

Lead Author: Sinclair, Sarah, Other Author: Webster, Louise Other Author: Woods, Dave
Company affiliations: Sinclair Knight Merz (SKM); Ideas Accelerator Ltd; North Shore City Council

PO Box 9806, Auckland, 1149, New Zealand

Tel (09) 928 5500 Fax (09) 928 5501 email ssinclair@skm.co.nz

RETHINKING SUSTAINABLE INFRASTRUCTURE USING INNOVATION TOOLS

Too often, developing and implementing infrastructure relies on the lessons of the past – we build in our lessons learnt and rely on recent history as a marker of what the future will be like. So, we rely on the past for our review of economic, environmental and social drivers and their impact on infrastructure projects. For infrastructure owners, and infrastructure providers, our challenge is how to move away from “we’ve always done it like this” to bring divergent thinking into our projects to make them more future-facing.

North Shore City Council sees innovation as a major factor in building sustainable outcomes. As an infrastructure client, NSCC asked innovation consultant Ideas Accelerator to work with SKM, its Principal Consultant on a major wastewater infrastructure programme of work; to develop a way of making innovation part of Business As Usual.

This paper covers how NSCC, Ideas Accelerator and SKM’s Sustainability Practitioner developed innovation tools to be used at key project stages to drive innovative, sustainable outcomes throughout infrastructure projects from feasibility studies through to construction. The paper will also focus on how sustainable outcomes were incorporated into the tools.

The paper covers the subsequent testing of the tools, lessons learnt, and outcomes when the tools were used on real infrastructure projects; using NSCC’s quadruple bottom line to appraise outcomes.

INTRODUCTION AND DEFINITIONS

Innovation is officially defined, within the OECD, by the OECD Oslo Manual, (1997). The definition has also been adopted by New Zealand’s Department of Statistics. It is defined as:

1. The introduction of a new or significantly improved product or service to the market
2. The introduction of a new or significantly improved process within a business

For the purpose of this project innovation was defined as; any activity that adds value to the organisation and its customers, through changes to systems, processes, or through the development of new products and services.

As an Engineering and Science consultancy with a strategic focus on sustainable development, SKM(2009) has developed a working definition of what we mean by sustainability as applied to our consultancy as “simultaneously enhancing community wellbeing, environmental health and economic productivity.”

North Shore City Council (NSCC) is striving to be an innovative council. It has a history of embracing leading edge technologies and new solutions to meet project management and delivery challenges. The Council recognises that its principal innovation resource is its own staff, alongside a few key contractors and consultants. By way of an innovation programme,

it has been seeking out ideas and opportunities that will enable the Council to reduce costs, improve customer satisfaction, provide better solutions, improve processes and ways of working together, improve project certainty (including consentability), and improve staff morale.

APPLYING INNOVATION AND SUSTAINABILITY TO INNOVATION PROJECTS

Part of the Programme was to consider how innovative approaches could be encouraged in the infrastructure projects that Council undertakes. Whilst a great deal of creativity and innovation is embedded in the day to day management of infrastructure projects; managers and contractors naturally focus efforts on risk mitigation and delivery, after the preferred option is agreed.

The Water Services department of Council has developed a strong culture of ‘continuous improvement’ since the instigation of an ISO 9000 Management system in the 90’s. In the last five years or so innovation tools and methodologies have been investigated and applied to organisational systems and processes as opportunities have arisen.

However, for innovation and sustainable thinking to occur, our challenge is to move away from “we’ve always done it like this” to developing ways to work better with our changing world – we can no longer rely on historic performance to give us the right answer for the future. So, engineers and designers need to be encouraged to think about project solutions in a wider context. Innovation objectives were identified by NSCC, they were:

- Continuous improvement
- Better, or more appropriate, solutions to problems
- Reduced cost of solutions
- Increased benefits from solutions
- Development of a process to enable these objectives to be achieved consistently.

EARLY INNOVATION AND SUSTAINABLE OUTCOME SUCCESSES

NSCC had already had some early innovation successes. In specimen projects innovation was used at an early stage to identify and find solutions for problems and issues that would not normally have been identified until much later in the design and construction process. Using large workshops, and tools such as strategic foresight (looking from the future back to the present), innovative and sustainable outcomes were developed for large projects such as Rosedale Effluent Tunnel & Outfall Project (Total value \$116 M) and Birkdale Sewer Amplification Project (Total value \$19M.) There was therefore strong support for developing a process to consistently bring innovation into projects.

DEVELOPING TOOLS TO GIVE A CONSISTENT APPROACH

North Shore City Council’s Wastewater Network Strategic Improvement Project commenced in the year 2000 and is ongoing – its aim is to achieve Network Consent by 2021. There are many challenges affecting the implementation of this ambitious city-wide improvement project in a densely populated, urban environment, with iconic beaches and reserves and amenity much valued by the residents. This has necessitated an innovative approach to problem solving from initial identification of solutions through to implementation. The project was identified as an ideal testing ground to build innovation tools into the project

process. SKM in association with Opus is Principal Consultant for this project, working in a co-located team in NSCC offices. The Principal Consultancy also commenced in 2000, so the team currently has 10 years ongoing involvement in the project.

To ensure the project objectives were met, Ideas Accelerator and SKM with subconsultants Opus designed and developed the following resources for use and application in the Water Services department. There are three main innovation resources:

- 1. Idea Initiation - 'Cloud 9 File';** The Cloud Nine file is a place where ideas, problems, opportunities and issues are collected (in a physical file) added to by others in the team prior to development. This physical file is circulated around a team; the file is read, added to and passed on and should reach each member at least once a month.
- 2. Idea Development Resource Kit;** The Idea Development Resource Kit contains resources and tools to assist in developing ideas from the Cloud 9 File. It will also be used to assist discussions at stages that have been identified in the Project Guidelines.
- 3. Project Guidelines and Tools;** The Project Guidelines resource contains the set of tools and templates that is the subject of this paper, that will assist the team to align thinking, make crucial project decisions and ensure that the project is ready to proceed to the next stage of development.

INTEGRATING INNOVATION TOOLS INTO THE PROJECT DEVELOPMENT PROCESS

As part of aligning the QA processes of the Project Office towards NSCC's own Quality System, SKM had been documenting the project processes and developing flow charts and templates to add a project-specific level of detail to North Shore's project management processes.

The projects undertaken by the project office had been separated into:

- **Concept and Preliminary Design;** where choices of different concepts to solve wastewater network problems, such as increasing storage, augmenting existing pipelines, or diverting/transferring flows, or where choices of initial decisions in implementing a concept, such as location and route, are identified and a preferred option chosen. This phase tends to concentrate on idea generation and comparison. The challenges of this phase are to demonstrate that full consideration has been given to a number of options, so that Council has fulfilled its objectives under the Resource Management Act 1989, and that it has applied Quadruple Bottom Line assessments as part of that process, to fulfil its obligations under the Local Government Act 2002 Amendment Act 2006.
- **Detailed Design;** where the details of how an improvement project is going to be built and operated are identified and resolved with end users, often including stages of consenting, and of preparing tender documents to enable the improvement projects to be tendered and built. This phase tends to focus on risk management to achieve construction targets. The challenges of this phase are again appropriate idea generation, but this time focussed at identifying risks and their mitigation measures. Workshops are held with end users to confirm operational requirements, buildability and procurement approaches, and future connections for long term capacity management in the network.
- **Construction;** where the asset is constructed under the supervision of the Council and its agents. The focus at this stage is on a high level of scrutiny involving many routine tasks on a daily, weekly or monthly basis. However the principal challenge at this stage is the

quick resolution of problems when they arise on site, so as not to affect programmes or outturn costs with time delays.

External to the wastewater network strategic improvement project are also the phases of operation and maintenance, and demolition.

For each phase, a flow chart had been developed to identify critical stages and NSCC sign offs. This includes workshops to sign off various stages. A significant challenge for a project of this size, encompassing many individual improvement projects, is to ensure a consistent approach and consistent deliverables for work delivered from the project office and elsewhere, and to ensure that lessons are learnt from previous projects and used as part of the continuing improvement process for new projects. To ensure consistency of approaches, from questions asked at project start up through to deliverables, Project Management Templates were developed for the various project stages, which meant that a comprehensive system existed on which tools could be superimposed.

DEVELOPING AND SELECTING TOOLS

The first stage of the innovation project was for SKM and Ideas Accelerator to discuss and refine each project stage; to define the purpose, outcomes and challenges and to look for opportunities to formally introduce innovation tools and techniques. It was agreed that we would start by trialling innovation processes in the concept and preliminary design stage, based on the idea of having maximum innovation impact early on in projects.

From an engineering or project perspective; innovation can be maximised anywhere solutions are to be identified and weighed up. As engineering of infrastructure comprises defining and solving a problem, innovation tools could theoretically be applied at each problem solving stage of 'idea generation' or 'idea testing' where a preferred solution is selected. However, the process of idea generation tends to be fairly constrained by the existing understanding of the problem, the challenges of including divergent thinking in design have been recognised. (Cooperrider, 2008)

Innovation and creativity tools and techniques aim to provide different perspectives in order to challenge existing assumptions and review the project opportunities and issues throughout the development process; either by encouraging divergent thinking in order to open up and develop new ideas or convergent thinking to analyse and assess ideas for further development.

Applying these tools and techniques in a pragmatic way to a very structured environment can have its challenges as there are many barriers that make it difficult for innovation at this level to prosper. There are strong organisational barriers including: a risk averse culture, lack of resources - time and money to implement and personal barriers such as lack of willingness to change, fear of failure, and lack of motivation to pursue new ideas. This means that in order for staff to adopt an innovation approach; it is essential to develop a set of tools and resources that integrates with the existing project development process and that is easily adapted and applied in a team situation, without taking up valuable resources, time and money.

Using the established process flow charts as a basis for further development, the team determined that the decision-making meetings ie start-up, option generation and option identification meetings were the most suitable parts of the project to introduce in formal

innovation processes, because these meetings are focussed on exploring ideas with key stakeholders, to ensure ultimate agreement to the process used and the option chosen.

Based on 7 years experience of applying innovation tools and techniques to processes and systems within large organisations, Ideas Accelerator chose to utilise and adapt two innovation tools; **Scamper** that assists in the generation of ideas – divergent thinking and **De Bono's Six Thinking Hats** that assists with the assessment or analysis of ideas – convergent thinking.

Both of the selected tools allowed for easy adaptation to fit an infrastructure context, whilst still ensuring that a range of different perspectives were applied. They were also easy to use and require little training in order for them to be effective.

Scamper is used as a check list of questions to spur ideas and help solve problems. It helps to open our minds to new possibilities by assisting us to think of changes that could be made to an idea and thus helps us to generate new ideas. Developed by Bob Eberle, the changes SCAMPER stands for are;

- **S - Substitute** - components, materials, people, what else? What other methods? What other materials? What other ingredients? Other perspectives, tone of voice? Who else?
- **C - Combine** - mix, combine or integrate, what ideas can be combined? What combinations of service / methods can we use? What technologies can we use and adapt?
- **A - Adapt** - alter, change function, what else is like this? What could we copy? What other processes could be adopted? What have other projects and other approaches used?
- **M – Modify / Magnify** - increase or reduce in scale, change shape, what can be made larger/extended? What can be added, stronger, higher, longer, more volume, pressure?
- **P - Put to another use** - what else could be made from this? Other markets, other extensions, new ways to use it? How can we use this in other projects?
- **E - Eliminate / Escape** - remove elements, simplify, reduce to core functionality, what can you condense, leave out, and reduce? Make more cost effective, time effective.
- **R - Reverse / Rearrange** - turn inside out, can we change the sequence or order of implementation? Other sequences? Change of pace and time? Change of schedule?

This method is used to challenge ideas, and gather more information for future research and subsequent implementation. (Mindtools, 2009)

De Bono's Six Thinking Hats; Six Thinking Hats is used to develop and assess ideas and opportunities; by using parallel thinking to help us to analyse ideas from six different perspectives. Parallel thinking is when our thinking focus is split into specific directions, thus avoiding potential adversarial situations (when different 'perspectives' are being applied to one idea at one time). The method is attributed to Dr. Edward de Bono and is the subject of his book, *Six Thinking Hats* (de Bono, 1999).

The premise of the method is that the human brain thinks in six distinct ways. Each of these ways is represented by a coloured hat, that indicates the thinking style that you should adopt when thinking from that mode. De Bono's Six Thinking Hats is a structured process used to ensure that an idea is evaluated and developed from a range of perspectives in order to improve the outcome or solution.

- **White Hat;** what information, fact and figures are available? What analytical fact and figures, data, tests do we need to carry out?
- **Black Hat;** Caution, judgment or devil's advocate, used to identify flaws or barriers. Who will oppose the idea? What are the risks associated with the idea?
- **Red Hat;** Emotions, feelings and instinctive gut reaction. How does everyone feel about the idea? What is your gut feel or intuition?
- **Yellow Hat;** Benefits, the optimist, seeking harmony. Who will support the idea? What benefits does it have for you and your customers?
- **Green Hat;** Creativity, ideas and statements of provocation and investigation. How could we do it in a different way? How could the plan be improved to increase its success?
- **Blue Hat;** Strategy, blue sky thinking and next steps. What are the next planning steps? How do we make this happen? Who is doing what? Are we solving the problem?

ADAPTING THE TOOLS FOR ENGINEERING PROJECTS –CONCEPTUAL DESIGN STAGES

It was agreed that the existing templated project management system would be used, with the intention of integrating innovation and making the innovation process so easy to use that it would be easier to use it than not use it. Ideally, the innovation tools should be able to be used in a standard project context, without a facilitator.

For idea generation, SKM and Ideas Accelerator brainstormed the overall ideas of SCAMPER – substitute, combine, adapt, which was merged with modify/magnify, put to other uses, eliminate/escape and reverse/rearrange, and what they actually meant in engineering terms. Terminology was kept as broad as possible, with a view to being able to adopt the ideas across Council projects if the trial was successful, e.g flows could be taken to mean fluid flows, or traffic flows. As SKM's Project Manager is also the Sustainability Practitioner for NZ, sustainability questions were incorporated where appropriate to bring in consideration of future changes, and to bring in community and social contexts as well as the standard technical and economic considerations.

The Generate Concepts Guide was developed by refining and adapting sets of questions, from the SCAMPER methodology, and incorporating some of the elements of TRIZ, a very structured innovation methodology used specifically for problem solving.

TRIZ, also known as the Theory of Inventive Problem Solving (TIPS), a Russian acronym, was developed by Genrich S. Altshuller in the 1950s. TRIZ theory holds that there are two types of problems people face: Problems with generally known solutions and problems with unknown solutions – it also operates using a set of questions to develop, assess and evaluate, problems, ideas and opportunities. The structured methodology gave us the idea of presenting the innovation tools as a series of questions to be asked at the decision-making meetings.

The Generate Concepts Guide was used to increase the number of ideas generated and was adapted to fit each phase of the project development process by asking a number of questions under the following headers: -

- How can we change the resources used, or future-proof the option for changes in resources or conditions?
- How can we change the problem – by changing flows etc?
- How can we change the solution, by changing layout etc?

- How can we add value to the solution we have?

The Generate Concepts Guide will be presented at the NZSSES Conference.

The questions above were intended to be asked at the ‘generate options’ workshop, and to act as a prompt for the meeting leader. The Generate Concepts Guide (based on the Scamper concept) was integrated into concept design and preliminary design process phases and was listed for use as part of the meeting and workshop template process.

For option analysis, SKM Opus and Ideas Accelerator reviewed the criteria required by NSCC’s Quadruple Bottom Line analysis, and the criteria used in SKM’s multi-criteria analysis, as well as the option agreement workshop agenda and meeting objectives. We determined that for preliminary and concept design, the meeting had 6 stages, which could be developed into a series of questions based on the six hats principles. These stages are;

- Weighing up each option in terms of the multi- criteria analysis, ie summing the relevant facts for each option (White hat). The options would be scored.
- Considering whether the option meets NSCC objectives, and whether it has any additional benefits or reasons for supporting it, outside the multi-criteria analysis and the objectives (yellow hat).
- Considering the risks associated with the option, including reasons for the option not gathering council or community support (black hat).

At this stage, the meeting leader would adjust the scores, to identify the preferred option and any close runners up to be considered further. The attendees would then brainstorm to check the outcome, as follows:

- Reviewing whether the option could be improved, and how it could be improved (green hat)
- Checking that everyone is happy, and in agreement (red hat)

The final stage, to close the meeting, is to agree on what happens next – future work stages.

The Evaluate Options Guide was developed as above based on using De Bono’s Six Thinking Hats method to challenge thinking from six perspectives, but without incorporating role play. It was integrated into each process phase and was listed for use as part of the meeting and workshop template process. The guide takes the form of a meeting structure for the person leading the meeting.

The Project Guidelines were designed so all resources; process flow maps, planning guides and meeting and workshop templates, were available for use in one place.

TRIALLING TOOLS AT CONCEPT DESIGN STAGE – OUTCOMES AND LESSONS

A key lesson in identifying innovation tools was that we were missing the opportunity to bring stakeholders into the project at ideas generation stage. A consequence of that was that potentially, stakeholders would be dissatisfied at a later stage with the range of options considered, which could impact on selecting a preferred option, or even on likelihood of attaining Landowner or RMA consent for the option implementation.

SKM and subconsultants Opus had just commenced a task to undertake concept design for a new pumping station to service a major growth area in the north of North Shore City. Preliminary assessments in the early 1990s had identified a potential site within a recreational reserve, and some geotechnical investigation had been undertaken, but no agreements had been reached with NSCC Parks as landowner. In addition, the area was developing significantly, and NSCC roading were planning several transport initiatives in the area, including developing a 'park and ride' facility.

NSCC Water and SKM Opus agreed that we would modify our option generation meeting to include potential in-Council stakeholders from Roading and Parks, as well as NSCC's Water stakeholders from Wastewater Planning, Projects and Operations, and Stormwater Planning. To cater for a varying extent of familiarity with the area, we agreed that the option generation meeting should be held on site. This would enable everyone to see elements such as local topography, extent of tree cover and other potential constraints to options.

We agreed that the site meeting should comprise an initial briefing stage, to establish the problem to be solved and summarise the work done to date on identifying a solution, and to encourage the others to talk about their plans for the area. This would be followed by a tour of potential sites identified by the project team, and any other sites identified by the team and the stakeholders whilst on site. The meeting would then re-convene to consider the idea generation concepts in the Innovation Toolkit. Briefing documents were prepared, comprising aerial photographs of the area, with existing wastewater network and potential sites identified so far overlaid, and an explanation of the option generation and option appraisal process.

Prior to the meeting, four areas had been identified as potential sites, some with two potential locations within a site. The group identified nine specific sites in total, and discussed the advantages and disadvantages of each site and specific issues as they went along.

The Generate Concepts Guide was used on site to generate ideas such as combining a toilet block into the pumping station if it was located on the reserve, and there was much discussion about community uses or benefits, and opportunities for different council departments to work together. However, the ELIMINATE aspect helped the project team to review whether a pump station was required, or whether capacity issues could be resolved by bypassing some of the flow to further downstream with a new gravity sewer. This bypass option has been added to the option list.

Lessons learned from undertaking the new option generation process and using the new innovation tool are as follows, based on feedback from the team and the stakeholders:

- Involving stakeholders earlier in the project brings in a need to develop briefing materials, and to spend more time explaining the project at an early stage, and in non-technical language.
- Site visits are very useful to communicate constraints, and to identify options which may not be obvious on paper.
- Stakeholders with different drivers will see different sites as suitable – if we bring them in at option generation stage and examine them, even if they are later proved un-viable we do not slow down the process by having to examine them or justify their exclusion later.
- The site visit identified a number of projects flagged for the same Reserve site – doing this at project scoping stage enables synergies to be explored and ensures that all parties are aware of each other's plans.

- The use of the ideas list of questions was a little stilted, because it was new to all participants. With familiarity, the meeting leader could probably make sure the questions flowed better and that all were appropriate for the problem being addressed.
- The process achieved all the goals identified above.
- Stakeholders commented favourably on the whole option appraisal process.

The Generate Concepts Guide was modified by SKM Opus for use in facilitating city-wide issues workshops as part of NSCC's recent update of the Wastewater Network Strategic Improvement Project. The Project Team has adopted both tools for use in ongoing projects, and the Option Evaluation tool is likely to be utilised in the near future.

The bypass option was subsequently chosen as the preferred option, reducing the construction cost by about 8%, and reducing the consenting and construction programme by approximately 1 year. Prior to this, the success of the trial in improving innovation and engagement meant that NSCC commissioned SKM and Ideas Accelerator to develop innovation tools for the project stages of Detailed Design and Construction.

DEVELOPING TOOLS FOR DETAILED DESIGN AND CONSTRUCTION

Detailed design proved to be more risk-focussed, and as such relied on the Project Management template risk documents as the basis for brainstorming ideas to mitigate risk and facilitate delivery. The team's focus moved to construction problem solving with the intention of developing a tool that could be used for rapid problem solving at design stage or on site.

Construction innovation is a well-developed science from the Contractor's perspective, to increase competitiveness and add value. From the Client and Consultant perspective, we therefore concentrated on the times when the whole project team comes together on site to troubleshoot specific problems. This process is very tightly focussed on solving a perceived problem in a defined time frame at minimum cost. Three processes were identified as being necessary to get a good outcome:

- Define and understand the problem
- Find solutions to the problem
- Evaluate the preferred option, and assess risks to implementation.

Ideas Accelerator suggested using Root Cause Analysis as a way of developing a simple tool that helps to define the real problem to be addressed. The team developed a tool which used '5 stages of why' to drill down to understanding of the problem to be solved. This was developed as part of a meeting Agenda, with an example built into the tool to make it easier for the people using the tool to understand what was being sought.

As brainstorming was agreed to be the most appropriate way of developing solutions to the problem once defined, the tool incorporated a brainstorming stage. This was deemed to be the best way to leave the ideas generation as unconstrained as possible. It directed users towards the Idea Development Resource Kit as containing useful brainstorming tools and techniques.

To assess the options, the Evaluate Options Guide was identified to still be a suitable tool, however the list of questions was abbreviated and the tool redeveloped. This was presented as a beermat, to introduce a sense of fun.

TRIALING DESIGN AND CONSTRUCTION INNOVATION TOOLS

The tools were trialled on a real site problem for a NSCC project that SKM was not involved in. NSCC staff led the meeting, and SKM staff were invited to attend to contribute ideas.

Our site problem was a very deep manhole. A large shaft 30m deep was excavated and de-watered to construct the manhole in . Once the manhole was in place, there was only 600mm to 1 metre of working room left around it. The Contractor needed to backfill around the manhole, to give a flat ground surface and allow the water table to recover. Initially, this had been designed to be done with flowable fill because there was no access to compact it, and it needed to be something that was watertight. However, this flowable fill was expensive and a workshop was held to seek a lower cost solution.

The use of the root cause analysis tool identified two separate problems: backfilling a constrained space, and making the manhole impermeable. The group brainstormed solutions to the two problems separately. Lots of options were defined for each solution, including elements of material reuse, such as sealing the manhole with waterseal paint, then using inert waste to fill the shaft.

The beer mat - evaluation tool was used to start assessing the options, but found that we stopped on item one – the cost and other implications of the different solutions were not known, because the solutions identified with were not what was anticipated. As there was insufficient data to analyse further, the ideas were taken back to the design and construction team. Due to time constraints and performance queries about water sealing, ultimately the flowable fill option was still used, however the tools had been successfully deployed.

The main lesson learnt from trialling this tool was that cost data is unlikely to be readily to hand, so two meetings, or a meeting plus further investigation may be needed to establish a solution. For site problems, it is therefore important to establish a collaborative problem sharing approach early on.

CONCLUSIONS

North Shore City Council is committed to an Innovation approach across its functions. It is believed that Council has made the first steps to progress from ‘Continuous Improvement’ to ‘Continuous Innovation’ with its innovation initiatives. It is expected that, with the help of its consultants and other stakeholders, the use of the many tools and processes in the area of innovation, such as those covered in this paper, Council will make significant steps towards ensuring that the community receives the best possible services , both now and in the future.

Subjecting the Project’s QA processes to scrutiny by explaining them to a third party has identified some improvements, and has reinforced the value of developing a process-based system aligned with NSCC’s processes.

The tools that have been developed are easy to use, and enable the project team to incorporate innovation tools into meetings easily as they have now been integrated as part of a ‘business as usual’ process. There are many approaches for assessing options in infrastructure design, but far fewer are in use for ideas generation. These tools are novel, in that they have been specifically designed with infrastructure problems and outcomes in mind, and bring a

structure for innovation across design and site problems as well as the traditional area where innovation is focussed, which is concept design.

Our experience to date has been that the tools and processes encourage buy in, and provide a good framework for encouraging divergent thinking in option identification and assessment. Innovation has already proven to deliver significant value to the council, its contractors and staff; through project cost reductions, increased efficiency and planning for better use of resources on site.

The innovation tools have been designed for wastewater, but would also be relevant to other water, and to transportation. With minor amendments they would be applicable to other infrastructure problems. We therefore believe they would be useful to other councils and infrastructure authorities in New Zealand, and the concepts would also be applicable elsewhere. In general, the authors believe that a structured approach to innovation has benefits in terms of both innovation and project management, and would encourage other authorities to identify and focus on key times for innovation within their projects.

REFERENCES

- OECD, O. f. E. C.-o. a. D. (1997). Oslo Manual - National Innovation Systems: 9.
- Statistics, N. Z. D. o. (2004). Innovation in New Zealand 2003. B. Pink, Statistics New Zealand, Te
- De Bono, Edward (1999), Six Thinking Hats, 1999, Back Bay Books Ltd.
- TRIZWorks, (2010), weblink <http://www.ciri.org.nz/trizworks/index.html>
- Cooperrider, Bryan,(2008) “The Importance of Divergent Thinking in Engineering Design”, Proceedings of the 2008 American Society for Engineering Education Pacific Southwest Annual Conference.
- Mindtools, (2009), weblink http://www.mindtools.com/pages/article/newCT_02.htm.
Accessed July 2009
- SKM (2009) Policy on Sustainable Development