From Vision to Reality: The Crucial Role of Environmental Engineers in Achieving Sustainability

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Abstract

Sustainable resource development embodies a range of objectives relating to utilitarian values, such as infrastructure integrity and function, as well as biodiversity, amenity and cultural values. Unfortunately sustainability goals often remain only a vision as practitioners and managers struggle to translate ideals from the often well-established policy, legislative and management regimes into a practical reality at the project level. Statutory and community provisions and diverse technical requirements can only be satisfactorily achieved by integration throughout the project planning, design and implementation procedure. This paper presents the environmental engineer's role in planning and design for sustainability, and illustrates the approach with examples from the natural resource management field.

1. INTRODUCTION

Recent decades have brought a change in many societies, from harsh development practices causing wanton damage to the environment and severe impacts on local communities, to more sensitive practices that recognise natural environmental processes and attempt to minimise bio-physical and socio-cultural impacts on the environment. The common catch cry of "sustainability" aims to maintain a high quality of human life whilst maintaining the ecological processes on which life depends (IEAust, 1994). Sustainability is about balancing human needs with those of the environment, or in simplest terms, providing for human utility and protecting natural ecosystem function now and in the future.

Sustainability goals are driven largely by statutory provisions at global, national and local levels such as international treaties and protocols (e.g. *Kyoto Agreement on greenhouse*, *RAMSAR convention on wetlands*); national strategies and programs (e.g. *COAG agreement on water reform*, *National Biodiversity Strategy*); and state, regional and local legislation and policies (e.g. *Regional Planning Strategy, Environmental Protection Act*). These goals are also strongly influenced by increased public interest and participation, introducing diverse stakeholder goals to development planning, and involving local communities in setting values, and in some cases, making decisions.

Unfortunately, in spite of society's vision for a better natural and socio-cultural environment, environmental degradation looms large as a result of existing human use and ongoing development pressures. Policy, legislative and management regimes, whilst articulating multipurpose goals, are often not enough to translate statutory provisions and community concerns into reality and practical multipurpose outcomes at the project level. For example, attempts to rehabilitate a degraded watercourse and protect human utilities such as road infrastructure and water supply facilities from erosion and pollution damage, often merely focus on the physical environment, and fail to deal satisfactorily with ecological processes (e.g. habitat conservation) and socio-cultural aspects (e.g. recreational or visual amenity). Similarly, goals for infrastructure development such as tourist facilities in sensitive coral reef environments, may focus on protecting ecosystem function (e.g. preserve corals) and cultural values (e.g. protect significant site), whilst fundamental physical aspects such as structural integrity under wind and wave loading are poorly dealt with.

Although the overarching provisions for sustainability (i.e. providing for human use and for natural ecosystem function) may be well established in statutory matters, and in spite of community and stakeholder commitment, the success or failure of many development or remediation activities relies largely on the practitioners and managers charged with the responsibility of implementing the project. Sustainable outcomes cannot be satisfactorily achieved merely by following prescriptive procedures, but only through creative approaches that address these statutory provisions, community demands and diverse technical requirements throughout the project planning, design and implementation procedure.

The disciplinary training (e.g. engineer, ecologist, architect), professional role (e.g. manager, scientist, designer), and philosophical emphasis (e.g. utilitarian, conservationist, sociologist) of practitioners and managers play a major role in facilitating, or sometimes obstructing, sustainable project outcomes. Environmental engineering - a design discipline - plays a crucial role in achieving sustainability objectives, as it combines conventional engineering process (emphasising utility), with science and management requirements (emphasising the natural, social and cultural environment).

This paper presents an integrated planning, design and implementation approach that accommodates statutory requirements and community aspirations, and is founded on a sound inter-disciplinary technical basis for addressing human – environment interaction. Using illustrations from natural resource development and remediation projects, it outlines the crucial role for environmental engineers (working with scientists, managers and other practitioners), in progressing visions of sustainability through to a successful reality.

2. DEVELOPMENT, REMEDIATION AND HUMAN-ENVIRONMENT INTERACTION

Human activity in the environment encompasses various forms of human – environment interaction. Sustainability can be achieved through various modes of human intervention or management, including *conservation* - preserving environmental values; *development* - mitigating environmental impacts; or *remediation* - rehabilitating degraded environments. The following discussion focuses on development and remediation, and the manner in which planning, design and implementation can address sustainability goals (Figure 1).

The most common human intervention is the effect of development on the natural environment, for which the impacts and consequences can be severe. Development starts with a need or aspiration - perhaps a demand for water for agriculture or for a township, which may lead to construction of a dam with associated impacts on the environment such as, reduced stream flows for downstream habitats or inundation of road infrastructure in the impoundment. The appropriate response is to mitigate these environmental impacts during project planning, design and implementation through, for example, provision of suitable environmental flows downstream, and construction of an alternative transport corridor upstream. Remediation is the other aspect of human intervention, where we start with a problem such as an eroded road-stream crossing, and endeavour to rehabilitate the degraded environment through infrastructure repair and reinstatement of natural stream form and ecological function.

Figure 1 shows the continuum between the development need or aspiration, the human activity or mitigation measure associated with development, the consequential environmental impacts or problems, and the remediation measures adopted to address these problems. The upper and lower segments of this diagram represent the development (need → mitigation) and remediation (problem → remediation) sequences – each encapsulating associated planning, design and implementation procedures that lead from definition of the problem or need to the solution. These procedures are discussed in more detail in subsequent sections.

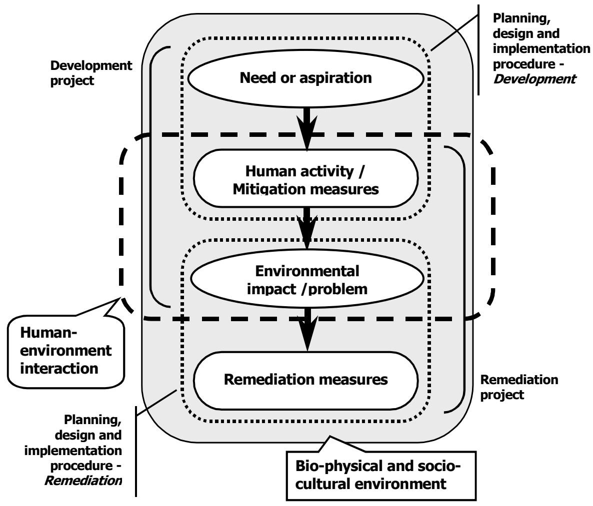

Figure 1. Development, remediation and environmental management

All aspects of human intervention can be considered to occur within the domain of the bio-physical and socio-cultural environment, as shown on the diagram in Figure 1. The central zone on the diagram depicts the fundamentals of human-environment interaction, where human activity, the bio-physical environment and the socio-cultural environment intersect, resulting in some form of environmental impact or natural impact (see Figure 2). Practitioners and managers must understand this interaction to successfully undertake development or remediation projects, which must meet human use needs (e.g. dam construction and road access; culvert infrastructure repair), and protect environmental processes and function (e.g. provision of environmental flows; geomorphic and ecological stream restoration).

The human-environment interaction diagram (Figure 2), which links human activities with the two environmental spheres (bio-physical and socio-cultural environment), identifies three types of impact, and provides the framework for understanding environmental impacts and the cause-effect relationships linking project actions to these impacts. Human impacts result from the effects of human activities on the bio-physical and socio-cultural environments (e.g. habitat degradation; pollution of water supplies), whereas natural impacts result from the effects of the bio-physical environment on the facility or the socio-cultural environment (e.g. flood damage to infrastructure; dust storm on a township). Accelerated natural impacts occur as a result of human activities affecting the bio-physical environment - in turn adversely affecting human utility and the socio-cultural environment (e.g. land clearing increasing flooding and dust generation - in turn affecting infrastructure and communities).

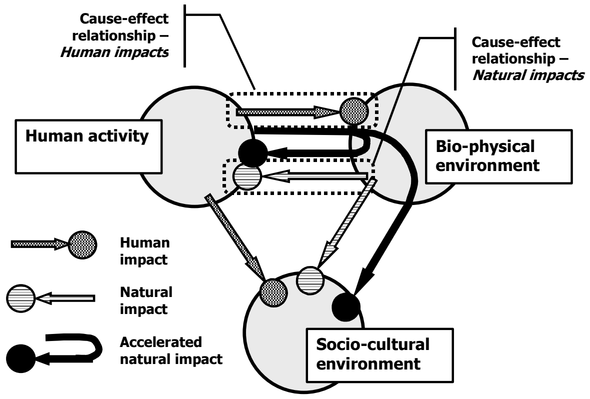

Figure 2. Human-environment interaction

An understanding of cause-effect for human impacts, natural impacts or accelerated impacts is fundamental to developing solutions to environmental problems or needs in remediation or development projects. Whereas the conventional engineering paradigm provides an understanding of the effect of the bio-physical environment on human utility (e.g. flood water loading on bridge decks), and the conventional scientific paradigm explains the effect of utility on the bio-physical environment (e.g. habitat degradation from encroachment on a stream), practitioners and managers must embrace these and other relationships encompassing the socio-cultural environment in order to achieve sustainability.

3. MULTIPURPOSE PROJECTS AND MULTIPLE OBJECTIVES

Whereas conventional development and remediation projects have emphasised narrow objectives relating to human use (e.g. water supply; flood and pollution control; infrastructure integrity), sustainable projects must adopt a range of objectives that provide for both human use and natural ecosystem function (eg. ecological processes, biological diversity), as well as amenity and cultural values. These are multipurpose projects incorporating multiple objectives across the environmental spheres shown above (Figure 2). The following illustrations deal with stream rehabilitation and urban stormwater management in the natural resource management field, however the principles apply equally to technology areas such as waste and pollution control.

In meeting multiple objectives for natural resource management projects (Table 1), the conventional utilitarian ‘hard engineering’ approach to stream stabilisation, flood control, and urban drainage, is replaced by a multipurpose waterway management approach. For example, Water Sensitive Urban Design – WSUD (Stormwater Committee Victoria, 1999) and other urban waterway methods provide for water quality improvement, habitat protection, recreation, and flood protection. New technology stormwater quality improvement devices (SQIDs) are used in conjunction with lighter structural works, revegetation and landscaping to achieve utilitarian and amenity goals, whilst endeavouring to preserve natural stream processes.

The convergence of values and goals for stream rehabilitation and urban stormwater management is a positive direction for natural resource management, and improves the prospects for sustainability. Practitioners and managers with diverse natural and social science backgrounds in stream rehabilitation, now have opportunities to cross-fertilise with engineers and others versed in urban stormwater design – a field that has been historically well resourced and enterprising in the development of new technologies.

Practitioners and managers also face many challenges in translating these multiple objectives through to implementation – constraints relating to planning, design and implementation protocols; interdisciplinary activities; and statutory, community and technical provisions, which are discussed in the following sections.

Table 1. Multiple objectives for natural resource management

Flood, erosion and utility damage
Reduce flooding
Minimise catchment erosion
Control stream erosion & sedimentation
Protect land, infrastructure & utility
Water quality and pollution
Improve stream water quality
Minimise waste pollution
Habitat and conservation
Conserve catchment habitat & biodiversity
Rejuvenate stream habitat & biodiversity
Control exotic animals and plants
Amenity, social and cultural issues
Improve stream corridor aesthetics
Enhance residential amenity and recreation opportunities
Protect cultural heritage
Maintain health and safety
Provide demonstration/extension sites

4. SPATIAL AND TEMPORAL PLANNING HIERARCHY

Stream rehabilitation, urban stormwater and other natural resource management fields display a range of spatial scales corresponding to an ecosystem hierarchy, which extends from regional planning, through catchment/local authority planning, stream reach/subdivision activities, to the site/precinct scale. Just as ecosystem elements are nested within broader ecosystems, human activities such as development of a suburban precinct, must be considered within this resource management hierarchy of scales. This notion can be extended to a spatial and temporal management planning hierarchy, which provides a framework for planning, design and environmental assessment, and helps transfer multipurpose goals from the broader planning scales through to tangible outcomes at the project or site scale (see Figure 3).

The framework incorporates a phased planning, design and implementation approach encompassing concept level, feasibility and detailed design phases that articulate from the regional to the site scale, progressively developing detail at finer spatial and temporal scales. The site or project scale planning and design procedure follows a series of phases and steps that lead from conceptual studies through detailed design and implementation to monitoring and review. Figure 3 shows the conjunction between stream rehabilitation (regional biodiversity, catchment strategy, reach action plan, site implementation), and urban stormwater planning (regional water quality, urban SWQMP, stormwater plan, erosion and sediment control).

The basic hierarchy of temporal project phases and spatial resource management scales applies for other natural resource management and sustainable design endeavours. Practitioners and managers can articulate through this tiered structure from regional planning to site implementation, applying the appropriate emphasis and timing, whilst ensuring that site implementation is undertaken within the broader resource management context. Conventional planning, design and implementation hasn't always been this comprehensive or complex, but it hasn't always provided good outcomes. In fact, many projects have conventionally started with implementation and failed to incorporate any broader scale planning. Regional and catchment scale planning now commonly provide the framework for finer scale design activities, but an enormous gap lies between these domains, as shown on the diagram, and practitioners and managers must be well equipped to bridge the gap.

5. PLANNING, DESIGN AND IMPLEMENTATION PROCEDURE

The fundamental planning and design requirement for development or remediation projects at the site scale is to proceed from a problem or need to solution or outcome (see Figure 1). This procedure must address the multiple design objectives for the project, and in order to meet future needs or address the cause of the problem, must recognise and understand natural processes and human-environment interactions. A systematic and organised approach capable of adaptation for particular cases, is crucial for the planning and design of multipurpose projects. A sequence of phases and steps following the classic problem solving and project procedure, is recommended. Figure 4 shows the commonality between the planning and design procedure for urban stormwater management (development project) and stream rehabilitation (remediation project).

Planning and design phases offer a number of advantages, in that they allow progressive development of concepts, assessment and approvals; they minimise site assessment and design in early stages; and they reduce unnecessary financial commitment to projects that may not proceed. The concept phase considers broad aspects and develops solution options; the feasibility phase involves detailed evaluation and a decision on the project; the implementation phase includes detailed design, manufacture and construction of the project, and the monitoring and review phase provides for monitoring and periodic review of the project.

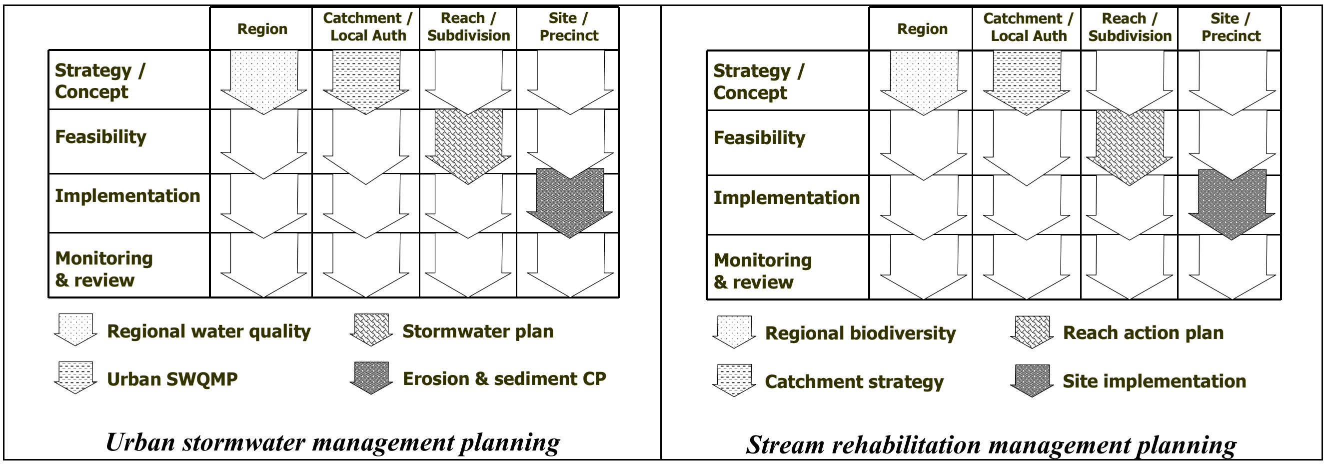

Figure 3. Illustrations of spatial and temporal planning hierarchy

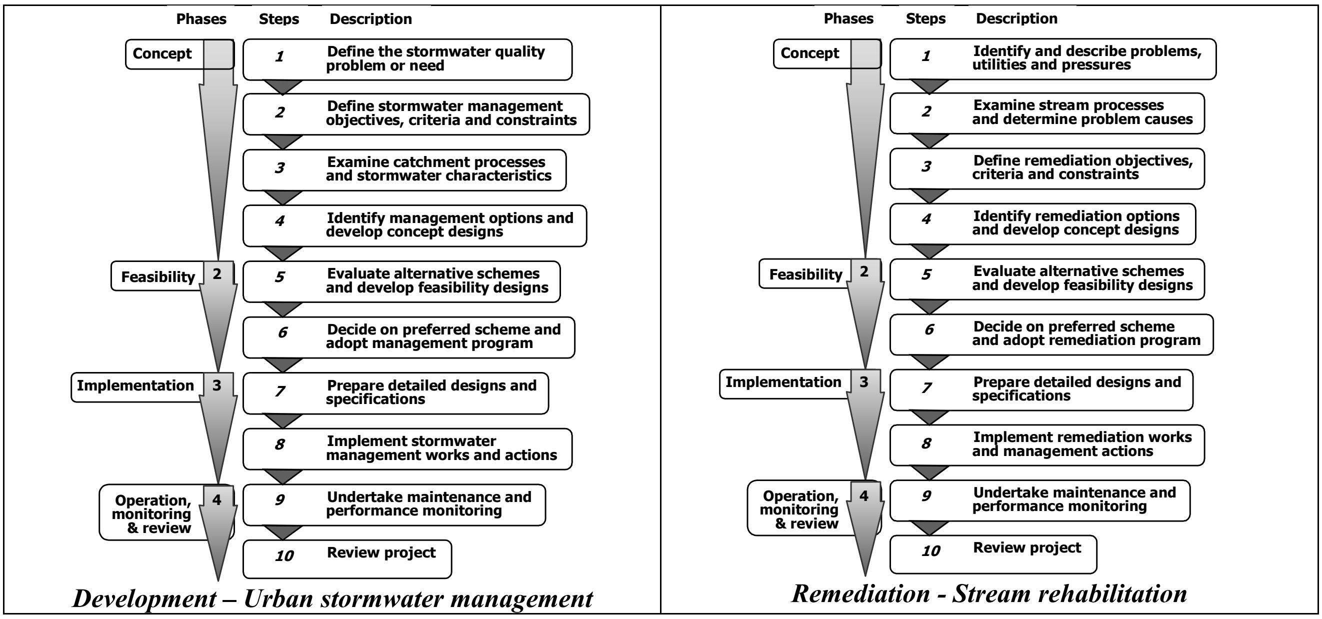

Figure 4. Design phases and steps – development and remediation projects

Planning and design for stream rehabilitation, natural resource management or other sustainable projects involves a diverse range of investigation and design tasks, which must be carefully integrated to develop the design solution. These tasks can be usefully categorised under statutory provisions, stakeholder consultations, site assessment, and planning and design groupings (see Table 2 for stream rehabilitation design tasks). The 10-step planning and design sequence outlined above provides a useful framework for preparation of a schedule of design tasks for any particular project. A design task schedule allows the project manager and the technical practitioners to understand their respective roles within a project, to see where particular tasks fit within overall project design requirements, to scope planning and design activities for an interdisciplinary team, and to establish the appropriate planning and design forum (e.g. individual task, workshop, site meeting).

6. THE ROLE OF THE SCIENTIST, THE MANAGER AND THE DESIGNER

Planning and design for sustainability requires successful integration of technical, statutory and community provisions, and careful scoping of associated design tasks throughout the planning, design and implementation procedure (refer Table 2). It is useful to understand the nature of these provisions, and the respective roles of managers (e.g. impact assessment study; statutory provisions), scientists (e.g. condition assessment; impact assessment), and designers (e.g. technical analysis and evaluation) in addressing them.

Figure 5 conceptualises these relationships. Statutory provisions (e.g. legislation; regulations; permits) are top-down influences on planning and design, and are commonly administered by environmental/project managers. Community involvement (e.g. stakeholder participation; formal and informal consultation) usually drives a project from the bottom-up, and is commonly undertaken by managers. Technical provisions involve site assessment (e.g. topographic survey; ecological studies) - commonly undertaken by the scientist, and planning and design (e.g. environmental evaluation; landscape design; structural analysis) - principally involving the designer.

Each of these provisions is essential to achieving sustainable outcomes. Meeting technical requirements is central to this success, and the designer plays a key role in integrating planning and design provisions. Although community conflict or statutory limitations may impede technical solutions, planning and design should proceed within this broader context. The spatial and temporal planning framework, the planning and design procedure, and the design task schedule described above are useful for achieving this.

Table 2. Planning and design tasks – Stream rehabilitation

Statutory provisions
Policy, legislation and management planning
Permits, licences and approvals
Stakeholder consultation
Property owners
Other stakeholders
Site investigation and characterisation
Topographic and infrastructure mapping
Catchment hydrology
Stream geomorphology
Geotechnical characteristics
Stream water quality
Instream/riparian habitat and processes
Amenity/cultural heritage
Planning and design
Layout and configuration
Hydraulic analysis
Foundation and drainage
Landscape design
Structural design
Environmental impact/risk assessment
Costing/economic assessment
Option evaluation
Management plans
Report/tender documentation

Environmental engineers offer a robust mix of management, science and design expertise, and are well equipped to undertake much of the planning and design for sustainable projects. Although a relatively young profession in its own right, contemporary environmental engineering deals with more than the conventional waste and pollution control, characteristic of its past. Environmental engineering couples the classical engineering strength of analysis with an understanding of the socio-cultural and bio-physical environment, and offers more to sustainable design than merely management and science – and more than conventional engineering.

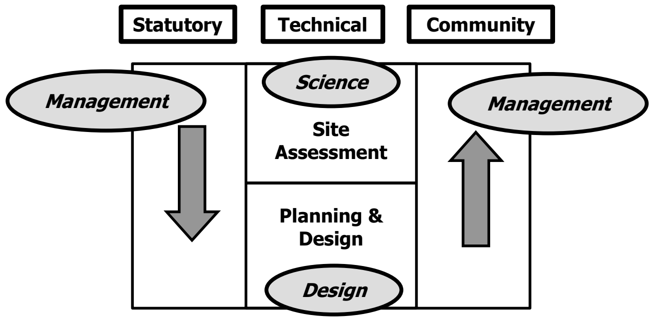

Figure 5. Statutory, technical and community provisions in planning and design

7. CONCLUSIONS

This paper has presented an integrated planning, design and implementation approach for sustainable projects, and has outlined planning and design activities that are well suited to the role of environmental engineers. Founded on sound inter-disciplinary technical input, this approach addresses multiple project objectives, and accommodates statutory requirements and community aspirations for development and remediation projects. The spatial and temporal hierarchy in management planning, the project planning and design procedure, and the planning and design task scheduling provide a framework for practitioners and managers to articulate from visions of sustainability at broad planning levels, to the reality of practical outcomes at the project or site scale. Using a range of planning and design tools and techniques such as these, environmental engineers, working with other disciplines, can effectively undertake multipurpose projects to achieve sustainability.

8. REFERENCES

Institution of Engineers, Australia, National Committee on Environmental Engineering (1994), *Policy on Sustainability*.

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