and structural engineers to prove that civil engineering is a profession of decent reputation.

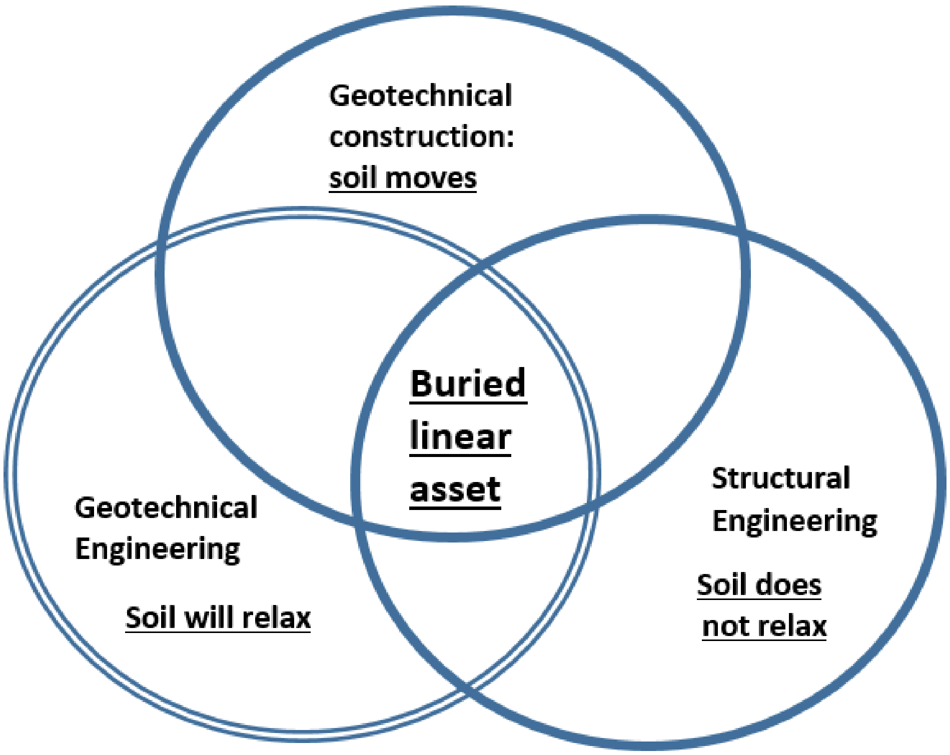

Figure 10. Collaboration in eliminating above "triple tunnel visions"

When there is a will, there is a way, and that is something that all Civil Engineers should hold to heart.

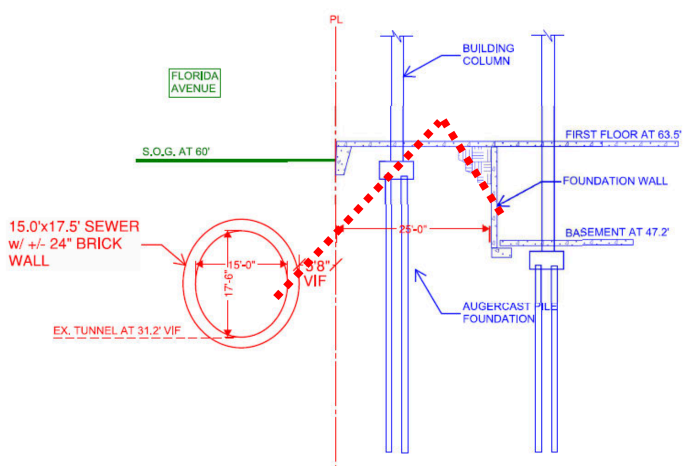

Figure 11. A dream setting for adjacent construction: mutual impact free

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Design-Build Project Administration: Case Studies from Water Utilities in the U.S. Southwest/Pacific Region

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ABSTRACT

Water utilities were traditionally required to deliver their projects using the design-bid-build (DBB) method. However, innovative and more efficient project delivery methods such as design-build (DB) are growing in use in this industry. The objective of this study is to benchmark DB project administration practices in the water industry, focusing on the U.S. Southwest/Pacific region. Structured interviews were conducted with four utilities that are experienced with successful DB delivery. One utility was selected to represent each of the four following states: Arizona, California, Colorado, and Nevada. The interview questions were organized into eight different categories: procurement, roles and responsibilities, risk and quality assurance, design, design review, cost and schedule estimates, submittal and submittal review, and communication and information flow. Findings include that all four utilities engage the design-builder before 10% of design completion. This study supports utilities interested in using DB and in identifying practices to improve their DB project performance.

INTRODUCTION

Many water utilities across the United States are currently undertaking rehabilitation and replacement projects to address existing pipeline deterioration and improve service. To keep up with this continuously increasing workload on their staff, utilities are adopting innovative project delivery methods such as design-build (DB) that allow for a more efficient delivery of their projects.

Water utilities were traditionally required to deliver their projects using the design-bid-build method. This method requires the owner to have two separate contracts, one with a designer and one with a contractor. However, changing public policies and state legislation has allowed DB to gain popularity in this industry, mainly as a result of its acclaimed benefits of optimizing risk management, improving cost efficiencies, and accelerating project schedules (WDBC 2008).

This objective of this paper is to benchmark the state of practice and present strategies and methods that allow water utilities to successfully implement DB. This paper aims to identify industry project administration practices that may be applied by water utilities for improving the delivering their DB projects.

BACKGROUND OD DESIGN-BUILD

Unlike DBB, utilities that deliver their projects using DB have one single contract with the design-builder that is responsible for both the design and construction of a project (Molenaar and

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Songer 1998). Moreover, the utility has one line of communication with the design-builder, who is required to handle all design and construction needs and concerns. In DB, the owner is capable of transferring certain risks such as design liability to the DB team. However, according to Culp (2011), this results in the owner losing some of their influence and control over their project. Design-builders are typically procured based on their qualifications and technical expertise through a request for qualifications (RFQ). For water projects that have challenging design and construction requirements due to complex equipment and technologies, RFQ's allow utilities to evaluate potential DB firms and select the most qualified design-builder for the job (Culp 2011). According to Bearup et al. (2007), the defining characteristics of a DB project include: 1. A single point of responsibility, 2. A schedule that allows for design and construction overlapping, 3. Preconstruction services, and 4. An owner that expects the design-builder to commit to a fixed project cost and schedule.

METHODOLOGY

In order to benchmark DB project administration practices in the water industry, the authors conducted structured interviews with experienced utilities that have successfully delivered their projects using DB. The research methodology for this study consisted of four steps, as seen in Figure 1. Initially, a literature review was performed and assessed both academic publications and industry developed design-build project administration practices across various industries and the water industry in specific. Then, an industry expert workshop was conducted with the assistance of five water industry experts. The experts assisted the authors in developing a comprehensive interview protocol. The interview questions were organized into eight different categories and DB practice specific questions were developed for each respective category. The final interview protocol consisted of 67 questions and was based both on the review of the existing literature and input from industry experts. This step was followed by compiling a list of large water utilities in the United States to consider as potential interview respondents. The initial survey was then administered and aimed to screen and identify the most experienced utilities to interview. Four water utilities in the U.S. Southwest/Pacific region were interviewed so far and information was collected on their DB practices. Finally, the findings were examined, and the utilities DB practices were identified and compared. The following subsections will detail the four-step methodology that this research study undertook.

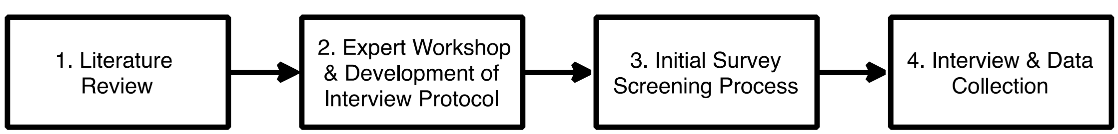

Figure 1. Research Methodology

Literature Review

The literature review aimed to investigate academic publications and industry manuals/guides that have explored DB project administration practices. Moreover, the purpose of this review was to evaluate successful DB practices across the various industries and identify DB specific items of interest that may be used to develop an interview protocol for this study.

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This section compiles and highlights DB project administration practices that have been discussed in the literature.

Molenaar et. al (2004) conducted a survey and case studies on three completed water and wastewater treatment plant projects to benchmark DB best practices for the water and wastewater industry. In their study, the authors identified nine best practices that may assist owners and practitioners using DB for the first time. The study identified the industry's best practices for project delivery decision, design-build contracts, risk allocation, proposals evaluation, determining the level of design for the request for proposals, design-build consultants, partnering and trust, identifying key players early, and permitting issues for DB.

DBIA (2015) released DB best practices for the water and wastewater industry, highlighting main differences of managing DB project delivery in this industry in comparison to other industries. The publication was divided in three sections, which included: procuring DB services, contracting for DB services, and executing the delivery of DB projects. The sections of DB services and contracting for DB services included three best practices each, followed by the section of executing the delivery of DB projects that consisted of four best practices.

WDBC (2016) developed a handbook to help owners and design-builders in the water and wastewater industry in facilitating a successful DB project. The handbook discusses several principles and best practices for DB, these include: how these organization can prepare to procure and manage a DB project, managing project risk, conducting the procurement process, and transitioning to owner operations.

WSCPARB (2017) published guidelines that define DB best practices to be used by Washington State public agencies. The guidelines discussed practices that help agencies in evaluating the use of DB for their projects, DB procurement, encouraging competition, and post-DB team selection.

Wagner (2018) discussed common myths of DB and its best practices. The author was able identify seven DB best practices, which include: executing team agreements, co-location, developing a good cost model, hosting a design validation meeting, maintaining a design-evolution log, creating an integrated culture, and committing senior leadership.

After completing the literature review, the researchers acknowledged that DB use in the water industry is tremendously increasing, and that there is a need to further grow the knowledge of DB best practices. Moreover, the practices identified in the literature were recorded and are used to develop the interview protocol for this study.

Expert Workshop & Development of Interview Protocol

An industry expert workshop was conducted through the participation of five water industry experts who have extensive knowledge in DB project delivery. The main objective of this workshop was to have the experts review the identified DB practices in the literature and to use their expertise to develop an interview protocol that can be used to benchmark DB project administration practices in the water industry.

The experts sought to ensure that DB project administration practices were highlighted for organizations that are less familiar with the implementation of DB and seeking to add this delivery method to their organization's project delivery toolbox. Hence, interview questions were developed through recognizing key differences between the administration of DB and DBB projects. This resulted in the identification of eight different DB practice specific categories for the final interview protocol, which was later developed into a list of 67 questions. The interview questions developed were based both on the review of the existing literature and input from the

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industry expert workshop participants. After completion of the initial interview protocol, the experts then reviewed each interview question carefully and validated their composition and necessity. Table 1 shows a brief summary of the eight key categories and DB practices of interest that questions targeted to address for the final interview protocol.

Table 1. Interview Protocol Categories Summary

#	Key Category	DB Practices of Interest	Number of Questions
1	Procurement	• In-house design completion • Design and construction management services • Percentage of total costs allocated for design • Project delivery method selection process • Proposal evaluation • Selection of subcontractors • Compensation types • Incentives • Owner and contractor contingency	16
2	DB Roles & Responsibilities	• Project team size and roles • Key staff • Distribution of responsibility with design-builder • Owner level of involvement & control • Responsibility matrices • Public relations & permitting • Substitution of DB team members	11
3	Risk & Quality Assurance	• Developing & understanding risk skills • Risk register • Inspections • Quality assurance and quality control • Specifications	7
4	Design	• Scope validation • Geotechnical and environmental investigations/reports • Design package standards • Technical specifications • Sustainable design • Innovative technologies	9
5	Design Review	• Design review schedule and meetings • Operations & maintenance team involvement • Level of design review	6
6	Cost & Schedule Estimates	• Schedule of cost estimates and level of confidence • Schedule development • Cost control & third-party cost control involvement • Guaranteed maximum price (GMP) • Incorporation of risk in project cost	6
7	Submittal & Submittal Review	• RFI & submittal review process • Streamlining submittal process • Co-location of project team	4
8	Communication & Information Flow	• Stakeholder collaboration • Minimizing impact on existing operations • Utilization of building information modeling (BIM) • Handover of operation manuals, as-built, and warranties • Knowledge transfer and lessons learnt	8

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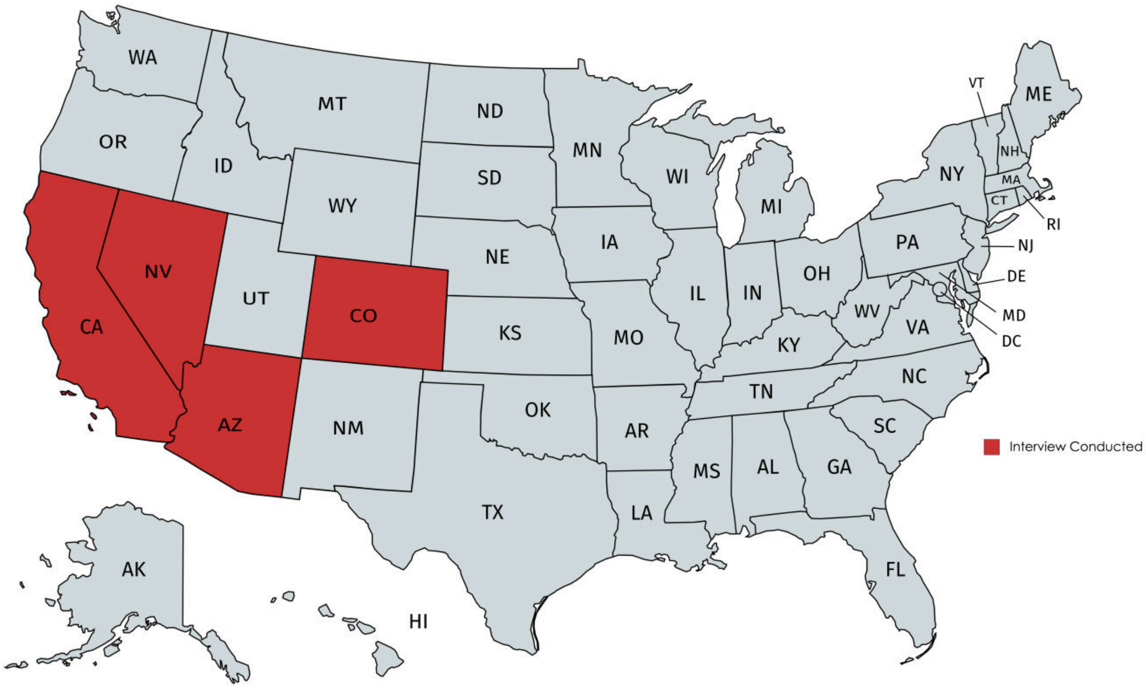

Fig. 2. Interviewed Utilities

Initial Survey Screening Process

After the development of the interview protocol and before the authors can initiate the interview and data collection phase, an initial survey was developed to screen potential water utilities to interview. The initial survey consisted of three questions and inquired on the amount of DB projects a respondent's organization has completed so far, the number of projects a respondent had been personally involved in, and the respondent's willingness to provide more information of their DB successes through a structured interview. The initial survey was designed to be user-friendly and to be completed in less than 1 minute. In order to distribute the initial survey, the authors compiled a list of 181 potential respondents in about 100 U.S. public water and wastewater utilities. The survey was administrated through the assistance of Qualtrics, an online surveying platform. The initial survey was administered over a 3-week period, to which 21 individuals responded. Resulting in a response rate of about 12%. Of the 21 respondents, only 14 individuals showed interest to participate in an interview process and provide data on their organization's DB practices.

Interview and Data Collection

After concluding the initial survey screening process, interested water utilities were contacted and interviews were scheduled. As of now, four utilities in the U.S. Southwest/Pacific region have provided data on their current and previous DB practices. Each one of these four utilities represent one U.S. Southwest/Pacific state. As seen in Fig. 2, the four states represented in this study include: Arizona, California, Nevada, and Colorado.

In order to ensure that the greatest amount of DB project administration practices exercised by these utilities are recorded, the interview process included meeting with several senior executives, project managers, project engineers, and contract administrators under various departments of the utilities staff. The interviews were conducted in about 1 hour and the research

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team directly transcribed their responses to the interview questions. The utilities' completed DB projects ranged from water transmission lines, water and wastewater treatment plants, and maintenance facilities.

For two of the four (50%) of the interviewed utilities, the owner was heavily involved in the DB process and had their own experienced in-house design and engineering staff that supported the design-builder's design and construction. The remaining two utilities (50%) depended on consultants to support the design and construction management of their projects. All four utilities shared similar motives for adopting DB project delivery for their projects, in place of traditional design-bid-build. Identified DB benefits by the utilities included: the ability to obtain the contractor's experience and constructability reviews; having one line of communication with the design-builder for all design and construction concerns; faster schedule and delivery; reduction in change orders; and opportunities for risk distribution.

Different forms of DB were used by the four utilities. For example, one utility has previously used the design-build-operate (DBO) method for one of their projects. Other utilized forms of DB included: progressive DB, one-step qualifications only, two-step, and best-value.

RESULTS AND DISCUSSIONS

After recording the data, the results were compiled, and DB project administration comparisons were conducted between all four utilities of interest. The results and discussions are split amongst the eight categories for which the interview protocol was developed and will be summarized in the following sections of this paper.

Procurement

In terms of design completion before contractor engagement all utilities stated that they typically complete less than 10% of their project's design in-house before engaging the design-builder. One utility specified that by doing so they are able to obtain earlier cost estimates for their projects. Moreover, 100% of the utilities agreed that engaging the design-builder early on provides opportunities for innovative design.

Utilities were asked if they procure the services of an owner agent for their DB projects, to which 50% of utilities mentioned that they do. However, one of the utilities only employed an owner agent for their organization's first DB project, as they were still unfamiliar with the DB delivery process.

In terms of allocating design costs as a percentage of the total project budget, two utilities typically distribute between 15% to 20% of their project budget for design, one utility assigns about 10%, and the remaining utility assigns about 5% to 7%.

Out of the four utilities, 75% of them evaluate their proposals based on a mixture of qualifications and costs. Only one of the utilities uses a purely qualifications only procedure for proposal evaluation, while the other three incorporate costs when evaluating potential design-builders.

Guaranteed maximum price (GMP) is utilized by only 50% of the utilities. One utility sets their GMP as early as 30% and as late as 80% of design completion. The other utility modifies their GMP throughout the design process and does not finalize it until the project has reached 100% design completion.

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DB Roles and Responsibilities

All utilities stated that their project team varies across the timeline of a project. Across the four utilities, depending on the project, staff size ranged from as low of one to two members during project initiation to a peak of 25 members. Identified project team members include the: project manager (PM), engineering representative, design PM, construction PM, property representative, procurement representative, archaeology representative, planning representative, project controls, safety manager, construction manager, public relations (PR) officer, and operators.

Project responsibilities that are retained by all four utilities included: property acquisition, environmental reviews internal, cultural resource clearance, quality assurance, and contentious issues. Responsibilities handed to the Design-Builder include: flood plain/washes/scours planning, utility coordination, permitting (may be shared with owner), right of way contractor (may share with owner), environmental permits (may share with owner), and PR (may share with owner).

Risk and Quality Assurance

Three of the four utilities use and maintain a risk register for their projects and the design-builder is specifically required to maintain this register during the project delivery process. These utilities perform risk workshops early on and allow the utility and design-builder to assign the risk to the party that is most suitable to handle it. Two utilities complete their project's quality assurance in-house, while shifting the responsibility of quality control to the design-builder. One utility entirely shifts this responsibility to the design-builder. Moreover, two of the utilities perform their site and equipment inspections in-house, while the other two utilities heavily involve the design-builder and/or a consultant in this process.

Design

All utilities include their operations team early on in the project and throughout the project design and construction process. Moreover, all utilities revealed that the design-builder or an external consultant is involved in their project's geotechnical determinations in the case they have not been completed previously by the utility. In terms of building information modeling (BIM), BIM was only used by 25% of the interviewed utilities. Moreover, 100% of the utilities have not sought LEED certification for their projects.

Design Review

In terms of design review, 75% of utilities use similar design review milestones, which are at 30%, 60%, and 90%. However, one utility uses 30%, 50%, 90%, and 100% design review milestones for their projects. During these milestones, all utilities involve their operations and maintenance (O&M) teams in the review process. Moreover, 75% of utilities also mentioned that design development is continuous in the case a design milestone submittal package has been handed to the owner for review.

Cost and Schedule Estimates

For estimating the accuracy of cost estimates, one utility revealed that their cost estimates get more accurate as their project's scope and specifications are further developed. During the

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conceptual level they stated to have a ±30% estimate, a ±15% estimate in the preliminary level, and during the detailed design level an estimate of ±5%. Two utilities revisit their GMP price at every design phase and adjust it as required. The required time to agree on a GMP is about 2 weeks, however, one utility mentioned that in extreme cases it can take up to 2 months to reach an agreement on the GMP.

The utilities also discussed their schedule development strategy, which typically includes their organization setting a project completion date and having the design builder work their schedules backwards to meet this need. However, one utility stated that they do not have this requirement and allow the design-builder to set the schedule of the project based on their assessment.

Submittal and Submittal Reviews

All utilities are intimately involved in the RFI and submittal review process for their projects. RFI's are submitted to the owner's PM or the owner's agent CM, and then directed to the responsible parties within their organization for review. One utility responds to RFI's within three days and submittals within one week. Another utility responds to RFI's within 14 to 21 days.

Moreover, 75% of utilities have staff that co-locate and asserted the advantages of co-location, which comprise of having team members manage several projects at a time. However, several disadvantages of co-location were noted and included: team members being unable to manage priorities, limited physical presence, and reduced availability for a given project.

Communication and Information Flow

To monitor a project's progress, one utility has regular weekly meetings with their major stakeholders, which include: the owner's PM, the design PM, and the construction PM. While one utility shared that they meet and interact with the design-builder on a daily basis.

To minimize impact on existing operations, all utilities require their O&M teams to coordinate heavily with design-builder across the project delivery process. For example, 75% of utilities stated that before shutting down or altering current plant operations, the design-builder is required to submit a detailed plan to the O&M team and receive their approval before mobilization.

In terms of ensuring that knowledge is captured after completion of a project, all utilities transcribe and document their lessons learned. Two utilities perform a lessons learned workshop at the end of the project, while the remaining two utilities develop an extensive construction report that summarizes the key points and takeaways of the completed project.

CONCLUSIONS AND FUTURE WORK

This paper investigated DB project administration practices in the water industry. Four interviews were conducted with utilities in the Southwest/Pacific region. Numerous project administration practices were collected under eight DB-specific project delivery categories. Several comparisons and differences were identified and discussed between the interviewed utilities. The practices identified in this study aim to support utilities that are looking to add DB to their project delivery toolbox. Utilizing these project administration practices will not ensure an owner a successful project, but may be a valuable starting point for these utilities. Key findings from this study include: 100% of utilities engage the design-builder before 10% of

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