

# BlueHealth: Water, Health and Well-being



Final Report

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The James  
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Institute



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This document was produced by:

David Miller, Sue Morris and Jane Morrice  
The James Hutton Institute  
Craigiebuckler  
Aberdeen AB15 8QH  
Scotland UK

Jenny Roe and Caroline Brown  
Heriot Watt University  
Edinburgh Campus  
Edinburgh EH14 4AS  
Scotland, UK

Catharine Ward Thompson  
Edinburgh College of Art  
The University of Edinburgh  
Lauriston Place  
Edinburgh EH3 9DF  
Scotland, UK

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### **CREW Management**

All queries related to this document should be directed to the CREW Facilitation Team

James Hutton Institute  
Craigiebuckler  
Aberdeen AB15 8QH  
Scotland UK  
Tel: +44 (0) 844 928 5428

Email: [enquiries@crew.ac.uk](mailto:enquiries@crew.ac.uk)

[www.crew.ac.uk](http://www.crew.ac.uk)

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# 1. EXECUTIVE SUMMARY

## Background to research

This research reviews the evidence base for both positive and negative relationships between water in the landscape, health and well-being (termed blue health). Water is important for human health, both physiologically and psychologically; however, much of the research on blue health has focused on pathogenic associations between water and health i.e. the effects of environmental toxicology and poor water quality on disease and illness. Empirical evidence for the salutogenic (health improving) effects of blue space appears to be weak and water has received little attention in urban planning as a potential health resource. In conjunction with key Scottish government agencies, the following themes were identified to be of priority interest and form the framework for this review: the salutogenic benefits of water settings; flooding and the impact on psychological well-being; sustainable drainage systems (SUDS) and their potential amenity and restorative health benefits. The research does not address other aspects of water security such as drinking water quality, levels of water use, foul water drainage, pathogenic impacts and water-borne diseases.

## Objectives of research

The research objectives were two-fold.

- Firstly, to systematically bring together and review the empirical evidence for the role of water settings (inland, coastal, rural and urban) (or blue space) on health and suggest how this information might be used for health promotion in Scotland.
- A second aim was to work with key stakeholders (e.g. Scottish Environmental Protection Agency (SEPA), Scottish Water, Health Protection Scotland, Scottish Flood Forum, British Waterways) to focus the review on their priorities.

Given the growing evidence base showing positive links between green space and health and well-being (green health) – and the well-developed theory underpinning this relationship - we posited that a similar association should hold for water environments i.e. that blue space can promote active recreation and increase physical activity levels; that it can facilitate increased levels of social activity – organised (e.g. via specific activities) or more impromptu contact; that it can promote psychological restoration and stress recovery. Our review of existing evidence on blue health was therefore structured around the physical, social and mental well-being effects of water environments, including the potential role of SUDS, which we postulated might act as restorative environments in urban settings owing to their visual amenity, species richness, and recreational potential. We made no specific hypothesis in relation to the impact of living with flood risk, other than this would be associated with long-term stress and poorer psychological well-being.

Two stakeholder workshops were held. These stakeholder discussions centred on how best the evidence for blue health might be used; prioritising gaps in knowledge; identifying future research opportunities; and establishing a blue health research agenda that will support policy makers and government agencies engaged in water management.

## Key findings

- I) Across all three themes of our research we found little empirical evidence and many gaps in the literature on the links between blue space and health.
- II) The scientific evidence for salutogenic benefit of blue space is strongest for mental health, with evidence of water settings as a preferred landscape offering perceived psychological restoration, with some limited evidence that coastal settings may offer greater benefits for walking.

However, there is a lack of objective measures and ‘real world’ research in everyday settings since much of the evidence has relied on self-reported indicators in student populations carried out in controlled laboratory conditions. The theory underpinning green health would suggest blue space ought to offer similar benefits in terms of promoting social contact and active living, but we found no empirical evidence supporting this.

- III) Qualitative research has shown that flood disasters can have severe and long-term social and health impacts, but there is lack of robust, quantitative and longitudinal evidence to support this. Much of the evidence base has focused on specific mental disorders (e.g. post-traumatic stress disorder (PTSD)) with little research on the everyday distress and anxiety experienced from living with floods and future flood risk. We found evidence of social and health inequalities with greater psychological impact of flooding being experienced by poorer communities, and amongst children, women and older people, but more research is needed to quantify this geographically and demographically. Whilst we found a number of educational initiatives directed towards places of flood risk (e.g. the Scottish Flood Forum mental health first aid course), we found no systematic analysis of the value of these initiatives to health and well-being.
- IV) We found some evidence of the amenity benefits of SUDs, particularly in support of the aesthetic and recreational value of SUDs, especially where they incorporate ponds. We found anecdotal evidence of the amenity value of SUDs in schools, particularly their benefits for outdoor learning and for promoting well-being in children, but no formal evaluation, nor any research exploring the risks associated with these features, how they can be best managed and the trade-offs with health and well-being. The environmental bias of senior teachers in schools is suspected to influence the adoption of SUDs in schools but further research is needed to explore this.

## **Recommendations**

Based upon our findings, the strongest recommendation to emerge is that water settings can be used as a tool to promote mental restoration. The parallel field of green health also suggests blue space can offer scope for active living and social recreation. Scottish policy makers should therefore consider promoting access to water settings for active and passive recreation. The potential for water features in urban environments should also be explored, both as a soundscape to screen traffic noise and for visual and social amenity. We also recommend, rather than referring to blue and green space as separate entities, that the two are conjoined i.e. as ‘blue-green corridors’ or ‘blue green space’; this is more appropriate to the Scottish environment, where, more often than not, water is found within the context of green space.

Specific priorities for further research, identified in consultation with stakeholders, include:

- Exploring the potential (in Scotland) for blue space to offer active recreation (e.g. outdoor swimming, water sports), and the potential for water-edge recreation, especially walking, alongside rivers, coastal cliffs, canal-sides and reservoirs/lochs.
- Considering the impacts of climate change and potentially rising ambient temperatures on demand for access to water for active recreation (e.g. outdoor swimming) and the implications for risk.
- Investigating the benefits of seaside recreation, including the opportunities of beaches for play, family recreation and active sports.

- Longitudinal research assessing: the impact of floods on mental health over time; social and health inequalities in areas of flood risk; and, the impact of educational initiatives designed to build resilience in communities affected or at risk of flooding.
- Primary research on the positive health and well-being outcomes of SUDS in schools (including longitudinal evidence of the impact on pupils over time and into adulthood).
- Secondary research mapping flood and blue-space data with Scottish health data.

**Key words**

Blue space; salutogenic health effects; landscape preferences; flooding and mental health; sustainable drainage systems (SUDS); restorative environments.

## 2. INTRODUCTION

Many underlying determinants of inequalities in health and well-being are environmental, and it is widely acknowledged that there is an association between health and access to green or open spaces. However, relationships between health outcomes and quality and extent of green and open space, and proximity to and use of such areas, have yet to be quantified appropriately and the underlying mechanisms remain poorly understood. Less still is known about the role of water as a component of such spaces. The water environment in Scotland is diverse, and while water is often a component of green space, some water landscapes are more about water than about green space. The geography of Scotland means that the majority of the population live close to the sea or a loch and that the coastal/water edge plays a significant role in experiencing the natural environment.

Issues of the environment and health are high priorities within the Scottish Government's strategic objectives of a Greener and Healthier Scotland. They seek to deliver improvements in people's surroundings and the environment and include, *for Greener*- "improve Scotland's natural and built environment and the sustainable use", and *for Healthier*- "help people to sustain and improve their health, especially in disadvantaged communities".

These priorities also link to a range of other policies including:

- The Flood Risk Management (Scotland) Act 2009<sup>1</sup>
- Sustainable development (*i.e.* 'Choosing our Future - Scotland's Sustainable Development Strategy'<sup>2</sup>), biodiversity (*i.e.* Scotland's Biodiversity: It's in Your Hands, the strategy for enhancement and biodiversity in Scotland<sup>3</sup>)
- The Scottish Land Use Strategy<sup>4</sup>
- The Land Reform (Scotland) Act 2003<sup>5</sup>
- The European Union Water Framework Directive<sup>6</sup>
- Sustainable flood risk management, principles of appraisal<sup>7</sup>
- Overall, these are also covered in Scottish Government's National Performance Framework<sup>8</sup>.

Links between mental and physical health and human rights to safe drinking water and sanitation are also recognised by the UN Human Rights Council<sup>9</sup>, reiterated in the Scottish Government's consultations on 'Building a Hydro Nation'<sup>10, 11</sup>.

Ecosystems provide services that are the foundation of human well-being, the understanding of which has relatively little in terms of a tested evidence base. Gaps in such an evidence base are being addressed through research supported by the Scottish Government's Rural and Environment Science and Analytical Services Division (RESAS), and in wider international activities. However, whereas much has been published on the importance of water (sea, lochs/lakes, rivers, waterfalls) as a characteristic of the landscape to which people respond positively or to which they are drawn<sup>12</sup>, relatively little is published on its potential role in relation to its restorative values, and positive contribution to well-being and mental health.

The BlueHealth study responds to these policies and evidence gaps and aimed to aid consideration of thinking of policy and practice linked to well-being and water. Following consultation with stakeholders, the study focused on three themes: salutogenic benefits of water settings; flood risk, mental health and well-being; and, Sustainable Drainage Systems (SUDS). Based on reviews of the literature, scientific principles and theoretical grounding for the framing of discussion of these



themes are set out, together with the evidence base. From this, research gaps were identified and recommendations for future research presented. The methodology is set out in detail in Appendix 1,

### **3. SALUTOGENIC BENEFITS OF WATER SETTINGS**

#### **3.1 Introduction**

‘Salutogenic’ means ‘health improving’ and refers to a health approach that focuses on the factors that support human health and well-being as opposed to those that cause disease (pathogenic). Salutogenic environments are those that ‘...support healthy behaviours and responses. The interest is as much in how experience within the landscape can act as a prophylactic against illness as in how it may moderate causes or mitigate effects of ill-health, mental or physical’<sup>13</sup>. In this section, we explore blue space as a potential salutogenic environment for supporting healthy lifestyles and well-being in Scotland.

#### **3.2 Problem and principal issues**

Trends in Scottish health survey data show mental well-being is worsening over time (from 2008 to 2010) in the middle age categories (35 to 64) and, although this change is not statistically significant, the figures are reflected in the increasing number of prescriptions being prescribed for anti-depressants between 2009/10 to 2010/11 (an increase of 0.5%). The Scottish Mental Health Association (SMHA) has estimated the cost of poor mental health to the Scottish economy as being £10 billion, up £1.4 billion in the past five years, with one in six working people in Scotland having poor mental health, such as depression or anxiety (2011)<sup>14</sup>.

Two-thirds of the Scottish population is overweight or obese, with obesity levels in Glasgow ranked the worst of any city in the UK with forty per cent of Glaswegians classified as either obese or morbidly obese<sup>15</sup>. Two thirds of the Scottish population is insufficiently physically active<sup>14</sup>. Scotland also has higher death rates from cancer, heart disease and stroke than anywhere else in the UK<sup>16</sup>, diseases where obesity and poor physical activity are known to be contributory health factors.

Set within this context, our research aims to show how blue space might act as a salutogenic environment to positively impact on some of the health issues above.

#### **3.3 Policy context**

In this section, we focus on the most recent Scottish policy designed to promote physical activity and mental health. Whilst a new mental health policy is about to be published, current policy guidance in *Towards a Mentally Flourishing Scotland*<sup>17</sup> states “Advocating for individual responsibility and self-help in mental health improvement is therefore set within a framework with equal attention to the creation of mentally healthy environments within which individuals and communities are empowered” (page 9<sup>17</sup>). A new National Walking Strategy has recently been announced that is designed to tackle obesity problems and encourage many more people to become physically active<sup>18</sup> building on the evidence base for promoting physical activity through primary care. ‘Good Places, Better Health’<sup>19</sup> flags the value positive physical environments can have for health and well-being, recognised also in the Early Years Framework<sup>20</sup> which promotes high quality play opportunities and increased physical activity in children.

Policy issues arising from stakeholder engagement indicate a need currently for appropriate measures (quality and health indicators) by which to measure blue health that clearly link to Single Outcome Agreements and Local Authorities priorities.

### 3.4 Scientific principles and theoretical grounding

The theoretical grounding and scientific principles for this study are provided by research on the relationship between green space and health (green health). There is now substantial evidence for a positive relationship between access to green or natural environments and people's perceived overall general health<sup>21, 22</sup>, longevity<sup>23</sup>, physical health<sup>24, 25</sup> and social health<sup>26, 27</sup>. The evidence is particularly strong for positive associations between experience of natural environments and mental health. Contact with natural environments promotes psychological restoration<sup>28</sup> in the form of improved mood<sup>29, 30, 31</sup>, improved attention<sup>30, 32</sup> and reduced stress and anxiety<sup>22, 30, 33</sup>. Epidemiological studies based in urban setting have shown these relationships appear to be stronger among deprived populations<sup>34</sup>. This is supported by more localised research consistently showing, within deprived social housing communities in Chicago, the benefit of green space both to cognitive restoration<sup>35, 36</sup>, reduced aggression<sup>37</sup> and reduced crime<sup>38</sup>.

Two emerging findings from the green health literature have potential impact on future research in blue health. An Australian study<sup>39</sup> has recently shown how quality of open space can have more impact on mental health than quantity of green space. Water can contribute significantly to the attractiveness of the landscape. However, measures of quality are largely subjectively arrived at. In Sheffield, Dallimer et al.<sup>40</sup> have used biodiversity indicators to explore more objectively relationships between quality of green space and health. Using self-reported indicators of mental well-being, they found that the mental health benefits of green space increased with species richness of green space. Whilst water was included as a landscape type in the study, the authors do not report any statistical relationships between water settings, biodiversity and health. Since water contributes to biodiversity value and species richness, the use of biodiversity indicators in future blue health research might offer a useful objective quality measure. However, the association of biodiversity with quality could be contested; for example, species-rich environments (e.g. intertidal zones) might also be smelly and visually dull, just as certain types of green space (e.g. dense woodland) can be psychologically challenging and frightening for those unfamiliar with the environment or concerned about safety.

Several theories attempt to explain these positive relationships between green space and health:

- (i) Biophilia hypothesis<sup>12, 41</sup> that we are naturally drawn to those places that have best facilitated our survival, and in particular, savannah-type landscapes offering prospect and refuge.
- (ii) Stress Reduction Theory (SRT)<sup>42</sup> which argues that an emotional response to the visual stimuli of the natural environment triggers physiological stress recovery.
- (iii) Attention Restoration Theory (ART)<sup>28</sup> which suggests that our primary response to nature is cognitive recovery, in turn facilitating emotional and stress recovery. Natural environments assist with attention recovery by allowing individuals just sufficient room for reflection and thought without demanding the directed concentration of the urban built environment.

### 3.5 Evidence

Based upon our understanding of the effects of green space on health, our review of the salutogenic benefits of blue space is structured according to the three pathways believed to mediate in the relationship between nature and health: (1) increased physical activity undertaken while experiencing natural environments; (2) the restorative psychological benefits arising from experiencing nature; and (3) the social contact facilitated or enhanced within such places. In a fourth section, we review the preference literature on blue space indicating the potential visual amenity of water settings. Owing to a recent comprehensive literature review<sup>43</sup>, we have focused

(mainly) on newly emerging findings. The most recently published research in the UK has found that good health is more prevalent in people living in closer proximity to the coast<sup>44</sup>. Analysing small-area census data for the population in England, this research found that, consistent with similar analysis of green space accessibility, the positive effects of coastal proximity may be greater amongst socio-economically deprived communities.

### **3.5.1 Physical health benefits of blue space**

Whilst walking alongside a river, loch or coastal edge is a common form of physical activity associated with blue space, we found very little empirical evidence that the presence of a water edge positively promotes levels of physical activity, or that people might walk further than they otherwise would normally if there is a water edge to walk along. In Australia, increased physical activity has been associated with living in close proximity to coasts<sup>45</sup>; other authors<sup>29, 46, 47</sup> have posited that waterside locations promote greater opportunities for physical activity and recreation, particularly sailing and swimming (in warmer climates) and, in rich marine habitats, snorkelling and diving. However, we could find no empirical evidence to indicate living near the coast or water is associated with greater levels of physical activity other than the Australian study cited above.

Water clarity is believed to impact on recreational behaviour<sup>47, 48</sup>. In Finland, in close-to-home water settings, water quality has consistently been found to positively affect swimming and fishing behaviour. However, it was shown to have no effect on boating behaviour<sup>48</sup>.

### **3.5.2 Mental health benefits of blue space**

The most substantial evidence for a health effect of blue space is on perceived restoration. Water settings appear to offer greater opportunity for psychological restoration than either green only or urban settings<sup>43, 47, 49</sup>. Specifically coastal/seaside visits are associated with more positive self-reported affective responses in UK adults (n=4500) as compared to rural or urban parks<sup>50</sup>. The authors postulate this is owing to positive associations from holidays/childhood memories; other researchers have suggested, owing to our evolutionary history, we are naturally drawn to water environments because they have supported human settlement (coasts, harbours, river margins)<sup>47</sup>.

There is very limited evidence of a salutogenic effect of blue space on stress or depression. Kjellgren and Buhrkall<sup>51</sup> found improved stress recovery (physiological and self-reported) from a group of chronically stressed participants following exposure to a park with a large lake, with similar responses from viewing the scene on film and during an actual visit (but they did not isolate any special effect of water). Exploring the effects of walking in different settings (urban, rural green, rural green-blue) in adults with mental health problems, Roe<sup>52</sup> found green-blue water to be more advantageous to stress recovery (self-reported) than either green or urban, especially for women, but participant numbers were small. Exactly what characteristics of blue-green settings are promoting restoration has received little investigation but, in coastal parks, water quality was not a significant environmental parameter associated with perceived restoration<sup>53</sup>.

Contrary to these findings, there are several studies that indicate blue space has no advantage over green space on psychological restoration<sup>54, 55, 56</sup>.

### **3.5.3 Social benefits of blue space**

Blue space clearly offers scope for recreation and social interaction— for example, the affordances of a beach setting for family recreation and play, which - even in a colder climate such as Scotland – offers opportunities for relaxation from social norms and for social pleasure. Whilst family recreation in coastal settings is currently the subject of a qualitative study by The Blue Gym (see

Section 3.5.8 below), we found no currently published evidence that water settings, or the recreational activity associated with it, can enhance social interactions, although – as with physical activity – we could plausibly posit it can.

#### **3.5.4 Preferences for water settings**

Water environments are amongst people's favourite places<sup>57, 58</sup> especially seaside environments<sup>57</sup>. Han<sup>59</sup> found the presence of water to be highly correlated with preferences, scenic beauty and perceived restoration, even when controlling for environment type, openness and scene complexity<sup>59</sup>. White et al.<sup>47</sup> have consistently found views of blue space to be rated more positively than for those of green only or built environments, controlling for people, animals and objects across different environments. Results appear to be consistent across different cultures and climates. Howley and O'Donoghue<sup>60</sup> found a preference for water settings amongst Irish residents; Faggi and Breuste<sup>61</sup> found a preference for water over other landscape features in people from Argentina.

#### **3.5.5 Factors influencing preferences for blue space**

Recent research suggests preference for blue space is more sensitive to environmental parameters as follows:

*Colour:* in photographic studies, the colour blue was found to be an important variable in reactions to setting – when the 'blueness' of a photographic image of a water setting is taken away (i.e. by presenting the same image in b/w) the effect is weakened – although the positive effect is not completely lost (White at al., under review). The authors speculate there may be a colour bias in our environmental responses (citing Schloss and Palmer<sup>62, 63</sup> who indicate blue is a preferred colour) and that this has strong associations with blue skies and aquatic environments.

*Climate:* blue spaces shown under overcast weather are perceived to be less restorative<sup>47</sup>. The effect of light on water and preference has not been explored although Faggi et al.<sup>64</sup> found water 'in light' was preferred by visitors to urban waterfronts (however, this is not defined). Temperature is another potential mediator of environmental preference for water settings: in hot climates (e.g. California) the cooler the temperature, the greater perceived restorativeness of coastal settings<sup>53</sup>. But does the reverse of this operate in temperate climates, i.e. do we prefer water in hot weather owing to associations with cooling down?

*Aesthetics:* The reflective quality of water is a preferred characteristic when compared to transparent surfaces<sup>65</sup>.

*Prospect and sense of openness:* Herzog<sup>66</sup> found large open water bodies were preferred to marshland and small streams. Hipp and Ogunseitan<sup>53</sup> found that a beach at low tide is potentially more restorative, which they postulate is owing to a more open, less crowded prospect. White et al.<sup>47</sup> have explored the prospect of water settings from above and below water level, with views above water perceived to be more attractive and more restorative than sub-aquatic water environments, which the authors suggest is owing to reduced water clarity, depth of field and fears of drowning or threats from marine predators.

*Aquatic sounds:* the sound of water may have a restorative potential in terms of promoting tranquillity<sup>67</sup> but there appears to be very limited evidence on the impact of water sound on psychological restoration. People prefer natural sounds of water as a screen for urban noise as compared to the sounds of formal water features<sup>68</sup>.

*Where you live:* preference for water environments was found to be higher amongst urban residents in Argentina<sup>64</sup> which the authors speculate is owing to a water scarcity (i.e. from culverting of streams) in the context of Buenos Aires.

### **3.5.6 Limitations in the current academic research**

There is an over-reliance on laboratory-based studies that use video or static photographic images, mostly presented in sunny climes, in student populations with measures of self-reported, perceived rather than actual, restoration. White et al.<sup>49</sup> have also identified a lack of consistency in the approaches to experimental studies and how water is represented.

### **3.5.7 Evidence from the grey literature**

Health benefits of canals: British Waterways Scotland (BWS) and The Waterways Trust Scotland have recently reviewed the health and amenity benefits of canals<sup>69</sup>, carrying out a cost benefit analysis of activities along the Forth and Clyde and Union Canals. This quantified the physical health benefits of activity along a canal (walking, running and cycling) using HEAT (WHO Health Economic Assessment Tool), showing an estimated £6.4 million health benefit. The report also quantified the benefit of travelling in 'clean air' to work as opposed to 'polluted air' and the safety benefits of using a canal towpath rather than a road for undertaking cycle journeys. A canal user survey showed 81% of canal users either "Strongly Agree" or "Agree" that the canal encourages them to take more exercise; 57% of canal users either "Strongly Agree" or "Agree" that the presence of the canal encourages them to walk / cycle to work; and 91% of survey respondents either "Strongly Agree" or "Agree" that the canal enhances their sense of personal well-being.

A similar benefit-cost analysis exercise was undertaken by the Department for Transport (DfT) on the impact of investment in a canal towpath in London (cited in Davis<sup>70</sup>). The towpath was transformed into a high quality walking and cycling route and assessed in terms of walking and cycling commuter use. Improved route surface quality and connectivity, in addition to the introduction of the congestion charge, led to considerable increases in usage, resulting in: a benefit-cost-ratio (BCR) of 24.5:1; savings of almost £5.5 million through reduced absenteeism; savings of £28.5 million due to increased physical fitness (based on numbers of preventable deaths).

### **3.5.8 Academic research in progress from The Blue Gym**

The Blue Gym research project is based at the European Centre for Human Health (see <http://bluegym.org.uk/research>) and has a number of relevant studies in hand. For example, the group is carrying out several other multi-method studies investigating the psychological and physical health benefits of exposure to natural water environments, including a study exploring how families use the beach, and the perceived risks, barriers and benefits associated with visiting the coast. This is a small qualitative study comprising in-depth interviews with 15 families with children aged 8 to 11 years living in Cornwall and Devon. The Centre also has several PhD studentships around the Blue Gym, including a project focusing on children's health and well-being, but no further information is currently available.

### **3.5.9 Summary of the evidence**

The strongest evidence for a salutogenic effect of water space is on perceived psychological restoration. There is some evidence to suggest coastal settings are perceived to be more restorative than other countryside and urban open spaces. The evidence base for mental health benefits relies

almost entirely on self-reported indicators. Preference for water settings is more sensitive to environmental parameters, such as light and climate. See summary of key literature in Appendix 2.

### **3.6 Stakeholder priorities**

The health-promoting benefits of blue space emerged as a major priority in discussion with stakeholders (7<sup>th</sup> February 2012) with a particular need to quantify the benefits, especially long-term, to health. This research needs to be compelling and persuasive in order to convince policy makers, planners, and developers to invest in providing access to and maintaining high quality water settings. Priorities were further reviewed at a second stakeholder event disseminating the research findings (31<sup>st</sup> May 2012) and ascertained the following agenda:

- (i) Identify the benefits and differentiation between different types of water settings e.g. 'blue-green' corridors, water in an urban setting, coastal settings.
- (ii) Identify the specific opportunities that blue space offers for active recreation (swimming, watersports) and the impact of climate change (e.g. increased ambient temperatures) on possible demand for outdoor active and passive recreation.
- (iii) The impact of water quality (e.g. exposure on pathogens) on active recreation and the potential impact of climate change.
- (iv) Explore issues of risk and safety and how these may act as a barrier to restorative and recreational experiences.
- (v) Explore issues of quality, particularly the management and maintenance of water settings.
- (vi) Synthesise the research between the salutogenic benefits of water and SUDS e.g. by exploring a SUDS landscape in an educational context, including outcomes on attainment, health and well-being and increased awareness of the risks of water.

### **3.7 Research Gaps**

The blue health research field lags significantly behind the green health evidence base. In particular:

- (i) At a population level, there is a lack of epidemiological studies showing effects of living near water on population health outcomes in Scotland.
- (ii) At a local level, there is a lack of knowledge of the physical and social well-being benefits of water settings. For example, does the presence of a water body influence the extent people walk? Do people walk further or less because of water barrier issues and/or owing to an enhanced aesthetic experience and richer species biodiversity (e.g. of a river riparian edge)?

Whilst there is more evidence for the mental health benefits of water settings, there are many gaps, which include:

- (i) No evidence of the effects of blue space on stress physiology and attention recovery.
- (ii) Very little evidence of the effects of long-term exposure to a green-blue setting.
- (iii) A lack of fieldwork experiments showing actual restorative experiences from experiencing blue space.
- (iv) A lack of evidence in the wider population – particularly effects of gender, socio-economic status, age and culture.
- (v) No understanding of environment type, scale or form of water body besides some limited evidence to suggest coastal locations are preferred.

- (vi) No impact of geographic location – does living on an island, for example, with good access to water have a greater effect than, say, in a land-locked country such as Switzerland. Is water more important to the UK?
- (vii) Very little evidence of effects of light and climate on water and potential health outcomes.
- (viii) No exploration of type of view – complexity, mystery and coherence is believed to lie behind preferences for green space, but it is not known whether this holds in relation to blue space.

### **3.8 Recommendations**

We suggest future research is directed to answering the following research questions:

- (i) Are there water typologies in Scotland (e.g. coast) that promote greater salutogenic benefits? What is the salutogenic benefit of water in an urban environment? And how does living in a city affect our preferences for being close to water?
- (ii) Does the presence of water improve the walkability of a district? What is the specific benefit of a water-edge to promoting levels of walking? Is fear of water a barrier to using blue space for physical activity and recreation?
- (iii) What is the impact of water quality on recreational behaviour?
- (iv) Does the presence of water generate physiological restorative benefits, for example, in the stress-endocrine response system?
- (v) Can blue space promote positive social connections in a community?
- (vi) What are the restorative values of SUDS and how risk can best be managed?

## **4. FLOOD RISK, MENTAL HEALTH AND WELL-BEING**

### **4.1 Introduction**

Flooding is mainly a natural phenomenon, which is an issue when such events make impacts on individuals and groups of people in populations. This means that, while all rivers and coastal locations are liable to flood on occasion, and that flooding cannot be totally prevented, policy can aim to exert influence over flooding, reducing the risk of disaster from flood events and reducing damage when flood events are inevitable. For Scotland, this requires the responsible authorities to take both structural and non-structural action to reduce risk, including natural flood management that a) restores the capacity of landscape forms to store water and reduce flux, and b) enhances existing natural capacity of such forms<sup>71</sup>.

Qualitative studies on health and social impacts of flooding show that flood disasters, and associated experiences, can have severe and long-lasting social and health impacts, with emotional and psychological impacts often being more severe and longer lasting (e.g. 4 years) than physical damage to property, lives and health<sup>72</sup>. The effects can include shock and disbelief, uncertainty, grief and loss, emotional exhaustion, loss of hope and meaning, General Adaptation Syndrome (GAS), PTSD, alarm, resistance and exhaustion<sup>74, 75, 76, 77</sup>. Persistence of post-event issues is strongly related to the flood depth and intensity<sup>78, 79</sup>.

### **4.2 Problems and principal issues**

In an average year, worldwide, floods kill 13,000 people, make 30 million people homeless, affect 60 million people, and cost US\$40 Billion. Within the UK, 10% of people (1.7 million homes) live in a 100-year flood zone, comprising 7% of the land (and 61% of best agricultural land), and £200 billion of commercial property<sup>80</sup>. In Scotland, approximately one in twenty-two of all residential properties, and one in thirteen non-residential properties, are at risk from flooding<sup>81</sup>, and 6.7% of prime agricultural land is within flood risk areas<sup>82</sup>.

In 2000 in Scotland, approximately 170,000 properties were reported as being at risk from flooding, at a value estimated at £50m<sup>83</sup>. The National Flood Risk Assessment 2011 estimated that the average annual cost of damages to homes, businesses and agriculture from all sources of flooding is between £720m and £850m, but this is a national figure which assumes flooding happens everywhere at once so is an overestimate. Werritty et al.<sup>75</sup> report the economic cost of flooding from coastal and river water in Scotland to average £31.5m per year from inland flooding and £19.1m from coastal flooding. It is predicted that over coming decades the country will endure more severe rainfall events in winter, especially in the east, contributing to more frequent flood event<sup>1</sup>. Despite flooding being the most common natural disaster in Europe, health risks are poorly characterised. A lack of good quantitative data has resulted in uncertainty in the full range of potential health impacts. Studies mainly concentrate on assessing effects of large events; even though more frequent, smaller events have important health impacts. Appendix 3a and 3b summarise examples of major flood events in Scotland and England (1993 to 2007), referred to in the scientific literature.



## Policy context

Scottish Planning Policy<sup>84</sup> represents ‘the Scottish Government’s policy on nationally important land use planning matters’. It notes that, when identifying areas for development, account should be taken of risks associated with rising sea levels and coastal flooding (although also seeking to promote public access to coastal area wherever possible), and from water courses, groundwater, sewers and blocked culverts.

The Flood Risk Management (Scotland) Act 2009 aims to ‘deliver timely and sustainable approaches to reducing the impact of flooding to Scotland’s communities, environment, cultural heritage and economy’. The Scottish Government is also focusing on increasing public awareness of their responsibilities in flood risk management. The public are encouraged to be more pro-active in taking precautionary approaches to ensure their own safety and safeguard their properties from flood risk and to ensure they know what to do in the event of a flood (Scotland’s Climate Change Adaptation Framework Water Environment and Resource Sector Action Plan, and the associated Health and Well-being Sector Action Plan<sup>85</sup>).

Responsibilities for implementing the new approach to flood risk management are shared:

- Scottish Ministers set the policy framework and are ultimately responsible for approving objectives and actions in flood risk management plans.
- SEPA has a central role developing flood risk management strategies which set objectives and identify appropriate measures. It also delivers information and provides the tools local authorities require to implement measures in plans. SEPA also has an important role developing strong working relationships with local authorities, Scottish Water and other public bodies, stakeholders and the general public.
- Local authorities manage flood risk in local areas, preparing local flood risk management plans and ensuring flood risk objectives and actions are targeted and delivered locally.
- People and communities are encouraged to engage with the planning process, sharing local knowledge and taking appropriate action.
- Scottish Water undertake risk assessment of flooding from surface water and combined (surface water and foul) sewers due to higher than usual rainfall events, and for reducing these risks through its capital investment programme.

The SPP promotes a risk framework for use in considering development, with three categories: little or no risk, low to medium risk, medium to high risk. Within the low to medium risk area, constraints on development include the siting of ‘essential civil infrastructure’, such as emergency services, which should be operational during extreme flood events. The medium to high risk category is identified as unsuitable for infrastructure including care homes.

The SPP also highlights the role of natural flood management and the use of natural features to slow, reduce or manage flood waters (although also the potential effect of flood on proposed open spaces, including gardens). It states that there should be a minimal area of impermeable surfaces, and the need for a coordinated approach to the use of sustainable drainage systems (SUDS) as a means of minimising ‘adverse impacts on people and the environment’.

SEPA runs a Floodline service for businesses and the general public in Scotland, using its website for flood warning alerts. Scottish Government has funded SEPA to develop a state-of-the-art national

flood warning dissemination service, Floodline direct warnings service, that automatically sends electronic flood warnings to all those who have signed up to receive them ([www.sepa.org.uk/flooding/sepa\\_floodline\\_service.aspx](http://www.sepa.org.uk/flooding/sepa_floodline_service.aspx)).

Scottish Government also funds the [Scottish Flood Forum](#) to work with communities, businesses and individuals to raise awareness of flood risk and develop resilience for future flood events. It also provides support and practical information about coping after a flood event. Scottish Water also publishes advice on how to deal with waste water flooding, and how to take precautions against this ([www.scottishwater.co.uk/you-and-your-home/water-quality/water-quality-factsheets/external-flooding](http://www.scottishwater.co.uk/you-and-your-home/water-quality/water-quality-factsheets/external-flooding)).

Health policy in relation to flooding notes that NHS Boards should ensure that current and future NHS properties are not built on flood plains nor be susceptible to river or coastal flooding. This includes consideration of impact on care homes and other facilities housing vulnerable people<sup>86</sup>.

In terms of policy responses, some of the changes in England and Wales, including some of the main environmental, contextual and behavioural drivers, have been analysed and future changes predicted<sup>78</sup>. It was found that flood damage potential has increased significantly, while flood policy has moved away from simplistic flood defence to 'making space for water'. Their study examines the mis-match between the aspiration in policy ideals, the reality of rising potential economic damages and the inability of the flood risk appraisal process to match aspiration with reality.

#### **4.3 Scientific principles and theoretical grounding**

A review of the effects of flooding on mental health<sup>87</sup> concluded that 'people's psychosocial needs, and the mental disorders that they might develop as a consequence of their being flooded, pose core challenges for public health.' The review found that recent literature on flooding has tended to focus on the concept of PTSD, and that little research has been concerned with 'the psychosocial needs of people who are distressed rather than disordered' (p4). The review also found that the morbidity of populations, including that which affects people who are involved in major incidents and disasters, has been largely neglected, despite this being a 'crucial' (p4) topic. With respect to PTSD, the review found that symptoms may take longer to decline than previous work suggests, and that social cohesion has 'a significant effect on susceptibility to symptoms of PTSD' (p5) and must be taken into account in developing public health strategies.

Findings on relationships between human health and 'place' in the context of flooding, and how that can impact on well-being and health-related flood behavioural response, have considered: (i) physical location within a floodplain, (ii) place as a social environment, (iii) people's changing relationship with, and perception of, place<sup>88</sup>.

The analysis of natural drainage systems shows that river basins have high levels of self-organisation that produce extremely efficient control of water flows. However, human interference in river basins to impose navigational improvements and flood control has led to the destruction of natural water flows, and to increasing interference in artificial flood defence systems that creates a positive feedback loop, thus exacerbating flood problems<sup>89</sup>. Additional problems are created by the building of drainage systems under surface areas of settlements, infrastructure and agricultural land. The installation of SUDS has been compulsory in Scotland since 2006, but the legacy of previously installed systems prevent the storage and absorption of water in the ground via natural hydrological systems, giving rise to serious local flood events. A further problem is the increasing amount of

home building on flood plains, which disturbs the ecological balance of such areas and thus increases levels of human insecurity from flood risk.

Places perceived as promoting well-being share properties of providing: a sense of security; a feeling of identity; satisfaction of material wants; and aesthetic pleasure<sup>90,91</sup>. Sense of place is a key concept in human geography, and is closely linked to the concept of landscape: 'Basic themes of cultural geography' are 'how we live in, experience, and shape a particular environment, about what living in and shaping that environment means to us, about how that environment (and thus our relationship to it) is changing in various ways<sup>92</sup>. Home is often conceptualised as the primary place in human lives: 'Home, more than anywhere else, is seen as a centre of meaning, and a field of care'<sup>93</sup>; and as an 'intimate place of rest [...] where you can be yourself'<sup>94</sup>. Therefore, threats to feelings of security or impacts on the home, such as those posed of flood risk, may adversely impact on well-being.

Recurring themes in geography are 'landscape', 'place', with a fundamental emphasis on 'how we construct knowledge of our world', 'nature' and 'inequality'<sup>92</sup>. The UK National Ecosystem Assessment<sup>95</sup> conceptualises natural environments as 'meaningful local places', which are of vital importance to the quality of life and well-being of individuals. Meaningful local places may also be 'socially valued landscapes' when their meaningfulness is shared by people outwith the local area (e.g. national parks). The NEA further argues that '[ ] humans cannot avoid interacting through their senses, emotions and bodies with elements of ecosystems that are nearby', and this is part of the creation of meaningful local places'. While it is the positive aspects of meaningful local places and socially valued landscapes that are emphasised in the NEA, it is clear from the literature that a positive sense of place can be displaced by negative emotions when the natural environment causes harm and distress, of which flooding can be a significant cause.

#### **4.4 Evidence**

Research has investigated the negative effects of water on health, including ingestion of water during sports activities<sup>96</sup>; drowning, which is the second leading cause of unintentional injury/death in children under 19 years<sup>97</sup>; and risks related to eating contaminated foodstuffs e.g. fish/shellfish<sup>98</sup>. Morris<sup>99</sup> notes that immediate deaths and injuries from flood events disproportionately affect vulnerable and high risk groups. He also queries whether non-specific increases in mortality directly linked to flood events are stress-related. However, the risks to mental health and well-being from flood risk and flooding are increasingly reported in the scientific literature.

Research investigating the relationship between flooding and health can be categorised into three main groups:

- The mental health impacts of flooding
- The role of forecasting and warning in mitigating the health impacts of flooding
- Wider implications of flooding for health services.

##### **4.4.1 Mental health impacts of flooding**

Several UK-based studies have examined the psychological processes and impacts of flooding and considered the implications for public health<sup>72, 76, 77, 87</sup>. The health impacts of flooding have been reported at various spatial scales, from globally<sup>100, 101, 102</sup>, by country<sup>79</sup>, for Scotland<sup>75</sup>, and England and Wales<sup>74</sup>. Relationships between health impacts and characteristics of flood, including onset of flooding, duration, depth and levels of contamination, have been revealed, and strategies to counter

the impacts identified. Tunstall et al.<sup>103</sup> report some longer term psychological effects (e.g. anxiety when it rains, flashbacks to flood event), and strong associations with longer term physical effects (e.g. heart conditions), but such studies have not controlled for confounding factors.

Relationships between health impacts and flooding examined at an individual level consider the level of flood awareness, whether the individual has been insured, occupational status, household income, housing tenure, extent of warning or guidance received<sup>74, 75, 104</sup> and prior exposure to flooding<sup>105</sup>.

Research shows social and geographical differentiations of impacts on mental health from flooding (and other climate change impacts) which exacerbate existing health inequalities<sup>106, 107, 108, 109</sup>. Kazmierczak and Cavan<sup>108</sup> explored the spatial distribution of surface water flooding and vulnerability of communities to flooding, to evaluate not only where the most vulnerable people live but also what makes them vulnerable. Some of the most vulnerable people in Greater Manchester (culturally diverse and materially deprived communities) were shown to be exposed to the highest risk of flooding.

Variables which increase the risk of mental disorders are young age, prior mental health problems, financial status, family or social dependencies, and previous experience of a traumatic event. The highest levels of anxiety are reported amongst under 65s, females and ethnic minorities, and disproportionate effects on women over men<sup>103, 108, 110</sup>.

Hayes et al.<sup>110</sup> report that women are more affected because of their greater emotional involvement and investment in the home, and also because they feel greater responsibility to restore the household to normal. Gender-based violence was also reported as increasing in the aftermath of flooding events. Social cohesion has a significant effect on symptoms of PTSD.

Mason et al.<sup>76</sup> examined the psychological impact of widespread flooding in UK, and identified risk factors for the development of psychological effects ('sequelae') in a population of adults (N = 3242). They highlight the large number of people who are potentially in need of psychological attention as a result of flooding, and the need for appropriate community support and access to primary care services. In addition, those affected may not seek medical help because of their perceptions of psychological and mental health issues, and likely diagnosis and treatment, with limited uptake of psychological support services. The full extent of depression therefore may not be fully reflected in the scientific literature<sup>108</sup>. There also appears to be a need to provide a less medically based model of support, and one more of community based support.

Consequences of flooding included increased levels of anxiety about future flood events (e.g. when there is heavy rain), a loss of trust/confidence in authorities, a sense of isolation and loss of sense of security (within homes, and within the community), and a changed perception of place as home and locality<sup>111</sup>. Hayes et al.<sup>110</sup>, in a review of the clinical and managerial impacts on flooding on community mental health, found that displacement is a trigger for psychological symptoms; with these being particularly acute the longer a person has lived in a place. To reduce future anxiety, early intervention is identified as being desirable, with associated monitoring of impacts on health and practical policies such as strengthening of flood defences, flood resistance and resilience, and the communication of such investments<sup>112, 113</sup>.

Responses to flood events have included the development of social vulnerability indices with one on flooding by the Flood Hazard Research Centre<sup>88</sup>. An extensive review of social vulnerability to

hazards is provided by the EU Consortium CapHaz-Net, through the Flood Hazard Research Centre<sup>114</sup>. Amlot and Page<sup>115</sup> provide an overview of guidance in response to traumatic events, in three stages. (i) The 'Impact phase', when greatest disruption occurs, individuals and communities are displaced, and have to deal with shock. Stressors include threats to life, encounters with dead bodies, feelings of helplessness, difficulties in communicating with family and friends, and geographic and social dislocation (see also Rubin et al.<sup>116</sup>). (ii) 'Immediate post-disaster phase', are the days and weeks following disaster during which authorities require to establish essential services, helplines, information to aid individuals and communities take stock of impacts. (iii) 'recovery phase', which may span months or years, and focus on re-building and restoring communities, but if poorly managed can lead to feelings such as distrust of authorities.

Research findings are mixed in relation to the impacts of shorter and longer-term effects. Werritty et al.<sup>75</sup> distinguish between tangible effects (e.g. loss of property and belongings) and intangible effects (e.g. stress, worry about future flooding, deterioration in health). They argue that intangible impacts register markedly higher than tangible impacts, and that immediate intangible impacts are generally higher than lasting intangible impacts. However, Ahern et al.<sup>101</sup> note that, although risks to health and well-being are understood, there is still scientific uncertainty about the strength of such associations, and the public health burden for specific health effects. They report that longer-term impacts, especially mental health, are often underestimated and probably receive too little attention from public health authorities.

In one study, the concerns of people involved in flood events included little or no support from agencies (apart from emergency services) during or after flood, and no specific aftercare or counselling<sup>117</sup>. Divides are reported to have opened within communities due to a lack of understanding by non-flood residents<sup>117</sup>.

Processes of recovery and implications for practice at various levels (individual, community, city, etc.) following the 2007 floods in Hull were examined<sup>118, 119</sup>. A strategic stepped model of care, including assessment and intervention and a multi-sector approach which involves both communities and agencies, has been identified as useful in responding to the mental health needs of flood victims<sup>87</sup>.

Whittle et al.<sup>119</sup>, in a study of local recovery following the floods of June 2007 in Hull, focus on the emotional 'work' in long term disaster recovery, such as severe flood events. People are identified as struggling not only to restore the physical fabric of their homes, but also to recreate the meanings associated with 'home' itself and their everyday lives. The authors argue that recovery is an emotional process, and is played out through relationships that exist within families, communities and workplaces. They also argue that emotional aspects of recovery cannot be separated from the more physical tasks involved. The practical importance is in the management of disaster recovery, and bridging a 'recovery gap' in the provision of aid for residents, such as the provision of support arrangements regarding insurance, site clearance, and re-building. The study also reports the need for support arrangements to be sensitive to both longer timescales and unexpected impacts.

#### **4.4.2 The role of forecasting and warning in mitigating the health impacts of flooding**

Forecasting and warning of flood events, levels of vulnerability in the population, and the implications of this for the 'at risk' population, including loss of life and injury, are seen as increasingly important in mitigating the health impacts of flooding, both physical and mental<sup>78, 108, 120, 121</sup>. Research from the United States suggests that early warnings reduce the levels of stress

experienced in the aftermath of a flood event<sup>122</sup>. This was because not only lives can be saved, but that the time to collect and take important documentation and emotionally important belongings helps in restarting people's lives after the event<sup>123</sup>.

In addition, because injury and bereavement are major causes of psychological distress, it has been suggested that timely flood warnings may reduce the health effects of flooding by enabling people to get their goods, and themselves, out of harm's way<sup>124, 125</sup>. However, in relation to pluvial flooding, early warnings may be less likely, so protective measures may need to have been implemented as an investment independent of any specific event.

In Scotland, SEPA has produced a flood map that provides a nationwide picture of areas assessed to be at risk of flooding from rivers and/or the sea. While the flood map is at general area level, and does not identify specific features of locations, it is designed to raise awareness and encourage individuals and organisations to take appropriate action. The Flood Map provides local authorities with a tool allowing a more proactive and planned approach to flood risk management and assists them in developing avoidance, alleviation and assistance strategies to their planning, flood prevention and emergency planning functions.

Methodological developments in assessing values of potential health impacts associated with flood defence improvements have included risk-based approaches<sup>126</sup>. Cost-benefit analyses of flood preparedness have also been investigated in relation to health and stress impacts associated with flooding<sup>127</sup>. Findings showed that over 60% of people at risk, or who have experienced floods, were willing to pay £150 or £200 per household respectively to avoid health impacts associated with flooding.

No other such willingness to pay studies were identified, and none explicitly relating to Scotland.

#### **4.4.3 Wider implications of flooding for health services**

The wide-ranging public health impacts of floods, including loss of life, compromised personal hygiene, disruption of sewage systems, disruption of health care services, impact on frontline support workers, and possible chemical contamination of homes and water sources have been reported by a number of authors<sup>104, 106, 128, 129</sup>.

In the US, the impacts on the health care system following hurricane Katrina have also been studied<sup>130, 131</sup>. This included the impact of the hurricane on mental health, showing the self-reported health and safety concerns were associated with poorer mental health, and that, two years after the Hurricane Katrina, the greatest predictors of poor mental health were higher numbers of children in a household and attitudinal characteristics such as fatalistic sentiments<sup>132</sup>. Therefore, resources for skilled staff and facilities were required for aftercare, several years after the event.

The importance of reducing vulnerability to flooding through pre event/emergency preparedness, response and post-event care/recovery has been emphasised by a number of authors<sup>79, 128, 133</sup>. Implications of the health impacts for practice include psychological health provision, dealing with contamination, training for frontline support workers, restoration<sup>104</sup>, and the geographic distribution of emergency services with respect to areas at risk of flooding. For older people, the overcrowding of care homes in the aftermath of a flood event results in increases in behavioural difficulties and psychological symptoms<sup>110</sup>. Therefore, emergency services and civil infrastructure require to be planned to be adequate to cope with capacity, and for surviving extreme events such as flooding. However, the Health Protection Agency report of 2011 states that 7% of hospitals and 9% of

surgeries in England are built on a floodplain (EA). In Scotland the National Flood Risk Assessment<sup>81</sup> reported that just over 10% of fire stations, 4% of schools, 5% of residential care homes and 5% of hospitals and health centres are built on a floodplain and at risk of flooding.

#### **4.4.4 Limitations in the current academic research**

There is a lack of robust, quantitative evidence which means that the full impact of flood events and flood risk on human health is not understood. There is also a lack of studies which emphasise the impact on different cultural groups, settings, age groups and periods of time, and the provision of post-event care. As yet, there is little understanding of the types of social mechanisms of flood risk management which are most appropriate for addressing long-term psychological effects arising from flooding and flood risk, and a lack of studies which explore and evaluate the impact of flood support schemes, such as the Flood Forum, on mental well-being and recovery.

While the impact of flooding on the mental health of children, young people and older people may be exacerbated because they are dependent on others, there is a lack of studies investigating this. There is also mixed evidence over the relative impacts of shorter and longer term effects on mental health and well-being, with Ahern et al.<sup>101</sup> noting scientific uncertainty about the strength of such associations, and that longer-term impacts, especially on mental health, are often underestimated, thus likely receiving too little attention in public health.

#### **4.5 Stakeholder priorities**

Issues arising from stakeholder engagement include a need for appropriate measures (quality and health indicators) which link to Single Outcome Agreements and Local Authorities priorities. Overall, the priority is to be able to quantify the social benefits of sustainable flood management, including those of human well-being.

More specific priorities relating to flooding and health and well-being, were identified as:

- the need to increase community resilience to flooding and the after-effects through education
- the importance of being able to identify effective flood recovery measures and quantify their long term benefits to communities and individuals
- the potential value of design solutions for new house building and modifications of existing housing stock
- the need for a better understanding of the impacts of flooding on mental health.

#### **4.6 Research gaps**

- (i) Guidance on the communication of the effectiveness of investments in community resilience to after-flood impacts on mental health.
- (ii) A need for qualitative and quantitative nursing studies to describe effects of flooding, with emphasis on older participants, larger samples, different cultural groups, different settings, and different periods of time.
- (iii) Adequate data for use in emergency planning in relation to social vulnerability, post event<sup>112</sup>, and more and better quality epidemiological data, including: centralised and systematic reporting for deaths and injuries<sup>79</sup>.

- (iv) Improved information on those especially liable to suffer health impacts - (a) location; (b) targeted assistance (e.g. elderly people, prior-event health problems, people living in poverty, those with dependents); (c) better provision of post-event care.
- (v) Effectiveness of communications of investments in resilience planning in reducing anxiety.
- (vi) Methodological challenges to studying flooding without a flood, such as the use of scenarios and sites of previous damage.
- (vii) Benefit / cost studies on investments in flood mitigation and health benefits.

The Health Protection Agency<sup>87</sup> lists the following areas of study as in need of more research:

- (i) The response to, and impacts before and after, major incidents including flooding
- (ii) Impacts of major flooding on people's psychosocial experiences in short, medium and long term
- (iii) Contextual and subjective qualitative features of people's experiences which distinguish distress after disasters from symptoms of mental disorders
- (iv) Longitudinal effects on mental health and ill health
- (v) On children and young people, older people, and people who respond to others' needs in aftermaths of flooding. This would identify higher risk groups, how and why certain people suffer more, what should be done in addition to current interventions.

They recommend that, for item (iv), better use could be made of a national psychiatric morbidity survey programme, to provide baseline data for populations that are flooded subsequently, and control data in non-flooded areas.

#### **4.7 Recommendations**

We suggest future research is directed to the following research challenges:

- (i) Larger population studies to enable the analysis of flood risk areas, or those which have experienced flooding, with data from the SEPA flood risk maps, population census and Scottish Health Survey (e.g. mental well-being, general health, numbers of people on prescribed anti-depressants).
- (ii) Smaller scale, qualitative, studies into the effects on interventions, such as building design in the home or an educational communication strategy (e.g. 'flood season' broadcast via media/community groups with specific recommendations as per Australian examples) and the monitoring of effects on stress levels.
- (iii) Evaluation of the role of proactive community flood groups in lowering anxiety about future flooding.
- (iv) Experimental design of control versus intervention site. For example, using two areas of comparable flood risk and developing a community intervention (e.g. simulations of flooding in the community) with a 'preparedness for flood strategy', from which outcomes can be measured against a control for which there is no education strategy.
- (v) A study of the economics of health impacts with respect to mitigation of flooding and flood risk.



## 5. SUSTAINABLE DRAINAGE SYSTEMS (SUDS)

### 5.1 Context

Sustainable Drainage Systems (SUDS) use soft features such as green roofs, permeable paving, swales, infiltration strips, ponds and detention basins to manage surface water. They have three main objectives: to treat water and improve water quality; to reduce flood risk by providing storm water retention and detention; and to enhance amenity. SUDS have been required in most new development in Scotland since 2006. Under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 SUDS are required for new developments with surface water drainage systems discharging to the water environment, except for single dwellings and discharges to coastal waters. As a result of this approach, in Scotland there are many thousands of individual SUDS features, with more built every year. In the SNIFFER report SUDS in Scotland, the Scottish SUDS database (July 2002) recorded that there were 3913 SUDS systems in Scotland and 767 sites in Scotland.

The National Ecosystem Assessment Synthesis of Key Findings<sup>134</sup> notes that ‘Urban green space is fundamental to sustaining urban life and, therefore, should be integral to the way in which it is planned and managed’. It quotes the Scottish example of SUDS which can substantially enhance ecosystem goods and services delivery and have already been incorporated into an estimated 80% to 90% of all new developments (p74). The high valuation that users place on water features has already been mentioned (Health Impacts – The Evidence, review 1), and well designed SUDS can provide wetlands that can be used for physical activity and nature-watching. However, other research notes that maintenance of SUDS features is especially important (perhaps more so than other green space) if they are not to become foul, stagnant or a health hazard<sup>135</sup>.

Given that SUDS are now a standard feature of developments across Scotland, where they provide ponds or blue space, they appear to have the potential to enhance the well-being of the Scottish population. The issue is how to ensure that SUDS are designed and managed to maximise and deliver multiple benefits, e.g. visual amenity, biodiversity, species richness, recreation (feeding ducks, pond dipping) etc. SEPA’s report on ‘Ponds, Lochs and Lochans’<sup>136</sup> noted that SUDS ponds can, at their best, support quite rich wildlife communities, although at the time most did not fulfil their ecological potential<sup>136</sup>. Various guidance documents set out parameters for the design and engineering of SUDS in different settings, and information about best practice<sup>136, 137</sup>.

One of the recurrent issues around SUDS ponds and their acceptability is to do with risk, particularly risk of drowning. RoSPA figures for 2005 show that in the UK there were a total of 435 deaths by drowning<sup>138</sup>, compared to around 32,000 killed or seriously injured in road accidents in the same year<sup>139</sup>. Of those killed as a result of drowning, 1% were in garden ponds; 11% were in lakes; 10% were in canals; and, 35% were in rivers or streams. The vast majority of these deaths were in deep and/or moving water not comparable to the ponds which characterise SUDS. This suggests that actual risk associated with SUDS ponds is very low, although perceptions of risk may be much higher.

### 5.2 Scientific principles and theoretical grounding

The affinities between green space and blue space as natural settings make plausible the theory that the mechanisms at work in relation to green space and health, are also at work in relation to blue space and health. Whether the mechanisms are biophilia, attention restoration or stress reduction, ponds and water features clearly have a significant role to play. However, it is not yet clear whether the effects of green and blue on health and well-being can be separated from each other.

Literature on green space appears to show that people derive greater benefit, and value more highly, environments which have greater biodiversity<sup>140</sup>. Water plays a significant role in relation to biodiversity, and ponds are known to provide rich habitats for a range of insects, plants, animals and birds<sup>136</sup>. As the SEPA guide on Ponds, Lochs and Lochans notes<sup>136</sup>, analysis has shown that small water bodies support just as many invertebrate species and considerably more uncommon and rare species as rivers. This is particularly true of water features which are part of a wetland system, suggesting that SUDS can be designed to deliver significant wildlife and biodiversity benefits. Indeed, it is known that water in the environment supports provisioning, regulating and cultural ecosystem services<sup>134</sup>. It is plausible to argue that SUDS ponds have the potential to support mental health and well-being, although there is no empirical evidence of this link.

### 5.3 Evidence

Public perceptions of SUDS features have been investigated by several researchers: Yuen et al.<sup>141</sup> demonstrated that green roofs have a positive impact on residents in high density areas. Similarly, the perception of rainwater harvesting by local residents was investigated by Ward et al.<sup>142</sup> who demonstrated that residents were keen on reusing the water from their own roof but reluctant to recycle runoff from other sources. Whether it concerns aesthetic improvements, access and community benefits or potential for public education and awareness<sup>137, 143</sup>, the term 'amenity' is often used to characterise the potential benefits the residents could find in a project.

There is limited research evidence about the amenity and aesthetic value of SUDS. The research that does exist points to residents valuing ponds more greatly than swales<sup>1</sup>. This appears to be particularly the case where ponds are attractive to wildlife e.g. ducks and swans, and are associated with attractive landscaping and overall environmental improvement<sup>144</sup>, echoing the green space work of Fuller et al.<sup>140</sup>. With respect to retention ponds specifically, Apostolaki et al.<sup>145</sup> summarised the results of door-to-door public perception questionnaires conducted between 2000 and 2002 amongst residents adjacent to 10 ponds situated in Scotland, England and Wales. The survey was in the form of an open ended questionnaire and aimed to assess public perception of SUDS ponds, including potential benefits and disadvantages. Overall, the survey demonstrated that there was significant interest in ponds and suggested that the presence of a well-established pond was perceived as improving property saleability and value by around 10%. Within the context of current surface water management, where costs have been identified as one possible barrier for SUDS implementation<sup>146, 147</sup>, it may be argued that charging residents a factoring fee, based on the additional value that pond amenity provides, could help to offset water management costs. Within this context, the work conducted in 2004 and presented by Apostolaki et al.<sup>145</sup> has highlighted that an opportunity exists to offset SUDS costs with the benefits they provide to residents.

Evaluating environmental goods in terms of monetary value has always been seen as a difficult task<sup>148</sup>. However, two main techniques have emerged which allow their assessment: hedonic valuation and contingent valuation. Hedonic pricing relates to the observation of house price variations due to different factors. The use of this method to value a detention basin<sup>2</sup> associated

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<sup>1</sup> A swale is a linear depression (ditch, with or without embankments) which may link to other SUDS devices such as ponds and detention basins

<sup>2</sup> A detention basin is an engineered depression or hollow designed to collect and store surface run off at times of high rainfall. These basins are usually dry, unlike SUDS ponds which are permanently wet.

with multipurpose green space found that the device had a positive impact on property values, while a detention basin without any green features was shown to have no discernible impact<sup>149</sup>.

Although hedonic pricing has been used with some success, the hedonic valuation of environmental benefits is not an easy exercise as it requires significant data on property values and the choice of variables selected by authors can appear quite subjective. In contrast, the contingent valuation approach consists of asking, through a structured interview, the price the respondent would be willing to pay for market or environmental goods. Compared to hedonic pricing, the contingent valuation method requires less data on the surroundings, but relies heavily on the respondents' willingness to participate. Despite this, it has been applied successfully to determine the value associated with environmental benefits<sup>150</sup>. Bastien et al.<sup>135</sup> attempted to evaluate the amenity value associated with SUDS ponds using hedonic pricing to see if it outweighs construction and maintenance costs. The study found that people living adjacent to a pond gained widely varying benefits from it (a place to walk the dog; amenity; biodiversity; enhancing property prices; drainage; education) and that the extent of these benefits was related to the amounts of litter around the pond. It also highlighted that ponds with the most visible safety features (double fencing, prickly bushes, life belts) were perceived as being the least safe. However, the risks involved were perceived as being lower than urban risks such as road traffic. Based on the survey, detailed economic analysis indicates that the benefits gained from the pond exceeded the construction and maintenance costs. The researchers argue that where SUDS are not adopted, there may be a merit in combining the maintenance costs of SUDS ponds with any factoring charge associated with the property.

As the discussion above reveals, there is relatively little evidence about the amenity benefits afforded by SUDS. Those studies that have been carried out have tended to focus on hedonic and contingent valuation in order to explore residents' views towards SUDS.

#### **5.4 Grey Literature**

As well as exploring the published literature, efforts were made to track grey literature on SUDS. No formal evaluations or reports of particular types of SUDS have been uncovered, although discussions with a number of practitioners has drawn together anecdotal evidence about SUDS and their benefits.

A particular theme of interest relates to SUDS in schools, as this was raised at the stakeholder workshop, capitalising on the opportunity to expose young people to SUDS and issues around water management, including urban diffuse pollution and flood risk. Discussions with practitioners have revealed a number of exemplar projects including:

- Castle Rock High School, Leicestershire
- Bushloe High School, Leicestershire
- Forest Way School, Leicestershire
- Melton Vale Post 16 Centre, Leicestershire
- Matchborough School in Redditch, W Midlands.

Anecdotal evidence suggests that SUDS can be used as significant educational resource within a school or college. However, there has been no formal evaluation of these types of SUDS either with teachers or pupils.

## 5.5 Research gaps

There are a number of significant gaps in the existing evidence, in particular:

- direct evidence of which elements of SUDS are beneficial for health and well-being
- risk perception and management of risk in SUDS
- use of SUDS in school grounds: the role of head teachers and key stakeholders
- exemplars of good design.

## 5.6 Recommendations

Overall, the research evidence around SUDS and their amenity benefits is limited, and concentrates particularly on hedonic and contingent valuation approaches. There are four potential 'sector' areas which may benefit from further research: design guidance for practitioners/planners; identifying the multiple value of SUDS to the community; the multiple value of SUDS in schools (any other public environments – sports centres/ecology centres/hospital/library/public parks); the needs of land managers/developers. Questions which potential research should address:

- (i) Are SUDS with stronger biodiversity values more beneficial to health and well-being?
- (ii) Is the greatest amenity value of SUDS from ponds and wetlands? Can we separate 'blue' value from 'green' value in blue-green SUDS corridors?
- (iii) How much of a barrier is *perceived* 'risk' to SUDS development (e.g. fencing of ponds)? How is risk communicated, managed and perceived?
- (iv) How can SUDS contribute to outdoor learning, health and mental well-being in school children? What influence do head teachers have? What do pupils and their parents think?
- (v) What contribution can safe exposure to water in childhood make to behaviour later in life?

Potential for research into:

- SUDS design and best practice for: amenity and human health and well-being
- SUDS in schools – exemplars (link with Grounds for Learning).

## 6. OVERALL CONCLUSIONS and RECOMMENDATIONS

While the contribution of green space to human health (green health) is reasonably well understood and researched, the same cannot be said for the role of water in human health, or blue health. Whilst research on green health is now making an impact on Scottish policy (e.g. *Equally Well*<sup>151</sup>, *Let's make Scotland more active*<sup>152</sup>) blue space remains an under-used resource for promoting health in Scotland. Based on early engagement with stakeholders and policy advisors, the focus of this project was to research:

- (i) The salutogenic effect of water settings
- (ii) The effects of flooding on mental health
- (iii) The potential for SUDS to offer multiple health benefits.

Our method was two-fold:

- (i) To systematically bring together and the review the empirical evidence identifying how water settings impact on health and well-being, both positively and negatively (e.g. from the risks of flooding and climate change).
- (ii) To disseminate this evidence and, in dialogue with stakeholders, identify how this information can best be used to support policy makers and Scottish government agencies engaged in water management.

We conclude that the state of evidence for blue health lags considerably behind its complementary research field of green health; it is therefore difficult to make specific recommendations to government agencies and other bodies on how best to manage their water to promote health or how best to incorporate blue space into public policies. At best, we suggest the evidence – and theory – can inform health policy; for example, blue space appears to have a positive effect on mental well-being (and this is supported theoretically); whilst there is little empirical evidence on physical health or the social benefits of blue space, arguably there are substantial benefits to be gained from, for example, the play opportunities offered by beach settings. Whilst little is known about the trade-offs between the types of blue and green space -and the quantity and quality of blue space - in Scotland (where 'blue' is frequently accompanied by 'green') we suggest 'blue-green space' may be a more appropriate way to approach future research

### 6.1 Major gaps across all three themes

- Variations in response to water settings in different sub-sections of the population, particularly children and elderly people, vulnerable socioeconomic groups, minority ethnic groups and people with disabilities. In short, we know very little about how health inequalities and environmental injustice extend to water settings or living in flood risk areas.
- Methodological issues: there is a lack of quantifiable evidence using objective measures of health and well-being. Much of the research depends on hypothetical, subjective reflections on a particular scenario or scene (e.g. the use of scenario methods to measure potential impacts of flooding). There is a need for evidence showing impacts of water settings on human physiology, combined with theoretical development underpinning health outcomes e.g. fear in association with natural settings.

- Very few studies measure the effects of an intervention (e.g. exposure to a water setting) comparing effects with a control site (i.e. with no intervention) over short-term or longer periods of time.
- There is a lack of understanding of the impact of climate and geography specific to the Scottish context in relation to perceptions of water (inshore and coastal) and the impact on health and well-being.

## **6.2 Major gaps in evidence across specific themes**

- Salutogenic benefits of water settings: there is a lack of evidence on what types of blue space are best for health, and how quantity and quality impacts on health (e.g. the biodiversity dimension). In most Scottish contexts, water interacts with green to form ‘blue-green’ corridors but we do not know the cumulative advantage that water adds to these settings. In addition, much of the current evidence base is reliant upon subjective reports of well-being in response to photographs.
- Flooding: there is a need to research how flooding impacts on social cohesion both within the family context and within a community. For example, how does social cohesion impact on resilience and the ability for a community to cope with flood damage; and the effects of stress on children and partners within a family context?
- SUDS: SUDS appear to offer potential multiple benefits but there is no empirical evidence.

## **6.3 Recommendations for further research emerging from the review**

### **6.3.1 Replication of methodologies**

- (i) Secondary data analysis: exploration of Scottish secondary public data sets (e.g. Social Attitudes Survey, Scottish Health Survey; SE web portal (citizen science component), Green space Scotland) for data pertaining to perceptions of and/or visits to water settings/recreational behaviour. This research could be extended to public data available in England and Wales<sup>153</sup>. This data search should aim to consolidate how certain events e.g. floods are reported and mapped.
- (ii) Population scale mapping of: proportions and locations of people at risk from floods; mapping of distance to water bodies (and by type) using comparable green space parameters (e.g. Natural England Guidelines for the creation of Suitable Accessible Natural Green Space (SANGS)), and correlating this data to public health data. This research needs to overcome methodological challenges in measuring quality of water (e.g. in relation to stagnant water in discussion with hydrologists) and identify quality data sources (e.g. National Inventory of Surface Waters) and/or using biodiversity indicators.
- (iii) A preference study for water settings specific to Scotland replicating existing methodology<sup>47</sup> and comparing findings to south east England.
- (iv) A qualitative study to gather evidence of the multiple benefits of SUDS in a school context drawing on the sites identified in England and Wales from our scoping study, and sites in Scotland. This would inform a quantitative study identify specific benefits linked to Scottish outcome indicators for health and well-being, sustainability and education. An adjunct of this research would be to identify the contribution safe exposure to water makes at an early age to behaviour later in life.

### 6.3.2 Emerging methodologies

- (i) A study exploring stress levels in communities which have varying percentages of actual or visual access to water settings using cortisol as a biomarker of physiological stress (replicating Ward Thompson et al.<sup>13</sup>) using Suitable Access Natural Green Space (SANGS) guidelines to define access parameters to blue space.
- (ii) A study exploring the effects of flooding on mental health, employing the latest computer technologies in simulating floods in two communities, with an experimental design comparing stress outcomes between an intervention site (e.g. emergency planning strategies) and a control (no intervention).
- (iii) Policy analysis and development of design and planning guidelines for water features in new developments.
- (iv) An exploration of the multiple benefit of urban water features in a Scottish context taking account of current and future climate (e.g. the effects of rising ambient temperature and increased demand for access to water for active recreation).
- (v) A study measuring the emotional benefits of water settings using the latest neuro-headset technology (Emotiv EPOC) to monitor brain activity currently being piloted in a University of Edinburgh-HWU collaborative project (analysis currently in hand).

### 6.4 Stakeholder priorities

Key messages from dissemination of this study at a stakeholder event, held 31<sup>st</sup> May 2012, indicated the following themes were a stakeholder priority for dissemination and/or further research:

- (i) Salutogenic benefits: the research findings – and theory – on the restorative potential of blue space be used to inform current policy on mental well-being and to promote blue space as a salutogenic environment; the potential for water-edge recreation, for example, walking along a riverside, canal or loch/reservoir to promote physical activity should be further explored; the opportunities for play, physical activity and social well-being in coastal/beach settings is another theme of interest; identification of health and well-being benefits of blue space using existing Scottish data sets (e.g. Thames Water Customer Surveys).
- (ii) Flooding/climate change: the long-term impact of flooding on mental well-being is a research priority using existing data sets (e.g. from Scottish Flood Forum); the impact of social inequalities in recovery post-flood event and ability to take preventative action to avoid future flood risk (e.g. people on low income, with a disability, older people); the role of education and communication in promoting resilience and preparedness for flooding.
- (iii) SUDS: stakeholders confirmed a need for primary research identifying health and well-being and learning outcomes in children with SUDS in school playgrounds; identification of the risks/barriers to accessing water and how best to manage this in children/young people.

Overall, whilst stakeholders agreed there was insufficient evidence on blue health, there was a consensus that the theory – for example, on blue-green salutogenic environments - could help inform current policy and direct future research.

## APPENDIX 1 Methodology

The BlueHealth project aimed to help deliver the CREW vision of creating new capacity by ensuring that emerging international knowledge and perspectives on water, health and well-being are available to the user community through:

- Raising stakeholder awareness of the state of knowledge of the role of water in relation to well-being (e.g. a cause of stress, or a factor influencing psychological restoration)
- Collating, and reporting on, the state-of-art in evidence of the role of water in relation to well-being
- Engaging in dialogue with relevant stakeholders to identify links across sectors in relation to water and well-being.

The project approach had five phases:

1. A first round of stakeholder engagement to scope the bounds of the project and identify aspects of water environments, health and issues to be considered.
2. A review of existing evidence on water, and mental health and well-being, on the topics of:
  - (i) water (inland and coastal, rural and urban) with respect to stress reduction
  - (ii) water as a threat (e.g. flood risk) and cause of stress
  - (iii) Sustainable Drainage Systems (SUDS) and wastewater
  - (iv) water quality interactions with those of well-being.
3. A stakeholder workshop to assess the significance of findings to current and upcoming policy or strategic interests at Scottish or local levels (e.g. in relation to options appraisal, planning and implementation of the Land Use Strategy or delivery on local authority Single Outcome Agreements). It was agreed at this stage to focus the reviews on the salutogenic benefits of water settings; flood risk, mental health and well-being; and SUDS.
4. Dissemination of finalised reviews to stakeholders and a second stakeholder workshop to discuss and finalise project recommendations.
5. Preparation and publication of findings for access via the CREW website (vCREW) (e.g. content for Frequently Asked Questions on health and water), KnowledgeScotland 2 (e.g. science brief), and other media as agreed with stakeholders and HEI partners.

### Introduction

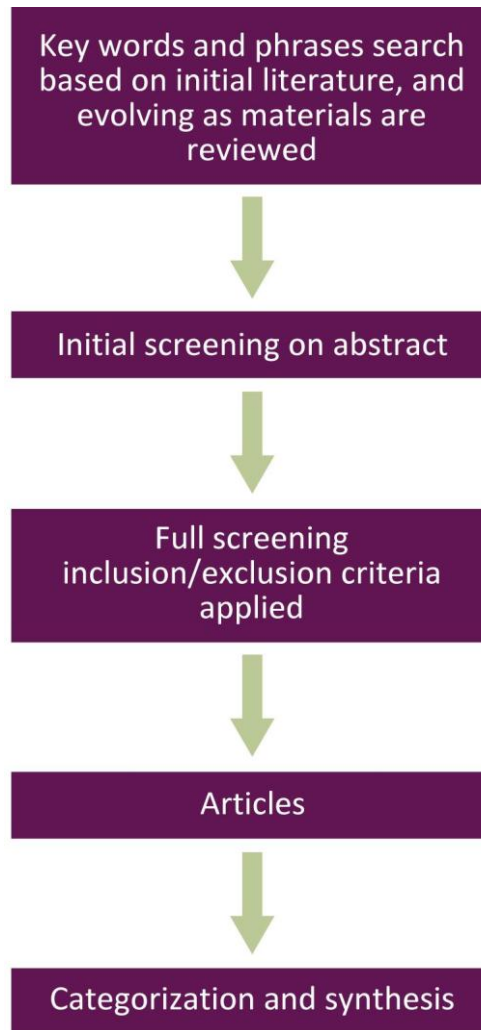
The preliminary findings from the reviews were the focus of a stakeholder workshop, held at the Scottish Environment Protection Agency (SEPA) offices in Stirling on 7<sup>th</sup> February 2012, with representatives from Scottish Government, Scottish Water, SEPA, Health Protection Scotland and NHS Health Scotland. Outputs from the workshop included a set of opportunities and priorities on which to focus further research effort, reflecting stakeholder views on the knowledge gaps of most interest or relevance with respect to their areas of responsibility.



## Literature reviews

In reviewing the evidence, we have used White et al.'s<sup>12</sup> definition of blue space to mean “any environment containing visible amounts of standing or running water but not falling rain or settled ice or snow”. Blue space encompasses natural environments such as coasts, rivers and lakes, as well as man-made features such as reservoirs, canals, ponds, and fountains.

The methodology followed the steps shown in Figure 1.



**Figure 1** Steps in methodology.

## Review strategy

For undertaking the literature reviews, the following resources were searched:

(1) Databases: Science Direct, PubMed; PsycINFO; Web of Science; Index to Theses.

(2) Web sites: [www.google.com](http://www.google.com); [googlescholar.com](http://googlescholar.com).

(3) Journals specific to the research field: Journal of Environmental Psychology, Environment and Behavior, Health and Place, Social Science and Medicine, Water Science Technology, Water Research, Water Resources, Journal of Flood Management, Journal of Water and Environment, Journal of Environmental Management.

'Grey literature' was also reviewed. This refers to papers, reports, technical notes or other documents produced and published by governmental agencies, academic institutions and other groups which are not published in the academic press. They also included the searching of websites of topic-related organisations such as BTCV blue gym, Wetlands Trusts, Natural England etc.

Search terms

*(1) Salutogenic key words:*

Health terms: Exercise, Physical activity, Walking, Health, Restoration, Well-being, (Well-being, Well being) Quality of Life, Play, Social, Recreation, Happiness, Anxiety, Depression, Stress, salutogenic, affect, spiritual, healing, cultural, feng-shui, mental health, psychology, sound, psycho-acoustics, bathing.

Environmental terms: blue space, water, river, lake, aquatic environment, riparian, stream, spring, canal, coast, sea(side), pond, wetland, fountains, water feature, sustainable urban drainage, flood(ing), marine environments.

Since many of the search terms used failed to retrieve appropriate literature, the search terms were simplified, replicating Volker and Kistemann<sup>13</sup>.

*(2) Pathogenic key words*

Health terms: pathogen, bacteriology, toxicology, microbiology, fear, risk, anxiety, depression, stress, accident, injury, hazard, damage, illness, morbidity, mortality, disease.

Environmental terms: water quality, contaminated water, microbial contaminants, septic tank, sewage, flood\*, climate change.

*(3) Flood key words*

Flood risk management, flood damages, emergency plans/planning, flood policies, flood disaster, psychological health and flood, environment and flooding, floods, flood impacts, health and flood, social dimensions of flooding, flooding, flood risk management, water hazards, Social Flood Vulnerability Index (SFVI), British Townsend Index, sewage contamination.

Further details of flood related search terms are listed in Appendix 4.

*(4) SUDS key words*

SUDS, drainage, green roofs, urban drainage, surface water, drainage ponds, swales, water sensitive design.

Inclusion criteria

- Published between 2001 and 2012, unless of particular significance
- Clearly stated salutogenic or pathogenic health and/or well-being improvement or preference/response
- Clearly stated definition of environment measured
- Clear methodology
- Conclusive evidence.

## Exclusion criteria

- Not published in English
- Any context that is not transferable to Scotland (e.g. developing countries)
- 'Ice' and related words in search terms.

## Screening

Using the above criteria the title and abstracts were firstly screened by 4 reviewers. Irrelevant abstracts were discarded, resulting in a number of relevant abstracts, categorized according to the original 4 themes of the project: health promoting benefits (salutogenic); negative psychological effects of flood/climate change, Sustainable Drainage Systems (SUDS), and impact of water quality in rural areas (e.g. effects of septic tanks). Further screening on the full text was carried out by individual reviewers focusing on the specific themes of the review.

## Stakeholder engagement

A stakeholder workshop was held on 7<sup>th</sup> February 2012, with 5 researchers and 9 attendees from 5 organisations representing water provision, water regulation and health agencies:

- Scottish Government
- Scottish Water
- SEPA
- Health Protection Scotland
- NHS Health Scotland.

The workshop followed telephone and email communications with these stakeholders to explore wider relevance of project content, and information on links to policy or 'grey' literature.

## Intended outcomes of the workshop

- Increased awareness amongst scientists, policy teams and public agencies of potential roles water plays in supporting well-being and health-related outcomes
- Recommendations for future CREW scoping activities
- Inform questions for RESAS strategic research programme (2011 to 2016).

## Themes presented at the workshop

Four themes were identified from a preliminary review of the literature on the relationships between water, health and well-being:

- Salutogenic benefits of water settings
- Flooding and threats
- Sustainable Drainage Systems (SUDS) and their benefits
- Water quality, focusing on rural environments.

For each theme, 5 minute presentations were made by the researchers using 3 categories:

- Issues identified

- Gaps in research evidence
- Potential discussion points.

Open discussion followed each presentation, and participants summed up their views on each theme using post-it notes, which were then collated on 4 A3 posters according to theme. After all presentations were complete and views recorded, participants were asked to nominate an overall priority area, and an overall reserve priority for further research from across all themes.

Overall priorities identified by workshop participants

Salutogenic benefits of water settings

- Quantify the benefits of water in the environment to health. It needs to be compelling and in a form that can be used to sway a project from most cheap solutions
- What are the long-term health benefits of blue space?
- SUDS in school grounds offering learned resilience and knowledge of natural systems through embodied experience [NB *posted between SUDS and Salutogenic theme posters*].

Flooding and threats

- Increasing resilience through education
- Benefits of impact of education
- Important to be able to identify effective flood recovery measures and quantify their long term benefits to communities and individuals
- Design solutions- house building/retrofit
- Mental health impact of flooding- better understanding.

Sustainable Urban Drainage Systems (SUDS) and their benefits

- SUDS aspects with biggest impacts on health and well-being, including impacts on health behaviours, such as physical activity
- SUDS: what features are best for amenity; what is best for health/restoration?
- Quantify benefits link to SUDS and flooding solutions
- Evidence on potential of SUDS (urban and rural) to enhance salutogenic properties of the environment.

Water quality, focusing on rural environments: No overall priorities identified for this theme.

Overall reserve priorities identified by workshop participants

Salutogenic benefits of water settings

- Explore the benefits of water and differentiation from or explore the contribution to benefits of green spaces
- Better understanding of health and blue space
- How important is water in an urban setting? How does it compare to green space/trees?

## Flooding and threats

- Having a sense of control of water flow and drainage on one's land- responsibility leads to resilience
- How to develop flood risk planning with local communities
- 'Education'. Not as a catch-all category but in specific relation to flooding and SUDS, where we discussed that experience increases resilience. I think we should explore how best to use education to increase peoples resilience to flooding and their tolerance for open water features.

## Sustainable Drainage Systems (SUDS) and their benefits

- SUDS: what features make SUDS 'attractive' for amenity, recreational use, and benefit well-being
- SUDS maintenance
- SUDS design solutions and maintenance; retrofit.

## Water quality, focusing on rural environments

- Quantifying and understanding extent of problem [of agricultural water quality]; who takes management ownership?
- Make the case for more joined-up thinking between agencies/stakeholders to come up with the solution rather than us staying within our own silos. Embrace radical thinking-innovation.

## Key themes emerging from the workshop post-it exercises (identified by the researchers)

*Salutogenic*: Quantifying benefits and health cost savings; maintenance; safety issues

*Flooding and threats*: Education; building resilience; design solutions

*SUDS*: Maintenance; participation; raising awareness of benefits

*Water quality*: Quantifying and understanding extent of problem and concerns; joined-up planning policy.

The overall conclusion from the workshop was to focus the reviews on the first three of the themes; results are presented in sections 3 to 5 of this report. A second stakeholder workshop was held to discuss these results, and to produce recommendations from the BlueHealth project. These are in section 6 of this report.

## APPENDIX 2 Summary of emerging evidence for salutogenic benefits of blue space

| Study Type                                   |  |  | Identified benefit |                     |        |  |
|--|--|--|--------------------|---------------------|--------|--|
| Laboratory and/or Photographic based studies | Type of measure  | Category of setting compared (study location)  | Physical           | Mental/ Restorative | Social | Preference/ Visual amenity   |
| White et al. <sup>47</sup>                   | Self-reported:<br>Pleasantness,<br>Aesthetic Behaviour<br>Emotion<br>Restorativeness<br>(cognition only) | Built scenes v green v blue v sub-aquatic (UK)   |                    | ✓                   |        | ✓<br><br>Above water view preferred to sub-aquatic   |
| White et al. <sup>49</sup>                   | Self-reported:<br>Pleasantness,<br>Aesthetic Behaviour<br>Emotion<br>Restorativeness (PRS)               | Built scenes v green v blue (UK)   |                    | ✓                   |        | ✓<br><br>water setting preferred to green or built scenes.   |
| Han <sup>154</sup>                           | Self-reported preferences, scenic beauty and restorativeness   | Desert, tundra, grassland, coniferous forest, deciduous forest and tropical forest taking into account 3 physical vars (complexity, openness and water features) (USA) |                    | ✓                   |        | ✓<br><br>water, complexity and openness significant predictors of preference and PR; water a preferred setting across all landscape typologies |
| Han <sup>59</sup>                            | Self-reported preferences, scenic beauty and restorativeness   | Ditto  |                    | ✓                   |        | ✓<br><br>correlation only  |
| Howley and O'Donoghue <sup>60</sup>          | Self-reported preferences and  | Intensive farming, wild nature, cultural landscapes, mixed   |                    |                     |        | ✓<br><br>age and environmental   |

|  |   |  |  |   |  |                                  |
|--|---|--|--|---|--|----------------------------------|
|  | environmental value orientations                              | farming, water (Ireland)   |  |   |  | values a predictor of preference |
| <b>Field based (Quasi-Experimental) Intervention studies</b> |   |  |  |   |  |                                  |
| Roe <sup>52</sup>  | Self-reported stress, emotion and arousal                     | Urban v rural nature v rural nature+water (Scotland)   |  | ✓   |  |                                  |
| Kjellgren and Buhrkall <sup>51</sup>                         | Self-reported well-being and physiological measures of stress | Simulated forest landscape with lakes/rivers versus actual visit to forest with lake (Sweden). |  | ✓<br>both environments effectively reduced stress |  |                                  |
| <b>Cross-sectional studies</b>                               |   |  |  |   |  |                                  |
| Ashbullby et al. <sup>50</sup>                               | Self-reported affective response                              | Urban open spaces; coast and beaches, countryside (UK)   |  | ✓   |  |                                  |
| Hipp and Ogunseitan <sup>53</sup>                            | Perceived restorative scale (PRS)                             | Coastal parks (California)   |  | ✓<br>climate a factor                             |  |                                  |
| Vesterinen et al. <sup>48</sup>                              | Swimming, boating and fishing behaviour                       | Close-to-home water settings (Finland)   | ✓<br>Water quality/clarity affects behaviour |   |  |                                  |

### APPENDIX 3a Major flood events, Scotland and England, 1993 – 2002

| Year | Country     | Place   | Main Catchments Affected      | Cause   | Deaths | Injuries                               | Properties affected  | Estimated Cost | Outcomes  |
|------|-------------|---|-------------------------------|---|--------|--|--|----------------|---|
| 2004 | Scotland    | Glen Ogle, Menstrie, Peebles, Ayrshire, Aberfeldy, Perthshire, Lochearnhead | Upland Tay, Teith, Don, Tweed | Excessive summer rainfalls in August was remnants of Atlantic hurricanes.   |        | 108                                    | 186 residential and 22 commercial  | £18m           | Local Authorities to provide information on flooding as it occurred (but NOT standardised). |
| 2004 | England     | Boscastle in Cornwall   | Valency                       | 200mm rain in 4 hours caused flash flood  |        | 150 people airlifted out               | 50-60 cars washed away   | £50m           |   |
| 2005 | Scotland    | Outer Hebrides  | Coastal flooding              | Severe storms causing a 'storm surge' when the raised water level becomes extreme (it reached 5.5m), resulting in coastal flooding. Exacerbated by excessive wave heights (14.3m) | 5      |  | Significant coastal erosion  | £15m           |   |
| 2005 | England     | Carlisle  | Eden, Petteril, Caldew        | 3 days heavy rainfall - 200mm in 48 hours   | 3      | Over 70                                | 1600 homes, 300-400 industrial/commercial properties. 60,000 homes left without power  | £250m          |   |
| 2007 | England and | South Yorkshire, Hull, Worcestershire, Gloucestershire, Thames Valley       |                               | 3 times as much rainfall compared with average  | 13     | 7000 people rescued from flood waters. | 55000. In urban areas, predominantly impermeable surfaces severely affected. Largest loss of essential services since WWII. 350,000 people near Gloucester left without mains water supply for over 2 weeks; 42,000 left without power for up to 24 hours. 400,000 school days lost. | £3.2b          | Pitt Review   |



## APPENDIX 3b Major flood events, Scotland and England, 2004 – 2007

| Year | Country  | Place  | Main Catchments Affected  | Cause  | Deaths | Injuries | Properties affected   | Estimated Cost | Outcomes  |
|------|----------|--|---|--|--------|----------|---|----------------|---|
| 1998 | England  | Evesham, Leamington Spa, Statford-on-Avon, Bedford, Northampton, Huntingdon, Banbury | Avon, Ouse, Nene  | Prolonged and excessive rainfall   | 5      |          | 4200  | £500m          | Establishment of National Flood Warning Centre by Environment Agency. Development of flood forecasting and warning systems. High profile public awareness campaigns launched. National address database of at risk properties based on Indicative Flood Plain Maps.   |
| 1993 | Scotland | Perth  | Tay, Isla, Tummel   | Prolonged and excessive rainfall, large amount of runoff contributing to the main flood peak from <i>all</i> major sub-catchments. Peak discharge of 2269m <sup>3</sup> s <sup>-1</sup> at Ballathie gauging station is 2nd largest at any UK gauging station. |        |          | In Perth, 780 properties affected - in excess of £10 million. 73 breaches of flood defences on agricultural land.                               | £30m           | Tayside Regional Council commissioned 2 major studies: a catchment study to enhance understanding of flood-generating processes of the Tay, and looking at the effects of afforestation to reduce snowmelt impacts; and a Perth flood study to assess structural options for flood mitigation. Cost of works to protect Perth estimated at £11.1 million. |
| 1994 | Scotland | Strathclyde  | Clyde, Kelvin, White Cart, Irvine, Nith   | Persistent rain over 48-hour period and across wide geographic area, such that peak river flow values were exceeded in all major catchments in the region.   | 3      |          | 700 homes flooded plus many commercial properties   | £100m          | Scottish Office issued a National Planning Policy Guideline, directing planning authorities to exercise the precautionary principle by refusing applications for floodplain development, except where other reasons take precedence over flood risk.  |
| 1997 | Scotland | Elgin  | Lossie, Findhorn, Pilmuir   |  |        |          | Road and rail closures.   |                | Moray Flood Alleviation formed by Moray Council in 2002, with priority areas of Elgin, Llanbryde, and Forres.   |
| 2000 | Scotland | Edinburgh  | Water of Leith, Braid Burn, Gogar Burn  | 3 days of heavy rain   |        |          | 750 properties, plus commercial properties including Murrayfield Stadium  | £25m           | Scottish Executive study published in 2002 estimated 8861 properties (4.0%) in Edinburgh were at risk from flooding on inland floodplains. Edinburgh Council has promoted Flood Prevention Schemes for the Braid Burn and water of Leith. Edinburgh Council also developing a Flood Risk Strategy.  |
| 2000 | England  | Lewes, Uckfield, Haywards Heath, Hassocks, Steyning, Tonbridge                       | Uck, Ouse (Sussex), teise, Medway, Derwent, Swale, Ouse (Yorkshire), Aire, Severn | Wettest autumn on record for 270 years, almost double the average seasonal precipitation (150mm in 12 hours).  | 0      |          | 10000 (59% had no flood defences) in over 700 locations   | £1b            | Aftercare groups formed. New advice issued.   |
| 2002 | Scotland | Elgin  | Lossie  |  |        |          | Over 200 households evacuated, 10 people airlifted to safety. Road and rail closures (Inverness-Aberdeen railway line closed for several weeks) |                | Roths and Pilmuir in Forres were added to MFA priority list.  |

## **APPENDIX 4 Key words relating to flood events and related studies**

Green exercise, water, duration, intensity, different green habitats, Rosenberg Self-Esteem scale (RSE), Profile of Mood States (POMS), Total Mood Disturbance (TMD) **[2010, UK]**

Flood disaster, flood policies, psychological health, place attachment, place identity, place alienation. Loss of control, psychological impacts, anxiety, stress, despair, isolation, post-traumatic stress disorder (PTSD), disruption, destruction, pollution **[2009, England]**

Shock and disbelief, uncertainty, grief and loss, emotional exhaustion, hope and meaning, post-traumatic stress disorder (PTSD), General Adaptation Syndrome (GAS), alarm, resistance, exhaustion **[1998 USA (Grand Forks, North Dakota)]**

Health effects, emergency planning, policies, multi-strike stressors, emergency plans, socio-economic deprivation, community breakdown, mitigation, Social Flood Vulnerability Index (SFVI), Townsend Index **[2006, UK Hertfordshire]**

Flood risk management, England and Wales, flood damages, quantitative analysis, project appraisal **[2007, UK]**

Environment, health, complexity, ecological problem framing, policy **[2010, Scotland]**

Aquatic environments, water, preferences, affect, restorativeness **[2010, UK]**

Floods, hazards, physical and psychological health, stress, place. GHQ-12, Social Flood Vulnerability Index (SFVI), British Townsend Index, deprivation, ethnic minority groups, helplessness, sewage contamination, anxiety **[2008, England]**

Flooding, flood risk management, General Health Questionnaire-12, physical health, psychological health, social characteristics, PTSS **[2006, E & W]**

Floods, impacts, health, community, vulnerability. Disruption, social dimensions of flooding, adjustment disorder, acute-stress disorder, post-traumatic stress disorder (PTSD), powerlessness, helplessness, SFVI, Townsend Index of deprivation **[2002, NE England]**

Community Mental Health Team (CMHT), immediate threat to life, displacement, property damage, increased social isolation **[2009, Oxfordshire]**

Post-traumatic stress disorder (PTSD), disruption, GHQ-12 (General Health Questionnaire), GAD-7 (General Anxiety Disorder), PHQ-9 (Patient Health Questionnaire), multivariable logistic regression **[2011, England]**

**Floods, trauma, depression, anxiety, survey.** post-traumatic stress disorder(PTSD), co-morbidity, Harvard Trauma Questionnaire Revised (HTQ-R), Hopkins Symptoms Checklist (HSCL-25), Coping Styles Questionnaire (CSQ), Diagnostic and Statistical Manual (DSM-IV) **[2010, England]**

Ecohealth, ecosystem approach, environment and health, environmental determinants of health, health promotion, integrated water resources management, resilience, social determinants of health, watershed governance, watershed management **[2011, Canada]**

Environmental values, arid landscapes, water values.

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**CREW Facilitation Team**

**James Hutton Institute**

**Craigiebuckler**

**Aberdeen AB15 8QH**

**Scotland UK**

**Tel: +44 (0) 844 928 5428**

**Email: [enquiries@crew.ac.uk](mailto:enquiries@crew.ac.uk)**

**[www.crew.ac.uk](http://www.crew.ac.uk)**

