BEDP ENVIRONMENT DESIGN GUIDE

# The Philosophy and Practice of Water Sensitive Urban Design – is it Consistent with a Whole System Approach?

**Renee Stephens, Cheryl Desha, Charlie Hargroves**

***Summary of***

## Actions Towards Sustainable Outcomes

### Environmental Issues/Principal Impacts

- Government, industry and society are requiring built environment professionals to design and build more sustainable urban water systems.
- A whole system design approach is one that engages all members of the design team at the beginning of a project, who work together cohesively in order to achieve integrated design outcomes.
- A whole system approach to designing urban water systems may allow designers to achieve superior water sensitive urban design outcomes.

### Basic Strategies

*In many design situations, boundaries and constraints limit the application of cutting EDGe actions. In these circumstances, designers should at least consider the following:*

- Engage all of the design team members at the beginning of the design process.
- Ensure the design team is encouraged to collaboratively produce a highly integrated water-cycle design solution during the concept design stage.
- Always consider the use of best management information and new technology in the context of the individual site conditions and the nuances of the project.

### Cutting EDGe Strategies

- Question the arbitrary use of 'best practice' approaches to ensure that the chosen water sensitive urban design solutions are based on the nuances of the site and the project.
- Obtain the benefits of 'front-loaded' design by engaging the design team in an intensive design workshop at the beginning of the project to develop an integrated water sensitive urban design solution for the development.

### Synergies and References

- *BEDP Environment Design Guide*: DES 36: Integrated Systems Design
- Wilson, A, Uncapher, J, McManigal, L, Lovins, LH, Cureton, M & Browning, W, 1998, *Green Development: Integrating Ecology and Real Estate*, a Rocky Mountain Institute Publication, John Wiley and Sons Inc, New York, USA.

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*This paper provides a critique of the Water Sensitive Urban Design (WSUD) paradigm by discussing its congruence with an established sustainable design principle called 'whole system design'. It was found that WSUD is congruent with the whole system design approach as a philosophy, but not in practice. Future improvement of WSUD practice may depend on the adoption of a front-loaded, teamwork-based design and planning process that is embedded in the principle of whole system design.*

**Keywords**
*water sensitive urban design, whole systems thinking, whole system design*

## 1.0 Introduction

This paper provides a critique of the WSUD paradigm by establishing its conceptual and practical congruence with whole systems thinking and design. WSUD and whole systems thinking and design are relatively new concepts that have the potential to contribute to sustainable design and development outcomes. Urban societies are increasingly recognising the value of urban freshwater water supplies, prompting the need for a new urban water management approach. This challenge should provoke an enthusiastic response from built environment professionals responsible for the evolution of urban landscapes.

As designers and engineers adapt to the WSUD challenge, it is constructive to critique the WSUD philosophy as well as the practice of WSUD by considering its relationship to the overarching sustainable design paradigm – whole system design. This paper will provide an explanation of the whole systems thinking and whole system design approach. This explanation will include the auxiliary design philosophies of regenerative design, biomimicry, and circular metabolism.

The WSUD philosophy will subsequently be critiqued, to assess its consistency with the overarching whole system design philosophy. The congruency of WSUD to whole system design in practice will be evaluated. Two key issues considered include the use of WSUD best practice solutions and the high level of design consultancy specialisation. Finally, the paper will present recommendations that may inform the future development of the WSUD paradigm, based on a whole system approach.

## 2.0 Whole System Design Philosophy

Alan AtKisson's 'To-do List for a Sustainable Civilization' states: "We still build incredibly wasteful, toxic and inefficient products and buildings… How we make things, and how we think about how we make things, must change radically" (AtKisson, 2006). This statement seems particularly pertinent amidst the current climate of water shortages in Australia, which are now even affecting our growing urban societies. It is apparent that achieving ecologically sustainable development in our suburbs and cities will require a new creative approach to achieve the required leaps in innovation. The emerging philosophies of whole systems thinking and whole system design potentially have great application within the built environment design professions. These philosophies may provide the fresh perspective needed to view storm water management problems differently, to enable the design of superior water management systems that support ecologically sustainable communities. The strength of a whole system approach is that great leaps in achievement can occur because progress is not based on the incremental improvement of an old solution, but rather the provision of a whole different solution that is so much *more* than the last (Hargroves and Smith, 2006).

Whole systems thinking is a way of a considering a problem that is based on an understanding of the interconnectivity of systems, allowing a solution to emerge that addresses multiple problems simultaneously (Wilson *et al.*, 1998). Whole system design is based on this form of interrogation. The end result is a well designed system that is superior in terms of both efficiency and productivity (Hargroves and Smith, 2006). According to Hawken, Lovins and Lovins (1999) a reduction of 90-95 per cent of material and energy use can be achieved in this way, while still providing the same quantity and quality of services that the community expects. This burgeoning conceptual framework has already facilitated remarkable leaps in innovation, particularly in the business sector (Wilson *et al*, 1998).

The whole system design philosophy is supported by various reinforcing design philosophies congruent with the fundamental principles of a whole system approach. These additional concepts broaden our understanding of how whole system design might occur. For the purposes of this critique, three major design approaches will be briefly analysed: the concepts of regenerative design, biomimicry, and circular metabolism.

### 2.1 Regenerative Design

John Tillman Lyle's regenerative design concept describes the aim of enhancing natural systems by using a novel design approach. The regenerative design concept is closely aligned with the principles of whole system design. Lyle describes a design approach called 're-aggregating' systems, whereby the interactions between parts, the connections, and the parts themselves are considered and designed concurrently (Lyle, 1994). Regenerative design is also achieved by the design of systems that optimise value by serving multiple functions (Lyle, 1994). As Amory Lovins stated, "Typically… designers had optimised isolated components for single benefits, thereby 'pessimizing' the system. Designing instead to optimise whole systems for multiple benefits yields multiple forms of value from single expenditures" (Lovins, 2006). According to the whole system philosophy, a system that serves many functions will inherently be more efficient than one that is designed to serve a single role only.

### 2.2 Biomimicry

Lyle also proposed that regenerative design should be based on nature as a model, particularly for the design of systems (Lyle, 1994). The concept of biomimicry developed by Janine Benyus also encourages designers to look to nature to inspire simple, elegant and well-honed solutions (Benyus, 2002). These two concepts may contribute a great deal to the realisation of whole system design, because they provide a lens through which to reconsider traditional design solutions and uncover superior, highly efficient and ecologically benign outcomes. In the words of Francis Bacon, "nature cannot be ordered about, except by obeying her" (cited in Bacon, 1999). An appreciation of inherently interconnected natural processes is surely useful for understanding the potential designs of man-made systems.

### 2.3 Circular Metabolism

Girardet's concept of a circular metabolism likewise considers the improvement of human systems based on observations of natural cyclic systems. The concept describes an optimal pattern of resource use in an urban environment that mimics natural ecosystems where already-utilised resources are re-integrated into the system in a cyclic fashion, rather than being expelled as unutilised waste (Birkeland, 2002). By this means, the by-products of a system are produced at a rate that can be safely assimilated by the natural environment. This concept suits the whole system principle of efficiency through design.

The concepts of regenerative design, biomimicry, and of circular metabolism all enrich the concept of whole system design, and each have a wide range of applicability within design professions. With increasing awareness of the degradation of natural waterways, a whole system design approach may provide valuable insight into how built environment professionals should be designing urban water management systems.

## 3.0 The Need for WSUD

Rapid urban expansion and consolidation in Australia and indeed worldwide is placing increasing pressure on receiving waters (Lloyd, Wong and Chesterfield, 2001). Waters downstream of urbanised catchments are susceptible to degradation due to an increase in surface runoff that is transported more efficiently, creating more flooding, more erosion, and the destruction of habitat (Rowney, 1999). The water quality of downstream waterways is also compromised due to the presence of pollutants carried by urban stormwater runoff (Egodawatta *et al*, 2006; Lloyd, 2004) that are in concentrations too high to be assimilated by the natural system.

As early as 1968 the European Water Charter recognised that good freshwater reserves are exhaustible, and stated that it is "becoming more and more important to preserve them, to use them sparingly and, where ever possible to increase them" (Thomas and Zeisel, 1997). In more recent years in Australia and globally, this recognition has been adopted by industry and the broader community who are now voicing growing enthusiasm and support for a better approach to urban water resource management (Lloyd, 2004).

With the realisation of this water management dilemma, a new urban design approach emerged in the early 1990s (Lloyd, 2001) and has since then become firmly imbedded in the lexicon of the built environment professions. WSUD encapsulates the aim to design for environmentally sustainable water management practices in the urban setting (Lloyd, 2001). Since the term has been enthusiastically adopted across such a wide range of professions, it is sensible to consider whether the WSUD philosophy and WSUD practice is congruent with the overarching whole system design approach. If WSUD was indeed expressed as a whole system design the capacity to dramatically improve the effectiveness of water management systems could be quite promising.

## 4.0 The WSUD Philosophy

In Australia the WSUD philosophy was first promulgated in 1994 by Whelans and Halpern Glick Maunsell who presented novel 'water sensitive' design guidelines for the residential urban setting. Their influential text developed for the Water Authority of Western Australia defined the WSUD philosophy as being comprised of five key goals: the management of a water cycle balance, the protection/improvement of water quality, the conservation of water resources, the maintenance of water related environmental values, and the maintenance of water related recreational values (Lloyd, 2001). This philosophy has since been adopted prolifically in Australia, and been incorporated into the design ethos of many built environment fields.

The current prominent Australian authors on the topic, Lloyd, Wong and Chesterfield extrapolated the essence of the WSUD goals, broadly describing it as a philosophical urban design approach that aims to incorporate a complete urban water cycle into urban development (Lloyd *et al*, 2001). The WSUD philosophy was more specifically defined by Wong and Eadie [16] as an improved approach to urban development planning and design that capitalises on the intrinsic link and opportunities between design, landscape architecture and storm water management infrastructure, delivering multiple storm water management objectives on this basis. The two umbrella storm water management objectives described in the Melbourne Water WSUD procedures are to regard water as a resource to be thoughtfully managed, and to implement measures that prevent damage of receiving water ecosystems (Melbourne Water, 2005). These are the overarching philosophies and goals of WSUD.

It is evident that WSUD is a holistic design philosophy that aims to produce many benefits by adopting an integrated approach to water management. Now synonymous with WSUD are the water management methods of conservation, detention, retention, filtration, dissipation, infiltration, and reuse – a combination of these strategies termed the 'treatment train' (see Lloyd, Wong and Chesterfield, 2002; Melbourne Water, 2005). The treatment train concept illustrates the whole system character of the WSUD concept. Whole system themes such as the interconnectivity of systems, multiple functions, nature as a model/inspiration for design, and circular metabolism are all present in the WSUD philosophy. And like systems in nature, a WSUD system is relevant at varying spatial scales, from individual allotments, to streetscapes, neighbourhoods, and entire catchments (Lloyd *et al*, 2002). The WSUD concept certainly reflects many of the characteristics of a whole system approach.

## 5.0 WSUD in Practice

Though WSUD is congruent with a whole system design approach in theory, this does not seem to be the case in practice. Successful practical examples of WSUD that demonstrate a commitment to the WSUD philosophy (see Lloyd, 2001) continue to stand out as exceptions. If WSUD is indeed the new urban design paradigm (e.g. Wong and Eadie, 2000), it is taking some time to be actualised 'on the ground'. Interestingly, it appears that a lack of a whole system approach during the design process has resulted in the limited realisation of WSUD in practice. In particular, the success of WSUD has been hindered by two main issues, namely, the uncritical use of 'best management' solutions and practice, along with the narrow specialisation of professionals that compromises the effectiveness of the design team.

## 6.0 WSUD Best Management Practice

In Australia the practical implementation of WSUD has been largely promoted by numerous 'best management' guides, manuals, and procedure publications (e.g. Brisbane City Council, 2005; Melbourne Water, 2005; Victoria Stormwater Committee, 1999; Whelans and Halpern Glick Maunsell, 1994). These manuals have provided designers, clients, and councils with a general understanding of the available technologies and techniques that can be implemented in a development to enhance the storage, infiltration, filtration and reuse capacity of an urban water system. Though these documents have been useful in furthering the WSUD practice, it is possible that the uncritical implementation of best management solutions has suppressed whole systems thinking, therefore negating the adherence to the WSUD philosophy in practice.

The inappropriate implementation of best management solutions and practices has resulted in common problems. It is commonly found that elements of the treatment train are located incorrectly, staged incorrectly, and improperly maintained (Lloyd *et al*, 2001; Wong and Eadie, 2000). An analysis of case study examples by Hatt, Deletic and Fletcher (2004) confirmed these issues are a problem, and also found that poor construction practices also compromised the WSUD objectives, particularly due to poor sediment control. This is a crucial concern because the timing and approach of the construction of WSUD elements can determine the effectiveness and longevity of the system (Leinster, 2006). It is evident that the insertion of best management solutions and practices into a conventional design and construction process negates the potential to sensitively manage urban water cycles.

Evidently the current promotion of best management practices does not necessarily complement the whole system-based WSUD philosophy. Instead, best management practices may inhibit free, creative thinking and design that holistically considers the interconnectivity of systems, the potential to mimic natural systems, and ways of truly producing a regenerative, cyclic urban

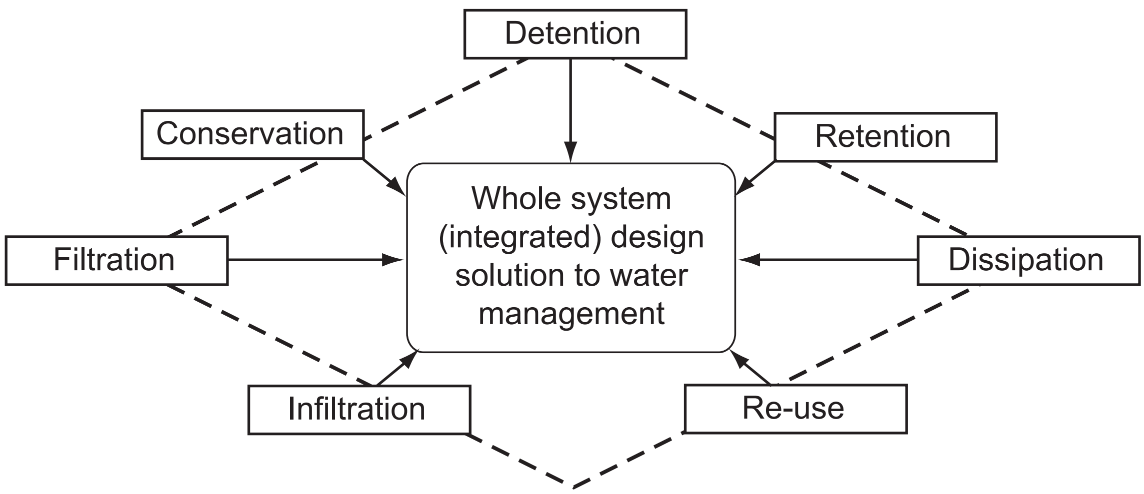


**Figure 1. The treatment train**

water metabolism. After all, the solution to producing communities that are sensitive to our water cycle may not yet be included in a design manual, and it is perhaps unlikely that the solution will neatly fit into the conventional stormwater system.

## 7.0 Increasing Professional Specialisation

According to Janis Birkeland (2002), the dominant Western cultural paradigm of this current era is in part based on reductionism, whereby "the world can be understood as a composite of separate elements or entities, and problems are best solved by specialisation, simplification and abstraction". The increasing specialisation of the various built environment design and engineering professions is evidence of this statement. Because of the increasing specialisation of the design and engineering professions, development practice has become increasingly disparate from a whole systems approach (Wilson *et al*, 1998). The specialisation of expertise is inherently not ideal when what is needed is a holistic, system approach. This prevailing reductionist, single-discipline approach to urban design has historically led to the failure of integrated designs (Lloyd *et al*, 2001).

The practical application of the WSUD philosophy has been greatly affected by this problem. One of the main reasons why WSUD is not being well implemented is due to uncertainty regarding this novel design approach and the new associated technologies. Because knowledge of WSUD measures spans across many professions (e.g. civil engineering, planning, landscape architecture, hydraulic engineering etc), WSUD information is often specific to a field of expertise and is difficult to access (Lloyd *et al*, 2001). This is perhaps the main reason why, for example, urban drainage continues to be managed in isolation from other components of the urban water cycle (Mitchell *et al*, 2006). It is logistically difficult for a design team comprised of specialists constrained by the challenging time pressures of any normal design project to produce a holistic WSUD outcome when such knowledge barriers exist.

Knowledge barriers not only prevent the actual design of water sensitive systems, but knowledge barriers also inhibit the approval of WSUD development proposals. Councils often lack the skills and knowledge required to assess and approve alternative development designs and are therefore wary of accepting the inherent risk associated with alternative approaches (Lloyd *et al*, 2001). The WSUD philosophy has experienced limited implementation in practice because whole systems thinking and design is not well-supported by the current design culture which is based on a high level of specialisation. The practical realisation of re-aggregated urban water systems is compromised by a design culture ill-equipped to identify and exploit the interconnectivity of systems.

## 8.0 The Potential for Improvement in WSUD Practice

Evidently WSUD in practice is not a true representation of the WSUD philosophy, because the practical implementation of WSUD is not based on whole systems thinking and design. The practical implementation of WSUD currently conflicts with a whole system approach, and is instead based on a reductionist design process that supports the uncritical insertion of 'best management' elements into a conventional water management approach. Many authors suggest that further improvement of WSUD practice must be driven by the making of design and construction guidelines, standards, regulations, and improved technologies (see Hatt *et al,* 2004; Lloyd, 2001; Lloyd *et al*, 2002). A statement by Bacon (1999) presents a more profound vision: "I suggest that we do not need an extra level of controls by government but an awareness of inter-dependencies, a willingness to collaborate…"

In order for this to occur, a fundamental change to the conventional design process will be required. Researchers from the Rocky Mountain Institute (Wilson *et al*, 1998) have suggested some elements required to encourage design practice reform. Two of these, front-loaded design and teamwork, are particularly pertinent to this discussion. These two design approach tools may greatly assist the practical application of whole system-based WSUD. According to the Rocky Mountain Institute, *'By conducting the fundamental planning work up-front with all players at the table, the whole-systems thinking approach… can be put to work by developers… It is much easier and cheaper to maximize the benefits of green planning and design by addressing these issues in the initial stages of a project'* (Wilson *et al*, 1998).

The City of Melbourne's Council House 2 (CH2) Building was designed with a front-loaded approach, resulting in many quantifiable benefits. The design team worked in an intensive charrette environment for two and a half weeks to produce a highly integrated and resolved schematic design (Malin, 2004). Compared with the existing Council House building, CH2 has achieved an 85 per cent reduction in electricity consumption, 87 per cent reduction in gas consumption and thus an 87 per cent reduction in emissions, and reduced water mains supply by 72 per cent, while saving 1.2 million dollars a year from increased staff health and happiness (City of Melbourne, n.d.). Now an iconic Australian 'green' building, CH2 provides a good example not only of sustainable architecture but also of the benefits of a front-loaded design approach.

Figure 2 summarises the benefits of a front-loaded design approach, which facilitates production of whole system design. Importantly, a front-loaded design process promptly establishes a more intimate understanding of the site's nuances and its potentialities, which according to Sim Van der Ryn

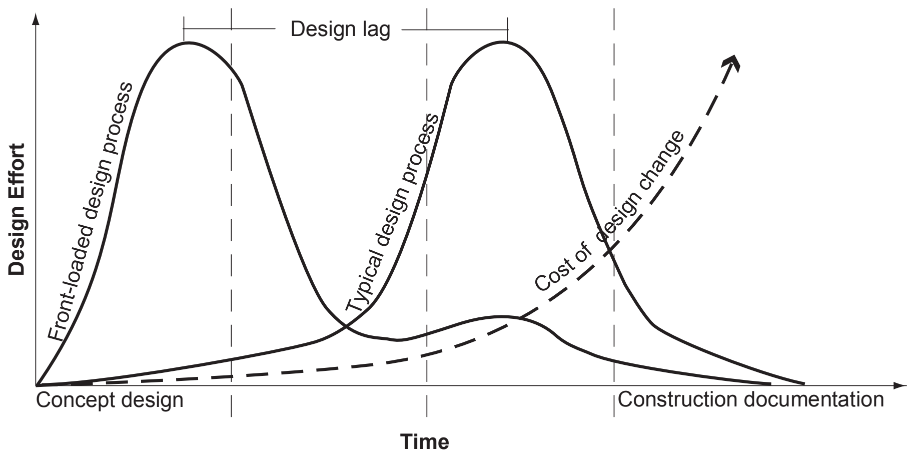


**Figure 2. Front-loaded design as a benefit of a whole system design approach**

and Stuart Cowan (cited in Hargroves and Smith, 2006), allows for the production of ecologically sensitive design outcomes. The possibility of producing a holistic water sensitive urban landscape must surely be much greater if the design is based on a thorough understanding of the character and potentials of the site, maximised at an early stage in the design process.

Front-loaded, site-specific design has to be the starting point for any project aiming to adhere to WSUD. Once the project goals and the existing site characteristics are thoroughly established it is possible for a design team to collaboratively conceive of ways of designing a sensitively managed urban water cycle. In such a scenario it is unlikely that designers would revert to the unsystematic use of best management measures. Rather, designers would be empowered to use current WSUD techniques and technologies judiciously and produce careful construction and maintenance guidelines to support the unique system.

A front-loaded design process is also essential to achieving the collaborative realisation of WSUD. An initial team approach to design ensures that all of the consultants in the design team can contribute to a thoughtful review of all the issues, and individually support the overall environmental and social goals of the development (Wilson *et al*, 1998). In the words of Lloyd *et al* (2001) "There is no place for the attitude "stormwater management should be left to engineers, or wetland design should be left to landscape architects". The current popular design axiom of 'coordination' between disciplines must be replaced with the term 'collaboration' in a teamwork-oriented design process. While 'coordinate', infers the post-design process of smoothing conflicting arrangements of elements within the development, the term 'collaborate' infers a sharing of input from all of the design disciplines at the initial stages of design. Despite the high level of specialisation of members that typically comprise a design team, it is likely that a front-loaded teamwork-oriented design approach may better facilitate creative dialogue between the consultants. The genuine adhesion of a design team is critical to facilitate the holistic exploration of WSUD solutions.

A design team committed to teamwork and a front-loaded design process can surely be in a better position to consider the WSUD opportunities, allowing designers to explore and embrace such whole system concepts as regenerate design, nature as a model and inspiration, and cyclic metabolism. A technical paper produced by the Australian Water Resources Council in 1973 described a new trend in storm water design practice: *"Wright … states that urban runoff is a resource out of place and '…should not be treated as an enemy to be sent downstream as fast as possible.' Instead the planner and engineer should be involved in considering water reuse, water quality, upstream ponding schemes and the improvements of the urban environment".*

Over thirty years later built environment professionals are still coming to grips with the potentials and the complexities of urban storm water management. As the various built environment design professions continue to grapple with the notion of WSUD, it is essential that the paradigm expands to include the guiding principles of whole systems thinking, front-loaded design and teamwork. It is envisaged that this progression would facilitate the physical realisation of water sensitive urban communities.

## 9.0 Conclusions on the Road to Genuine WSUD

It is unlikely that genuinely sustainable urban water cycles will be cultivated from incremental alterations to conventional water management systems. A new way of conjuring design is required. The whole systems thinking and whole system design philosophies present a discernible means of designing more holistic, elegant, and sustainable urban landscapes. The WSUD philosophy innately reflects the broader principles of a whole systems approach, recognising the interconnectivity of systems and borrowing such concepts as re-aggregation, nature as a model/ inspiration, and cyclic metabolism. Indeed WSUD promotes water as a potentially cyclic resource and endorses imitation of natural processes that maintain clean water supplies.

The practical implementation of the WSUD however, deviates from its philosophical fundamentals. The holistic and whole system-based philosophy is most-often superseded in practice, replaced with the uncritical application of 'best management' design solutions. Additionally, the increasing specialisation of design consultants appears to impede the collaborative teamwork required to generate a holistic understanding of system interconnectedness, and the opportunities therein. Evidently there is the potential for the future improvement of WSUD practice, which might induce further progression towards creative and effective outcomes.

A front-loaded, teamwork-based design and planning approach could greatly contribute to this change. It is envisaged that a fundamental shift in the design process may unveil the real extent of urban water cycle problems and most importantly, the real extent of possibilities. After all, design is fundamentally based on the challenge of finding a solution to suit a problem. There is perhaps no grander problem that our civilization faces in this day and age than unsustainable communities. Sensitive urban designs that unlock wonderfully novel solutions to our water management problems have the potential to greatly contribute to the future quality of human life, the long-term sustainability of our water resources, and the wealth of life therein.

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## Biography

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The Natural Edge Project is a partnership for research, education and strategy on innovation for sustainable development, hosted by Griffith University and the Australian National University. More information about the work of The Natural Edge Project can be found at http://www.naturaledgeproject.net.