemingly the majority of modellers on the internet forums identify themselves with capturing certain past or present space-times (and not necessarily specific, for instance 'West Sussex in the 1960s'), a politics from within the hobby, especially omnipresent through the hobby's books and magazines (e.g. Freezer, 1993; Nevard 2011; Simmonds 1990) and some electronic media (e.g. County Gate 2013; Meko 2014; RMweb 2013), rests on an attitude that many modellers could be doing more to capture space-times 'better'. 'Better', as will be seen in 4.6 includes questions of affective atmosphere.

4.4: Nostalgia and love

A sizeable majority of modellers model a past. However, quite a number when they started in the hobby modelled a present. A turning to the past, or an impetus to be with what was once present, may be imbued with memory and/or loss. Jones notes how ‘memory [...] is [...] a key wellspring of agency, practice/habit, creativity and imagination’ (Jones O 2011a, p.875). For Brad: ‘[Railway modelling] gives me an opportunity to travel back to my youth [...], I guess the era has passed and there’s no way back, railway modelling provides me that vehicle to re-create a time and place I truly miss’ {f}. For Bartlett writing of his layout: ‘As with many other people, my model railway provides me with a means of delving into the past and reliving those fond memories of years gone by’ (2011, p.162). Similarly, for Tim:

‘I want to step back to a time when steam was not the exception, but car ownership was, to an era when travelling was an adventure with my parents to somewhere with a beach. I do not care one jot if my memory is imperfect, but the sensation being transported by train was simply wonderful and I can capture those moments as the train travels through my beloved Dorset, then I will have succeeded’ {f}.

For Justin, his model railway is about feeling: ‘My model railway is about enabling me, in a small way, to feel that sense of exhilaration I suddenly found there and then’. Justin models diesel locomotives within a Berkshire landscape after an enchanting childhood encounter, an everyday prospect vanished today. Justin finds solace that ‘a bit of what I loved is in the loft, or should I say, love, because it still exists, there in my loft’.

The testimonies aforementioned are all related by the presence and absence of ‘possession’. The miniature affords possession as noted in 2.5.1. Through the miniature, but also abstraction, loved things, places, infrastructures and landscapes can be recreated of a kind in model railways and *within* the personal space of the home or the communal space of the club. The abstraction involved in model railways means these loved space-times can remain relatively safe (save usually dust, bugs, pets and damp if these are not controlled) in that the past is the present always. The future, in many ways giving meaning to how a model railway may be imbued with memory and/or loss, never arrives. Whilst this idea is evident in Tim’s testimony from earlier, it is explicitly clear in a magazine article by Dougherty on his Victorian timed layout. Impassioned by his love of the County Donegal Railway Company, his ‘ancestral homeland’, the ‘slow pace’ of life and the scenery,

the layout ‘recreates the peace and quiet of County Donegal and brings me back into an ever more peaceful era before the internal combustion engine began to make in-roads into this last haven of solitude’ (1978, p.191).

Nostalgia, an emotion inflicted with memory, is a longing to return to the past, a homecoming. Nostalgia has attracted some critique from geographers (see Della Dora 2006; Legg 2004, 2005) and arguably nostalgia is being evoked in the statements from Brad, Bartlett, Tim and Justin. Nostalgia has its origins in medicine, as Beganović iterates: ‘It was used to describe and determine an illness [...] detected in Swiss mercenaries condemned to long absences from home, filled with boredom and the monotony of everyday life’ (2012, p.147). Nostalgia, a kind of sickness, is very visceral and mobilises enthusiasm in the hobby for the likes of Tim and Brad. Alternatively, over time, nostalgia may become part of the enthusiasm for the hobby. For instance, for Stuart: ‘I was modelling the recent stuff yes, all contemporary scenes. I just liked modelling what I loved’. Stuart, now still modelling his ‘love’, finds an added impetus with time and perspective:

‘[I]here is now more to it than just an enjoyment of modelling [the period] [...], I am kind of going back to places that have since changed for the worse [...]. It’s sad, but I am happy because I create those gone places again and inhabit them through and in my modelling and it can be very good to be there sometimes’.

Modelling might be a therapeutic practice and models might be a kind of therapeutic object or landscape (on therapeutic landscapes see Williams 2007). The therapeutic, infused with feelings of comfort, may arise through the making of and engaging with layouts of a loved space-time and be one of the joys of making, being with and playing with a layout. This is particularly evident in Mark’s testimony:

‘In all the times of trouble that we have in the world I can honestly say that apart from my wife, I can turn to my layout and shut out what I don’t [want to] know. My layout comforts me with past memories that keep flooding back time after time which makes me feel there is something good and nostalgic to be proud of and not everything is destructive’ {f}.

Making, maintaining, playing and encountering a model railway layout can be imbued with ‘love’. Love is an emotion and might be thought about as a ‘combination of care, commitment, trust, knowledge, responsibility and respect’ (bell hooks xvii in Geoghegan and Hess 2014, p.8). Morrison et al (2012) have recently suggested geographers consider love with regard to its relationality, spatiality and how it might be involved with the political. For Thien, ‘love makes intimate knowledge of particular places, is composed of specific spatial practices, and attaches one to another whether in affection or despair’

(2011, p.316 in Tyler and Henkin 2014, p.292). Making, maintaining and engaging with a layout might be seen as practices of love, especially in an aim of resurrection and remembrance for what is lost and which can be loved again in a material, miniature and abstracted form. There are also questions of ‘intimacy’ here, intimacy following Valentine and Hughes being a ‘knowing, caring for (emotionally as well as practically) and loving another/others (2012, p.243). Relations can be made between model railways and notions of intimacy. This is in the sense that abstraction, the miniature, the making of the model railway and play with it affords closeness and power with what is loved. For instance, for David:

‘How else can you do what you can here [in railway modelling], [in railway modelling] you get to recreate and have something and do something with that you have an affinity for and it’s just the size of a table. You can linger and look, you can get up close in ways that you couldn’t in reality and of course [...] within your own home [...]. It is can be comforting to know sometimes that you have that place [in the form of a layout] there in your loft [...] it’s not forgotten’.

A layout may become an object of ‘love’, love emergent from what the layout and possibly play with it presents, a landscape, time, memory, atmosphere and place loved itself.

Modelling the past might be a treatment for the sickness that is nostalgia, modelling seeking to quell the sickness through constructing what causes it. Mark’s account, along with the other modeller accounts on nostalgia, has parallels with Boym’s (2001) ‘performance of nostalgia’. Boym identifies two kinds of nostalgia; ‘restorative’ and ‘reflective’ nostalgia. Restorative nostalgia is ‘signalled by nostos: the desire to return to the original’ (Della Dora 2006, p. 228); ‘to rebuild the lost home and patch up the memory gaps’ (Boym 2001, p.41 in *ibid*). Horning figures restorative nostalgia as ‘a monolithic reconstructed version of the past’ (2004, np) and materialising for Della Dora in ‘well-defined’, often overwhelming landmarks designed to resurrect [...] glorious [national] past[s]’ (2006, p.229). For Boym (2011), restorative nostalgia does not define itself as nostalgia. ‘Reflective’ nostalgia meanwhile is different, it is ‘a self-aware remembering of the past that focuses on our longing for better times while acknowledging life’s ever-changing one-way flow’ (Horning 2004, np). Boym considers ‘it reveals that [unlike restorative nostalgia], longing and critical thinking are not opposed to one another [...] [and is] [...] concerned with historical and individual time’ (2007, p.15). In other words, for Williams: ‘[W]e can love things about the past, but also critique them’ (2013, np).

Model railways may fall across both restorative and reflective nostalgias, ejecting certain features of one to the other such that Boym’s (2001) reading of nostalgia is arguably

too dichotomous. Railway modelling might be understood certainly as restoring a past (restorative), but rather than being a national or another kind of collective past (restorative) more often is a very individual one (reflective) and from the monumental to the personal space of the home. Furthermore, restoring a past in railway modelling might be understood as nostalgia by modellers (reflective) and one where critique (reflective) is very present. For instance, for Martin who models the 1980s period:

‘I know the past was not all that rosy. I had a difficult time when I was a kid, but I loved warts and all what my model is about [a locomotive shed in London]. The trains were pretty wrecked some of them as you can see, they were bad times, but it’s the tremendous atmosphere of it all that makes me sad in that it has gone’.

4.5: Making a perfect world?

The artist Stuart Robinson suggests railway modelling is about making a perfect world and this section pivots around his idea that:

‘[Model railways] are an idealised world [...], a world that depicts a romanticised image of a specific time, a time when things were ‘better’, but a time that ultimately did not exist. In this world, like the world of movies, a story can be created, the past can be how we want it to be, and the future, or indeed the present, does not need to exist. This can be seen as a synonym that mirrors the way we often look at our own lives, the past being created by our selective memories into an optimal version of itself with the rough edges removed’ (2012, np).

Whether in regard to architecture, tourism or children’s play, the miniature model has often been associated with the perfect and untainted, dreamy, utopian, make-believe or fantasy (Armstrong 1996; Kersel and Rowan 2012; Koch 2010; Momchedjikova 2002; Stewart 1993). Koch has written about architectural models on public display in a state-led city development project and where ‘the grit and grime of everyday life is entirely absent [in the models] [...], their surreal cleanliness present an unobtainable image of order. The author of the miniature model is most successful if he or she chooses to expose only the best side of life, creating a fantasy world’ (2010, p.780). In a sense here, the model of the city is a model city (with model in the ideal sense of the word). Whilst readings of the miniature as perfection, utopia and fantasy are vital, indeed politically vital, such readings of the miniature, particularly as perfect, limit discussion on the miniature and miniature models.

Graffiti, 'urban grime' and dilapidation for many railway modellers are part and parcel of an affective atmosphere desirable to model. Remembering Robinson's point that railway modelling is about 'an optimal version of [the past] with the rough edges removed', idealising was not springing to mind when model railway writer Barry Norman, working with members of the Model Railway Journal's modelling club, decided to create an imaginary mid-1940s inner-city layout where:

'Gloom of a northern city in the war years inspired us. We wanted to hear the clanking of buffers echoing between the backs of terraced houses and the feel of the dust-laden wind gusting through smoke-blackened alleyways. It was to be an everyday scene: the corner shop, the local pub and a busy urban station with its cobbled forecourt and cramped platform sheltered beneath a dingy canopy. Here [...] was to be grimy urban gloom' (Norman 1993, p.2).

Modellers may go to substantial lengths in terms of research effort, modelling technique and/or personal expense to undertake 'weathering' of models. Weathering is known as a 'corrosion of metals, efflorescence on stone and brick, fungal attack on organic materials and the wear and tear of everyday life' (Dorsey and Hanrahan 2006, p.387), involving 'tarnish[ing], bleach[ing], stain[ing], erod[ing] and otherwise modify[ing]' (Dorsey et al 2005, p.411). Weathering might be the effects on objects from the agency of humans (made through marks, depressions, stains), non-humans ('birds, bats, rodents, insects, bacteria, plants, fungus, lichen' (Edensor 2011, p.242)) and atmospheric forces and matters ('moisture, ice, wind, acid rain', pollution (Edensor 2013, p.457)). Of course, a weathering effect is often an entangling of several or more of these human, non-human and atmospheric agencies.

Weathering can co-produce an 'enchanted' atmosphere, being an important aspect of what gives objects and space meaning and emotive resonance for railway modellers. Enchantment is read following Bennett as 'a state of wonder [...], a momentarily immobilizing encounter; it is to be transfixed, spellbound' (2001, p.5 in Woodyer and Geoghegan 2013, p.196). Weathering and an enchanting atmosphere can be evidenced in Norman's (1993) testimony from earlier, but Alistair can make the idea more explicit: '[W]eathering is an important aspect of the environment I am trying to create [...], without it my model would look like a toy town, it wouldn't be the place I am trying to recreate [...]. Worn steps, pot holed roads, rusty tin sheds and dilapidated fences are part of what makes the place special to me'. For Manchester Model Railway Club's Robert, weathering is a practice of 'creat[ing] atmosphere. We are trying to depict Liverpool Lime Street [station and area] in the years 1945 to 1947 [...]. It was no more than two years after the

secession of hostilities and things are still rather dull and dismal [...]. Using both [weathering] powers and paint I am trying to create this dull atmosphere' (Model Railways Live 2012a, np).

Modellers will mimic with a variety of materials and particular tools and techniques the effects of humans, non-humans and atmospheric forces and matters on model objects (see figure 22 below and figures 23 and 24, pp.84-85). Weathering can enhance emotional attachment to objects and models can be loved because of the pleasure derived from the weathering attempt. For Sharp: 'A simple pleasure is to fill the loop line with vehicles and enjoy the faded lettering, peeling paint and rusty ironwork. Like a well-worn face, they show character' (2007, p.218). Weathering might also be a means to personalise a commercial product as Ian suggests: 'Weathering is one way of doing that because you've turned a bog standard commercial product into something that's very much personal to you and your outlook and your railway' (Railway Channel 2010, np).



Figure 22. Heavily weathered locomotive. Scene from 'St Marnock Engine Shed' (early 1960s, Glasgow), a layout by Mike Bissett. Source: Model Railways Live (2012b).



Figure 23. Scene from ‘Tetley Mills’ (early 1960s, West Yorkshire), a layout by David Shakespeare. Source: Shakespeare (2012).



Figure 24. Scene from 'Maindee East Engine Shed' (c1964, Newport, South Wales), a layout by Steffan Lewis. Source: Model Railways Live (2012c).

Modellers may be frightened of weathering buildings, locomotives and other objects because of a perceived lack of embodied skill with tools and materials. For Colin: 'Practice makes perfect, I have only started to feel confident [...]. I developed my techniques on old models [...], bad weathering can really spoil an otherwise good model'. The significant monetary value of model trains and sometimes other 'stock' (coaches and wagons) causes anxiety to weather them. Hobby resources in the form of books (Welch 1993), magazine articles (Sibley 1987) and YouTube videos, blog posts and internet sub-forums (Fleming no date; Model Railway Forum 2009; NSTrainFan 2013) appear which, alongside commercial weathering products such as 'weathering powders', are about enabling modellers to feel more confident in weathering. The model paint manufacturer Humbrol describes its weathering powders as a 'versatile means of adding realistic weathering effects to your models, figures and dioramas. They can be mixed to create different shades, enabling a full range of finishes from dust to mud, soot, rust and many more' (2014, np). Some railway modellers offer their skills in weathering for a fee. For Dovedale Models: 'This [...] is available to those who have built a model, but may not be so confident or have the time or patience to paint and finish it. I can offer that finishing touch [giving] your model that realistic appeal' (no date, np).

Because the hobby is differently practiced, other modellers might identify with creating perfect pasts or presents. For Phil:

'I built my layout to make me happy [...]. I never intended to be true to history [...], I spend enough time in the imperfect and unfair real world [...]. In model railroads, I find the peace and harmony that is lacking in 1:1. Maybe someday our prototype world will be one in which there is no crime, there is full employment, there is a beautiful/healthy environment, there is no need for weapons and we are all universally happy people of a variety of skin tones and cultures. One can always hope' {f}.

Phil's model railway is the world as it should be for him. It is a utopia and the miniature enables Phil to create his utopia at home. His model becomes a space of escape with therapeutic purposes. As Koch (2012) has declared, utopia has had little explicit geographic interest (although see Harvey 2000; Hetherington 1997; Kraftl 2007; Pinder 2002) and has Greek roots of 'a place (topos) [...] both happy (eu) and nonexistent (ou)' (Koch 2012, p.2447). Phil has sought to assert 'the possibility of a different world to be considered, desired [...], express[ing] the possibility of living in a world other than the one that [is] see[n] around [him]' (Lethem 2010, np). Phil is able to dwell imaginatively via play in his utopic construction, a construction bereft of sentient beings and where utopia is never

threatened or destroyed by them.¹⁰ However, damp, mould, warping of card and plastic models by sunlight and destruction by humans, pets and wild animals can wreak havoc if these threats are not mitigated.¹¹

Phil's testimony draws attention how the space-time of a model railway layout may contrast with the modeller's and raising issues of the relations between spaces of comfort and discomfort (Price and McNally 2013; Sellick 2013). Making and playing with a model railway might be a comforting practice and with a feeling of comfort generated by feelings of discomfort elsewhere. This 'elsewhere' might be at home and tension between family members or perhaps issues at work, a nostalgic longing, or a concern with contemporary society for instance.¹² For David:

There's been many a time, I've been glad of this hobby. I have other vents like a good dog walk or a blast of the dumbbells, but there's no denying that I find settling down at the workbench extremely therapeutic. The hobby has been like a secure bolthole and it was particularly so during a dark and scary part of my life in my mid-teens. Ever since then it's been a nice retreat when I have worries on my mind or a bad experience to get through' {f}.

Relations between comfort and discomfort find themselves affecting what a modeller might model and where model space might be a perfect model world in the process. For Simon: 'For me, the graffiti is just an eyesore and why would I model something I consider to be ugly on my model railroad that I am building for my pleasure?' {f}. Simon feels uncomfortable about modelling what he dislikes, affecting the comforting potentiality of his hobby in making and ultimately in play. Referring back to Stuart Robinson's (2012) comment that modellers model a past as 'how they want it to be', this issue can be less to do with a desire to forget in a pursuit of creating a perfect past than to forget so as not be affected by the discomforting in making and play. Colin's testimony exemplifies this issue:

'My 1930s era layout has no evidence of racial segregation, the Depression, or the unfair treatment of women that existed in the 1930s - and I completely agree with Lee's decision to omit graffiti. I don't think we have a case of 'rose-coloured glasses' - if anyone knows how the world really looks it would be model railroaders, attention to our

¹⁰ This is different from some Victorian era model (ideal) villages in the UK for people to live in. The UK model village of Bourneville in Birmingham was founded by a George Cadbury of Cadbury's who wanted to create a utopia for his workers and their families (Power and Houghton 2007). However, from the start it needed forms of control and power through spatial planning and over the body via rules to ensure this (Bailey and Bryson 2006, also see Bailey and Bryson 2015; Bryson and Lowe 2002).

¹¹ 'Home is materially and spatially imbricated with nature, nonhumans and the 'outside'' as Power (2009, p.1025) has highlighted (also see Kaika 2004; Power 2007).

¹² On nostalgic longing and perhaps contemporary society as well, Mark's comment as referred to in 4.4, is pertinent.

prototypes is part of our affliction. I think we do it to keep the social mess from detracting from our own joy' {f}.

Forgetting can be a positive as well as a negative (Muzaini 2014). For Colin, in forgetting aspects of his modelled space-time he can enjoy modelling and engaging with models. For others though, and for Neil: '[H]istory should be as it was even when we do not like it' {f}. For Joe: '[M]odelling the [American] south in the early part of the 20th century, with the Jim Crow laws [...], black people had different restrooms, different drinking fountains etc. [...] [I]t was a part of our history, so to be accurate; you model it as it was' {f}.

4.6: Research for a layout

Most railway modellers will do some kind of research in making a model railway and for engagement with it ('operating' the layout according to prototype practice). This section is interested in how research is involved in a practice of modelling and engagements with model layouts.

Doing research for making a model railway layout, but also assessing how to 'authentically' engage (play/operate) with a layout, may involve all manner of practices; from observing the summer hue of an oak tree, talking with local people about a place's past to delving into an archive looking at an architectural plan or train operating rulebook. The doing of research - involving things, people, spaces and places – will be of differing intensity for each modeller, might be prolonged and might be as much an enthusiasm in doing model railways as making or play. An interest in research in railway modelling may develop from or compliment a research interest in transport history, local history and/or family history. There are 'geographies' in all of these of course as Graham implies:

'[T]he places I choose to model are places as much for the railway as the potential to find out more about what intrigues me about them [...]. I am interested in thinking about how they came about, how they've changed over time and what they are like today [...]. [D]oing more research than is needed I think just goes with my desire to learn more about something [...]. I also like to know what I am modelling [...], it makes my modelling feel more special and the model more real [...]. [More real] because you are not looking at a stranger, but rather a friend because of this layer of history [in the imagination] [...]. Some people say, 'huh you are just making structures and greening baseboards', but that leaves me cold [...]. I think understanding the stories, understanding how places have changed adds something to my

modelling such that I don't see myself as doing dimensions [...], its bringing a place, within the confines of the space I have available, back to *life* (emphasis original).

For Graham here knowledge and sentiment about a place's past give meaning to his practice of modelling and where such matters enable his model to feel more 'real'. At the same time, in the practice of researching, modelling ties Graham deeper emotionally to a place. This issue is important in the context of the emotional relations railway modelling 'works itself in', and affords, with landscapes, infrastructures, atmospheres, places, things, people and institutions such as a railway company. By 'works itself in' I mean to say some intensity of an emotional relation with such things usually pre-exists any kind of practice of research and this idea can be evidenced in 4.4. Nevertheless, research can 'afford', can intensify, relations with landscapes, atmospheres, places, things, people and institutions.

As noted at the beginning of this section, most modellers will undertake some kind of research and regardless of whether they intend to model a 'real' space-time or more of an imaginary one, for instance, a layout that presents a 'world [...] that might have been' through a counter-factual 'switching event' (Gilbert and Lambert 2010, p.252). Adam affirms:

[A]t the other end of the scale you find some people who build a near recreation of a real location, but with a slight twist whereby [for example] a housing development is missing and the railway has fitted into this location. The line may be a 'what if' based on a line which was actually planned in real life, but run out of funds, or one which is totally imaginary. At this end of the spectrum, I have known modellers who base their imaginary station on actual survey maps taking into account the contours of the line and over aspect that the real builders would have faced' {f}.

Making a model of a more imaginary place might be regarded as difficult to do 'convincingly' by many hobbyists and in the sense that the imaginary place could be felt as highly plausible, as real, both to the self and the wider hobby community. For Paul:

'There are pluses to both approaches [copy and imaginary]. For the prototype, all the design work has been done for you, track layout, signalling, operation, but you do have to research it properly to avoid the pointing finger of the rivet counters [a negative term used to describe people with an enthusiasm for 'excessive' detail]. A freelance layout allows more flexibility in design and operation, but you have to be careful that it remains within realistic boundaries of what the prototype operator would have done in that situation' {f}.

Making an imaginary layout convincing for Mike requires considerable knowledge about railway practice:

‘If you have enough books and photos of your prototype location, you can model it pretty accurately without actually knowing why you’re building what you’re building. Why is that signal arranged in that particular way? Why is the signal box at that end and not the other? Why does the Up line curve left after the overbridge? But if you want an ‘accurate’ model of a fictitious location, you need to research these things [...]. [For instance], you need to know the signalling principles of the company you want to model and the topography and geology of the area you wish to locate your model in’ {f}.

Whether modelling a real, once-real or more fictitious location, modellers might look for knowing, among other things, how an object weathers, train service rhythms, an object as dimension or an embodied feeling for an object, place or landscape. Embodied feelings may arrive through a visit and the doing of ‘in the field’ fieldwork, but just as much through photographs, pictures and text whilst at home or in an archive. The model railway writer Barry Norman was affected by photographs of Lydham Heath station taken in the 1930s:

‘I was attracted by the atmosphere of the station and wanted to say something about the neglect and sadness of this frail railway struggling to exist in a beautiful part of Shropshire. The rusting rails lying beneath weeds and withering grass were a poignant indication of the economic depression of the Bishops Castle Railway [...]. It was this image of decline that provided the focus for all my thinking. I wasn’t just trying to model the station as it may have been; I wanted to do more than that. I also wanted to encapsulate the atmosphere of the place. [...]. It is not sufficient in my view just to choose a station to model. It is important to interpret it so that you play upon the ideas and feelings the station conveys to you’ (1993, p.1).

A diversity of texts from maps, architectural and engineering drawings, railway company documents to local and railway history books might be important in a practice of model railway research. Modellers may have developed their own archive and/or reference library at home and/or at a club. Several enthusiast societies exist to help modellers in their research work such as the Historical Model Railway Society (HMRS) located in the UK. The HMRS was ‘founded in 1950 by historians and modellers to collect and exchange records, drawings and photographs’ (HMRS 2014a, np). The motivation for the HMRS to exist as a society is to ‘encourage modellers to build with greater historical accuracy’ (HMRS 2014b, np).

Magazine articles, books, blog posts and websites may be produced by modellers with a view to encouraging and/or easily enabling other modellers to pursue ‘accuracy’ in aspects of modelling or to make ‘authentic’ model railways. The motivation to author books, articles, websites and blog posts lie with particular ideals of modelling and model railways and constituting a mimetic politics resting on an attitude that some modellers

should be capturing space-times ‘better’ (the plausibility philosophy of railway modelling as described in 4.3). The idea is that particular ideals on mimesis need stimulating in other modellers and can be in response to concerning or annoying ‘problems’ identified with layouts at model railway shows, in magazines and on internet forums and YouTube. Examples of problems modellers have been concerned or annoyed with, and motivating their writing, includes train movements (Nield 1988), motor vehicles (Morton 2007), farms in space-time (Clowes 1984) and railway company colour schemes (Stationcolours 2014). With regard to train movements, Forster and Hodson have sought to highlight the ‘steps’ involved in ‘how a real steam shed worked’ (2010, p.52). Train sheds, Foster and Hodson go on to declare, were ‘structured places rather than seemingly random collection of locomotives moving around aimlessly’ (ibid). Affective atmosphere can also be involved in concerns about layouts and a motivational force for writing. A recent article by Nevard (2011) concerns itself with ‘15 steps to true S&D atmosphere’. S&D refers here to the ‘Somerset and Dorset Joint Railway’, a much-beloved railway to its enthusiasts and closed under the ‘Beeching cuts’ of the 1960s (see Hammond and Hammond 2010). Nevard’s article ‘presents 15 ways to help your layout really capture the feel of the S&D’ and details the ‘modelability’ (2011, p.38) of these ways. What for Nevard helps produce a feeling, or certainly a feeling of the S&D for him, includes: ‘[D]ouble-headed expresses [...], locomotives powering lengthy passenger trains over the Mendips’, ‘rural charm [...], the signalman’s rather elderly Morris 8 series E on the platform’ (ibid) and matters such as correct (or authentic) stonework colours and textures, signs, woodwork patterns and brick colours.

The premise of Nevard’s article is to get S&D modellers to critically reflect on whether their layout may capture ‘*true* S&D atmosphere’ so as ‘everyone knows what your layout represents’ (2011, p.38, emphasis added). Nevard’s article was irritating for Gerald:

‘I understand why people do it and [the magazines] provide lots of useful information, but the tone to a few [like Nevard’s article] is a bit condescending [...]. This is a *hobby* and if people are happy with their layout who’s to say they are wrong, they are doing something right! As long as the layout does what I want it to do [...], enables me to go feel that time and place [when I was a schoolkid, commuting on the trains] then who should dispute that?! (emphasis original)

Some modellers might not be enthused to undertake research on certain things or the layout more generally. For instance, for Harry: ‘[W]hether the signal gantry ought to be there or there [pointing to several places on the layout], there is little difference to me. As long as I am happy and it gives the impression, why bother’. Research requires

embodied effort which can be physically and emotionally taxing and may be a turn-off to undertake research (something authors might seek to combat by producing informative articles). Relatedly, the doing of research, particularly where archives and libraries need to be visited, documents and photographs copying and books purchasing, can be expensive enough to prohibit research.

Observation, a subject of critique for some time in historical geography and particularly historical geographies of science (see Kennedy 2008; Matless 1998; Robinson and Mills 2012; Withers and Finnegan 2003), is self-identifiably for many modellers an important ‘embodied skill’ (Robinson and Mills 2012) in the course of their research and important in making atmosphere. For instance, for Gerry:

‘Any modeller worth his salt would aim for creating the correct atmosphere on his layout through research. In fact, I would go so far as to say the viewer should be able to gain an idea of the line’s pre-grouping origins and area of country being modelled without a train being in sight. Observation of architecture, signalling, stone walling or fencing, cattle or sheep country and so-on’ {f}.

Gerry refers to ‘correct’ atmosphere in a context of making a point that if a layout describes itself as set in the Lake District for example, Gerry expects the layout to feel to him like the Lake District. For Gerry, observation enables ‘correct’ or ‘authentic’ feelings of landscape to arise when encountering a model.

The model railway club South London Area Group (SLAG), describe an aspect of how they went about ‘set[ting] the scene’ (SLAG 2010, p.23) of their show layout loosely based on Padstow railway station in the springtime landscape of North Cornwall:

‘Researching the North Cornwall area via the internet proved to be a very helpful start, throwing up some gems which are typical of the area. That was supplemented by literal field research [...], landscape information about such things as soil, hedgerows and flora. Up to then we had known nothing of a ‘Cornish hedge’ let alone that this is typically a hedge bank, built of slate and earth with trees and scrub growing on top, but if we were going to set the scene with our modelling we had to understand all of this’ (ibid, p.23).

For Lynch and Law, observation is an ‘array of different perceptual activities: looking for, looking at, peering, spotting, inspecting, perusing, seeing as and seeing-at-a-glance’ (1999, p.339 in Robinson and Mills 2012, p.413). Observation might also be, as Macdonald in the context of birdwatching has shown: ‘[A]n investigating – identifying, recognising, recording: information [...] being sought and being obtained for a purpose, ostensibly the gathering of data’ (2002, p.61 in Robinson and Mills 2012, p.413). Equipped with notepad and camera, a SLAG member took a field trip to study hedging in North Cornwall,

describing salient features supposed vital to hedges there and, therefore, critical features to model if a layout was to produce a feeling of the North Cornwall landscape:

‘Variable height, mixed species, ragged top, slightly windswept, generally short, gappy, lush, verdant and stocky. Few trees, mainly shrubs. Generally, 2-3 meters high and appearing maintained. Often constructed on a low earth bank (sometimes seemingly with stone core, but not usually visible as such), say nominally 1-1.5-meter-high from which the subsequent vegetation has grown unrestrainedly predominately upwards and to some extent outwards’ (SLAG 2010, p.23).

Given SLAG’s proposed layout was to be set in the spring of 1954, members observed how hedges looked at the time via photographs, noticing: ‘[A] lack of management during, and immediately post-war [...], hedges [being] [...] partly overgrown’ (SLAG 2010, p.23). With the photographs, the members made the decision to give their model hedges an unkempt appearance.

With regard to operating the layout, SLAG had to find model ‘stock’ (trains, passenger carriages and wagons) and a pattern of railway operations that would be plausible. This required significant investigation, for instance:

‘[S]tudying the British Railways (Southern Region) Carriage Working Notices revealed that there was a considerable lay-over time for stock arriving at Padstow [the station SLAG were inspired by], presumably for cleaning and servicing. Thus, there would be considerable movement of trains between the platform and the carriage sidings’ (SLAG 2010, p.49).

Robinson and Mills (2012) have shown how observation is not only about observing, but also being observed. Gerry’s statement from earlier that ‘the viewer should be able to gain an idea of the line’s pre-grouping origins and area of country being modelled, [requiring of the modeller] [...] observation of architecture, signalling, stone walling or fencing, cattle or sheep country and so-on’, is a case in point. A modeller with their model at a show may find they will be judged by other modellers on the plausibility of the layout and from there the thoroughness of their investigative work. The possibility of scrutiny will mean modellers might feel compelled ‘go the extra mile’ in their research efforts to ensure the layout is suitable to withstand critique. Andrew looks back fondly of a show encounter when he was a teenager:

‘My Castle Class 5071 ‘Spitfire’ became the subject of scrutiny [...]. ‘Spitfire was a Southern loco and would not have been shedded at Newton Abbot [...], also it was to the best of my knowledge never rebuilt, so would not have run without its streamlined casing as you have modelled here’. His parting words were ‘you need to do your research in this hobby young man’ [...]. I restrained from replying and was

consoled by a wry smile from my colleague who simply exclaimed ‘I’ll go and get the brews lad!’ Looking back now, all of his proclamations were actually factually correct, non-more so than the advice concerning research!’ {f}.

Model railway shows can be spaces for a model’s critique on matters of space-time and by association modellers may find themselves a subject of critique. Some modellers may eschew displaying their latest modelling efforts and/or stop building layouts with shows or particular shows in mind because the possibility of scrutiny makes these spaces discomforting. Modellers may prefer instead to keep their layout/s at home/the clubhouse or go to shows anticipated to be ‘friendly’. Michael explains why he is not keen to ‘show’ his model railway layout:

‘I have been to a few [model railway shows] and they often differ in the quality of the layouts. I have seen some [layouts] and thought mine is way better than that! When it comes to it though I think [to exhibit] you have to be confident about yourself and your work. This is the most important thing [...]. I just don’t think anything I do is *really* good so this lacking in confidence really stops me from saying, ‘right let’s put this out there’ [at a model railway show]. Also, I think exhibiting at a model railway show is not my kind of thing because from what I gather [...] you’re [...] operating the [layout] ‘on edge’ all the time, nervous about if anything goes wrong [...] or nervous about what [attendees] will say’ (emphasis original).

Whilst some modellers may shy away from exhibiting because of a lack of confidence and/or fear over how they and their layout may be critiqued, for others the critique possible with model railway shows can be welcome and affording. For Elliot: ‘Scrutiny, yes certainly. But I would be very disappointed if it were not so. [...], I like the attention the models get and [I] am happy to talk to visitors about them’ {f}. For Matt: ‘I’ve found exhibiting hard work, but I enjoy it tremendously and love having a discussion with anybody about any merits or problems with my work’ {f}.

Some modellers at exhibitions will display near to the layout the research materials they have sourced and usually alongside a written account of the layout, detailing what the layout represents. For Darren: ‘I’ve had modelling standards criticised and the authenticity of models and operating procedures questioned, usually politely, sometimes not so [...]. I always carry a folder of photos for the awkward squad [...] [who say that a] loco/working/timetable/building/feature is fake’ {f}. Darren brings together, in a folder, photographs important in his research. This folder and its photographs enable Darren to quickly prove, to the best of his knowledge, his model’s ‘authenticity’.

4.7: Material affordance, material agency and mimesis

Recently, geographers have started to engage explicitly with ‘making’ (Carr and Gibson 2015; Price et al 2014), or more specifically ‘creative making’ with creative making involving the working up of crafted material objects, from stone quoins (Paton 2013), ‘yarn bombing’ (Price 2014) to dry stone walls (Patterson 2014). Model railways can be seen as a creative engagement with issues of challenge, play and experiment with objects and materials. In this latter regard, railway modelling can be practiced as a ‘craft hobby’ (Yarwood and Shaw 2010) alongside such practices as quilting (Stalp and Conti 2006, 2011), woodwork (Turney 2004) and DIY (Watson and Shove 2008). Modellers may find producing their model worlds enjoyable, a joy. They may spend months, even years working on a layout and then soon after completion start making another one, or the making of just one is always in a state of continual coming-into-being, always to be ‘improved’. Other modellers have less interest in making, seeing it as a necessary means to an end; to have and play trains with a model.

Modellers who enjoy the craft side of the hobby will buy model kits (buildings, railway carriages, platform benches) and ready-made or ready-appropriated models (the former, but also walls, grasses, hedges and trees), but may transform these in some way, whether through weathering, painting and manipulating. Modellers may also appropriate and transform materials in a practice of mimesis, working with materials to create models of cliff faces and rocky outcrops, vegetation, rivers, trees, fences and buildings among other things and often practicing an ‘inadvertent environmentalism’ (Collins 2014; Hitchings et al 2015). Indeed, as railway modeller Marriot writes: ‘[R]ailway modellers have always been adept at spotting items that can be put to uses far removed from what they were originally intended for. This could be using a product intended for one scale in another or, as Allan Downes does, recycling unwanted everyday products’ (2010, p.50). Modellers will make something rather than buy a commercial product for a number of possible reasons; they gain enjoyment and pride in a self-made object, have a dislike of a commercial product, a commercial product might not be suitable or available and/or budgeting can be a factor (see Freezer 1987).

This section is interested in tracing relations between modeller and material in the making of models at the modeller’s worktop. This is a very important aspect of modelling

for many railway modellers and this section draws conceptual inspiration from several strands of thought on non-human things. Firstly, this section is interested in the archaeologist Knappett's (2004) writing on 'affordances' of materials. Knappett is interested in the uptake of materials, what a material lends itself to doing, where 'the properties of materials may be understood in terms of their performance, their relation to other materials and their context of production and use' (Were 2013, p.584).¹³ Secondly, but just as important to this section as Knappett's writing, is Bennett's (2004, 2010) work on 'things'. Bennett's project, which has been the subject of considerable interest to geographers (see Tolia-Kelly 2013), has been to usher in a consideration for the 'vitality' of non-human 'things', essentially looking at non-human agency. In Bennett's words: '[By] vitality [...] I mean the capacity of things – edibles, commodities, storms, metals – not only to impede or block the will and designs of humans, but also to act as quasi-agents or forces with trajectories, propensities, or tendencies of their own' (2010, p.viii). Bennett's work can be seen as a levelling of human power over the non-human, for Roberts it 'reinstates the importance of the object not as a prosthetic tool for human agency, but as a 'thing' capable of acting on its own terms' (2012, p.2516). This section follows in the wake of the geographer Patchett's (2010) work on taxidermy practice in its mobilising of materials in craft and craftwork, hitherto 'theorised' for Patchett 'as processes conducted by active human agents upon inert and passive materials' (2015, p.73) (see Crawford 2009; Frayling 2011; Gane and Back 2012; Sennett 2008). In mobilising the agencies of materials in modelling practice, we can think about the place of negotiation within mimesis.

The back cover blurb to Hill's (2010) book *'Creating realistic landscapes for model railways'* pronounces: 'With chapters on modelling trees, grass, water, fences, rock, walls and hedges, this book will tell you everything you need to know to design and create a unique and special setting in which to operate your model railway' (Hill 2010, np). Like many books on model railway landscaping as well as weathering and structure modelling, Hill's book is produced with a view to impart knowledge and technique on achieving mimetic effects with materials via image and text (see figure 25, overleaf). Knowledge and technique becomes for Hill through years of embodied engagement: 'I have been modelling railways for over thirty years' (2010, p.2), or for Booth: 'I bring to the project many years of experience and the myriad skills acquired by any modeller with time and practice' (1994, p.1). Online forums, blog posts and YouTube content have recently

¹³ Knappett's work on affordances moves beyond Gibson's (1979) 'theory of affordances' by arguing affordances are more than directly perceived.

Figure 25 redacted over copyright

emerged as online spaces presenting attempts at mimesis judged successful. This idea of ‘showing making’ (Lehmann 2012) is to disseminate usually for self-interest (status within hobby) and/or philanthropic reasons (developing the hobby). For instance, for Barlow on the purpose of his magazine article on ‘*Tree developments*’: ‘Some experts have had a real good crack at solving the problem, but there is still no such thing as the perfect model tree. I would not for a minute claim my efforts have changed that, but they might represent an approach worth developing. I share them for what they are worth’ (2001, p.107).

‘Model-making’ can be considered an ‘activity [involving] creating small worlds expressed in another medium’ for the economist Morgan (2012, p.30). It is working in ‘another medium’ such as copper wire, sanding sawdust and paint for making a hedge, teddy bear fur and paint for grass, paint, glue and resin for water, brick card and paint for walls, that can be so effective in maintaining enthusiasm for the hobby. For instance, for Brian talking about his ‘scenic modelling’:

‘My scenic modelling skills are always evolving [Brian shows me some old photographs of his previous layouts] can you see? [...]. I am never really satisfied with what I have done, I am alright for a while, but that satisfaction wears off. It can be annoying because other people say, well that looks good, but that’s the way it goes, it’s just me [...]. I have this drive to challenge myself [...], to try different ways of doing things with different materials and different landscapes [...], seeing if I can do better’.

It is engagement with materials within a challenge of mimesis that keeps Brian interested in the hobby and where materials have an agency Brian has to negotiate. Whilst negotiating with material agency might be thought of as annoyingly disruptive to the will of the human, it is the negotiating with material agency for Brian that is part of the enthusiasm for the hobby. This is an important point because many railway modellers do not so much model in spite of modelling, but rather because of modelling. Relatedly, certain atmospheres, landscapes, objects and places might become positively affecting in so much as the challenge they present to express. For instance, for David:

‘When I saw the Leighton Buzzard Quarry I knew I had to model it, with the whole of the washing plant in its entirety [as a diorama] [...] because that rusty metal drew me like a magnet. Derelict ironmongery fascinates me [...]. When the rust is starting to peel the paint off of the undercoat, the primer, back down to the dusty bare rusty metal, something clicks in my brain and says ah! I must model that!’ (Model Railways with Bob Symes 1988, np)

Modellers might regard their material engagements as play. The anthropologist Miller has argued how, in the context of craft, ‘we can hone a skill to take pride in making

things and revel in work that has no clear boundaries from the world of play' (2012, p.3). Miller goes on to note how many of the objects at the Victoria and Albert Museum's (V&A) '*Power of Making*' exhibition (2012) 'show how skill can be used to have fun through mimicry' (ibid). For Stuart:

[Making], its hands on, you are using your hands [...] no one its telling you what to do it is just you and the materials and you are seeing if you can achieve something [...]. Materials don't bite back in the way that people do, but that does not mean to say they don't give you challenges [...]. I think there is a play aspect for me and its wrapped up in finding a better way to model water or trees [...] because here you have a lot of things you could do to get there, you can be spontaneous, you don't know the outcome and you don't get too disheartened when things go wrong or so long as you keep it in perspective'.

The affordance of a material to modelling might be strongly related to its material agency. In making houses and other kinds of structures, Barlow writes about how he has found the agency of several materials important: 'I [...] have a preference for natural materials like card, paper and wood [...] not just because they are relatively easy to work with, but because when they warp or settle they tend to do so in a gentle, downward fashion. When the plastics decide to go they usually furl or bust in a spectacularly unrealistic fashion!' (1990, p.558). In choosing a material for landscape foundations (where a material needs to give shape to the contours of landscape as well as give some support to whatever is placed on it), Lees stays away from expanded polystyrene after finding:

[I]t is extremely difficult to cut and shape because of the tendency to crumble into pieces which in turn separate into tiny beads which are the basis of its structure. These beads have a life of their own for they disperse far and wide and cling to every conceivable surface [...]. I rapidly came to the conclusion that the sensible thing to do was to consign the material to the scrap bin from whence it came' (1990, p.490).¹⁴

Barlow (below) writes about making trees with several kinds of cable, finding the agency of one cable over Bowden cable (to make branches) more desirable because of its propensity not to hurt his body and requiring less bodily effort to manipulate:

'This kind of cable can also be quite vicious. When fully unravelled the smallest strands stab and prick fingertips unmercifully and it is true to

¹⁴ Commercial manufactures make special modelling materials for railway modellers and they sometimes promote material agency in product advertng. For instance, Slater's Plastikard Limited describes its plastikard product as 'a specially balanced composition of a number of ingredients, each one of which is chosen to provide certain properties. The resulting material is tough yet flexible. This amazing sheet plastic is produced to very fine tolerances of thickness, is damp proof and is not affected by normal climatic changes. It bonds almost instantly with a suitable solvent and nothing seems impossible with PLASTIKARD and MEK-PAK, the perfect bonding medium' (Slaters Plastikard Limited 2015, np).

say that every model tree I have ever made has literally cost me blood. This is why I rather admire Barry's pragmatic approach in using softer wire producing an effective result for less swearing. His method will be also somewhat quicker as Bowden cable is quite difficult to manipulate, requiring heavy duty pliers for straightening and strong wrists and fingers for the unravelling process' (2001, p.105).

Placing questions of mimesis into links between affordance and material agency, Harvey writes about how water may be 'represented':

'Some modellers have experimented with real water, Dave Rowe more than most [...]. You just can't scale the splashes and ripples; the surface tension simply doesn't allow it [...]. Another method often advocated by modellers involves the use of transparent casting resin, poured into the moulded bed of the channel to set solid [sometimes]. Many accounts of its use have been tales of disaster with leakage, failure to set and other difficulties' (2006, pp.33-35).

Harvey suggests the use of water to represent itself does not work well on a layout because of scale issues. Water's agency, in particular its surface tension and the affects from stone and rock on water among other materials, cannot look exactly the same when smaller. This leads on to a point about material agency, affordance and scale. Materials will be adopted for use in relation to how they perform (and sometimes with other materials) for a model railway scale. For Neil: 'I am very happy with plastic [for making buildings] and I will use metal if it has to be because it's something delicate [...], wood I don't like [for delicate things] because [...] physically you can't get wood small enough'. Scale is mobilised and practiced here as ratio: '[A] proportional relationship between things' (Oxford English Dictionary (OED) 2015a, np) as opposed to level, which geographers focus on (see Marston et al 2005). Scale here affects the uptake of materials and practice with them in modelling. Although there are differences between the kind of scale railway modelling practice is shaped by and scale as level, Simons et al's (2014) reading of scale as 'making'/'unmaking' 'relations' between 'human and nonhuman' actors offers ground for similarity.

To refer back to modelling water, for Paul his problem with the use of real water is 'electricity and the addition of extra damp around the layout, damp is one of the biggest enemies of model railways, trust me' {f}. In the place of water, Harvey (2006) considers casting resin, a popular approach. This is because of a three-dimensional appearance and casting resin is not necessarily reactive to paints; the use of paints can help give a murky effect. Modelling experiences with the material as Harvey noted earlier are not always positive: '[T]ales of disaster with leakage, failure to set and other difficulties' (2006, pp.33-

35). ‘Other difficulties’ may be related to practice. For instance, on the same subject of water, Topping warns readers about how the making of a mimetic effect of ripples in resin (resin as the body of water) has to be tied with what the resin is doing at a point in time, therefore requiring a great deal of vigilance to achieve ripples:

‘The top resin layer was left until it had reached a smooth sticky-toffee state and with a toothpick the surface was plucked with a slight curving movement into small eruptions [...]. Timing is vital, if too early the eruption would subside and if too late it would not be formed properly, this is a job for considerable patience and an uninterrupted free time of several hours’ (1978, p.170).

The making of a model railway in working with materials might generate feelings of satisfaction and joy, but also frustration, sadness and bodily and emotional pain. For Alistair:

I had a hell of a time working on making those cliffs [on the layout] [...]. You get frustrated and some heartache when things don’t work out the way you thought they might or hope or you are struggling with something [...]. [Modelling] can put you in a bad feeling, but you have to control it and kind of keep it to my dedicated modelling time [...]. In fact, I would say getting frustrated and all the rest of it keeps me motivated to do things [in the hobby]’ (emphasis original).

Waterman writes about the emotional and painful affects he and his team of modellers experienced in a practice of mimesis, trying to get teddy bear fur looking like grass:

‘It was with great trepidation that we approached the problem of grass because there were three big banks on the layout [...] and we knew they would be a challenge [...]. We must have spent over seven to eight months trying desperately to make the grass look the way we wanted it to look and although we thought it was ‘OK’ we knew we could do better because Mike Taylor, our Team Leader, wasn’t really jumping up and down with satisfaction at the results we’d achieved so far! We’d all got huge blisters on our hands from where we’d cut the [teddy bear] fur down and we’d even ruined a pair of gentleman’s shears. Then, one Sunday morning, out of pure frustration, Big Steve Naylor [...] happened to have a blow lamp in the boot of his car and decided as a last resort to set fire to the teddy bear fur! [...]. I don’t think even he expected such a spectacular result but, *et voilà*, it worked! Because the teddy bear fur is fire retardant, it did not go up in flames, but it did shrink and shrivel and with the added realism of lying in the direction that the wind had blown’ (2009, p.71).

In Waterman’s narrative, his team’s uptake of the teddy bear fur involved questions of similarity and difference with a piece of grass and an area of grass, similarity and difference being affordances of the teddy bear fur for Waterman and his team (similarity in so much as the teddy bear fur was composed of massed, flexible, vertical fibres each mostly alike

and difference in the sense that the teddy bear fur had a different cellular biology, composition and size). The teddy bear fur via tools and techniques was altered to give it a more mimetic appearance, something Waterman and his team found frustrating and painful to achieve since they had no previous experience in getting the effect with the material. Arguably, the material became almost hated. The fur's mimetic potential lay in the balance until, out of frustration, a blow lamp was actioned into service. How the blow lamp was used and its effect on the fur was positive because how the material was affected meant it looked more like grass. Through frustration and damaged tools came new mimetic knowledge which facilitated more easily the rest of the layout's grass making. Here, following geographers Carr and Gibson, we might take a more 'productive view of the concepts of failure, error and adjustment' with materials, 'vital to the process of making rather than obstacles to be overcome' (2015, p.7).

Choosing or not choosing materials may involve an understanding of them through previous experience (Were 2014) and, as in Waterman's case, this experience might be a frustrating one because of the difficulties encountered or time and effort spent on a failure and the effects of efforts are more often than not uncertain. This is where the hobby books, articles and online media on landscape and structure modelling can become important. These are written with a view of helping and/or offering people inspiration, bypassing experiment, frustration, disappointment and significant time. However, many modellers are often keen to develop their own techniques since ultimately one modeller's 'good' tree might be another's 'bad' tree.

Before this section closes, it is worth noting that whilst a layout may become an object of 'love' as noted in 4.4 through what the layout and possibly play with it presents, a layout, but also something made for it, may also become an object of love through the embodied effort ('blood, sweat and tears') placed in its making. It might also become through sentimentality and memory across space and time for the craft placed in it. For Harry:

'These layouts I have kept [Harry has 'cannibalised' or discarded the constituents of his others], this one was one of my layouts I made at the time our first son was born so I vividly remember doing bits on that so I have kept that one, its rather precious [...]. This [other] one [...] is important [to me] because of all the work that went into this [...] and I think I really developed some [modelling] techniques on this one so I am attached to this one as well for that reason'.

Relating to Harry's testimony, Gauntlett's (2011) 'making is connecting' thesis, a particularly significant work with potential to help geographers think through the

geographies of making (Price 2015), argues that making connects or brings people together. This is, of course, true, but Gauntlett misses one strand of ‘connection’ by eliding the emotional connections with the made object through the process of making and which Harry’s testimony evidences.

4.8. Affective atmosphere

Affective atmosphere has been of interest to geographers in recent years, research attending to how atmospheres ‘constitute a crucial aspect of human and social life’ (Sørensen 2014, p.1) and particularly focused on the ‘engineering’ or production of atmosphere (see Bille 2014; Bissell 2010; Edensor 2014; Lin 2015; Watts 2008). Engagement by geographers with atmosphere has centred on atmosphere as understood by Böhme whereby atmospheres ‘imbue everything [...], bathe everything in a certain light, unify a diversity of impressions’ (2008, p.2 in Edensor 2013, p.1). McCormack assesses atmosphere as ‘something distributed yet palpable, a quality of environmental immersion that registers in and through sensing bodies whilst also remaining diffuse, in the air ethereal’ (2008, p.413). Atmosphere can be thought of as co-produced by subject and object and of having an aerial spatiality. The use of the term ‘atmosphere’ is extensive on model railway internet forums and as will have been noticed so far, in books and magazines on layouts and also mobilised by a number of interview participants. This section is interested in how atmosphere is involved in model railways, including the making of a layout.

Atmosphere can motivate people to model and, therefore, delimit the layout’s spatiality. Atmosphere can be affecting, much like when Böhme argues that atmosphere may be ‘something which can come over us, [taking] possession of us like an alien power’ (2008, p.3). For instance, Chris had become enchanted by the atmosphere of a particular train scrapyards:

‘One of my first layouts I ever made was actually to do with atmosphere because when I was a young [amateur railway] photographer I remember going to look around this one locomotive scrapyards. I knew it would be a particularly atmospheric place because of course I loved trains and these places are like places of death, mortuaries if you wish. When I went there, there was something of a really gut wrenching atmosphere [...]. There was an overcast grey sky, it looked like it was about to rain, early morning. There was a perfectly good engine being shunted into the scrapyards. By the side of the yard there were parts [of

already broken engines]. I can still remember it now, but that feeling about the place got me interested in railway modelling actually because I thought I have got to see if I can try and convey that heart-breaking atmosphere’.

As Thibaud suggests, atmosphere ‘gives rhythms to our movements and modulates the matter in which we move’ (2011, p.209 in Edensor 2014, p.2). As part of atmosphere’s possessive capture, atmosphere may also inspire and impel action in the world such as modelling. Chris was moved emotionally to model the atmosphere which for him pervaded the scrapyards. This can lead us to the issue of ‘modelling’ an atmosphere and the enthusiasms behind that, but more can be said for the moment about other atmospheres with modellers. The atmosphere encountered by Chris was a specific atmosphere. However, atmospheres can be quasi-imaginary. For instance, particular places as Edensor suggests are well known to be particularly ‘thick’ with atmosphere: ‘[T]he ancient gothic cathedral [...], a forest full of birdsong, or a windswept mountain’ (2014, p.2). A case in point in UK railway modelling and implicated with the ‘rural idyll’ (Bunce 1994) is the idea of the country railway station, particularly of the Great Western Railway and in the inter-war (1918-39) period. For Derek: ‘That’s pretty well been overdone now. You get a lot of people who go after that bucolic [...] atmosphere [...]. The ingredients [are] small station, countryside, a little bit of [train] activity and nostalgia does the rest’.

Whilst atmospheres ‘may hinge on their material grounding’ (Sørensen 2014, p.2), movement and rhythm are important given ‘change is an inherent aspect of places’ (ibid, p.3) and Derek’s mention of train ‘activity’ refers to railway rhythms (timetabled) and movement of trains. Movement and rhythm might be important for railway modellers to atmosphere since both can be an important aspect of place and landscape (on rhythm see Edensor 2010). For Pendon Museum (2014, np), the country branch line railway has an ‘unhurried atmosphere’ and one modellers may seek to produce through the charge of trains and the kind of timetable the model is run to. Although Jason (below) does not mention atmosphere, his testimony underscores the importance of rhythm and movement and to which modellers might find important to atmosphere:

‘For me, apart from the obvious enjoyment factor, I think movement can play its own part in ‘telling the story’. After all, ‘operation’ is what the real railway was/is all about. So how the timetable ebbs and flows throughout the day/week/seasons, what shunt moves were undertaken and [...] how they were undertaken, the relationship between the signals and where trains moved to/from, the relative speed of trains, etc. are all things that movement can add to the depiction of a scene. A layout where the operation is accurately portrayed is not only absorbing to

watch, but can also contribute to creating a convincing time capsule’
{f}.

Modelling enables people to produce and be with particular atmospheres they are enchanted by and may love and cherish, making these atmospheres present within the personal space of the home or at a model railway show. For Smith: ‘[S]truck by the tremendous atmosphere [...] I found myself wondering how much of that scene I could reproduce on my model railway’ (2013, p.1). The atmospheres modelled may be comforting, enchanting, but they might also be thought-provoking, enjoyable and challenging to make. Modelling enables atmosphere to be a creative engagement and vice versa. For instance, for John: ‘I wanted to try and capture some of that emotion, some of that feeling, an essence [...], it’s so difficult to put an atmosphere back into a model. Some people do manage it and they manage it through sound, lighting, back scene, various textures, colours and that’s where my aspirations are’. Equally for Mark: ‘How do you do that, how do you do this, how can I get that atmosphere, these are really quite exciting searching questions and this is [...] what modelling is about for me’. Meanwhile for Tim, his hobby is ‘all about the challenge of creating an atmosphere and feel of a scene’ {f}. Similarly, Peter suggests: ‘I would say my aim is not to continually improve but to continually ‘innovate’ my approach to achieving atmosphere and to gain a satisfaction of my creativity’ {f}.

Some modellers might be keen on producing an atmosphere because of thought about its potentiality to take hold of others. Here, models have affective power (which should have already been evident particularly in 4.4 and 4.5). For Neil, who gets joy from seeing people affected in particular ways by his layout at a model railway show: ‘I want them to be really taken up with the atmosphere I think I have been successful at conveying [...], it’s great when people are feeling the atmosphere I wanted to evoke [...]. That’s a sign I have succeeded in my modelling work’. Whether at a model railway show, on YouTube or via pictures in a magazine or on the internet, a layout and its atmosphere may ‘pull’ someone back again and again to experience it.¹⁵ That said, at model railway shows, but also through the hobby magazines and online forums, a layout may repulse, or rather more mildly, annoy a viewer. This can rest on senses of incorrectness or inauthenticity; that the layout does not capture its ‘place atmosphere’, for instance, what the Lake District

¹⁵ On viewing there is also an issue that in encountering layouts and atmospheres modellers and spectators are, I tentatively suggest, not so much a body in the midst of the haze of atmosphere as bodies out of atmosphere. This particular thread to studying affective atmosphere was unfortunately not considered until the writing up of this chapter.

landscape or a sojourn on the ‘Somerset and Dorset Joint Railway’ feels like for the viewer. Senses of incorrectness or inauthenticity will likely at once both dispel and produce an atmosphere, perhaps an unlikeable atmosphere infused with disappointment. The arising of such a kind of atmosphere is blamed on the modeller and affective atmosphere is part of a mimetic politics of model, modelling and modeller.

The atmospheres model railways co-produce with human bodies are arguably atmospheres reliant on the imagination to ‘fill in the gaps’ left in abstraction’s wake. Model railway atmospheres might always be quasi-imaginary. This idea is tentative and was unfortunately not discussed with modellers in interviews or on online forums. However, much that may make an atmosphere cannot be produced on a model railway, particularly certain sounds, smells and movements, lighting effects and even certain atmospheres. Patrick (below) resigns himself to a view that modelling atmosphere is a disappointing project because those atmospheres he wants to produce are illusive to creating on a layout:

‘I would love to say that I have captured the atmosphere of the railroad moments I think are remarkable, but no matter what devices I employ I think it is impossible. How do you capture the feeling of stepping off a freight train at a meeting point just to walk around a little bit? Your meet happens to be at the exact moment a rain shower stops in the early evening and the heat of the day causes the grass to smell that certain way. The grass smell combines with locomotive exhaust, creosote and hot steel [...]. No matter what I do I will be disappointed because the results will come up short’ {f}.

As Lin notes: ‘[A]ffective eruptions’ [of atmosphere] may, in fact, bear the imprints of actions preceding their situational coalescences’ (2015, p.289). Recent work on atmosphere has attended to its production, whether this might be through atmospheres at a football stadium (Edensor 2014) to the making of ‘cosy’ atmospheres at home through lighting effects (Bille 2014). The remainder of this section examines in detail the production of atmosphere on a model railway layout and which raises an important case of how embodied practice may inform modelling as a mimetic practice and be important to models as representations. From the perspective of geography work on atmosphere, this section furthers work on atmosphere by considering the ‘representation of the atmospheric’ (Kazig et al 2014), looking at the ‘ability’ and practice of ‘(re)present[ing] atmospheres and ambiances’ (ibid, np); the production of atmosphere in a different medium from that which the atmosphere exists or is supposed to exist.

As emphasised in 2.5.3, abstraction has recently been the subject of a reassessment by McCormack (2012) who posits that geographers ought to think about how practices of abstraction may be ‘provisional and prospective, intended to open up potential space-times

rather than close them down' (p.724), where abstraction may provide a way of 'drawing out elements of the world in ways that make them thinkable and sense-able' (p.727). Abstraction 'is experiential, not artefact' for Gerlach (2015, p.280) and the remainder of this section is interested in how such perspectives from McCormack and Gerlach on abstraction are involved in how railway modellers think through and produce affective atmospheres.

In thinking about abstraction and affective atmosphere, attention centres around questions of 'detail', an intensity of mimesis, but space for a layout is also relevant. As Rice suggests 'space is, of course, the most usual and most restricting of the elements within which the layout must be designed, although it can sometimes be circumvented by a bit of lateral thinking' (1990, p.10). The other 'restricting' elements Rice identifies are 'money', 'time' and 'satisfaction', but these can influence how much of available space is used. Along similar lines to Rice, Smith (2011, np) suggests:

'Modelling the real railway scene can add an extra dimension to our hobby, but if we try to model everything exactly to scale, we are often constrained by space, time, finance and capacity. This means a compromise has to be reached to complete a model railway that has the feel of the real thing [...] atmosphere'.

As model railway writer Andress states: 'In the creation of realism in railway modelling we require an artist's representation rather than a precise scaled down reproduction. We are aiming to give the impression and atmosphere of the subject, to reproduce the features which give it appeal and character' (1988, p.5). Working with spatial constraint can be a pleasurable and/or annoying experience for modellers because of challenge with an existent location in trying to garner its atmosphere. Buildings, features and places, landscapes and spaces will often be valued as to their importance in constituting atmosphere. Some of these things might be left out in a model, regarded as less important to atmosphere or alternatively might be adapted someway, very often through compression and abstraction. For Anthony:

'I have to think if it is possible [to model the location] first with the space that I have I mind otherwise it becomes very difficult if not impossible. I might say then 'well I could just decide to model a part of it as a diorama' if I really wanted to, but if I can think of a way what I do is think about what is the spirit of the place [...]. What impresses on me most, what are the most important [constituents] to the atmosphere for me? [...] So I compose a list [...] and then put them in priority, the first things kind of jump out [at you and] the latter ones are details really which can be left out. I might [then] want to do a mock-up where I can arrange things and alter distances and things and see how they feel [...]. I get a great sense of satisfaction when you start to get the vibes about

the place [from the model] and especially when you have done a lot of foreshortening and left things out’.

A context of a valuing of material features and a kind of spatial planning with them in relation to space constraints is not the only connection between atmosphere and abstraction on a model railway. Carter expounds a sensibility that:

‘Correctness of scale and completeness of detail are not everything, for it is just as important to know what to leave out as what to put in. Too much detail will mar a model as surely as will lack of it; and every detail is neither possible nor desirable in the smaller scales nor is it effective in producing atmosphere [...]. The question of finish is a very important one that rarely receives the attention it deserves [...]. Take, for example, a brick wall as often seen in model form and compare it with a real wall. The model will often appear hard, unreal and glaring with bright red bricks spaced at mechanically perfect intervals. This is the very effect it is least desired to produce. When an artist paints a tree or a field, he does not paint every blade of grass or leaf, but by a suitable use of masses of colour in light and shade he conveys to the observer the idea of a tree or a field of grass. Similarly, a wall, a roof or a paved platform can be indicated without the inclusion of minute detail. The reader cannot do better than to study real station buildings, embankments and cuttings, bridges and tunnel-mouths looking for ‘general effect’ as well as for their structural details’ (1940, pp.59-60).

Carter is suggesting modeller’s practice what Callum (below) considers an ‘impressionistic’ approach to railway modelling:

‘The most evocative [layout] landscapes tend to be those [that] convey the impression of the scene rather than those where everything is portrayed in miniature detail. [...] [M]aybe it’s like comparing a formal great master where everything is painted to the finest detail to the impressionists like Sisley or Monet, where they captured feeling and atmosphere rather than detail? Colouring and composition are the most important things. The odd millimetre here and there is unimportant to me. I don’t look at the real world like that’ {f}.

Carter and Callum draw attention to an ‘impressionistic’ sensibility to model railway design and value. This ‘impressionistic’ sensibility is referred to by some modellers as ‘artistic’ or for Ryan ‘mood inducing’ {f} in philosophy and frequently contrasted, as evidenced by Carter’s and Callum’s words, with concern for a significant intensity of detail. James asserts: ‘Are we not in much the same position as an artist in the course of painting a picture? Are we not, perhaps, trying to capture something of the magic of the railway, as it appears to each of us? A clinical approach is not necessary’ {f}.

A ‘clinical’ approach to modelling (and with the term ‘clinical’ suggesting a lacking in a particular feeling), for David, inhibits the emergence of ‘atmosphere’: ‘What gives a

layout atmosphere for me it is about the overall picture painted, how it's presented and how it all fits together. Some layouts at the finescale end of the spectrum while technically perfect can appear too clinical and consequently lack atmosphere' {f}. Atmosphere may be produced within this impressionistic sensibility by giving an affective tone to space overriding any concern for as high an intensity of detail as possible, particularly structural details in relation to colour. Peter suggests: 'Yes atmosphere impression rather than detail. I mean if you look at some of my stuff in detail you think what on earth has he done that for, but if you look at the whole it feels to me and that's what I want'.

Chris imparts how he has tried to create a certain tone of feeling to his scrapyards layout:

'I have sought to tie the entire scene together not only through complimentary detail, but through a dark grey palate tone [...]. This [the dark grey palate tone] is an attempt at trying to help conjure up, or perhaps emphasise is a better word, a mood of sadness [given that locomotives are being scrapped here]. [...] [T]ying everything to a dark tone is also [...] influenced by the time of day and weather [conditions] I have set it in [the layout backscene is a very dark grey overcast winter sky] [...]. It's near the end of the day, a storm seems to be approaching, looks like it is going to rain [...]. This emphasises the miserableness of the place and perhaps a metaphor [...] for the impending doom that is going to happen to those engines waiting their turn'.

On Chris's layout, detail (for instance to the structure of the scrapyards itself in terms of colour and texture, different shades and colours of rust, or different shades and colours of brick) is compromised to generate a tone of feeling which is further emphasised through using just several tones of colour across the whole layout. Whilst some modellers will paint each individual brick separately and working with several shades per brick, Chris 'washes' his with just one colour although of several tones. Chris is trying to generate an ambience through 'a matter of linking the various components to one another, making them work together and integrating them by giving the same tonality to all that appears' (Thibaud 2014, p.6).

Earlier, both James and David regarded models and a practice of modelling with a high intensity of detail as being somewhat 'other'. Andrew asks:

'Are you saying that obsessive observance of accuracy can lead to sterile models and sterility effectively means a lack of life so without life you can't really have atmosphere, consequently such layouts don't cut it? For me though it's the observation of the real life mundane and special deftness of touch in modelling that breathes life, realism and thus atmosphere into a layout. Such a touch is possible with the impossibly highly detailed or the broad brush impressionist approach, but in the case of the former it's a difficult touch to achieve. I know of models and

layouts that have been built to the finest of detail that have atmosphere. I refuse to believe that rivet counting is a negative term when used as a reference to the quest for excellence' {f}.

For Millhauser, the miniature 'implies a relation, a discrepancy', it 'charms' and where 'the eye [...] will quickly tire if it does not perceive thoroughness of execution, richness of detail' (1983, p.129). Millhauser evokes that 'the miniature seizes the attention by the fact of discrepancy and holds it by the quality of precision. The miniature strives toward the ideal of total imitation' (ibid, p.132). The 'impressionist' sensibility and technique to model railway layout design queries this narrative of Millhauser's miniature. However, a high intensity of detail with an object and/or the layout may be shied away from for reasons other than producing atmosphere. It might be because of a lack of enthusiasm, for instance for Ian: 'I just want to convey a sense of a real railroad not recreate it in miniature' {f}. Another reason might be materials and skills. It will be very difficult to make certain details, for instance exquisitely made flower heads. Furthermore, the embodied effort a high intensity will require might be rendered formidable as Stuart suggests: 'I would like to see you sitting there for hours on end with your arm aching [from holding a paintbrush]'. Another reason is the perspective from which the object and/or layout will be encountered from as Jim relates:

'It is about convincing the eye. I myself have made models professionally with individual bricks and painted them separately to the customers' requirement and then it is sited on the layout at the rear and viewed from a few feet away, you can't tell any different [from washing the building in one colour' {f}.

In Jim's case, if details cannot be seen there is an argument for negating the embodied effort of putting them there.

4.9: Playing trains

The purpose of a railway is to move things: '[P]eople, parcels and products from place to place' (Freezer 1993, p.13). For Martin (1960, p.4):

'There is romance in the ordinary operations of a railway. Romance brought up the nine-fifteen. The arranging and planning of trains, the running to timetable, the signalling and shunting, the working of points; all these operations and many others are endlessly interesting. No one

enjoys them more than the owner of a model railway. He controls the whole system, like an enormous giant, he has a complete world literally at his fingertips. Whatever he chooses to do, nobody will write to the newspapers complaining that a train is always late or overcrowded?.

Martin here emphasises how model railways afford the possibility of engaging with ‘the railway’ in ways impossible beyond a model. The model railway enables a kind of total control and power with the railway system.

Model railways might be considered as inviting possession to a railway world ‘that is elusive; we do not possess’ (Millhauser 1983, p.130). The elusiveness of a ‘real’ railway might be the impossibility of being able to have the railway within total control for matters of play. Whilst temporality can be an issue here (i.e. the past is not able to be returned to), this is not necessary for the past (of a kind) might be reconstructed, like with heritage railways (see Halsall 2001; Rhoden et al 2009; Wallace 2006). For Lévi-Strauss (1962), the miniature is not defined only by a reduction in size, but as a product of this scaling down; abstraction - the loss of certain features and the making of the feigned. On features, this might be as Varutti highlights, ‘volume, smell, colour’ (2011, p.2), but we can also think about the absence of humans and forms of social and political power and control. On the feigned, mimesis has its part to play through *plastic* cows, passengers and trees and so on. A model railway layout, despite having some semblance with ‘reality’ (our idea of it), is radically different and it is the difference just as much as semblance which can be alluring for modellers. Power is eluded and spatial volume depressed, enabling the potential for relaxed and comfortable play with the railway as a system. For Binstead: ‘The owner of a model railway, has, in effect, his own country where he is absolute monarch and where he can go and spend a happy holiday as often as the mood takes him’ (1943, p.4). The *Modern boy’s book of hobbies*’ (1937, p.88) pointed out that: ‘You can speed up the express, reverse the slow goods into a siding out of the way, pull off the signals, run the whole line in fact without moving from your seat’.

The abstraction that is the model railway enables play with its referent; the model becomes a performative site for the enactment of desires and fantasies in relation to playful engagement with the railway as a system and without ‘dread’ to refer to Millhauser (1983) and in the comfort of the home. For Walter: ‘I’d also keep my 7mm scale model [railway layout since] operating the real thing would be too much like work and I would want to retreat to a world where I was the despotic ruler!’ {f}. For Walter, his model railway enables him to engage with trains in an easy and comforting way and where forms of human related power and control do not exist beyond that emanating from the self. Relatedly, for Sam,

his model railway enables potential for spontaneous and creative play with the railway system:

‘It’s one thing seeing or perhaps reading or imagining about a railway, but it’s quite another to be able to have something that is real and [...] well it’s to do with potential, having the potential to do things with what you are fascinated by [...] when you want and what you want. I might just feel like ‘oh I want to run that train with those carriages and look at that for a bit’ or I might want to compose and run a goods train and do some marshalling of wagons [...]. I might just feel an urge to just do something [with the railway] sometimes after work or on the sofa and I can just do it [...], it’s therapeutic because you have all these things (trains) and the railway there and you can do what you like’.

Spontaneity and creativity though finds itself stymied to a degree in efforts of many modellers to ‘run (a model railway) like a real railway’ (Foster and Hodson 2010, p.52). This might be through firstly adopting a company railway rule book which governs elements of railway practice so as ‘to ensure that transportation happened safely and as efficiently as possible’ for Graham {f}. Secondly, adopting a timetable, and thirdly, attempts to mimic operational practice, for instance ‘steam shed operations’ (a ‘steam shed’ is a place where steam trains were stored and maintained). For the benefit of other modellers, Forster and Hodson (2010) press home the ‘steps’ involved in ‘how a real steam shed worked’. Steam sheds, Foster and Hodson go on to assert, were ‘structured places rather than seemingly random collection of locomotives moving around aimlessly’ (p.52).

Woodyer notes of critics of commercialised toys who argue that ‘the creative accident of play is foreshortened as play scenarios become increasingly pre-scripted by media’ (2010, p.195) (see Thrift 2003, p.401). This is ‘thought to prompt a loss of the ability to fantasise and be creative and spontaneous, features which are commonly regarded as fundamental components of ‘authentic’ play’ (Woodyer 2010, p.195) and where for Kline ‘imaginative play has shifted one degree closer to mere imitation and assimilation’ (1989, p.315 in *ibid*). In the wargaming chapter, this thesis queries the notion that the pre-scripting by media of play leads to a ‘loss of the ability’ to ‘fantasise’ and be ‘creative and spontaneous’ and that ‘imitation and assimilation’ ought to be ‘*mere*’ and against ‘imaginative play’. However, this idea can also be demonstrated in model railways. Mimicry, ‘as-if-ness’, is important to Caillois’s (1961) figuration of play and Shaw and Sharp (2013) in the context of video games point out that rules can generate the ‘productive pleasure of play’ (p.344). For Fraser: ‘Operating a model railway is much like playing a role-play game, for instance, Dungeons and Dragons. You have rules, you take on an imaginary character or characters (train driver, shunter, guard or signaller) and try to be faithful to their roles

within the rules' {f}. Gareth details what he does on his small layout, where he finds interest in wagon shunting:

I form up a freight train in a typical order that would have been seen [in the days of] BR [British Railways] [...]. I then run it into the yard and then try to shunt the wagons with their different loads into their respective sidings using the least possible moves [as] the Guard and Shunters would have done. This can require a lot of concentration to make the moves slowly and steadily in a realistic fashion' {f}.

As Caillois suggests: 'Play can consist not only of deploying actions or submitting to one's fate in an imaginary milieu, but of becoming an illusory character oneself, and of so behaving' (1961, p.11). In Caillois's concept of 'mimetic play' 'the distinction between the self and other becomes porous and flexible. [...], mimesis as mimicry opens up a tactile experience of the world in which the Cartesian categories of subject and object are not firm, but rather malleable' (Puetz 2002, np). Gareth becomes 'other', a Shunter and necessarily becoming one through rules.

For Freezer: 'Of course we are all playing trains, but as in any other activity you play according to the rules' (1993, p.14). Freezer's assertion draws us into a 'politics of play' (Woodyer 2012) and mimesis, and relatedly questions of 'model' and 'modeller'. Freezer goes on to suggest that: '[I]ndeed, if for any reason the model cannot be run in a realistic fashion it can only be regarded as a developed train set, an overgrown toy, since it fails to follow the most significant feature of the prototype, moving people, parcels and products from one place to another' (ibid). 'Free' forms of play like that practiced by Alistair from earlier, or for John practices of "let's see how fast that one will go" or "how many wagons it will pull" might be rendered transgressive or so/not so in certain space-times, a sensibility shot through by moral geographies of appropriate 'conduct' (Matless 1995, 1997, 2005). For Nield:

[W]ithin limits, consenting adults can do what they like with their model railways in the privacy of their own home, but when they put them on display they have a duty, I believe, both to the viewing public and to the image of our hobby in general, to operate them properly' (1988, p.88).

For Derek (below) mimetic play is vaunted within the space-time of the model railway show and constitutive of moral constructions of the model (ideal) modeller:

'Yeah prototypical railway practice at home, but sometimes it's nice to just unwind and relax just messing about [with trains] [...]. At an exhibition I wouldn't do this [...], it's about creating atmosphere [there], it's an element of the time and place I am portraying, isn't this what we should be aspiring for? I mean you just don't have zooming expresses

on a country branch line do you? [...] I wouldn't be doing justice to [the time and place of the layout], the effort I put into the modelling, show organisers, myself and the visitors'.

Arguably we see here an idea of the ideal of having 'discipline', discipline following Pye (1968) the 'unswerving commitment to the application of underlying principles' (Yarrow and Jones 2014, p.266). The principle is mimetic play rather than freer forms of play within the public space of the model railway show.

This section on play closes on questions about 'vertical geographies' (Harris 2014). The miniature affords gigantism for the embodied subject (Millhauser 1983) and, as will be garnered from earlier in this section, is vital for a model railway becoming a site for the enactment of the performance of desires and fantasies in relation to playful engagement with the railway as a system. Indeed, for Carter: 'There is romance in the ordinary operations of a railway. [...] No one enjoys them more than the owner of a model railway. He controls the whole system, like an enormous giant, he has a complete world literally at his fingertips' (1958, p.4). The vertical geographies models can afford imbue power and authority in the production of an all-encompassing visuality, often termed 'birds-eye', 'god-like' or 'helicopter view'. Merriman, in the context of an engagement with a model of the M1 motorway located at M1 construction headquarters, points out how 'authority, expertise and knowledge' can be 'translated and performed' through 'descriptions and animation of the material [...] overviews provided by models' (2005a, p.125).

The all-encompassing visuality model railways can afford, making Derek 'feel[...] like a giant', is something which many modellers when designing and playing with their layouts, and especially taking them to shows, will seek to eschew to varying intensities. For instance, for Denny:

'Where would our [model figure] [trainspotter] be viewing [the trains]? He is able to dodge around in the area quite a bit, but he wouldn't be viewing from a helicopter or the top of a tower-block. Happily, he'd be on a platform, or perhaps on a bridge or the side of a cutting, at most 50-60ft up. So our [layout height] should be not much more than 12in below eye level to get a typical lineside view' (1991, p.113).

4.10: Conclusion

This chapter has examined how model railway layouts afford and are made to produce particular affective engagements with loved, lost and/or enchanting space-times. Furthermore, modelling has been considered an embodied practice, one affected by

and/or producing love, memory, atmosphere, place, landscape, enchantment, possession, matters of mimetic challenge with materials and a mimetic politics to models and modelling.

The chapter has highlighted how love, memory, atmosphere, place, landscape, mimetic challenge with materials, enchantment and questions of possession can be a vital force in relation to what may impel railway modellers to model. Models can be about possession and curiously the presence and absence of possession. As revealed in relation to memories, utopias and atmospheres, it is through the miniature and abstraction that loved things, places, atmospheres, infrastructures and landscapes are recreated of a kind in model railways, affording particular affective engagements with loved and/or lost/enchanting space-times. These space-times might make model railway layouts and engagement with them therapeutic and comforting and deriving importance and meaning from discomfiting elsewhere and whens. Model railways, alongside practice, play and imagination, 'bring' the affective constituents of particular space-times to the home and can be intimately engaged with, including affording mimetic play. Furthermore, via abstraction forms of human and non-human action and power are elided, including (model) time.

Railway modelling is an embodied practice, affected by and generating in spatial ways memory, love, atmosphere, landscape, place, enchantment, possession, matters of mimetic challenge with materials and a politics to model and modelling. The embodied practice of railway modelling for some can be a therapeutic practice and/or a practice of love because of what is being modelled (a loved place etc.). In several sections to this chapter, modellers have described the atmospheres that have enchanted them. Atmospheres, and which may be quasi-imaginary, have been shown in this chapter to inspire action such as modelling, whether for the challenge atmospheres present to express and/or through what they *do*, that is to say how they affect. As evidence of the affective power of models, it has been revealed how atmospheres are the subject of a mimetic politics within the hobby, the idea that a model and modeller ought to produce an 'authentic' or 'correct' atmosphere.

In the context of a mimetic politics, model railway layouts and railway modelling may provoke divisive feelings, practice and emotions. Geography, whether through place, landscape and/or atmosphere, is central to a mimetic politics, generated by and affecting railway modellers and models in spatial ways. As detailed, modellers might feel impelled to undertake careful and/or more research before a model is 'shown' at a model railway show,

whilst for others these places are far too discomfoting to attend because of the possibility of critique. Also, models may be engaged with differently in play at home and at a show. A mimetic politics, including mimetic play, generates and partly rests on a notion of what a 'model' railway is not ('train-set' or a 'toy railway'). This raises questions about the meaning of model, or rather after Woodyer (2010) on toys, the fluidity of meaning.

Railway modelling can be a craft practice and this chapter has been interested in the relations between modeller and material. Railway modelling involves working with another medium in a practice of mimesis and it is this issue that can be so effective in maintaining enthusiasm for the hobby. Many railway modellers do not so much model in spite of modelling, but rather because of modelling. As referred to earlier, there is the challenge of creating atmospheres, but equally landscapes, objects and places and which might become positively affecting in so much as the challenge they present to express. Modellers, with tools and techniques, grapple and experiment with material agency, an agency negotiating the practice of mimesis and intensities of mimesis possible. Negotiating with material agency can be part of the productive pleasure of railway modelling, but it can also make it frustrating, difficult and disappointing and even a viscerally painful experience. Furthermore, a model may become an object of love through the embodied effort ('blood, sweat and tears') placed in its making. It might also become through sentimentality and memory across space and time for the craft placed in it.

Most railway modellers will do some kind of research in making a layout and for engagement with it ('operating' the layout according to prototype practice). The doing of research for model railways might work itself in and/or afford particular embodied relations with landscapes, infrastructures, atmospheres, places, things, people and institutions such as a railway company. This chapter also sought to show how the embodied skill of being 'observant' is demanded by some modellers over the production of an 'authentic' or 'correct' atmosphere in a model. Being observant is regarded by many modellers a particular embodied skill vital in making their models and for some affording it's withstanding of critique from the observations of others. Models and research become contestable objects and practices through each other and over a mimetic politics. Several points made earlier about a mimetic politics can be related here.

Finally, many railway modellers regard affective atmosphere as important to their modelling efforts and this chapter dwelt on a particular modelling sensibility concerning how modellers think about and practice the production of atmosphere on their model railway layout. An 'impressionist' sensibility and technique to railway modelling was

examined and where matters of affective atmosphere and abstraction informed modelling practice, making present 'a palpable, sensuous, connection between the very body of the perceiver and the perceived' (Taussig 1993, p.2) (the modeller to the 'modelled'). This discussion raises a point on how embodied practice may inform modelling as a mimetic practice and be important to models as representations.

5: Hydraulic models

5.1: Introduction

This chapter considers how, at the heart of the impetus and enthusiasm for hydraulic models, are the agencies of water worlds and their uncertainties to humans and inherent changeability. Hydraulic models and modelling practices and knowledges are shown to make present, act on and present environmental futures and are affected by and/or produce possession, threat, uncertainty, confidence, contestation, consternation, material and object agency in the contexts of water worlds, spatial imaginings, decision-making, scale, non-human affect and government-science relations.

This chapter's discussion on hydraulic models is structured by six empirical sections each pivoting around particular concepts and model and modelling engagements. The chapter begins by introducing hydraulic models with some attention given to hydraulic models today, before then moving in 5.3 to assess the affordances of models in the inter-war and immediate post-war period. This is done by looking at how hydraulic models were involved with uncertainty, confidence and diverse agents, including the UK government via the Hydraulic Research Station (HRS). Relations between precaution, non-human affect and experiment are examined in 5.4 where hydraulic models and modelling are considered objects and practices shaping the capacities of water infrastructures/interventions to affect and be unaffected by water worlds in particular ways. Section 5.5 looks at how and why models, modellers and modelling come to be critiqued by diverse agents. The section brings to the fore particular 'presence of the future' feelings and emotions. Modelling practice at the HRS is brought into sharp focus in the remaining sections of the chapter. Section 5.6 traces the research practices and technologies involved in knowing water worlds, looking specifically at relations between water worlds, fieldwork practice, uncertainty, instrumental knowledge and the future. Questions of 'scale effect', a particular phenomenon associated with physical hydraulic models, is the subject of 5.7 and where it is shown how scale effect can negotiate the

confidence placed in model studies. The final empirical section, 5.8, examines several aspects of modelling practice, firstly the spatial and affective affordances of ‘inscriptions’ as abstract entities and secondly how and why the limitations of models and modelling as epistemic objects and practices were recognised by the HRS. Salient points from this chapter are the subject of 5.9, the conclusion.

5.2: Introducing hydraulic models

Water as river or sea can be a conveyance for trade, water being vital to the ‘survival of liberal capitalist formations’ (Ekers and Loftus 2008, p.698). Water can also withhold debris, sediment, various liquids and solids. Water has agency, and an understanding of water as having agency for Gibbs unsettles notion of water as ‘separate, discrete matter that exists and behaves in a uniform or homogeneous manner across time and space’ (2014, p.58). Human geographers have begun to take this rethink of water seriously (see Anderson and Peters 2014; Bear and Bull 2011; Gibbs 2013; Jones O 2011b; Lavau 2013; Lehman 2013; Merriman 2015; Peters 2012; Walker et al 2011). The agency of water becomes through the weather and climate, the moon, the topographic and geomorphic. Water’s agency is shaped by and/or gives shape and/or force to all kinds of things, from sediment, formations of sediment, landscape to ‘water infrastructure’; weir, breakwater, dock, training wall, reservoir, irrigation canal, dike, floodgate, as well as interventions from dredging to bridge piers. It is the agencies of water worlds and those of infrastructures and interventions that the hydraulic modelling described in this chapter seeks to understand. Figure 26 (overleaf) presents the whereabouts of infrastructures the hydraulic modelling of civil engineering seeks to make present within water worlds.

Water worlds are affirming for humans in many ways such as enabling flows of goods and services, providing materials, food, energy and also opportunities for leisure practices. However, water worlds can also be threatening. Floods, storms, corrosion and the changeable and uncertain qualities of water worlds can generate emotions and feelings like fear for threat, whether in regard to human and non-human life, flows of goods and services and/or transportation infrastructures (from dock and port, road bridge to breakwater). Equally, human engagements with water worlds, whether through flood and

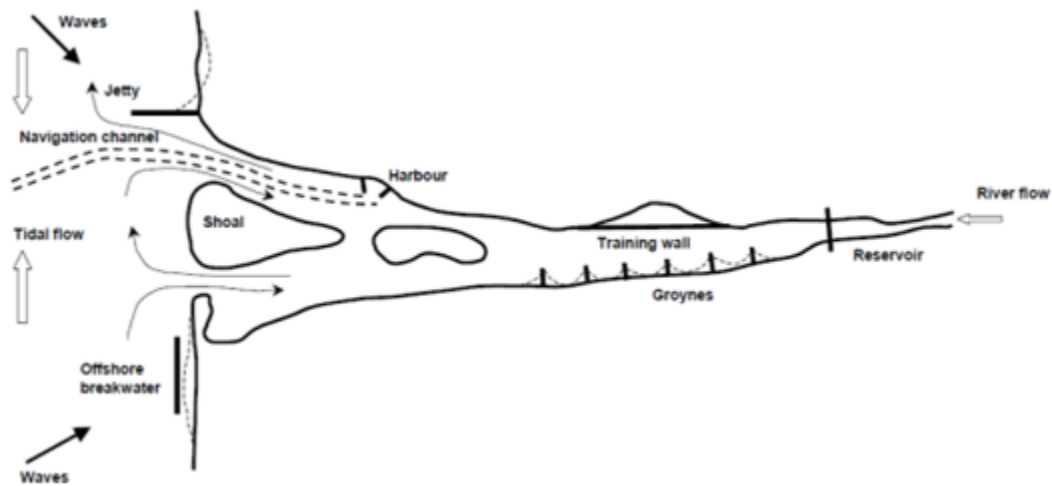


Figure 26. Relative locations of infrastructures that many hydraulic model studies make present. Source: Misplaced.

coastal defence works, transportation infrastructures or dredging and drainage schemes, can potentially endanger human and non-human life, flows of goods and services and the economic viability of human engagements because of the agencies of water worlds and their uncertainties to humans and inherent changeability. It is within this context of threat that hydraulic modelling has emerged in relation to civil engineering and has been of interest to diverse agents like river, port and dock authorities, local and national governments, civil engineering firms and civil engineers.

The emergence of hydraulic modelling for civil engineering projects with physical scale models is complex (for a detailed overview see Ettema 2000). It developed within several European university and independent research centres concentrating on fluid mechanics and civil engineering near the turn of the 20th century. Physical hydraulic modelling involves the application of basic to complex mathematical equations relating to certain physical laws that enable equal force, motion and form relations to be made between two different fluid flow situations (see Sterrett 2002). Through mathematical equations, physical hydraulic models are scaled representations of aspects of coastal, estuarial and river dynamics. Diverse materials are often used when sediment transport is the/an object of study.

Fluid mechanics ‘in pipes and channels or through hydraulic machinery’ (Allen 1954a, p.2), what is termed ‘closed channel’ hydraulics, has, over time, been solved mathematically. Mathematics has been used since the time of Aristotle to develop theoretical solutions to hydraulic engineering problems involving closed channels. Fluid mechanics in the contexts of estuaries, coasts and rivers, what is termed ‘open channel’

hydraulics, has been more difficult to comprehend mathematically and in many cases still remains, despite the development of hydraulic modelling with computers, The environmental processes inherent within water worlds, usually exceedingly complex and holding many uncertainties (Pye and Blott 2014), makes understanding them usually even more difficult (see Karunarathna 2011; Karunarathna et al 2007; Spearman et al 1998). Furthermore, what is known about water worlds can be negotiated by the technologies, practices and knowledges of modellers that co-produce that knowledge in the first place.

This chapter is historically orientated in its assessment of hydraulic models and for reasons explained in 1.3. However, as noted in 5.1, like the other case studies comprising this thesis which are orientated more to the present, as well as differences across time there are similarities, not least in the impetus for hydraulic model research and the stories of experiment, fieldwork, decision-making, uncertainty and the limitations of modelling this chapter presents. Differences are important to note and in the period of this chapter physical models were the mainstay of hydraulic research. Since the 1960s physical models have gradually been overtaken in use by computer models, at first for less complex environmental contexts. Within computer models, rather than physical mimicry with materials (including water), mimicry is numerical (through mathematical models) and since the 1990s computer models and results can be visualised in 2D and 3D. Computer models in certain contexts when compared with physical models are cheaper to make, operate and quicker and easier to communicate research findings (Sassaman et al 2009). Nevertheless, physical models are still widely used and often in conjunction with computer models ('hybrid model studies') in cases where a computer model itself is not amenable for modelling purposes whether because of the problem/s for consideration or on cost grounds. A future for physical models for van Os et al is 'assured', 'physical models will keep their pivotal role for many decades to come' (2004, p.7).

Water worlds support an abundant diversity of non-human life although how these are affected by civil engineering infrastructures and interventions within hydraulic modelling seem not to have been of concern in the model studies undertaken by the HRS during the 1940s and 50s. Habitat loss and change and the emergence of an environmental politics since the 1960s has meant that within European Union member states, intentional infrastructures and interventions will now need to undergo an Environmental Impact Assessment (similar kinds of assessments are needed in other countries). Because of environmental regulation, interest in habitat conservation and restoration and the affordances of computer modelling, hydraulic modelling since the 1980s has increasingly

developed links with ecology and ecological modelling and vice versa (particularly evident by the very recent moves to define an ‘ecohydraulics’ (see Maddocks et al 2013)). Hydraulic Research Wallingford (HRW), the HRS’s post-privatisation entity, has a dedicated team involved in ‘[combining] predictive models of hydraulics [...] with ecological models for use in river, estuary, coastal and marine studies’ (HRW 2015, np). The advent of computer modelling has afforded some ecological processes to interact with hydraulics in models, something physical models cannot do (Novak et al 2011). Van Os et al for Hydralab (a consortium of large European hydraulic laboratories) notes: ‘Hydraulic research is developing more and more beyond traditional civil engineering to satisfy increasing demands in environmental studies and natural hazard assessment’ (2004, np).

As will be detailed in the next section to this chapter, a significant number of research centres emerged for hydraulic modelling across Europe, North America and countries in Asia over a period of just a few decades in the first half of the 20th century. Research centres were variously termed ‘laboratory’, ‘institute’ or ‘station’, staffed usually by hydraulic engineers turned modellers and were set up and funded mainly by government (some were private) to cater for public and private sector engineering projects.¹⁶ When compared to computer models, physical models require significant space and a diverse array of costly and specialist instrumentation and infrastructure so as to enable the model to operate and be monitored. Although hydraulic modelling during the period of this thesis chapter was not limited to the big research centres (models being sometimes built by those who wanted a study or by individual consultants (see Thomas 1956)), the advent of computer modelling and alongside (and enabling) demands beyond ‘traditional’ hydraulic engineering has meant in recent years hydraulic modelling has become a much more spatially diffuse practice, undertaken by a huge number of consultancies. Nevertheless, many of the hydraulic research centres emergent in the first half of the 20th century with physical modelling, including the HRS, have retained a significant position via the extent of expertise and facilities both for physical and computer modelling, links with industry and government, development of computer programs, research breadth and quality of knowledge dissemination.

¹⁶ Differences in research centre name do not necessarily matter. In the HRS’s case ‘station’ was decided upon because ‘laboratory’ suggested a research centre that was small (see Hydraulics Research Board (HRB) 1947) rather than any kind of difference in the practices undertaken there.

5.3: Intervening on uncertainty: Affordances of hydraulic models, government and the HRS

This section considers the affordances of hydraulic models and modelling in the inter-war and immediate post-war period from the point of view of diverse agents, from ‘river boards’ and dock authorities, to civil engineers and government. In considering affordances of hydraulic models and modelling, this section finds at centre stage the feeling state of ‘uncertainty’. Uncertainty is an inherently geographical feeling because, following Brown, it is ‘emerge[nt] [from] the interaction of mind and matter’ (2004, p.371). Uncertainty is a particular ‘state of confidence [...] defined in the broadest sense as (degree of) trust or conviction’ (Brown 2010, p.77). Uncertainty is approached in this section in relation to several frames of reference as a feeling state to be intervened on in the context of water worlds and mobilising here mimesis.

A fundamental part of the colonial project for government authorities in British India was irrigation work (D’Souza 2006; Gilmartin 1994, 1995), important to ‘expanding cultivation, increasing governmental revenue and enhancing government prestige and control’ (Gilmartin 1994, p.1143). In the service of such aims was ‘irrigation science’, a pursuit of civil engineers versed in and developing an evolving mathematical language in an attempt to comprehend the dynamics of irrigation channels, but also sometimes river matters (see Gilmartin 1994). Sir Claude Inglis (1883-1974), who was to become the first Director of the HRS (1947-1958), spent forty years in Indian irrigation work (1905 - 1945) and in 1920 became Director of a new Bombay government centre for irrigation research: the Irrigation and Hydrodynamics Research Station, Pune (IHRSP). The IHRSP came to employ models through problems facing canal and irrigation engineers within the Bombay Province (see Thomas and Paton 1975) (an administrative subdivision of British India).

Over time, the IHRSP developed its modelling work into river training, flood protection, port works and also designs of bridges and dams (Allen 1947). Most of the IHRSP’s work focused on maintaining and extending economic activities. The use of models in hydraulic engineering was gathering apace elsewhere in the world, particularly in the United States, Germany and Holland. The use of models in these countries generated some interest from public and private agencies, including civil engineers (see Mosselman no date; Reuss 1999). The seeming potential of modelling to make more confidently and at less expense infrastructures and interventions that perform (for a while at least) as desired by humans within the agencies of water worlds, mobilised the interest. The same

emergent enthusiasm occupied the Government of India (GOI) (see Inglis 1945). Operating on a shoestring budget, the GOI was enthusiastic for hydraulic modelling because of how it could save money since ‘bad’ designs through failure or ‘over-engineering’ cost monetarily.¹⁷ The GOI, as a large infrastructure developer (ports and docks, railways and hydro-power projects), expanded and gave more funds to the IHRSP, becoming in 1937 the ‘Central Irrigation and Hydrodynamic Research Station (CIHRS). Headed by Inglis, the CIHRS dealt with GOI projects across India and could also serve private agencies (Inglis 1945), helping the CIHRS to pay its own way slightly.

Like in British India, hydraulic modelling came to be viewed by many national governments (China, Germany, US, among others) as worthy of support through the establishment of research centres, as noted earlier variously termed ‘laboratory’, ‘station’ or ‘institute’. Despite differences in name, what took place at these centres was the same thing; experimental knowledge production. Hydraulic modelling was intimately fostered by each government for initially sometimes different reasons and within a ‘policy goal’ characterisation of government-science relations as opposed to ‘government with science’ (Whitehead 2009). For the UK as will be detailed shortly, an economic case was important, like with British India. In the context of the US, it was with regard to the maintenance of human life through the possibility of better river management in the Mississippi basin which motivated the government, in the wake of the life taking Mississippi floods of 1927, to set up the ‘Waterways Experiment Station’ (WES) (for detail on the early history of the WES, see Fartherree 2004; Reuss 1999). Existent river management practices in the Mississippi basin made the 1927 floods worse in their human impact. One of the primary aims of the WES was to use models to help civil engineers negotiate the power of the Mississippi without harm from its very negotiation. *Popular Mechanics* (1933) lauded the WES in an article entitled “*Taming Ol’ Man River*”: ‘[T]he hydraulic laboratory is a crucible in which the river and harbour engineer may test the practicability of every plan before it is put into execution’ (p.899).

Civil engineering in/with water worlds before the advent of hydraulic modelling was in no way an ineffectual practice, civil engineers stymied by the inability to understand the agencies of water worlds. Revill (2007) has shown how the 18th-century canal builder William Jessop sought to improve for navigational purposes the River Trent. In recommending how to do it Jessop based suitability of what to do on a mixture of observation via technology (instruments) and the body, some of the theory at the time on

¹⁷ On the shoestring budget of the GOI see Legg (2007).

fluvial processes, local knowledge and his previous experience. However, constituting and making dynamic a water world via physics, particular knowledges, scale, miniaturisation, abstraction and mimesis, and being able to intervene, manipulate, control and experiment, offer something Jessop's practice might not. This was/is felt to be greater confidence over questions of 'watery affect' with the intervention/infrastructure through the making of futures as actionable due to modelling knowledge and practice (by 'watery affect' I mean change produced by an intervention/infrastructure's agency within and on the agency of water and its material contents and also the other way around). Professor of hydraulic engineering, Jack Allen, onetime Board member of the HRS, in a 1959 talk to the Delft Hydraulics Laboratory admired but was also alarmed at the faith British Victorian port-engineers placed in themselves as to the influence and permanence of their creations, 'basing their designs and their methods of construction very largely on their own experience and intuition, unaided by laboratory testing [with scale models]' (1959, p.17). Allen went on to suggest to his laboratory audience: 'There is also evidence of a changing attitude. The feeling that perhaps further developments and improvements might be more confidently undertaken if experience and intuition could be supplanted by more fundamental knowledge and controlled experiment' (ibid). Jessop, however, was not devoid of confidence in his engineering practice, like other engineers before the arrival of 'controlled experiment' via models.

Hydraulic modelling attempts to intervene on uncertainty. Uncertainty, as noted at the beginning of this section, is a feeling 'emerge[nt] [from] the interaction of mind and matter' (Brown 2004, p.371), a particular 'state of confidence [...] defined in the broadest sense as (degree of) trust or conviction' (Brown 2010, p.77). Models and modelling become imbued with a desire for greater confidence in cases where for Novak 'experience is often missing - usually due to the uniqueness of the design and circumstance. Furthermore, many problems of non-uniform and steady flow, sediment motion [...], density currents and cases of complicated geometry [...] [all] defy theoretical treatment' (1971, p.16).

Research with a model might afford not only a feeling of confidence, but also one of comfort within hydraulic engineers and decision makers in regard to watery affect with intentional intervention/infrastructure. For instance, Cashin, Engineer-in-Chief to the Lyttleton Harbour Board, suggested: 'The present state of knowledge and the available techniques of hydraulic model investigation [...] enable engineers to set out maritime schemes which until recently would have been deemed to be taking an undue risk in the interest of economy' (Cashin et al 1956, p.30). The civil engineer Jannis Mazure, writing in

his 1937 PhD thesis, argued hydraulic model studies ‘bolstered the self-confidence of [...] engineers, prevented costly mistakes, and avoided spurious damage to third parties, thus conserving trust in the technical leadership’ (Mazure 1937, p.9 in Disco and Van den Ende 2003, p.533). Mazure draws attention to an aspect of the affective power of model studies by suggesting they may not only generate self-confidence within engineers through the potential of predictive power, but also enable engineers to preserve, if not bolster, the confidence placed by others in them. However, confidence and its relation to model studies has many intensities (such that Mazure’s assertion has some hyperbole to it) and is made through sensibilities, knowledges (including modelling and water world knowledges), modelling materials, techniques, decisions, scientific instruments and modeller and institute reputations. Such is it that confidence is never always placed in a model study and by a diversity of agents, not just civil engineers, but modellers themselves, politicians, publics and others. In the time period covered by this thesis chapter, some civil engineers were dubious about the epistemic potential of model research and due to questions of scale and material which could lead for Murdock of ‘Wimpey and Co.’ to ‘misleading interpretations’ (Cashin et al 1956, p.34), an aspect examined in 5.7. Jack Allen in his 1947 introductory book on hydraulic modelling suggested:

‘It is the Authors belief that since the 1930s there has been rather a change of attitude and a more generally favourable disposition towards the acceptance of the model as a working instrument, at any rate for guidance, is now discernible in the profession as a whole. This is not to say that the adverse criticisms have been completely resolved or dissolved [...]. Indeed, it is hoped that perusal of these pages will serve to indicate the limitations of the method and the fact that much fundamental work remains to be done. And clearly much will depend upon the accumulation of evidence as to the behaviour of structures actually made as compared with model forecasts. To claim at this stage a complete reliability would be as scientifically unsound as to reject the method because the models have distorted scales and use bed materials whose individual grain-sizes are out of all proportion to the linear scales’ (1947, p.200).

Whilst hydraulic modelling is meant to intervene on uncertainty, it is a practice rife with uncertainty from both within and outside hydraulic modelling practice. Uncertainty affects the extent to which it might be regarded as possible through hydraulic modelling to reproduce/imitate/represent/simulate something. A mimetic perspective on hydraulic models is important because, alongside modelling knowledge and practice, hydraulic models are meant to present futures under particular conditions, they are intended to give modellers inclinations of, worlds to be, future worlds simulated and represented. Drawing

upon Caillois's (1961) concept of 'mimetic play' where the distinction between the self and other becomes porous and flexible, climate and hydraulic models as epistemic objects for knowing futures (ensuring there are no 'bad surprises' (Anderson 2010a after Derrida, 2003)) might not only be judged through modelling practice and knowledge to represent the other, but also be the other, its future 'drawn down into the present as [an] object of action and intervention' (McCormack 2012, p.728).

Given a number of national governments had developed hydraulic research centres over the early decades of the 20th century (this included the Netherlands, Russia, China and Italy (see Allen 1947)), the UK arrived comparatively late, the year being 1947. A special committee of the Department of Scientific and Industrial Research (DSIR) was tasked with assessing for the DSIR's Advisory Council how publically funding civil engineering research could boost government policy goals in a post-war future. The DSIR was a government department which had been set up in 1915 and funded research where the private sector would not (see Clarke 2010). The DSIR funded 'normative' government laboratories, places producing knowledge for a group in society (van Rooij 2011) and private laboratories.

The DSIR committee made a sub-committee, the Hydraulics Sub-Committee (HSC), to look into hydraulics with the intention for the HSC to produce a report. The HSC was composed of three high profile hydraulic engineers and they started their work by producing a detailed memorandum as to 'the advantages [...] a station would be to engineers and others who design and construct all kinds of sea and river works' (HSC 1945, p.10). The memorandum was to be read and commented on by potential stakeholders; heads of major infrastructural engineering companies, river boards and dock and harbour authorities and with their responses potentially used as evidence. The memorandum also asked these potential stakeholders to provide details as to hydraulic problems facing them.

The memorandum bemoaned the poor facilities for hydraulic research in the UK: '[W]e have no central station on an adequate scale to meet the needs of engineers, in whose hands lie the annual expenditure of vast sums on the maintenance and new construction of waterways, docks, harbours and coast protection both at home and in the Empire' (HSC 1945, p.6). The memorandum argued neither UK universities nor the private sector could cope in ensuring adequate facilities such as experimental plant, the development of scientific instruments to aid modelling practice and the need for a single-site station 'in order to build up and train a strong team of highly trained workers experienced in every aspect of the work. Only through such concentration can interchange of ideas be ensured'

(ibid). This issue over the spatial proximity of research workers runs into debates on questions of ‘centres of calculation’ (Latour 1987) as well as knowledge interactions (Howells 2012), the latter something that was not happening currently. Both of these issues will be looked at momentarily.

The memorandum elicited a number of lettered responses.¹⁸ Responses were overwhelmingly enthusiastic towards the need for a ‘central station’ and in the HSC’s report for the DSIR the HSC abstracted the responses and paraphrased those they regarded important in maintaining their argument. The HSC sought to stress how respondents placed value in undertaking model research with value around precaution against ‘bad’ interventions/infrastructure, and with ‘bad’ in the sense of these infrastructures/interventions causing heavier than ideal financial cost through the ‘failure’ or over-engineering of them (over-engineering emergent through precaution against threat, precaution a product of uncertainty). For instance, the HSC noted how Wignot of the Dee Catchment Board told them how his Board had been ‘saved by a model investigation [at Victoria University], finding a scheme unsatisfactory which would have cost £800,000’ (HSC 1945, p.14). Because the HSC perceived a lack of facilities and ‘expertise’ in the UK for hydraulic research, they sought to show the DSIR how several authorities were finding themselves in an uncomfortable limbo as to their economic development. Explaining the London Midland and Scottish Railway’s Heysham harbour engineer’s predicament:

‘He goes on to explain that his Board have already agreed to small-scale experiments concerning schemes of improvement and development for the harbour. But these experiments are only intended as preliminary to a comprehensive model investigation ‘not at present possibly in this country’. This latter investigation has, therefore, been deferred for two or three years’ (HSC 1945, p.13).

A statement by Doran, Chief Engineer of the Ouse Drainage Board, was copied in the HSC’s report verbatim:

‘[I]solated and sporadic [model] work by individual engineers who can only devote a limited time and who possibly lack the necessary scientific background is not the proper method. [Furthermore] [...] of course, the results of such experiments (and some which might not be entirely tolerable) are confined to the individuals concerned and are not available for application elsewhere’ (HSC 1945, p.13).

Such a statement provided weight to the HSC’s pre-existing idea of a ‘central station’ as the most conducive way to develop hydraulic model research in the UK. This issue was

¹⁸ These are existent, see TNA: AY 17/12.

also stressed in the DSIR committee's report to its Advisory Council. For the HSC, Doran's picture of hydraulic practice was problematic to developing hydraulic modelling knowledge and from there more confident modellers and confidence inducing model studies because whilst model studies aim to quell threat, model studies might cause threat since designs have reality on the basis of a modelled milieu and modelling knowledge. Abstraction here becomes rather problematic. It was argued 'staff be concentrated in one place so that they can be transferred from one job to another and their experience not lost by dispersal'. Furthermore, it was posited that 'a central station offers the best facilities for free exchange of ideas among the staff. As Barnes has argued, place is 'critical to the formation of ideas' (2004b, p.566 also see Barnes 2003) and historical geographers of science have sought to emphasise the importance of the situational to scientific knowledge (see Finnegan 2008; Livingstone 2003; Naylor 2005). The idea for the HSC was with a 'central station' modellers could develop and share knowledge and jointly learn through practice, producing better model studies and where knowledge from studies could be easily and identifiably disseminated through research papers and journal articles. A comment by Green on Area Based Models, that 'a measure of intuition, common sense and expert judgement' is needed to make a good model (2013, p.4), is important here. The HRS was being envisioned as an important and powerful 'centre of calculation' (Latour 1987) for hydraulic research, a 'centre of calculation' being 'venues for the production and dissemination of different types of knowledge' and 'dominating other places at a distance' (Jöns 2011, p.167).

Inglis also took part in the discussions with the HSC. Inglis had left his post as Director of the CIHRS just before Indian independence (1945). In a written statement accompanying the report, Inglis asserted how model studies in India had prevented expensive civil engineering works from being destroyed or harmful. For instance, Inglis (1945, p.2) on the Tando Mastikhan Fall:¹⁹

'The Tando Mastikhan Fall was an outstanding example in which a very cheap design would have failed in a few months, but was turned into a highly efficient energy destroying structure as a result of experiments by merely adding walls [with] others across the pavement to act a baffle for dissipating energy and a deflector to prevent downstream scour?'

Inglis (ibid) also suggested:

'Nowadays no large work is carried out by government in India without model experiments and consultation, but as the best men available for hydrodynamic research stations are not now being selected they will not

¹⁹ Inglis does not say what kind of structure this is and no details can be found out about what it might be.

enjoy the same confidence as hitherto-fore and a research station very soon loses its reputation if it makes a few mistakes. Thus, if British engineers and contractors have the advice and help of a suitably staffed and well-equipped research station available, they should be able to secure a large share of railway, port and irrigation works to be carried out not only in India, but also in devastated Europe and other countries, to the great benefit of our export trade’.

Inglis’s idea was that with British GOI hydraulic engineers not being selected post-independence and senior positions taken over by Indians, the quality of modelling work in India would decline (for an unknown reason) and potentially with ‘mistakes’ in modelling work having very real consequences like infrastructure failure (a subject discussed in 5.7). The result for Inglis would be uncertainty placed in the modelling work of Indian hydraulic research centres since model results could lead to problematic designs of infrastructure/intervention. Inglis anticipates a benefit to the UK government from poor modelling work in India because British companies with ready access to a well ‘staffed and [...] equipped’ station could be in stronger contention for Indian and Asian contracts on the basis of greater confidence in modelling work and, therefore, designs. It was an overseas business case for a ‘central station’ the HSC sought to stress to the DSIR committee, and again stressed but rather more forcefully by the DSIR committee in its report for the DSIR Advisory Council. The DSIR report suggested a central station could boost British civil engineering contracts and secondly, save money on ‘uneconomic designs’.

How the Advisory Council took the arguments of the HSC and DSIR committees is not clear, there were not found any detailed minutes of discussion in the Advisory Council minute papers.²⁰ Nevertheless, it is likely these arguments were primary mobilisers in a decision over the establishment of the HRS in 1946. Herbert Morrison, Lord President of the Council (July 1945 - March 1951) (not the DSIR Advisory Council, rather a UK government cabinet position and with responsibility for the DSIR), was ‘anxious that Science should make its full contribution to the problem of increased productivity’ (Hydraulic Research Board (HRB) 1948, p.1). For a meeting with the DSIR Advisory Council in 1948, Sir Francis Wentworth-Shields (representing Sir William Halcrow, Chairman of the HRS) made a note to himself so as to help address the panel on a question of contributing to ‘increased productivity’:

‘[The station] will solve, by means of working models, the many problems involved in producing good and efficient designs for

²⁰ Minutes of the DSIR Advisory Council can be found at TNA: DSIR/2.

harbours, docks, rivers, canals and power stations in this country and throughout the Empire and thus assist industry by saving very large sums of money and much time which would otherwise be wasted on costly works needed for transport and power production [...]. It will enable British engineers to submit designs for similar works abroad which will surpass rival designs of foreign engineers. This is because their efficiency has been assured by means of first-rate model investigation and the importance to British industry of security that such works abroad shall be designed by British consultants is obvious because British engineers naturally incorporate in their designs plant and materials of British manufacture' (Wentworth-Shields 1948, np).

Naylor has observed that 'states have used science both to understand and to intervene in the affairs of that nation, as well as to engage in geopolitical struggles with their competitors, whether that be in an intellectually competitive way or to help them gain economic, political or military advantage over others' (2005, p.8). Government-science relations are multifarious in their forms and tasks (see van Rooij 2011; Whitehead 2009). In the DSIR's case, affordances of hydraulic modelling and the developing of a 'community of practice' of hydraulic research workers at a 'central station' were brought to governmental attention for enabling national economic benefits at home and abroad. The agency of water worlds and their relations with the agencies of infrastructure and interventions became of concern for the UK government because hydraulic models and modelling could offer an intervening on uncertainty; uncertainty was costly in monetary terms, producing non-action, timid or over-engineered schemes. Also, after Inglis (1945), hydraulic models and modelling had the possibility of making a scheme safe, as far as possible, from bad design. Bad design potentially causing financial loss through failure and/or causing harm to people. *Popular Mechanics'* assertion of the WES that 'American engineers in this laboratory have a tool enabling them to go forward in subordinating the forces of nature to the welfare of mankind' (1933, p.901) and later Pathé News's (1969) reference to the HRS as a place where 'gradually science is taming the waters to work for man', suggest an effort for control and power over a threatening non-human environment for matters of economic prosperity and the maintenance of human life. Incidentally, the Pathé newsreel, as well as an earlier one (1964), presented the HRS hydraulic modeller as worthy of reverential respect within a narrative of fighting for control over a threatening non-human environment. The 1964 newsreel referred to HRS modellers as 'water wizards' in 'tackling problems of threat' from water worlds. Threats included; 'dock development' and 'the remorseless pounding of the sea' and 'solve[ing] the problems of flooding [...], London is in danger!'

Whilst hydraulic modelling is meant to intervene on uncertainty, hydraulic modelling is rife with uncertainty from both within and outside the practice. For the HSC and for Inglis, government could intervene to some degree on this uncertainty through the making, financing and therefore technological supporting of a particular spatialised ‘community of practice’ of hydraulic modellers (the HRS). Arguably, the British government (via the DSIR) through establishing the HRS according to the HSC vision, sought to generate a feeling state of confidence within and around British hydraulic modelling practice for reasons of national economic and political importance, both at home and abroad. Causes of uncertainty, attempts and technologies for its mitigation and how uncertainty is negotiated will become prevalent in several later sections (5.6, 5.7, 5.8) looking at hydraulic modelling practice at the HRS.

Before this chapter moves forward, several points can be made about the HRS as an institution, providing some context to the empirics of this chapter.

The HRS was established in 1947 and with Inglis as Director until 1958. The HRS took over the small and infant hydraulics section of the National Physical Laboratory (NPL) at Teddington in London. The NPL was a DSIR asset. In the meantime, designs were undertaken for a purpose built ‘central station’. In 1949, a site opposite the River Thames near Wallingford in Oxfordshire was chosen by Inglis, principally for its ease of connections with London. The River Thames also offered the kind of water volume needed to go through models without injuriously affecting downstream river conditions. The HRS moved from the NPL to its new home at Wallingford in 1951 (see figures 27-28, overleaf).

Facilities at HRS Wallingford, and during the 1950s a sizable part of the HRS’s budget allocation from the DSIR (40%), were given to developing knowledge about the agency of water, particular agencies within water worlds (including model ones) and hydraulic modelling practice. These were all vital inquisitive and often experimental practices in attempts at intervening on uncertainty, but also knowledge development more generally.²¹ Whilst important knowledge would be generated in the process of the HRS’s research work for various public and private agencies, what was termed ‘applied’ or ‘ad hoc’ research, this would not always be the case. Time and effort needed to be given to key matters outside the pressures of applied research and often its context specific demands. This kind of research was termed ‘fundamental’ (see Clarke 2010). The HRS

²¹ We can also think about for instance the development of artificial sands (as sediment) for use with models or, in the case of knowledge about the agency of water, ways of predicting wind action on water.



Figure 27. Exterior to 'Main Hall' c1956. Source: HRS (1956)

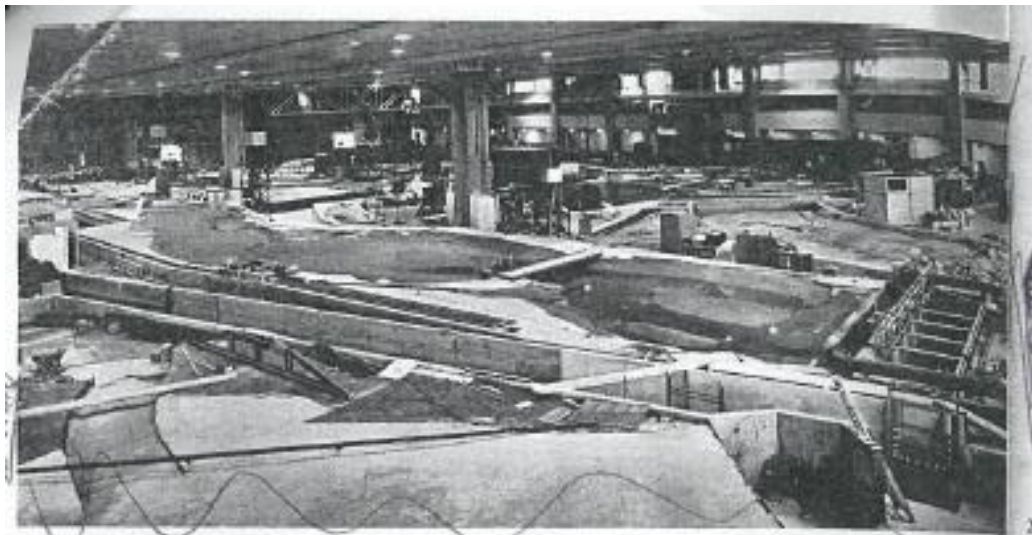


Figure 28. Interior to 'Main Hall' c1950s. Source: HRS (1960a, p.17).

sought to contribute to hydraulic modelling theory and practice through publishing results of experiments, like other hydraulic research centres at the time. There were annual reports from 1952 until privatisation (1982), containing fairly detailed narratives of experiments (e.g. HRB 1954). Secondly, research papers which were in-depth studies on experiments, these ran fairly infrequently from the late 1950s to the 1970s (e.g. HRS 1960b). Lastly, and from the late 1940s onwards, journal articles (e.g. Hunt 1954). Inglis actively encouraged HRS modellers to write journal articles on completion of studies. Chief recipient was the *Institute of Civil Engineer's Proceedings* (ICE) and from the 1970s onwards *Coastal Engineering Proceedings*, *Journal of Hydraulic Research* and the *Geographical Journal*.

The organisational structure of the HRS comprised 'scientific grades' ('experimental officers'), 'industrials' (carpenters, labourers) and several administrative positions (typists and clerical officers). The HRS archive is silent on the experiences of the carpenter working with materials or the junior experimental officer doing a task they might find as boring, repetitive and routine like monitoring a model.²² Many of the people working with models on the HRS staff might not have regarded themselves as 'modeller' in the first instance, if at all, but as carpenter, civil engineer, mathematical physicist or surveyor. Experimental Officers (EO's) were sometimes specialists, or had particular specialisms, such as hydrography and geology. Many EO's either possessed a civil engineering qualification or had come from a civil engineering background, like Inglis. Some EO's had a physical geography background although civil engineers such as Inglis had significant knowledge about coastal, estuarine and river dynamics. Indeed, at the time, self-identified civil engineers as modellers were helping to lead the knowledge development of such environmental systems. For instance, Inglis and his Assistant Director at the HRS, Fergus Allen, in a 1957 paper entitled '*The long-term effects of training walls, reclamation, and dredging on estuaries*' (Inglis and Allen 1957) had, for one commentator: '[B]roken new ground in suggesting that the behaviour of tidal channels in a sandy estuary could be explained in terms of the regime theory' (Inglis et al 1957, p. 252).

²² A HRS brochure trumpeted the 'skill, patience and sound judgement' of HRS carpenters (HRS 1960a, p.18).

5.4: Precaution, watery affect and experiment

Anderson has noted how ‘a range of practices have been invented, formalised and deployed for knowing futures and, therefore, attempting to ensure that there are no ‘bad surprises’ (2010a, p.782). Modelling, as Anderson notes, is one of these, ‘render[ing] futures actionable’. Hydraulic models and modelling have relations with ‘the future’ and where after McCormack ‘abstraction [...] is crucial to the articulation and imagination of actionable futures through which to intervene in and manage a range of contemporary risks and threats’ (2012, p.728). From across the ‘future logics’ of preemption, precaution and preparedness, precaution is the most prevalent future logic for which model studies in hydraulics are undertaken. For the Intergovernmental Panel on Climate Change: ‘[P]recaution’ relates to decision-making in situations of [...] uncertainty. It applies in the absence of sufficient data or conclusive or precise probabilistic descriptions of the risks [...], or in circumstances where the possibility of unforeseen contingencies or the possibility of irreversibility is suspected’ (2007, p.129). Links between precaution and hydraulic models and modelling will be explored in this section. Most HRS model studies relate to the question: ‘How do designs of infrastructure or the action of an intervention perform?’ In this question, agencies of water worlds and infrastructures or interventions become something to negotiate through a model study via experiment and with an idea of closing down potentially problematic, threatening futures. The calling for and undertaking of a model study can be understood as an anticipatory action. Some studies are related again to anticipatory action, like when infrastructure is needed to prevent an area flooding or a river from changing course. For instance: ‘It is feared that, if unchecked the Kosi [river] will soon reach a lower-lying area [of Bihar, India] where its transgression may be more swift and disastrous [...], devastating villages and ruining good agricultural land’ (Rao 1958, p.10). Infrastructure, or in another case an intervention like dredging, is the threat’s attempted mitigation.

Important in considering precaution and hydraulic models and modelling is agency and affect. So far, the term ‘watery affect’ has been used as shorthand for meaning change produced by an intervention/infrastructure’s agency within and on the agency of water and its material contents and also the other way around (change to intervention/infrastructure produced by water and its material contents). With reference

to several experimental model studies from the HRS, this section draws out watery affect in the context of precaution and experiment. The section takes for its formulation and importance of affect inspiration from several strands of recent thought approaching human geography.

Ash (2014) has sought to suggest how affect is not only a human phenomenon, but after Deleuze (1988), a non-human one as well. A basic definition of affect can be the producing of an effect, a change. For Deleuze (1988), affect is the ‘outcome of an encounter between entities and how entities are affected by these encounters’ (Ash 2014, p.1). Hydraulic examples are relevant here, for instance: ‘How will construction of the dock affect the distribution of the tidal currents?’ (Dunbar 1947, p.2) or, how would ‘movement of silt from seaward [...] affect the barrage and the estuary’ (Allen 1955a, np). Ash, drawing upon several conceptions of affect, regards that technical objects are shaped by their ‘capacity to affect’ (2014, p.4). Technical objects, Ash figures, are ‘inorganically organised objects [...], assemblages of manufactured components that allow an object to perform some kind of task or activity’ (ibid). Ash asserts how important humans are in shaping the potential for objects to affect and with a call to trace the particular ‘actors, objects and institutions that attempt to shape affect for their own ends and purposes’ (2014, p.2). As should have become evident so far in this chapter, although made clearer in this section, diverse agents have sought to shape the capacities of water infrastructures/interventions to affect and be unaffected by water worlds in particular ways.

In considering affect and ‘water infrastructure’, water infrastructure is deemed here as brute materiality or ‘thing’ with its conception as a useful ‘tool’. Affect can be related to object agency with the idea from Shaw and Meehan that ‘objects are force-full, brimming with affect, productive of difference and generative of power’ (2013, p.220).²³ Object agency has already been discussed in 4.7 in relation to how railway modellers negotiate with material agency. Water has object agency as well as any water infrastructure although not an intervention like dredging, dredging being an action has agency, but not object agency.²⁴ The *potential* (out of uncertainty) for harmful watery affect with hoped for or needed infrastructure/interventions affects humans, generating embodied affects such as feelings and emotions like concern and fear. These impel the action of calling for a model study. Aspects of relations between feelings and emotions and watery affect will have been

²³ Shaw and Meehan are seeking to bring Object Orientated Ontology into geography (see Ash and Simpson 2014; Meehan 2013; Meehan et al 2013; Meehan et al 2014).

²⁴ Graham Harman, one of the key thinkers of Object Orientated Ontology (particularly Harman 2002, 2005) has considered object in the words of Meehan et al as ‘a unified ‘thing’ composed of a multitude of features which are themselves objects’ (2014, p.61).

noticeable in 5.3, but are further mobilised in the section following this one. Meanwhile, this section turns now, with reference to several HRS experimental model studies, to consider watery affect in the context of precaution and experiment.

In 1952, the Ministry of Agriculture and Fisheries (MAF) sought model research from the HRS into land reclamation in The Wash. Given that Wash soils are highly fertile, the MAF saw further drainage as important in contributing to Britain's agricultural output. The plan for the HRS was 'by treating the Wash as a whole, the four outfalls might be improved by suitably designed extensions to the existing training works and an additional 50,000 acres or so of saltings might gradually become available for reclamation' (Hydraulics Research Board (HRB) 1953a, p. 19). The existing training works for the HRS were very unsuited:

Investigation [through historical charts of The Wash] shows that the various training works for improving the tidal outfalls of the four principal rivers not only had the expected subsidiary effect of causing rapid accretion on either side of the trained portion of the outfalls, leading to a rapid advance of the salt marsh edge, but they also eventually caused deterioration in the channel itself downstream of the trained stretch. The result was that while large areas rapidly became available for reclamation, the primary object of training the outfalls and improving the drainage of the fenland was not realised. The chief problem, therefore, is to find a way of designing training works which will not only hasten accretion, but will also improve the drainage of Fenland' (ibid).

The HRS was concerned by an affect of the 'training works' (infrastructure for control of the flow of a river or tide) on the downstream river channel, causing deterioration and, therefore, drainage problems. Such a potential of the training works to produce such an affect does not seem to have been anticipated, or was beyond anticipation (beyond knowledge), causing the training works to become 'broken tools' of human power over the non-human within the context presented. The aim of the model study was to work out a way of designing training works that within The Wash milieu performs agency in the service of the MAF.

In 1959, Southampton Docks sought a model study to determine how dredging could best be tackled:

The authorities concerned had been very emphatic that any innovation or alteration in the estuarial regime must not bring with it any disturbance which might be of operational disadvantage [...]. Southampton was a port which had been wonderfully endowed by nature with freedom from a number of the problems which beset other ports and pre-eminent among its advantages was the relative absence of siltation. While other ports had to employ fleets of dredgers working

day and night for most of the year to enable ships to enter and leave them for a limited time at high tide, the extent of siltation in Southampton water was so slight as never to provide full-time employment for one dredger [...]. The model described [...] now provided a very useful instrument for studying the effects of any future projects: and there were one or two under consideration which Mr Jellett [Chief Docks Engineer, Southampton Docks, British Transport Commission] hoped to investigate on the model in due course' (Wright et al 1960, p.194-5).

Southampton Docks commissioned a model study with the aim of finding a dredging scheme capable of improving the approaches to port for flows of goods and services. For Southampton Docks, a model, along with trusted modellers, was thought to enable a curiosity via experiment for finding out how dredging, already minimal, could be further reduced on monetary grounds. Southampton Docks were not keen on experimenting in 'the real' with the intervention (dredging) on the matter that such action could potentially generate injurious affect in the sense of the bringing about change in Southampton Water, potentially harming flows of goods and services and putting itself at commercial risk. A hydraulic model, described as an 'instrument' for experiment, was held by Southampton Docks to afford the spatial containment and neutralisation of harm.

Experiment is an 'explorative style' of 'researching and thinking' (Kullman 2013, p. 879) and within hydraulics is about making the future a less threatening prospect over questions of affect and agency. Hydraulic models as abstract and miniature entities are conducive to such an explorative practice as experimenting because they at once neutralise the potential for 'bad' things to have an impact as well as make engagement with water worlds, futures and infrastructure and interventions either more amenable or possible.

Whilst the two vignettes described discuss infrastructures and interventions affecting, nothing has been said so far on infrastructures or interventions being affected. One vignette is of Dymchurch sea wall:

'A model investigation was carried out on behalf of the Kent River Board into a suitable design for the length of the old Dymchurch sea wall that is about to be modified and repaired. The present wall has been fairly satisfactory, but in recent years the pavement has worn thin and it has been damaged by gales with increasing frequency [...]. The modifications had to be of a kind that could be achieved by adding material to the existing wall. The revised design was to give improved resistance to over topping and was, if possible to reduce wave attack on the upper slope' (HRB 1955, p.25).

Over time, the force of the sea, powered up by gales, eroded the wall gradually altering its agency from a powerful deflector of force to one more subsumed by force. The wall,

affecting water by deflecting it away, became over time affected by water itself. Along with various wave actions which the wall was not well designed to tackle, within an experimental design process the HRS sought to ensure the wall for the Kent River Board, like the training works for the MAF, performed the desired agency in a milieu. The HRS writing of the result:

‘The design found to be most satisfactory [...] its main feature - the addition of a 3.3ft layer to the lower slope, tapering to nothing at the upper and lower ends of the slope was effective in reducing wave attack on the upper slope because it compelled all waves, even at very high tide levels to break before they reached it. It also had a slightly beneficial effect in reducing overtopping by compelling the waves to break further away from the crest the wall. The erection of a 4ft wall at the rear of the crest was most effective in preventing overtopping. The effects of a trip wall, 3ft high at the junction of the upper and lower slopes and of large roughness blocks at the same place were investigated as possible means of reducing overtopping, but both proposals were rejected as undesirable. At high stages of the tide, they both increased the amount of spray thrown into the air which would have been carried over the wall whenever there was an onshore wind’ (HRB 1955, p. 25).

Through narratives of experiment and/or through figures, results of model experiments are described for various audiences and whether this is as an internal document, a report for the agency needful of the research results or, as in the sea wall case, a year report for the DSIR. In the context of experiment with hydraulic models, how model water worlds across space and time are affected by and affect infrastructure/interventions is observed by modellers and technologies. These technological and embodied observations are attempts, often in the wake of every new arrangement of a design (a new experiment), to register and/or consider agency and affect. Through measuring instruments, film, photography, lighted floating candles (tracing currents) and embodied observation, agency and affect might be recorded in figures such as those presented by 29 and 30 (pp.140-141). Each figure, and which can become important in recording the results of experiment/experiments for consultation and dissemination, respectively presents an experiment in the sense of assessing a different positioning and design of a jetty and training work and relations with affect. The aim was to ‘prevent the inflow of bed water by causing the Basin to fill from the surface layers [...], structures designed to reduce or prevent circulation in the Basin were also tested’ (HRB 1953b, p.13). Full and dotted lines show the ‘behaviour of the surface and subsurface currents during the flood tide’ (ibid). The scheme shown in figure 29 did not produce the desired result, being regarded as ‘ineffective’. The scheme shown in figure 30 was successful, however, by ‘produced[ing] a

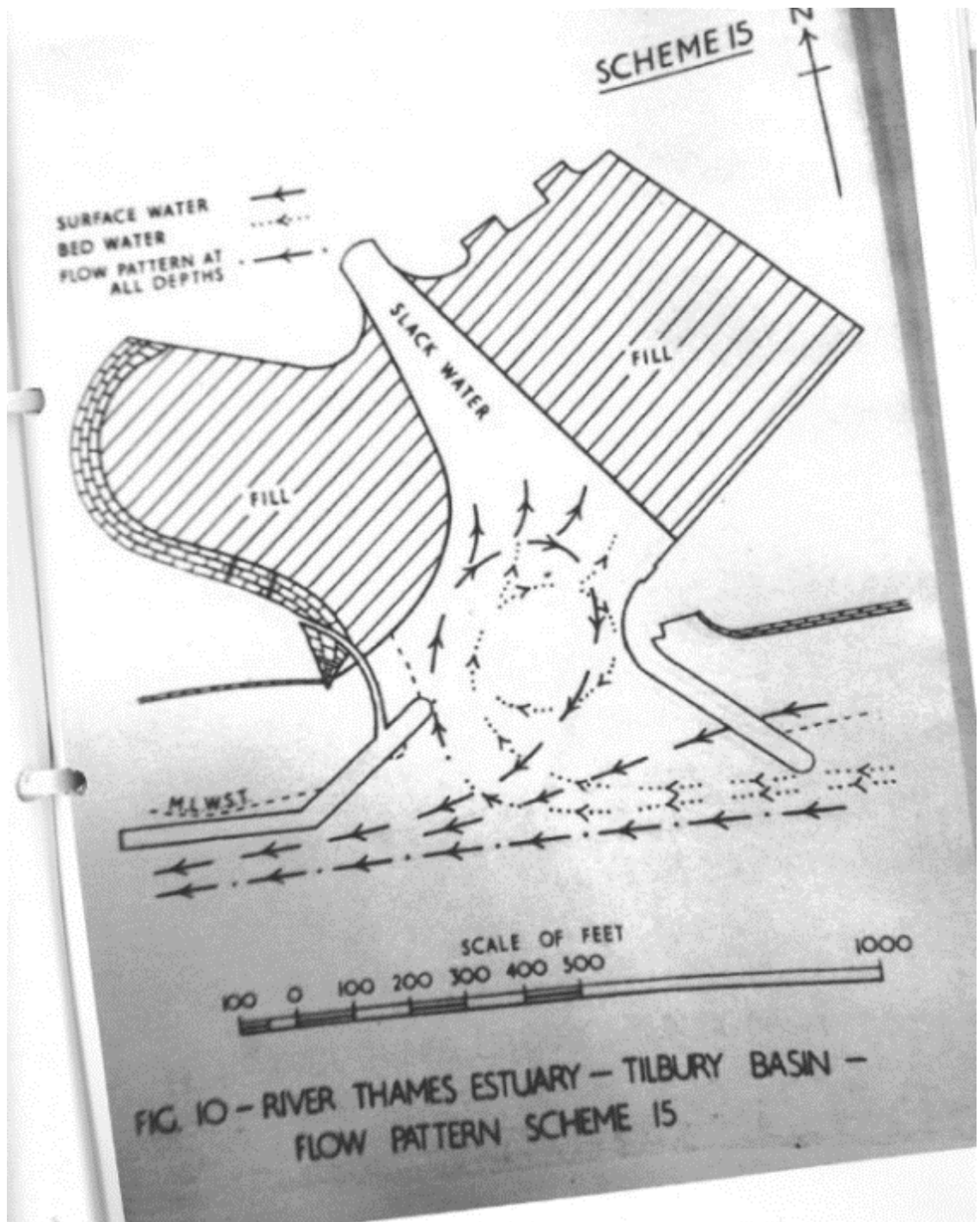


Figure 29. Figure showing results of an experiment in relation to 'scheme 15'. Source: HRB (1953b).

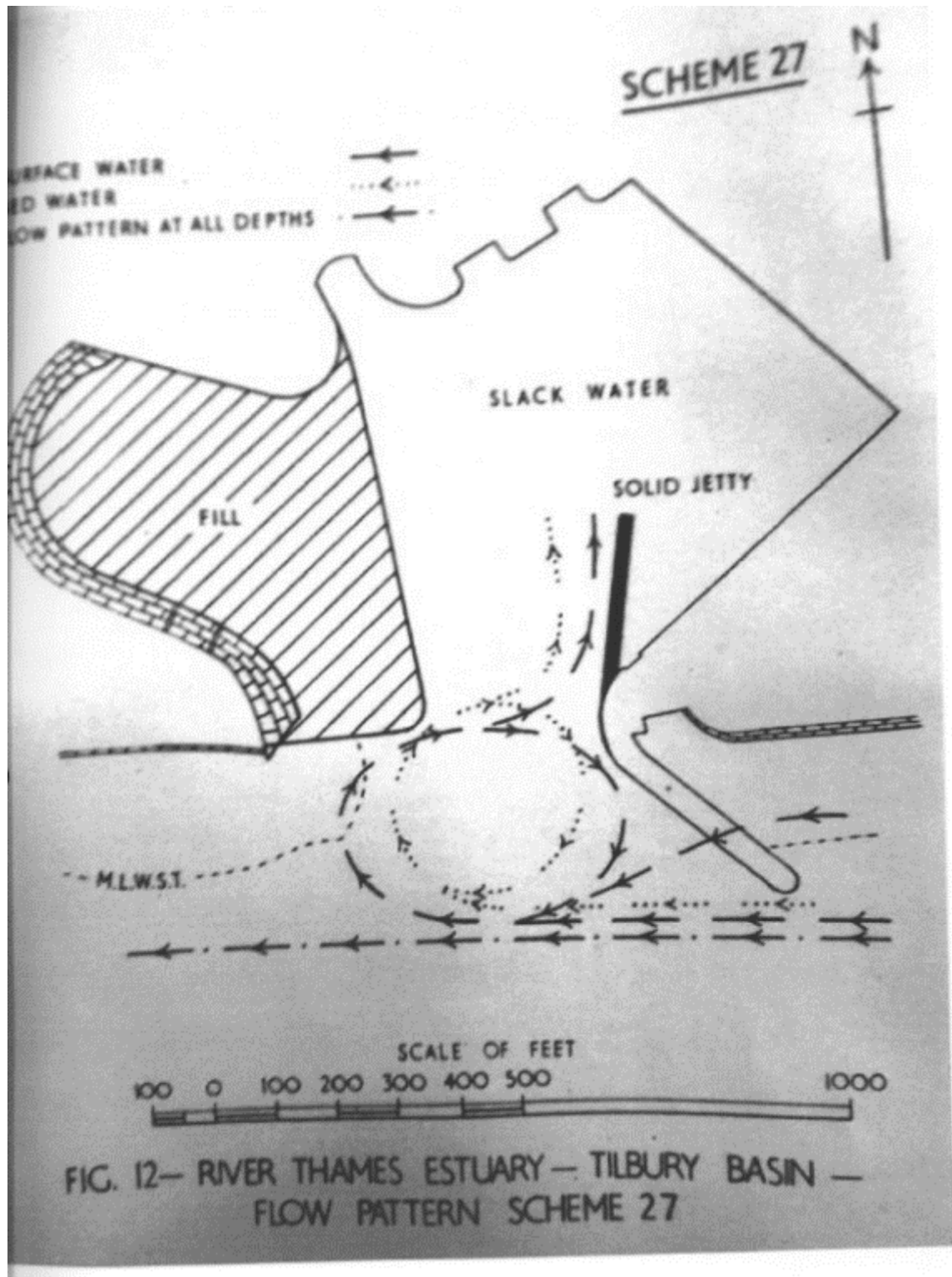


Figure 30. Figure showing results of an experiment in relation to 'scheme 27'. Source: HRB (1953b).

slow inflow of water into the Basin at all depths and prevented circulation completely' (HRB 1953b, p.13).

5.5: The Severn Barrage study: Mimesis, futures, affect, decision-making and questioning confidence

In recent years, geographers have been attending to how the future is involved in the present. For Holloway, the future may be 'understood as a temporality that is folded and unfolded in, and through, practices and achievements in the geographical present' (2014, p.1) (also see Anderson 2010a; Anderson and Adey 2012). As highlighted in 5.4, hydraulic modelling can be a precautionary practice, called to action on the basis of the future, whilst hydraulic models and modelling practices and knowledges aim to make present, act on and *present* futures. Essentially, hydraulic models and modelling practices aim to possess futures; giving modellers, politicians, civil engineers and various authorities inclinations of worlds to be, future worlds simulated and represented. Hydraulic models and modellers, like many other environmental models and modellers, are involved in decision-making (Beven 2010). Decisions involve the making of futures (McCormack and Schwanen 2011), the creation of new geographies and modelling is one 'technique', following McCormack and Schwanen, that can make decision-making 'palatable, explicit and actionable' (2011, p.2811). This section is interested in how and why models, modellers and modelling may come to be critiqued by diverse agents and in relation to their role in decision-making and the creation of new geographies, in this case, a 'landscape of energy' (Nadaï and Van der Horst 2010). Through this, the section examines how hydraulic models and modelling may mobilise various 'presence of the future' spatial imaginings, feelings and emotions (Anderson and Adey 2012; Holloway 2014) and which also impel practice with regard to how models as mimetic objects and modelling as a mimetic practice are involved in opening up and closing down futures within decision-making processes. In contemplating the critique of model futures, affect, emotion and feeling and relations with models, modellers, modelling and landscapes, places and environments, are seen as especially important in how critiques of models come to matter, including politically. The empirics

of this section draw almost exclusively from files from the UK Ministry of Power in relation to a model project the HRS would come to undertake between 1947 and 1955.

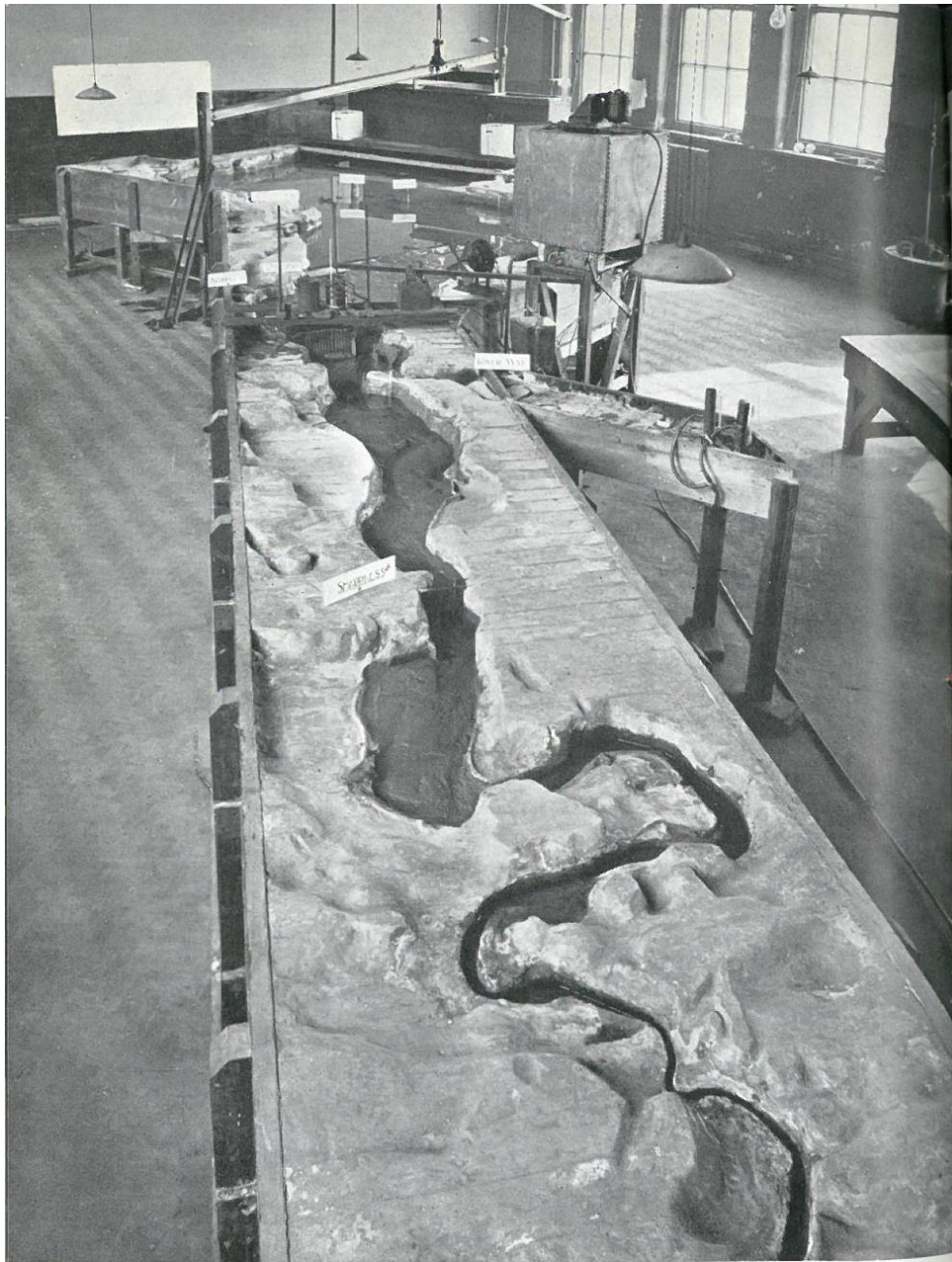
In 1943, the Ministry of Fuel and Power (MFP) sought to re-visit a 1933 government study into the possibility of constructing a tidal barrage across the Severn Estuary in the English Stones area (see MFP 1944-1946). The power of the tide was envisioned as a potential energy resource. A revisit was caused by a desire on the part of the Treasury and the MFP to lower coal consumption for electricity generation. This rested on a worry as to the cost of coal increasing in the future, accentuated by the gradual reduction in coal resources. However, the question of the estuary actually becoming a landscape of energy was only through events of high coal prices and/or high unemployment, the project formalising a precaution essentially against both (see Lloyd-George 1945).

A panel of three ‘technical experts’ reviewed the 1933 proposal and then produced a revised one (see Vaughan-Lee et al 1945). The 1933 proposal by the Severn Barrage Advisory Committee (SBAC) (see SBAC 1933) had been the outcome of five years of model research on behalf of the government by professor of engineering Arnold Gibson of Victoria University (see Gibson 1933) (see figure 31, overleaf). Gibson was a specialist in hydraulic modelling. The aim of the model study had been to anticipate ‘the effect of various types of barrage on tidal levels and navigation’ (SBAC 1933, p.3) with the aim of stopping any ‘deleterious effect on navigation’ (Hansard 1943, p.704). For the SBAC:

‘The investigations on the model have [...] shown that a barrage would not injuriously affect navigation *below* the barrage. Even with dredging, a barrage would not seriously affect navigation *above* the barrage at any time of the tide and would appreciably improve it at low water. If a comparatively small amount of dredging were undertaken, navigation above the barrage would be at least as good at high tides and very considerably better at all other times’ (1933, p.3, emphases original).

The study had been undertaken so as to facilitate a decision by the SBAC as to whether a Severn Barrage would be actionable. A threat to navigation had been very likely closed down it would seem, enabling decision-making to be more palatable. For Chair of the SBAC, Lord Brabazon, the model study had made present the future. Speaking in the House of Lords in 1943:

‘[The] model was based on soundings made by the Admiralty in 1849. [Gibson] built that model, and he then proceeded to flood it with tides [...]. He imitated the tides [...], he brought 1849 up to the present day [and] the model corresponded exactly with the present-day position. So



XV. THE SEVERN TIDAL MODEL SEEN FROM THE UPSTREAM END

On the right-hand side is a projecting wooden box incorporating a portion of the River Wye not included in the model as originally built

SCALES: Horizontal 1:8500
Vertical 1:200

Figure 31. 1933 Severn Barrage model at Victoria University, Manchester.
Source: Allen (1947).

extraordinary was the model that at the particular times of spring tides we [...] [got] the bore in the upper regions of the Severn. That showed how remarkable the model was. The barrage was then put in place in the model and we went on from the present day to a hundred years in the future, swilling the tides out and working the barrage to see whether it would have an effect on the ports of Bristol and Avonmouth. The results were quite satisfactory and no trouble arose, which meant that one of the difficulties had been cleared away' (Hansard 1943, pp.704-5).

The Severn Estuary in its modelled incarnation had been taken 100 years into the future with the barrage in place (100 years were the estimated lifespan of the project). The model for Gibson and Brabazon had satisfactorily mimicked aspects of the Severn Estuary's past and present, helping in placing some confidence in the model's 'making present of the future' (Holloway 2014) with regard to how a barrage would affect and be affected by the estuary.²⁵ The model for Brabazon becomes understood as the estuary itself, the model *is* the 'other' (the Severn Estuary) because of how for Gibson the model has closely mimicked the real estuary. The estuary's future with barrage for Brabazon had become knowable and the project actionable, the Severn Estuary pending other matters could become an energy landscape.

The study's involvement in facilitating a decision on the barrage generated fear for the future for the port and dock authorities at Newport, Avonmouth and Bristol (see Hansard 1930). These authorities imagined a disastrous future for themselves whereby the barrage harmed navigation. The model study became a target for critique in the hope of avoiding the feared future the model study had opened up for them. In an aptly entitled *Times* newspaper piece '*Fears for the South Wales Ports*', the engineer for the Newport Harbour Commissioners questioned the extent to which confidence could be placed in the model study: 'The tidal waters of the Severn Estuary are highly charged with silt and any estimate of the probable volume of siltation above the barrage based on model experiments cannot be regarded as conclusive' (The Times 1933, p.7). However, the dock and port authorities would soon breathe a sigh of cautious relief because the 1933 scheme did not proceed. For Brabazon: '[N]obody took any notice of it at all [...]. I think the reason [was] that [...] [it] saved the consumption of over a million tons of coal a year and from an area like South Wales, where there was a tremendous amount of unemployment at that time: so it had no friends at all' (Hansard 1943, p.707).

²⁵ Past and present behaviour of an environmental system is important in environmental modelling to thinking about its future (for overview see Beven 2010).

The 1945 revised proposal took the conclusion of the 1933 model study (that a barrage would not cause problems to navigation) as valid. This conclusion was invested in, being used as a baseline to predict modifications with an assertion that ‘modifications appear likely to improve rather than otherwise the results obtained with the model’ (Vaughan-Lee et al 1945, p.38). However, the authors suggested building a new model, but this time with a representative from the ‘dock authorities’ on a model committee of ‘hydraulic experts’. Within the MFP, there was widespread confidence in the future prophesied by the 1933 model study (see MFP 1944-1946). One of the port and dock authorities, the Port of Bristol Authority (PBA), understanding a new report was being made, quickly sought to find a way to damage the confidence placed by the government in the 1933 study’s prediction. This was by calling into question the modelling practice of Gibson by reading his 1933 model report. The PBA sought Doodson of the Liverpool Tidal Survey at the University of Liverpool, to critique Gibson’s work (Doodson was an established authority on tidal prediction, see Carlsson-Hyslop 2010).

Doodson had a major concern about the ‘validity of the tidal model’ in a letter to the PBA (Doodson 1944, np). This was over Gibson not addressing in the model ‘tidal friction’ as found in the estuary (tidal friction is affected by bed and shape on the tide). Doodson argued:

‘[The reproduction of the] tidal motion if true, must be due to fortuitous compensation of the defective frictional losses in the estuary [...] by excessive frictional losses in the river portion [...]. It is unreasonable to suppose without adequate proof that there would be the same fortuitous compensation if a barrage were set up between the area of defective [...] and [...] excessive frictional losses. It is therefore considered to be unwise to accept the indications of the model as a valid representation of the tidal motion after the construction of the barrage’ (1944, np).²⁶

A copy of Doodson’s letter was sent to Lloyd-George, Minister for Fuel and Power (1942-1945) and with the PBA complaining how:

‘Inaccurate and inadequate data were used [...]. The tide-producing apparatus in the model did not reproduce the tidal conditions [and] the model surveys for the specified ‘years’ did not reproduce important

²⁶ On the matter of tidal friction, in a personal letter to Inglis who was tasked with constructing a new model in 1947, Doodson suggested the ‘shock losses’ were ‘exaggerated’ in the model because of the ‘exaggeration of its vertical scale’ (1947, p.2). Doodson goes on to say: ‘[T]he effect of this uncertainty as regards friction losses on the tidal elevation is perhaps not of very great importance as it is perhaps not vital for Bristol that the present tidal range should be maintained, but the effect on the currents will be very large. The rate of deposition of sediment, and the places where sediment is deposited depend critically upon the tidal currents’ (ibid). Doodson became a member of the Severn Barrage Model Committee (SBMC) which was tasked with supervising the work of Inglis and the HRS. Doodson at the first meeting of the SBMC, maintained his charge on the model with regard to tidal friction (see SBMC 1954). So as to accommodate Doodson’s concerns, a lessening of the model’s scale distortion was to be undertaken.

alterations in the estuary that are recorded in Admiralty surveys for corresponding years [...]. The authority does not accept the finding of Professor Gibson to the effect that navigation would be in no way prejudiced by the barrage' (1944, np).

Several months later from the PBA address to Lloyd-George and Doodson's critical analysis, Clarry, the Newport Member of Parliament also addressed Lloyd-George:

'I was in my constituency yesterday and paid an unofficial visit to the Town Council there [Newport]. I now hasten to let you know their views on the Severn Barrage Scheme. Whilst in principle they are not in any way antagonistic to the idea of a hydro-electric scheme, they are very seriously perturbed at the repercussions on the port of Newport by any drastic interference with the tidal flow up the Severn. It is suggested, therefore, that before you finally approve the scheme, further practical experiments should be made in connection with silting on a new model which should be made for that purpose' (1944, np).

For the MFP, it quickly became clear a new model was needed and with representation of the dock and port authorities on a model committee. This was squarely to assuage the dock and harbour authorities fears and make the barrage project easier to implement and perhaps politically actionable. Such participation is 'instrumentalist' in approach (Krueger et al 2012). For one member of the MFP in a minute: '[W]ithout [a model] I gather there would be intense opposition from the Severn ports if it were ever necessary to construct the barrage' (Watt 1944, np). As noted earlier, the revised barrage scheme report (Vaughan-Lee et al 1945) called for a new model and dock and harbour authority participation. The PBA had pressed the writers for these (see Jones 1945), but the MFP might have as well. Members of Newport Town Council found themselves in a jubilant mood on finding out the report suggested a new model and with participation of the dock and harbour authorities. The council informed Lloyd-George they had just passed a resolution that 'the corporation and harbour commissioners place on record their appreciation of the recommendation' (Purpitt 1945, np).

In 1947, the Severn Barrage Model Committee (SBMC) at the HRS was formed, existent until 1955 and with the HRS undertaking the modelling work that will be of some importance to the remaining sections of this chapter. Committee members included several representatives of the dock and harbour authorities. The SBMC had the aim of creating a replica of Gibson's model, but for various reasons work on it was not started

until 1953 and the SBMC only sat twice.²⁷ The Severn Barrage project was called off for a modelling reason addressed in the next section.

Being involved with the modelling work was very important for the dock and harbour authorities because from such a position, unlike the 1933 model study, they had some amount of control in shaping the model study and from there influencing a decision on the feasibility of the barrage itself. Whilst a modelling practice like hydraulics is involved in decision-making, modelling itself involves making decisions. In the context of hydraulic modelling, decisions can occur around questions like; ‘what scale/s should be used’, ‘what needs to be modelled’, ‘what are the research questions that need to be addressed’ and ‘how are they to be’ or ‘do we take this interpretation/results as sound’ among others. Being able to have a voice on these questions, which those from the ports and docks now had, was from the SBMC’s perspective a practice that might very well ensure their commercial survival. For the MFP, it was a matter of making sure the future made present was not a divisive future, but one that could be shared, thereby making the project more politically actionable.²⁸

As noted in 5.3, confidence and its relation to model studies is not something given, but rather a feeling state made. Confidence has differing intensities (including no confidence) and is generated through sensibilities, knowledges (including modelling and water world knowledges), modelling materials, techniques, decisions, scientific instruments and modeller and institute reputations. Such is it that confidence is never always placed in a model study and by a diversity of agents. Within the 1933 Severn Barrage model study, a great deal of confidence was placed in the study’s prediction by civil servants both at the time and in the years of the revised proposal. Why this was the case is not clear, but matters of mimesis, Gibson’s eminence as a hydraulic modeller, the length of the study (taking five years) and later that the model study was widely praised within the hydraulic modelling community (Allen 1947) could have contributed. For the professional magazine ‘*The Engineer*’, the 1933 model ‘formed a record of experiments with estuary models hitherto

²⁷ Work starting later was due to several factors. Firstly, the MFP did not consider the barrage project to be actionable anytime soon and regardless of any modelling work. This was because for the project to be feasible an event of high coal prices or and/or high unemployment needed to occur. Another factor was that Inglis was undertaking a major estuarine study on the Thames and Inglis thought concentrating on this project for a while would enable an easier time in completing the Severn Barrage project as experience and new knowledge would be gained (see Mason 1948).

²⁸ Futures, however mobilised (imagined, performed, calculated), are inevitably bound up in the here and now. Of further interest to geography would be attempts to explore collaboration and participation in anticipatory futures which have lacked attention (although see Dodds 2012; Holmes and Krzywoszynska 2014). Focus on co-production in anticipatory futures involves examining the actors, institutions and practices, processes and social relations that go into calculating, imagining and performing futures.

unparalleled, certainly in this country and not we believe equalled in wealth of detail by any records published in other countries' (1959, np). Doodson, the SBMC minutes read: '[C]onceded that the investigation was a wonderful piece of work for its day' (SBMC 1954, p.3).

For the port and dock authorities, the model study was a source of consternation over questions of mimesis and critiqued because of its eminent power in a decision and with the Severn Estuary becoming a space of contestation and also consternation, the latter of which ports and docks also became. A highlighted, several concerns worried the port and dock authorities over the model study. One of these was 'inaccurate and inadequate data'. 'Data' ('facts and statistics'), as will be seen in the next section, are important to hydraulic modelling because data is what is used to generate mimetic relations between the model and modelled. A second concern involved modelling practice. The PBA via Doodson questioned the model on how Gibson had failed to evaluate 'tidal friction' post-barrage, a phenomenon Doodson estimated in a personal letter to Inglis would have 'very large' 'effects on the currents [...]. The rate of deposition of sediment and the places where sediment is deposited depend critically upon the tidal currents' (Doodson 1947, p.2). Also related to practice and a final reason why the PBA argued the model could not be taken to provide a likely window on a post-barrage future, was that the intensity of past bed-change mimesis was problematic. Gibson did not have a problem with what discrepancies there were, however, and as will be noted in 5.8 some intensity of (known) discrepancy between model and modelled is expected.

The 1933 Severn Barrage model and debate underlines how models, modellers and modelling can produce and inflect various 'presence of the future' emotions, feelings and spatial imaginings. The Severn Barrage study and debate made present and gave character to several feelings of angst, confidence and hope, each mobilising particular spatial imaginings; the Severn Estuary could become a 'landscape of energy' (confidence); navigation would be disastrously affected (angst/fear); and finally disaster could be averted with a place on the model study (hope). All these drew on and mobilised practice. Model studies have the power, through decision-making, to open up and close down futures and despite being one particular case, the critique of the 1933 Severn Barrage model can be used to make a point on how and why hydraulic models, modelling and modellers may be critiqued. Infrastructures and interventions *become* in the real on the basis of model studies and so questions of mimesis in regard to models and the practices of modellers become ripe for critique. In considering the critique of model futures, affect, emotion and feeling

and relations with models, modellers, modelling and landscapes, places and environments, are especially important in how critiques of models come to matter, including politically.

5.6: Knowing water worlds: Fieldwork practice, uncertainty, instrumental knowledge and the future

Hydraulic modelling involves an endeavour to know water worlds. Pasts and presents of water worlds are attempted to be known for the purpose of experiment and with water worlds coming to be understood, although not exclusively, in an abstract way and physically and materially. Hydraulic modelling is a practice wherein the complexity of the water world as a ‘four-dimensional materiality’ (depth and time and two dimensions of area) (Steinberg 2013), full of ‘dynamism and vitality’ (Palmer and Jones 2014, p.223) is comprehended. This section focuses on researches on water worlds and incidentally enabling a human geographic reading of water worlds following Mack as something other than ‘either [...] the backdrop to the stage on which the real action is seen to take place – that is, the land – or [...] simply as the means of connection between activities taking place at coasts and in their interiors’ (2011, p.19 in Anderson and Peters 2014, p.3, also see Peters 2010; Steinberg 2013). Water worlds become in this section spaces of difficult study for hydraulic modellers, often making modelling a fraught, at times ineffective practice because of uncertainty. As stated in 5.5, water worlds have the potential to make models and modelling a contested practice and water worlds can become spaces of contestation and also consternation. In this section, water worlds can become spaces of consternation for modellers in relation to uncertainty, a feeling state sought to be ameliorated through knowing water worlds and it is shown here via particular practices and technologies which try to make confidence in modellers, models and modelling. Through how this section engages with water worlds and modelling practice, it finds how the practice of mimesis is negotiated by the materiality and agencies of water worlds and also how technologies of abstraction in the context of scientific instruments have a generative role in knowing water worlds, involving hopeful dispositions.

Hydraulic models only ever present ‘bits’ of water worlds, certainly spatially and very often in terms of the inclusion/exclusion of its materials, patterns and forces. Either

before or through fieldwork, the question is asked: 'What is/are the concerning thing/s that will affect and/or be affected (particularly wave action, bed movement and change, flooding and bank/beach/cliff erosion). The agencies of water worlds and how they are regarded in terms of importance define the spatial scope of a model in as much as thought about how the scheme in question may be thought to markedly affect and be affected. Models can be very focused such as ones concentrating on wave action with a breakwater. Where bed movement and change is a concern, models are spatially extensive. For instance, Jack Allen in his introductory book on hydraulic modelling warns readers 'the limit shall be sufficiently remote from the site of the works concerned to make it tolerably certain that the [bed] conditions at the entrance to the model will be sensibly unaffected by the proposed works' (1947, p.276). In the context of a model to ascertain the best dredging scheme for Southampton Docks, modellers Wright and Leonard after reading several journal articles about the watery agencies in the vicinity, determined 'the site of the proposed dredging scheme and the general hydraulic regime precluded any possibility of modelling Southampton Water' (1959, p.4), instead including the nearby Solent.

What data is needed for a model relates to the research question/s the model study is intended to address. In attempts to gain knowledge, charts of the river, coast or estuary in question may be assembled, displaying elements in space and time of its past, whilst material in suspension (e.g sediment) or bed material may be brought to the surface by instruments so as to sample for measuring and mapping purposes. Salinities, current velocities and water temperatures might be measured and mapped along with tides, depths (soundings), wind records and current directions.

As will have been evident in 5.5, hydraulic models can be critiqued on the data used, not used or phenomena that could have become data (e.g. Doodson's 'tidal friction'). To begin this section, concerns over the data used for the 1933 Severn Barrage study can be detailed. Gracey, of the Port of Bristol Authority (PBA) argued in a circulated memorandum to the HRS, Severn Barrage Model Committee (SBMC) and the Ministry of Fuel and Power (MFP), that for instance on the subject of tides, the number of selected observing stations and of automatic gauges (to measure tides) were 'too small', temporal observation 'too short' and the available data 'inadequate to establish mean levels, ranges, periods and curves' (1947, p.3). Gracey was of the view that the 1933 model parameters (measurable factors) (and which would define tolerably well for Gibson the Severn Estuary for the lifespan of the Barrage) were deficient. The model was, contrary to Gibson and Brabazon and others, not the Severn Estuary. Gracey's memorandum was critiqued by

Jack Allen, one of the modellers working under Gibson on the 1933 study and a member of the SBMC:

‘I feel that the reader of Commander Whitla Gracey’s memorandum will probably conclude that there was an unusually small amount of data for the 1926-1933 Severn investigation. In fact, the contrary is true in every respect: tide and current data, surveys, silt, salinity, sand samples and river discharges. I do not think more information on these matters has ever been available for any tidal river model investigation either in Britain or abroad [...]. The Severn would, in general, be peculiarly well favoured in these respects and in the detail with which the model was scrutinised to compare its behaviour with all the available data’ (1948, p.4).

Unfortunately, Allen does not address Gracey’s concerns over the temporal extent of the data, but temporal extent is a subject that will be raised later in this section. Gracey’s memorandum and Allen’s rebuff draw attention to how the Severn Estuary, like any water world, can be defined for hydraulic model work. What should be noticeable is that the estuary is apprehended in a quantitative way, the domain of number, whereby following Nash ‘knowledge [is] mediated by complex instruments [...], an objective and scientific understanding of nature’ (2000 p.1005). This is of a similar conceptual thread to Lynch’s (1990) idea that scientists address phenomena through the visual and mathematical practices that make them calculable. Scientific instruments, as Humphreys (2004) asserts, can extend human’s ability to observe (but also collect) phenomena and for Bourguet et al (2002) measure it to a standard. However, it is important to point out that the agency of instruments can affect how phenomena and spaces and places are known (Holden 2005). Phenomena, as interpreted by scientific instruments, can be made sense of by humans through the chart, table and graph, what Latour (1999) would regard as ‘inscriptions’ (see figures 32-34, pp.153-155). The making and use of scientific instruments and inscriptions lie with an attempt to come to terms with the dynamism of water worlds. Scientific instruments and inscriptions can be considered ‘technologies of abstraction’, technologies that as will become evident over the course of this section in the case of scientific instruments, are made and used with a hopeful disposition towards their *prospective* potential to make thinkable and sense-able water worlds.

In 1954, some years into the Severn Barrage study, an estuarial phenomenon the HRS named ‘upstream bed-drift’ (silt moving up the bed of an estuary from the sea on the flood tide) had been ‘discovered’, at least within hydraulic knowledge (see Inglis and Allen 1957). Upstream bed-drift had been found by chance via a Geiger counter on a HRS research boat for a study on the Thames Estuary. The possibility of this phenomenon

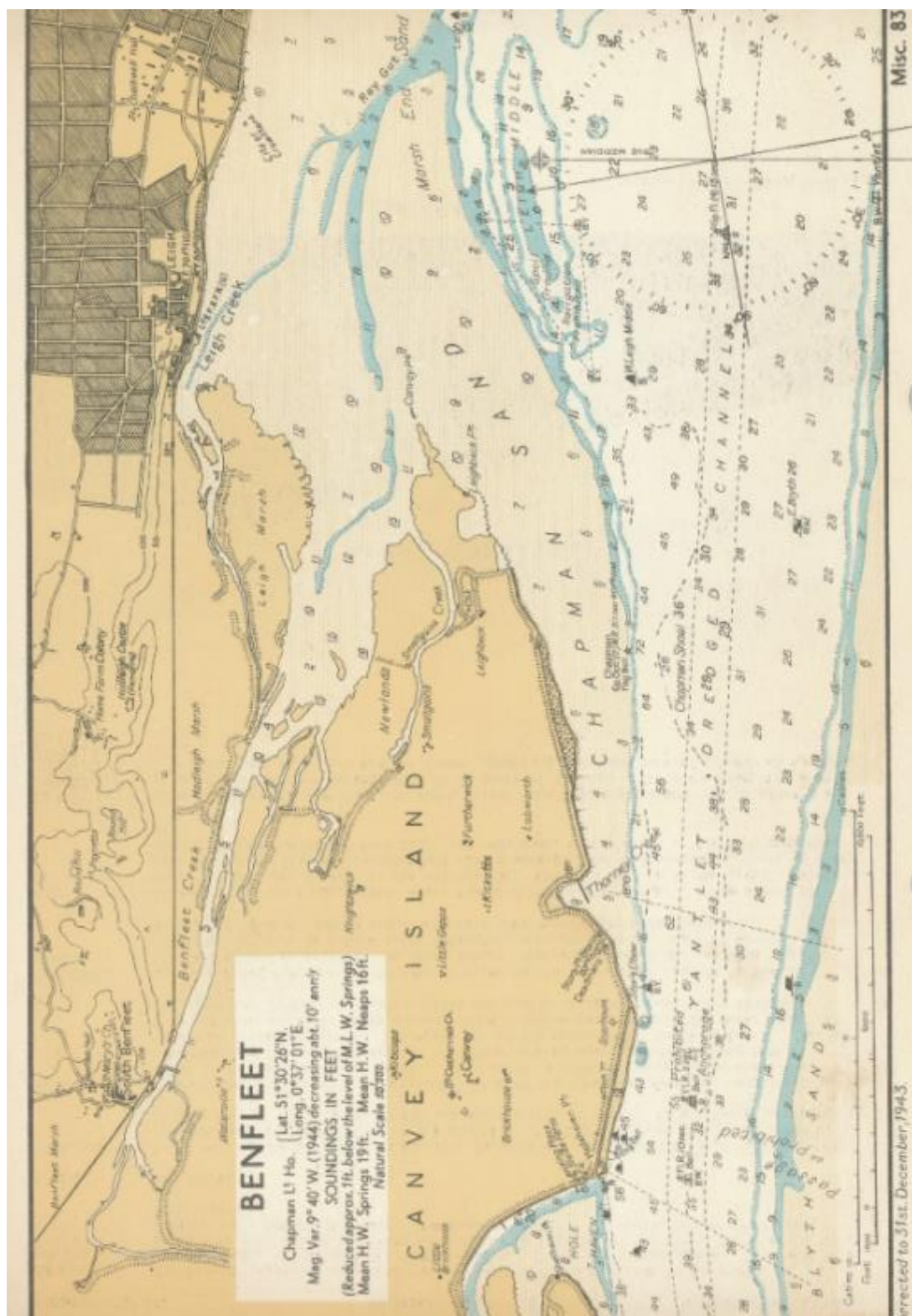


Figure 32. Admiralty, Royal Navy, chart of Benfleet, Essex, 1943. Source: Admiralty (1944).

SEVERN RIVER BOARD

Fisheries and Pollution Prevention Department

ANALYST'S REPORT

Chief Chemist.

D. H. A. PRICE,
B.Sc. (Tech.),
LEICESTER, ENGLAND.

River Severn at Minsterworth continued.

Date	Time	Tide at Sharpness		09.00 flow at Bewdley million gallons per day.	Suspended solids in parts per ml.		
		Preceding High Water	Height Ft. Ins.		Total	Ash	% Ash
14th November, 1953	08.30 hrs.	00.09	19 2	2,219	653	570	87
26th "	09.05 "	25th 22.56 26th 11.10	23 5 23 1	697	1,975	1,778	90
8th December,	11.45 "	07.45	26 1	815	175	151	86
17th "	11.30 "	04.28	22 4	621	974	803	91
1st January, 1954	12.30 "	04.28	17 10	643	19	113	84
10th "	15.30 "	11.32	27 4	448	135	147	82
23rd "	16.10 "	10.34	26 10	3,440	142	147	88
5th February,	10.30 "	09.19	31 4	740	2,649	2,339	90
17th "	10.30 "	08.03	27 4	1,944	74	67	90
4th March,	09.30 "	07.31	28 2	1,609	154	121	79
16th "	11.30 "	06.03	21 5	918	195	166	86
22nd "	10.00 "	03.34	17 5	1,021	342	297	87
23rd "	10.30 "	04th 23.28 9th 11.54	24 1 22 0	1,123	74	62	84
24th "	13.30 "	09.59	24 2	464	68	42	62

/Cont.

Figure 33. Severn River Board report on tides at Sharpness, volume of river flow at Bewdley and the amount of suspended solids near Avonmouth. Source: Severn River Board (1954).

Bed dune formation in Tidal river:

Position	Date	Wavelength feet	Height feet	Method of sounding Echo	Tide Mean SPI tide. 22
C/S 87 to 88	4-7-40	165	4	Echo.	
C/S 88 to 89	4-7-40	165	3 to 5	Echo	
C/S 89 to 90	4-7-40	110	5	Echo.	
C/S 90 to 91	4-7-40	110	2½ to 5	Echo.	
C/S 91 to 92	4-7-40	110	2 to 4	Echo.	
C/S 92 to 93	4-7-40	73	2 to 3	Echo.	
C/S 14/0 to 14/1	4-7-40	94	2 to 4	Echo.	
C/S 14/1 to 14/2	4-7-40	70	2 to 4	Echo.	
C/S 92 to 96	24-10-41	240	2	Pole	Spring
C/S 15/2 to 15/5	24-10-41	280	2	Pole	
C/S 92 to 96	7- 5-43	220	2	Pole	Mean s 22'8"

Figure 34. Bed dune formation records, Humber Estuary. Source: Kenny (1948, p.13).

occurring in the Severn Estuary required the HRS to talk to a key local contact developed through the study:

‘This morning Mr Groves discussed the Severn Barrage question with [Fergus] Allen, Jaffrey and myself [Inglis]. He has lived on the Severn all his life and he and his brother probably know more about it than anyone else [...]. A point of great interest which confirms our experience in the Thames is his statement [about] [...] a liquid mud layer on the bed [...] put into suspension during high flood tides’ (Inglis 1954a, np).²⁹

The discovery of an ‘upstream bed-drift’ for the HRS had formidable implications for the Severn Barrage study. Upstream bed-drift could not be easily known in such a way to enable confidently its mimicking in the model. Upstream bed-drift presented, as Spencer of the MFP noted in a memorandum: ‘[E]xtraordinary difficult observations in open sea conditions to obtain the data to feed into the model’ (1955, p.6). Inglis, in a memorandum for the SBMC:

‘[M]easurement of the excess upstream bed movement over downstream movement of silt would present extraordinary difficulties, partly because there is no known method of measuring movement of material along the bed, but chiefly because simultaneous observations across the whole of the mouth of the estuary would be necessary to assess the excess of landward bed movement over the seaward movement [...]. [A]part from the fact that the work would take many years, the results would be uncertain’ (SBMC 1955, p. 2).

Unless the amount of movement of suspended material and bed material in and out of the estuary under existent conditions could be measured and mapped and through this, confidently mimicked in the model, how the barrage would influence the future movement of material could not be assessed. To know upstream bed-drift in the way needed for a model, the HRS would be pressed to develop a stratagem for surveying it and utilising and developing measuring instruments, since as Doodson noted ‘the difficulty in making measurements of it [is because] [...] there was no solid bed in which meters could rest, they would simply disappear into the mud’ (SBMC 1955, p.5). Whilst the HRS were likely to develop a way of measuring movement of upstream bed-drift along the bed, they were less certain the differential between landward and seaward movement could be known

²⁹ Contact with Groves and how the HRS described him as ‘[having] lived on the Severn all his life and he and his brother probably know more about it than anyone else’ draws attention to a practice of ‘inclusive forms of knowing from non-professional domains, such as the knowledge of people living, working or recreating in a place of model application’ (Krueger et al 2012, p.5). Initial contact was made with Groves not out of desire for knowledge, but because Groves had written to the HRS about how he could help collect mud samples.

anytime soon. This issue in part led to the MFP abandoning the Severn Barrage project in 1955 and ultimately the ports and docks breathed a sigh of relief.³⁰

Upstream bed-drift draws attention firstly to an issue that knowledge of water worlds is limited and that in many ways it is in the need to model them and attendant reasons that constitute a context in which knowledge of water worlds is made. Secondly, that knowledge acquisition can be difficult because of the materiality/materialities and agencies of water worlds and ineffectual for uncertainty over the same matters. The third and final point is the fallibility of model studies. The absence of upstream bed-drift from the 1933 model study brings into question the study's conclusion beyond the PBA and Doodson's criticisms. Had the Severn Barrage been built, it may have affected and been affected by the Severn Estuary in ways not imagined or intended by its modellers and the government. With this in mind, hydraulic models, like other kinds of models, do not mimic 'reality' but rather our 'idea of reality' (cf Nordstrom 2012 on geochemistry and models). Hydraulic models and modelling when understood this way, and when we include questions as to the future agencies of water worlds, mobilise for modellers feelings of uncertainty, questions as to the limitation/s of modelling and a politics of, and epistemologies to, modelling (in the context of environmental modelling see Beven 2010; Brown 2004, 2010; Budds 2009; Rocchini 2011). Needless to say, as physical geographer Lane (2005) suggests, we can only 'quantify' a little bit of uncertainty, or rather I would frame it such that uncertainty is only made present in relation to what is *known* as unknown. Naturally, beyond the little bit of the unknown that is known, there is a whole realm of 'unknown unknowns' (Beven 2012) such as the upstream bed-drift issue for Gibson.

Uncertainty about water worlds caused the HRS to quell an enthusiasm by the Ministry of Local Government and Planning (MLGP) for research with models into coastal erosion problems. In 1951 the MLGP were seeking research into 'best designs' of groynes, revetments and sea walls, a general kind of research (see DSIR 1951). In response to the MLGP query, Inglis pointed out that knowledge about coastal processes was lacking. As such, confidence could not be entirely placed in model studies: 'I regard [this] as a long-term question depending on accumulating knowledge and I consider the results obtained

³⁰ As well as the difficulties faced in knowing upstream bed-drift the HRS considered that upstream bed-drift would cause the Severn Barrage's performance to decline over time as noted by Spencer of the MFP: 'Whereas DSIR had hitherto thought that the research problems centred round shifting sandbanks below the dam, they now think that an equally important problem is deposition above the dam of slit carried up on the tide. This would reduce the water storage capacity and if it occurred other than very slowly the dam might become economically valueless before the capital invested was amortised' (1955, p.1). Another factor in the abandoning of the Severn Barrage project for the MFP was an enthusiasm by the Ministry from 1953 for nuclear power as a way for providing for the UK's energy needs, see TNA: POWE 25/151.

in ad hoc model investigations of coast erosion problems will, in the present state of our knowledge, have to be used with great caution' (1951a, p.2).³¹ Inglis here is trying to manage the confidence placed in model research from potential clients. Inglis is seeking to protect his personal reputation, as well as that of the HRS and the activity of hydraulic modelling more generally, from undue hope, more on this in 5.8.

By 1951, the HRS had established a dedicated survey team for the collection of hydraulic data for model studies and other major hydraulic research centres like WES and Delft (Netherlands) had one. Having a survey team was important to 'the collection of accurate and relevant data' (1951b, np) for Inglis. For Deputy Director Fergus Allen it was a 'string to the bow [of the HRS] [because] alongside freeing up some time for the SEO's [Senior Experimental Officers], it gives some relief to [agents] if they are not sure about what they are doing, as well as giving greater confidence in model studies' (1955b, np).³² Previously in UK based HRS projects, the agents requiring a model study would be pressed to acquire data and with advice from the HRS via correspondence and meetings. As Inglis and Allen have asserted, having a survey team was important because it relieved pressure on the model's agents and with fieldwork strategy and practice easier to manage and a 'quality control' of a kind could be felt to be ensured. Having said this, the model's agents might have significant knowledge about the past and present agencies of the water world in question and as part of the HRS fieldwork this was drawn on (see Cashin et al 1956). Distance and questions of travel and expense posed a limit on the activities of the HRS's survey team. Fergus Allen noted in a report to the HRB on his 1953-4 visit to CIHRS that 'the advantages of a station survey team are obvious [...], but as problems are submitted to them from all parts of the subcontinent the administrative and practical difficulties are also obvious' (Allen 1955c, p.26). The HRS's survey team did not venture outside the UK and possibly for the same reason Allen gives for CIHRS's lack of a survey team. On projects abroad, distance was overcome by paper correspondence with the agencies wanting the model study and/or undertaking the data collection. Instruments, certainly in the case of a model of Portsmouth Harbour (Freetown, Sierra Leone), were shipped over for use.³³

³¹ Relating to a lack of knowledge of coastal processes, Inglis is more explicit on this in a 1949 letter to the Ministry of Health about coastal protection models: 'I do not think the factors controlling bed movement in the sea are sufficiently understood to enable us, at this stage, to know the exact reasons why changes are taking place, much less to reproduce them in our models. So, as a first step we want to examine specific problems in the field, to see how far we can measure and diagnose and explain what is happening and decide what further data are required and how these can best be obtained – instruments required etc' (Inglis 1949, p.1).

³² It is not clear what kind of academic and/or professional background the survey workers had.

³³ Although the HRS undertook studies abroad, there are no extensive National Archive files dealing with the projects. This is unfortunate because it would have been interesting to examine if there was any kind of

Forsyth, in her review of the geographical literature on scientific fieldwork, has suggested that ‘the place of nonhumans as active agents – shaping scientific research [...] - in the field remains largely absent’ (2013, p.55). Fieldwork for model studies was usually very difficult and with the agencies of water worlds and fieldwork instruments and other technologies shaping the practices of it. The empirical rigours that fieldwork might demand might be affected by the embodied effects of fieldwork on HRS workers. In a study on Southwold Harbour:

‘Since there was no suitable wave recorder for the low, short waves [...] [found in an area near to it] [...], the waves were recorded by photographing with a cine-camera the rise and fall of water against three tide gauges. The analysis of the film and the production from it of a wave-height curve was a laborious process and for this reason only a few complete waves were plotted for each condition of wave and tide’ (HRB 1955, p.37).

Here, the method to acquire knowledge was felt so ‘laborious’ a more limited survey of waves ended up being accepted. Indeed, fieldwork practice design/strategy might take these embodied affects of the fieldwork into account. An internal HRS report on ‘*Data required for investigations on siltation in estuaries*’ (HRS 1955) suggested that because:

‘[In working with a particular current meter] the tape moves rapidly through the recorder and a continuous record soon becomes unwieldy and extremely laborious to analyse [...], the record should, therefore, be made only for a half a minute at intervals of ten minutes. This will provide ample information except at the periods near high water slack and low water slack when the interval should be reduced to five minutes’ (HRS 1955, p.2).

Disappointment and frustration had taken hold of HRS workers early on in the Severn Barrage study in 1948 because many of the HRS’s tidal gauges (to record tidal levels) had been ‘lost in the mud’, swallowed up by the estuary and rendered ‘irretrievable’ (Inglis 1948, np). It was thought to postpone until better conditions in the estuary developed, anticipated in the spring of the following year. Having to abandon measuring tides until amenable estuarine conditions enabled the HRS’s data collection instruments to work, raises an issue about how the non-human world may disrupt the practices of scientific fieldwork.

HRS fieldwork practice was very much shaped by the patterns and forces of water worlds and often because these patterns and forces were important subjects of study. Several examples are outlined here. Firstly, the HRS internal note ‘*Data required for*

politics to fieldwork and data given the context that fieldwork happens and data is collected ‘at a distance’ from the modellers.

investigations on siltation in estuaries' (HRS 1955) required that for 'salinity observations [...] bed and surface samples should be taken simultaneously at 20 minute intervals throughout the tidal cycle' (i.e. for 13 hours) (p.3) and that 'ideally this sampling should be carried out at springs and neaps, for both dry weather and upland flood conditions' (ibid) ('salinity' is total salts, 'springs' is high/low tides at full moon whilst 'neaps' the same but at quarter moons). Secondly, longitudinal salinity distribution sampling would start at the mouth of the estuary when salinity is nearly equal to that of sea water and finish in the estuary's upper reaches when salinity is as 'low as one or two parts per thousand' (ibid). A final example is a method for gaining knowledge about the 'shape' of an estuary. This was very much negotiated by the particular estuary in question, its material make-up and forces such that place has a part to play in the strengths and weaknesses of a method to gain scientific knowledge (Rees 2006). An internal note '*Data required for investigations of tidal estuaries*' (HRS 1954) suggested that on the HRS's Wyre Estuary study (Lancashire):

'[S]urvey of cross sections [of the estuary] by chain and level gave the most accurate and comprehensive information, but its application to other estuaries is limited because it can only be used if most of the estuary runs dry at low tide. Also, it was the most expensive method and took the longest time. The latter objection is important if changes occur rapidly' (p.4).

Another way of comprehending the shape of an estuary was 'cross sections by echo sounding', but this method was problematic in those estuaries with lots of soft mud because 'no reliable levels can be obtained from stretches which are covered by it' (HRS 1954, p.4).

Wherever possible, knowledge of the water world in question via maps (e.g. Ordnance Survey), charts (e.g. admiralty charts), books (e.g. geological history), records (e.g. River Board data on silt load, tidal heights and others) and reports (other research) would be utilised. Such materials, each having a priority to portray aspects of a water world, were composed by a diversity of agents, from the military such as the UK's Admiralty, to public bodies like the UK River Boards. In the Severn Barrage study, existent knowledge on the estuary important for the model lay spatially fragmented, but was brought together at HRS Wallingford.³⁴ Such knowledge was not uncritically apprehended and used,

³⁴ Several years into the Severn Barrage study, Inglis, according to Fergus Allen: '[Felt] some anxiety about our knowledge of the estuary [and] our collection of data' among a number of other worries which included 'the details of the problem we have undertaken and the actual experiments we propose to carry out' (1954b, np). In response to Inglis's anxiety HRS modeller Jaffrey composed a numerically listed note of existent knowledge as below (Jaffrey 1954, p.1);

1. 'Admiralty surveys of 1922-28 and charts of earlier surveys
2. Port of Bristol 5 yearly surveys of King Road

although the question of how and why is not so clear in the archive, but for inscriptions a good spatial, temporal, methodological and instrumental context appear important ('when, how and where these data were observed' for Juston et al (2013, p.118)). An example of this can be evidenced from the Severn Barrage study when Fergus Allen corresponds to modeller Jaffrey: '[T]he data on salinities and suspended load at Avonmouth, Beachley and the Shoots seems enough to start with - if the actual sampling positions are known. Are they? (just 'Avonmouth' and 'Beachley' doesn't tell one much)' (Allen 1954b, np, underline original). Existent knowledge felt as lacking or problematic might give shape to the practice of fieldwork. For Jaffrey in the Severn Barrage study:

'[I]n the case of bed material, although many samples over a wider area were examined [in a previous survey], they were described in very general terms [...]. If it is deemed necessary to obtain bed samples for laboratory analysis then a bed sampler or grab or scraper type will have to be devised and arrangements made for a survey team to cover the river on a grid of say ½ mile side' (1954, p.4).

As noted earlier in this section, knowledge about water worlds for modelling is in part made by instruments that extend human capacities to observe and collect phenomena and measure it to a standard. Scientific instrumentation has been of substantial interest since the 1980s to historians of technology and historians and philosophers of science (for overviews see Bud and Varner 1998; Record 2013) and more recently to historical geographers of science (see Livingstone and Withers 1999; Naylor 2006; Whitehead 2009; Withers 2013). The importance of instruments in hydraulic knowledge production, and its claims to epistemic authority, can be attested through instrumental absence via the upstream bed-drift problem and the Hydraulics Sub-Committee's comment that 'much of our present lack of knowledge is due to the absence of suitable instruments for observing, measuring and recording the phenomena' (1945, p.16). In the service of the need to be able to know and quantify, to claim and practice epistemic authority and for a hydraulic model to become an epistemic object, the HRS, like the Waterways Experiment Station (WES) and many other hydraulic research centres, had its own 'instrumentation laboratory'. This was a place where instruments were developed so as to improve on

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3. Gibson's report
 4. Commander Whitla Gracey's memorandum
 5. Lt Commander Berncastles' report, 1947
 6. Liverpool Tidal Institute report on tides and tidal streams in the Bristol Channel and Seven Estuary, 1948
 7. Admiralty data on salinity and suspended solids, 1928
 8. Aerial photos (RAF) (Royal Air Force)
 9. Admiralty report on tidal steam observations at New passage, 1936?

accuracy from other instruments or methods as well as make methods of recording and use of instruments easier, less laborious than before. Instruments would also be tinkered with and maintained. New instruments would be patented sometimes, be able to be purchased, and written up in specialist journals for dissemination and possible replication and adaption elsewhere (for the HRS particularly *Journal of Scientific Instruments*, e.g. Sandels 1956).

Whilst commercial firms made some non-exclusive hydraulic modelling instruments (e.g. the 'Robinson current meter'), hydraulic modelling demanded many specific instruments with some made for just a study, being essentially place-specific. In this latter case, being able to easily tinker with existing instruments and devise new ones according to place demands was regarded as producing more confident modellers (less uncertainty). The HRS instrument workshop was created and funded by the DSIR to fulfil its desire to intervene on uncertainty as per 5.3.

This section will close on the future. Water worlds are dynamic, changeable environments and data on the past and present of these spaces are gathered and collected for helping make present the 'not yet'. Hydraulic modelling, and environmental modelling more generally, potentially invites responses to Anderson's question: '[H]ow does the future relate to past and present?' (2010a, p.780). Anderson argues that in not attending to 'interrelations between past, present and future [...] the risk is that we repeat a series of assumptions about linear temporality: specifically, that the future is a blank separate from the present' (ibid, p.793).

Because a hydraulic model is a 'closed system' and not an 'open' one like the modelled, humans have to provide model 'inputs' over the time of the experiment. This might be volumes of silt, forces and volumes of water (velocity and discharge), wave and tidal patterns and equally forces, events and patterns such as flooding, storms and channel changes. Such volumes, patterns, events and forces might affect and be affected by materials in the model, whether the structure/s for the experiment, bed formations, sediment transportation, erodible banks or cliffs. In both real and model, volumes, patterns, events and forces help make depths, features and extents to water worlds (and in the real also cultural attitudes to them, see Griffiths and Salisbury 2013). Depending upon the problem faced, temporally extensive data on patterns, forces, events and volumes is often desired, and the more the better, because it enables the discerning of trends that, with judgement, could be said with variant intensities of certainty to occur in the future.

The future, for its interrelation with the past and present, can be worrying when there is little data with which to confidently perform experiment. For Gerald Lacey who was on the HRB: '[O]ne of the saddest entries which an engineer could find in a record of rainfall or river discharges was a whole decade during which observations had been discontinued, though started again. That was a crime against hydraulics and hydrology' (Hardy et al 1956, pp.353-354). The HRS archive is surprisingly silent on critical questions of the interrelations between the past, present and future, 'critical' because the negotiation of the future with snippets detailing the past and present can be problematic and not just in hydraulic modelling, but across the environmental modelling spectrum (see Beck et al 1997; Beven 2012, 2013; Oreskes and Belitz 2001).

Lacey's despair at the incomplete nature of some rainfall records can be related to Gracey's concern noted at the beginning of this section about the 1933 Severn Barrage model study in which 'temporal observation' was 'too short' and the available data 'inadequate to establish mean levels, ranges, periods and curves' (Gracey 1947, np). For both Lacey and Gracey, the worry is that temporality of data will deaden future change, stifling the potential for difference beyond the data. For many hydraulic model studies, including current studies, there is a 'deadening effect' for several reasons; the vibrancy and unknowability of water worlds, the use of means and averages and the future as difference as much as trend and pattern. Elements of this can be evidenced for instance via Novak et al:

'To prove the model, the actual sequence of discharges in the Danube (according to daily readings at the gauging station in Bratislava) was reproduced on the model for the period of three years and the resulting bed forms compared with those recorded in the prototype [...]. The same sequence of discharges for the period of three years was then used to study the effect of various river-training measures to find the best solution. The proposed measure, when carried out in the prototype, resulted in a bed configuration that on the whole closely corresponded to the one predicted from the model. Small differences – apart from other uncertainties could be attributed to the fact that, although the actual flow duration curve for the period used on the model closely resembled the actual one, the actual sequence of discharges was, of course, not the same as the one used on the model' (2011, p.350-352).

As will be detailed in 5.8, temporality of data can be one issue that affects how the epistemic 'character' of a model is made and thus its predictive character.

5.7: Scale effect and the negotiation of confidence

One of the most noticeable differences between a hydraulic model and the modelled is, of course, size and very often models are geometrically distorted. Relating to size and distortion is scale (Montello 2001). Scale, which is inherently spatial and, therefore geographic, has many meanings. As Ruddell and Wentz argue, scale ‘can be used to describe the level of detail, or scale of observation, [it] can also refer to the scope of spatial extent of the study area, known as the geographic scale’ (2009, p.682) among other examples. These definitions of scale are not how scale is understood and practiced with hydraulic models although, as noted in 4.7, also model railways. Scale is rather understood and practiced as ratio: ‘[A] proportional relationship between things’ (OED 2015a, np). Relation is implicit in this mobilisation of scalar meaning. Whilst in a model railway all things are, or at least are hankered to be in ratio (or equal relation) to each other, this is often not the case in physical hydraulic modelling. Often a physical hydraulic model for lack of space, need for embodied and instrumental observation and the mitigation of water’s surface tension effects, besides several other human and non-human factors, will have a different scale ratio in the horizontal and the vertical (geometric distortion). For instance, HRS modeller Russell explaining his choice of vertical and horizontal scales (1:180 and 1:90 respectively) with a model of Port Lyttleton in New Zealand:

‘The horizontal scale of 1/180 was arrived at as a consequence of a desire to include as large a scale as possible all the bays and headlands that reflect waves towards the harbours, some space for paddle-generated waves to settle down in, and some space for the waves to be slowly dissipated in. If the experiments had been made with an undistorted model the analysis of the experimental results would have been easier, but, unfortunately, a vertical scale of 1/180 would have resulted in such shallow depths that waves would have been excessively damped by friction as they travelled up the model. It was calculated by a method due to Hunt that if the vertical scale were 1/90 the damping of the waves would be just tolerable’ (Russell 1956, p.5-6).

Furthermore, particular material things within a hydraulic model can have a different scale from the geometric scales. Russell again: ‘[T]he slopes of flatter inclination, e.g. the faces of the breakwaters [...] were treated differently [...], these slopes were reproduced without distortion with the object of enabling waves that break on them in the prototype to break similarly in the model and dissipate the same proportion of their energy’ (1956, p.6).

Why it is possible for any physical hydraulic model to have any practical relevance to agents (River Board, dock authority etc) or in other words for physical hydraulic models to become epistemic objects, lie with the application of basic to complex mathematical equations (and of relation to certain physical laws) that enable equal relations to be made between certain aspects of the fluid flow situation in the model and modelled. For ‘distorted’ models in river, estuarine and coastal engineering (the majority of models so far discussed, including the 1933 Severn Barrage model) time and velocity scales are related to the linear scales by the principle of ‘dynamical similarity’ ‘and adhering to these time and velocity scales except in so far as small modifications may be suggested by a comparison of [...] [model] phenomena with the corresponding phenomena in nature’ (Allen 1947, p.311).

Whilst scale and geography (and with scale, primarily understood as level) has come under substantial critique in a 2005 paper by Marston et al (2005) who calls for its abandonment in favour of a flat ontology, scale in geography despite such a call is stronger than ever (see Legg and Brown 2013; MacKinnon 2011). Geographers have been considering how scale as level may have particular effects or consequences (Legg and Brown 2013; Legg 2009; Simons et al 2014), ‘have meaning and power for actors in the world’ (Jones et al 2013 p.192; also see Legg 2009; Loftus 2015) and composed of sets of practices and discourses (Gibbs et al 2015; Moore 2008), for Simons et al ‘material-semiotic practices of making and unmaking relations between numerous heterogeneous actors, both human and nonhuman [...], the ‘stuff’ scales are made of’ (2014, p.635). Although there are differences between the kind of scale hydraulic modelling practice works with and scale as level, Simons et al’s (2014) reading of scale as ‘making’/ ‘unmaking’ ‘relations’ between ‘human and nonhuman’ actors offers ground for similarity. As will be detailed in this section, scale, in its making and unmaking of relations, has the potential to generate material affects, something that can generate embodied affects in so much as to how a hydraulic model phenomenon, what is called ‘scale effect’, can negotiate the confidence placed in HRS model studies.

Scale has effects in physical hydraulic modelling and as a product of abstraction and miniaturisation, there is a phenomenon called ‘scale effect’, or alternatively ‘scale defect’ (Novak 1984; Novak et al 2011). Scale effect, to use the most prevalent term, is where there is a discrepancy ‘involved in extrapolating the results obtained on models to full scale’ (Allen 1947, p.31) because of ‘prototype parameters which are not correctly scaled to the miniature universe resulting in force ratios which are not identical between

the model and its prototype' (Heller 2011, p.296). Russell's choosing of certain vertical and horizontal scales for a model of Port Lyttleton (as described earlier in this section) was an attempt to avoid scale effects when considering wave action.

Unless scale effect is recognised and ameliorated, or in prediction and design accounted for, scale effect can compromise structures and solutions which owe being to experiment in the milieu of the scaled (model) water world. A destructive example of a compromised structure was the ruination by storm waves of Sines breakwater (Portugal) in 1978 (see Baird et al 1980). The breakwater, which included concrete 'armour units' on the outside, was found to be strong enough in the hydraulic model investigation, but it was not in 'reality'. Jensen writes:

'It further became evident that extreme care should be exercised in the interpretation of results from small scale model tests where the fragility of the units could not be modelled and where the armour layer in the model would be intact after the tests. Minor rocking of a number of units and settlements of the armour layer looked innocent in the model, but in nature it would mean breakage of units and possible failure of the breakwater' (2013, np).

Trying to avoid, being aware of, and compensating for scale effect was, and is, an important part of physical hydraulic modelling practice. Some civil engineers during the period of this chapter were dubious of the epistemic potential of model studies because of scale effect. Scale effect for these people produced worry around how model studies could relate to the 'real' water world, including matters of uncertainty, whilst others were more pessimistic about the epistemic potentials of model studies because of scale effect. For Murdoch of Wimpey and Co, commenting on Russell's (1956) Lyttleton Harbour model:

'With the distortion at present necessary in model-making it might be possible to distort the model so that, while it gave wave-heights and wave conditions corresponding to the actual harbour at certain points, such correspondence might not apply generally, leading to misleading interpretations. Dealing further with those apparent uncertainties, there was an exaggerated vertical scale, a time scale, the extreme sensitivity to prototype period [...]. There were also the questions of the bed material, with its possible different deposition characteristics, scale effects, flow characteristics, and so on, wave reflexion from all the points in and around the harbour, absorption of wave energy, and possibly others which the author had not mentioned, but which according to other investigators might have some influence, e.g., surface tension effects and the effect of dust on the water surface. Would the Author say whether he agreed with others on that point?' (Cashin et al 1956, p.34).³⁵

³⁵ It is worth to point out Russell's reply to Murdoch's query: 'Taking Dr Murdoch's origins of uncertainty in the rigid models first: vertical exaggeration, he thought, he had dealt with in the Paper. The existence of a time scale introduced no errors. Sensitivity to prototype period introduced no errors if the speed control on

Alertness to scale effect for Fergus Allen in a talk to the River Boards Association Conference made hydraulic modelling a rarefied and embodied practice ‘for skilled and experienced workers’ only, otherwise modelling could have ‘dangerous’ consequences:

‘Soon after it is started a well-designed mobile bed river model will reach regime condition after which any change the model may reveal in the configuration of its bed from the introduction of for example training works, will be an indication of the type of change to be expected under similar conditions in nature. That is not to say however that the changes may be precisely scaled up in time or that the extent and amount of accretion or scouring in certain parts of the model can always be scaled up to indicate precisely the extent and amount of accretion or scour [...]. [I]n other words the model results have to be interpreted and translated in terms of corresponding river behaviour. These [...] make the interpretation of model results a matter for skilled and experienced workers and the idea that a person without previous experience in the subject can build and operate a model by rule of thumb methods from textbooks is very dangerous and not to be encouraged. The results claimed from such an investigation may be wholly misleading’ (1954a, p.3).

Scale became a subject of contestation at the HRS when relations between model and the modelled were felt to be at stake. In 1955, the DSIR sought the HRS to make models at a smaller scale rather than meeting a request by the HRS for an extension to its ‘research hall’. The DSIR also reckoned that the decision of model scales should lie with it, not the HRS. HRB members were ‘astounded at this proposal and considered it most unsuitable’ (HRB 1955, p.4). Doran, Secretary of the HRB, expressed that ‘the scales of models must on no account be dictated by considerations of space: if this were done the results might be disastrous’ (ibid). The ability to make a decision on scales for a model had been, and were to remain (certainly up until 1956), with the HRS. The smaller the scale distortion the better because bigger distortions make scale effect more prevalent. At the time of the DSIR’s suggestion, spatial constraints, contrary to Doran, were already influencing choice of model scales as Doodson noted: ‘[T]he Shrewsbury flood relief model no 2 which [I] had seen in operation during the morning visit, was clearly as small as practicable and [I] would say that the dimensions generally were the minimum which it would be possible to use’ (HRB 1955, p.4). Although spatial constraint influenced the

the wave-generators was adequate [...]. The existence of surface tension introduced errors in the speed at which the shortest waves travelled but never with any of the waves that had been employed had the error amounted to as much as 1% and that error had been neglected. He had not heard that dust on the surface introduced errors. The mobile-bed model, on the other hand, had to be judged by quite different standards’ (Cashin et al 1956, p. 37).

HRS's scale choice (including the agent's budget), important in scale decision-making was adopting scales that could enable phenomena to be mimicked and within an acceptable intensity of scale effect, requiring significant knowledge and expertise. The worries of the HRB in regard to the DSIR taking scale decision-making power from them and wanting ever smaller models underlines how scale is vital in mobilising a hydraulic model as an epistemic object.

5.8: Inscriptions, limitations and predicting

In models addressing the movement of sediment and/or erosion and scour, materials are used to mimic those of the water world's bed, bank and/or sediment. Bed, bank and sediment materials from the modelled are not always used in the model because in this scaled milieu the 'real' material will not always behave in the way it would do. Materials are not scaled to size however, this would be impossible, but neither is it important. The crucial thing is that the material behaves like that 'observed in the [...] prototype under comparable conditions' (Allen 1947, p.166) and/or, causing prototype behaviour to other agencies in the conditions. The 'conditions' are hydraulic forces (namely velocity, discharge (river and estuary), tidal (estuary and sea) and wave action (sea)). These forces may, or may not be scaled in relation to the square root of, or another mathematical relation to, the geometric scales. The forces animate sediment by forcing scour, movement and/or fall (deposition).

Materials such as sawdust, sand, china clay, pumice, emery, brick and tile might be adopted, trialled and experimented with for a propensity to perform in a desired way within the context of the scales of the model. This might be as bank material and, therefore, 'eroding at the correct rate, maintaining the proper side-slope and discharging appropriate amounts of material into the model' (Allen 1947, p.255), or bed material where propensity of movement and rate of disposition are important. Finding the right kind of material for a model study was often a trial and error process, taking a sizeable deal of time and effort. In Gibson's Severn Barrage model of 1933, thirteen different fine materials were candidates for the Severn's bed materials including various sands, emery and pumice. These were tested out by first each being moulded to a survey of the estuary in 1849 and then recording what the material did and after successive tides the extent to which it mimicked bed changes as mapped by a 1927 Admiralty survey:

‘The best overall agreement with natural phenomena was exhibited by the ‘80-mesh’ silica sand (diameter 0.00700 inch) although the finest of the emeries behaved very nearly as well. The sand having a diameter of 0.00582 was too easily carried upstream on the flood tide without any compensating scour downwards on the ebb, and that having a diameter of 0.00814 inch did not possess as high a tendency to stabilise itself in the form associated with the Admiralty surveys’ (Allen 1947, p.215).³⁶

Questions of materials and their relations with modelling practice are interesting in hydraulics for a similar reason as examined within the model railway chapter. This is where materials have affordances and agency and with material agency often negotiating modelling practice in various ways. Principally for word space and some overlap with 4.7 (materials and railway modelling), this chapter does not consider materials and hydraulic modelling practice any further.

This section is about hydraulic modelling practice and relations with inscriptions, limitations of models and predicting with models. It firstly contemplates how ‘inscriptions’ are involved in modelling, specifically looking at how these abstractions are involved in enabling the exploration of spatial relationships, giving models affective power and making them epistemic objects. The section then turns to address how and why the limitations of models and modelling as epistemic objects and practices were recognised by the HRS in its making predictions and particularly in the case of loose boundary mobile bed models.

Inscriptions such as surveys, diagrams, tables and graphs do more than what Latour (1990) has suggested, that is being important to scientific communication and knowledge creation, for they also become central to practice. The inscription and abstraction of the survey, diagram, table and graph enable hydraulic models to become epistemic objects. Such inscriptions, emanating from the model and the modelled through instrumental and embodied observation and the intensities, spatialities and temporalities which they impart, guide and critique practice with a model in an effort to make similarity of agency. After McCormack (2012) on the prospective potentials of the diagram as abstract entity, hydraulic inscriptions (including the diagram), as will be detailed, can work as a research and communicative tool to explore ‘spatial concepts and relationships [...], an inventive rather than a representational device’ (Manolopoulou 2005, p.520 in McCormack 2012, p.724).

³⁶ Important people in working with materials, making the bed changes and also moulding the bed were the skilled carpenters and labourers whose experiences and contributions are absent in the archive as noted in the methodology chapter.

Making similarity of agency is termed the ‘calibration’, ‘validation’ or ‘proving’ the model stage. These are HRS but also current terms given to the time when a model is made to reproduce aspects of what is known of the modelled. The 1933 Severn Barrage study garnered confidence in its prediction as noted in 5.5 because the model had mimicked known bed changes via charts. Bed changes were the chief concern of the Severn Barrage model study. Usually in such mobile-bed models, if a model reproduces known bed changes from the past and present, it is judged, often with qualifications on the making of the future, to be able at providing a reasonable basis on which experiment can ensue. For Fergus Allen on the Wyre Estuary model:

‘A detailed study of past surveys and the present behaviour of the estuary revealed that these changes repeat themselves, that is to say, they are cyclic in character, having a period of about 6 and 2/3rd years. The model reproduced these cyclic changes, and, having thus demonstrated its reliability, made it possible to forecast the effect of guide walls in maintaining the channel alongside the jetty and also the subsidiary, but important, long term changes which such structures might have on the regime of the estuary as a whole’ (1954c, p.6).

Similarity of agency with HRS models was in part worked through, and made apparent by, the production of diagrams, tables and graphs and how they compare with those from the modelled. For instance, engagements with various modelling technologies were negotiated by the need for the technology to produce an effect similar to that in ‘the real’. In the case of a ‘tide generator’, the success or failure of its calibration and operation rested on what kind of match the graphical tide curve produced by the model had with that obtained from the modelled, see figure 35 (p.183). In the Forth Estuary model:

‘The cam on the tide producing machinery was adjusted to reproduce the shape of tide curve at Rosyth. This was achieved by a trial and error process. An eccentric circulator cam was first used and observations made of the tide obtained in the model at Rosyth and at a point in the estuary corresponding to Oxcars, the motion of the displacer and the motion of the three-way valve. From these observations, suitable ordinates for a new cam were derived and the observations repeated. This process was repeated until a reasonably good fit to the shape of the representative tide curve at Rosyth was obtained. The stroke of the displacer and the mean water level in the model were then adjusted to give the appropriate high and low water level’ (HRS 1951, p.7).

To some degree, the HRS models become known through numeric and graphical inscriptions as well as, or as opposed to the actual reality of the model. This is particularly apparent in a case of a model leaking water, noticed when someone was plotting graphically the mean tide level: ‘A certain drift in mean tide level was noticed in the model. The cause

of this was found to be the slow leakage of water from behind the tide generator into the model itself' (HRB 1953b, p.3).

As Latour (1990) asserts, diagrams, tables and graphs among other inscriptions are important in scientific communication and knowledge creation. In hydraulic modelling, inscriptions can be used to show to particular people (fellow modellers, the model's agents or others), often of different space-times, the extent to which a model mimics a particular phenomenon and the extent to which the model can be thought of as an epistemic object. This is via the making of a reference from text to figure in progress reports or final reports, where inscriptions might find model and real phenomena superimposed and shown to be within particular degrees of agreement, or where such phenomena can be otherwise compared easily, see figures 35-38 (pp.171-175). Such inscriptions fold at once long durations of model operation and make phenomena and model-modelled relations discernible, whether quantitatively or through survey. They help give a model affective power. This might be as feelings of disappointment or, what is aimed for; confidence, although also joy and many other emotions and feelings might find intensity. Inscriptions have affective power, they may attempt to persuade, enlighten and caution, helping to make feelings, judgements and decisions.

Vital in the need to be able to make similarity of agency and know what is happening in the model water world post the 'validation' or 'proving' the model stage were numerous technologies and instruments placed within or above a model. In the Thames Estuary study, film was utilised to record the passage of lighted candles on floats to trace currents: 'Floats were released at positions and times in the tidal cycle corresponding to those observed in the estuary [...]. Taking the effect of vertical exaggeration into account, there was fair qualitative agreement' (HRB 1955, p.8). Instrumentation was just as important in knowing the model water world as the 'real' one. The model water world, despite its greater human fabrication, was difficult to know without instruments such as a current meter, bed level plotter, velocity meter or wave recorder because phenomena often need quantifying to be made sense of, for enabling spatial comparisons via inscriptions to be made and for futures to become legible. The same argument from 5.6 concerning the motivation behind the HRS developing fieldwork instruments applies to model instruments as well.

In the case of 'moveable-bed' loose-boundary models (a model where bed movement is important to the model study and, therefore, the bed is composed of a 'moveable' as opposed to a 'fixed' bed), getting the model to produce known bed changes, especially in estuaries, was often difficult, even unachievable. A model of the Wyre Estuary

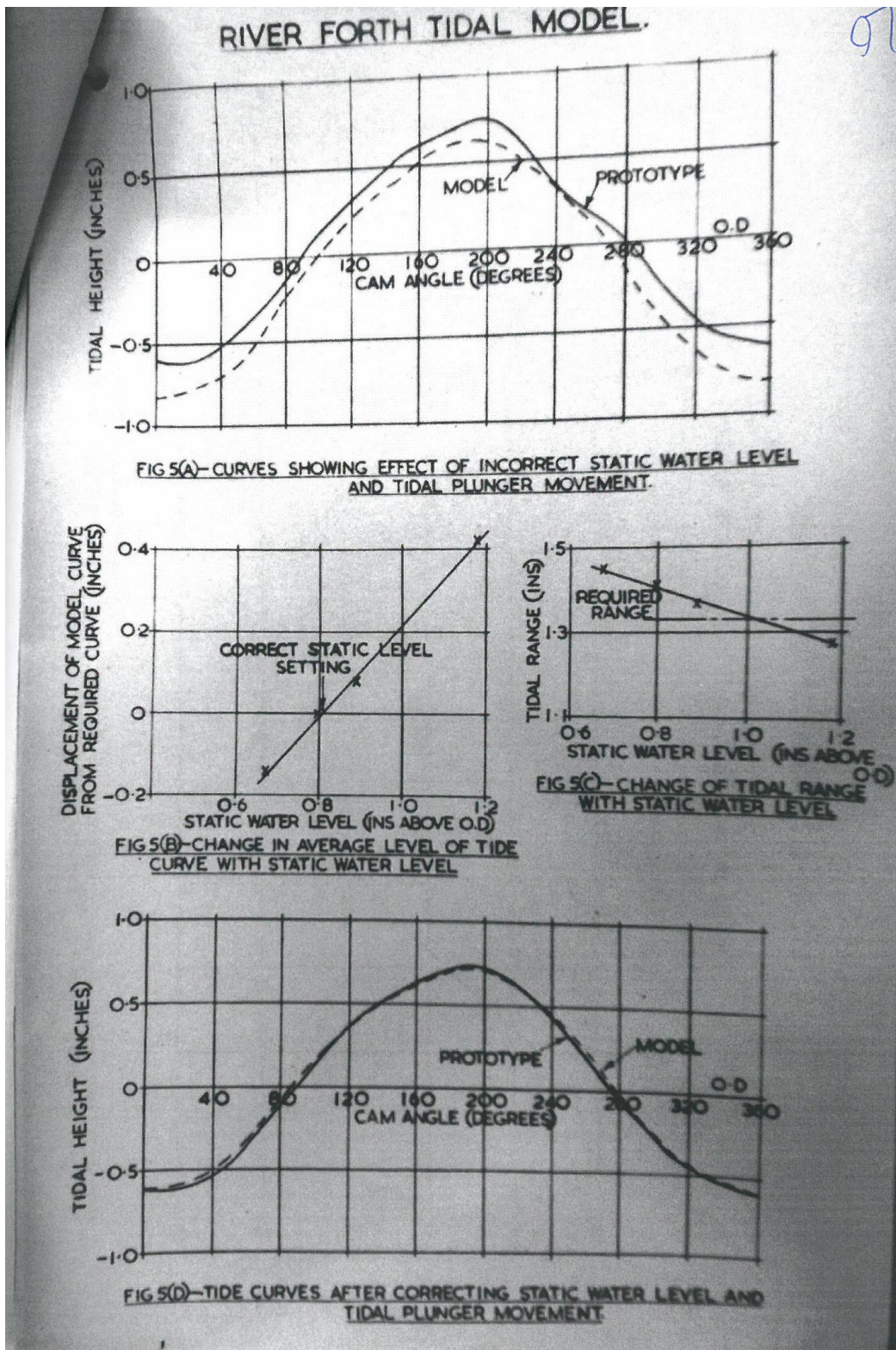


Figure 35. Inscriptions showing 'fit' between model and prototype behaviour. Source: HRB (1951).

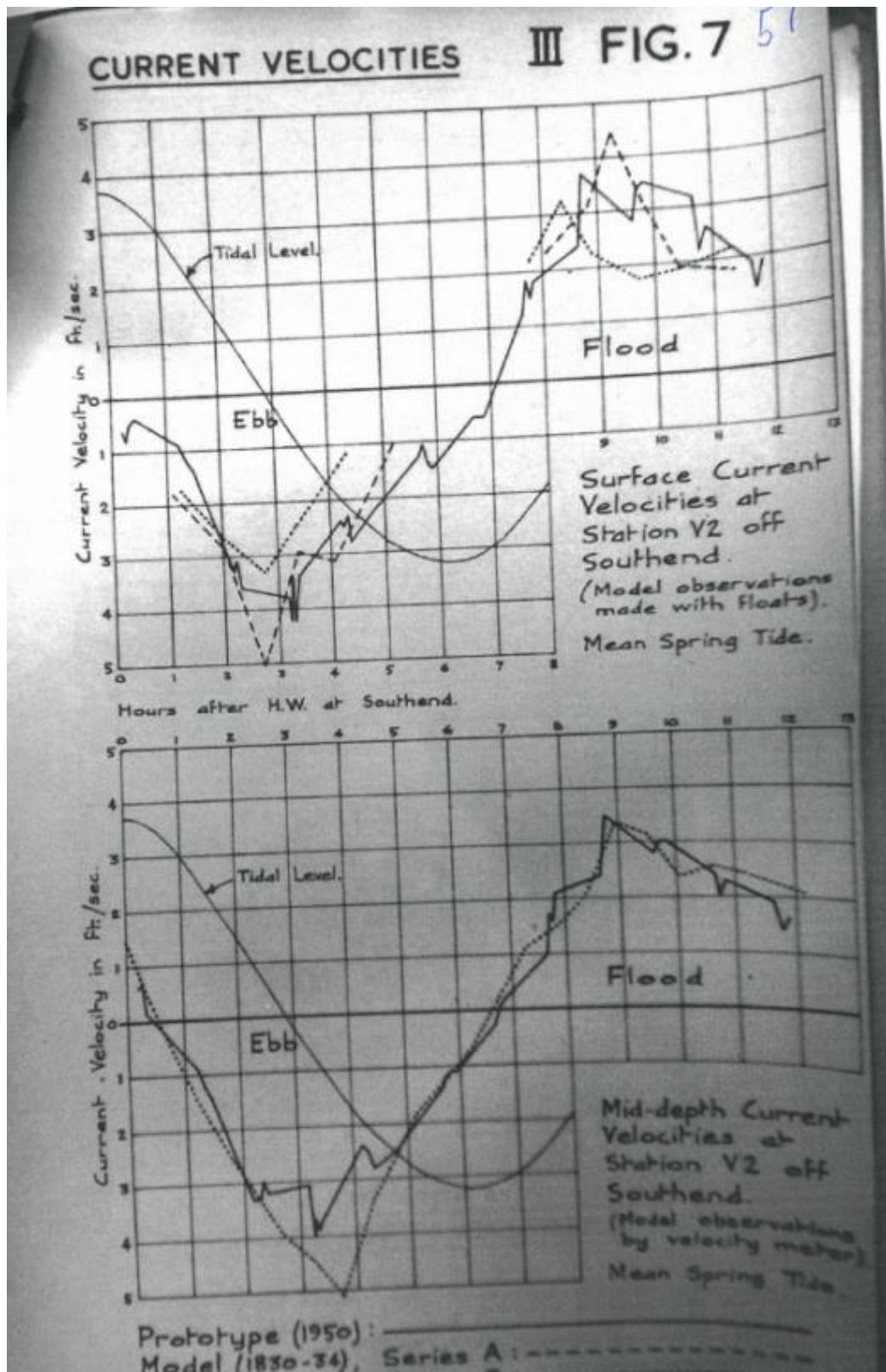


Figure 36. Inscriptions showing 'fit' between model and prototype current velocities.
 Source: HRB (1951).

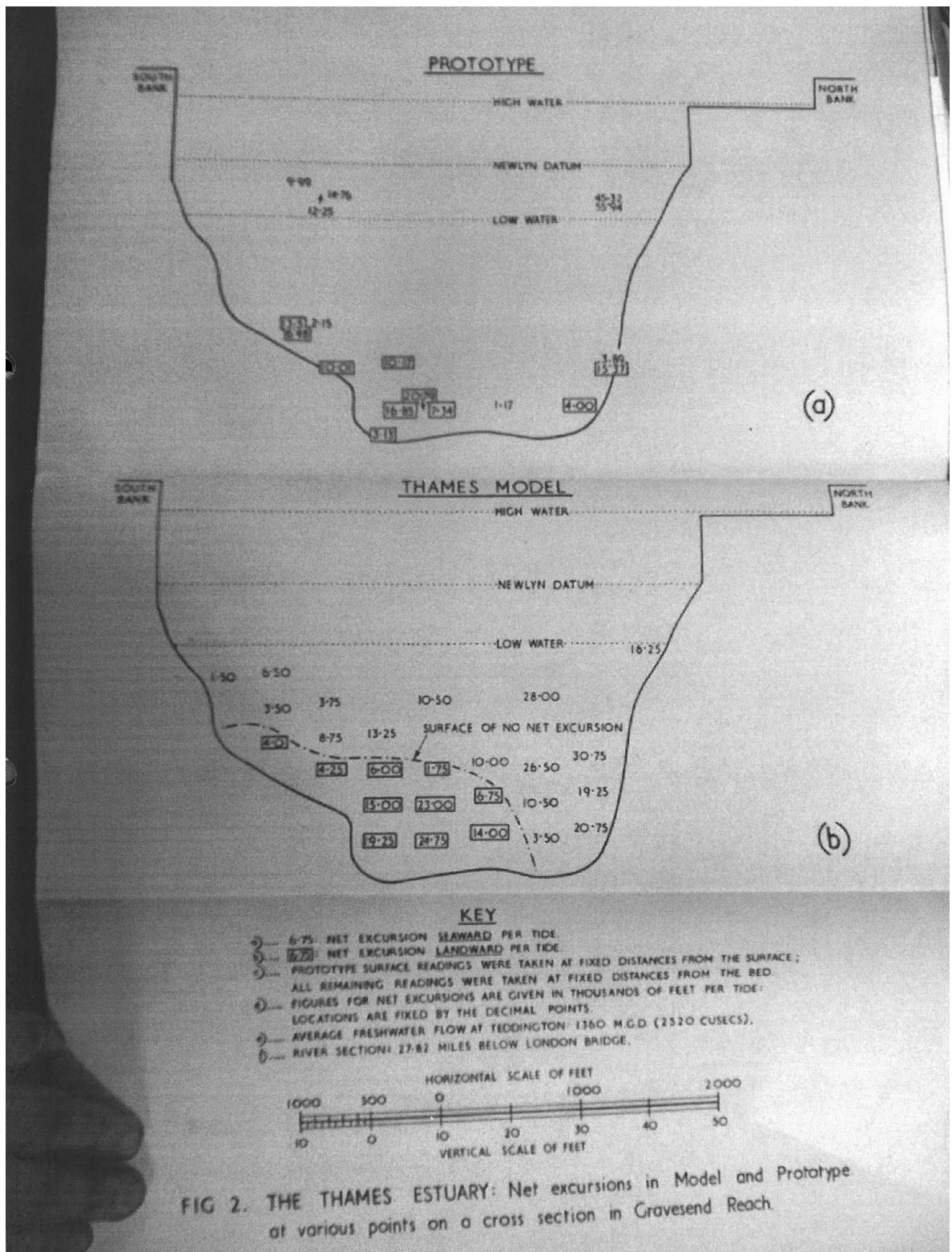


Figure 37. Inscriptions relating to the Thames Estuary: 'Net excursions in model and prototype at various points on a cross section in Gravesend Reach'. Source HRB (1955).

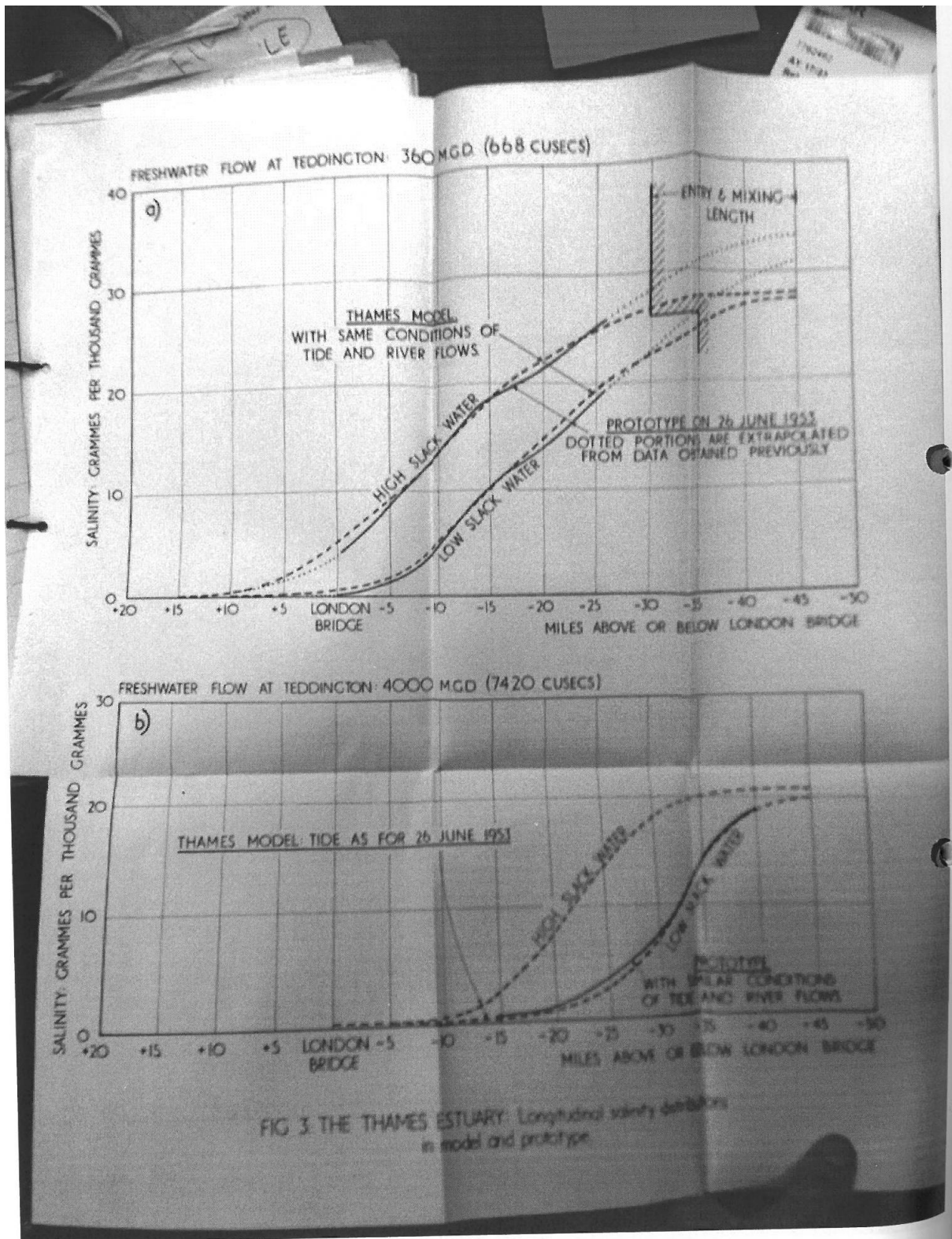


Figure 38. Inscriptions relating to the Thames estuary: 'Longitudinal salinity distribution in model and prototype'. Source: HRB (1955).

was increasingly becoming a source of annoyance for Inglis over part of 1953. The model was 'giving trouble' (HRB 1953b, p.4). Scalar issues were the chief problem, the scale of the model meant it would not produce a return movement of a channel in an area of the model estuary. The return movement in the Wyre Estuary was part of a periodic and rhythmic channel fluctuation over a period of several years as observed in the estuary itself:

'The main experimental difficulties were concerned with the return movement of the channel from the east to the west bank in the Burn Naze compartment. It was found that a tidal period shorter [...] favoured this part of the fluctuation, but the movement was then so rapid that the east shoal did not build up fast enough for a cutting face of adequate height to develop - which is necessary before the channel can begin a second fluctuation' (HRB 1953b, p.6).

There was little success with finding the 'experimental conditions necessary for a rapid fluctuation of the channel' (HRB 1953b, p.5). A reduction of tidal period as mentioned in the note above drew some success, but caused problems itself. Nevertheless, eventually an increase of material (silt) was found to produce a more real-like fluctuation although 'not as great as in the prototype' (ibid). In the end, more similarity was unattainable and/or inconsequential to what was wanted from the model: '[S]uch errors are important where quantitative results are required, but where comparative results of different [design of infrastructure] treatments are the object, small errors are unimportant as they are approximately the same in the various treatments and cancel out' (HRB 1953b, p.5).

As Maslin and Austin claim of climate models: 'By their very nature, models cannot capture all the factors involved in a natural system and those that they do are often incompletely understood' (2012, p.183). Hydraulic modelling, whether numeric (computer) or physical, might be considered a doomed practice from the start since a model is only a feign of a water world and with the statisticians Box and Draper's oft-quoted assertion in mind that 'all models are wrong' (1987, p.424). Involved is the sometimes complex problem of confronting the futures of water worlds. How the Wyre Estuary channel problem noted earlier was embroiled in the model study raises an issue of how, firstly, model limitations are worked with and affect how the epistemic 'character' of a model is made (character regarded here as 'qualitative' or 'quantitative', since these are differing categorisations used by the HRS) and, therefore, its predictive character (although this is not always the case, for instance 'Climategate' (see Pearce 2010; 2012)). Secondly, that model limitations are sometimes produced by the epistemic character envisioned.³⁷ These

³⁷ This is not to forget that hydraulic models also have unknown limitations, such as the bed-drift issue and its lack in Gibson's model as described in 5.6.

aspects have similarities with railway modelling where intensities of mimesis (as detail and indeed of mimetic play) might be unobtainable or undesired.

Although models have their problems in the environmental sciences, Box and Draper's assertion noted earlier that 'all models are wrong' was immediately appended by them with 'but some are useful' (1987, p.424). Certainly, as the hydrologist Beven notes: 'Even if our models are wrong in detail, they might well reflect dominant causal characteristics of the system and consequently be useful in making predictions' (2013, p.80). Inglis believed complex models, including mobile bed models and more still of estuaries, as capable of providing the hydraulic modeller with the ability to gain an impressionistic vision (and, therefore, prediction) of how designs of infrastructure/intervention will affect and be affected by the water world in question. This is in contrast to simpler models such as simulating several wave heights over a model breakwater and examining how the design influences and is influenced by waves. What will happen in 'reality', including the future, is epistemically clearer.

On the matter of impression, Inglis, writing in the context of a debate with Crawley of the DSIR about the outcome of the HRS Severn Barrage study, considered: 'I must particularly emphasise, however [...], that loose boundary models, even if large, do not reproduce in detail what happens in nature in an estuary or river. The results have to be interpreted' (Inglis 1954b, p.1). In the HRS Severn Barrage study, there was a clash of model expectation. A major critique of the Gibson model came from Gracey of the Port of Bristol Authority in 1947 as noted in 5.6. Gracey pointed out how, over a period from 1849 to 1927, model surveys did not mimic 'important alterations in the estuary that are recorded in Admiralty surveys for corresponding years' (1947, np). At the first meeting of the Severn Barrage Model Committee (SBMC) at the HRS, Inglis took issue with Gracey's argument. Inglis's point was that a model could not provide 'exact reproduction' of the estuary, but instead an impression. Exact reproduction was impossible for several reasons; firstly, scale effect, secondly that some data from future times of the estuary were used to generate its past and thirdly, and including the former reasons, the model was not *the* Severn Estuary. Inglis reckoned however that the model could take on an identity as the Severn Estuary, but not to the same intensity as what Gracey thought, and into the future. Before the bed-drift discovery, Inglis judged Gibson's model, of which HRS had built a replica, as broadly sound. Although any estuarine model could only give for Inglis an impressionistic vision (and, therefore, prediction), it could still be a very important one. Inglis, writing for the attention of the SBMC, states:

‘It follows that no claim can be made for exact reproduction of all bed changes in loose boundary models, particularly in the case of tidal models with large vertical exaggerations [...]. Where a loose boundary model is most useful is, as in this case, for comparing results before and after a major change is made in the conditions, i.e. before and after the introduction of a barrage. In such a comparison though the model cannot be expected to reproduce every change which occurs in the sandbanks some of which will be due to abnormal conditions such as storms or currents induced by storms - yet as changes due to inserting the barrage will be very marked and the degree of insensitiveness in the model will be the same with as without the barrage, the major effects of adding the barrage will be clearly demonstrated’ (1954c, pp.2-3).

As shown in this chapter, knowing water worlds, especially estuarine and coastal systems can be very difficult and remains so to this day (see Karunarathna et al 2007; Karunarathna 2011; Pye and Blott 2014; Spearman et al 1998). Limitations of the model medium, the ability and technique to reproduce phenomena and limitations of knowledge of water worlds and futures (uncertainty, as well as unknown unknowns) should ideally negotiate the epistemic and predictive character of any model study. Juston et al (2012, p.1119) argue in regard to hydrological modelling:

‘It is a common view amongst scientists that the public and policy makers need, and want, certain deterministic predictions. However, communicating uncertainties and limitations of scientific knowledge can have a significant importance in gaining and retaining the trust of the public and decision makers. Failing to openly admit the limitations of knowledge can cause severe distrust in both science and regulatory institutions’.

The 1960 prospectus to the HRS pointed out unashamedly that estuaries are ‘so complex [...] it is not always possible to arrive at quantitative conclusions, but invaluable qualitative and comparative results may be obtained, particularly by workers with extensive experience in this field’ (HRS 1960a, p.10). For Inglis, if hydraulic modelling was to be a respected and a valuable epistemic practice it had to be honest with itself. Inglis was momentarily agitated by a hydraulic modeller from the National Physical Laboratory (NPL) when, apparently boasting to Inglis, the modeller suggested the NPL were ‘capable of undertaking any [model] project with confidence and with exacting results’ (Inglis 1946, p.1). The statement incensed Inglis so much that he wrote about it to his friend Sir William Halcrow (who was later to be Chairman of the HRS), Inglis went on: ‘[S]uch a mind-set is dangerous it can bring model research easily into disrepute [...]. Furthermore, what is all the more extraordinary, but unsurprising, Hankins makes such a claim and the only model

which they have so far dealt with is in my considered opinion, almost worthless [...]. This, needless to say, is strictly *entre nous*' (ibid, emphasis original).

Being honest about the limitations of models and modelling, made through uncertainty about water worlds and futures and how model water worlds for these and other reasons can never be regarded as totally mimetic, was something HRS modellers appeared to practice, declining studies because of it as emphasised in 4.6. Inglis complained several times that agents (those who wanted a model study) would sometimes have too high an expectation of what kind of information a model study could provide with any certainty, believing it was 'the model and not our expertise that is wanted' (Inglis 1952, np). Inglis's insinuation here is that some agents figured a model as an all-powerful tell-all object and divorced it from the realm of modelling epistemology, whether in regard to knowledge about water worlds, futures and/or models and modelling.

Whilst hiding uncertainty in an analysis of a model study might at first imbue within the model agent/s a feeling for modelling's decisiveness and evident value, this would be lost with the intensity of difference between prediction and actuality. Furthermore, predictions, when acted on in hydraulics, have consequences and the thought of provoking misguided action by absencing uncertainty might instil fear within modellers and cause institutional tarnishing, as evidenced when Inglis asserts that 'a research station very soon loses its reputation if it makes a few mistakes' (1945, p.2). Equally, model agents were, and are, often conscious of uncertainty in modelling. In the case of the HRS, agents sometimes had knowledge of hydraulic modelling and/or especially of the water world in question and with their own uncertainties of each. Although the HRS archive is silent on how model studies were discussed with agents beyond textual reports, some studies with modeller, agent and other interested party discussion were published in the *ICE proceedings* (see Allen et al 1955; Cashin et al 1956; Price et al 1964) where agents and others had a very keen eye for critique. Being open to the fallibility of model research in communicating model results was and is a way of gaining professional and/or institutional modelling credence (Beven 2010).

5.9 Conclusion

This chapter has considered how, at the heart of the impetus and enthusiasm for hydraulic models, are the agencies of water worlds and their uncertainties to humans and inherent

changeability. Hydraulic models and modelling practices and knowledges have been shown to make present, act on and present environmental futures and affected by and/or produce possession, threat, uncertainty, confidence, contestation, consternation, material and object agency in the contexts of water worlds, spatial imaginings, decision-making, scale, non-human affect and government-science relations. In a chapter that has been historical in orientation, aspects of what has been addressed here can find relevance when examining hydraulic modelling today. This can be around the impetus for model research and the stories of experiment, fieldwork, decision-making, uncertainty and the limitations of models and modelling.

This chapter has emphasised how hydraulic models and modelling practices and knowledges aim to make present, act on and *present* futures, giving modellers, politicians, civil engineers and various authorities inclinations of worlds to be, future worlds simulated and represented. Hydraulic model studies are about enabling decision-making to be more ‘palatable, explicit and actionable’ (McCormack 2011, p.2811). Particular attention has been given to how hydraulic models, alongside modelling practices and knowledges, try to intervene on uncertainty about possible infrastructures/interventions within water worlds and threat to mobilities and capitalist accumulation, human life and to the intervention/infrastructure itself. Hydraulic models, from the perspective of diverse agents and modellers, can be encountered with a hopeful disposition around the potential via experiment to produce interventions and infrastructures that perform, for a while at least, as desired by humans within the agencies of water worlds. A particular narrative that hydraulic models can be placed within is one of seeking control over a threatening non-human environment.

In the context of the spatial and embodied engagements with hydraulic models and modelling, water worlds within this chapter have been spaces productive of threat and uncertainty as well as spaces of consternation (including being threatened) and contestation and all involving sometimes diverse temporalities such as futures and pasts. Hydraulic model studies have the potential to shape, and they do shape, water worlds materially and also how they are experientially encountered and engaged with. It has been shown how engagements with hydraulic models as epistemic objects and modelling as a research practice are also affected by engagements with water worlds and in diverse spatial and embodied ways. Hydraulic model studies because of this can be encountered with fraught, uncertainty, confidence, difficulty, hope, threat and disappointment among other embodied affects.

A notable thread running through all the sections of this chapter has been the matter of mimesis. Hydraulic models are feigns of water worlds yet infrastructures and interventions *become* in the real on the basis of model studies. Hydraulic model studies have material affects and, therefore, models, modellers and modelling practices and knowledges can become ripe for critique. Though the case of the Severn Barrage model and debate it was shown how models, modellers and modelling in a context of decision-making can produce and inflect various ‘presence of the future’ emotions, feelings and spatial imaginings with regards to water worlds and questions of mimesis. All these drew on and mobilised practice. For the PBA and others, the model study for its relations with mimesis was a threat and provoked them to seek to close down the frightening future the model study had opened up for them.

Significant attention in this chapter was given to the knowing of water worlds by HRS modellers and who aimed for confidence in model studies. In the knowing of water worlds, the chapter emphasised how fraught, difficult and impossible a practice knowing water worlds, including futures and pasts was for them, water worlds often becoming spaces of consternation. Uncertainty about the agencies of some water worlds meant the HRS shied away or were prevented from undertaking model studies. Whilst hydraulic model studies seek to negotiate the agencies of water worlds, they are also affected by these agencies, negotiating the epistemic potentials of models for the HRS. In the context of fieldwork practices, it was shown how a surveying team and technologies of abstraction in the form of measuring instruments were important to the HRS in making confidence in model studies. Scientific instruments, along with the inscriptions, were produced and used with hopeful dispositions towards their prospective potential.

Outside modelling practice, model studies were imbued at times with undue expectation and which Inglis and the HRS sought to temper seemingly so as to maintain their own, the HRS’s and hydraulic modelling’s reputational ‘well-being’. Equally though, hydraulic modelling practice in a general sense was sometimes regarded as a dubious epistemic practice, with a model a dubious epistemic object. Physical hydraulic models are water worlds themselves and it was revealed how ‘scale effect’, a product of abstraction and miniaturisation with the potential to generate material affects, could lead to a pessimistic attitude about the epistemic potentials of model studies. The chapter assessed how scale, for its making and unmaking relations, has the potential to generate material affects in hydraulics, something that can generate embodied affects in so much as how scale effect can negotiate, as was detailed, the confidence placed in HRS model studies.

Scale effect raises a question about abstraction and miniaturisation as problematic within hydraulics. Scale effect in physical hydraulic modelling required and requires embodied skills and considerable knowledges in making spatial relations between two different fluid flow situations, making for Allen (the HRS Deputy Director) hydraulic modelling a rarefied practice. Furthermore, physical hydraulic models are difficult to know and to critique mimesis without particular devices. This chapter highlighted the prospective potentials of inscriptions as abstract entities in enabling the exploration of spatial relationships in so much as helping to give hydraulic models affective power and making them epistemic objects. Although abstraction is something to be overcome, it is also often only through abstraction that such a precautionary action as hydraulic modelling becomes possible and relevant. Hydraulic models as miniaturised and abstracted mimetic objects (whether physical or on computer) enable and/or make more amenable the 'explorative style' of 'researching and thinking' (Kullman 2013, p. 879) that is experimental practice. Hydraulic models, via the practices of experiment, can be seen as spaces for shaping the potential for objects to affect and this chapter after Ash (2014) has traced the 'actors' and 'institutions' that 'attempt to shape affect for their own ends and purposes' (2014, p.2).

Whilst hydraulic modelling is meant to intervene on uncertainty, as shown in this chapter it is a practice rife with uncertainty from both within and outside hydraulic modelling practice. This chapter began and ends on underlining how and why the British government sought to intervene on hydraulic uncertainty. It was detailed that for the Hydraulics Sub-Committee, government could intervene on uncertainty through the making, financing and therefore technological supporting of a particular spatialised 'community of practice' of hydraulic modellers (the HRS). Arguably, the British government (via the DSIR) through bringing about the HRS according to the Hydraulics Sub-Committee vision, sought to generate a feeling state of confidence within and around British hydraulic modelling practice for reasons of national economic and political importance, both at home and abroad.

6: Miniature wargaming

6.1: Introduction

This chapter considers how models and modelling are involved with war as a ‘realm of experience’ (Sylvester 2013). This is in relation to the spaces and places of war and also in the transformation, expansion and production of these through models. Miniature wargaming models, modelling and engagements are shown to generate and be affected by war as a realm of experience in relation to feeling, emotional and imaginative states. On the generative aspect, for the most part this is in how models, modelling and engagements are related to other human bodies and/or space-times in the contexts of the military and battlespace.

This chapter is composed of six empirical sections, each pivoting around particular concepts and model and modelling engagements. After an introduction on miniature wargaming in 6.2, the first empirical section, 6.3, considers the emergence of the miniature wargaming hobby. Section 6.4 examines the embodied relations in miniature wargaming between, although also to, ‘big’ (real) and ‘little’ (miniature, abstract) war and mobilising enthusiasm for the practice of miniature wargaming. Model figures are a paramount component of miniature wargaming enthusiasm and play and 6.5 focuses on diverse engagements with these models with reference to imaginary spaces and notions of ‘the still’ and surfaces. The chapter in 6.6 turns its attention to the textual ‘rulebooks’ (or ‘warfare models’), considered here as ‘teleplastic technologies’ and made with an aim of enabling, but at the same time modulating mimetic play. The section looks at how rulesets and game designers seek to enable particular feeling, emotional and imaginative states relating to other human bodies and space-times through mimetic play. Related to rulesets, 6.7 details a particular sensibility to wargames design where *more* abstraction and styles of abstraction are held to open up potentials for such emotional, feeling and imaginative states. The final empirical section, 6.8, covers significant ground as to how war’s violence

and suffering permeates the hobby and with space important to the discussion in several ways. Salient points from this chapter are the subject of 6.9, the conclusion.

6.2: Introducing miniature wargaming

For the miniature wargames writer Teague:

[Miniature] [w]argaming involves re-creating battles of the past – either real or fictitious – using a board on which model soldiers and scenery are placed. In order to make a given period as realistic as possible, soldiers are modelled wearing the appropriate uniforms and the buildings and objectives correspond as far as possible to originals of the time’ (1973, p.3).

Miniature wargaming developed in the UK and America during the 1950s and 60s and is a multifaceted hobby practice, involving wargames design and painting and gaming with miniature figures on a physical battlefield landscape. With regard to wargames design, wargamers may compose or tinker with what is often called a ‘warfare’ or ‘conflict model’. This is a textual document (a ‘rulebook’) made up of rules and ‘mechanisms’ that represent combat practice and aim to negotiate play and enable particular feeling, emotional and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace. Unlike computer games, this ‘model’ (the representation of warfare/conflict) is ‘external’ (engaged with actively by the gamer) rather than ‘internal’ (models in computer games are also written in code).

Sabin (2002) has suggested that the hobby is ‘practised by socially elite groups of people’ who are ‘almost exclusively male, well educated, from professional occupations and middle-aged (having been introduced to the hobby in their teens)’ (Yarwood 2015, p.661). Whilst miniature wargaming is certainly a male dominated hobby, through my interview research I would suggest it is a more socio-economically diverse hobby than Sabin asserts.

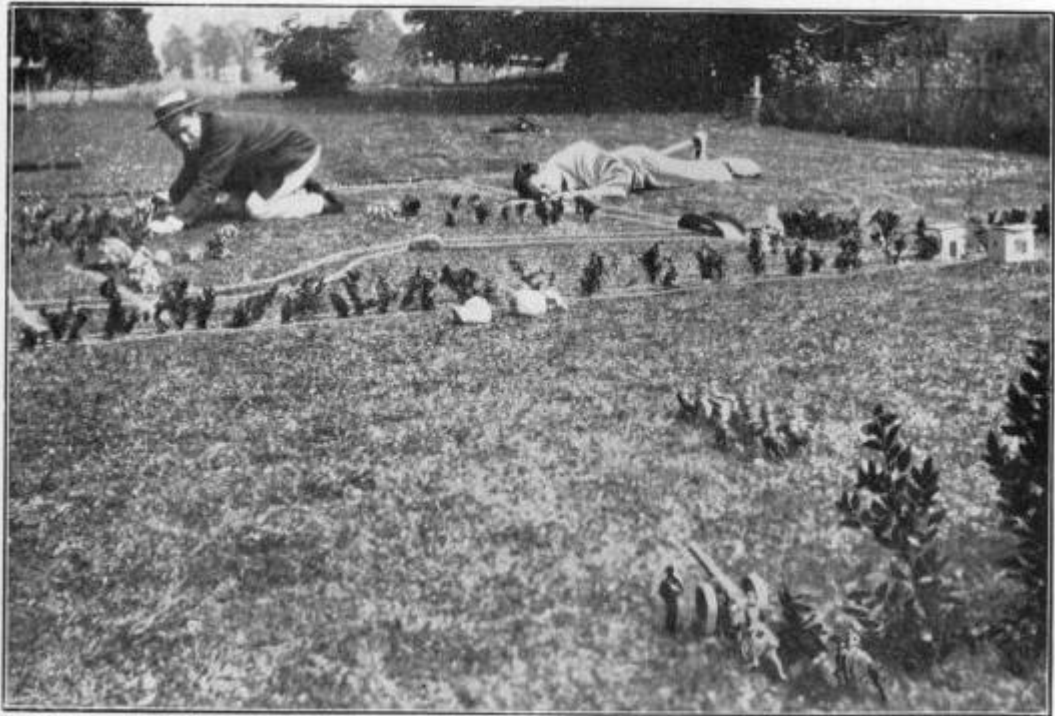
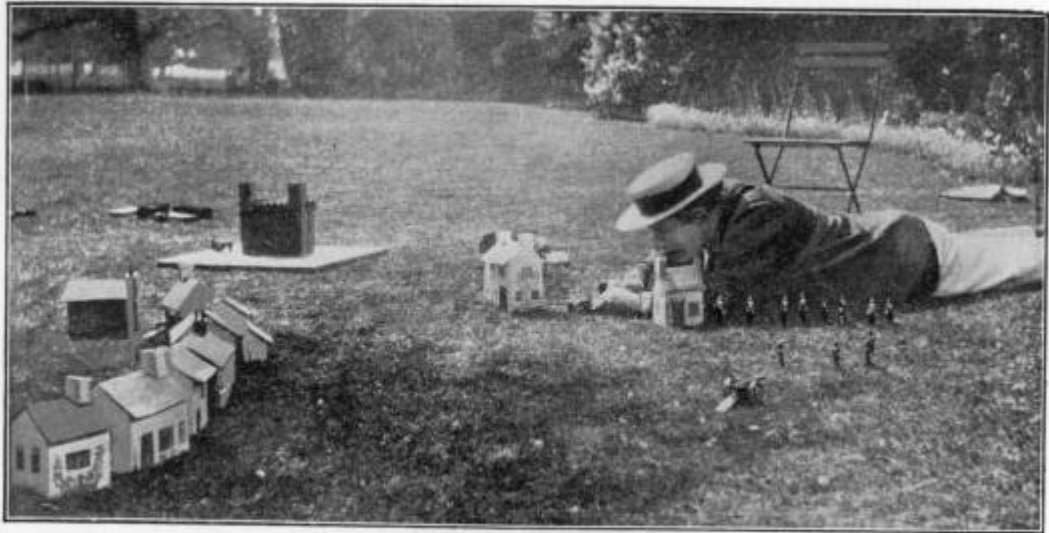
Miniature wargaming is a very social hobby given that wargamers will usually desire to play against an ‘opponent’ rather than undertake a ‘solo’ wargame. Wargamers are often members of a local wargames club, meeting every several weeks or so for a ‘gaming session’ of several hours and usually at a community centre of some sort (from a St John’s Ambulance hall, church hall to Rotary Club meeting rooms for example).

In recent years, war-themed videogames have been of substantial interest to geographers and other social scientists. They have been particularly eager to describe the ‘military-entertainment complex’, whereby the military (particularly the US military) and the entertainment industries are entangled in producing videogames (Power 2007; Robinson 2012; Schulzke 2013; Shaw 2010). As Power writes, ‘digital wargames have an important role to play in making US militarism appear benign’ (2007, p.284) and scholars have treated them as forms of propaganda (see Schulzke 2013). Unlike computer games, miniature wargames as Yarwood observes ‘have had little direct intervention from the military itself, Sabin (2002) notes that an interest in ‘military affairs’, characterised by ‘militaria, reading and battlefield tours’, have made a greater contribution to wargaming than interventions by the military themselves’ (Yarwood 2015, p.660).

6.3: The emergence of miniature wargaming

‘Kriegspiel’, a wargame with miniature figures of soldiers and war machinery used by the 19th century German and British military for training, inspired the celebrated writer H.G Wells to compose ‘*Little Wars*’ (Wells 1913). ‘*Little Wars*’ was a popular and influential ruleset, the first commercially available and was for playing at home or elsewhere in a leisure capacity. With toy soldiers, Wells declared that ‘*Little Wars*’ might be a ‘game for boys from twelve years of age to one hundred and fifty and for that more intelligent sort of girl who likes boy’s games and books’ (ibid, p.7).³⁸ In Victorian and Edwardian Britain, toy or model soldiers were popular, especially among young boys. They were widely accessible through the efforts of the toy company ‘Britains’ (Dilley 1974) and with British and wider European imperial militarism generating enthusiasm (Brown 1990). Wells’s military friends told him they found Kriegspiel ‘a very dull and unsatisfactory exercise, lacking in realism, in stir and the unexpected’ (Wells 1913, p.101). In ‘*Little Wars*’, Wells and his military friends sought to craft a playful and ‘realistic’ ruleset, modelling movement and ‘fire effect’ (effect of shooting) among other aspects and with war waged in a ‘model country’ (see figures 39-40, pp 186-187). Fire effect was produced with working toy naval guns and Wells suggested several projectiles to mimic the effect of different types of fire; dowels for rifle-fire and screws for shell. Effect of fire on human bodies, besides evident

³⁸ Wells was not the first person to consider composing rules for gaming war in a non-military context. Many rules would not have been written down and unpublished or have been since lost (see Brown 1990).



THE WAR GAME IN THE OPEN AIR.

Figure 39. Several plates of '*Little Wars*' played in the garden. Source: Wells (1913).



Figure 40. Well's playing 'Little Wars'. Source: Illustrated London News (1913).

'hits', was worked out by determining the proximity of ordinance to them. Wells offered his rules for tinkering: '[W]e proffer them, not as a finished set of rules, but as material for anyone who chooses to work over them for improvements' (1913, p.105).

Just as today there are differing attitudes to war and gaming and war itself, so there were in Victorian and Edwardian Britain (Brown 1990; Kennedy 2014). Wells considered '*Little Wars*' could make present the 'suffering [...] too monstrously big for reason' of 'Great War': 'Little War brings you to it as nothing else but Great War can do' (Wells 1913, p.99). Wells sought to impress that real war was not fun and heroic, that it was only via its unreal counterpart through mimicry, play, abstraction and the miniature that war could be so. This was something that many years later Pathé News (1970) exclaimed of miniature wargaming: 'This sort of war can be fun!' On a theme developed in section 6.8 on miniature wargaming generally, Wells's '*Little Wars*', distanced from any 'real' battlefield and different in terms of practice, afforded a transitional space made through objects, play, fantasy and comfort and in which violence could not be wrought on valued objects and landscapes or on bodies as fleshy sentient beings.

'*Little Wars*' was cheaply available, reviewed widely at the time and reprinted on several occasions, but it did not foster on any grand scale an organised hobby of wargaming. Gush and Finch in their '*Guide to wargaming*' for hobbyists describe the inter-war period (1918-39) for recreational wargaming, certainly among adults, as on the whole a 'dark age' (1980, p.26). War had been only too real and with 'some reaction against model soldiers [...], held to be in some way responsible for the great conflagration' of the First World War (ibid). Gush and Finch go on to write that 'a number of [adult] enthusiasts kept the pastime alive and developed some of its basic methods, though they were isolated, probably shunning public gaze for fear of ridicule and largely ignorant of each other's existence' (1980, p.26). Several individuals formed the 'British Model Soldier Society' (BMSS) in 1935, a worldwide society of few members (400 by the 1950s) and who were primarily collectors (see Pathé News 1939). BMSS had a yearly 'Tactical Cup Challenge' with rules developed from '*Little Wars*' and with a '*Bulletin*', where, in the 1950s, several influential personalities such as Tony Bath and Charles Grant expounded and disseminated their rule developments.

By the 1950s aspects of armed conflict in miniature wargaming became the subject of quantification and 'probability' ('the measure of the likeliness that an event will occur' (Anderson et al 2013, p.171)) via dice for added realism, notably in modelling 'fire effect' (see figure 41, overleaf). Previously, as noted earlier, toy naval guns and aiming skill

produced the action. Feelings and emotions of (model) soldiers in the sense of ‘morale’ became the subject of quantification and probability as well. Partly as a result of these efforts by several individuals (Bath and Grant among others) for finding more satisfying ways of modelling aspects of war for the tabletop, a review by the ‘*Manchester Evening News*’ suggested of Don Featherstone’s (1970a) book ‘*War game campaigns*’ that wargaming could be ‘regard[ed] [...] almost as a science’. This review was proudly placed on the leaf to Featherstone’s book and gave for a teenage Pearson (2008) a sense that he was going to do something ‘better, more grown-up [...] clever and adult’ (p.128). This was when Pearson compared what he was going to do with what his friend had been practicing: ‘Deano was a bit disappointed to find that my games replaced flaming missiles with dice, but I explained that, while on the surface the inferno option might seem more exciting, it was at heart puerile’ (ibid, pp.127-128).

Figure 41 redacted over copyright

Miniature wargaming was very much focused on pre-20th-century warfare although the First and Second World Wars were not ‘un-wargamed’. In the 1960s and 70s the hobby garnered many adherents, sparked at first by a general interest book on wargaming by the WW2 veteran Donald Featherstone (1962) and which formed part of a series of books on

hobbies. The hobby also grew in the US. In the UK during this time, there were four high-street magazines, numerous conventions and a large number of general interest books devoted to the hobby. Pearson writes of this time:

[Featherstone's] 'Advanced war games' had come from the village library. I had, by now, borrowed every book on wargaming they had (12 books) [...]. The fact that there were so many books on the topic in the library of a small village in North Yorkshire indicates how far wargaming had come [...]. Where once there were only two hundred wargamers in the whole of the English-speaking world, now there were over two hundred wargame clubs in Britain alone and shops selling lead figures on every high street [...]. Wargaming was given a [...] patina of glamour by a number of celebrities, mainly actors, who had taken to the hobby [...]. By 1971 wargaming was so far into the mainstream it featured in an advert for Good News chocolates' (2008, p.129).

In a similar way to the model railway books of the 1930s, introductory books on miniature wargaming sometimes sought to describe what a practice of 'miniature wargaming' was by inferring what it was not. This was ultimately for a purpose similar to those practiced by several model railway authors; one of emphasising the seriousness of the hobby partly in response to fears about the social stigma of adult play with the miniature. Hyde, on his early wargaming years in the 1970s, writes: '[T]he big fear for all wargamers in those days was that people would mock them for 'playing with toy soldiers' [...], the soldiers were not toys; Action Man was not a doll – our lives seemed defined by what things weren't rather than what they were' (2007, p.125). Tunstill, in his book *'Discovering wargames'*, sought to impress on his readers how miniature wargaming was different from 'playing toy soldiers':

'This really is the difference between playing 'toy soldiers'; when two scratch sides are composed of numerous painted or unpainted figures of various periods including cowboys and Indians, and one either throws stones at them or fires matchsticks from a spring loaded cannon; Wargames, where one keeps to a set historical period for the type of figures and also paints them into the correct uniforms of the period; and [...] where the correctly uniformed and equipped troops move and fire in accordance with a time and distance scale, which is based on actual war office manuals and army regulations' (1969, p.6).

Scale is important to Tunstill's sensibility and clothing and colouring of figures take on an importance in relation to the space-time of the intended battle or wider conflict. Furthermore, miniature wargaming is related to particular strictures by Tunstill. These discipline the human hand for Featherstone: 'Poised militantly upon [the battlefield], the inert mini-warriors await the breath of life that can be given in only one possible way, but hands, however willing, can only manoeuvre them when prompted by accepted guidelines

and rules' (1988, p.7). Indeed, for Featherstone: 'It is pointless to construct a terrain resembling a historical battlefield and then let loose upon it a host of infantry, cavalry and artillery whose general milling about bears no relation to [reality]' (1970b, p.10).

Like model railway magazines and books, but also hydraulic model reports, books and articles, wargaming magazines and books sought and seek to 'mirror and inform the societies in which they are produced and consumed' (Keighren 2013, p.745). The first editorial of *Wargamers Monthly* paints a picture of a particular kind of practice, one where Tunstall and Featherstone's sensibility of what miniature wargaming is could be enabled:

'Our policy is straightforward: to provide the wargamer with the information he or she wants in order to be able to fight battles with model soldiers. This information obviously includes ideas about rules, battle reports, figure reviews, etc. It also includes information with a more generally appeal such as accounts of campaigns, uniform data and descriptions of historical armies. Whilst much of the latter may equally interest military modellers, militaria collectors or others with a general interest in military history, we will maintain our policy first and foremost for the wargamer' (O'Hogan 1977, p.1 in Peterson 2012, p.29).

6.4: Big and little war enthusiasm

Following Scarry (1985), war as armed conflict is intent on 'injury' to the human body. The sociologist McSorley (2012, 2014) has recently advanced an 'ontology of war' orientated around the 'countless affective, sensory and embodied ways through which war lives and breeds' (2012, p.1). War is practiced (Shaw 2005), made of embodied practices for McSorley, 'structures of feeling and lived experiences through which war and militarism take place' (2012, p.2). Contemporaneous with, and similar to McSorley's embodied ontology to war, has been the International Relations (IR) scholar Sylvester's (2011, 2012, 2013) call for an IR understanding of 'war as a realm of experience rather than a set of cause and correlates and abstract actors' (2013, p.13), arguing that the body experiences war through 'the physical and emotional connections with war that people live' (ibid, p.5). Such a reading of war is mobilised within this section and important for this chapter. Geography is important to both McSorley and Sylvester's arguments. For McSorley 'a focus on the body tends to render any clear demarcation of discrete war zones and times problematic, emphasising instead the enactment and reproduction of war through affective dispositions, corporeal careers, embodied suffering and somatic memories' (2013, p.2).

Although by no means seeking to trivialise war's embodied spatial and temporal reach beyond battlespace such as the destruction of home (Brickell 2012), to experiencing and living with 'Posttraumatic stress disorder' (Ochberg 2013), representations of war like wargames 'expand' the 'spaces and places of war' (Rech et al 2014). Miniature wargames are usually played for certain experiences associated with particular space-times of war, notably battlespace combat, although the gaming of war *through* and *with* abstraction, the miniature and mimesis can be important as well. On the matter of gaming war, taking account of miniature wargaming opens up explorations of a pervasive and popular leisure practice in which war is central. Gaming war takes place in, and gives shape to, a diversity of spaces from the Georgian landscape park (Seymour and Calvocoressi 2007), the garden (Sterne 1996 [1759]; Wells 1913), the home and bedroom (Pearson 2008) and the military training area among others.³⁹ Incidentally, gaming war, but also within this war as play, whilst often afforded through a warfare model (and simulation), does not necessarily lie with the space and practice of the representational. War as military practice is often understood, experienced and influenced by war as play and game (Apter 2009; Cornell and Allen 2002; Der Derian 2003; Shaw 2010).

This section considers enthusiasms for 'big' (real) and 'little' (miniature, abstract) war among wargamers. Interest is with the embodied relations in miniature wargaming between, although also to, big and little war and mobilising enthusiasm for the practice of miniature wargaming. Enthusiasm is read here following Geoghegan as 'an emotional affiliation that influences passions, performances and actions in space' (2013, p.45). Enthusiasm is often related to as a kind of a 'bug' ('have you got the bug?') and formed by and forming affective links to things, often involving 'enchantment' and whether with objects, atmospheres, practices, spaces, places, people and landscapes. In attending to big and little war enthusiasm, this section begins by tracing the embodied relations between big and little war, highlighting how enthusiasm is produced, influenced and negotiated by an embodied ontology to war. The section then turns to focus on enthusiasm for, and practices with, objects involved in miniature wargaming; model soldiers, rulesets and several non-mimetic objects like tape measures, measuring sticks, rulers and die.

³⁹ In relation to the garden '*Little Wars*' (Wells 1913) can be an example, but much earlier are the exploits of the character 'Uncle Toby' in Laurence Sterne's comic novel '*The Life and Opinions of Tristram Shandy, Gentleman*' (1996 [1759]). Uncle Toby, a war veteran, set about recreating sieges, complete with model fortifications and earthworks (although not soldiers), in the grounds to his house. Arguably, Toby turns the pastoral landscape of his garden into a violent landscape as a way to come to terms with his emotional and physical wounding.

Bourke asserts that ‘weapons and war have long enchanted British and American culture’ (2014, p.5) and many wargamers are captivated by particular battles, conflicts and periods of historical warfare, impelling them to wargame and/or wargames have sparked interest. Warfare and politics, landscape (and/or terrain), personalities and people, military dress, weapons (including capabilities), movement, tactics and strategies can be involved in enchantment, read following Bennett as ‘a state of wonder’ (2001, p.5 in Woodyer and Geoghegan 2013, p.196). For Hyde, there is a romance and affective atmosphere to the Napoleonic cavalry and infantry battle: ‘[You] may secretly hear the bugles call as [...] cavalry draw their sabres and nudge their mounts into a trot at the beginning of a charge, smell the sulphurous clouds of musket smoke as the defending infantry fire volley after volley’ (2007, np). Eardley presents his enthusiasm for the deadly power of medieval weaponry: ‘I have always been fascinated by the efficacy of the longbow in medieval warfare’, its ‘armour piercing capability’ (2011, p.31). For Neil, who wargames the Napoleonic Wars (1803–1815), ‘colour, pageantry and tactics’ drew him to the period, something that he can recreate on the tabletop, like Eardley with his technological enthusiasm and Hyde with the affective atmosphere of a Napoleonic battle. Terrain (a military reading of landscape (Woodward 2005, 2012) or land that has a ‘strategic, political, military sense’ (Elden 2010, p.806)) and its relations with tactics and weaponry Adrian finds interesting:

‘Desert warfare, North Africa [1940-1942] because of the big tank battles [...], a passion I got from reading the exploits [...] and watching my dad wargame. With the North Africa campaign, you do get lots of fast movement [between military forces] because obviously of the desert terrain and you can achieve some nice manoeuvres tactically and although you can get surprise you also get awesome one-on-one bust-ups [between tanks]’.

Just as model railways might be therapeutic for people, wargaming can be too. For Jack: ‘I’d like to be clear: my own interest in recreating any historical battle is not looking to share in the participants’ traumatic psychological experiences. It’s closer to the truth that I’m probably trying to escape some of my own’ {f} ({f} signifies online forum content). For Chandler in ‘*History Today*’, miniature wargaming ‘offers an often almost therapeutic escape into the colourful days of the past, all the thrills without the spills as it were’ (1980, np). This idea of the ‘thrills without the spills’ involves the abstraction of the wargame and through which there is no chance of bodily harm to the self or the soldiers under one’s command. The abstraction involved in miniature wargaming is what can make

aspects of war playable and gameable for wargamers, an important point looked at in detail in 6.8, but for the moment for Mark:

‘I recognize war as an extremely powerful force and I’m drawn to the human drama in it. It makes for a colourful story and satisfies a natural curiosity without my having to become even slightly involved in an actual conflict. It’s probably the same reason people have been reading the *Iliad* for the past three thousand years - wargames bring us a bit closer in a risk-free way to some of the most tragic and triumphant moments of human history’ {f}.

Sometimes wargamers are enthused by battles and conflicts because of a personal connection with them. For Edward: ‘I play Spanish Civil War, WW1 and WW2 because my family lost [...] members in the wars, so I grew up with tales of my ancestors. It’s one way of my honouring them’ {f}. For Edward here war viscerally exists within him not so much as something fascinating, exciting and exhilarating, but as embodied suffering (although of course this is not to say that war can be experienced by wargamers as only one or the other). Edward wargames to make present the insuperable loss war inflicted on his family. Wargaming for him is a practice of remembering, but also one of commemorating. Remembering and commemorating may provoke or inflict wargaming enthusiasm. For Gerry: ‘From my perspective, wargames help to commemorate the battles and certainly those who fought in these wars, whether they lived or died, need to be remembered’ {f}.

A particular battle or conflict through gaming and/or modelling (in making a ruleset) might produce unpleasant feelings and emotions such as pain and shame and whether for the wargamer and/or someone else such as a fellow gamer or family member. Emotional turmoil and the visceral can negotiate enthusiasm for what it is that wargamers play and model and equally negotiating the practice of collecting miniature models. Although in extolling the play of his ‘*Little Wars*’ Wells highlighted a contextual difference between ‘big war’ and ‘little war’ in regard to abstraction (that little war was not *real* war), emotional aspects linking big and little can affect play. Play might be felt as ‘trivialising’ an event of particular gravity and/or through gaming bringing to the fore unpleasant feelings and emotions, making play unbearable. Further discussion about war and the emotions and feelings relating to violence and its affects to the practices of wargaming lie in 6.8 but for the moment for Bruce:

‘[Chechnya] I wouldn’t touch it [model and play it] with a barge pole, it is too recent, it’s too raw [...], there were civilian massacres, no way no. I remember watching it on the TV and hearing the news [...], I couldn’t do that, no not at all. There are

some conflicts that you need time for the emotions to subside, they might never do though, but Chechnya is so bad’.

Decision-making is a prominent enthusiasm and practice in wargaming and constituting for many wargamers enthusiasm for military matters. Wargamers will perform the role of a senior commander, for instance, one wargamer acknowledging his different spatial and contextual position calls himself ‘The Dining Table Napoleon’ (see The Dining Table Napoleon 2015) and promotional material for Slitherine’s ruleset ‘*Fields of Glory*’ asks ‘[h]ave you got it in you to become an Alexander the Great?’ (Slitherine 2015 np).⁴⁰ In playing actual historical battles for John: ‘Wars have shaped history, and it is incredibly fascinating to consider the many ways the outcome could have been different and how it could have been altered’ {f}. Wargaming might afford experiment with history: ‘One of the promises of wargaming is the opportunity to experiment with different tactics in order to investigate outcomes that might vary from the historical record’ (Smith 2008, p.2). Counterfactual history is a particular enthusiasm for some wargamers, for Anthony ‘refights’ are ‘briefly [a] step into the shoes of some of history’s great military commanders’ {f} and where on decisions as well as chance events, alternate space-times ensue, for David: ‘I get to put history right. America stays loyal. Charles the First gets to keep his head and there is no evacuation at Dunkirk’ {f}. From events on the battlefield ‘there is a sense of consequences spreading out in a kind of timespace cone from the imagined change’ (Gilbert and Lambert 2010, p.248):

(Brian) ‘Wargames are not just about what happened historically, but also about what could have happened and the choices the commanders faced. No historical conflict was ever set in stone from the beginning. There is a series of events that resulted in the battles, campaigns and wars that resulted in them turning out the way they did. You take out one of those events and the results are completely different. Part of the fun of recreating these conflicts is [that] we can explore these ‘what ifs’.

As will have been evidenced in the hydraulic models chapter, decision-making has material and embodied affects. Furthermore, decision-making enrolls and is influenced by various temporalities (past, present and future), spaces, non-human things and various actors, agencies and agendas. In both military practice and wargaming emotion and feeling are involved in decision-making. For Michael:

‘I am fascinated to read about military history and the problems and opportunities the Commanders faced [and] the decisions they took [...]. Conflict is very emotional [...], so much adrenaline about and so is the

⁴⁰ Popular terms for being a wargaming general and which are used in self-deprecating ways within the hobby include ‘armchair general’ and ‘tablet-top general’.

game [...]. I think [...] that you go through the same crises of confidence, joy, exhilaration, hope, despair and such like as any real Commander goes through [...]. I think most of us are after the tensions, difficulties and emotions of war which all stem from the decisions that you or your opponent makes [...]. *You* make the decisions and sometimes you are never confident about them, a stab in the dark perhaps, but it makes you empathise with the fact that real generals are only human. You also better realise just how much [of] your personality influences your decision-making and this has led me to [a greater interest in the personalities and stories of several generals] [...]. Bad decisions can be nasty, but amazing if they are from the opponent!

Although some miniature wargamers play solitaire at home, and most have done it from time to time, miniature wargames are more often than not highly social practices taking place, as highlighted in 6.2, among friends at home or club members (who also may be friends). For Alistair, miniature wargaming, for its orientation around the miniature models, affords particular kinds of gaming atmospheres:

‘Miniature gaming is a social activity, you are playing face-to-face against another person, and possibly shoulder to shoulder with others if it is a multi-player game. Although MMP’s [Massively Multi-Player, online games] and online shooters have social aspects, it’s not the same kind of contact that you have with miniatures. Miniatures are especially better for playing with actual, real world friends’ {f}.⁴¹

As Yarwood has suggested: ‘Perhaps most significantly, playing with a model offers one way of negotiating the internal and external narratives that surround a miniature. It is the everyday practices of playing that exceed representation and offer the momentary possibility of configuring alternative ways of being-in-the-world’ (2015, p.657). Play with the miniature can help create ‘imaginary spaces’ (Woodyer 2010), for Shaw ‘much of the fun found in play is the blurring of [...] [subjective fantasy and objective reality] into a mixture of objects and sensations that are not quite ‘self’ or ‘world’” (2010, p. 793). ‘Game’ can be important here with van Creveld’s view that:

‘A game is an activity characterised above all by the fact that it creates its own little world [...] with the space where the game is held, and for as long as it lasts, cause and effect are abolished. The nature of the activity does not matter much. As long as it is done for ‘fun’, as people say, almost anything may be turned into a game’ (2013, pp.1-2).

⁴¹ Grant writes about the pleasure of being able to watch his opponent visibly suffer from a good ‘stratagem’: ‘Finally of course, there is the delight of putting into practice the stratagems assimilated by reading and research and the understandable satisfaction of observing the furrowed brow and perspiration-beaded lop of an opponent as one sees a sapient manoeuvre take effect and contemplates his favourite regiment totally discomfited or put to flight’ (1973, p.viii).

Model landscapes and figures afford as well as participate in the imaginary spaces of the miniature wargame as *Spirits and Dice* (2014, np) explains:

{f}[P]laying a miniatures game is sort of signing a contract with your imagination, you are playing a game about war and yet we are using little models of metal and plastic to move and measure [...]. We understand instinctively that these miniatures are just symbols for the actual experience, just how our brain instinctively translates words into mental images when possible. It's how the board above suddenly looks like the epic battle below'.

For *Spirits and Dice*, model figures demand the mobilisation of the imagination in an intensive and creative way, something that for Ryan makes model figures particularly special: 'Those types of people [computer gamers] don't understand about the use of imagination. When you wargame you don't have all the fancy graphics and sounds, but your imagination adds much more than the computer game ever could' {f}.

Model figures for wargamers are far more than just symbolic abstractions. They can be objects of enchantment, for Ross: 'I still marvel at the composure, detail and just the overall look of some [model soldiers]. Some truly are works of art!' {f}. For Pearson: 'Most of the time the little men brought a ray of happiness into my life. Often, when I was working and struggling for an idea or the final paragraph of a newspaper column I'd get up from my desk, pull open a drawer at random and inspect the contents' (2008, p.133). Emotions and often memories are attached to model figures, becoming objects of love; lovingly cared for. Emotional attachments to the model landscapes are usually less intense because these landscapes are more often than not temporary (being just for one game). Emotional attachment to a model figure is made through various enthusiasms, but for many wargamers this includes sculpting, collecting, painting, admiring and tactically handling figures. For Richard:

{f}'One of the many great things about miniature gaming is that you have a personal investment in the miniatures. When you take the time to pick an army, research its history, pick the manufacturer you like the best, and then spend time painting and assembling it all, you really develop an attachment to the figures that you just won't have with a few pixels on a computer screen. My figures are 'my boy's', and they are unique, again unlike computer games' {f}.

The wargame becomes an opportunity to 'show off' models, for Chris: '[There is] the pride from a new paint job or conversion being admired by your friends'. For Russell, wargaming with his model soldiers enables him to craft a narrative journey for them (his 'friends'): 'I take them out the box and they go on journeys with me, ready to fight another war'. For Joel: '[W]hen my scratch-built war elephants actually manage to get into combat

and trample the enemy, I feel proud in a way that I never feel when playing a PC game' {f}. In Joel's case, the emotional attachment to model soldiers provokes feelings that are an important part of his gaming experience and enthusiasm. The wargames table, with models assembled, can be a visual spectacle, enchanting, like no other for Daniel: '[The] visual spectacle, a properly set up table can look awesome and with nicely painted figures creates the look and feel of a battle more than any boardgame could' {f}. That the 'visual spectacle' is material is important and Gush and Finch make this point astute: 'A wargames table is the only place where you can actually *see* a Roman legion getting ready to receive a barbarian charge, Zulus rushing a British square, the New Model Army facing the Cavaliers, the 8th Army advancing, or the full panoply of the Napoleonic era' (1980, p.16, emphasis original).

Mimesis with wargaming landscapes is very often negotiated by the model soldiers and weapons and play with these. Incidentally, the need for a tactile engagement means gamers have a 'birds eye' or 'helicopter' view of battlespace. As will be detailed in 6.6, whilst some wargamers like this 'giant's view', others seek to negotiate it. The crafting of model landscapes can be an enthusiasm and for play and experiment with materials. The discussion in 4.7 about material affordance, material agency and mimesis in the context of model railways is equally applicable here. Producing a model landscape might generate tactile pleasure with the model soldiers for Polemarch: 'I do get pleasure from handling the soldiers in that model terrain' (2011, np). Producing a model landscape may also help afford imaginary spaces of the wargame. Like with the model soldiers, that the model landscape is physical, able to be apprehended in particular tactile ways, is what can make miniature wargaming enchanting and, therefore, an important element of the enthusiasm for wargaming. For David: 'I [...] love bending down to take a miniature's eye view of the battlefield - you can't beat that!' {f}.

As will have been noticeable in this thesis so far, some models such as railway layouts can be intriguing and wonderful for their 'sham' nature, the complete 'fake', the '*melancholia artificialis* - the longing for artifice' (Olalquiaga 1998, p.140, emphasis added). For Steve: 'A long [...] time ago I read 'Wargames' by Donald Featherstone and was captivated by the pictures of plucky Rebels charging up plasticine hills, to attack doughty Yankee's sheltered behind the cemetery walls of the plastic church' (Steve 'The Wargamer' 2015, np).

Affording and embroiled in play and the imaginary spaces of the wargame are several non-mimetic objects including tape measures, measuring sticks, rulers and dice. Tape

measures, measuring sticks or rulers are used for measuring the distance of a threat and/or target (in the case of a target to see whether it is within ‘contact’ range). Far from having a secondary presence, such instruments, enabling distance as quantity to be perceived, can be an important part of the miniatures gaming experience and what might drive enthusiasm for the hobby and making a difference with the ‘screened ecology’ of videogames (Ash 2012). For Colin: ‘I like the tactile feel of sliding out the measuring tape and angling it around the table. Then again a big draw of tabletop games over the alternatives like video games is rolling dice, moving miniatures, etc’. The ‘rolling of dice’ is an attraction for Colin. A die creates chance, which as Caillois asserts ‘signifies and reveals the favour of destiny’ (1961, p.32). Die open up as well as close down potential space-times, being particularly affective objects for that reason. For Mike, within the imaginary spaces of the wargame die can become ‘associated in the player’s imagination with opposing effort on both sides – the sword stroke and then the parry or block, or the strength of the furious charge vs. the resolute solidity of the counter-charge, etc’ {f}.

This section will close on rulesets. A ruleset for Polemarch is a ‘model’ of warfare, made up of lots of other models: ‘We try to ignore the fact, and treat a set of rules as a single model, but the clue is in the name: a ‘set’ of rules. Each rule within a ruleset constitutes a model, which is part of an overall process, a dynamic model of a battle’ (Polemarch 2012a, np). As highlighted earlier, a ruleset represents combat practice and aims to negotiate play and enable particular feeling, emotional and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace.

War as battlefield practice becomes an exciting challenge to mimic for the tabletop and with model figures. Not all wargamers are interested in ruleset design, although many tinker with rules. For those interested in ruleset design, this can be the predominant enthusiasm for wargaming. This may be because of a love of working with abstraction and ‘styles’ of it to translate war for the tabletop (something that is addressed in 6.7), to the design constraints that inflect miniatures wargaming and the feeling in play of a successful rule or ruleset. It may also be of dissatisfaction with how a ruleset and/or its elements ‘feels’, interest in sharing with and enabling in others particular embodied affects, making money (rulesets can be commercial of course), displaying modelling skills through play, and finally perhaps to ensure the hobby thrives conceptually in its attempts at gaming war. Beyond these particularly rule-centric reasons, modelling a particular period or conflict (battles are not really done) can be because of a love of the personalities, political contexts,

weapons, landscapes, tactics and strategies omnipresent with a period of conflict. Wargame modelling involves research with these issues and might be regarded as a practice enabling the coming into being of hankered after space-times through play and game.

6.5: Model soldiers: Imaginary spaces, the still and surfaces

As noted in the previous section, model soldiers might be regarded as objects of beauty, affective in the sense of mobilising enchantment and can be objects worked on and played with in highly embodied ways, generative of certain tactile and imaginary pleasures. Considering engagements with model soldiers more closely, this section examines these objects with reference to imaginary spaces, the still and ‘surface’. The still has generated attention from geographers (see Bissell and Fuller 2008, 2011; Cresswell 2012; Lisle 2009, 2011; Patchett 2010) and becomes important in this section for understanding how model soldiers are made, practiced with, how they may affect and constitutive of ‘politics of play’ (Woodyer 2012) centred on questions of mimesis (a mimetic politics of play). Surfaces meanwhile have been the subject of a critical assessment by Forsyth et al where they posit that ‘surfaces and interfaces can be productive, enlivening and enchanting spaces’ (2013, p.1017) and where ‘material surfaces are valued in many ways’ (ibid). Similarly to the still, surfaces become important to this section for understanding how model soldiers are made, practiced with and how they may affect and involving a mimetic politics to play, although also model. Important to both discussions on the still and surfaces are imaginary spaces. This section seeks to consider how imaginary spaces, as spaces made through mimetic play, are differently practiced, how they can be afforded but also made unattainable through objects on questions of surfaces and the still, and mobilise particular practices and politics with objects because of these.

To begin this section, what is a model soldier within the miniatures wargaming community, why might an object be rendered one? The question can also relate to miniatures of tanks and other weapons. For Russell:

‘Sculpting should be about trying to get at what the characters are feeling or doing [...], the passion [has got to be there]. I expect to see a well-expressed pose [...], not daft ‘hi yeah’s’ [from Airfix figures], [these are] defiantly toys [Russell shows me a box of them], meant for some rough

treatment [...], but you have to be careful with these [Russell picking up several of his model figures]. Facial and uniform features are important too [...]. I think authentic painting is important in making something into a model. You have a casting, producers will call it a model [like Wargames Foundry or Warlord Games], but good painting is also vital in my opinion’.

Russell’s discussion of model and soldier figures relates to materials, practices, emotions, attitudes (or poses) and intensities of mimesis around detail and painting. These are particular qualities that set apart a soldier figure as ‘model’ from say a ‘toy figure/soldier’ or ‘plastic figure/soldier’ for many producers (often minus the painting) and wargamers (often equally minus the painting). What hobbyists or producers might regard as a ‘model’ is also referred to by them as ‘miniature’ or simply ‘figure’. As a note of intent, bearing in mind how for some wargamers and producers a figure may become a model through painting, the juxtaposition ‘figure/model’ is used in places in this section.

The physicality of a figure/model is made by a sculptor. A sculpture is made usually in clay, a mould is taken and then filled either with alloy, plastic or resin. Sculptors are often miniature wargamers and either work for a company, have set their own up (such as ‘Wargames Factory’, ‘Warlord Games’, ‘Wargames Foundry’) or are freelance. A wargamer might commission figures/models, although most will purchase them either individually when available that way or as a ‘set’. Figures/models will belong to a particular ‘unit type’ (e.g. ‘Camel Riders’, ‘Clan Highlanders’ or ‘French Dragoon Guards’).

In the making and purchase of wargame figures/models as well as practice with them, the still is something to negotiate. Stillness is inherent within the figures/models in the same way that taxidermy is ‘stilled representation’ (Patchett 2010) and often having a photographic quality in so much as the photograph’s ability to still action (Lisle 2009, 2011; Perez 1983). The model battlefield landscape, when the imaginary spaces of the wargame might be latent, has a stillness to it, one where ‘galloping horses [are] arrested in mid-stride’ (Rice 1990, p.6) and infantry have their bayonets always drawn, ready to kill.

Besides uniform/clothing and weaponry details which sculptors address with reference to various kinds of research materials, sculptors will think about what kind of pose a figure/model will have.⁴² For sculptor Allen who works independently:

[The customer] might want that exact same pose with different faces.
[The customer] may not want to have to buy umpteen different packs

⁴² Research materials for soldier’s uniforms and weaponry include primary and secondary sources and contact with academics. Secondary sources mostly include various scholarly and more popular military history books focused on uniform and weaponry (see Cheesman 1975; Haythornthwaite 1998; Summer 2003, 2009), although this can include of course older sources too (paintings, illustrations and various kinds of written accounts for instance) which dominate our understanding of particular places and earlier periods of warfare.

to assemble a unit that is ‘properly marching’ [...]. A skirmish gamer would then recoil at this boring range of automatons with no character whatsoever. That gamer wants variety and individually identifiable models [...]. Then there’s the question of what kind of troops are being portrayed. Are they peasant rabble or [the] King’s Guards? Were they historically highly regimented or did they fight in loose formation? Should your range be mixed to match the character of the troops involved? To me, the key is just having a philosophy for your range; some kind of rationale that works for you as a producer and that you can sell to your customer’ {f}.

Expanding for a moment on Allen’s philosophy behind a range of models, a single model/figure or a set might be orientated around not only a unit and time/period, but also, because of the inherent stillness of them, particular space-times of a battle, characterised by what a human body would be doing. For instance, a set of 16th century Pikemen presented holding their pikes horizontally. Pikes would have been in this position near to and during combat. Furthermore, a set might be influenced by a desire to resist stasis or inertia although the same goes for a single model/figure. In Calpe Miniatures’s ‘charging horses’ set, each figure has a ‘selected pose [...] [so] that in combination they give an accurate representation of the various castable stages of the galloping movement’ (2012b, np). Here, the ‘discrete moments’ of each figure bleed into one another, enabling a highly animated scene. Indeed, animation is central to how Sawyer’s company ‘Warlord Games’ thinks about its approach to its model making:

‘We prefer animated models [...]. I know that some people like their models to all be standing thick and fine, in neatly regimented ranks and that’s fine too, but if you look through our range, you won’t find a standard bearer standing still, he’s fighting with a sword or a pike, getting stuck-in and leading-on the boys [...], there’s pathos in there, character and heroic subject matter’ (Sawyer 2014, np).

The stilled representations that figures/models present are affective, negotiating for many wargamers what figures are used and/or how they are used on the tabletop battlefield and can be related to mimetic play and the coming into being of imaginary spaces. Different sensibilities, and from there practices, attempt to overcome a mimetic flaw of model soldiers - their inert materiality.

For Marcus: ‘I am far more annoyed when you cannot get the same marching pose, why anyone would want a battalion in line all in firing pose is beyond me, they only look appropriate if they are actually at 50 yards in a firefight after the attack has failed, the rest of the time they look stupid’ {f}. For Marcus here, models that are firing look out of place (‘looking stupid’) in a spatial context beyond a combat area. It is this tension between the

space-times the pose is suggestive of and the game space that the pose exists in, that mobilises particular sensibilities and practices in an attempt at mitigation. Mitigation is in an effort to close down annoyance to this unreal, potentially disrupting the imaginary spaces of the wargame.

For Nigel: 'I try to model every unit marching as I feel it is a sufficiently neutral pose to look good on the table whatever formation the unit is [...] doing, firing figures in 'column of march' just [does not] look right' {f}. Equally for Peter: 'I prefer advancing, or marching. To me, both look fine in almost any situation, from marching in column, assaulting in line, to defending a position. By contrast, shooting poses only really look good when defending and look positively weird in column' {f}. Both Nigel and Peter use figures that have poses they find malleable to several different space-times. Another sensibility and practice for other miniature wargamers is to use a pose representative of what soldiers would be doing on the battlefield for most of the time. For John: 'Pikemen, even on the day of battle spent much more time marching or standing around than they did actually fighting, so 'upright' has to be the easy answer' {f}. Equally for Jason: 'I prefer a walking horse and a rider with a shouldered sword. This is the way they move around the battlefield most of the time. It is only in the final 30 to 50 yards that they go into the gallop and charge' {f}. Other wargamers might 'mix up' the poses so that there is 'always something going on that looks right' for Erik {f}.

Another approach attempts to mimic more intensely from the above sensibilities and practices what the soldiers would be doing through swapping poses in response to change. For Gordon: 'I alter all cavalry figures on [the] table to represent its exact status [...]; standing, moving in road column or attacking in line. If horses and riders are separate, I need only two poses of each' {f}. For other players this approach might be problematic, making the battlefield landscape into a 'frenzied' place of 'flying hands [...] swapping [the figures] back and forth' as Mark asserts {f}. This raises a wider point about how the space of the wargames table can become a place where different sensibilities to negotiating stilled representation play out through practice and potentially cause discomfort and annoyance, although as Tim argues: 'I don't let it get in the way, you can't really force someone to change the way they play, it's a hobby you know, although some people negotiate because they want other people to enjoy it too'.

There are many wargamers that do not have a particular sensibility to negotiating stilled movement. For Tony: 'I don't care; the models come alive in my mind!' As Woodyer has pointed out, toys as objects can 'enchant and [...] inspire the imagination, prompting

anthropomorphic thinking and the creation of imaginative worlds' (2010, p.326) and models can do the same. Perhaps what can make such divergent sensibilities in attitudes to stilled representation, where a 'blurring of [...] subjective fantasy and objective reality' (Shaw 2010, p.793) needs more help in the one sensibility than the other, rests on people's differing intensities, formulations (including space-times) and even mere existences of 'pretence' ('the action of pretending; make-believe, fiction' (OED 2015b np) in relation to play with objects and space. Something not dwelt on by geographers of play Woodyer (2010) and Shaw (2010) is aspects of these questions. The debate over stilled representation, but also surface as will be charted soon, can help here. In relation to the non-emergence (of variable durations) of pretence, enchantment with model soldiers and landscape as model and artifice can be important, for instance for Aaron: '[S]ometimes if you have just painted your models and you play your first game or see some for the first time some you really like it can be a real distraction from the game, you just can't stop admiring them!'

This section turns now to consider surface and the model soldier. In a similar way to the still, surfaces, alongside imaginary spaces made through mimetic play, become important for understanding how model soldiers are made, practiced with and how they may affect and involving a mimetic politics of play although also model.

For Aaron: '[P]ainting the figures you are breathing some life into them, they become more familiar, more real [...], you're turning something evidently metal [or plastic] into something more evidently human'. With brush, skill, imagination and with reference to a diverse array of primary and secondary sources, the bare metal or plastic surface of the sculpture becomes 'painted'. The material properties and pigment of paint, the sculpted surface and the embodied skills of the painter, enable a surface where tints, shades and tones mimic visually those surfaces of the body (such as the skin, clothing and the eye) and various objects.

The 'bare metal' or plastic surface of a figure/model is a space often meticulously worked on with paint, itself productive of a new surface. Figures/models are usually purchased unpainted although specialist companies and individuals offer a 'painting service'. Many wargamers paint, but each wargamer will have a different intensity of enthusiasm for it. For Matt: 'It frustrates me somewhat that I have to make up models and paint them before I enter the battlefield' {f}. Painting, usually undertaken at home, might be something to be enjoyed and savoured or a more suffering experience. Unpainted figures for Ben, whilst beautiful, are objects for transformation, to be 'given life', the

practice of which can be highly affective in positive ways: 'I do enjoy painting and feel it is one of the reasons my blood pressure is so low. The research before or during any project is always enjoyable and it's great to see a figure 'come to life' as I paint it'. Paint and the practice of its application for Ben have life-affirming qualities in mimicking skin and eyes as well as making those non-fleshy parts (uniform, clothing etc.) much more real. In attending to the surface of things and the surface of the figure itself, the figure becomes something else from what it once was, becomes imbued with new meaning. As highlighted earlier, this might be as 'model', but it can also be in highly personal ways. For Bruce:

'In painting I am making another friend in my army. I know it sounds daft, but I am creating this character, the colour of his hair and coat, he's another one of my brave soldiers that is often at the mercy of my tactical mishaps. Thankfully he always lives to fight another day otherwise I would be pretty distraught!'

Meanwhile for Simon: 'My unit is just not a unit unless it is painted. As soon as one little fella has a red beard and another a brown beard, all of a sudden they start to look like characters, you can imagine them as drinking buddies' {f}. Finally, for Lee: 'painting [is about] what it can do for your imagination and your feelings about your own army. I feel so much happier [...] now that they're mostly not just a pile of metal'.

Enthusiasm for the practice of 'giving life' (painting) includes for Ben the opportunity to engage with the tailoring and fabrics of military uniforms: '[S]ome [uniforms] made men real peacocks about town [...], the therapeutic part [I get comes] from painting the uniforms, seeing colour take over the surface [...] [and] the feel of the long brush strokes on these big wavy coats'. For Ben, here the miniature affords closeness with uniforms and painting affords enchantment. Some wargamers enjoy the mimetic challenges that figures/models and paint might present. For others, the embodied practice of painting might not be especially enjoyable, but nevertheless an enthused practice because of what painting a figure/model will do in the future and/or the space-times it opens up. This includes the possibility to play with other wargamers, but Kyle paints in part so that he 'feel[s] a greater connection to [his] figures' {f}. The time and embodied effort placed in painting a figure for Kyle mean that his figures mean more to him than would otherwise be the case. Particularly important for many wargamers is how painting can help enable imaginary spaces as Jack suggests: 'The figures when painted are a gateway, what motivates me to paint is being able to suspend my disbelief when I am gaming [...]; that what I am seeing in my imagination is on the tabletop' {f}. Jack's use of the term

‘gateway’ is important, highlighting how painting can help a figure/model become a ‘transitional object’, enabling alternate space-times to be opened up with the imagination.

Most wargamers will seek to paint the uniform, kit and clothing of their miniature troops in colours that would have thereabouts been sported by the modelled. Colouring, undertaken with reference to a diversity of primary and secondary sources, can often be a highly fraught practice in terms of ‘authenticity’, becoming trickier to grasp when there is a dearth of primary source material. Colouring can motivate critique and critique by fellow wargamers at a club can impel wargamers to pursue intensities of research (like with railway modellers and display layouts in 4.6). Lack of confidence about the ‘right’ kind of colouring can cause worry. The miniature wargames writer Hendry tries to reassure the newbie Ancients wargamer: ‘[D]on’t worry if you don’t know it all, no one does! And if someone tries to tell you you’re wrong, [...] that your tunics are the wrong colour, don’t worry, they’re as likely to be wrong as you!’ (2012, np). Debates and tensions at the wargames club have the potential to arise over painting and questions of mimesis as Bruce asserts:

‘There might be a hoo-hah from several if you do a real faux-pas like painting British [Napoleonic] Grenadier’s in blue [rather than red], but no one is of that persuasion. The odd person might have a niggly about some minor thing, but we are here to game and details don’t matter much when you can’t see them on the tabletop’.

As remarked earlier, painting can be a suffering experience, even if there is some enthusiasm for its practice. The ‘rush’ of enthusiasm might soon drain after a few similar figures/models are painted, becoming boring through repetition, making painting them tough for its monotony, requiring ‘strong personal discipline’ (Kawczynski 2013a, np) to keep going. For Derek, to make painting durably bearable: ‘[W]here possible I think the thing is to use your imagination. Mix in overcoats, bare heads, bonnets de police, slightly different coloured coats, leggings, etc.’ {f}. The amount of sculptured detail on the larger figures/models (28mm and 25 mm) can be daunting for Darren: ‘Napoleonic uniforms [...] [are not] easier to paint [...], [they have] a million overlapping straps, packs, and various doodads hanging off everywhere, and sculptors are obligated to sculpture them all [...] which means I have to paint them all’ {f}. Particular intensities of detail and questions of scale and its effects/affects can be involved in attempts to mitigate the monotony and/or amount of embodied effort that has to go into painting. Whilst there are many reasons why wargamers choose particular figure scales (and, therefore, gaming scales), 6mm (1:300) for Tony offers the ‘massed spectacle of troops without having to spend ages on each one’ {f}. For Crespo: ‘What counts in [...] paint[ing] 6mm is the effect of the

whole unit, not the detail of the individual miniature' (2011, np). However, wargamers, working in whatever scale, to combat effort and monotony might also negotiate the intensity of detail painted.

Unpainted figures/models displaying a metallic or plastic surface when brought to a club and wargames table for play might provoke negative reactions from club members. For Adrian, mobilising an analogy with the naked human body: 'You would *never* even think to bring an unpainted force [...]. It would be like intentionally showing up without clothing' {f}. For Giles, who is a club Chairman:

'I have never had a situation when someone has persisted in using unpainted/partially painted [...] figures over a long period [...]. I would guess that the ribbing/joking would be more regular [...]. Certainly this happened with a player who basically never had any armies of his own! He had figures, but was very slow and disorganised in painting and so never, he came to us for about 10 years, actually used his own armies'.

Unpainted figures/models upset many wargamers. A key reason is that such figures/models ruin the visual spectacle of the game and make the coming into being of imaginary spaces through mimetic play impossible, more difficult and/or affect its intensity. For Adam: 'I find it hard to engage with a game that's not painted [...], it totally killed me seeing all those awesome models unpainted' {f}. For Nigel: 'A major appeal of the game is the imaginative and imagery based aspect, which is completely ruined by unpainted models' {f}. For Brad: '[I]t does take away from the feel of the game. I really like the total immersion of playing with and against a fully painted army' {f}. Finally, for Lee:

'I have done it [wargaming with unpainted models] on several occasions with an opponent who played with his models, but the models throw everything off kilter because they create, I don't know, this barrier [...] to feeling in the world of the game because what you are seeing isn't right so you are not so immersed. I guess you could get used to it, but once you have played with wonderfully painted models you don't want to go back!

Not painting figures/models can be inflicted with a moralistic discourse pivoting on the embodied effort placed in the surfaces. For Ashley: 'Why is using an unpainted army disrespectful to your opponent? Because your opponent has taken the time and trouble to paint his army. He expects that the person he plays against will have made a comparable investment in time and resources to field an attractive army' {f}. Forcefully for Ross: 'I *hate* unpainted miniatures in any game. It is lazy, disgusting, rude, ugly, pointless to the max' (emphasis original) {f}.

Wargamers who constantly play with unpainted figures/models in Giles's experience 'are very rare'. The topic though is a perennial one on the hobby's online forums. Painting figures/models might be an aspiration for those who play with unpainted figures/models as Giles asserts:

'I think in my group as a whole [unpainted figures are] acceptable, but expected to be temporary. Most commonly this has been [...] done [and is still being done] by players new to the hobby. So either they are still building [their] army or they have organised a game and underestimated the time needed to paint the figures or similar 'beginners mistakes'. In short, the experienced players know how much effort it takes to get a fully painted army on the table and give a little room to new players to get their act together'.

Unlike Giles's club, a dominant sensibility in other clubs can be a less forgiving. For Sinclair: 'On our [club] website and publicity we explicitly state don't expect to bring unpainted figures and be able to put them on the table [...], though we will offer support and try [to] encourage them to paint to the standards of our club' {f}. Each wargames club has its own 'culture' (made of attitudes and practices) for Giles and included is a sensibility to figures/models that may be attractive or unattractive to potential new recruits. Many clubs, such as Sinclair's, attempt to nurture painting. For Nick:

'If they have an IQ of more than 10 they should be able to tell that everything is painted on the board. We will do whatever we can in terms of helping them with [...] uniform info, painting tips, etc., but unpainted figures is a huge no-no with our group. This has worked well in the past and has created some pretty good painters and club members over the years' {f}.

Paint on a figure for Taylor does not influence how he experiences play: 'Why paint an army when you can visualise it in your own minds eye and just get the fuck out there and roll the dice?' {f}. Here, imagination fills the gaps left in the wake of abstraction. For Taylor, whether a figure is painted or not does not affect the coming into being of imaginary spaces. Painting may add nothing to some wargamers play experiences, but might be valued in other ways. For John, this means foreclosing guilt and maintaining friendships: 'I'd feel bad if I rolled up with a grey plastic and metal unpainted force' {f}. Meanwhile for Trevor, painting opens up particular space-times: 'If I didn't paint my models I wouldn't really be able to join the club, so painting enables me to have contact with other gamers as part of a club' {f}.

6.6: Modelling war for the tabletop, part one: Teleplastic technologies, mimetic play and an embodied ontology to war

For Perla: ‘The [historical] wargame designer builds his world [...], the creative building of an internally complete and consistent world whose broad contours are contained within the bounds of historical context’ (1990, p.173). More specifically for Sabin:

‘Wargame modelling [...] [is about] capturing the complex details of a real conflict [...]. Military simulation games [...] seek to simulate the terrain of the battle area, the deployment and capabilities of the military forces, and the passage of time during the engagement, thereby providing a synthetic experimental environment that mirrors in certain key respects the real range of potential courses and outcomes associated with [...] armed conflict [...]. The equally fundamental component [...] consists of an iterative set of active decision inputs by one of more players to guide the simulated actions of the combatants and to respond to the changing course of the simulated conflict, in order to maximise their relative or absolute performance in terms of [...] victory criteria’ (2012, p.4).

Miniature wargaming rulesets are textual objects and after Perla (1990) and Sabin (2012) can be seen as crafted models of warfare in their careful production of a game-world. Through human engagement, they have performative or simulative relations with mimesis (also see Dunnigan 2000; Thompson 1962; Weiner 1959). Miniature wargaming rulesets are composed of ‘human-friendly’ rules and ‘mechanisms’. Players actively engage with these unlike in videogames where rules and mechanisms are written in code, ‘computer-friendly’ and ‘internal’ rather than ‘external’ (By 2012, p.158 also see Deterding 2010). Rulesets are naturally composed of various ‘rules’, for Berg et al: [Wargame] rules are not exactly light reading - the number of concepts and procedures to be explained in detail can hardly be dealt with in a few easy paragraphs of colloquial English. The closest analogue to a set of rules would be a set of computer program statements’ (1977, p.103). Rules control and/or discipline gaming practice/play and in relation to mimesis. Also vital to a ruleset are ‘mechanisms’. A mechanism will work with a rule or rules, but is also something different. Mechanisms are formalised techniques, involving practice, concepts and often gaming objects, particularly dice and a deck of cards. Mechanisms are representations involving and affording practice through engagement with them and are designed to produce particular kinds of gaming practice/play with a mimetic objective. Mechanisms are sometimes referred to as models.

This section attends to the miniature wargames ruleset. The miniature wargames ruleset is read here as a ‘teleplastic technology’. This section is interested in how rulesets and game designers seek to enable particular feeling, emotional and imaginative states relating to other human bodies and space-times through mimetic play (e.g. ‘I feel like Napoleon at Waterloo’). The section begins by sketching out what rulesets try to do. The section then turns to thinking about teleplasticity after Ash (2010) before moving to examine how rulesets model aspects of armed conflict, with attention given to an embodied ontology to war.

Important in modelling war for the tabletop is the materiality, throw and affordance of the numbered die, but also sometimes a deck of cards. As Hiller notes: ‘[C]ontingency, chance or the undetermined’ have a part in the ‘unfolding of events’ (2015, p.97). ‘The throw of the die’ and the selection of a card from a stack are engines producing chance, with game events in space-time often being tied to ‘probability’ (the ‘likelihood of being realised’ (OED 2015c)). A die produces a number (a ‘result’) and probability defines what the number (or numbers when dice are involved) means and in terms of game events. In the instance of cards, probability defines the frequency of an event in a card deck. Game events and the making of chance are tied to the turbulent and affective nature of Fog of War, movement, terrain, firing, melee (combat), morale and command. Conflict is modelled and played around these, although they do influence one another and involve battlefield mobility, emotions, landscape, decisions, violence and non-human agency.

Whether a glossy commercial ruleset such as Mersey’s (2014) ‘*Lion Rampant*’ or hand-scribbled ‘notes’ at home, rulesets are made to afford things. The blurb to Buchel’s ‘*Muskets and Tomahawks*’ ruleset asserts that it ‘*immerses* players in the tactical *feel* of warfare of this era as they lead their forces to accomplish their assigned mission’ (Buchel 2012, np, emphases added). Borg on his Napoleonic ‘*Command and Colours*’ declares: ‘The Napoleonic tactics you will need to execute to gain victory *conform* remarkably well to the advantages and limitations inherent to the various Napoleonic National Armies of the day and the battlefield terrain features on which they fought’ (2010, p.2, emphasis added). ‘*Fields of Blue and Grey*’ (American Civil War rules) is proffered by its designer as ‘more than just a collection of game mechanics to play a game [...] [it is] actually an attempt to *imitate* what might have happened on a battlefield’ (Abbott, 2014, np, emphasis added). Affective atmosphere can also be important. Field of Glory’s ‘*Ancient Rules*’ ‘allows us to *capture the atmosphere* of battles ranging from the dawn of history to medieval times’ according to its blurb (Field of Glory 2015, np, emphases added) and ‘*Gå På*’ for Årnfelts ‘uses a rather

abstract system to *capture the atmosphere* of the 18th century battlefield, but still contain enough detail to give the different armies character' (2012, np, emphasis added). Besides rulesets advocated as imitating, conforming (to history), producing feeling and atmosphere or enabling immersion, several other concepts have also been used to describe what rules do, including 'simulate', 'represent' and enabling the performance of 'accuracy'.⁴³ Each word might have some relation to another.

Several of the rulesets described above assert the production of 'feeling' (including affective atmosphere) as an affordance of their ruleset and this can be tied to mimesis, where a ruleset might for Theo 'give a feel for how the various troops maneuvered and responded to each other, the battlefield and battle events' in relation to knowledge about historic warfare {f}. On knowledge about historic warfare and feel, for Giles: 'Feel, much of it has to do with [...] adhering to the laws of physics, but mostly it is based on expectations. Those are developed by gamers over years of playing games and reading history among other things'. 'Feeling' can be about the embodied affects of command and conflict. Although prefiguring discussion on modelling, Jones highlights this when referring to the '*Repique*' series of rulesets he designed:

'Repique and Piquet have both stressed different methods of treating time in the play of a miniature wargame using cards to make the flow of time unpredictable, and, in Repique, adding variability in the extent of movement within any move time frame as well. These mechanics bring back suspense and the need for the gamer to deal with some level of risk in sending troops forward into battle. They nicely mimic some of the angst of command in battle, and require some level of courage in decision making by lowering the unrealistic levels of 'knowns' in many wargames of exactly when, and how far, a unit may move' (2010a, np).

Miniature wargaming rulesets can be considered as teleplastic technologies. Ash has asserted how videogames can be read as teleplastic technologies. 'Teleplastic' relates to Caillois's concept of 'teleplasty', meaning a 'molding or forming at a distance' (Ash 2010, p.415), a 'morphological mimicry' or 'genuine photography [...] of shape and relief on the order of objects and not of images' (Caillois 2003, p.96 in Ash 2010, p.415).⁴⁴ For Ash,

⁴³ In the case of Warlord Games's '*Black Powder*' ruleset, the designer's state: 'Naturally, we wish our game to be a tolerably convincing *representation* of real battle' (Priestley and Johnson 2010, p.2, emphasis added). For the designer of '*LaSalle*' (Napoleonic wars): 'LaSalle can also be used to *simulate* historical battles of the Napoleonic Wars' (Mustafa (2013, np, emphasis added). For Hasenauer on his American Civil War rules '*Regimental Fire and Fury*': 'It took years of refining the rules and much play-testing to find the balance between playability and *historical accuracy* players expect in a Fire and Fury game' (2015, np, emphasis added).

⁴⁴ For Ash (ibid): 'Teleplasty describes those technologies that pre-shape the potentials and possibilities for human action, movement and sense. In this sense, technologies do not only preempt what one can do and the ways in which one can do it; technology itself acts to pre-empt possibilities for sense by shaping the user's 'phenomenal field' (their capacity to sense space and time, and entities within that space-time)'.

what characterises teleplastic technologies and, therefore, the environments they produce and of which they are a part, ‘is the creation of limited potentials for movement and action’ (2010, p. 417). Rulesets, as teleplastic technologies, are meant to control play, in one way for instance for designers of *‘By Fire and Sword’*: ‘The rules system *allows* for the use of a variety of tactics, formations and ways of warfare used during the 17th century and takes into account the differences in training, arms, armour and morale of the various types of units’ (Wargamer Company 2013, np, emphasis added). For Colonel Scipio: ‘There’s nothing like the sinking feeling that comes when one of your play-testers says, ‘well, can I do this?’, and you realise there’s no rule for it. And you can’t think of a way to represent their desired action. It’s a difficult job’ (2013, np). Control can be felt as disabling though and rulesets or particular rules might be disciplinary rather than controlling in orientation. Stuart suggests:

‘In war-games rules, the degree of variability or randomness, or whatever, the range of possible outcomes, anyway, should tend to be larger than we might think of as realistic [...]. I do not like [...] rules which say ‘cavalry cannot break a steady square of infantry’, I’d rather see you can charge a square if you want, it’s not a great idea, but there is a very remote chance that you might succeed’ and let the rules and experience look after themselves. Let the [black] swans in [black swans mean unforeseen impact-full events]. If something unlikely happens in a game because of an unlikely dice-roll then that’s fair enough. Something unexpected happened [...], just today the militia broke the grenadiers’.

This section is interested in figuring teleplastic technologies as doing more than that pronounced by Ash; productive of ‘limited potentials for movement and action’ (2010, p. 417). Miniature wargaming rulesets do more than provide ‘limited potentials’ because rulesets and game designers seek to enable particular feeling, emotional and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace. Caillois’s concept of ‘mimetic play’ (1961), used in the hydraulic models chapter, can help us think about this. As Caillois suggests: ‘Play can consist not only of deploying actions or submitting to one’s fate in an imaginary milieu, but of becoming an illusory character oneself, and of so behaving’ (1961, p.11). In Caillois’s concept of ‘mimetic play’, ‘the distinction between the self and other becomes porous and flexible. [...], mimesis as mimicry opens up a tactile experience of the world in which the Cartesian categories of subject and object are not firm, but rather malleable’ (Puetz 2002, np). This section considers how rulesets, through their limiting potentials, but also just as entities,

seek to enable particular feeling, emotional and imaginative states relating to other human bodies and space-times through mimetic play.

Woodyer notes of critics of commercialised toys who argue that ‘the creative accident of play is foreshortened as play scenarios become increasingly pre-scripted by media’ (2010, p.195) (see Thrift 2003, p.401). This is ‘thought to prompt a loss of the ability to fantasise, and be creative and spontaneous, features which are commonly regarded as fundamental components of ‘authentic’ play’ (Woodyer 2010, p.195) and where for Kline ‘imaginative play has shifted one degree closer to mere imitation and assimilation’ (1989, p.315 in Woodyer 2010, p.195). This section queries the notion that the pre-scripting by media of play leads to a ‘loss of the ability’ to ‘fantasise’ and be ‘creative and spontaneous’ and that ‘imitation and assimilation’ ought to be ‘mere’ and against ‘imaginative play’.

With a similar perspective as part of 4.8 (abstraction and affective atmosphere), this section finds how embodied practice may inform modelling as a mimetic practice and be important to models as representations. It is detailed how wargame designers grapple with an embodied ontology to war for generating imaginary spaces through mimetic play with the warfare model and its rules and mechanisms, including breaking down distinctions after Caillois (1961) between self and other (e.g. ‘I feel like Napoleon at Waterloo’). Some attention is given to mimetic tensions that exist in designing wargames, the product of different sensibilities towards gaming war. Discussion revolves around four concepts and several have a particularly geographical hue to them. First, attention is given to how and why ‘morale’ (emotions of soldiers) is modelled through rules and mechanisms, before then doing the same with regard to terrain and its affects and then friction (impediment) and finally lack of situational awareness, commonly known in military theory and practice as ‘Fog of War’ (FOW).

As Anderson and Smith write, the ‘human world is constructed and lived through the emotions’ (2001, p.7 in McQuoid and Dijst 2012, p.26) and for McQuoid and Dijst ‘the way we feel and anticipate feeling in certain places or situations can assert great influence on our behaviour’ (2012, p. 26). ‘Morale’, something Anderson postulates as a ‘collective affect’, ‘esprit de corps’ or ‘intense fellow feeling’ (2010b, p.220) has long been synonymous with war. Morale has been targeted and intervened on (‘boost’ or ‘break’ morale), indeed for Napoleon I (2002), morale was decisive to the hope of victory.

Early miniature wargaming lacked morale in rulesets. Tabletop battles were ‘last man standing’ bloodbaths. For Austin: ‘[O]nly robots will stand and fire in the face of terrible odds and certain death’ {f}. By the 1970s and 80s ‘a huge part of battlefield

decisions in real life' {f} for Austin was produced by morale on the tabletop and that for Jones 'prevented combat, limited combat, or, when all else failed, required retreat when certain conditions were created' (2014b, np). Producing morale in tabletop battle makes battles more realistic for many wargamers, including generating particular feelings and emotions and their involvement towards becoming other, being a General or another commander. Morale also wrestles control of play from the gamer as a commander. For Wood: '[A] system of morale in a wargame is designed to give some element of calculated risk of your army 'melting away' and the game coming to a more 'realistic' end than just wiping out the enemy' (2013, np). For Whitaker:

'[Morale] can be modelled with dice effects and rules: they're semi-predictable, but uncontrollable at the conscious level, so you shouldn't be able to override them by, if you like, gamer decree. The conscious effects are rather more interesting. Do we continue the attack? Dare we risk it?' (2013, np)

Each designer may have their own technique of modelling morale in a game although dice and probability is the chief mechanism in bringing about morale and from there particular embodied affects. On the cusp and/or after particular game events (this might be a game turn or a detrimental fire and death event for instance) morale is something to be measured (non-numerically) through a 'test' and bodies of soldiers or individual soldiers (in the case of skirmish gaming) start the game with a rating based on experience and training. This rating is judged by the designer although other factors can be important such as, for Gush and Finch, 'protection and armament [...], what system [they were trained in], timid [...] impetuous [...] tribal, feudal, mercenary' (1980, p.142). For Giles:

'You have to think about whether the unit [...] did any training, had they [saw] combat before, were they elite troops or something, were they known to be tough or were they easily scared. That affects the morale rating [...]. You get this from reading the books on the historic battles. Sometimes people refer to primary sources if they are available. There is always a subjective element to how they behaved especially if we know little'.⁴⁵

Considering morale is fraught with conceptual, subjective and historical problems. For Neil, because of questions of place: 'For us is really difficult for example to grasp the effect that fighting at the ends of the world had on the morale of Alexander's Macedonians' {f}.

⁴⁵ Disagreement with the rule designer about how units 'behaved' may lead to gamers tinkering with the ruleset.

Better rated units have a higher likelihood of overcoming morale 'tests' (failing a morale test on a good unit, for instance, might require one die roll result of 6, worse units would require a result between 3-6 for instance). For Don: 'Failed morale checks downgrade the status of a unit, which affects the unit's ability to perform the more 'gung-ho' actions such as assaulting or rapid firing' {f}. Here, a unit in poor condition may require a certain subtraction off of a die roll result and/or where 'hits' become difficult as per morale mechanism. Drawing on his reading of Napoleonic warfare, Thomas in his ruleset makes relations between morale and the spatial qualities of combat formation when considering 'testing' morale:

'Units in square formation enjoy a favourable morale rating; their very nature meant they could never be outflanked, which created a great sense of 'esprit de corps'. Accordingly, if they fail a morale test they may make a second attempt. Hordes are by contrast penalised. They may have been large, but were also utterly undisciplined. Since this defect could induce extreme panic, two die rolls must be made every time a test is required and if both rolls fail, two bases are removed' (Thomas 2009, p.93) (the removal of basing refers to the removal of a base of models; this is to represent the fleeing of soldiers).

'Terrain' is an important aspect of armed conflict. As Gordillo and Elden write: '[The] three-dimensional materiality of terrain profoundly affects and constrains mobility, visibility, and action' (2014, np). Terrain is the visible surface of land and can affect military practices such as tactics (Doyle and Bennett 1997, 1999, 2002). Terrain might be regarded a military reading of landscape (Woodward 2005, 2012) or land that has a 'strategic, political, military sense' (Elden 2010, p.806). Terrain can make wargaming fun because of the difficulties and opportunities it presents in attaining military success. Given that gaming with wargame rulesets are not usually about 'replaying' exact battles, gamers will often design their own battlefield landscapes, deciding on certain environments and the placing of terrain features such as hills, ridges, dips, woods, trees and houses.

For Robin: '[T]errain [...] can be modelled with varying degrees of detail and [conceptual] abstraction' {f}. Tabletop landscapes are usually more abstract than a model railway layout because of their temporal permanence and the tactile needs of positioning and moving models. In the game, rules and game mechanics give model terrain features meaning and imaginary agency, particularly with regard to movement and firing of troops. The agency of terrain and its affects upon military mobility and fire become something to model through rules, dice and probability. Designers assess how particular spaces, topographical features and objects may affect performances of military objects and practice

and how these might be modelled for gaming. Jones summarises his game's rules on terrain:

‘Examples of each use or effect of terrain [...]. *Cover*: Woods, wall, structures usually diminish the effect of fire by either subtracting from the firer's effect or adding to the defence's resistance to fire [...]. *Increasing effectiveness*: Often rules give a firer or defender on a hill, or higher, ground than its adversary, advantages. The most common is that artillery in the Horse and Musket period shoots farther and with better effect from slight elevations. Downhill charges are often given advantage’ (2013a, np, emphases added).

‘Subtracting from the firer's effect’ relates to a subtraction of the die result, decreasing fire effect. Terrain's ‘adding to the defence's resistance to fire’ may be modelled through thinking about probabilities of a ‘hit’, for instance, to ‘hit’ a field unit in ‘cover’ may require a 4-6 result, trickier than ‘open ground’ which might require a 3-6. The probabilities themselves, like the morale probabilities, are subjective. For Giles, a decision on probabilities comes through the rules writer's knowledge, derived from studying the topic covered and on warfare generally:

‘This reading can be [...] more commonly histories of the events, first-hand accounts, etc. [i.e.] you use more or less unbalanced historical sources as historical statistics, [i.e.] more reliable sources are rare. You would also use other works on the realities of warfare, the art of strategy and tactics, psychology, most commonly focused on combat, etc’.

Terrain of course also affects military mobility. Rulesets are stipulative of how movement should take place on the tabletop. Jones summarises:

‘Examples of each use or effect of terrain. *Restrict or slow movement* [...] woods that slow or prevent certain combat types from entering [i.e. Artillery not entering woods]; rough ground or hills that slow the rate of advance of units. Conversely, roads may either simply free units on them from the effects of surrounding terrain, or, increase the rate of movement by some units’ (2013a, np).

Judgements are made as to how different kinds of terrain affect, in an abstracted sense, military mobilities. For Jones though:

‘Any restriction on movement effects by terrain should be a variable, not a fixed deduction [...]. In every battle report by contemporary participants' movement is not very predictable, distances covered are wildly removed from any sure $D=T*D$ formula [...]. [Variant movement] is easily handled if the movement system is already a variable roll, as it is in both of [my] *Repique* [rulesets], but even in fixed movement games, it seems to me that terrain's effect should not be predictable, and have wide variation. The occasions in history of terrain causing the unexpected delay or failure are simply too prevalent to

ignore. The angst caused by entering woods or forests to commanders is rooted in the unknown effects that ensue this should be a factor in the war-game' (2013a, np).

Curiously, in a game for Jones, 'fixed movement' (movement, however, can take place within a maximum) does not enable particular spatial experiences of a commander: '[T]he angst caused by entering woods or forests' (ibid 2013a, np), essentially hindering becoming other. With fixed movement, how terrain will affect is known, but in real life this was/is not always the case, 'real ground is almost never predictable' for Jason {f}, whilst for Chaz: 'That a wood is blatantly obvious does not mean that you can have any idea of its character' {f}. Knowing how terrain can affect might enable a particular style and experience of gameplay where terrain has minimal impact upon tactics and strategies because what terrain *does* can be pre-empted. For Roger: '[T]his is the stuff that needs modelling [...], why do we want such silly non-realistic games where everything [...] goes exactly to micromanaged plan? No friction?' {f}. For Graham: 'In De Bellis Multitudinis [*DBM*, a ruleset for Ancients wargaming] there are die rolls to determine how hard a river or stream will be to cross' {f}. Besides variable movement with die or dice rolls, the use of 'chance cards' as a game mechanic can also enable terrain to generate anxiety, for Peter: 'Piquet [a ruleset] has them as 'stratagem' cards such as thickets in woods, hidden path/ford found, rabbit warrens, etc. It even has a 'cats and dogs' stratagem which deluges the field with rain and reduces black powder weapon effect'.

Terrain causes 'friction', a concept popularised in military studies by the influential 19th century military theorist Carl von Clausewitz (2008) describing 'impediment to military action' (Kiesling 2001, p.85), 'uncertainties errors, accidents, technical difficulties, the unforeseen, and their effect on decisions, morale and actions' (Paret 1992, p.112). Friction, important in thinking about mobilities (Cresswell 2010), is for Clausewitz 'the only concept that more or less corresponds to the factors that distinguish real war from war on paper' (2008, p.119).⁴⁶ Designers grapple with friction, although to a differing intensity and to generate embodied affects and practices that friction can produce. This might be uncertainty, indecision, chaos, frustration, surprise, stress and confusion among others and affecting and/or in relation to questions of 'command and control', where for Justin, 'every

⁴⁶ Clausewitz's derived his concept of friction, as Asal et al assert, from thinking about mechanics and 'the intrinsic omnipresent rubbing of parts against each other in a complex machine' (2014, p.479). It was Clausewitz's view that, following Asal et al: 'An army in the field, a government etc is a complex system made up of numerous parts doing an array of defined tasks that in the end are to combine into successful implementation of [a] plan and achievement of [a] goal. But each of these individual tasks can be delayed, misapplied or even fail in unpredictable ways due to an interaction of incompetence, misunderstanding and/or unforeseen circumstances' (2014, p.479).

situation has its own problems and calls for its own unique solution' {f}. For Clarke: '[W]hilst the dice introduce the unquantifiable in most wargames, when it comes to firing, [games often] ignore the unquantifiable friction in the areas of command and control. I don't think you can model warfare, even in a game, without this kind of friction being present' (2011, np).

Command and control friction can include movement, or rather stoppings, slowings and immobilisations. For Clausewitz: 'Action in war is like movement in a resistant element. Just as the simplest and most natural form of movements - walking, cannot easily be performed in water, so in war it is difficult for normal efforts to achieve even the most moderate results' (1832, p.119 in Paret 1993, p.112). Adrian is trying to model the chance of tank breakdown in a set of rules for the North Africa campaign (1940-1943) of WW2:

'Certain vehicles, the usual suspects [...] Matildas, A10s, M13s [...] are classed as unreliable. Command and control is based on a card based system using a normal deck of playing cards, including the jokers [...]. If a battalion is dealt one of the jokers it has to test for 'fates or fortunes' and has a fifty-fifty chance of good luck or bad luck. If it has bad luck half of the results will penalise unreliable vehicles or vehicles in rough going [...]. I'm assuming a loss of one or two vehicles from a four vehicle platoon, as mechanical failures, shed tracks or bogged etc. This works out at a 3.7% chance of a battalion/regiment losing a platoon of unreliable vehicles per 20-minute move. So in a battle lasting say, five hours, that means a roughly 50-50 chance of a battalion with unreliable vehicles losing a platoon's worth [...] which generally tallies with history [...]. Not a huge amount, but enough to upset finely crafted plans and so worth including in a game'.

Clarke's rulesets attempt to produce considerable 'command and control' friction, more so than other rulesets and designers. For Clarke:

'One [group of gamers] likes the certainty of Jomini's fixed rules [Jomini was a military theorist, contemporary to Clausewitz]. For them, the challenge is a fight between two Generals whose skills in the art of war will decide the victory. This is represented by rules which tend to be fixed and devoid of friction [...]. In the other camp are those of us who prefer a more Clausewitzian view of history. We can make our plans, but we must be aware that by simply sending an order we cannot assume absolute compliance' (2011a, np).

Wargaming is differently practiced and Clarke identifies two very different sensibilities to wargaming and from this designers and rulesets that model friction to a differing intensity. The one sensibility regards particular intensities of friction as thwarting the wargames table and the imaginary spaces of the wargame as an experimental and intellectually gladiatorial

space, a sensibility where becoming other is becoming wholly or in part perhaps a master tactician and strategist unaffected by tactical and strategic disaster. For Jones:

‘Many gamers want rules that constrain choices, and present a limited and unambiguous decision matrix. If they know the rule, and they apply it correctly, they want a predictable and expected outcome with [a] tiny risk of variable results. They want to limit surprises, or the unexpected, as much as possible’ (2013b, np).

This observation from Jones links in with Clarke’s relation between such a sensibility and the 19th century military general and theorist Jomini’s theory of war (see Jomini 2007), where, as Rean writes: ‘In the attempt to introduce rationality and rules into war, Jomini’s work served to downplay the violent nature of the conflict and made it seem like a game or geometric exercise in which the manoeuvring of troops on a board became more important than the combat’ (2008, np). For Jones, the wargames table becomes ‘a perfect world where rationality and predictability reign!’ (2013a, np).

An aspect of friction is Clausewitz’s (2008) ‘Fog of War’ (FOW) concept which means uncertainty in the context of situational awareness and something important for many wargame designers and gamers in the context of command and control. Clausewitz’s expression of ‘fog’ is figurative and derives from the effects of an opaque pall of thick rifle smoke forming and hanging over the battlefield, causing for anyone a ‘fog-bound’ like experience where of the visible, ‘presence merges into absence’ (Martin 2011, p.458). Clausewitz uses the elemental qualities of fog to describe the presence of the unknown and uncertain ‘about the enemy’s intentions, strength disposition, movement [...] [and also] uncertainty about one’s own forces when communication networks break down’ (Asal et al, p.482).^{47 48}

Elements of FOW can be difficult to model on the tabletop. For instance, as Josh notes ‘you are a 500-foot-general’ {f}. This vertical geography, producing an all-encompassing visuality, often termed ‘birds-eye’, ‘god-like’ or ‘helicopter view’, betrays in most gaming cases a horizontal orientation of warfare, where following Elden after Virilio (1989) on aerial warfare ‘*battlefield* becomes *battle.space*’ (2013, p.36, emphases original).

⁴⁷ The ‘elemental relational materialism’ (Martin 2011, p.454) produced by fog and how it exists, forms and dissipates is a trope that within military studies accompanies the concept of FOW. For instance, FOW might be something to ‘pierce’ (Steinweg and Bowman 1994), to ‘lift’ (Giblin and Monson 2010) and to ‘dissipate’ (Gray 2003).

⁴⁸ On fog, Clausewitz states: ‘[W]ar is the realm of uncertainty: three-quarters of the factors on which action in war is based are wrapped in fog of a greater or lesser uncertainty’ (1976, p.101 in Sabin 2012, p.107). Clausewitz goes on to argue: ‘[T]he imperfection of human perception and judgement [...] is more pronounced in war than anywhere else. We hardly know accurately our own situation at any particular moment, while the enemy’s, which is concealed from us, must be deduced from very little evidence’ (ibid, p.217 in ibid).

Terrain, enemy positions and troop and weapon types can be known when in reality they might not. Also, there is no uncertainty about the results of combat and the whereabouts of own troops and weapons.

For Alistair: ‘Situational awareness is generally poorly modelled in wargames, just as it is in most professional military simulations, if only because it takes a shed-load of effort to do so’ {f}, although in the opinion of Army Group York: ‘[T]he most serious limitations of tabletop wargames is the difficulty of simulating this ‘Fog of War’ (2013, np). How to model kinds of fog for the tabletop present ‘conundrum[s]’ for Giles, whilst for Ken: ‘Not knowing how effective your fire at the enemy is, is [one of the most important game design] challenges that all of us face’ {f}. Certainly, particular aspects of FOW are easier or, in fact, possible to model on the tabletop. Durham Wargames Group considers how Clarke’s ruleset design incorporates FOW:

‘[FOW] is done through the use of what are termed blinds. A blind is simply a template that is placed on the table to represent the general area occupied by the troops. Figures are not placed on the table until successfully spotted [with scouts and on a dice throw]. Hence, hidden forces may move about the table represented by blinds. The use of dummy blinds adds further uncertainty as to the location of enemy troops. Furthermore, a defender can consider any major terrain feature as a blind so that an attacker may be initially confronted with what appears to be an empty battlefield. In such situations, an attacker may well find he needs to devote most of his initiative dice to effective reconnaissance and spotting’ (2013, np).

On this issue for Clarke: ‘I do think I have dealt with the ‘birds eye view’ issue as practically as possible with the use of blinds’. Blinds, therefore, produce fog on the tabletop battlefield in substituting presence with (an intensity of) absence. For Jones though ‘[blinds are] somewhat better than earlier methods, but still fairly clumsy, and dummy or not, there are few ‘surprises’ emerging from the Fog’ (2010b, np). Jones, in his *Piquet* ruleset, devised another way:

‘Piquet tried to do this conceptually, by basically stating that the tabletop ‘lied’ and that the positions on the table may, or may not, portray the accurate situation. This offered a concurrent explanation for units moving an extreme distance, or not moving at all, and also meant that the player had to allow for things not being what he expected at any given moment, an element of the Fog of War [...]. I also liked the fact that this conceptual approach required no added devices on the table, it was free of clutter. It did prove difficult for some gamers to get their head around the idea’ (2010b, np).

FOW can find negotiation in its production through the embodied effort needed to set up and play with blinds, and in Jones’s *Piquet* coming to terms with a complex mechanic.

FOW, or intensities of FOW, might not be part of a wargame or modelled in a ruleset for these reasons although another negotiation in the production of FOW involves differing sensibilities to wargaming. As noted in 6.4 and 6.5, for many wargamers seeing and playing with their miniature models is a delight, the use of blinds means that for a duration of the game they cannot experience this ‘spectacle’, as Neil asserts: ‘[M]any gamers want to see that spectacle of figures from table edge to table edge, it does stir the blood, so not much is done with it in some quarters and many rules sets’ {f}. For other wargamers, the spectacle of miniature troops is not so fundamental to the imaginary spaces of the game and so for Dominic: ‘For me, it’s about the game, not the spectacle, so this [FOW] will work for me’ {f}. Relating to a point made earlier about a gaming sensibility identified by Clarke and Jones that finds friction problematic to enabling ‘a perfect world where rationality and predictability reign [...]’ (Jones 2013a, np), FOW can be negotiated around this issue as well.

6.7: Modelling war for the tabletop, part two: Playability, abstraction, effect, elegance and imaginary spaces of the wargame

This section highlights a particular design sensibility currently rather popular in the miniature wargaming hobby. This is a sensibility where *more* abstraction and styles of abstraction are held to open up potentials for emotional, feeling and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace.

Rulesets reproduce *aspects* of war intentionally and ‘unintentionally’ (limits of what can be produced) and, as will have been gathered from the previous section, are crafted models of warfare, performative or simulative in relations with mimesis. The making of these models, and often involving care, passion and diligence, are infused with particular modelling sensibilities and practices. For Clarke:

‘Personally I am not keen on the term ‘simulation’ as it suggests a dry interpretation of combat that attempts to deal with a million and one minutiae and I am not convinced that is possible. I am, however, convinced that it is possible to model some aspects warfare within the framework of a game. Indeed, I have long stressed my belief that in

order to produce a good wargame a set of rules should combine both a plausible model of warfare and also be fun' (2011b, np).

Clarke highlights several different modelling sensibilities. In the one sensibility he identifies there is a quest for detail and this is one where players enjoy engaging with detail, the gamer is heavily involved in and enchanted by what Jones calls the 'process' of the game: '[I]hey [the players] want to know, and possibly control, every possible combat decision and outcome' (2011c). For instance, a game might require morale to be 'tested' in more conflict situations than another ruleset or where sarcastically for Kawczynski: '[Y]ou roll dice to see how the wind would affect a bullet fired at five in the afternoon on a chilly autumn day at the distance of 359 meters at someone peeking out of a foxhole exposing 22% of their body' (2013, np). For Ian:

'In the past, historical wargames got too full of themselves, and became too pedantic, too didactic, and ignored the entertainment demands in an effort to become 'serious' simulations. They became so laboured and such a task for gamers that it was little surprise that fantasy games [...] blossomed as an alternative [...]. The historical wargames of the late 1980s and early 90s began a rebellion against the heavy footed games [...] and became simpler, faster, and with more than a little fun being an object of the designs'.

For Ian here process orientated games were/are unedifying, being laborious (although for process enthusiasts, anything but). For Clarke: 'The image that you present of hours spent looking at tables crammed with a myriad of 'realistic' factors in order to achieve a result simply flies in the face of [my] [...] whole principle; placing a gamer in the same decision making process as a real commander' (2011a, np). Within this sensibility, rules and mechanisms are considered disabling as well as enabling in becoming other through mimetic play and imaginary spaces. For Anthony: '[A]nything you can do to keep the player immersed in his make-believe role for as long as possible is a good idea. Every time he has to break out of his make-believe in order to look at a chart or do some math, or even to roll a die, it breaks the spell' {f}. Similarly, for Fraser: 'The players should descend into this imaginative experience and get lost in it [...]. If the players are thinking '*Whee! I'm Marshal Murat! Charge the enemy! Sweep him away!*' Well, then you've done a good job as a game designer' {f} [emphasis added].

'Playability' (ease of ability for play), or rather for Mark 'such a loaded term, I prefer the ergonomic-centric phrase 'ease of use'' {f}, becomes an important issue for non-process orientated wargame designers in their modelling negotiations with 'reality' (although this is not to suggest 'playability', to use the most prevalent term, is exclusively

their preserve). Playability in a wargame model becomes through particular intensities of abstraction, enabling becoming other through mimetic play and imaginary spaces. For instance, for Clarke and Skinner discussing their WW2 ruleset '*I ain't been shot mum*':

[Clarke:] 'There are a few bits in the original rules that focused too much on the cause rather than just considering the effect [...]. The new ones are much more streamlined and, as a result, are easier to play through and get the correct result without micro-managing the process [...]. [Skinner:] That's also true with the AFV [Armoured Fighting Vehicle] damage effects. You can really break that down into three distinct possibilities. It should either affect the gunnery or the movement capability of the AFV or the morale of the crew inside it. You really don't need to know exactly what the specific damage is, it's a bit like when you're driving a car and the engine goes wrong. You might hazard a guess that it's the fan belt or the fuel pump, but ultimately what you really have to deal with is the effect this is having on your ability to drive the vehicle. That's very much the approach we've taken here. It simplifies the process, it removes all those sub-tests like 'does your engine catch fire, roll a D6' and replaces them with restricting movement and a possibility of breaking down. The same with gunnery. Your gun is either firing properly or with reduced effectiveness or not firing at all. As the player, you have to make decisions based on the limited information you have. Let the bloke in the workshop worry about just what damage has been done' (Roundwood Report 2011, np).

In this example, just 'effects' of AFV damage are 'gamed' and some are prioritised, those deemed critical to the AFV and its crew as a valuable military resource. This focus on 'effect', or for Chris 'results', is its own design philosophy (effect/results driven games). For Tim: 'In an effects based result game, you don't care about the details as much as what the effect means'. For Josh: I think of 'effects-based' rules [as] meaning that we don't have to have a mechanic designed to simulate the particulars of what it is supposed to represent' {f}. Stuart relates that:

'With effect based games what you are trying to do is compose a [warfare] model where you only include that which is relevant to *your experience* as a commander. There are things that you don't know or at any rate don't need to know [...]. Focusing on results, taking a lot of reality out of reality so to speak, actually does two neat things. Firstly, it's getting closer to the reality of the commander's experience and situation and secondly the game becomes much more flowing, a more enjoyable gaming experience, you are not so much a human computer!

Continuing the playability theme, ruleset, rules and mechanisms may be crafted in such a way as they encapsulate some detail yet are nimble to play with, often referred to as 'elegant'. 'Elegance', an elusive concept and one with sensuousness behind it for Goldblatt (2007), is important for many wargame designers and players. Within, but also outside

miniature wargaming, elegance is something sought after (e.g. in mathematical models (Kramer 2008) or economic geography models (Plummer 2000; Sheppard 2001)). For Goldblatt: '[E]legance is often associated with a kind of fluidity, smoothness of surface and style' (2007, p.12). This idea captures what elegance can mean for many miniature wargamers. For Michael: '[A]n elegant rule system [...] is one that performs the task it is designed for with the minimum of difficulty for the player or user' {f}. For Brett: 'To me, an 'elegant' ruleset is one that allows players to replicate complex military actions using relatively simple and intuitive game mechanics. Elegant rules capture the feel of a given period, without bogging the game down with too many complex rules' {f}. Elegant rules and mechanics involve focusing on 'effect'. Edward describes a particularly 'elegant' 'mechanic':

'Regimental Fire and Fury has an activation roll for each brigade. The result is applied to each regiment or gun section within the brigade, but each of those sub units may have different modifiers. This is an elegant mechanic for three reasons. First, it's an improvement on original Fire and Fury because you do not roll separately for each manoeuvre element, but once for a command of several. Roll high, and you'll know that all your units will be OK. You do not need to calculate odds for all of them. On a middling roll, you can figure the result on the worst off unit. If he's OK, everyone else will be too. Second, the manoeuvre roll combines the 'orders' phase and 'morale' phase that many games include. That one roll will allow a unit in good order to see how far it can move. That same roll will allow a unit in disorder to rally, or it may cause it to run away. Third, the manoeuvre roll enforces the command radius. Units within range of their brigade commander check on the 'in command' band. Units outside that range check on the 'out of command' band. An out of command unit may still be effective, but you cannot rely on it to do much. So all of those things are handled by a single die roll' {f}.

6.8: The violence of war and the wargame: Politics, identity, abstraction and an embodied ontology to war

War, as armed conflict, following Scarry (1985), is bent on 'injury' to the human body. Nordstrom and Robben write that 'violence is an unsettling topic - it raises piercing questions of human nature social (in)justice and cultural viability and about our personal responsibility and accountability in the face of these' (1995, p.138 in Woon 2013, p.34). War is infused with senses of suffering, loss and pain (Hyndman 2007). This section focuses on

how war's violence and suffering permeates the hobby. The section begins by finding how a moral and ethical politics surrounds miniature wargaming and one that can negotiate how modellers perform their hobby identity. The section then moves to find how abstraction has been rendered problematic by scholars on miniature wargaming, presenting skewed perspectives on the violent realities of war. However, with the idea that 'war is fundamentally not apart from the rest of social life' (McSorley 2012, p.2), the section goes on to detail how; firstly, the violent nature of war can negotiate the kinds of space-times generated on the table-top. Secondly, how the 'lived body' (Anderson and Wylie 2009) becoming abstract, an unsensing model, is fundamental to engagement with miniature wargaming. Thirdly, how violence wrought on (model) bodies within the imaginary spaces of the wargame may affect experiences of mimetic play. Fourthly and finally, how emotional attachment hewn from the embodied effort and/or personal styling placed in a model's surface, can make war's violent nature affectively present in wargaming, negotiating the imaginary spaces of the wargame and mimetic play.

On a point of clarification as well as intent, this section does not deny the affective power of representational media like wargames (including computer games) to shape perceptions (e.g. Allen 2011; Huntermann and Payne 2010; Power 2007). However, it does posit for a more nuanced view than so far has been the case in regard to literature on miniature wargaming, 'war play' and discussion of computer wargames in game studies where Pötzsch has recently argued that 'the potential effects of such games on individuals or collectives cannot be simply postulated but have to be accurately explained' (2015, p.18).

As Goldstein asserts: 'societal attitudes to (children's) war play are, and apparently always have been ambivalent [...]. Opponents argue that war play [...] perpetuates war and is unseemly [...]. Proponents argue that war play affords [...] an opportunity to try to come to terms with war, violence and death' (1998, p.55). 'War play' has a politics to it, being divisive to variant intensities. For Perla: '[T]he fact is that wargames and wargaming are consistently misunderstood, denigrated, even denounced' (1990, p.17). The politics can be a lived reality for some wargamers, with a spectre of a poor opinion of themselves from others negotiating how identity is performed in particular social contexts and spaces. For Adam who lives alone:

'People ask 'what do you do' [in your spare time]. I am reluctant to say wargaming, but I say 'military history' and that's true actually. When you get to know me better I will mention it, but only if necessary. [...]. I don't bring it up at work because I think they might think it's a bit juvenile or that I am a bit sad [...], playing with little models which are

associated with children's play and then you are using these towards violent ends, so in a way I [...] keep [the hobby] hidden from others'.

Equally for Pearson: 'I was very reluctant to tell anybody. Even among the inadequate milieu of hobbies wargaming ranked very low. The non-believer regarded it, at best, [...] the province of socially inadequate geeks, at worst of gun fiendishing belligerents [...], so I hid this aspect of my life away in the closet' (2008, p.45). Fear of being ill-judged by others, besides negotiating how identity is performed within particular social contexts and spaces, negotiates how the hobby is placed in the space of the home for Pearson although equally Adam. Adam keeps his hobby objects (models, rulesets, books) hidden out of sight and access from friends and visitors: '[I]ncongruously behind the Hoover [under the stairs]'. The majority of my interviewees, however, were not worried about the place of hobby objects within the social spaces of the home (e.g. living room, dining room). Many had models here taking pride of place in display cabinets, but Ben had sought to negotiate the hobby within the home for reasons other than considered above:

'I like to keep [the hobby] spatially contained [Alistair lives with his partner Anne and has his own hobby room, formerly a reception room where he paints and stores his models]. [...] Anne would be fine if I put some models in the cabinets [in a living room] and she has got some of her artwork around the house so we could negotiate on that, but I don't want to be reminded of the hobby everywhere I go in the house. [...] Also, I'm not keen on having wargames stuff in the living room because I don't think they don't fit in there, I mean you usually have crockery!'

For Russell though, he would like to display his models, but because of sensibilities of family members he cannot:

'I would like to [have my models on prominent display] because I am proud of them yes, but that would upset Julie [Russell's partner] [...] and my Dad who comes to visit sadly enough. Dad was in National Service [and] he is not keen on my wargaming because he thinks it makes a mockery of those who fought and he doesn't even like model soldiers either. [...] He thinks they glorify war so fair enough. [...]. Julie is less frank about my models on display, but she does not like them either for the same reason, [but also because] she has her friends over and I think she doesn't want people to know about my 'juvenile' hobby so to have a quiet life I just don't raise the idea'.

Many miniature wargamers have similar perspectives and experiences as to what causes a moral and ethical politics to surround their hobby; issues of 'play' and 'game' are important and these were crucial aspects to the dislike of the hobby for Russell's father and partner. For Polemarch:

‘Perhaps it would be better to consider the ethics of wargaming in terms of warmongering and playing with people’s lives. Where I have encountered concerns from the non-wargamer, it has been in terms of: ‘How can you get entertainment from sending [...] men off to be killed?’ and ‘How can you derive pleasure from an event in which hundreds/thousands of people were killed?’ [...]. The commentators have failed to distance the wargame from the reality and perceive ‘real’ people as being killed in the games and the wargamers as celebrating that fact’ (2012b, np).

Equally for Guy:

‘As I see the issue, a war is a life or death struggle waged for reasons of power or - less frequently, but you wouldn't hear it from the protagonists! - morality. By contrast, a game is, by its most commonly recognised definition, a light-hearted activity whose chief purpose is the amusement of its players. I think this is the root of the problem, for it is difficult to reconcile this essential oxymoron’ {f}.

As several scholars have shown, ‘war toys’ and children’s play with them has been the focus of critique from anti-war, non/anti-violence or peace activists and groups since the turn of the 20th century (Andreas 1969; Brown 1990; Goossen 2013; Hammar 1970). Play with war toys has been thought to produce, in part, a militaristic society, pervading the home and contributing to the event of war (Brown 1990; Varney 2000). Stearn notes that in Edwardian Britain:

‘[S]ome parents would not allow their children to have war toys and [this] was obviously true with Quakers and other pacifists. In fact, war toys were a continued, if relatively minor, concern of the peace movement. For example, in March 1914 – i.e. before the First World War - the National Peace Council, which was a sort of umbrella organisation of pacifist organisations, stated their ‘grave objection to toy soldiers’. And at the Child’s Welfare Exhibition at Olympia they put on a display of ‘peace toys’, with ‘not miniature soldiers, but miniature civilians. [...] not guns, but ploughs and the tools of industry’ (2013, np).

In more recent years, miniature wargaming and the places and spaces of it have been a target of protest. UK wargaming conventions were picketed by the Campaign for Nuclear Disarmament in the 1980s according to one interviewee. Further back in time and in the US, for Bobek: ‘As a college student during the Vietnam War I remember some angry war protesters labelling all wargamers as warmongers’ (2007, p.5). For Elliot:

‘The attitude of outsiders looking at wargaming in seriously negative ways is not a new one. There’s always been a judgmental discontentment with the sense that wargamers may be warmongers or somehow desensitizing the actions of real war. But one could draw a stronger more meaningful complaint about first person shooter video games which

train immediate reactions to be violent instead of thoughtful as a wargame must' {f}.

H.G. Wells thought playful engagement with his commercial ruleset '*Little Wars*' (1913) (as considered in 6.3) might dampen any enthusiasm for 'real' war, if not delegitimising it altogether. Wells writes:

'Here [with '*Little Wars*'] is a homeopathic remedy for the imaginative strategist. Here is the premeditation, the thrill, the strain of accumulating victory or disaster - and no smashed nor sanguinary bodies, no shattered fine buildings nor devastated countrysides, no petty cruelties [...]. My game is just as good as their game, and saner by reason of its size. Here is War, done down to rational proportions, and yet out of the way of mankind [...]. Great War is at present, I am convinced, not only the most expensive game in the universe, but it is a game out of all proportion. Not only are the masses of men and material and suffering and inconvenience too monstrously big for reason, but - the available heads we have for it, are too small. That, I think, is the most pacific realisation conceivable, and Little War brings you to it as nothing else but Great War can do' (pp.96-98).

Miniature wargames, producing violence abstracted to the 'tin murder' of model soldiers (Wells 1913, p.6) and the destruction of a 'model country' (ibid) constitutive of fake buildings, was vaunted as a technique by Wells for the making of safe aggression and (relatively) unharmed affects and equally making present, in a comfortable way, the violence of war. Abstraction, through its distancing for Wells, enabled the space-times of war to be apprehended in particularly affective, potentially fruitful ways. However, the cultural historian Schwartz (1996) in his tome '*The culture of the copy*', has queried this narrative of abstraction, as have several other scholars (Beresin, 1989; Brown, 1990; Varney, 2000). Schwartz has posed the question as to whether miniature wargaming might 'deceive [...] [players] about battle, desensitise them to death, destine them for wars where winning is accountancy?' (1996, p.260). Schwartz goes on to suggest: 'The wargame immediately confronts us with the dubiousness of simulation, dilemmas of replication and disorders of repetition' (ibid). Miniature wargaming might be considered to present us with 'virtuous war', a term coined by Der Derian (2001) to mean the virtual (the disembodied simulation) and virtuous ('war as clean, good, as surgical, abstract and bloodless' (Power 2007, p.284)).

For Michael, a 'quasi-wargamer':

'I mean [the wargames] they are not really interested in what is going on outside of the confines of that battlefield and in a lot of cases that cannot be, but I do think wargames have the power to distort your view on history and it can be tied into what's your broader intellectual diet and I

think being a military history buff can sort of cause you to lose sight or appreciate other important aspects of these stories and eventually you end up just sort of viewing wars as an intellectual exercise, [a] contest [...]. You go into wargame forums and you will [...] see [...] a lot of people who really think that the best army will solve things and if you don't win the war fast it's because the commander skewed something up not because the war is unwinnable, because it's an intractable conflict or whatever' (Three Moves Ahead 2010, np).

For Michael here, miniature wargames are problematic because of what is not modelled and gamed. War is *more than* violence on a spatially delineated tabletop 'battlefield'. Rather, battlespace has affects that pervade bodies, landscapes and objects, eloquently for Nye: '[I]t takes men from their [families] [...]. It leaves behind shattered lives of these people who have had a part of them ripped out of their souls if not their bodies' {f}. Michael is also concerned about enthusiasm for military history around strategy and tactics and which raises a question about enthusiasm having 'adverse' potentials (hitherto geographers have seen enthusiasm as a force of 'positive' potential (see Craggs et al, 2013; Geoghegan 2009, 2013, 2014)). The problem Michael gauges is that enthusiasm for military history can overwhelm how war is apprehended, war might be understood in a Jomini-like way, where the 'violent nature of the conflict' is unmade and 'made [to] seem like a game or geometric exercise in which the manoeuvring of troops [...] [becomes the] more important' (Rean 2008, np).

Older military histories or history explicitly concentrating on strategy and tactics may silence visceral and embodied experiences for Tyler and Henkin (2015) and not only of bloodshed but of chaotic happenings and moral and ethical dilemmas (e.g. Cole 1965; Gabriel and Boose 1994; Goldsworthy 1998). For Clyde: '[M]ost military histories gloss over what happened to civilians, being killed incidentally, robbed, raped, starved to death, and driven from their homes' {f}. Military history texts can present 'heroic and overly virile glorifications of war' for Tyner and Henkin (2015, p.289) and rulesets may overtly reproduce it, the title of Slitherine's (2015) ruleset '*Fields of Glory*' is emblematic and for Tristram: 'I think that [wargaming] reinforced [in] my mind [...] that war was about brilliant generals without considering the deaths, but contradictorily, it also reinforced the image of the heroic battlefield where you could make a difference and where heroic deaths were meaningful and redeeming' {f}. For George:

'What we indulge in our hobby is not the macabre detailing of the mortification and mutilation of human bodies and souls, but the idealisation of the military virtues, just as we idolise and lionise the cops in crime dramas, the hospital staff in medical dramas and the persons who hold civilisation together when some poor person is victimised by

the sociopathic and criminal elements in society. We celebrate in wargames the military virtues: duty, honour, loyalty, patriotism, subordination, self-sacrifice, and humanity, stoicism, courage and love' {f}.

For Rik:

'As a community I think we are largely guilty of no more than seeking to enjoy the undeniable 'fun' aspects of warfare: tactics, machinery, uniforms, pageantry, gallantry, camaraderie, etc. while steering away from the areas that are no[t] fun, the mud and the blood, the terror, the death and suffering, torture, shell shock, politics, etc. The uniformed dispassionate observer might see this as [...] glorifying war, but those of us involved in the hobby know that this is largely not the case, we are all interested in the history and are aware of the horrible realities of war, but simply choose to sidestep them in our games because they aren't fun and detract from our enjoyment. We are engaging in war that is 'sanitised' so that it can be fun which is not the same at all as pretending war is really a glorious thing overall' {f}.

Whilst tabletop warfare may look like 'virtuous war' (Der Derian 2001) ('war as clean, good, as surgical, abstract and bloodless' (Power 2007, p.284)) and more sanitary than 'shoot-em-up' computer games like the '*Call of Duty*' series, Rik asserts that miniature wargamers *know* about how war violently affects the body; 'death and suffering', 'shell shock', 'terror'. As highlighted in 6.4, some wargamers have been affected in embodied ways by the violence of war and some wargamers are veterans. Rik argues that the uncomfortable realities of war are not present because of a naivety, but because they are uncomfortable to make present in whatever kind of abstract way possible.

The remainder of this section seeks to consider how, firstly, the violent nature of war can negotiate the kinds of space-times produced on the table-top. Secondly, how the 'lived body' (Anderson and Wylie 2009) becoming abstract, an unsensing model, is fundamental to engagement with wargaming. Thirdly, how violence wrought on (model) bodies within the imaginary spaces of the wargame may affect experiences of mimetic play. Fourthly and finally, how emotional attachment hewn from the embodied effort and/or personal stylising placed in a model's surface can make war's violent nature affectively present in wargaming, negotiating the imaginary spaces of the wargame and mimetic play. In considering these points, this section has in mind a response to Schwartz's question of whether miniature wargaming might 'deceive [...] [players] about battle, desensitise them to death, destine them for wars where winning is accountancy?' (1996, p.260). Hearing from wargamers about their feelings and emotions relating to war and wargaming 'brings to the fore that war is fundamentally not apart from the rest of social life' (McSorley 2012,

p.2). As McSorley asserts: War 'lives and breeds' through 'countless affective, sensory and embodied ways (2012, p.1) and a 'focus on the body tends to render any clear demarcation of discrete war zones and times problematic, emphasising instead the enactment and reproduction of war through affective dispositions, corporeal careers, embodied suffering and somatic memories' (2012, p.2).

Particular wars, battles, conflict scenarios and armies might be uncomfortable to model and game, being shied away from. For Bruce, when asked what conflicts he would not compose a ruleset on and/or game:

[Chechnya] I wouldn't touch it with a barge pole, it is too recent, it's too raw [...], there were thousands of civilian killings, no way no. I remember watching it on the TV and hearing the news [...]. I couldn't do that, no not at all. There are some conflicts that you need time for the emotions to subside, they might never do though, but Chechnya is so bad'.

Bruce finds the Chechnya conflict (1994-1996) appalling as a potential wargame on account of the civilian killings involved. Wargaming is usually a social practice. Gaming and/or modelling of a particular war, battle, scenario and/or belligerent might ostracise a wargamer because particular moral and ethical boundaries have been crossed. For Tyler:

I think matters of decency in real world scenarios are of importance. For example, I would expect to be ostracised by the [wargaming] community if I did a scenario involving a Paratroop Company attacking a concentration camp to rescue those people imprisoned. It's bad taste and morally questionable [...]. Equally the same applies if I said 'Oradour-sur-Glane, can you intercept the SS and save the town?' (Oradour-sur-Glane is the name of the French village where all residents were massacred by the Nazi Waffen SS in 1944) {f}.

John has an aversion to the imperial geopolitics behind the conflicts of the British Empire in Africa:

'The [British] imperial conflicts in Africa are quite popular and I am interested in them [...]. I think some of it is to do with the [post-imperial nostalgia] among some. Featherstone [...] found gaming [the Anglo-Zulu war] quite an honourable thing to do [from the standpoint of remembering the Zulu's], but personally I just can't get fun out it [...]. [The reason is] because it's tied in with the whole imperial project and that's everything I stand against. Admittedly we can disconnect game from reality like playing the Nazi's, but I don't know, we are all different!'

In contrast to Edward from 6.4 where it was detailed how his playing the Spanish Civil War, WW1 and WW2 are inflicted with remembrance and commemoration for lost family members from those conflicts, for Tim:

‘Several years ago several from our club thought we ought to base a few games on [WW2] Normandy, not the beach landings, further [inland]. I said ‘I’ll give it a go’ [...]. My grandfather fought there and he never really wanted to speak about it [...]. [A]s I was playing the game he was on my mind constantly. I imagine I must have been thinking [...] ‘what the hell am I doing’, making light of his suffering, stuff that was so awful he never wanted to tell me. He might have been fine with wargaming Normandy, but I stay away from gaming a lot of WW2 for guilt really’.

Running through the testimonies of Bruce, Tyler, John and Tim are painful emotions in relation to gaming particular wars, battles or violent events. These are all relatively recent occurrences and for Tim family history was the cause of his distress. Some wargamers prefer gaming ancient, medieval and Napoleonic warfare because 20th-century conflicts are too emotionally charged although events, from or set however far back in time, can provoke adverse reactions such as the killing of civilians. Wargaming an Ancient Greek equivalent of the Chechnya conflict or one set in an imaginary future will very likely be undesirable. Indeed, Yarwood has suggested that one of the reasons the fantasy and science-fiction miniature wargaming genres ‘have grown in popularity’ is because ‘Orcs or space marines have no real-world equivalent and so their modelled deaths are less troubling’ (2015, p.670).

As noted via Wells, the abstraction of the wargame removes violence, enabling conflict to be approached. For Ian: ‘[Wargames afford] some insight without risking life and limb’ and in ways and with purposes different to each wargamer. In a similar turn of phrase as Wells’s ‘tin murder’ (1913, p.6) and emphasising concern for how war affects beyond the battlespace, for Adam ‘there are no tin widows’, for Bruce ‘no lead orphans’ and for Graham ‘the only ‘casualties’ are lead or plastic and they are removed only to be unpacked for the next battle’ {f}. The artificiality of model soldiers is mobilised when the politics over the ethical and moral case for wargaming rears its head. The materiality of a model soldier is important because what it is *not*; it is not a ‘sense-able’ ‘fleshy’ body, a real soldier, a ‘lived body’ (Anderson and Wylie 2009). In the place of the lived body is an inert and unsensing object of lead or plastic (graphics in videogames). Being like this, models can assuage emotional recoil to killing and being killed. What’s more of course, they are unharmed. For Lindsay:

‘In my experience all rules do a rotten job of realistically modelling any aspect of real life warfare. That’s why I like playing them, there is little risk of me or my buddies being killed whilst playing a tabletop wargame. Me and my buddies’ survival [are] paramount to my enjoyment of any wargame’ {f}.

However, this is not to suggest that model soldiers are bereft of any kind of emotional sentiment when gaming. For some wargamers this is the case, for others not. For Paul: 'I never look at the [...] soldiers [...] I push around my false field of battle as real people' {f}. For James: 'When I play wargames, there is little to no connection between the model on the table and the real-life consequences of the actual life and death that was going on in the situation the game is trying to model. For me it is a 'tactical problem' {f}. For Leo: 'I [do] not feel empathy towards my model troops [...]. Wargames, if anything, make you feel like Stalin probably did; who cares if another lead model, representing many lives, is taken off the board? I want to win!' {f}. For Leo here, models afford an absence of 'empathy', mirroring for him attitudes to bodies and conflict by key decision-makers. However, for other wargamers, models are invested with emotion in the context of the imaginary spaces of the wargame and with mimetic play fraught with worry, caution, hope and sadness. There might be an emotional connection and interest in the bodies of soldiers that the models represent. Being transitional objects within the imaginary spaces of the wargame, the models here *are* the real thing for Adrian:

'The models are mobilised in my mind, that's where they are living and breathing, what's on the table, yes helps in the imagination [...]. When I lose a battalion or something I wouldn't get as upset in real life because it is a game [...], but it's not great, there's a sense of loss there. You know, I am actually really attached to my armies [...], I mean the history, what they did, and so taking off a stand [of model soldiers, meaning they have died] means a lot, you think I have let my troops down and my one ambition is to win but always try and keep losses down'.

Models may be invested with emotions and mobilising a sense of care and concern for them in wargaming through the embodied effort and/or personal styling placed in a model's surface. Drawing upon Gauntlett's (2011) 'making is connecting' thesis, for Price: '[W]e connect ourselves to materials and to do so requires social and emotional engagement with others' (2015, p.85). Yet, as noted in 4.7, making/modelling can *make* emotional connections to the thing being made. Each wargame figure, whilst it may represent a number of men, might become a personality through styling and/or an object of particular enchantment and love for a number of other reasons such as tales, memories and contexts of its painting, perhaps sculpting. Personalities may be mobilised within the imaginary spaces of the game but models might not entirely work as transitional objects during the game, the models themselves might actually be going to battle. As already highlighted in 6.4, wargaming for Russell with his model soldiers enables him to craft a narrative journey for them (his 'friends'): 'I take them out the box and they go on journeys

with me, ready to fight another war' and where for Joel 'when my scratch-built war elephants actually manage to get into combat and trample the enemy, I feel proud'. However, pangs of loss might occur after the bodily impacts of war, modelled with dice and probability, require the model to depart the table. For Russell: 'another friend to the side, you think 'he won't be helping anymore', so it's sad not be able to play with them [...], but next time!'

6.9: Conclusion

This chapter has considered how models and modelling are involved with war as a 'realm of experience'. (Sylvester 2013). This has been in relation to the spaces and places of war and also in the transformation, expansion and production of these through models. Miniature wargaming models, modelling and engagements have been shown to generate and be affected by war as a realm of experience in relation to feeling, emotional and imaginative states. On the generative aspect, for the most part this has been through how models, modelling and engagements are related to other human bodies and/or space-times in the contexts of the military and battlespace.

People engage with the miniature wargaming hobby for a variety of reasons. As described in this chapter, particularly important are enthusiasms relating to the following; aspects of war as an embodied military practice (like 'terrain and tactics'), the modelling and/or gaming of war *through* and/or *with* abstraction, the miniature and mimesis, war as a 'game', and commemoration and remembrance. All of these enthusiasms become mobilised through practice with warfare models and model soldiers. Both of these kinds of models have been shown in this chapter to affect in various ways, including the particular space-times they can be held to produce. In relation to the space-times wargame models can be held to produce, this chapter has considered how miniature model soldiers can be transitional objects within mimetic play, configuring and engaged with through the imaginary spaces of the wargame. With regard to warfare models, this chapter has detailed how, drawing upon 'teleplasty' and again mimetic play, warfare models are made to enable particular feeling, emotional and imaginative states relating to other human bodies and/or space-times in the contexts of the military and battlespace.

The 'transitional' potentials within mimetic play of miniature wargame models to produce alternate space-times, imaginative in orientation and relating to the military and battlespace, were considered in the context of debates, sensibilities and practices on the surface and with the stillness of such models. The still and surfaces, on questions of mimesis and how they potentially generate and adversely affect imaginary spaces made through play, were shown to be the subject of a 'politics of play' (Woodyer 2012). Painting a miniature figure/model for many wargamers makes a figure/model a transitional object, a 'model' and one that is meaningful, enchanting and loved. For others, the painted nature of a model does not affect its transitional potential, but, with wargaming being a social practice, can provoke anger from others and so many will paint, opening up particular space-times for them and their models. Equally, the stillness inherent to miniature wargame models has the potential, if not negotiated, to create spatial tensions that gamers can find problematic to models becoming transitional objects. How this chapter approached imaginary spaces made through play raises questions about people's differing intensities, formulations (including space-times) and even mere existences of 'pretence' in relation to play with objects and space.

In the context of warfare models and modelling, the chapter has examined how wargame designers grapple with the embodied experiences of war for generating imaginary spaces through mimetic play with the model, including breaking down distinctions after Caillois between self and other. Through mechanisms, quantification, probability, rules, die, cards and historical sources, designers try to enable the gamer to *become* military commander and engagement with warfare models are meant to enable particular feeling, emotional and imaginative states relating to these military bodies and/or space-times in the contexts of battlespace. The chapter examined how morale, FOW, terrain and friction were modelled by designers, these aspects important for them to the embodied experiences of commanders. In relation to these experiences, abstraction and styles of abstraction in modelling were revealed to be important in enabling gamers to experience them. The warfare models have been considered as 'teleplastic technologies' that attempt to mould or form 'at a distance' (Ash 2010, p.415), producing 'limited potentials for movement and action' (ibid). However, taking account of miniature wargaming models and its relations with mimetic play, we can also contemplate how teleplastic technologies can do more than this. Furthermore, the discussion on warfare models raises a point on how embodied practice may inform modelling as a mimetic practice and be important to models as representations.

This chapter has considered war as a ‘realm of experience’ (Sylvester 2013), for as McSorley asserts: War ‘lives and breeds’ through ‘countless affective, sensory and embodied ways (2012, p.1). Play with the models mobilised here produce and thus ‘expand’ the ‘spaces and places of war’ (Rech et al 2014), and play and other engagements with models have been argued in this chapter to remind us that ‘war is fundamentally not apart from the rest of social life’ (McSorley 2012, p.2). The chapter dwelt on the embodied relations between ‘big’ (real) and ‘little’ (miniature, abstract) war, including highlighting how enthusiasm for miniature wargaming is produced, influenced and negotiated by war as experience. Through the miniature, abstraction and mimetic play, the enchantments of war (whether ‘terrain and tactics’, military dress, adversarial atmospheres) may be affectively conjured in miniature wargaming, enabling affective engagements with them. Beside enchantments, remembrance and commemoration were also shown to be an enthusiasm for some, miniature wargaming making present the insuperable loss war inflicts. Particular violent practices and their affects through gaming, negotiate wargaming enthusiasm for many, affecting what kinds of space-times are modelled and engaged with for/on the table-top.

Miniature wargaming has been shown in this chapter to be a contentious practice. Miniature models might produce unpleasant feelings and emotions in relation to war as experience and it was described how one interviewee negotiated the place of his models at home because of how family members felt about them. Mimetic play with models can also produce unpleasant feelings and emotions in relation to war as experience. It was considered how play with the miniature and modelling for gaming might be felt as ‘trivialising’ an event of particular gravity and/or through gaming bringing to the fore unpleasant feelings and emotions, making play unbearable. Adult play with ‘the miniature’ and the gaming of war in this way were shown to negotiate, for reasons of social stigma, how some wargamers perform their identity in particular social contexts and spaces. Miniature wargaming has been felt by activist groups to ‘perpetuate war’ and for scholars and others the hobby produces skewed perspectives on the violent realities of war.

On the issue of skewed perspectives, the chapter considered how abstraction is involved here. Not wishing to deny the affective power of representational media like wargames (including computer games) to shape perceptions, the chapter queried the narrative of skewed perspectives. With the idea that ‘war is fundamentally not apart from the rest of social life’ (McSorley 2012, p.2), the chapter detailed how; firstly, the violent nature of war can negotiate the kinds of space-times generated on the table-top. Secondly,

how the 'lived body' becoming abstract is fundamental to engagement with miniature wargaming. Thirdly, how violence wrought on (model) bodies within the imaginary spaces of the wargame may affect experiences of wargaming. Fourthly and finally, how emotional attachment hewn from the embodied effort and/or personal styling placed in a model's surface, can make the violent nature of war affectively present in wargaming, negotiating the imaginary spaces of the wargame and mimetic play. These points when taken together posit for a more nuanced view of the affective power of representational media to shape perceptions than has so far has been the case in literature on miniature wargaming, 'war play' and discussion of computer wargames in game studies.

7: Conclusion

7.1: Introduction

This thesis has sought, with reference to three different contexts of models and modelling practice, to consider aspects of the importance of geography in understanding what models can be, what and how they can *do*, and how and why models may be made and engaged with. In the formulation of its ‘affective geographies of models and modelling’, this thesis has focused on the representational and more-than-representational qualities of models and has traced its spatialities via conceptions of affect, emotion and feeling, alongside abstraction, the miniature and mimesis. Having done so, this thesis has hopefully opened up conceptual space to consider models and modelling from a particular perspective, one that recognises how space is central to lived and embodied engagements with models and modelling.

After reaffirming several points made in chapter 2 concerning scholarship on models and modelling, the final chapter begins by outlining how findings from this thesis give shape to five key ‘geographies of models and modelling’ when considering aspects of the importance of geography in understanding what models can be, what and how they can *do*, and how and why models may be made and engaged with. The chapter then moves beyond detailing relations between geography and models and modelling. It submits six broad lessons about models and modelling that can be identified from the findings of this thesis and which cut across and speak to all case studies.

7.2: Scholarship on models and modelling

Several points from chapter 2 can be reaffirmed. Firstly, cultural and historical geographers have primarily dwelt on the embodied practices of modelling (Adey 2010, 2013; Ploszajska 1996; Yarwood and Shaw 2010) and/or embodied practices with models (Koch 2010;

Yarwood 2015; Yarwood and Shaw 2010). Space is important to these discussions, but this thesis has been premised on the issue that much more needs to be said about the spatialities that ensue in and around modelling as practice and models as entities. Within the history of science, a sub-discipline of significant engagement with models and modelling (Chadarevian and Hopwood 2004; Knight 2014; Rossi 2010; Wintle 2009, 2014), historians have not made space as present as geographers.

A second point that can be reaffirmed from chapter 2 is about models and modelling in philosophy. For Badiou (2007 [1966]) models are ‘artificial’ entities and for Lévi-Strauss (1963) ‘constructed’ and ‘knocked together’. Furthermore, for Badiou (2007[1966]) in his exposition of a ‘materialist epistemology of mathematics’, models are only ever ‘partial representations’, thus for Cantot and Luzeaux (2011) they should be approached always with a ‘critical spirit’ in scientific practice. Models and modelling have received most theoretical attention from philosophers of science. Importantly for this thesis, they have appraised how models can potentially affect and generate spaces, practices and conceptions about the world. After Hesse (1963), models have agency, whilst for Morrison and Morgan (1999) models can ‘function as tools or instruments. Meanwhile for Pickering (1995), models and modelling can be about a coming to terms with the ‘material agency’ of the world.

7.3: Five cross-cutting themes and conceptual contributions

As made clear in chapters 1 and 2, there are many kinds of model, such that models do a lot of different things. Bearing in mind the diversity of models, this thesis has been intent on contributing to conceptions of models, and relatedly modelling. This section advances in detail five cross-cutting and interrelated themes that pervade through all of the case studies of this thesis. As has been noted before, these are orientated towards conceptual contributions to models and modelling in human geography, but have potential relevance to discussion of models and modelling within the arts and humanities more widely, such as the history of science and the philosophy of science. The following cross-cutting themes *and* contributions are dwelt on; firstly, models and modelling can generate space-times and, in so doing, produce affective engagements with those space-times. Secondly, that models,

modelling and material and embodied affects can shape how spaces (including models) may be constituted, affected, encountered and engaged with. Thirdly, how practice can inform modelling as a representational practice and be important to models as representations. Fourthly, modelling as a mimetic practice which, as well as model and modelling engagements, can involve embodied relations whether with places, landscapes, environments, events, people, materials, objects (including models), and temporalities of pasts, presents and futures. Fifthly, how models and modelling engagements can be involved with the miniature and an 'affirmative critique' of abstraction.

With the aim of this thesis attending to ways in which geography can be important to lived and embodied engagements with models and modelling, affect, emotion and feeling have been key conceptual underpinnings in pursuit of this aim. Chapter 2 detailed these concepts, positing each as similar yet different. Feelings and emotions are qualified affects, they are performed and engender action, performance and practice. Considering affect, for Spinney 'concerned with how emotions, sensations, atmospheres and feelings arise out of relation encounters between objects, spaces and people' (2015, p.234-235), has enabled the spatialities of this thesis to be figured, whether with mimetic play and imaginative spaces, the miniature, abstraction, people and practice, environments, events, spaces and places.

7.3.1: Models and modelling can generate space-times and, in so doing, produce affective engagements with those space-times

All the case studies comprising this thesis are about, at heart, the generation of, and engagement with space-times. The model railway chapter considered loved, lost and/or enchanting places, landscapes and affective atmospheres. The hydraulic models chapter examined threat, uncertainty and environmental futures. Finally, the miniature wargaming chapter dwelt on feeling, emotional and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace.

The space-times that models and modelling can generate in this thesis are significant in embodied ways and with models and modelling becoming important, affective objects and practices respectively in relation to these. The model railway chapter found how model railway layouts and modelling afford particular affective, highly intimate engagements with loved and/or lost/enchanting space-times and inflicted with possession. These space-

times might make model railway layouts and engagement with them therapeutic and comforting and deriving importance and meaning from discomforting elsewhere and when. Contrary to some ideas about model railways and the miniature more generally as creating perfect worlds, 4.5 sought to stress how graffiti, urban grime and dilapidation are part and parcel of the space-times model railway layouts may generate.

At the heart of the impetus and enthusiasm for hydraulic models are the agencies of water worlds and their uncertainties to humans and inherent changeability. Hydraulic models and modelling practices and knowledges have been infused in this thesis with hopeful dispositions towards the possession of environmental futures through the making present, acting on and the presentation of them. The environmental futures models and modelling can make present and *present* have been detailed as producing threat, confidence, consternation, contestation and highlighting how the future is involved in the present. For Holloway, the future may be ‘understood as a temporality that is folded and unfolded in, and through, practices and achievements in the geographical present’ (2014, p.1) (also see Anderson 2010a; Anderson and Adey 2012).

In regard to contestation (and productive of and produced by embodied affects), this thesis has considered how engagement with hydraulic model study space-times can be made through embodied relations with the environment modelled, pivoting on questioning mimesis and ultimately made through the power of hydraulic model studies within decision-making processes to shape environments. The model railway chapter also dwelt on how mimesis affects engagements with models as objects generative of space-times. Attending to peer engagements at model railway shows, it was detailed in 4.6 how model railways on matters of mimesis may provoke divisive feelings, practice and emotions.

This sub-section considers debates on mimesis further momentarily, but the wargaming chapter found how miniature models and warfare models afford, through mimetic play, war as a ‘realm of experience’ (Sylvester 2012) and in relation to feeling, emotional and imaginative states relating to other human bodies and/or space-times in the contexts of the military and battlespace. These models, through mimetic play, ‘expand’ the ‘spaces and places of war’ (Rech et al 2014). Both the wargaming and model railway chapters (although the latter only to a slight degree in comparison with the former), considered how miniature models generate space-times through being ‘transitional’ objects within mimetic play, configuring and engaged with through imaginary spaces.

Just as miniature wargaming models, modelling and engagements have been demonstrated to generate war as a realm of experience, so are these negotiated by war as

experience. Sections 6.4 and 6.8 emphasised how the violent nature of war can negotiate the kinds of space-times modelled and engaged with for/on the table-top.

Across all three case studies, models and modelling have been revealed to be divisive objects and practices on account of mimesis and the space-times they generate for people. Modellers can be implicated here. As already emphasised, the hydraulic models chapter considered the ‘contestation’ of models and modelling practice. Across several sections of the model railway chapter, it was detailed how modellers, models and engagements, as well as modelling practices, are implicated in a mimetic politics within the hobby, the idea that a model and modeller ought to produce an ‘authentic’ or ‘correct’ atmosphere. Within the miniature wargames chapter, the ‘transitional’ potentials of miniature wargame models to produce alternate space-times through mimetic play engendered a ‘politics of play’ (Woodyer 2012) over mimesis, specifically about the still and surfaces and how these potentially generate and adversely affect imaginary spaces. These mimetic politics in miniature wargaming and model railways involve questions of ‘model’ and have been revealed in various ways to affect how people practice the hobbies respectively, and in spatial ways, as the next theme and contribution details.

7.3.2: Models, modelling and material and embodied affects can shape how spaces (including models) may be constituted, affected, encountered and engaged with

In various ways, models, modelling and material and embodied affects have been found to shape how spaces (including models) may be constituted, affected, encountered and engaged with. For instance, in the context of engagements with hydraulic models and modelling, water worlds have been understood in chapter 5 as spaces productive of threat and uncertainty, as well as spaces of consternation (including being threatened) and contestation, and all involving sometimes diverse temporalities such as futures and pasts. This thesis has shown how hydraulic model studies have the potential to shape water worlds materially and also how they are experientially encountered and engaged with. Hydraulic model studies can offer comfort for engineers and others in making watery projects more confidently actionable and in the case of the inter-war Severn Barrage project enabling the British government to envision the Severn Estuary as a viable ‘landscape of energy’ (Nadaï and Van der Horst 2010). However, for the Port of Bristol Authority and others, 5.5 detailed how the 1933 Severn Barrage model study on matters

of mimesis and its space shaping potential produced and inflected very different 'presence of the future' emotions, feelings and spatial imaginings. The Seven Estuary became a space of contestation and also consternation, shaping how the Severn Barrage model project was later developed with the HRS; through stakeholder participation in modelling decisions.

The hydraulic models chapter also underscored just how important hydraulic models and modelling practice were for the immediate post-war British government. It was detailed in 5.3 that for the government appointed Hydraulics Sub-Committee (HSC), government could intervene on uncertainty about hydraulic model research through the making, financing and, therefore, technological supporting of a particular spatialised 'community of practice' of hydraulic modellers (the HRS). The British government through bringing about the HRS according to the HSC vision, sought to generate a feeling state of confidence around (although also within) British hydraulic modelling practice for reasons of national economic and political importance, both at home and abroad.

The model railway chapter considered how layouts and modelling may provoke divisive feelings, practice and emotions. Geography, whether through place, landscape and/or atmosphere, is central to a mimetic politics, generated by and affecting railway modellers and models in spatial ways. The chapter found railway modellers can feel impelled to undertake careful and/or more research before a model is 'shown' at a model railway show, whilst for others these places are far too discomfoting to attend because of the possibility of critique. A research practice which can be involved in the mimetic politics - being 'observant', was detailed to be a vital embodied skill in many modeller engagements with places, landscapes, objects and atmospheres and whether through, photographs, maps, diagrams or field visits.

The hydraulic models chapter also considered field-work engagements. Significant attention in that chapter via 5.6 was given to the knowing of water worlds by HRS modellers and who had an aim of making confidence in their model studies through particular surveying methods and technologies of abstraction in the form of special measuring instruments. Confidently knowing water worlds for the HRS was a fraught, difficult and impossible a practice, water worlds often becoming spaces of consternation. Uncertainty about the agencies of some water worlds meant the HRS shied away or were prevented from undertaking model studies. Reasons for a shying away were underlined in 5.8 alongside considering a wider recognition from the HRS as to the limitations of models and modelling as epistemic objects and practices within their making predictions. Predictions create material and embodied affects and it was detailed that for reasons about

these the HRS sought to 'be honest' about uncertainty, managing the confidence placed in model research from clients. Doing this protected the Director's reputation, as well as that of the HRS and the activity of hydraulic modelling more generally, from misguided action and undue hope in model decisiveness and evident value.

With the idea after Forsyth et al that 'surfaces and interfaces can be productive, enlivening and enchanting spaces' (2013, p.1017) and where 'material surfaces are valued in many ways' (ibid), 6.5 detailed how painting the surface of a miniature figure/model for many wargamers makes a figure/model a transitional object, a 'model' and one that is meaningful, enchanting and loved. Indeed, in 6.8 it was underlined how emotional attachment hewn from the embodied effort and/or personal stylising placed in a model's surface, can make the violent nature of war affectively present for some wargamers. For other wargamers, the painted nature of a model does not affect its transitional potential, but with wargaming being a social practice, can provoke anger from others and so many will paint, opening up particular space-times for them and their models. As considered, a requirement of access for many wargames club meets is a set of painted miniatures, enabling others to experience desired alternate space-times through mimetic play.

7.3.3: Practice can inform modelling as a representational practice and be important to models as representations

Aristotle's formulation of mimesis has been important to this thesis for his recognising the more-than-representational qualities of mimesis. As considered in 2.6, Aristotle thought contra Plato that, in the words of Potolsky: '[T]he realism of a work is intellectual [...], mimesis matches our innate or conventional ways of knowing the world. Realism occurs in the interaction of work and viewer [...] and not of work and world' (2006, p.97). Impressionist painting was posited in 2.6 as one pertinent example of Aristotle's mimesis, where the aim was/is to generate a 'sensation in the eye that views the subject, rather than delineating the details of the subject' (Divers 2004, p.348). Aristotle's mimesis could be said to judge representations as 'active assemblages which are informed by, and in turn intervene with, everyday embodied practices' (Griffin and Evans 2008, p.12).

As with impressionist painting, embodied practice may inform modelling as a mimetic practice and be important to models as representations. In the model railway chapter, an 'impressionist' sensibility and technique to modelling was attended to in 4.8

where affective atmosphere was revealed to inform modelling practice, making present ‘a palpable, sensuous, connection between the very body of the perceiver and the perceived’ (Taussig 1993, p.2) (the modeller to the ‘modelled’). Railway modellers were shown, like impressionist painters, as trying to generate a ‘sensation in the eye that views the subject, rather than delineating the details of the subject’ (Divers 2004, p.348). As contemplated, a technique to achieve this is for modellers to compromise on model detail in terms of colour and texture so as to generate a tone of feeling, further emphasised through using just several tones of colour across a whole model railway layout. What we see here is the generation of an ambience through ‘a matter of linking the various components to one another, making them work together and integrating them by giving the same tonality to all that appears’ (Thibaud 2014, p.6). Within this ‘impressionist’ sensibility and technique to railway modelling, layouts deemed to be focused on detail are felt as ‘clinical’ or ‘sterile’, suggesting a lacking in a particular feeling.

The idea that embodied practice may inform modelling as a mimetic practice and be important to models as representations was addressed at substantial length in the context of warfare models and modelling. Sections 6.6 and 6.7 found how wargame designers grapple with the embodied experiences of war for generating imaginary spaces through mimetic play with the model, including breaking down distinctions after Caillois (1961) between self and other. Through mechanisms (formalised techniques), quantification, probability, rules, die, cards and historical sources, designers try to enable the gamer to become military commander. Engagement with warfare models are meant to enable particular feeling, emotional and imaginative states relating to these military bodies and/or space-times in the contexts of battlespace. It was specifically examined how morale, Fog of War, terrain and friction were modelled by designers, these aspects important for them to the embodied experiences of commanders.

The warfare models have been read as ‘teleplastic technologies’ that attempt to mould or form ‘at a distance’ (Ash 2010, p.415), producing ‘limited potentials for movement and action’ (ibid). However, mobilising miniature wargaming models and its relations with mimetic play, we can also appreciate how teleplastic technologies can do more than this because rulesets and game designers seek to enable particular feeling, emotional and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace.

7.3.4: Modelling practice, as well as engagements with models and modelling, can involve embodied relations whether with places, landscapes, environments, events, people, objects (including models), materials, and temporalities of pasts, presents and futures

Within all case studies, the practices of modelling and engagements with models and modelling have been found to create and are made through embodied relations whether with places, landscapes, environments, events, people, objects (including models), materials, and temporalities of pasts, presents and futures. How engagements with models and modelling in this thesis can involve embodied relations will have been evident from discussions in all three of the previous themes and contributions so far. This sub-section concentrates on aspects of modelling as a practice and its embodied relations. Several points made in the previous themes and contributions are of equal relevance here, namely how practice can inform modelling as a representational practice and how a mimetic politics affects people's practice of the model railway and wargaming hobbies, involving people and diverse spaces.

In 4.4, it was found how railway modelling can be a comforting and therapeutic practice for the making of a loved place, landscape and affective atmosphere and with modelling sometimes gaining affective resonance from uncomfortable pasts and presents. Railway modelling was posited as potentially a 'practice of love' (Geoghegan and Hess 2014) towards a space-time, especially in an aim of resurrection and remembrance for what is lost and which can be loved again in a material, miniature and abstracted form. The concept of nostalgia, a yearning for a lost space-time, was important to 4.4 in that modelling (and engagement with models) can sometimes be about quelling the 'sickness' that nostalgia has been described as. On the concept of nostalgia, 4.4 critiqued Boym's (2001) influential reading of the concept, suggesting that the example of railway modelling complicates it; model railways may fall across both 'restorative' and 'reflective' nostalgias, ejecting certain features of one to the other such that Boym's thesis is too dichotomous.

Railway modelling can be a craft practice. In 4.7 and drawing upon material agency and Knappett's (2004) writing on material affordances, the chapter considered relations between modeller and material at the worktop. Railway modelling involves working with another medium in a practice of mimesis and it is this issue that can be so effective in maintaining enthusiasm for the hobby. Many railway modellers do not so much model in spite of modelling, but rather because of modelling. There is the challenge of creating atmospheres, but equally landscapes, objects and places. These might become positively

affecting in so much as the challenge they present to express. With tools and techniques, railway modellers may grapple and experiment with material agency, an agency negotiating intensities of mimesis possible. Whilst negotiating with material agency might be thought of as annoyingly disruptive to the will of the human, it can actually be part of the enthusiasm for the hobby, although as made clear it can also make it a frustrating, difficult, disappointing and a viscerally painful experience. Section 4.7 also noted how a model may become an object of love through the embodied effort ('blood, sweat and tears') placed in its making.

Whilst the place of mimetic negotiation in railway modelling is often an affirming one, this could not be more different from hydraulic modelling and where hydraulic modelling and embodied relations have also been made especially present through mimesis and material agency relations.

Forsyth, in her review of the geographical literature on scientific fieldwork, has suggested that 'the place of nonhumans as active agents – shaping scientific research [...] - in the field remains largely absent' (2013, p.55). Whilst hydraulic model studies can be an attempt at coming to terms with, and shaping the agencies of water worlds, hydraulic modelling practice was shown in 5.6 to also be affected by these and negotiating the epistemic potentials of models for the HRS. As noted in 7.3.2, the knowing of water worlds by HRS modellers was involved with an aim of making confidence in model studies. As detailed in 5.6, technologies of abstraction in the form of measuring instruments were produced and used by the HRS with hopeful dispositions towards their prospective potential and the overcoming of uncertainty and the making of confidence. In the effort at overcoming uncertainty and making confidence, HRS's fieldwork practice, including development, engagement and use of instruments, was revealed to be a fraught, difficult and impossible a practice at times, making these water worlds, and including their futures and pasts, spaces of consternation. As noted earlier in 7.3.2, uncertainty about the agencies of some water worlds meant the HRS shied away or were prevented from undertaking model studies and for reasons underlined there and detailed in 5.8.

Whilst hydraulic modelling is meant to intervene on uncertainty, as shown in this thesis it is a practice rife with uncertainty from within and outside hydraulic modelling practice. As described in 5.3, the British government sought to intervene on hydraulic uncertainty not only from outside of hydraulic modelling practice as considered in 7.3.2, but also on uncertainty among hydraulic modellers. Through the making, financing and, therefore, technological supporting of a particular spatialised 'community of practice' of

hydraulic modellers (the HRS), for the HSC the British government could intervene on uncertainty, made through a problem of mimesis and material agency. The British government (via the DSIR) through bringing about the HRS according to the HSC vision, sought to generate a feeling state of confidence within (and around) British hydraulic modelling practice for reasons of national economic and political importance, both at home and abroad.

7.3.5: How model and modelling engagements can be involved with the miniature and an 'affirmative critique' of abstraction

This is the final, but no less significant cross-cutting theme and conceptual contribution. The miniature, an inherently geographical concept, and abstraction, have been mobilised in this thesis in similar ways. They have been shown to play a generative role, alongside mimesis, in the embodied relations that the model contexts of this thesis have been viewed and experienced by diverse people as affording. Furthermore, like mimesis, they have been involved in and/or productive of diverse embodied relations with models and modelling beyond matters of affordances.

The miniature and abstraction can be closely related. As noted in 2.5.1, for Lévi-Strauss (1962) the miniature is not defined only by a reduction in size, but as a product of this scaling down; abstraction - the loss of features and the making of the feigned (mimesis). On features, this might be as Varutti highlights, 'volume, smell, colour' (2011, p.2), but, as with the model railway and miniature wargaming case studies, we can also consider the absence of humans and forms of social and political power and control. In the context of hydraulic models, we can think about, besides matters of volume, the absence of particular environmental agencies.

As considered in 2.5.1, the miniature has been read by a number of philosophers and writers as imbued with power. The miniature alongside abstraction can invite possession, enabling a sense of intimacy, and each of the case studies to this thesis has involved worlds that are 'elusive; we do not possess' (Millhauser 1983, p.130).

As shown in 4.9, a model railway enables play with its referent. The model becomes a performative site for relaxed and comfortable enactment of desires and fantasies in relation to playful engagement with the railway as a system. Spatial volume is depressed and forms of social and political power and control, among other aspects, are absent.

Relatedly, as revealed over 4.4 and 4.5, loved things, atmospheres, places, infrastructures and landscapes can be made intimately present *within* the personal space of the home or the communal space of the club. The abstraction involved in model railways means they can remain relatively safe (save usually dust, bugs, pets and damp if these are not controlled) in that, for instance, the past is the present always. The future, in many ways giving meaning to how a model railway may be imbued with memory and/or loss, never arrives. Equally, utopias (whether pasts, presents or imaginary futures and worlds) are never threatened or destroyed.

The miniature wargaming chapter saw how, through the miniature and abstraction, war and commemoration, remembrance and enchantments (whether ‘terrain and tactics’, military dress, adversarial atmospheres) can be affectively conjured, enabling affective engagements with these in the context of a game and importantly without the ‘lived body’ (Anderson and Wylie 2009) coming under threat. With the depression of spatial volume, war becomes ‘tabletop’ war and through abstraction becomes bloodless. In place of the lived body is lead or plastic. Being like this, as noted in 6.8, models can assuage emotional recoil to killing and being killed.

Enthusiasm for model railways and miniature wargaming can lie with the difference as much as the similarity between the ‘model’ and the world by which the model ‘makes sense’. Besides the points just made on these two case studies, in the context of model railways for instance, layouts can be intriguing and wonderful for their ‘sham’ nature, the complete ‘fake’, the ‘*melancholia artificialis* - the longing for artifice’ (Olalquiaga 1998, p.140, emphasis added). In the context of miniature wargaming, in 6.4 the thesis noted how wargamers can find enthusiasm and gain pleasure from engaging with tape measures, measuring sticks, rulers, die and rulesets (also in 6.7).

In the model railway and miniature wargaming chapters, the miniature, besides mobilising embodied affordances, generated problematic affects. Section 4.9 drew attention to how the all-encompassing visuality miniature models might afford, making people feel like giants, is something many railway modellers will eschew when designing, playing with and showing their layouts. Of a more political nature, raising an issue of a ‘politics of play’ (Woodyer 2012) infused by the miniature, 6.8 detailed how wargames play with the miniature might be felt as ‘trivialising’ an event of particular gravity and/or through gaming bringing to the fore unpleasant feelings and emotions, making play unbearable. Adult play with the miniature and the gaming of war in this way were found

to negotiate, for reasons of social stigma, how some wargamers perform their identity in particular social contexts and spaces.

Miniature wargaming has been shown in this thesis to be a contentious practice in relation to the miniature and abstraction. As noted in 6.8, anti-war, non/anti-violence or peace activists and groups since the turn of the 20th century have considered war toys and miniatures as producing, in part, a militaristic society, pervading (through their size) the home and other spaces and contributing to the event of war. Moreover, as detailed in 6.8, several scholars have questioned the role of the abstraction in miniature wargaming for presenting skewed perspectives on the violent realities of war. Whilst not denying the affective power of representational media like miniature wargames to shape perceptions, with the idea that ‘war is fundamentally not apart from the rest of social life’ (McSorley 2012, p.2), the thesis has argued how abstraction can be a way of coming to terms with war’s violent realities, as noted earlier making warfare approachable for people.

As suggested in 2.5.1, there is a question about the desire of abstraction, including the miniature, within hydraulic modelling. ‘Scale effect’, considered in 5.7, was shown to be a problematic product of abstraction and miniaturisation, requiring embodied skills and considerable knowledges in making spatial relations between two different fluid flow situations (the model and modelled), making for Allen (the HRS Deputy Director) hydraulic modelling a rarefied practice. Scale effect, with the potential to generate material affects, could lead to a pessimistic attitude about the epistemic potentials of model studies.

Nevertheless, it is often only through abstraction and the miniature that the precautionary action of hydraulic modelling becomes possible and relevant. Hydraulic models as miniaturised and abstracted mimetic objects (whether physical or on a computer) enable and/or make more amenable the ‘explorative style’ of ‘researching and thinking’ (Kullman 2013, p. 879) that is experimental practice. As McCormack has asserted, ‘abstraction is [...] crucial to the articulation and imagination of actionable futures’ (2012, p.728). Hydraulic models and modelling practices and knowledges aim to *possess* futures, making them present, acting on and presenting them, giving modellers, politicians, civil engineers and various authorities inclinations of worlds to be, future worlds simulated and represented. On this matter of possessing futures, the miniature and abstraction involved in hydraulic models and modelling, in a similar way to the other case studies, invites possession, enabling a sense of intimacy to worlds that are ‘elusive; we do not possess’ (Millhauser 1983, p.130).

Abstraction within this thesis has been highlighted as having ‘provisional and prospective’ qualities, ‘intended to open up potential space-times rather than close them down’ (McCormack 2012, p.724). As part of this reading, the thesis has illustrated how abstraction as ‘drawing out elements of the world’ (ibid), is related to an array of modelling techniques and practices, materials, attitudes and ‘technologies of abstraction’ (scientific instruments and inscriptions). In the hydraulic models chapter, it was emphasised how water worlds, including model water worlds, are made thinkable and sense-able (but also become potentially contestable spaces), through measurement instruments and practice with these. Engagements with measurement instruments are infused with a hopeful disposition over their prospective potential. In the same chapter and developing Latour’s (1999) concept of ‘inscriptions’ (charts, diagrams, tables and graphs), water world and model inscriptions as abstract entities were described in 5.8 as having prospective potential in enabling the exploration of spatial relationships, helping to give hydraulic models affective power and making them epistemic objects. In the model railway chapter, it was shown in 4.8 how abstraction is crucial to how some railway modellers think through and produce affective atmospheres, abstraction critical in making present ‘a palpable, sensuous, connection between the very body of the perceiver and the perceived’ (Taussig 1993, p.2) (the modeller to the ‘modelled’). The same kind of engagement with and affordance of abstraction was considered in 6.7 of the miniature wargaming chapter. Here it was detailed how a sensibility of more abstraction and styles of it are held to open up potentials for emotional, feeling and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace.

7.4: Six broad lessons and further contributions

The previous section examined how findings from this thesis give shape to five key ‘geographies of models and modelling’ when considering aspects of the importance of geography in understanding what models can be, what and how they can *do*, and how and why models may be made and engaged with. This section moves beyond detailing relations between geography and models and modelling. It submits six broad lessons about models and modelling that can be identified from the findings of this thesis and which cut across and speak to *all* case studies. It is shown how these lessons are connected with

contributions to several of the theoretical concepts this thesis has deployed (abstraction, the miniature, mimesis) and debates in geography concerning the human and non-human, the representational and the more than representational. To make clear, the six lessons are; one: models and modelling and the absence and presence of possession. Two: modelling as a negotiated practice/placing negotiation within mimesis. Three: modelling as ‘drawing out elements of the world’/an ‘affirmative critique’ of abstraction. Four: models and modelling as connecting us with the world/a critique of the ‘disappearance of the real’ after Baudrillard and Virilio. Five: models and modelling and human and non-human relations. Finally, six: models and modelling and the more-than-representational.

7.4.1: Models and modelling and the absence and presence of possession

This thesis demonstrates how modelling can be prompted by the absence and/or elusiveness of possession, a state made through spatial and temporal relations, from lost halcyon atmospheres, uncertain and worrying environmental futures, bodies at war, to power and control over these spaces and times. Modelling can be seen through this thesis as a practice towards rendering present possession of what is absent and/or elusive, and models become proxy agents that may be felt to enable intimate, proximate and instrumental engagements with these, affording something to happen (from enacting power, to pursuing violence) that humans might be otherwise unable and/or unwilling to perform.

Models for Lévi-Strauss (1962) are ‘constructed’, they are inherently ‘artificial’ (Badiou (2007[1966]) (in so much as being proxies). Abstraction and miniaturisation pervade models and modelling and as demonstrated by this thesis models are constituted with the human and non-human (whether water, wood, probability, affective atmosphere or synthetic fur), whilst modelling finds its mimetic possibility, challenge and impediment through powerful non-human agents. Possession (through the presence of what is absent and/or elusive) is made tangible or, indeed intangible, through the more-than-human qualities of models, modelling practice and wider knowledges and experiences of the world. Yet, possession is never really achieved, for models are firstly proxies and where applicable, are secondly constructed (modelled) in the context of a more-than-human world affecting how and what we know.

As Jones et al have observed: ‘absence and presence are intricately woven rather than exist as binaries: they are co-constituted, and co-exist simultaneously’ (2012, p.258, also see Hetherington 2004; Hyde 2016; Jones et al 2016). Discernible from this thesis, models and modelling involve a play of absence and presence, something productive of affective relations with models and modelling. As Hetherington has observed;

‘[T]he absent can have just as much of an effect upon relations as recognisable forms of presence can have. Social relations are preformed not only around what is there but sometimes also around the presence of what is not [...], indeed the category of absence can have a significant presence in social relations and in material culture’ (2004, p.159).

In the making of, enthusiasm for, and engagement with models, absence/absencing is as pertinent as presence/making present. Absencing - in the sense of ‘distancing, withdrawing, burying and erasing’ leads to ‘exclusion, marginality and invisibility’ (Wylie and Harrison 2012). Absence/absencing has been shown in this thesis to be involved with the affordances of models and modelling. Whilst absencing generates distance, distance is effected by models in an effort to achieve presence of possession on particular terms. Across all the case studies, the miniature (an absence of ‘real’ size) makes things less formidable (Lévi-Strauss 1962; Millhauser 1983), for instance in hydraulics enabling and/or making more amenable the ‘explorative style’ of ‘researching and thinking’ that is part of its ‘experimental practice’ (Kullman 2013, p. 879). The absence of the social in model railways enables the enactment of control and power and where the past can be the present always. In miniature wargames, the worry of killing and being killed is assuaged through lead or plastic soldiers, whilst in hydraulics experiment and futures can be occasioned by the absence of uncontrollable non-human forces and processes affecting water worlds.

7.4.2: Modelling as a negotiated practice/ Placing negotiation within mimesis

Mimesis has been mobilised in this thesis because its ‘denotation of imitation, representation, portrayal’ (Puetz 2002, np) relates to how we can think spatially about aspects of what models can be, what and how they can *do*, and how and why models may

be made and engaged with. The anthropologist Taussig has described mimesis as being ‘the faculty to copy, imitate, make models, explore difference, yield into and become other’ (1993, p. xiii). Special readings of mimesis in this thesis have revolved around Caillois’s (1961) ‘mimetic play’ and Aristotle’s conception of mimesis in which representations are ‘active assemblages [...] informed by and in turn intervene with everyday embodied practices’ (Griffin and Evans 2008, p.12).

This thesis demonstrates how modelling is a negotiated practice on matters of space and mimesis. Three empirical circumstances can be emphasised, chiefly; contestation, non-human agency and finally representation and embodied practice.

Non-humans as active agents negotiating modelling practice permeated all the case studies. In the context of hydraulic models, it has been seen how, whilst modelling can often be an attempt at coming to terms with, and shaping, non-human agencies (e.g. bed-drift, scientific instruments, water), it is fundamentally affected by them, negotiating the very epistemic potentials of scientific models. In model railways and miniature wargaming however, negotiating with non-human agency (e.g. materials, model soldiers, wargaming blinds) in an effort of mimesis can actually be part of the enthusiasm for modelling. Across contexts though, non-human agency and its impacts on a desire for mimesis make modelling a frustrating, disappointing, difficult, fraught, viscerally painful experience and at times an impossible practice.

Modelling finds its mimetic possibility, challenge and impediment through non-human agency. The attention given to *doing* mimesis in this thesis has elided scholarly engagement with the concept. Aristotle and Plato appraise mimesis in the context of debates on depiction with objects and performance (see Potolsky 2006). Meanwhile, 20th century philosophers of mimesis Adorno and Horkheimer (1972 [1944]) and Benjamin (1986[1933]) in their focus on mimesis within social practice examined the ‘communicative correspondence between the subject and object’ (Kang 2014, p.45), incidentally mobilised in this thesis through Caillois’s (1961) ‘mimetic play’ (and developed by introducing non-human agents (models)). By considering mimesis as more-than ‘original and copy’ and ‘subject and object’, this thesis presents empirical work that highlights the negotiation inherent in mimetic practice. Besides the possibility, challenge and impediment of mimesis through non-human agency, as noted earlier this thesis has considered two other empirical circumstances of negotiation; contestation and representation and embodied practice.

Models and modelling have been shown in this thesis to provoke divisive feelings, practice and emotions in relation to space and mimesis and which in turn have been found

to negotiate how modelling and mimesis are spatially practiced. The model railway case study considered how exhibition modellers can feel obliged to undertake careful and/or more research, being ‘observant’ with places, landscapes, objects and affective atmospheres. In the hydraulic models case study, it was detailed how the British government sought to intervene on concerns about hydraulic model research through the making, financing and, therefore, technological supporting of a particular spatialised ‘community of practice’ of hydraulic modellers (the HRS). In the miniature wargaming case study, the bare surfaced (unpainted) miniature soldier was demonstrated to be a problematic entity for many on its lack of transitional potential within mimetic play, affecting how some engage with the surface.

The final empirical circumstance of negotiation and modelling and mimesis is representation and embodied practice and in the context of creating affective atmospheres (model railways) and imaginative states (miniature wargaming). This is detailed towards the tail of the next section because it involves abstraction.

7.4.3: Modelling as ‘drawing out elements of the world’/An ‘affirmative critique’ of abstraction

Like mimesis, abstraction has been mobilised in this thesis because it relates to how we can think spatially about aspects of what models can be, what and how they can *do*, and how and why models may be made and engaged with. For McCormack: ‘Abstraction is the process by which simplification takes place, and abstractions are taken to be those representational forms through which this process is stabilised and through which its results circulate’ (2012, p.717). McCormack’s recent reassessment of abstraction, an ‘affirmative critique’, has informed how this thesis has engaged with the concept. Chapter 2 dwelt on McCormack’s reassessment in detail (sections 2.5.1 and 2.5.3). McCormack has argued how abstraction can be ‘provisional and prospective, intended to open up potential space-times rather than close them down’ (2012, p.724).

Abstraction has become something of a straw figure in geography (abstraction as ‘universalising’, ‘alienating’, reductive and ‘distancing’) and two observations from McCormack have been important for this thesis. The first is that abstraction is ‘differentiated: there are more ways than one of being and becoming abstract, and abstraction participates differentially in processes of thinking, feeling, and perceiving’

(p.726-7). Following from this, whilst abstraction can mean a distancing, '[e]qually, if we accept that the world is already withdrawn from us, then abstraction provides a way of drawing out elements of the world that make them thinkable and sense-able' (p.727).

Whilst this thesis has not overlooked problems of abstraction around its universalising, alienating, reductive and distancing qualities (as detailed in 7.3.5), McCormack's 'affirmative critique' has enabled a different look at abstraction and modelling and in turn this thesis has presented substantial empirical work in geography that responds to McCormack's critique. As already emphasised in 7.3.5, the thesis has detailed how abstraction as 'drawing out elements of the world', is associated with a variety of 'technologies of abstraction' (scientific instruments and inscriptions), attitudes and modelling practices and techniques. In the hydraulic models case study, it was made clear how water worlds, including model water worlds, are made thinkable and sense-able through measurement instruments and practice with these. Engagement with measurement instruments are charged with a hopeful character over their prospective potential. In the same case study, water world and model inscriptions as abstract entities were shown as possessing prospective potential in allowing the investigation of spatial connections, helping to furnish hydraulic models with affective power and making them epistemic objects. In the model railway case study, it was revealed how abstraction is pivotal to how some railway modellers think through and produce affective atmospheres, abstraction being key in making present 'a palpable, sensuous, connection between the very body of the perceiver and the perceived' (Taussig 1993, p.2) (the modeller to the 'modelled'). A similar engagement with abstraction permeated the miniature wargaming case study. Here, a sensibility of more abstraction and styles of it were demonstrated to be regarded to open up potentials for emotional, feeling and imaginative states relating to other human bodies and space-times in the contexts of the military and battlespace.

7.4.4: Models and modelling as connecting us with the world/ A critique of the 'disappearance of the real' after Baudrillard and Virilio

The miniature has been important to this thesis for the same reasons as the other concepts; an integral quality of models and modelling. As Pietrobruno notes, at base 'the miniature compresses the large within the small' (2011, p.175). The miniature, decided for Stewart 'in the context of our [...] corporeal dimension' (1993, p, 46), is usually associated with small physical things and representations ('a miniature'), but following Baudrillard (1988)

and Virilio (1995) is also present through and because of virtual technology (which miniaturise). As detailed in chapter 2, the miniature has been the subject of several important readings, particularly from Bachelard (1994), Levi-Strauss (1962), Millhauser (1983) and Stewart (1993). All regard the miniature as imbued with power and this thesis has, as will have been evident from 7.3, presented intimate and possessive affordances of the miniature and miniaturisation, often alongside abstraction.

As considered in 2.5.2, whilst Millhauser (1983) and Stewart (1993) have written about miniatures as representations of significant value for how they compress the large within the small, Baudrillard (1988) and Virilio (1995) have taken the opposite view. Baudrillard, for example, writes of the effect of miniaturisation and technology and its 'making objects miniature', and he argues that 'the disintegration of human scale through miniaturisation drives contemporary society toward a further disappearance of the real' (Pietrobruno 2011, p.175). Virilio, also having in mind the effects of the miniature and miniaturisation and technology, has a similar idea to Baudrillard when he says that 'the potential to connect to the world and other human beings at their veritable scale is being stripped away' (1995, p.62). Although mindful of the differing empirical context over the effects of the miniature and miniaturisation between this thesis and the writings of Baudrillard and Virilio, through this study miniatures and miniaturisation can be read in a positive light. Within all of the case studies, the practices of miniature modelling and engagements with miniature models have been found to create and are made through embodied relations with places, landscapes, materials, environments, people, events, bodies, objects and temporalities of pasts, presents and futures.

7.4.5: Models and modelling and human and non-human relations

In mobilising affect, read after Spinney as 'concerned with how emotions, sensations, atmospheres and feelings arise out of relational encounters between objects, spaces and people' (2015, p.235), this thesis has been attentive to human and non-human relations. Through geography's 're-materializing' (Jackson 2000), non-humans are now recognised as 'active presences' (Pitt 2015), enabling a critique of the idea of the 'human subject as separate and liberated from nature and fully in command of self and nonhuman others' (Castree and Nash (2006, p.501). Whilst models and modelling might be related to control and power as argued in 7.4.1, through this thesis modellers can be understood as acutely

aware that ‘control and power [does] not exclusively reside within the human’ (Forsyth 2016, p.799).

Four thematic human and non-human relations in the context of models and modelling can be drawn from this thesis and which also include contributions to human and non-human geographies: modelling as involving attunement to non-humans and dynamic more-than-human relations; non-humans as effecting and negotiating modelling practice; models as non-human extensions for enhancing human agency; and finally, models as co-producing spaces.

On ‘attunement’, miniature wargame modelling has been shown to apprehend the hybridity of warfare, the more-than-human dynamic relations between ‘soldier, technology, animal, environment and elemental’ (Forsyth 2016, p.799). In model railways, the importance of atmosphere (as the ‘bringing together of different “bodies”’ (Shaw 2014, p.89)) has been highlighted in modelling efforts and sensibilities, whilst in hydraulics how modellers try to understand the material agencies of water worlds has been demonstrated. Modelling as involving attunement to non-humans and dynamic more-than-human relations can also be considered in the context of this thesis’s tracing of how railway and hydraulic modellers collaborate with material agency to create their models (from casting resin to water).

As found in geographical work on gardens (e.g. Power 2005), human and non-human agency clash besides collaborate. As already made clear in 7.4.2, this thesis has emphasised how non-humans are active agents negotiating the mimetic potentials of modelling work. How human and non-human agency clash and collaborate in this thesis contributes to geography scholarship arguing for the making present of non-human agency in scientific and craft practice (Forsyth 2013; Latimer and Miele 2013; Patchett 2015, 2010).

Non-humans and dynamic more-than-human relations have been demonstrated to lie at the heart of the impetus and enthusiasm for models and modelling, from affective atmospheres, the agencies of water worlds and their uncertainties to humans, battlefield strategy and tactics, to working with materials.

Models can be understood in this thesis as non-human extensions for enhancing human agency, from enacting power, to pursuing violence, including in the contexts of pretence (model railways and miniature wargaming). As detailed in 7.4.1, the case studies are all predicated on the presence of possession, models as proxy agents that may be felt to enable intimate, proximate and instrumental engagements with particular space-times.

Finally, besides seeing models (as spaces) as co-produced, it has been emphasised how models co-produce spaces, whether effecting affective atmospheres, imaginative spaces, or water infrastructure, in turn shaping water worlds. We can gauge from this thesis how humans and non-humans ‘do not just co-habitate, but actually co-produce spaces’ (Galloway 2013, p.57) (see Panelli, 2010; Philo and Wilbert, 2000; Whatmore, 2006).

7.4.6: Models and modelling and the more-than-representational

This thesis has attempted to underline how the body and its ‘intersensory unity with a world’ (Doughty 2013, p.31) is a fundamental quality of models, modelling and model engagements. It has sought to mobilise the more-than-representational qualities of models and modelling with a recognition of the entwining of representation and affect, practice and performance in complex and diverse ways (Merriman et al 2008). Following recent theoretical and empirical emphases in cultural geography on practice, performance, embodiment and affect, representations can be read as ‘active assemblages which are informed by, and in turn intervene with, everyday embodied practices’ (Griffin and Evans 2008, p.12).

Affect, embodiment, practice and performance have been shown to be important to models as representations and modelling as a representational practice. Firstly, and as emphasised in detail in 7.3.3, embodied practice can inform modelling as a representational practice and be important to models as representations. Secondly, and with the idea from McCormack that ‘[representations need to be] reanimated as active and affective interventions in a world of relations and movements’ (2005, p.22 in Griffin and Evans 2008, p.8), models have been shown to be generative of affect, productive of and shaping embodied practice and spatial engagements.

7.5: Closing remarks

This thesis has sought to consider ways in which geography can be important to what models can be, what and how they can *do*, and how and why models may be made and

engaged with. In tracing spatialities of models and modelling, the thesis has mobilised embodied relations, several model contexts and key concepts and with a focus on the representational and more-than-representational qualities of models. Through the ‘five interrelated research themes and contributions’, this thesis has opened up conceptual space to consider models and modelling from a particular perspective, one that recognises how space is central to lived and embodied engagements with models and modelling. Through the ‘six broad lessons and further contributions’, this thesis has contributed towards and extended several of the key concepts mobilising the geographies of this study as well as developing our conceptual thinking on models and modelling.

It should be noted that it is recognised that the geographies mobilised in this thesis are just a fragment of the affective and wider geographies to models and modelling. Like any research project, this thesis is not a ‘complete or enclosed piece of work’ (Forsyth 2012). The thesis has been orientated around three case studies, it has given privilege to several concepts, been informed by particular theoretical developments and shaped by archives, participants and texts, as well as enthusiasms, skills and apprehensions on my part as an ‘embodied researcher’ (Horton 2008).

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