INTERDISCIPLINARY INTERSECTIONS:

New roles For digital technologies and landscape architecture in the design of large scale infrastructures

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Abstract. The introduction of BIM is assumed to introduce higher degrees of collaboration and efficiencies within design and construction practices. The potentials of this collaboration tend to focus on architecture, engineering and construction (AEC). Landscape architecture is rarely discussed within this model, technically nor conceptual. This paper explores the potentials of landscape architecture's contribution to this new model of digitally driven collaboration. Drawing on interviews with the architects, landscape architects and engineers we explore the role of landscape architecture in the conceptualization, design and construction of the Victorian Desalination Plant, a highly political project located on an ecological sensitive coastal site. This paper highlights the centrality of the landscape digital model in mediating the critical intersection between the design parameters, physical attributes of the site, performative qualities of the design and the disciplines of architecture, landscape and engineering. This model also formed the dominant method for communicating the complex project to stake holders and clients. Significantly, this model was not developed into a BIM model, with content instead integrated into the architectural and engineering models. This research highlights one of the major difficulties in conceptualizing the positioning of landscape architecture within a BIM driven collaborative process. To operate effectively, landscape architecture must engage across the multiple scales and disciplinary intersections. Consequently, landscape architects must understand the digital and spatial languages of architecture and engineering, and conceptualise where their contribution lies within 'paperless' design and construction processes. This outcome differs significantly from current debates within landscape architecture which instead focus on the identification of 'the' specialist BIM software most appropriate to the discipline, as distinct from understanding BIM as a collaborative process.

1. Introduction

In recent years, there has been increasing interest in disciplinary collaboration within design practice. This focus has been heightened by the growing acceptance of BIM, which is conceived as a powerful platform for collaborative. As observed by Ashcroft (2010) ‘BIM’S power is enhanced by collaboration, and collaboration is made more effective through BIM.’ Sharples (2010) expands further on BIM’s potential stating:

combined with top-down measures, like integrated project delivery, that encourage collaboration, this technology can ultimately help the parties in the construction project work as a team with shared goals and responsibilities.

To date, consideration of the collaborative potentials of BIM overwhelmingly focus on the relationship between engineering, architecture and the construction (AEC) industry.

The profession of landscape architecture has been slow to engage with the potentials of digital technologies within design and construction processes. Instead attention has remained predominantly on visual simulation modelling (Bishop & Lange, 2005; Mach & Petschek, 2005; Orland et al, 2001). This reluctance to align landscape architecture more closely with the allied disciplines of architecture and engineering however is being challenged by legislative changes to construction processes. By 2016 it is expected that the UK government will mandate BIM in all major projects (Ahmad & Aliyu 2012). Similar intent is being expressed in Australia.

These significant changes to construction processes and procedures have generated concern within landscape architecture; namely ‘that lack of expertise in the use of Landscape Information Modelling could effectively remove landscape architects from the supply chain’ (Ahmad & Aliyu). Debate centres around the operability of software, for example which BIM software (Autodesk Revit, Bentley, ArchiTerra, Vectorworks Landmark) is the most appropriate for a ‘LIM,’ a landscape architecture centric model.

We suggest that the intent to delineate LIM from BIM (a common position in landscape architecture) together with the desire to identify ‘the’ optimum software highlights two problematic conceptualisations of BIM. First, it demonstrates that BIM is not understood as a collaborative process which crosses disciplines concerned with the construction of the built environment. And secondly, it suggests that many landscape architects are conceiving BIM as a one-stop digital platform in which to design and document their work.

We argue that before reducing the discussion to software selection, it is important to consider broader conceptual questions of how landscape architecture fits within expanded notion of collaboration afforded by digital technologies. What is our critical contribution to the built environment and, further what is landscape architecture’s value within a revised AECL (Architecture, Engineering, Construction and Landscape) collaboration?

The Victorian Desalination Project, constructed in south-eastern Australia, offers a valuable precedent for exploring this question. The highly political project is one of the largest infrastructural works in Australia in terms of both water supply and capital investment. It is considered the 'largest public sector investment in water infrastructure in Australia' and 'the world's largest Public Private Partnership (PPP) project' with a planned total investment of AU$ 9.5 billion and AU$3.5 billion public contribution (State Government, 2009). The project has been conceptualised as a public service to prepare the Melbourne metropolitan region for the impact of climate uncertainty and challenges of decreasing precipitation. Upon completion, the desalination plant aims to provide a secure water supply for Melbourne, Geelong, and regional towns in the South Gippsland and the Western Port regions, and will have a capacity to provide up to 150 gigalitres (GL) of water a year with the potential for expanding the supply to 200 GL per year.

The project is also highly controversial and contested for its scale and potential environmental impact. While the plan sets out to deliver a 'green' and climate change conscious project, the project’s dependency on coal to meet the extensive energy demands of the infrastructure has attracted extensive criticism. In addition, the construction site is situated in a highly sensitive coastal environment. To mitigate the environmental impact, the competitive tender process included strict evaluation criteria that bidders needed to consider in their proposals, including visual intrusion and noise; protection of beneficial uses of the coastal and marine environment; provision of recreational values of the adjacent coastal reserve, and establishing and maintaining 'the highest level of health, safety and aesthetics throughout the delivery and operation of the Project' (State Government, 2009).

The plant was therefore not only envisaged as infrastructural facility but also as part of a new 225 hectare coastal park with extensive revegetation.

The project was awarded in 2009 to the AquaSure consortium based on a submission that promises to deliver a:

world class architecture and landscaping, integrating the plant into the coastal environment and incorporating a large network of recreational trails, wetlands and one of the largest ecological restoration programs (State Government, 2009).

Under the leadership of the engineering joint venture Degrémont-Thiess Services the design and construction team included ARM Architects, PeckvonHartel with Parsons Brinkerhoff / Beca engineers, landscape architects ASPECT Studios and ecological specialists, Practical Ecology.

The initial design concept by AAE Architects of France, ASPECT Studios and PeckvonHartel proposed the integration of the infrastructure within a dunal landscape. These ideas were then developed further by ARM Architects, who replaced AAE Architects in the next design phase.

The ambitious scope of this project, together with the involvement of a landscape architecture practice with a high digital capability (including experience in parametric design which is rare in landscape architecture) makes the Victorian Desalination Project an excellent project to explore collaborative relationships. Drawing on interviews with the architects, landscape architects and engineers, this paper explores the influence of digital technologies in the collaborative development, delivery and promotion of this project.

The first section focuses on the relationship between landscape architecture, architecture and digital technologies in the conceptualization and design development of the architecture and the master plan. This is followed by a discussion on the intersection between landscape architecture, engineering and construction pragmatisms. The paper concludes with reflection on the general process of collaboration and the potentials of digital technology to reconceptualise practice.

2. The Green Line -the intersection between Architecture and Landscape

The integration of the architecture and landscape was central to the success of the winning bid. Unlike many design approaches that seek to visually hide or mask the presence of infrastructure within visually and ecological sensitive sites, this project aims to integrate the project within this unique coastal landscape (Figure 1). So how was this intersection achieved, and what role did digital technologies play?

Figure 1. Scale and coastal context of the Victorian Desalination Plant. (State Government Victoria, 2009. Partnerships Victoria: Project Summary)

The first design moves were determined by the engineers, who provided the overall footprint of the major structures and infrastructure based on geological factors (given the site was a former swamp and quarry site). The architects ARM identified three broad strategies for developing a design relationship to the site: ‘an expressed object in the landscape, objects as part of the landscape and hybrid solutions’ [1]. A hybrid approach was adopted, generating a design strategy which became known as ‘the green line.’ Over time, the term ‘the green line’ became an important short hand for describing this complex and vast project (Bauer 2013).

This hybrid approach emerged from a diverse range of influences encompassing land art, sustainability concerns, international and Australian precedents for large scale infrastructure and the history of Aquarius [1]. The most extensive engineering plant was accommodated in a vast central structure measuring over 20,000 square metres. This plant was essentially accommodated in a ‘large shed’ (Lambrou 2013). The architect’s ability to work in 3-dimensions (using 3D Studio Max) was critical in transforming the extensive plant into more articulated form and experience.

As stated previously, the visibility of the project was of major importance to the client. Two issues were influential. First, minimising the appearance of the plant from a series of points nominated by the client; and secondly, considering the view of the project from the air, given many of the media images would be taken from above (via a helicopter). Articulation of the roof form, combined with the large green roof structure (over 260 metres long) emerged as major design strategies for engaging with the visual aspects of the project.

A close working relationship between the landscape architects and architects was critical to minimising the project’s visability. The design form emerged through a collaborative process, with the two disciplines sitting side-by side to modify the architectural 3-dimensional model. Working within the slope requirements for the green roof and selected visual locations, the roof form was developed through the pushing and pulling of points within the model.

Through this successive testing, the view of the roof from ground level emerged as ‘a fragmenting landscape’ developing into a series of dunes. (Lambrou 2013). From above (Figure 2), the scale was minimized significantly, aided by the patterning of the flat roof surface and the green roof structure which merged into the broader master plan move of ‘the green line.’ Initially the roof surface was designed as a gravel patterned surface. Long term maintenance issues however resulted in the pattern being conceived as a two tone membrane.

Figure 2. Aerial View of the Green Line. (State Government Victoria)

The architect’s exploration of surface pattern continued into the design of the elevations. Different projections of water rippling and flooding patterns were projected on to the 3-dimensional model. Fragments of this model were then sent to the contractor for test panel samples, informing the design of the large concrete façade panels (Figure 3). The architects are very explicit about the role computer modeling plays in a generative design process. In their hands, it is not conceived as a representational tool, but instead a valuable feedback process which ‘informs us back’ (Lambrou 2013).

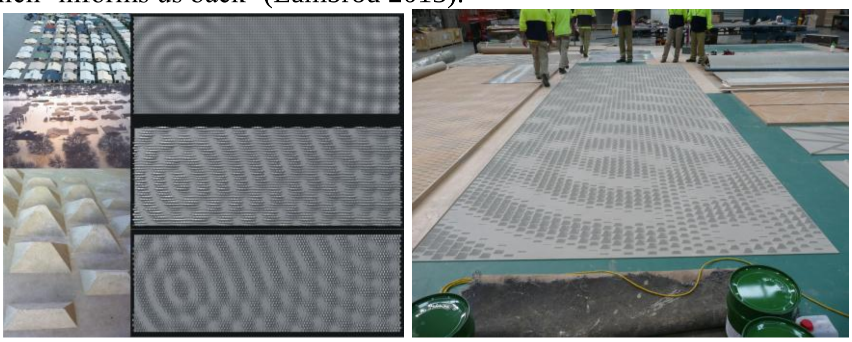

Figure 3. Transforming surface patterns into materiality. (ARM architects)

At times, these patterns and experimentation extended into the land form as shown in Figure 4. However it was at this point where different disciplinary intents emerged between the landscape architects and architects. To the landscape architects, landform represents far more than a pattern, instead part of a complex ecological system. This understanding necessitated the development of a more expansive 3-dimensional model produced in Maya based on detailed site information and base terrain information provided by the civil engineers. Working at a larger scale, the landscape architects became responsible for integrating the architectural agendas with the complexity of existing topography, ecology, drainage lines and visual implications. The green line formed only a small proportion of the entire site, as shown in Figure 5.

Although technically ‘last on the job,’ the landscape architects and their 3 dimensional model assumed a pivotal role in resolving how all of the components crossing engineering, architecture, landscape architecture, related to each other (Sago, 2013). It was this model that facilitated an engagement with the ‘tyranny of scale’ so inherent in the complex and political scheme (Sago, 2013). The model also featured a parametric component which allowed a more complex and accurate exploration of topography, experience, ecology, and visualisation.

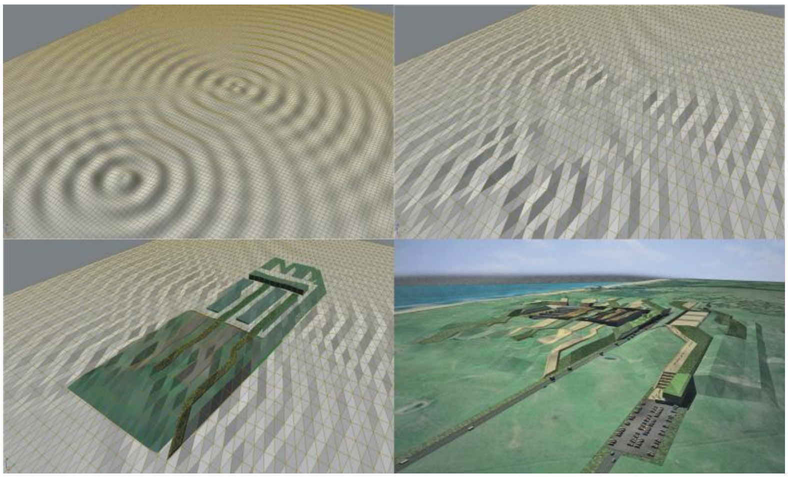

*Figure 4.*Architectural explorations of surface patterns. (ARM architects)

Figure 5. The entire site of the Desalination Plant. (State Government Victoria)

Importantly the model allowed the designers to work concurrently across multiple scales; testing the impact of their proposals from accurately located GPS points (Figure 6), while also understanding the experience of space at a more immediate level. The visibility of the scheme for example was examined from as far as 10 kilometres away. Within this process, the visual impact of the scheme did not form the dominant design parameter, instead offering just one of many criteria that the designers responded to. This differs significantly from more conventional approaches to the design of large scale infrastructure where often the sole input of the landscape architect is to 'screen' the works, after the majority of the design decisions have been finalised.

The landscape model allowed the expansion of design focus from the architectural scale into consideration of how this infrastructural insertion would work within the broader framing of the ecological park. The model's ability to shift scale and represent complex and irregular topographic form facilitated the interrogation of the relationship between the constructed dunal topography encompassing the plant and the larger natural ecological coastal system. This shifted the positioning of the dunal forms from a screening gesture to instead be conceived as part of an experiential and ecologically driven design.

Figure 6. Checking the view of the project from GPS located points. (State Government Victoria)

Within conventional representational methods which rely on multiple sections and 2-dimensional contours, testing the design across multiple scales would be extremely time consuming and difficult to comprehend. The screen shot from the Maya model, shown in Figure 7, highlight the ability to visualise and understand the complex relationship between the infrastructure and topographic form.

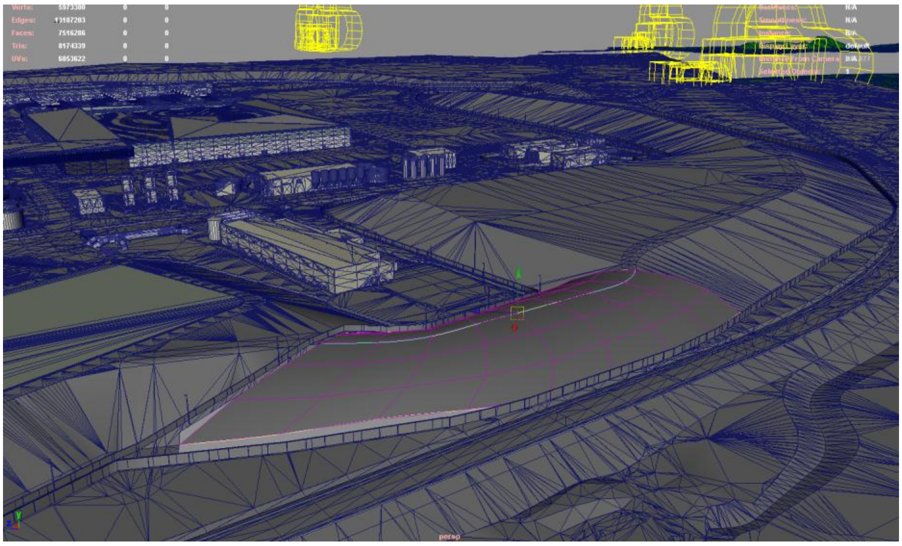

Figure 7. The Landscape Maya model which highlights the positioning of the infrastructure within the larger context of the ecological park. (ASPECT Studio)

Significantly, it was the landscape model which assumed the important role as the major representation for presenting the complexity of the project to the diverse stake holder groups who included politicians, State Government Architect, engineers and government representatives. While the architects had their own images and renders developed from their 3D Studio Max model, these were presented in isolation and focused on the architectural design. All of the consultants considered the landscape model 'the ultimate communication tool'(Bauer 2013).

This model formed the basis for gaining major approvals. During the extensive client meetings required for a project of this scale, the landscape architects would talk directly to the digital model which was navigated by a colleague. These meeting were 'very efficient' which resulted in minimal interruptions in the project (Bauer 2013). If we adopted more traditional models of presentation such as plans, sections and collages, reflect ASPECT Studio, 'we couldn't be sure that twenty people in the room would get it at the same time' and 'there would be enormous amount of time spent answering questions' (Bauer & Sago 2013). The centrality of the model also served to elevate the hierarchical position of the landscape architects within the consultancy team.

The landscape model not only offered the broader contextualization of the project, but told the process of the project, which by default highlighted the rigour achieved in the scheme. The model was pivotal in 'telling a really good story'(Sago 2013).

In the next part of the paper we shift focus to examine the relationship between the landscape architects, engineering and construction processes. Due to the nature of their work, the landscape architects established a very close relationship with both civil engineers and architects. Somewhat surprising, the engineers and architects developed a less pivotal relationship, partly due to the more constrained role of the architecture.

3. Integrating Pragmatics with Experience: the intersection between Civil Engineering and Landscape Architecture

Balancing the extensive cut and fill generated by an infrastructural job of this magnitude forms a major factor in achieving a successful outcome. As lead consultants, the engineering firm had committed to a 'cut and fill' volume design during the tender phase, which was considered essential to maintain from a cost control perspective (Long 2013). The landscape architects formed an essential role in achieving this outcome, while at the same time exploring the potentials of topographic landform as experience and space.

The engineers provided the landscape architects with calculations of fill, rough locations of mounds, together with prescribed heights to which they needed to respond. The Maya model proved invaluable for allowing the landscape architects to work iteratively, while simultaneously understanding the implications of their design on cut and fill volumes. Parametric drivers were established on top of the rough mounds provided by the civil engineers. Form could then be manipulated and tested through the pushing and pulling of points. At times the side profile might also be fixed by the engineers. However the landscape architects could still move the tops and crown lines to explore different configurations and undulation, as demonstrated in the screen shot shown in Figure 8.

The establishment of a command inside Maya allowed the landscape architects the ability to run 'cubic meter volume calculations' alongside their topographic modelling explorations (Sago 2013). While not offering the precision of real time calculation, 'this process was as close as possible to obtaining a real time review with the existing technology' (Sago 2013). The ability to test form directly within 3-dimensional space offers a very different experience to traditional 2-dimensional modes of design more reliant on contours and sections. As the landscape architects observe, this process 'fundamentally changes the way that designers play with the forms they are working with shifting the way they see them, experience them and think about them'(Bauer & Sago 2013).

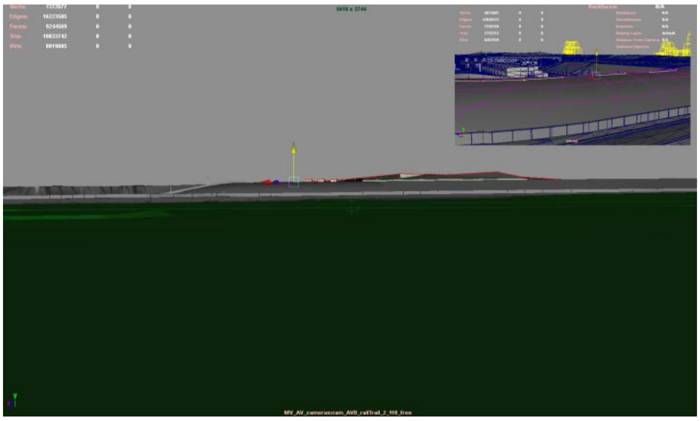

Figure 8. Real time review of topographic form, cut and fill volumes and design performance. (ASPECT Studio)

This mode of working provided ASPECT Studio with enormous confidence in responding to the parameters established by the engineers, in addition to the ability 'to spit out fast visualisations to the people who had to approve their work' (Sago 2013). Most importantly, it provided the landscape architects with a clear understanding of what they had produced, 'as every bit has a purpose worked out in 3-dimensions (Bauer 2013)

The ability to understand and manipulate the intent of the topographic land form fundamentally shifts the landscape architect's position within a large scale infrastructural project. The landscape architects are now integral to the design itself, no longer limited to screening infrastructure (predominantly through vegetation) after all the design and technical decisions are completed. In contrast the landscape of the Victorian Desalination Plant is conceived as a spatial experience in its own right. Consequently, the topographic form of the landscape emerged as 'playful and really interesting'….not just a boring and pragmatic thing' (Bauer & Sago 2013). Figures 9 and 10 demonstrate the multi-functional role of the landscape which performs as experience, ecology, visual mediator and a major design element.

This expanded role for the landscape architects was also achieved with financial efficiency. Firstly, the major topographic forms emerge from the need to maintain the huge amount of fill generated from the excavation on site. Secondly, the iterative design generation process facilitated by 3- dimensional modelling was time efficient, with the landscape architects suggesting it was produced in less than 20 percent of the time required using more conventional representation techniques. Thirdly, this speed in working with land form resulted in the exploration and consideration of far more iterations and possibilities than in other more orthodox design processes.

ASPECT Studio's detailed topographic design was eventually converted by the civil engineers into their 12 d civil engineering model (with the architects ARM documenting their work within a Revit model). Few problems arose in the translation of the design between these different digital models. Information from the 12 d model was subsequently converted by surveyors into data to direct the grading machines on site. This final construction phase represents the end of a largely 'paperless' design and construct process, moving from virtual space to realized topographic form.

Figure 9. View of the green line land form meeting the green roof of the Desalination Plant. (State Government Victoria)

*Figure 10.*View from the publically accessible ecological park towards the Desalination Plant. (State Government Victoria)

This largely design and construct model, is now being considered by the Victorian State government as a best practice example for the design of large-scale infrastructure. From its inception, the complexity and aspiration of the project was supported by the good financial resourcing and establishment of a strong review panel, which included designers and the Victorian Government Architect. These factors, alongside political commitment that the project be delivered to a high standard, combined to produce an environment of innovation.

5. Understanding the Collaboration

The overall scope and complexity of the Desalination project provided enormous challenges for all stakeholders involved in the project's design and construction. The project was extremely fast paced, a factor of financial constraints and its political significance (heightened by a decade-long drought in south-eastern Australia). At times over 400 people worked simultaneously on the project making it 'very different to any other projects' the consultants would usually engage in (Long, 2013).

It is clear from this review of design and construction processes that the consultant's shared commitment to working in a digital environment, from the beginning of the bidding phase through to the construction and implementation, proved invaluable in managing the complexities of scale, together with the technical, ecological and aesthetic attributes inherent to this type of project. In doing so, it allowed the project team to develop an alternative communication process. The three-dimensional environment created the possibility for a shared design language, making it easier for all parties to evaluate the consequences of individual design actions on the larger project scale. It also allowed for the visualising of emerging issues instantaneously, which then could be resolved in collective manner. It can be suggested that the overwhelmingly positive experience of working on the project expressed by the engineers, landscape architects and architects is a result of the design process's success in establishing scope for 'multiple authorships'(Bauer, 2013).

However it is important to note that there was no singular model. Instead at least four digital models produced in various soft wares were significant; the landscape architecture model, the architect's design model and BIM model and the engineers BIM model. Consequently the development emerged across multiple digital platforms. The Desalination Plant project demonstrates that working within digital models produced a ‘conversational design process’ where hierarchical and disciplinary boundaries dissolve as designers and computer specialists are sitting side by side, irrespective of their disciplinary roles. In this way the landscape architects would often directly influence architectural design decision-making.

Since the digital models provided immediate evidences of functional, ecological and aesthetic implications of design moves it empowered the landscape architects to lead in significant parts of the project. It also assisted in achieving general consensus in the design and construction processes with very few points of frictions. According to ASPECT Studios, the only moment of disparity occurred when the architects became concerned that the landscape was performing ‘too well’ in blending the building within the landscape and 'making it disappear'. To re-establish a clear visual and spatial delineation between the building and the landform, the architects insisted on introducing a hard concrete wall at the point of intersection.

Focusing more specifically on the landscape digital model, it is possible to isolate three major influences. First, the model performed a vital role in managing the complexities of scale inherent to the project. Secondly, the model was influential in defining the design process as an integrated system which encompasses infrastructural, experiential and ecological performative aspects in a highly technical project. And finally, the model provided the most valuable means for communicating this complex project to the diverse client group. These contributions align with the advantages cited within a BIM centred design and construction process. In a 2013 presentation McGaw-Hill for example highlighted the top five advantages of adopting BIM. These included:

- Spatial coordination;
- Presentation of the visualisation of architectural design;
- Improved collective understanding of design intent;
- Improved overall project quality; and
- Quantity take-off.

It is clear that the landscape architects contributed significantly to four of these categories. However as discussed in the paper, the landscape model was not developed as a standalone BIM model, with content instead informing the architectural and engineering BIM models.

This outcome highlights one of the major difficulties of conceptualizing the positioning of landscape architecture within a BIM driven collaborative process, especially on a project of this size and complexity. To operate effectively, landscape architecture must engage with multiple scales and intersect across architecture and engineering. Compatible software packages are key to this process, first to ensure that all parties work with the same datum and, second, work to the individual strength for delivering the required tasks. However this process also points to potential shortcoming in the landscape architecture profession focusing on the identification of ‘the’ specialist LIM software which can do it all.

Instead, as this research suggests, the landscape architect needs to be familiar with the operability of multiple digital platforms, together with an understanding of the specific digital and spatial languages of architecture and engineering. Given the disciplines well documented hesitancy to engage with digital technologies within design, this will require a more comprehensive repositioning of the discipline than simply identifying appropriate software. This outcome points to potential shortcoming within current debates within landscape architecture which focus on the identification of ‘the’ specialist LIM software.

More importantly landscape architects need to clearly identify their contribution within increasingly complex design projects. For example, ASPECT Studio's well developed digital literacy (including a parametric design approach) allowed them to confidently insert themselves within the complex and increasing 'paperless' design and construction processes that shaped the Desalination Plant. Without this 3-dimensional capability and literacy, the landscape architects would have been not shared the common spatial language which was central in supporting an iterative and multi-disciplinary design process. To maintain a pivotal and relevant role within complex infrastructural projects, landscape architects need to frame their knowledge beyond the pursuit of a singular 'LIM" model to instead familiarize themselves with multiple digital platforms, including an understanding of the digital and spatial languages of architecture and engineering.

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11 April 2013 Interview with Jesse Sago and Kirsten Bauer ASPECT Studios

12 April 2013 Interview Melvyn Long Theiss

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