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Sustainable Built Environment National Research Centre AUSTRALIA

BIM Adoption Case Study Report

Review of Benefits, Challenges, Strategies and Lessons Learnt for the Water Industry

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1. Introduction

It goes without saying, that safe water quality and appropriate sanitation are essential to sustaining economic growth and the high standard of living in any country. With numerous construction and engineering partners working on a multitude of water infrastructure projects and providing various formats of design documentation information, water organisations require the collaborative and digital approach to ensure efficient information management for water assets. This in turn would enhance the capacity for operating, maintaining and monitoring infrastructure, plants and expansive natural assets over their entire lifecycle. Nevertheless, where some industries are already successfully incorporating Building Information Modelling (BIM) workflows into their business processes and distribution networks, the water industry has been relatively slow to adapt to this change.

BIM as a process enables to produce a model as an assembly of digital information and facilitates collaboration and information exchange. It delivers value, efficiency and safety while recognising the whole life of asset knowledge and better business information management (BIM4Water, 2017). BIM is also business change which requires introduction of new policies and investment in people, technology and processes to realise the long-term benefits. Overall, the key benefits of BIM include but are not limited to (Araszkiewicz, 2017; BIM4Water, 2017; Hosseini et al., 2018):

- Supporting the whole life of an asset.
- Better design solutions, facilitated standardisation in design and more off-site prefabrication.
- Fewer unexpected design changes during construction.
- Better planning of site activities and construction sequencing.
- Improved constructability.
- Improved on-site safety.
- Reduced capital costs.
- Visualisation (i.e. a complete picture of the facility is available without visiting the site).
- Faster, more accurate and transparent costing and cost management.
- Reduced waste and rework through better trade coordination, automated conflict avoidance, easier design interpretation and greater accuracy.
- Increased client satisfaction.
- Enhanced stakeholder engagement earlier in the design process when the greatest value can be derived from their input.
- Improved risk management.
- Easier capture of As-Built information during construction for use at handover.
- Reduced workload compared with manual data collection and file indexing due to automated data migration.
- Information can be easily stored, transmitted, searched, sorted and filtered.
- Earlier availability of asset information during the design process.
- Enhanced knowledge management.
- Better information and data management.
- More accurate decision-making required in asset management by considering lifecycle thinking during the design, construction, operation and maintenance phases.
- Improved monitoring and reporting on operating costs and asset performance.

To ensure the delivery of the benefits from the adoption of BIM within the water organisations it is important to learn from best practices, recognise key challenges and identify critical success factors.

This report reviews the experience of a number of organisations across the globe in order to explore benefits realised across each project, challenges experienced in application of BIM, strategies and the most important lessons learnt by water sector organisations transferring to BIM and Digital Engineering.

2. Case Study Review

2.1. Hamilton City Council Wastewater Treatment Plant

2.1.1. Project Summary

The council's Pukete Wastewater Treatment Plant was built in 1975 to provide secondary and tertiary treatment. A $28m upgrade was conducted in 2002 to modernise the facility's asset information. However, the lack of As-built information, uncertain accuracy of existing data, and location of asset information made the job harder (Hamilton City Council, 2020).

The council's decision to adopt more advanced asset management practices turned the spotlight on processes for collecting and centralising data, with a view to dynamic information modelling. In collaboration with the client, a BIM engineering team developed a data model that would eventually be incorporated into the asset management process for the council.

Figure 1: Hamilton City Council Wastewater Treatment Plant (Hamilton City Council, 2020)

2.1.2. BIM Application

- The project team propelled a drone to examine the whole plant site producing a photo-realistic 3D view of hard surfaces including building shells and ground features.
- For the building interior (i.e. process area), the survey team used laser scanning with LiDAR (Light detection and ranging) laser scanning to produce 3D point cloud of the facility.
- The model was migrated to a cloud-based building lifecycle management platform.
- To create a single source of truth for operation and maintenance activities, the centralised asset information included process flow diagrams (PFDs), operation manuals, process and instrumentation diagrams (P&IDs).
- Existing operator barcodes were linked with the actual equipment, so that onsite contractors would have an opportunity to confirm whether operators were working on correct equipment.

2.1.3. Challenges

- Enabling sustainable growth which focuses on two main areas, namely delivering right information (i.e. right place, right time), and planning for, and responding to growth opportunities.
- Meeting improvement expectations.

2.1.4. Benefits

- Providing accurate information of the current state and layout of the building as a single reliable resource, which had previously been lacking.
- Providing functions to visualise and interrogate more detailed information about the assets.
- The BIM model served as a tool to run contractor safety inductions.
- 360degree view allowing detection of potential clashes (e.g. a pipe fitting into a wall space).
- Reliable information to work with.

2.1.5. Lessons Learnt

- Getting started with BIM

Due to BIM being a high investment both time and money wise, it is critical to identify key projects where BIM can offer more benefits.

- BIM execution plan

Every project has their specific execution plans. For example, a client may change requirements at the procurement phase to inform contractors that BIM would be implemented for the project.

2.2. Gouthwaite Reservoir Spillway Improvement Works

2.2.1. Project Summary

Gouthwaite Reservoir has the biggest dam in Yorkshire (115km), with the greatest streams of any spillway in the district. In reaction to floods in 2015, there was a need to re-construct the water retaining spillway structure and introduce siphon pipework to prevent the onset of winter floods in consequent years (BIM4Water Gouthwaite, 2020).

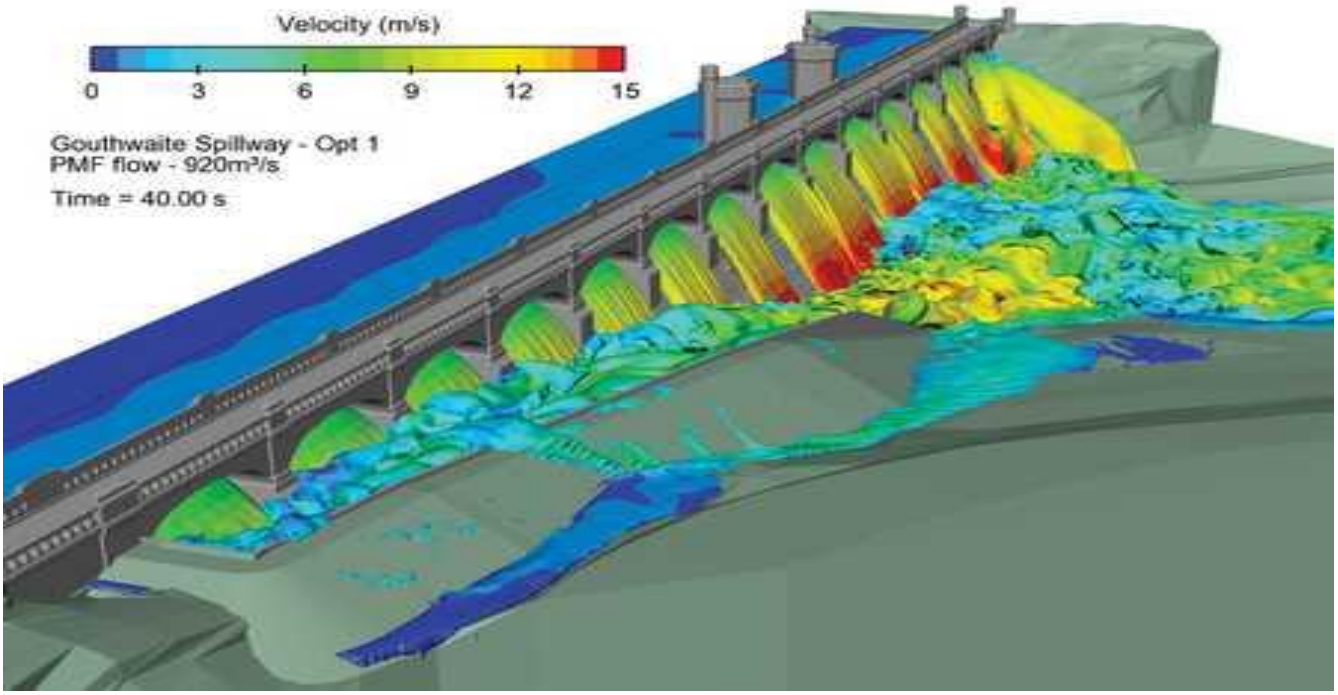

Figure 2: Gouthwaite Reservoir Spillway Improvements Works (BIM4Water Gouthwaite, 2020)

2.2.2. BIM Application

- Due to the complex geometry of the reservoir, various software was utilised to produce a united model.
- The project team utilised an integrated process of laser scanning in order to empower increments in time and cost saving advantages and to produce accurate models of existing structure and surroundings.
- *Civil 3D* was utilised to create longitudinal segments and ground surface for the site. *Revit* was utilised to create a model for mechanical and piping work.

2.2.3. Challenges

The Project CDE was in Bentley ProjectWise, leading to the lack of compatibility with Navisworks. As a result, the model had to be separately hosted on local CDE.

2.2.4. Benefits

- Close coordination between design and construction teams.
- Digital Safety, Health, Environment and Quality (SHEQ).
- Reduced safety related risks.
- As-built model allowed for carbon footprint calculation for sustainability purposes.
- Improved asset data capture processes (i.e. reduction in time and cost during data capturing activities and improved data quality).
- Better understanding of construction sequences and better planning with the help of Autodesk Navisworks.
- Confidence in data delivered to operation and maintenance team.

2.2.5. Lessons Learnt

- Ensure software interoperability.
- Collaboration is the key.
- It is essential to identify an optimal Level of Detail and Level of Information at the beginning of the project.

2.3. Minworth Thermal Hydrolysis Plant

2.3.1. Project Summary

Minworth is Severn Trent Water's largest wastewater treatment facility that treats sludge arising from a population equivalent of 2.3 million. This project contributes to Severn Trent's goal to reduce their Carbon Footprint by 10% and to have 25% of their biosolids produced at an enhanced sludge status (BIM4Water Minworth, 2020).

2.3.2. BIM Application

- Laser scanning of the existing plant to provide an accurate baseline data.
- 3D modelling.
- 4D programming to enable 'digital rehearsals' (i.e. simulation of site activities for a more effective planning).
- Augmented Reality (AR) and visualisation.

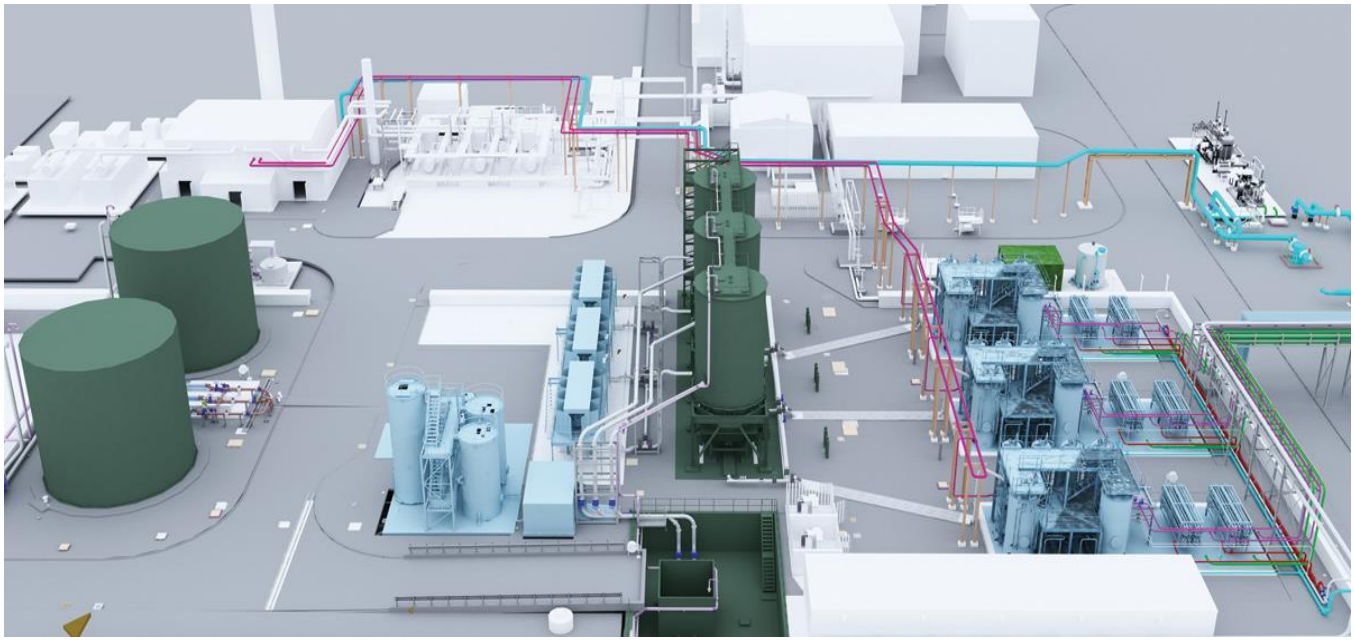

Figure 3: Minworth Thermal Hydrolysis Plant (BIM4Water Minworth, 2020)

2.3.3. Challenges

- At the initial stage, one of the major challenges was to operate BIM tools and techniques to drive DfMA.
- Understanding of new digital tools.

2.3.4. Benefits

- More collaborative team approach.
- DfMA resulting in better planning which helped to reduce waste and rework.
- Improved quality.
- Significant health and safety benefits.
- Effective delivery and commissioning.
- AR and VR use for accessing the construction site.
- Improved operators training using digital technology.

2.3.5. Lessons Learnt

- Understand the integrated project delivery and digital strategies at the beginning of project.
- Prepare time and cost work breakdown structure (WBS) at the beginning of the project.
- Use visualisation for better coordination.
- Visualisation and digital rehearsals add real benefit to the delivery team.
- Understanding the Level of Detail needed within the 3D model is very important. A lot of time could be wasted when modelling elements to the *n*th degree, when simple geometry with data attached could deliver the same benefits. The point cloud could be used where the more accurate representation is needed.

2.4. Kawana Sewage Treatment Plant Upgrade

2.4.1. Project Summary

Kawana STP (Sewage Treatment Plant) is located at Sunshine Coast, Queensland, Australia. The main purpose of the project was to increase capacity from 90,000 EP (Equivalent population) to 200,000 EP. The design process for this project was done by using various 3D modelling tools federated into a single BIM model. During design and construction process, BIM model helped to inform design review, clash detection and enhanced safety procedures. The BIM model provided an accurate, virtual representation of the complete plant and contained all pipework asset data that could be exported into the utility asset management plan (Kent and Smith, 2019).

Figure 4: Kawana Sewage Treatment Plant (Kent and Smith, 2019)

2.4.2. Challenges

- Completion of P&IDs before 3D modelling is undertaken.
- Issues with vendor data (e.g. the design team receiving the data, choosing the right level of LOD and asset tagging).

2.4.3. Benefits

- Minimised construction costs by detecting clashes and clearance issues before construction proceeds.
- Reduced occurrence of project defects and need for rework.
- Improved operability and maintainability of the plant.
- Improved safety.
- Improved preconstruction design review due to VR.
- Improved 3D design review.
- Improved documentation accuracy by generating 2D drawing views and associated element tagging and bills of materials directly from the model.

- Integration of asset data generated by the design and construction team with the utility's asset management.

2.4.4. Lessons Learnt

- Clearly define project and asset data requirement at the start of the project.
- Well defined and documented engineering specification is needed for input into BIM design software.
- Process and instrumentation diagrams (P&IDs) should be completed or approved by a client before 3D modelling is undertaken.
- Well define software to be used.
- Have BIM execution plan which helps to tell what is to be done, when and by whom.

2.5. Northumbrian Water Group (NWG) Exemplar BIM Project

2.5.1. Project Summary

Northumbrian Water Group (NWG) have historically collected asset information / data at contract completion. This information / data has varied in both quality and quantity, therefore the use of it has not been optimised which results in the limiting of decision-making and inefficiencies (BIM4Water NWG, 2020).

The NWG have undertaken the refurbishment of two pumping stations to collect digital information to allow the asset owners to successfully integrate this data into their asset management system. The new process aims to improve the asset information management and data transfer at project handover, ensuring better informed decision-making at the operation and maintenance stage. The NWG aims to establish a standardised process of having a single asset information system to be utilised through the whole lifecycle of an asset.

2.5.2. BIM Application

- Testing the ability to successfully collect data from the supply chain in a format NWG systems could easily digest it into their existing systems.
- Producing Organisational Information Requirements (OIR), Asset Information Requirements (AIR) and Employer's (Exchange) Information Requirements (EIR) for the projects.
- Focusing on the data collection during design and construction.

2.5.3. Challenges

- Poor quality of digital data.
- Getting everyone to understand that the data is as valuable as the physical asset.

2.5.4. Benefits

- Collecting the data in a structured format and linking it to the geometrical data are immense to the client. BIM compliant partners understand the needs and data requirements from the start of the project.
- Various NWG departments having access to high quality digital data about their assets.
- Solid foundation for managing the assets and presenting the information and data in a way which has clear quantitative and qualitative benefits for the client.
- Integrated systems and databases.

2.5.5. Lessons Learnt

- A client needs to understand what data and information they require in order to operate their business.
- It is important for a client to communicate to the supply chain how they need the information to be delivered so it can be easily digested.
- Defining organisational and asset requirements is critical.
- Project directors must pay special attention to naming conventions applied to files and documents in the BIM model.
- Data standards ensure the quick and easy extraction of common data from BIM models to agnostic platforms such as Excel.

2.6. Thames Tideway East

2.6.1. Project Summary

The Thames tideway tunnel is a significant framework venture in London and is intended to lessen the flow of untreated sewage to the River Thames. In general, the project comprises to large interception and conveyance tunnel which is connected to the existing sewer network at 24 interception sites, 11 of which are located along the riverbank. Currently, this project is under construction with the Diaphragm wall being completed (BIM4Water Tideway, 2020).

Figure 5: Thames Tideway East (BIM4Water Tideway, 2020)

2.6.2. BIM Application

- Connecting the design management plan, BIM execution plan (BEP) and information management plan was considered to be pivotal in guaranteeing the effective delivery.
- Producing standards, guidance and resources to support the delivery of BIM by the contractor.
- Having internal systems to support a CDE to receive the information from the contractor at key delivery milestones and handover.

2.6.3. Challenges

- This project was assessed to have a non-compliance design due to a failure in effectively reviewing model information.
- The skills to work in the 3D model environment varied across the project team. More training was requested, and the model review process was noted as difficult due to the software not being user-friendly.

2.6.4. Strategies

- To systematically mitigate the risk, weekly review sessions were set up.
- BIM execution plan and information management plan were essential to ensure the successful delivery.
- The software and process checking were undertaken before the start of the project.
- Training programs were conducted within the design team.

2.6.5. Benefits

- Quicker information transfer on delivery compared to previous major projects.
- Model based delivery method helped to increase productivity.
- Reduced uncertainty in information transfer.
- Improved design model engagement.
- Reduced design change workflow.
- Collaboration between stakeholders.
- Improved H&S activities.

2.6.6. Lessons Leant

- Ensure the access to appropriate software and hardware.
- Improve understanding of the model Level of Detail and Level of Information.
- More training is required for involved personnel.

3. Summary of Key Lessons Learnt and Critical Success Factors

Digital technology-based practices such as BIM are powerful collaborative processes that can facilitate information management, with the potential to revolutionise management of the water sector.

For a company to realise the benefits from implementing the principles of BIM and to support an efficient approach to information management the following key lessons learnt have to be taken into consideration:

- Do not model all data to the *n*th degree.
- Make sure the organisation's information systems are integrated to enable interoperability, simple data flows and data exchange process.
- Implement a change management program for the technological improvement opportunity.
- Do not try to change everything at once.
- Properly communicate to the entire supply chain regarding what information is needed, when and in what format.
- Sufficiently consider software data compatibility, standards and ownership.
- Do not allow particular software solution driving the strategic planning of the organisation.

The mentioned key lessons learnt and associated critical success factors define some implications for a successful adoption of BIM across the asset lifecycle.

1. *Do not model all data to the nth degree*

It is unnecessary to model all data for all assets and to the highest degree. Due to BIM being a high investment both time and money wise, it is critical to identify key assets and key projects where BIM can offer more benefits. Organisation needs to have a good understanding of the right Level of Detail and Level of Information (LoD-LoI) requirements that will add value to business functions.

2. *Make sure the organisation's information systems are integrated to enable interoperability, simple data flows and data exchange process*

Within organisations, a lot of projects are developed in silos. It is important to ensure that organisations have a BIM strategy that everyone works to. The BIM strategy and clearly defined information requirements must consider all of the organisation's information systems to ensure seamless transfer between them, simplify associated data flows and avoid failure to update models. The accuracy of data transmission among different departments must be also ensured. Moreover, organisations are advised to not continue to use technology for day-to-day asset management that pre-dates BIM technology. For example, as BIM does not replace an enterprise asset management or Computer-aided Facilities Management (CAFM) system, these systems should be integrated.

3. *Implement a change management program for the technological improvement opportunity*

BIM is not just a single 3D object but primarily a business process. It is the implementation of revised business processes and information standards. As all organisations differ, it is necessarily to tailor to individual circumstances and develop a BIM strategy along with a roadmap and framework to guide further development. The implementation of BIM requires an organisational change management program, good communication, as well as cultural change. The BIM strategy needs to adequately consider people, constraints, organisational structure, resources to be dedicated for a period of time, and coordination of implementation activities. Identification of roles with responsibility for information management is essential.

4. *Do not try to change everything at once*

BIM strategy should follow the principles of ISO19650 and stage the transition sensibly and target best value opportunities first. Measured benefits support further enhancement of buy-in from employees.

Willingness to change everything at once might lead to the development of an unclear BIM strategy that would fail to cover the lifecycle of the asset.

5. *Properly communicate to the entire supply chain regarding what information is needed, when and in what format*

It is important to ensure that the supply chain is fully engaged with BIM and fully understands the benefits, processes and requirements for the delivery of the digital asset in addition to the physical one. This requires engagement with all stakeholders through the capital delivery and operation phases of the asset. For the supply chain to deliver the correct information in the correct format there must be a clear understanding from the client about what information is required and why, how and when this information will be used, and the expected level of interoperability with other systems. Setting up proper information requirements (e.g. Organisational Information Requirements, Asset Information Requirements and Employer's Information Requirements) makes it less complicated and demanding to maintain asset information. Ideally projects should aim for 90% of asset information being available to the owner operator before construction begins and not wait until the commissioning and handover process.

6. *Not sufficiently considering software data compatibility, standards and ownership*

Strategy ensures that new and old systems can talk to other and that data is owned by the organisation and not a provider. BIM is part of the overall enterprise information and data management. Elements crossing several functions include storage, process review, security, standards review, etc. Common standards allow a high degree of automation for transferring and then maintaining the digital asset during the asset lifecycle with significantly reduced manual intervention. This in turn leads to better information quality and a simpler governance process. Projects should share a Common Data Environment (CDE) enabling improved visibility and consistency of asset and facility information, reducing replication and simplifying the transfer of information.

7. *Do not allow particular software solution driving the strategic planning of the organisation*

Organisations need to consider the opportunities, constraints and gaps first and then select software solutions fitting their strategy.

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