Pima County
Regional Wastewater
Reclamation Department

Regional Optimization Master Plan
Alternative Delivery Methods

Alternative Delivery Methods

Pima County Regional
Wastewater Reclamation Department

FINAL - August 2008

GREELEY AND HANSEN

Table of Contents

Report Summary 1

Section 1 Introduction 1-1

Section 2 Project Background 2-1

Section 3 Alternative Project Delivery 3-1

3.1 Traditional Design/Bid/Build 3-1
3.2 Construction-Manager-at-Risk 3-1
3.3 Design/Build with County Operations 3-3
3.4 Design/Build/Operate 3-5
3.5 Design/Build/Maintain 3-7
3.6 Design/Build/Finance/Operate 3-8
3.7 Design/Build/Finance/Own/Operate 3-10
3.8 Cost Savings Experience with Alternative Delivery 3-11

Section 4 Multiple Criteria Analysis 4-1

4.1 Optimizing Risk Allocation 4-2
4.2 Project Quality and Asset Management 4-3
4.3 Implementation Schedule 4-4
4.4 Regulatory Compliance 4-4
4.5 Sustainability 4-5
4.6 Staff Considerations 4-5
4.7 Level of County Control 4-6
4.8 Market Viability 4-6
4.9 Flexibility 4-6
4.10 Predictability of Costs 4-6
4.11 Legislative, Fiscal and Legal 4-7
4.12 Multiple Criteria Analysis Summary 4-7
4.13 Multiple Criteria Analysis Scoring Table 4-7

Section 5 Evaluation 5-1

5.1 Mitigation of Risks 5-1

Table of Contents

Section 6 Risk 6-1

6.1 Benefits of Risk Management 6-1
6.2 Risk Register and Risk Report 6-2
6.3 Risk Ranking 6-2
6.4 Risk Workshops 6-2
6.5 Qualitative Risk Analysis 6-3
6.6 Quantifiable Risk Analysis 6-4

Section 7 Financial and Risk Analysis 7-6

7.1 Financial Model 7-7
7.1.1 Capital Costs 7-7
7.1.2 Operation and Maintenance Costs 7-8
7.1.3 Financial and Economic Variables 7-9
7.1.3.1 Tax Exempt Interest Rate and Term 7-9
7.1.3.2 Private Interest Rate and Term 7-9
7.1.3.3 Private Cost of Equity 7-9
7.1.3.4 Capital Inflation 7-10
7.1.3.5 Operation and Maintenance Inflation 7-10
7.1.3.6 Energy Inflation 7-10
7.1.3.7 Discount Rate 7-10
7.1.4 Financial Model Outputs 7-11
7.2 Risk Model 7-12
7.2.1 Risk Model Results 7-12
7.3 Sensitivity Analysis 7-14
7.4 Tornado Diagram 7-15

Section 8 Recommendation 8-1

Section 9 Conclusion 9-1

Section 10 References 10-1

Table of Contents

List of Figures

Figure 2-1 Metropolitan Tucson Service Areas 2-2
Figure 2-2 New Water Reclamation Campus Schematic 2-4
Figure 2-3 Future Area Development Site Plan 2-5
Figure 3-1 Design-Bid-Build with County Operations 3-2
Figure 3-2 Design-Bid-Build Timeline 3-1
Figure 3-3 Construction-Manager-at-Risk 3-2
Figure 3-4 Construction-Manager-at-Risk Timeline 3-2
Figure 3-5 Design/Build with County Operations 3-4
Figure 3-6 Design/Build Timeline 3-4
Figure 3-7 Design/Build/Operate 3-6
Figure 3-8 Design/Build/Operate Timeline 3-6
Figure 3-9 Design/Build/Maintain Project Delivery Method 3-8
Figure 3-10 Design/Build/Finance/Operate 3-9
Figure 3-11 Design/Build/Finance/Operate Timeline 3-9
Figure 3-12 Design/Build/Finance/Own/Operate Project Delivery Method 3-11
Figure 7-1 Baseline Present Value of Life Cycle Costs 7-12
Figure 7-2 Risk Adjusted Present Value Comparison 7-13

List of Tables

Table 3-1 Lake Pleasant Water Treatment Plant – DBO Compared to Benchmark Estimate 3-13
Table 4-1 MCA Criteria and Definitions 4-1
Table 4-2 Multiple Criteria Analysis Summary Table 4-8
Table 4-3 Multiple Criteria Analysis 4-14
Table 6-1 Risk Quantification Workshops and Attendees 6-3
Table 7-1 New WRC at Roger Road Capital Cost in 2008 Dollars 7-7
Table 7-2 Construction Costs Breakdown in 2008 Dollars 7-8
Table 7-3 Annual O&M Costs in 2008 Dollars 7-9
Table 7-4 Financial and Economic Variables 7-11
Table 7-5 Results of Risk Analysis 7-14
Table 7-6 Savings Relative to CMAR 7-14
Table 8-1 Results Summary Table 8-1

List of Appendices

Appendix A Risk Mitigation Plan
Appendix B Quantifiable Risk Analysis Tables
Appendix C Tornado Diagrams

Report Summary

The project delivery method decision for the new Water Reclamation Campus (WRC) at Roger Road impacts various aspects of the project including financing, procurement, ownership, and the associated levels of risk carried by the involved parties. The new WRC will be located in Pima County, Arizona adjacent to the existing Roger Road Wastewater Reclamation Facility (WRF) and will have a wastewater treatment capacity of 32 million gallons per day (mgd) utilizing nutrient removal technology. The existing Roger Road WRF will be decommissioned and demolished following the successful construction and operation of the new WRC. The decision to proceed with the construction of a new facility is prompted by permit requirements. New effluent limitations mandated by the Arizona Department of Environmental Quality (ADEQ) set lower limits of nitrogen and ammonia concentrations in the effluent discharged from the Roger Road wastewater treatment facility into the Santa Cruz River. The date for compliance with the new ADEQ standards is January 30, 2015.

The Regional Optimization Master Plan (ROMP), dated November 2007, used traditional procurement bases for scheduling and development of construction costs. In recent years Construction-Manager-at Risk has been used more frequently in Arizona for water and wastewater treatment facilities is becoming a common traditional approach in the State. Other methods are available in Arizona, which may offer a better value for the owner because of compressed timelines and ability to place risks on parties most capable of holding and managing them. Alternative project delivery methods available for the new WRC include Design/Build (D/B) with County Operations, Design/Build/Operate (DBO), Design/Build/Maintain (DBM), Design/Build/Finance/Operate (DBFO) and Design/Build/Finance/Own/Operate (DBFOO).

Two of the alternative project delivery methods dropped early in the process were DBM and DBFOO. Under DBM creation of the scope documents and administering the outcomes are complex. Therefore the use of DBM is a seldom used with very few reference projects. Those projects have had mixed results. DBFOO was dropped from consideration because the transfer or sale of County property is complex. Moreover, as the Designated Management Authority (DMA), the County may need to take over these facilities in the future for cause. Therefore, in the event the private enterprise fails, County has retained the ownership of the land.

Each alternative project delivery method contains varying considerations for procurement, financing and risk. Costs developed for the new WRC at Roger Road were based on the ROMP. These costs include numerous capital cost components required to construct the necessary facilities. Operation and maintenance costs including energy, labor, chemicals, supplies and materials are another cost consideration. Certain variables vary depending on the delivery option, including inflation, interest, discount rates, non-inflationary cost fluctuations, design/construction schedule, annual cash flow, present value of project costs, risk adjusted range of present value of project costs, impact of individual risk components and preliminary rate impacts.

In development of the business case, the amount of risk retained by the County differs according to the project delivery method selected. Risk is inherent in any transaction and can be transferred, but never eliminated. Risks can be viewed from both qualitative and quantitative perspectives and must be taken into consideration when examining the various alternatives. Risk workshops identify project risks, refine

the identification and description of risk events, discuss the mitigation options and, where possible, quantify risks.

Each alternative contains different inherent risks. But each alternative also offers opportunity for risks to be transferred to, or shared with, other parties. Under DBB, there is risk associated with hiring the low bid contractor because unlike other methods, qualifications cannot be evaluated in the procurement process. Also under DBB, no single party guarantees that the project will work as intended. The County retains most risks associated with the design and construction of the facility.

Under other project delivery methods like DB, DBO and DBFO, there is flexibility to allocate risk to the party best able to manage that risk. For example, in these three options liability for plant design and construction is transferred to the contractor.

To compare the various options, a Multiple Criteria Analysis was used to tie qualitative and quantitative analysis into one easy-to-read table. The Multiple Criteria Analysis allows for review and discussion of specific criteria and allows for the weighting of criteria based on the owner's preferences. The Multiple Criteria Analysis facilitates the choice of procurement option that best meets established criteria and maximizes overall value.

The Multiple Criteria Analysis shows that DBO carried the least risk and lowest probable risk adjusted net present cost. The DBO delivery method meets the established qualitative success criteria, has the lowest risk adjusted life cycle costs and meets the desired delivery schedule. In addition, the use of DBO is widespread and has been successful in similar projects. If the issues required to implement DBO cannot be resolved, the use of DB remains a viable option that has been successfully used in similar projects and has inherently fewer issues. Issues to be addressed by the use of DBO include workforce issues, public financing approval, Board of Supervisors (BOS) acceptance and market interest in DBO projects.

Based on various alternative project delivery analyses and workshops, the project delivery method identified as best suited for the new WRC at Roger Road is the Design/Build/Operate.

Section 1 Introduction

The Pima County Regional Wastewater Reclamation Department (PCRWRD) identified and investigated alternative project delivery methods available for procurement of the new Water Reclamation Campus, which will replace the existing Roger Road Wastewater Reclamation Facility (WRF). The Regional Optimization Master Plan (ROMP) study used traditional procurement methods as the basis for scheduling and costs, and had recommended consideration of alternative procurements. Other procurement models investigated to determine which alternative is best suited to meet the needs of PCRWRD included:

- Design/Build/Operate
- Design/Build/Maintain
- Design/Build/Finance/Operate, and
- Design/Build/Finance/Own/Operate

The project delivery analysis evaluated each alternative project delivery model for life-cycle costs, risks, and qualitative / quantitative factors and issues. The analysis included a stakeholder process to receive input from users and managers most affected by the new WRC project. This was accomplished through a series of three workshops soliciting stakeholder input. The result of the whole analysis process is a recommendation for the most appropriate approach to be used in the new WRC project at Roger Road.

Section 2 Project Background

PCRWRD owns and operates wastewater treatment facilities and conveyance systems in Eastern Pima County. The PCRWRD system is made up of two major wastewater treatment facilities, miles of conveyance pipeline lines, conveyance system lift stations and several small wastewater reclamation facilities in the non-metropolitan area. PCRWRD's mission is to provide quality service and to protect public health, safety and the environment.

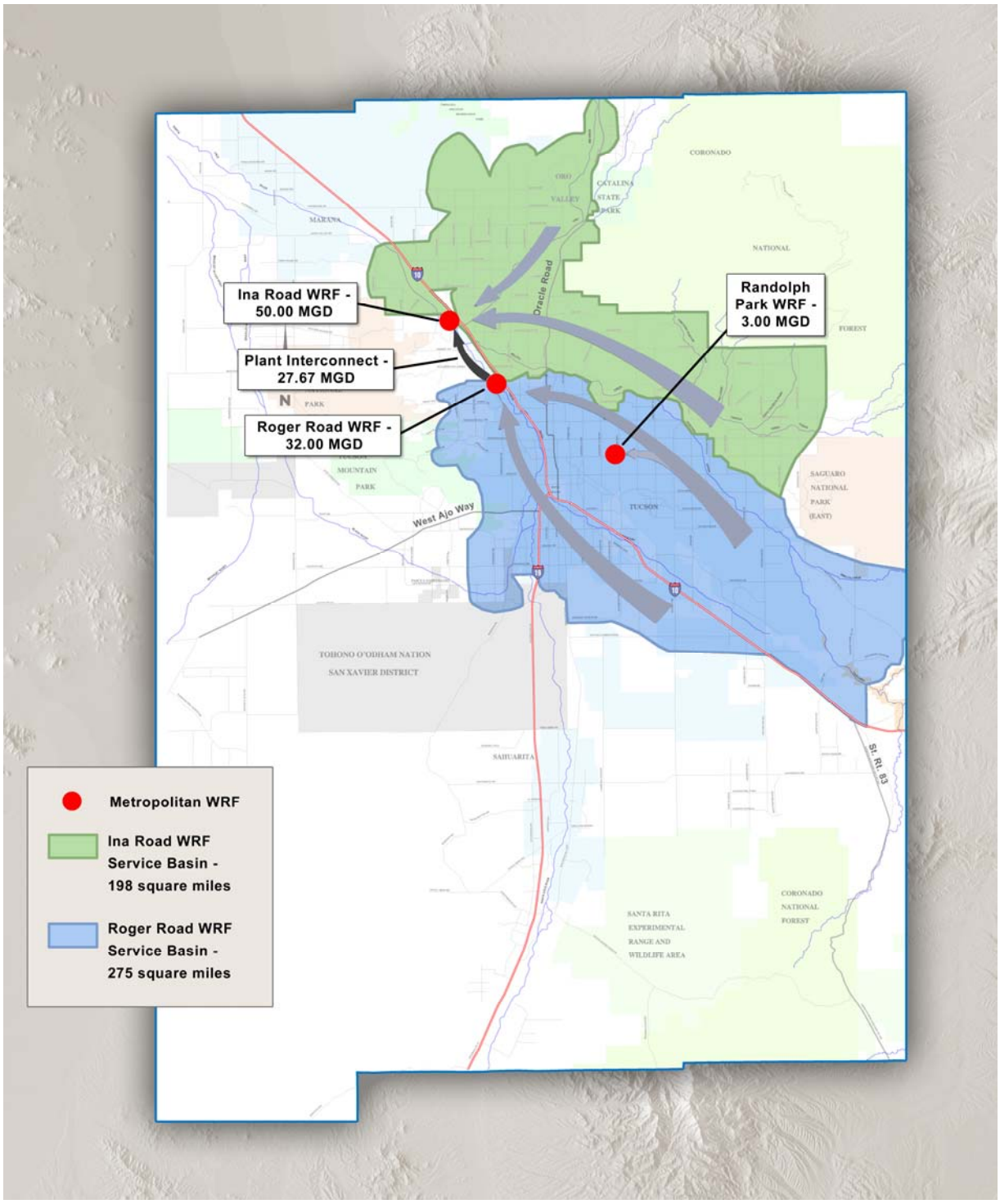
The Regional Optimization Master Plan (ROMP), dated November 2007, identifies changes that must be made to the PCRWRD wastewater infrastructure to address anticipated ADEQ permitting modifications in addition to a growing population. The ROMP study was performed to determine the optimal strategy for regulatory compliance, which includes:

- Long-term flow and capacity management
- Treatment of future wastewater flow increases from Pima County wastewater service basins
- Rehabilitation of existing facilities
- Optimization of biosolids handling and reuse
- Utilization of biogas
- Optimal methods to provide reclaimed water
- Addressing community concerns: odor control, noise abatement and aesthetics

The new WRC at Roger Road is one of the metropolitan facilities detailed in the ROMP study. Required changes to the facility are schedule driven by regulatory requirements, which are to reduce total nitrogen and ammonia concentrations in the effluent by January 2015. Currently, the Roger Road WRF operates and treats wastewater from a 275 square mile service area and is located at 2600 W. Sweetwater Drive, Tucson, Arizona 85705. The service area covers a large portion of the metropolitan Tucson and areas south and southeast of the city as seen in **Figure 2-1.**

A portion of the discharge is used for reclaimed water distribution service and the remaining portion is discharged directly into the Santa Cruz River. The permitted capacity of the current treatment facility is 41 million gallons per day (mgd) and the average winter influent flow (peak season) is approximately 39.7 mgd.

Figure 2-1
Metropolitan Tucson Service Areas



The Roger Road WRF is the older of the two large metropolitan facilities (the other being the Ina Road WRF) and was first opened in 1951. The facility opened as a12 million gallons per day (mgd) activated sludge facility. Later expansions added a separate 13 mgd trickling filter facility in 1960, followed by a 13-mgd activated sludge/contact stabilization facility in 1967. The facility was consolidated with the additional of two, 165-foot diameter by 26-foot deep plastic media biofilters with return activated sludge capability in 1979.

Digested biosolids from the Roger Road WRF are conveyed to the Ina Road WRF via force main. The digester biosolids from the two facilities are combined and undergo further processing prior to final disposal.

A new facility was recommended in the ROMP to make up for shortcomings of the current facility, which include meeting more stringent regulations and standards set forth by the ADEQ. Process modifications and changes are required to lower ammonia and total nitrogen discharge levels to meet future effluent quality regulations. Modifications are required to repair process units, replace equipment and structures, which have passed their useful service life, address odor control and safety issues, and upgrade the facility to be compliant with environmental, regulatory and building code requirements. All of these issues were discussed within the ROMP study.

Conclusions developed with administrators, managers and staff of PCRWRD and with other stakeholders was to construct a new WRC at Roger Road, which will replace the existing Roger Road WRF. The new WRC at Roger Road shall work in conjunction with proposed modifications and expansion to the Ina Road WRF to meet lower effluent standards and provide wastewater treatment for 82 mgd expected from the service areas. Flow will be split such that the new WRC at Roger Road will have a capacity of 32 mgd while the Ina Road WRF will handle a flow of 50 mgd.

The new WRC at Roger Road shall be located north and west of the existing Roger Road WRF between the Santa Cruz River on the west and Interstate I-10 to the east. As stated, 82 mgd is expected from the service area of the two metropolitan facilities based on the population projections and flow estimates contained in the ROMP. Design of the new WRC is based on expected stringent effluent requirements and effluent reuse requirements, which are:

- Ammonia nitrogen concentration below 2 mg/L
- Total nitrogen concentration of 8 mg/L or lower
- Low turbidity

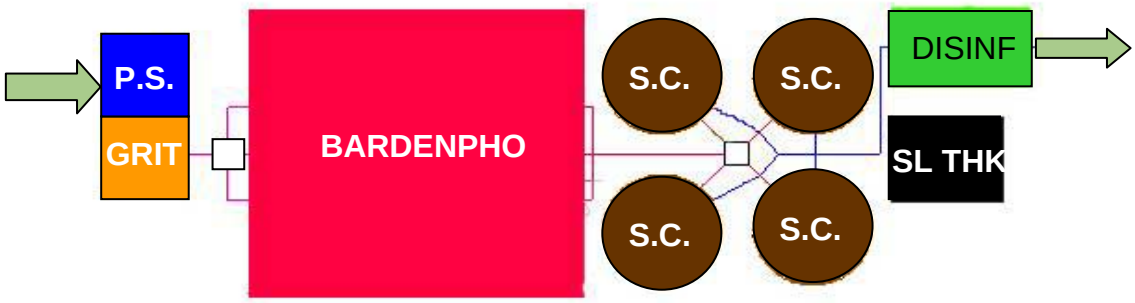
To meet the effluent goals, various biological nutrient removal systems were researched, and the Bardenpho process was determined the most reliable and cost effective for use at the new WRC. The decision to build a new facility instead of expansion and/or modification of the current Roger Road WRF was due to cost including uncertainties and risks involved with rehabilitation. Both economic and technical factors were considered, and construction of a new WRC was determined the favorable option.

Components of a new WRC, as shown schematically on **Figure 2-2**, include:

- Site Preparation
- Headworks
- Bardenpho Treatment (including Clarifiers)

- Solids Thickening / Pumping to Ina Road WRF for handling / treatment prior to beneficial land application
- Disinfection
- Administration / Control Building
- Standby Power Generation
- Existing Roger Road WRF Demolition

Figure 2-2
New Water Reclamation Campus Schematic



Multi-faceted recreational and ecological facilities for use by the region are being studied for the area surrounding the Roger Road site. The study anticipates that future facilities recreational facilities will be located on land owned by the City of Tucson, Pima County and the State of Arizona. A possible site plan of a new park development is illustrated in **Figure 2-3**.

The proposed plan includes construction of tournament grade facilities for soccer, softball and baseball and maintenance of riparian habitat along the Santa Cruz River. Walking and biking trails, picnicking areas and other features would connect Columbus Park to the new recreational areas and surrounding communities. In addition, the plan offers a connection to the Silver Bell golf course to make one large public space for community use. The Transportation Department has plans to improve the intersection of El Camino del Cerro and I-10, which would greatly improve access to the park site. Other alternatives for the site are being investigated and a final decision will be made at a later date.

Figure 2-3
Future Area Development Site Plan

The new WRC at Roger Road aims to produce high quality effluent as well as improve quality of life in the area by creating recreational and environmental opportunities for the community. To meet the stringent ADEQ effluent standards, the new WRC will need to be under construction by January 2011 and in service by July 2014 with permit compliance by January 2015. These deadlines are necessary for a smooth transition from one facility to the next. Therefore, a preliminary project delivery decision is desired by July 2008 to move the program forward with a final recommendation by late December 2008

Section 3 Alternative Project Delivery

Historically, many alternative project delivery procurements began as traditional design/bid/build projects and were subsequently implemented using design/build or design/build/operate methods for a variety of reasons. The most common reasons are the need to reduce costs or accelerate schedules. In the recent past, State or local legislations have prohibited use of alternative project delivery, but this is not the situation in Arizona where alternative design/build project delivery has been successfully employed, although Pima County has had very little experience with this project delivery method.

Potential alternative project delivery methods are reviewed to evaluate their applicability to the construction and perhaps operation of the new WRC. Project delivery methods listed below are described in the following sections.

- Traditional Design/Bid/Build with County Operations
- Construction-Manager-at-Risk with County Operations
- Design/Build with County Operations
- Design/Build/Operate
- Design/Build/Maintain with County Operations
- Design/Build/Finance/Operate
- Design/Build/Finance/Own/Operate

A timeline to implement the WRC project with the project delivery method is developed for later comparison of approaches.

3.1 Traditional Design/Bid/Build

The design/bid/build (DBB) structure is the traditional method of project delivery being used successfully for most water and wastewater capital projects in the United States. This method involves three basic participants: design professional (DP), general contractor and County (operating agency). Typically, a sequential approach is utilized for the design, construction and operation. In an attempt to integrate expertise of the participants, techniques including constructability reviews, operability reviews and value engineering are incorporated into the design build process. After construction, facilities are operated by County staff.

The first step of this method is to retain a design professional through a qualifications based submittal (QBS) process. Its responsibilities include determining facility requirements for the County, and define (implicitly) many of the risk elements of the project. The design professional is responsible for the engineering design of the facility and the development of contract documents for competitive bidding by the County.

In the second step, bids are tendered in conformance with the contract documents and the lowest responsive, responsible bidder is selected, without negotiations, to construct the facilities. Either the design professional, an independent engineer, or County staff assures that the builder's performance is in compliance with the contract documents and assists in resolving any issues or conflicts or both. The County retains design liability.

Relationships of responsible DBB parties are illustrated on **Figure 3-1.** A timeline for the new WRC implementation utilizing the DBB process is shown on **Figure 3-2 DBB Timeline**.

Figure 3-1
Design-Bid-Build with County Operations

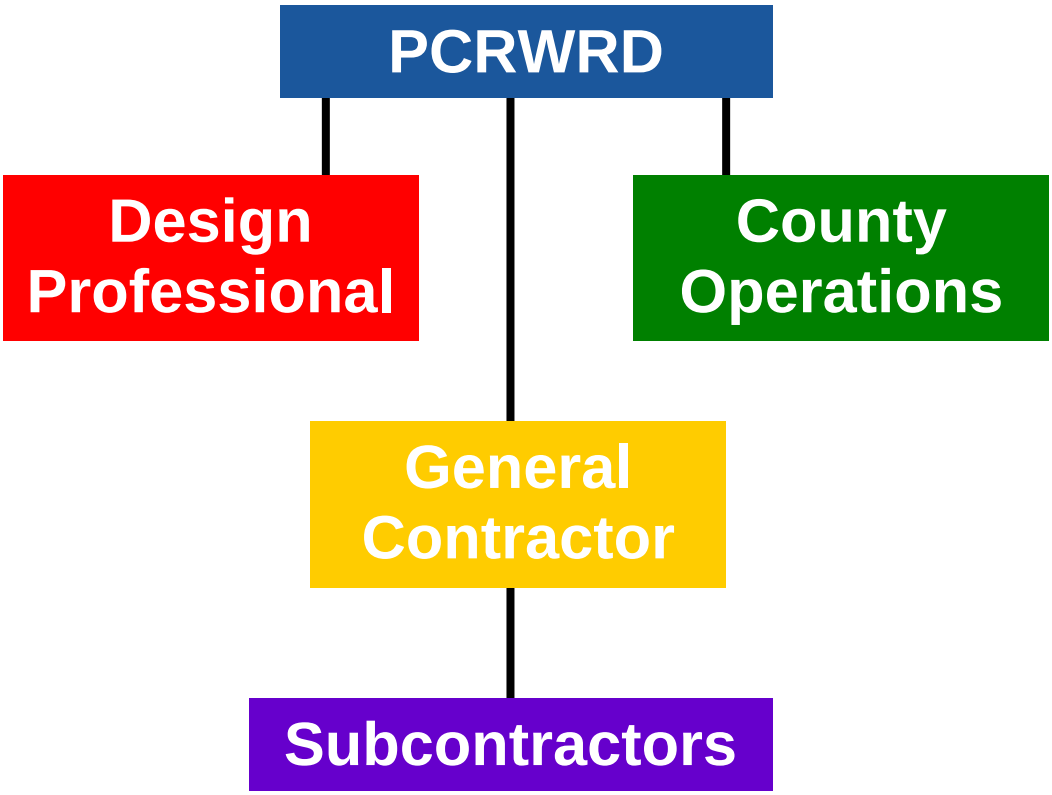
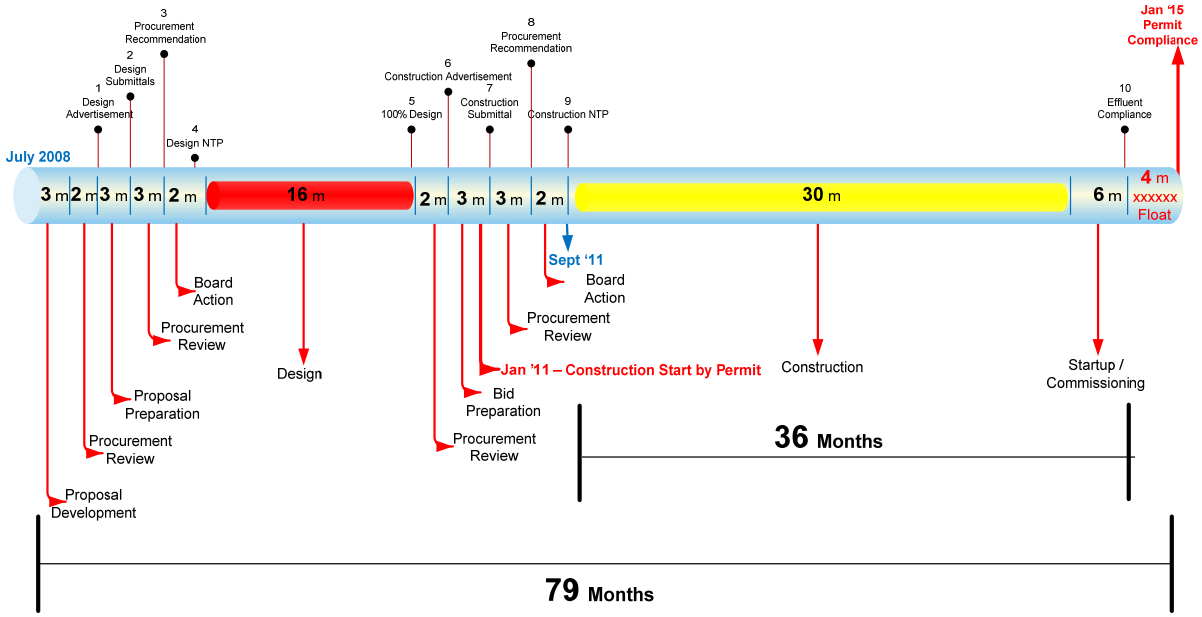


Figure 3-2
Design-Bid-Build Timeline



3.2 Construction-Manager-at-Risk

Construction-Manager-at-Risk is often abbreviated in the industry as "CMAR". In this method, there are two major participants in the contract with the County. The design professional is contracted by the County through a qualifications based submittal (QBS) process and is responsible for the design. The construction manager is contracted by the County and is placed at risk early in the project for delivering the work within a guaranteed maximum price. The construction manager provides coordination services in lieu of a general contractor and provides design phase input and assistance. At some point in the design process, the construction manager and the County establish a Guaranteed Maximum Price (GMP) to which the construction manager is contractually bound. The design professional provides conceptual and detailed requirements for the project use in developing a GMP. The County is involved during the design phase by bringing operations expertise into the project; however, once the GMP is established, changes in the project scope may impact the GMP. The construction manager provides design phase consultation in evaluating costs, schedule, implications of alternative designs and systems, and materials; and assumes the risk of construction after the GMP is established. The construction manager self performs portions of the construction and selects qualified construction subcontractors for the remaining portions to complete the work.

The selection of the CMAR by the County is based on their qualifications and generally occurs shortly after the selection of the design professional. The construction subcontractors are usually not selected until after the design phase is complete and are not involved in the design phase of the project.

This method is best suited for large, new or rehab projects that are schedule driven, are difficult to define, or require construction input during the design phase. This method is least suited for small projects, or where projects are very well defined.

Relationships of responsible CMAR parties are illustrated on **Figure 3-3.** The associated project timeline for the new WRC is shown on **Figure 3-4 CMAR Timeline**.

Figure 3-3
Construction-Manager-at-Risk

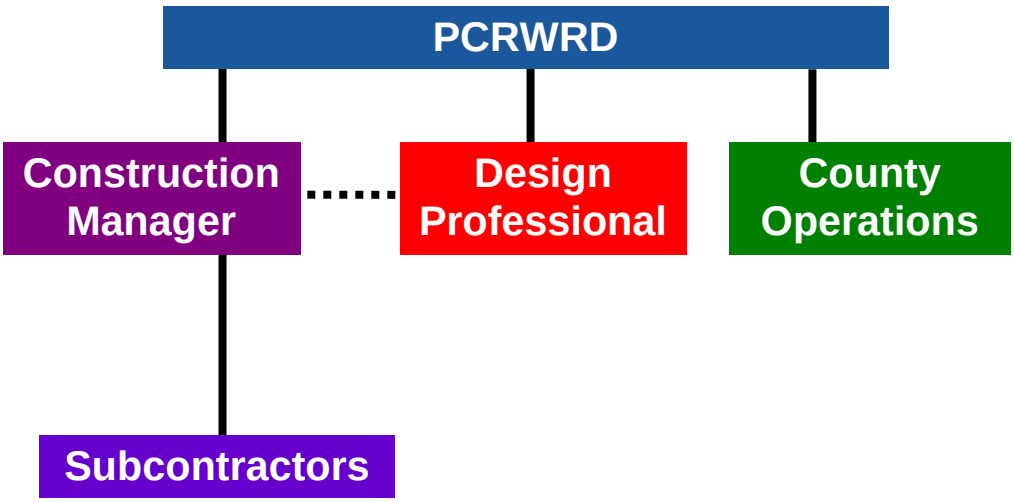
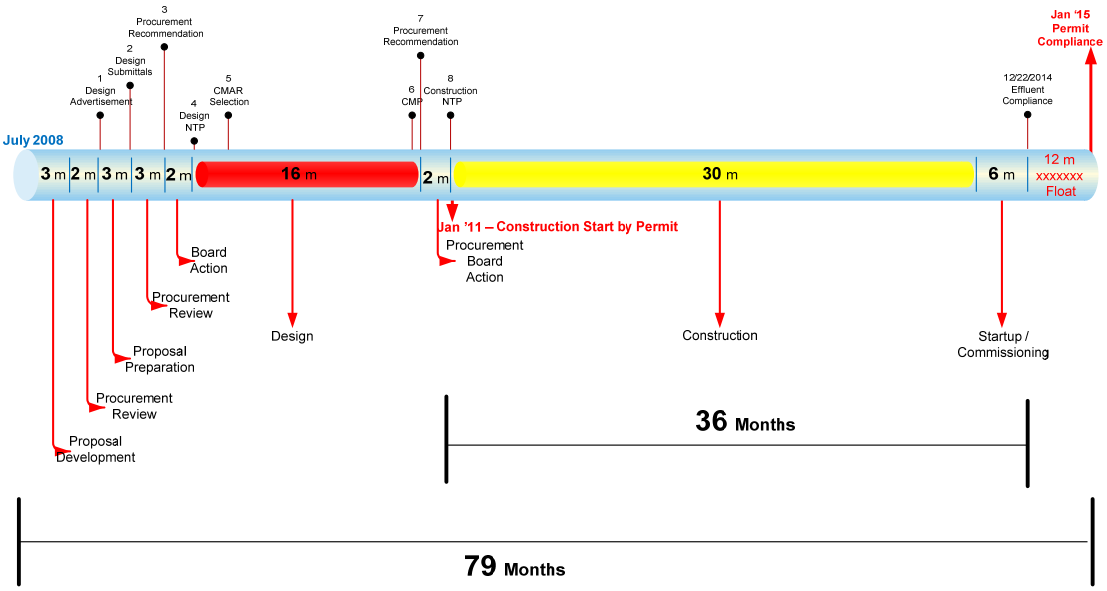


Figure 3-4
Construction-Manager-at-Risk Timeline



3.3 Design/Build with County Operations

In the basic design/build (D/B) delivery method, there is a single entity contracted to provide both design and construction services. The County usually develops performance requirements for use in securing a design-builder. The design-builder contracts directly with subcontractors and is responsible for delivery and performance of the project, and specifically assumes design as well as construction liability. Selection of the design-builder is based on the proposal offering the best value to the County, in terms of qualifications, technical and business merit, and project costs. Independent technical, legal and/or financial consultant(s) may serve as County's agent(s) in managing the procurement process, establishing performance criteria and monitoring performance. A conceptual to preliminary design (10 to 30 percent) may be prepared at the direction of the County to detail the prescriptive and performance requirements of the project. The design/build contract is negotiated based on a formal Proposal.

This delivery method requires the County to be knowledgeable of its needs and objectives for the project and be directly involved in the process. A key element to success is trust between the County and the design-builder, and the opportunity and necessity for the design professional and contractor to work closely together to develop the winning Proposal. For this method, the design-builder is provided with a description of the desired end-product or project outcome. The design-builder is responsible for developing the detailed design and specifications, selection of material and equipment, constructing the facility and meeting performance requirements.

Proposers, oftentimes a team of design professional(s) and contractor(s), respond to a Request for Qualifications (RFQ). A short-listed group of qualified proposers responds to a Request for Proposals (RFP) by submitting technical, price and business proposals. The competition process, established early on in the procurement process by the County, ensures an award; which is primarily based on price, technical and financial qualifications.

Relationships of responsible D/B parties are illustrated on **Figure 3-5**. The various landmarks that must be met during the WRC project to achieve project compliance are illustrated on **Figure 3-6**.

Figure 3-5
Design/Build with County Operations

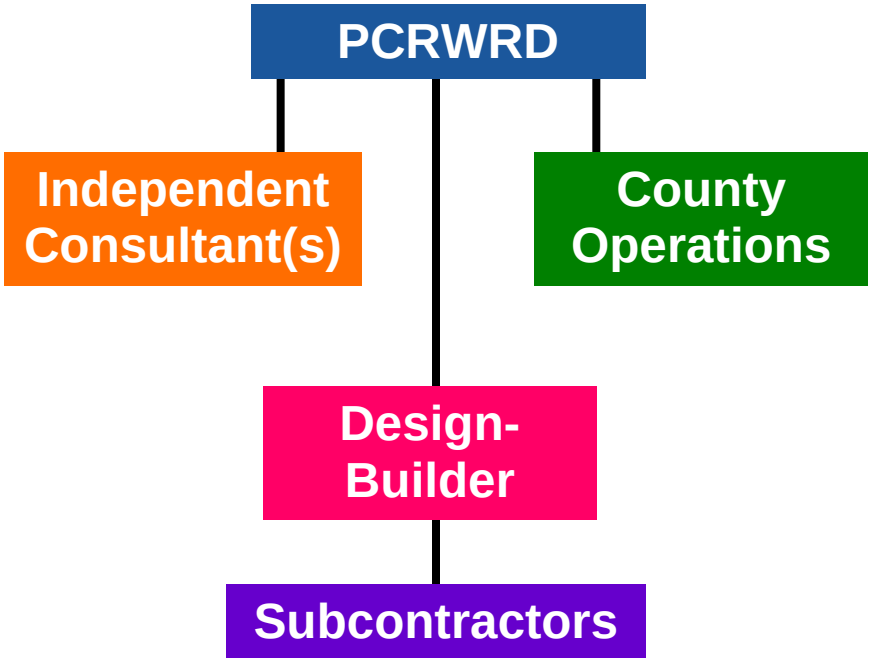
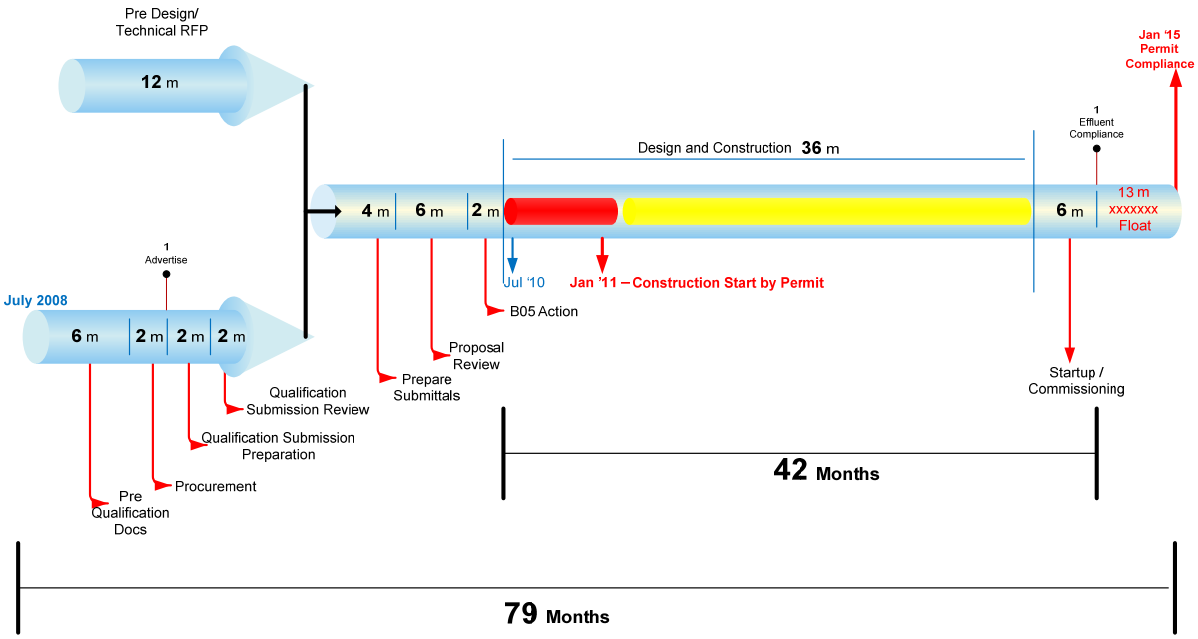


Figure 3-6
Design/Build Timeline



3.4 Design/Build/Operate

The design/build/operate (D/B/O) method is similar to the design/build method in **Section 3.3** except that the long-term operation and maintenance (typically 20 years) of the facility is combined with the design and construction into a single service contract. A variation to the long term operations and maintenance contract is to have a period of performance of less than 5 or 10 years, although the trend in today's market is for 20 year contract operation periods. As with D/B, independent technical, legal and/or financial consultant(s) may serve as County's agent(s) in managing the procurement process, establishing performance criteria and monitoring performance.

In the D/B/O method, the County has the ability to transfer a significant amount of responsibility and risk associated with a project to a single point of responsibility. That single party is responsible for the integration of design, construction, operation and maintenance expertise for the development of the facility in accordance with performance criteria established by the County.

Primary purpose for combining the design, construction, operation and maintenance into a single contract is to effectively integrate all three areas of expertise and responsibility during all phases of the project. The single party, who will guarantee the performance of the full service contract, has the incentive to balance cost efficiencies and long-term operation and maintenance costs and establish an optimum life-cycle analysis. At the end of the contract cycle when the facilities are converted to County operations, contract requirements will need to state and prove that the facilities are fully functional, systems can continue to achieve permit compliance and condition of the equipment is appropriately maintained during the life of the contract.

Proposers, generally a team of a design professional(s), contractor(s) and an operation and maintenance organization, respond to a Request for Qualifications (RFQ). A short listed group of qualified proposers then respond to a Request for Proposals (RFP) by submitting technical, commercial and legal proposals. The negotiation process, established early on in the procurement process by the County, ensures an award, which is primarily based on price, technical and financial qualifications. Contract negotiations are permitted, and it is not required that the lowest price proposer be selected if another proposer offers the best value overall.

During the contract period, County retains the ownership of the asset and responsibility for rate setting, billing, collection and administrative services.

Relationships of responsible D/B/O parties are illustrated on **Figure 3-7**. In addition, various landmark deadlines with use of D/B/O for the WRC are illustrated on **Figure 3-8**.

Figure 3-7
Design/Build/Operate

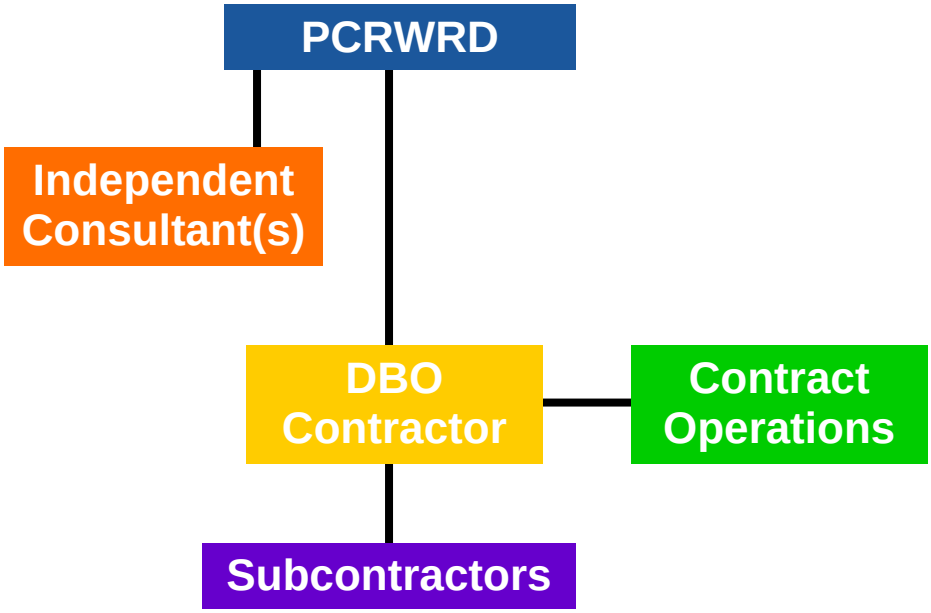
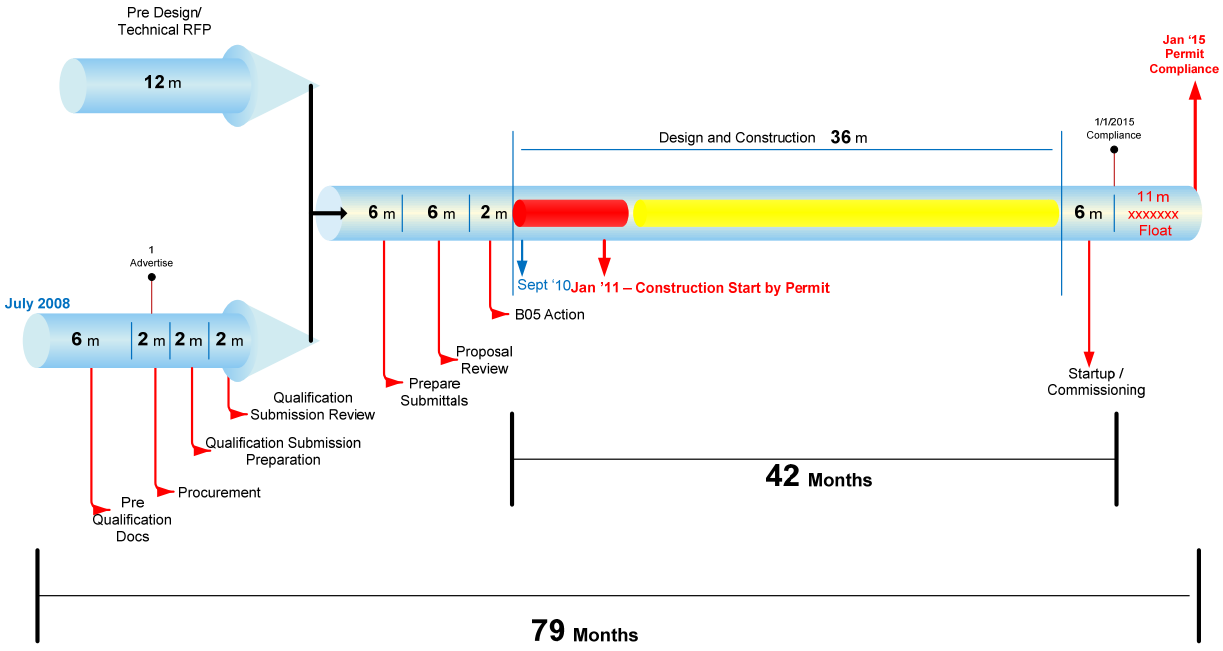


Figure 3-8
Design/Build/Operate Timeline



3.5 Design/Build/Maintain

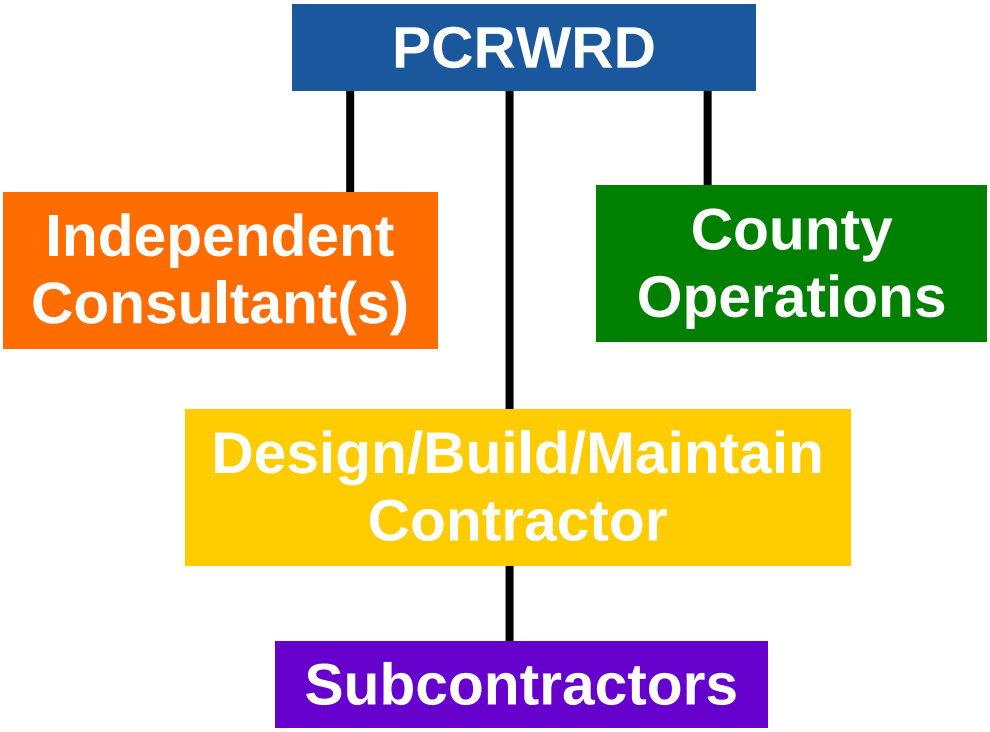
The Design/Build/Maintain (DBM) Method is similar to D/B, except that the longer term maintenance of the facility is combined with the design and construction into a single contract with the County operations. An independent consultant(s) may serve as the County's agent by assisting in establishing performance and maintenance requirements along with performance process and monitoring performance. The primary purpose for including an extended maintenance period (5 to 20 years) is to assure that the quality of equipment provided and the quality of installation are paramount. It moves the project delivery method closer to design/build/operate, except it allows for continued operation by the County.

In the DBM method, the County has the ability to transfer significant responsibilities and risks associated with a constructed project to a single point of responsibility. The single party is responsible for the integration of design, construction and maintenance of the facility for a significant period of time in accordance with performance criteria established by the County. The County relinquishes significant project control to the DBM for design, construction and maintenance aspects of the facility. Since selection of the design-builder is not generally based solely on price, the County has the opportunity to consider qualifications and experience in the selection process. Since the County will own and operate the facilities, it must carefully evaluate standards of proposed predictive, preventive and corrective maintenance, as well as repair and replacement to ensure that the facilities operate efficiently and that the condition of equipment is appropriately maintained during the life of the contract. Standards need to be established so that at the end of the contract period, equipment is left in satisfactory condition.

Proposers, generally a team of a design professional(s), contractor(s) and maintenance organization, respond to a Request for Qualifications (RFQ). A short listed group of qualified proposers then respond to a Request for Proposals (RFP) by submitting technical, commercial (business) and financial proposals. The negotiation process, established early on in the procurement process by the County, ensures an award, which is primarily based on price, technical and financial qualifications.

Relationships of responsible DBM parties are illustrated on **Figure 3-9**. Because use of this project delivery method is rare and has had mixed results, a timeline with this approach for the WRC is not provided.

Figure 3-9
Design/Build/Maintain Project Delivery Method



3.6 Design/Build/Finance/Operate

Design/Build/Finance/Operate (DBFO) method is similar to the D/B/O Method described in **Section 3.4** except that the facility is financed by the DBFO entity during the design, construction and long-term operations period of the facility. As with the D/B method, independent technical, legal and/or financial consultant(s) may serve as the County's agent(s) in managing the procurement process, establishing performance criteria and monitoring performance.

Service fee includes an allowance for construction debt service (as well as its operating and maintenance costs), and as a result the County will have no direct bond or debt service liability. If the contractor fails to provide service, the County can withhold the periodic service payments from the contractor, which includes the repayment of capital and interest. In extreme circumstances of default, the County can terminate the service contract.

During the contract, the County retains ownership of the asset and also the responsibility for rate setting, billing, collection and administrative services.

Relationships of responsible DBFO parties are illustrated on **Figure 3-10.** Various stages of the WRC project with the DBFO procurement are broken down and illustrated by the timeline on **Figure 3-11**.

Figure 3-10
Design/Build/Finance/Operate

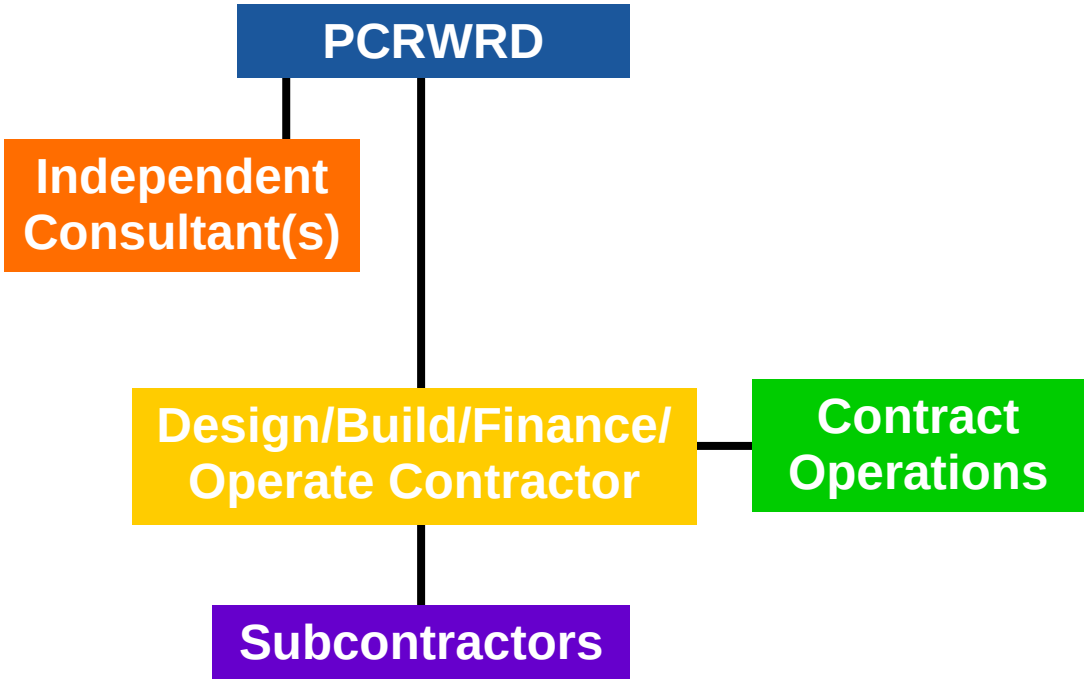
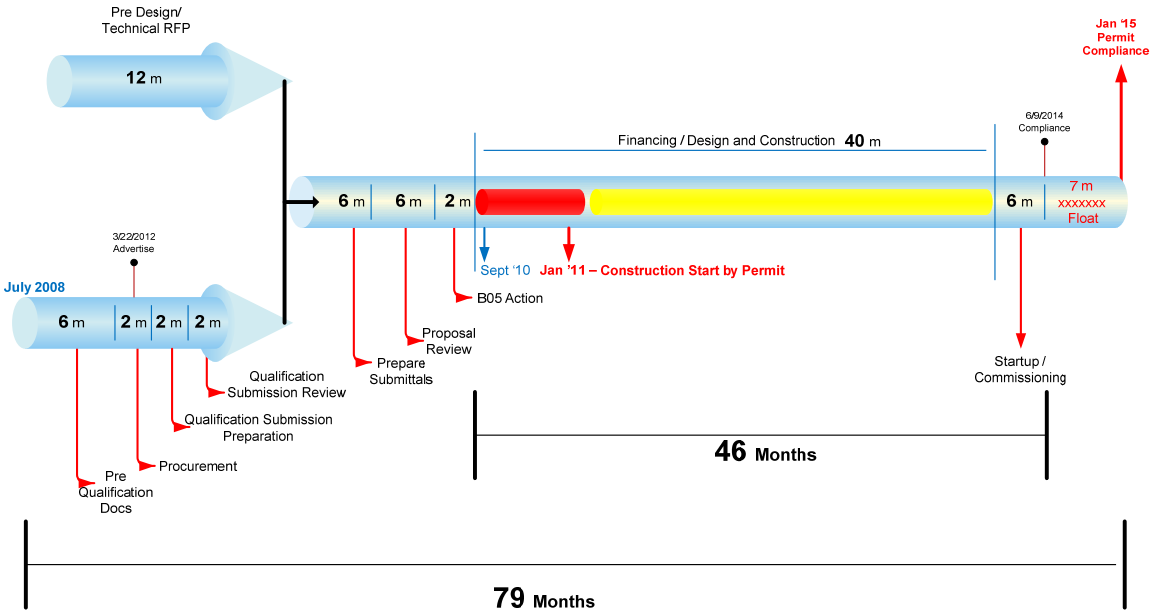


Figure 3-11
Design/Build/Finance/Operate Timeline



3.7 Design/Build/Finance/Own/Operate

Design/Build/Finance/Own/Operate (DBFOO) method is similar to the DBFO Method described in **Section 3.6** except that the facility is owned by the DBFOO entity during the long-term operations period of the facility. With this delivery method, the project is financed by the DBFOO entity. Again as with the D/B method, independent technical, legal and/or financial consultant(s) may serve as the County's agent(s) in managing the procurement process, establishing performance criteria and monitoring performance.

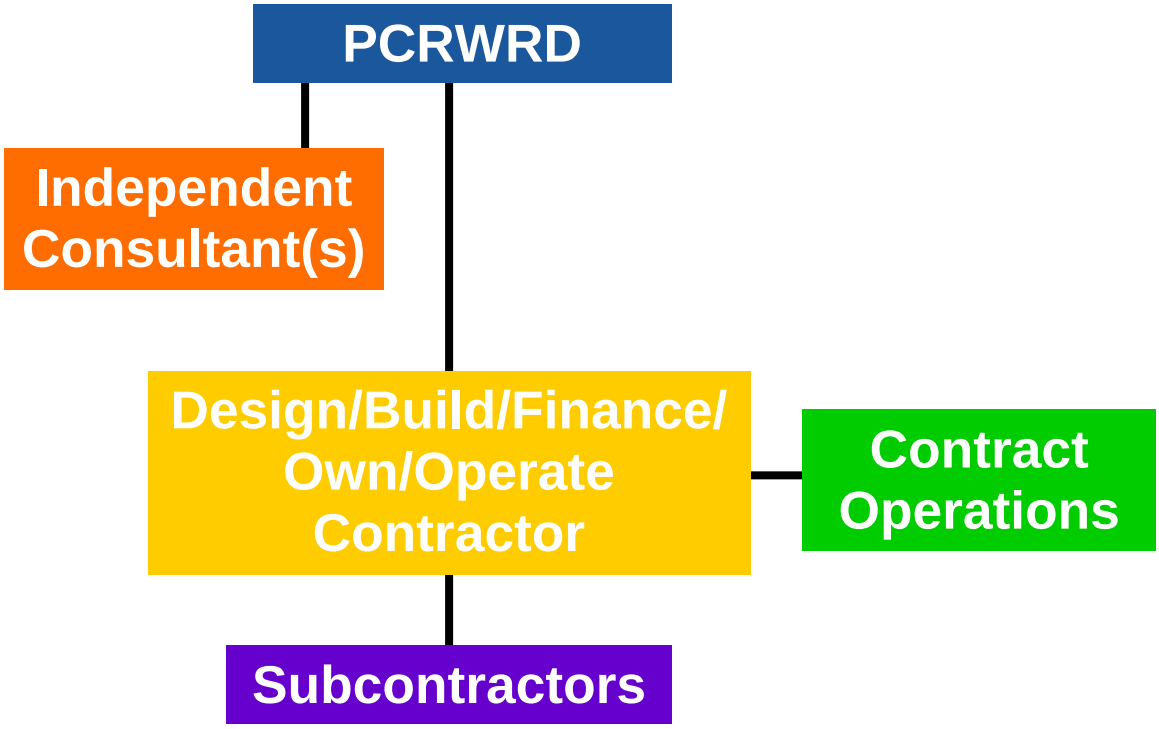
The DBFOO contractor, as the tax beneficial owner, will depreciate the project and contribute equity, which will reduce the amount of debt needed to finance the project. As a tradeoff, the contractor will own the project when the service contract expires, and the County must then purchase or rent the facilities at fair market value if it wishes to continue to receive service from the plant.

The service fee includes an allowance for the contractor's debt service (as well as its operating and maintenance costs), and the County will have no direct bond or debt service liability. If the contractor fails to provide service, the contractor does not receive payment. If a resolution cannot be reached between the involved entities, termination of the service contract may occur with the project ownership reverting to the County without cost. The potential for such a provision can take the place of a service contract guarantee by the contractor.

During the contract, the County retains the responsibility for rate setting, billing, collection and administrative services.

Relationships of responsible DBFOO parties are illustrated on **Figure 3-12**, which is the same as the DBFO except ownership of the facilities is held by the DBFOO entity. Because use of this project delivery method is rare because of the interest rate differential between public and private financing and transfer of County assets (property) to the public sector, a timeline with this approach for the WRC is not provided.

Figure 3-12
Design/Build/Finance/Own/Operate Project Delivery Method



3.8 Cost Savings Experience with Alternative Delivery

Expected cost savings associated with the use of an alternative delivery methods compared to traditional or conventional methods have been examined and can be attributed to various factors. DBB is a delivery method that is widely used with these types of projects and has a long history associated with its use. DBB achieves open, aggressive competition for construction, which is the largest portion of a project's cost. An issue is that the involvement of multiple parties each having singular interests and liabilities to protect can result in conservative project design and construction that increases project cost. Gaining a firm project cost under DBB is not obtained until the design is complete and bid, which is much later than in the D/B or CMAR methods. Omissions and inconsistencies in the design documents almost always result in added costs to the owner. CMAR carry many of the aspects and features of a DBB approach for procurement.

Costs of the DBB delivery method are affected by the following considerations:

- Not all of the information generated during the DBB process is necessary to construct the project. Under DBB, the design professional executes the work under the assumption that the least qualified contractor will build the project and the design professional will go to extremes to make certain that all the most basic information is included within the design documents. In addition, protective clauses are included in the bid documents to limit claims. A maximum amount of detail

is provided so that even the least qualified contractor has the detail needed to construct the facilities in accordance with the design intent.

- Design professional may have to account for multiple equipment choices and "or equal" considerations instead of designing for a specific piece of equipment.
- Routing of piping, conduits and HVAC is often are designed with some overlap. There is an initial design by the design professional and a second design by detailers who are responsible for preparing fabrication and material ordering documentation.
- Technical specifications are often very detailed to include protective language and to completely describe material and equipment.
- Redesign often results from changes to selected equipment or details during the shop drawing process.

Various comparisons have been performed to compare how project costs would change for D/B relative to a DBB delivery method. In their comparison of costs for buildings, Sanvido and Konchar[1] found that the use of DB provided an average of 6.1 percent reduction in unit construction costs with a 99 percent level of certainty when compared to DBB. It has been found that with water and wastewater projects, larger savings have been achieved.

Several case studies were looked at to determine estimates of capital cost savings from water and wastewater facilities that used the D/B approach.[2] Compared to the savings expected using DBB as the chosen delivery method, the D/B alternative provided a range of savings from 14 to 43 percent with an average of over 29 percent.

A survey was done of several municipal water and wastewater facilities that used D/B to determine how capital costs compared if DBB were used. Results found that there was an average capital cost savings of 39 percent for the 19 projects studied. In addition to looking at DBB projects, there were 22 design/build/operate projects examined in comparison to D/B and it was determined that the average life cycle cost savings was 26 percent. The survey was performed by William Reinhardt who is the editor of Public Works Financing.[3]

These various comparisons are based on projects bid based on one delivery method and compared to the estimated costs as if the project were bid as a DBB (CMAR). The best way to determine the relative capital cost of a project delivery by design/build/operate and conventional DBB for a project is to bid the project using both delivery alternatives. There are two known cases where this has occurred with one in Washington Borough, New Jersey and the other in Lee, Massachusetts. The project in New Jersey was for a $9.9 million wastewater treatment project where a savings using the D/B approach was 12.1 percent.[4] The project in Lee, Massachusetts was for a 1.5 million gallons per day (mgd) sequencing batch reactor wastewater treatment plant with a DBO bid 35 percent less than the $21 million DBB bid.[5] The dual track approach for bidding two project delivery methods simultaneously is not recommended for Pima County because of the size of the project and the current construction marketplace.

[1] "Selecting Project Delivery Systems"
[2] "Alternative Delivery Method Investigation for the Lake Pleasant Water Treatment Plant"
[3] "Design-Build-Operate Gains Popularity in U.S. Market"
[4] "A Growing Trend"
[5] Cohen, A.

There have been other various treatment facilities that have reported cost savings associated with an alternative delivery method. The City of Longmont, Colorado reports construction cost saving of $2.8 million for a D/B water treatment plant with a $43 million budget (a 6.5 percent savings).[6]

City of Seattle has two projects, Tolt Water Treatment Plant and Cedar River Project, which reportedly cost less due to the use of DBO. The Tolt Water Treatment Plant called for construction of a new 120 mgd facility. The City reports saving of at least 30 percent by using DBO and reports a net present worth savings of 47 percent including operating cost savings.[7] These savings were based on a comparison of the actual DBO costs with a benchmark cost estimate based on a 30 percent design of the Tolt facility. The benchmark design was based on two value engineering (VE) reviews including cost estimates by the VE team and a third independent cost estimate. The second Seattle project was for a second wastewater treatment plant (Cedar River Project) where life cycle savings compared to the benchmark project were 31 percent ($50 million savings relative to a $159 million benchmark)[3].

Another study, conducted by the City of Lynn, Massachusetts examined the cost saving for a wastewater treatment plant. A life cycle savings of 45 percent using the DBO approach was reported.[8]

The City of Phoenix's Lake Pleasant Water Treatment Plant used the DBO delivery method. **Table 3-1** summarizes the three DBO bids received and the benchmark project cost of net present value of design, construction and 20-year operating costs. Benchmark costs were based on a 20 percent design.

Table 3-1
Lake Pleasant Water Treatment Plant – DBO Compared to Benchmark Estimate

	All American	Bradshaw	EarthTech
Price Proposal Net Present Value	$336,701,630	$361,636,969	$286,709,244
City Benchmark	$366,492,876	$366,492,876	$366,492,876
Difference from Benchmark	($29,791,246)	($4,855,907)	($79,783,632)
Percent Difference from Benchmark	8.1%	1.3%	21.8%

EarthTech was the selected contractor but withdrew because of financial problems with its parent company, Tyco. The successful contractor for the project was All American. Final project costs were 8.1 percent below the City's benchmark costs.

There are differences between the delivery methods that should be noted. Under conventional DBB, the contractor is usually entitled to a change order if the project is disrupted by the owner's actions, a change in project conditions, or because design problems arise. In the D/B approach, the first two occurrences above may lead to a change order, while the third usually does not. The D/B entity is responsible for plans and specifications and cannot use errors in them to expect a change order. If the owner changes the criteria during the project, a change order may result. A study of 104 public sector D/B projects found

[6] "Colorado Water Treatment Plant Earns Design-Build Award"
[7] "Tolt Treatment Facility"
[8] "Best Practice: Lynn (MA) Water/Wastewater Innovation Saves Ratepayers Hundreds of Millions"

that cost growth during construction was 3 to 4 percent[9] while a separate study found the cost growth for a D/B project was 5.2 percent *less* than for DBB projects[1].

[9] "Public-Sector Design/Build Evolution and Performance"

Section 4 Multiple Criteria Analysis

The Multiple Criteria Analysis (MCA) provides information in an easy-to-read table that assists in tying qualitative and quantitative risks together. Criteria by which all alternative delivery methods can be compared against are listed on the table along with each of the alternatives under consideration. A matrix evaluation is used to score and rank each of the alternatives. The analysis summarizes the values of each criterion as compared against the others and leads to the recommended procurement model.

The matrix was constructed and presented during a series of workshops. In the first dedicated workshop, qualitative criteria were reviewed for inclusion in the analysis and finalized. At the second workshop, the weightings and scoring was reviewed and finalized. At the third and final workshop, the quantitative analysis was added to the Multiple Criteria Analysis to complete the table and produce the recommendation. The use of the Multiple Criteria Analysis helped determine the alternative that maximizes overall value of the project and also meets established project criteria.

The Multiple Criteria Analysis examines various issues of each alternative including:

- Optimizing Risk Allocation
- Project Quality and Asset Management
- Implementation Schedule
- Regulatory Compliance
- Sustainability
- Staff Considerations
- Level of County Control
- Market Viability
- Flexibility
- Predictability of Costs
- Legislative, Fiscal and Legal
- Risk Adjusted Net Present Cost

Definitions of the MCA Criteria are found in **Table 4-1**.

Table 4-1
MCA Criteria and Definitions

Criteria	Definition
Optimize Risk Allocation	How the procurement model effectively allocates risk to the party best able to manage that risk and the County's ability to enforce that risk allocation.
Project Quality and Asset Management	How the procurement model can impact the long term quality of the asset including opportunities in the procurement method for innovation in design, construction or program delivery.
Implementation Schedule	How the procurement model affects the implementation schedule.

Criteria	Definition
Regulatory Compliance	How the Project's ability to comply with regulations and permitting requirements is impacted by the procurement model.
Sustainability	How the Plant's ability to be sustainable over the long term is impacted by the procurement model.
Staffing Considerations	How the County's staffing requirements are impacted by the procurement model.
Level of County Control	The ability of the County to exercise control during the procurement process under consideration.
Market Viability	Assessment of the market conditions to determine the likelihood that the procurement method would result in a process that is competitive.
Flexibility	The flexibility to accommodate future regulation changes and other capital or operational changes.
Predictability of Costs	The potential for project costs to increase during design, construction and operation.
Legislative Fiscal and Legal	Legislative, legal or fiscal considerations of the application of the various procurement models.
Risk Adjusted Net Present Cost	Lifecycle cost of project (20 years of operation + construction), risk adjusted
Risk Adjusted Capital Cost	Capital costs of the project including all project soft costs and construction costs.

4.1 Optimizing Risk Allocation

Using a conventional DBB method, there is a risk associated with hiring the low bid contractor without the ability to base selection on qualifications. The County will warrant the design to the construction contractor. In addition, the County has negligible claim against the design professional for design and the construction contractor is not responsible for any operational problems at the facility. Unlike some of the other methods, there is no guarantee that the project will work as intended, either upon completion of construction or over the long term operating period. In these models, the County will typically retain most risks associated with design and construction of the facilities over the long term. Typically, the design professional and contractor provide bonding and insurance; however, the County's ability to collect under these protective measures can take time and involve extra costs such as legal fees with little guarantee of payment.

Use of D/B as a delivery method provides more flexibility in assigning risk to the entity best suited to handle that risk. Contract provisions and technical specifications define allocation of risk using performance based requirements. Design liability for plant construction is transferred to the contractor over the short term. The County will retain risk associated with design and construction over the long

term (after warranty period). After construction, the County is fully responsible for long term operation and maintenance of the plant.

The DBO provides more flexibility in assigning risk to the party best suited to manage that risk because the model now includes a long term operations component. The contracted DBO entity guarantees the quality and effectiveness of the plant upon completion and also over the long term operating period. Design liability for plant construction and performance is transferred to the DBO entity. Since this model does not include financing, the County must rely on contract language and parental company guarantees to enforce the risk transfer. Enforcement of risk transfer may involve extra costs for the County (i.e. legal fees).

The DBFO procurement model provides the maximum flexibility in assigning risk to the party best able to manage that risk. Contract provisions and technical specifications define the allocation of risk using performance based requirements. The DBFO entity guarantees the project will work upon completion and perform over the long term operating period. The DBFO consortium is typically led by the operator who injects capital into the project. This injection of equity instills an owner-like responsibility for managing risks into the operations of the plant without actually transferring ownership. The County would not make capital/construction payment to the DBFO entity until the plant is operational in accordance with the performance specifications. If the completion of the plant is delayed, or the plant does not perform as required over the operating term, the County does not pay the periodic performance payment (or penalties are assigned against that payment). As this periodic payment includes the repayment of capital as well as operating costs, the County has the maximum flexibility to enforce the risk transfer inherent in the contract documents without resorting to a legal process.

4.2 Project Quality and Asset Management

In the conventional procurement methods, the County selects all aspects of the design and will be in control of making selections that will assure compliance with the regulatory requirements. The County is in charge of long term maintenance of the facilities and may be prone to deferring maintenance under budgetary pressure. Under the conventional methods, the County only provides one design for tender. This design is not “market tested” to ensure it is the most efficient and flexible design.

With all the alternative procurement delivery models, the County has a choice of three designs from which to choose when awarding the contract. Designs are completed in a competitive environment and likely will result in a more innovative and flexible design.

For a D/B delivery method, the County is responsible for creating output specifications used during the procurement process. Contractor selection can be based heavily on qualifications reducing risk that an unqualified contractor may win the contract. A study of 104 public sector D/B projects found owner satisfaction to be excellent. Another study of 351 projects found that owner satisfaction was better for D/B projects than for DBB projects. Since the responsibility for operations is not included in this model, there is a higher risk that the project will use poorer quality equipment with higher maintenance requirements over the long term.

Adding the “O” has shown to provide additional savings through intensive operator input during design of the facilities. The application of knowledge from a pool of operator experts results in an efficient and innovative design. Contractor selection is through a stringent qualifications process, which reduces the

chances that a marginally qualified team is awarded the project. The County prepares performance specifications that involve the operations of the plant as well as the design and build components. The DBO entity must meet those specifications in order to be paid their operating costs. Typically construction costs are paid to the DBO entity during the design-build phase in accordance with milestones that are built into the contract.

The DBFO model has all the benefits attributed to the DBO model. The inclusion of the financing component in the model brings an added level of due diligence by the financers. Operators (typically in wastewater treatment plant projects) will inject capital into the project as equity. There is a tendency for improved design when the consortium team has to submit a 25 to 30 percent design with fixed costs in competition with other parties. The added benefit of the DBFO model is the fact that the construction costs are not paid to the consortium DBFO entity until the facilities are constructed in accordance with the specifications and provides performance compliance over the operating period. The contract will include "*hand-back*" specifications that outline the condition of the facility and equipment when the contract ends. The County has the ability to withhold portions of periodic payments during the final five years of the contract to protect the County against a sub-standard facility at the end of the contract period.

4.3 Implementation Schedule

A risk associated with the new WRC at Roger Road is meeting permit compliance by January 2015. All of the methods can potentially meet this deadline, but a conventional method requires an earlier start because of the longer implementation schedule.

Alternative procurement options combine the design and the build team which results in shorter implementation schedules. Planning and procurement phases of the alternative procurement models do vary with the model and can be more lengthy than the traditional. According to the information collected during the alternative project delivery workshops, D/B and DBO projects have similar time frames, which are less than those for either DBB or CMAR. While the use of a DBFO delivery method provides financial incentives to meet the project timeline, there is a higher level of complexity associated with the planning and procurement phases of this method.

A study of 351 projects found D/B to delivery projects 33% faster than DBB and 23% faster than CMAR because design and construction can and do occur concurrently. Shorter project schedules can provide savings by reducing effects of inflation and reduced interest during construction.

4.4 Regulatory Compliance

The County selects all aspects of design for projects under conventional procurements. To meet regulatory compliance, the County uses its normal permitting procedures and has control and responsibility for non-construction and operating permits.

In all alternative procurement models, the County is responsible for preparing design and construction performance specifications that will result in a plant that meets the needs of the regulatory agencies.

For D/B projects, the County will control operation and will select a proposal that will be designed and constructed to meet specified performance and regulatory standards.

Both DBO and DBFO models have similar regulatory compliance issues in that the service agreement transfers risk associated with technology and plant operation while requiring the operator to meet all regulatory compliance during the contract operations period. In the DBO model, if the plant does not consistently meet regulatory compliance, portions of or the full operating service payments may be in jeopardy. Under the DBFO model, a portion of or the full periodic performance payment, which includes both capital and operating components, are at risk.

Under the DBO and DBFO models, the regulatory agencies have to review partial design submittals rather than complete 100 percent designs as typical. This may cause some review agencies to change their procedures and policies. Inclusion of the operator in the design process improves the chance that the plant will be compliant over the long term.

4.5 Sustainability

Sustainability is another important issue when selecting the design method appropriate for the new WRC at Roger Road. For conventional projects, the County is in charge of all design aspects and sustainability. All documentation for LEED (Leadership in Energy and Environmental Design) compliance or certification falls on the County.

Under D/B, DBO and DBFO, the County can establish sustainability requirements in the legal contracts and can transfer risk associated with meeting the requirements to the private sector. The private sector partner then becomes responsible for certification of compliance paperwork. With all three alternative procurement models, there will be financial penalties if the certification does not happen; however, the amount of the penalties will be different under the three models with the DBFO having the most severe penalties.

4.6 Staff Considerations

Staff considerations associated with the project varies between the alternative delivery methods.

For all of alternative delivery models, County staff and its agents will be responsible for the production of output based performance specifications and management of the resulting legal agreements. This involves requires significant involvement of staff and a team of advisors, especially during the planning and procurement phases of the project. The time involvement decreases during the implementation phase of the project and drops off further during operations and maintenance.

Under DBB, CMAR and D/B, the County is responsible for long term operation and handles all workforce issues required by the facilities. The County must deal with having to address vacancies resulting from an aging workforce entering retirement.

For the DBO and DBFO projects, there will be up-front work required by County staff to define project specifications and evaluate proposals. The contractor provides operating staff and is responsible to provide sufficient personnel for operations and maintenance. Effort will be required to successfully transfer existing staff to the new operator or elsewhere within the County system.

4.7 Level of County Control

Level of County control for conventional delivery projects is high because the County controls all design details, but also incurs the highest risks.

In alternative project delivery models, the County controls the project through production and enforcement of the output performance specifications. During operations and maintenance, the County has the advantage of performance based payments; and in the case of the DBFO, those payment include capital costs as well. In alternative project delivery, the County can determine how much risk to accept. Many of the advantages associated with the various alternative project delivery methods is realized only if the County is willing to reduce their degree of direct management of the project.

4.8 Market Viability

Previous experience and market viability with a given project delivery method plays a role in the associated risks. Conventional methods like DBB and CMAR are very common with these types of projects, and in the case of DBB produce the highest number of bids.

The D/B market has grown over the past few years and is reasonably well developed in the United States. Under both DBO and DBFO, there is less competition in the marketplace because of the limited number of companies currently in the contract operations market for large plants.

4.9 Flexibility

There are different levels of flexibility available based on the project delivery method chosen. For conventional and D/B project delivery, the County is in control of any construction or operational changes following construction and therefore can make any decision to change the facility; however, changes during construction under a traditional model could be expensive. Under an alternative delivery model where design is competitively bid, design flexibility and ability to modify the plant in the future could be a large part of the technical evaluation for selection.

It is understood that the County will need to continue to update the plant in accordance with future regulatory standards and changes in technology. When the plant is under County operations and maintenance (i.e. DBB, CMAR, and D/B); the County will have complete flexibility to manage that process.

Under private operations, the County will need to negotiate changes with the operator. Terms and process regarding these changes will need to be documented in the contract. The County can require that the Operator follow a particular procurement process for changes over a specified amount. This can include competitive tender and national advertising. The contract can also require the operator to study, or assist the staff in studying, impacts of changes and produce a cost benefit analysis of the change. Depending on the project delivery model chosen for the changes, there may be an opportunity for risks to be effectively allocated to reduce subsequent costs.

4.10 Predictability of Costs

Discussion regarding the predictability of costs can be found in **Section 7**

4.11 Legislative, Fiscal and Legal

For conventional project delivery, the County can employ traditional long term financing with low interest rates, established legality and low issuance costs. Under D/B and DBO, the price of the project is known much sooner than a DBB project and legality is established. For DBFO projects, higher interest rates are encountered with private sector financing but there is minimal administration, which may reduce impacts on County debt limits. Currently, there are legal and fiscal unknowns associated with this alternative project delivery method.

4.12 Multiple Criteria Analysis Summary

The MCA criteria identified and discussed above are provided in more detail in **Table 4-2**. This table lists the criteria and summarizes how the various project delivery methods differ from each other.

4.13 Multiple Criteria Analysis Scoring Table

This MCA scoring table ranks the various criteria for four alternatives: Conventional (DBB or CMAR), DB, DBO and DBFO. Two alternative methods, DBM and DBFOO, were dropped from consideration. DBM is a rarely used project delivery method and have few sources for reference. In addition, the preparation of the necessary scope document and the administering of this method are very complex. DBFOO was removed from consideration because of the difficultly associated with private financing and selling or transferring of County property. Pima County is the Designated Management Agency (DMA) for the area and may need to take over the facility in the future, if the private entity were to fail. Thus, it is best if the land is available under County ownership.

The MCA scoring table for the new WRC under the various alternative project delivery methods is shown in **Table 4-3**.

Table 4-2
Multiple Criteria Analysis Summary Table

Criteria	DBB / CMAR	DB	DBO	DBFO
Optimize Risk Allocation	Risk associated with hiring the low bid contractor without the ability to evaluate qualifications. Design is warranted by the County. No single party guarantees that the project will work as intended, either upon completion of construction or over the long term operating period. County typically retains most risks associated with the design and construction. County must rely on bonding and insurance for unforeseen problems.	Provides some flexibility in assigning risk to the party best suited for that risk. Contract provisions and technical specifications define the allocation of risk using performance-based requirements. Design liability for plant construction is transferred to the contractor for the short term. The contractor guarantees the project will work as intended during an acceptance test after substantial completion, but not during operations. The County retains the risks associated with design and construction over the long term (typically the risk can be transferred initially to the DB contractor for the warranty period only). The County is fully responsible for long term operations and maintenance for the Plant.	Provides more flexibility in assigning risk to the party best suited for that risk because of the integration of the operator. Contract provisions and technical specifications define the allocation of risk using performance-based requirements. DBO contractors guarantee the project will work upon completion and also over the long term operating period. Design liability for plant construction and performance is transferred to the contractor. Since this model does not include financing, the County must rely on contract language and parental company guarantees to enforce the risk transfer. This model is dependent on performance based payments; if the contractor does not perform, the County does not pay for the services.	Provides maximum flexibility in assigning risk to the party best suited for that risk. Contract provisions and technical specifications define the allocation of risk using performance-based requirements. DBFO contractors guarantee the project will work upon completion and also over the long term operating period. Design liability for plant construction and performance is transferred to the contractor. Lead consortium is the operating partner who injects capital into the deal. The County does not pay for the Plant (Capital Costs) until it is operational, and only when it is operating in accordance with the performance specifications. Depending on the performance, the contractor may even forfeit some of the capital repayments.
Project Quality and Asset Management	County selects all aspects of design, will be in control of making selections that will assure	Under this model, the County is responsible for creating output specifications used during the	Adding the "O" to DB has been shown to typically provide additional savings through	The equity partner in a DBFO will manage life cycle costs effectively to minimize long term risks.

Criteria	DBB / CMAR	DB	DBO	DBFO
	compliance and will control the operation. . The County self-performs long term maintenance and may be prone to deferring maintenance under budgetary pressure. Under the conventional system, the County is only given one design. This design has not been "market-tested" to ensure that it is the most innovative and flexible solution.	procurement process. In response to the RFP, the County will have the pick of three designs that comply with the specifications. Greater risk of poorer quality equipment with higher maintenance requirements. Under this scenario, the County has the ability to choose from three designs. The designs were created in a competitive market and would likely result in a more innovative and flexible design.	operator input to design. Improved designs can result when proposers have to submit a 25% design with fixed costs in competition with other parties. There is competition as to design, construction and operations and maintenance. Requires collaboration among the designer, builder and operator. Under this model, the County is responsible for creating output specifications used during the procurement process. In response to the RFP, the County will have the pick of three designs that comply with the specifications. The County also creates operating specifications that the contractor must meet in order to be paid.	In a DBFO, the operating partner typically injects equity into the project. Improved designs can result when proposers have to submit a 25% design with fixed costs in competition with other parties. There is competition as to design, construction and operations and maintenance. Requires collaboration among the designer, builder and operator. Under this model, the County is responsible for creating output specifications used during the procurement process. The County also creates operating specifications that the contractor must meet in order to be paid County can withhold capital repayments during the final years of the term to ensure that the plant is in a good condition at the end of the term.
Implementation Schedule	Capable of meeting the regulatory deadline of January, 2015, although DBB must begin much sooner. The DBB model has the longest implementation schedule once the procurement model is chosen.	Capable of meeting the regulatory deadline of January 2015 and the contract award deadline of January 2011.	Capable of meeting the regulatory deadline of January 2015 and the contract award deadline of January 2011.	Capable of meeting the regulatory deadline of January 2015 but unlikely to meet the contract award deadline of January 2011.

Criteria	DBB / CMAR	DB	DBO	DBFO
Regulatory Compliance	County selects all aspects of design, will be in control of making selections that will assure compliance and will control the operation.	County will control operation and will select a proposal that will be designed to meet specified performance standards and regulatory requirements. Acceptance testing ensures that the facility meets regulatory and performance requirements prior to the County taking control of the plant. The County is responsible for long term compliance with the regulatory agencies.	The Service Agreement transfers the risk associated with regulatory requirements during the operating contract. Failure to meet these requirements results in liquidated damages, an obligation to pay regulatory fees and penalties and, depending on the severity of the non-compliance and number of circumstances, may result in an operator default.	The Service Agreement transfers the risk associated with regulatory requirements during the 20 year contract operations period. Failure to meet these requirements results in liquidated damages, an obligation to pay regulatory fees and penalties and, depending on the severity of the non-compliance and number of circumstances, may result in an operator default.
Sustainability	The County will be fully responsible for all aspects of sustainability.	The County can require the sustainable requirements in the performance specifications and can apply financial penalties if the specifications are not met. If the specifications include certification, the private consortium is fully responsible to achieve that certification.	The County can require the sustainable requirements in the performance specifications and can apply financial penalties if the specifications are not met. If the specifications include certification, the private consortium is fully responsible to achieve that certification.	The County can require the sustainable requirements in the performance specifications and can apply financial penalties if the specifications are not met. If the specifications include certification, the private consortium is fully responsible to achieve that certification.
Staffing Considerations	County fully responsible for the operation and maintenance of the plant. The County self-performs long term maintenance and may be prone to deferring maintenance under budgetary pressure.	Requires intensive up-front involvement by County staff, which should decrease during the project's design and build phase. County fully responsible for operation and maintenance of the plant. The County self-performs long term	Requires intensive up-front involvement by County staff, which should decrease during the project's design and build phase. The contractor has the responsibility to provide the operating and maintenance staff and during operations the County	Requires intensive up-front involvement by County staff, which should decrease during the project's design and build phase. The contractor has the responsibility to provide the operating and maintenance staff and during operations the County

Criteria	DBB / CMAR	DB	DBO	DBFO
		maintenance and may be prone to deferring maintenance under budgetary pressure.	involvement is reduced to oversight of the contract operations. Effort is required to insure successful transition of existing staff to the private operator.	involvement is reduced to oversight of the contract operations. Effort is required to insure successful transition of existing staff to the private operator.
Level of County Control	The County controls the day to day management of the project.	The County controls the project through the use and enforcement of performance based specifications. The County does not control the day to day management of the project.	The County controls the project through the use and enforcement of performance based specifications and payments. The County does not control the day to day management of the project.	The County controls the project through the use and enforcement of performance based specifications and payments, which includes a capital component. The County does not control the day to day management of the project.
Market Viability	The County has more experience with DBB and CMAR than with the alternative methods. Historically, DBB is the most widely used delivery method and would probably generate the most competition for construction.	Significant numbers of companies are in the Design Build market. Will require development of new procurement documents, procedures and contract forms. The County may wish to retain an advisor to manage the procurement including development of the documents and procedures.	Because of the limited number of companies currently in the "O" market for plants of this magnitude, there will probably be less competition for DBO than for DB. Will require development of new procurement documents, procedures and contract forms. The County may wish to retain an advisor to manage the procurement including development of the documents and procedures.	Because of the limited number of companies currently in the "O & F" market for plants of this magnitude, less competition for DBFO than for DB & DBO. Will require development of new procurement documents, procedures and contract forms. The County may wish to retain an advisor to manage the procurement including development of the documents and procedures. The DBFO model for WWTPs is not common in the United States and this will be a new model for most of the local market players.

Criteria	DBB / CMAR	DB	DBO	DBFO
Flexibility	The County will be directly managing the design and construction phases of the project and can implement changes as required. The County has full control of the plant during operations and can implement changes as required using normal practices.	The County will need to negotiate changes with the DB contractor during the design and build phase of the project. The County has full control of the plant during operations and can implement changes as required using normal practices.	The County will need to negotiate changes with the contractor during the contractual term of the project. The terms and process on how to manage changes will be detailed in the legal agreements. Depending on the procurement model chosen for the changes, there may be an opportunity for risk to be effectively allocated.	The County will need to negotiate changes with the contractor during the contractual term of the project. The terms and process on how to manage changes will be detailed in the legal agreements. Depending on the procurement model chosen for the changes, there may be an opportunity for risk to be effectively allocated.
Predictability of Costs	Contractor is usually entitled to a change order if project conditions change or design or construction problems occur. The County is not protected from disputes among the design engineer and the builder. Occasionally associated with bid protests, and also often the subject of litigation once the construction contract is executed. The County workforce operates and maintains the project with no guaranteed fixed annual O&M cost.	A change in project conditions may result in a change order but design or construction problems do not. Contractor is responsible for plans and specs and cannot use deficiencies in them to expect a change order. The County workforce operates and maintains the project with no guaranteed fixed annual O&M cost. Less prone than DBB to bid protests and litigation because of the prequalification of contractor teams and the extended opportunity to negotiate a mutually advantageous contract under which the contractor is willing to assume design liability A study[1] found cost growth for DB projects was 5.2% less than for DBB project for 351 projects.	Operators provide input during design that may further reduce the potential for overruns. Agreements obligate contractors to provide long term operation and maintenance services for a guaranteed fixed annual service fee, adjusted only for indexed inflation. Provides a single point of project responsibility. The County thus is immune from finger-pointing among the contracting team members. Less prone than DBB to bid protests and litigation because of the prequalification of contractor teams and the extended opportunity to negotiate a mutually advantageous contract under which the contractor is willing to assume design liability	Operators provide input during design that may further reduce the potential for overruns. Agreements obligate contractors to provide long term operation and maintenance services for a guaranteed fixed annual service fee, adjusted only for indexed inflation. Provides a single point of project responsibility. The County thus is immune from finger-pointing among the contracting team members. Less prone than DBB to bid protests and litigation because of the prequalification of contractor teams and the extended opportunity to negotiate a mutually advantageous contract under which the contractor is willing to assume design liability. The inclusion of financiers and

Criteria	DBB / CMAR	DB	DBO	DBFO
				equity providers add a due diligence element to the Project, especially with respect to budget and schedule management.
Legislative, Fiscal and Legal	Allows County to use its typical long term financing approach with the low interest rates available for public financing, established procedures, established legality and low issuance costs.	Firm project price is known much sooner than in DBB. Legality is established.	Firm project price is known much sooner than in DBB. Legality is established.	Will involve private financing with higher interest rates but has advantages of minimal administration, may reduce impacts on County debt limits and the County will not be required to pay a service fee until the facility is operational. May offer potential for longer debt maturity. The payment to the DBFO contractor may be included in the "expenditure cap" for the County. This possibility is currently being analyzed. More legal and fiscal unknowns with this model.
Risk Adjusted Net Present Lifecycle Cost				
Risk Adjusted Capital Cost				

References

1. Sanvido, V. and Konchar, M., "Selecting Project Delivery Systems," Project Delivery Institute, State College, PA (1999).
2. Molensar, K.R., Songer, A.D., and Barash, M., "Public-Sector Design/Build Evolution and Performance," ASCE Journal of Management in Engineering, page 54 (March/April, 1999).

Table 4-3
Multiple Criteria Analysis

Pima County WRC - MCA Scoring Table

		Ranking				Scoring Calculation			
	Weight	Conv	DB	DBO	DBFO	Conv	DB	DBO	DBFO
Optimize Risk Allocation	8	2	6	8	10	16	48	64	80
Project Quality and Asset Management	10	5	6	8	9	50	60	80	90
Implementation Schedule	10	5	10	10	9	50	100	100	90
Regulatory Compliance	10	7	8	10	10	70	80	100	100
Sustainability	4	7	5	7	7	28	20	28	28
Staffing Considerations	4	6	6	8	8	24	24	32	32
Level of County Control	4	10	8	6	5	40	32	24	20
Market Viability	6	10	9	8	7	60	54	48	42
Flexibility	3	10	8	6	6	30	24	18	18
Predictability of Costs	6	4	6	8	8	24	36	48	48
Legislative Fiscal and Legal	6	10	10	10	3	60	60	60	18
Ranking						**452**	**538**	**602**	**566**

Conv = Conventional = DBB and CMAR
Ranking: 1 to 10 with 10 being excellent
Weight: 1 to 10 with 10 being extremely important

Section 5 Evaluation

One step in analyzing which project delivery option is the best suited for the new WRC is the identification and description of the risks inherent with each method. A list of the risks identified for this project includes:

- Pre-Financial Closing Interest Rate
- Post-Financial Closing Interest Rate
- Pre-Financial Closing Inflation Rate
- Post-Financial Closing Inflation Rate
- Failure to Create Output Specifications
- Interest Rate – Debt Series 1
- Interest Rate – Debt Series 2
- Interest Rate – Debt Series 3
- Interest Rate – Private
- Capital Inflation
- O&M Inflation
- Energy Inflation
- Design Scope Changes – Owner Initiated
- Construction Scope Changes – Owner Initiated
- Design Errors
- Technical Inadequacy
- Design Review Requirements
- Design Schedule
- Inexperienced/Weak Contractor
- Cost of Construction Materials
- Shortage in Labor Supply
- Contaminants
- Geotechnical
- Site Conditions
- Cultural Resources
- Scope Changes During Operations
- Capital Repair and Replacement
- Maintain Equipment for Warranty
- Operation and Maintenance Costs
- Latent Defect – Design
- Latent Defect - Construction
- Interface/Integration
- Energy Consumption
- Design Approval
- Regulation Change - Design
- Occupancy Risk
- 208 Plan Amendment
- Corps of Engineers Permit
- State Environmental Permit

After the risks for the project have been identified, it is then possible to risk adjust the different cash flows associated with the different procurement models. Risk analysis approximates how financial model outputs are impacted by the variability of inputs. Risks are described in greater detail below, including the benefits of risk management and the various risk identification process.

5.1 Mitigation of Risks

After all the risk are identified and studied in detail, it is then possible to discuss mitigation measures for risks. Depending on the cost, all risks can potentially be mitigated or only risks that add to the total risk should be mitigated. A list of risks, possible ramifications associated with those risk and mitigation options for each are detailed in **Appendix A**.

Section 6 Risk

The risk analysis and management process for the new WRC at Roger Road begins at the planning stages for the business case stage through procurement and financial close. Key risks factors are:

- Documenting risks associated with implementing the project;
- Incorporating risks into the project's financial models;
- Considering risks during drafting of project agreement; and
- Managing the retained risks throughout the implementation of the project.

Special focus is placed on identifying project risks, allocating them between the public and private sector, developing preliminary risk management strategies and incorporating risks into the benchmark costs (public sector comparator). The risk analysis will be periodically updated throughout the procurement process to financial close.

6.1 Benefits of Risk Management

Undertaking the risk management process in a structured manner provides the County with an opportunity to maximize value for money in several ways.

- Effective Risk Management leads to:
  - Improved strategic management;
  - Better selection of strategic objectives and associated targets as a result of risk identification, analysis, evaluation, treatment and monitoring process;
  - Greater ability to deliver against realistic and achievable objectives and targets;
  - A shared common understanding of objectives and the way opportunities can be harnessed;
  - A transparent process wherein risks and actions taken to treat and monitor them are clearly visible to key decision makers; and
  - Identification of each party's tolerance of risk.
- Improved governance and operation management through:
  - A balance between risk responsibility and ability to control that risk;
  - Higher standards of accountability;
  - Promotion of innovation;
  - Improved capacity to manage risk in the face of competing obligations;
  - Enhanced managerial control and less reliance on crisis management; and
  - A process based on continuous improvement.
- Improved financial management through:
  - Better informed financial decision making on scenarios or option analysis;
  - Enhanced financial control;
  - Reduction in financial costs associated with losses due to service interruption, litigation and poor investment decisions; and
  - Effective allocation and use of public and private sector resources.

End result of an effective allocation of risk between the contractual parties is a maximization of the project's value with the least overall negative impacts.

6.2 Risk Register and Risk Report

A risk register is a key tool for the risk management process and forms the basis from which a project's risk management plan is developed.

A risk register helps the project team to understand the true nature of risks involved in a particular project and to thoroughly consider all events that could impact the project through the procurement, design, construction and operations phases. Use of a probability (Monte Carlo simulation) program on the risks allows for multiple trials to vary inputs and log potential outputs. The spread in the range of outputs illustrates risk associated with project.

The register records and identifies risks in a structured manner to facilitate assessment and evaluation of risks, and provide a transparent and comprehensive tool for communicating risks to key stakeholders and decision makers.

For public private partnership (alternative project delivery) procurements, the risk register provides a tool with which to explicitly identify and manage risks. It provides a structure to record detailed information on risks, identify mitigation options and assess financial impacts so as to treat them in a manner most appropriate for the project and the parties involved.

Accompanying the risk register is the risk report. This report documents the risk process followed in the project including assumptions and calculations.

6.3 Risk Ranking

Risks are ranked by examining the combination of the likelihood of the risk event occurring with the consequence of the risk event.

6.4 Risk Workshops

The first step in the risk management process is to identify project risks and populate a preliminary risk matrix for discussion. The risk matrix is revised as a result of the detailed discussions amongst the stakeholders of the project. The discussions included a review of the risk event's description, identification of the cause and effect of the risk event, ranking of the risks and discussion of mitigation options.

Quantification workshops were held to provide more detail on the risk events and probable limits of impacts. In these workshops refinements to the identification and description of risk events, expansion of mitigation options and quantification of risks occurred.

Members of the various risk workshops are shown in **Table 6-1**.

Table 6-1
Risk Quantification Workshops and Attendees

Design / Construction	Legal / Financial / Commercial	Operations / Maintenance / Rehabilitation	Regulatory and Approval
Client Team: Mandley Rust Jaime Mike Kostrzewski Ron Riska Pete Mulvey Bob Braden Eric Wieduwilt Pat Paddock Noel Ortiz John Carter **Consultation Team**: Jerry Bish Andy Richardson Eric Peterson Harold Smith Mark Harrison Sue Fimrite	**Client Team:** Harlan Agnew Chuck Wesselhoft Jeff Nichols Amy Katzenmeyer Diane Bracken Mike Kostrzewski John Carter Ron Riska **Consultant Team**: Jerry Bish Andy Richardson Eric Peterson Harold Smith Mark Harrison Sue Fimrite	**Client Team:** Jackson Jenkins Jim Doyle John Sherlock Dave Garrett John Warner Paul Jordon Jack VanRiper Pat Paddock Steve Melendaly Noel Ortiz Ron Riska **Consultant Team**: Jerry Bish Andy Richardson Eric Peterson Bart Kreps Mark Harrison Sue Fimrite	**Client Team:** Jackson Jenkins Bryon McMillan Harlan Agnew Chuck Wesselhoft Jeff Prevatt Ron Riska **Consultant Team**: Jerry Bish Andy Richardson Eric Peterson Bart Kreps Mark Harrison Sue Fimrite

6.5 Qualitative Risk Analysis

Qualitative risks are those that cannot be quantified with a value, number or amount. Qualitative risks associated with the new WRC at Roger Road may include:

- Failure to Create Output Specs
  - Issues with communication result in County not receiving what it wants or needs
- Design Scope Changes – Owner Initiated
  - The County desires changes to the design during the Design phase
- Construction Scope Changes – Owner Initiated
  - The County decides to make changes during the Construction phase
- Design Errors
  - An error or emission during design results in the need for a Change Order

- Technical Inadequacy
  - The facility fails to perform as expected even though the facility was designed and constructed properly
- Design Review Requirements
  - Design review is not performed in a timely manner
- Design Schedule
  - Design phase takes longer than estimated
- Inexperienced/Weak Contractor
  - Selected contractor is unable to perform as expected
- Shortage in Labor Supply
  - Qualified labor is not available during project when needed
- Contaminants
  - The uncovering of soil contamination or other issues of environmental concern are found during construction
- Geotechnical
  - Subsurface soils are not conducive to construction
- Site Conditions
  - The soils or other properties on site present unforeseen issues or culturally significant items are uncovered
- Scope Changes During Operations
  - Performance requirements change during the Operations period
- Maintain Equipment for Warranty
  - Equipment installed is not maintained properly
- Design Approval
  - Regulatory approvals of the design are delayed
- Regulation Change – Design
  - During the Design phase, regulation changes are encountered requiring changes during design
- Occupancy Risk
  - County is unable to secure Occupancy Permit at the end of Construction
- 208 Plan Amendment
  - 208 Plan Amendment for the new WRC at Roger Road is not approved
- Corps of Engineers Permit
  - County is unable to secure Corps of Engineers (COE) permit
- State Environment Permit
  - County is unable to secure all required Arizona Department of Environmental Quality permits

6.6 Quantifiable Risk Analysis

Once risks were identified, described, and categorized, the quantifiable risks were listed under the following broad categories.

- Project Management
- Design and Construction
- Transition and Commissioning
- Operations, Maintenance and Rehabilitation

- Equipment
- Financial, Commercial and Accounting
- Supervening Events

Each risk was quantified with the view of assessing the potential cost implications of each risk to the project. This process involved a two step process that was performed in a workshop setting. The first step in the process was to examine each of the risks and determine whether it was feasible to quantify the potential financial impact that each risk could have on the project. The next step in the process involved defining each risk's range of probable impacts on cost under each of the project delivery models under consideration. This step was accomplished by first determining the probability of occurrence for each quantifiable risk and then determining the range of possible consequences if the risk did occur. This range was defined by selecting a minimum consequence, a maximum consequence and a most likely consequence for each risk. Risks that are determined to be quantifiable, the likelihood that the risk would occur and the range of impact that each risk could have on a particular component of the total life cycle cost of the project. See **Appendix B** for details.

This information was used to create probability distributions for the financial impact of risk on the total life cycle cost of the project under each delivery model.

Section 7 Financial and Risk Analysis

To facilitate a comparison of expected project life cycle costs under each delivery model, a financial and risk analysis model was developed. The model was used to calculate a baseline and a risk adjusted present value of life cycle costs for each of the delivery methods under consideration.

Costs for the new WRC at Roger Road were based on those developed in the Regional Optimization Master Plan. Costs include: influent pumping, screening facilities, grit removal facilities, odor control, Bardenpho wastewater treatment technology, clarifiers, disinfection, sludge thickening, sludge transfer pump station, site work, paving, architectural, fencing, irrigation and landscaping, engineering, overhead, profit and contingency. Operation and maintenance (O&M) costs include: labor, energy, and other related costs.

Project financing must be considered in determining the delivery method best suited for the new WRC at Roger Road. Variables like inflation, interest and discount rates, non-inflationary cost fluctuations, design/construction schedule, annual cash flow, present value of project costs, risk adjusted range of present value of project costs, impact of individual risk components and preliminary rate impacts differ for each delivery option.

Present value of project costs for the County varies based on the project delivery method selected. For conventional project delivery methods, the present value costs include the total life cycle costs to County for design, construction and operation of the new WRC at Roger Road. With DB costs include the proposed cost for design and construction, life cycle cost of County operations, and cost of retained risks. For DBO project delivery present value of project costs includes proposed costs for design, construction and operation in addition to cost of retained risks. Design/Build/Finance/Operate (DBFO) has proposed cost for design, construction, operation and financing plus the cost of retained risks.

The procurement method selected lends itself to a certain predictability of costs for the project. If DBB or CMAR is used, the contractor is usually entitled to a change order in the event project conditions change. In addition, the County operates and maintains the project with no guaranteed fixed annual operation and maintenance (O&M) cost.

For D/B, a change in project conditions may result in a change order but design or construction problems do not. Like conventional procurements, the County operates and maintains the project and there is no guaranteed fixed annual O&M cost. But unlike conventional procurements, D/B procurement is less prone to bid protests and litigation.

The DBO option uses inputs provided by the operator during design, which reduces the potential for overruns. Like the D/B alternative, DBO is less prone than conventional procurements to bid protest and delays due to extended negotiation time to gain a mutually advantageous contract. O&M costs are fixed as part of the contract.

The DBFO is similar in that it also is less susceptible to litigation. DBFO allows operators to provide input during design minimizing the potential for overruns. The addition of financers to the process allow

for additional due diligence to the project, especially with respect to budget and schedule management. O&M cost are fixed as part of the contract.

7.1 Financial Model

The financial model incorporates the design and construction costs of the WRC as well as estimates of the annual O&M costs for the facility. The model is used to calculate a baseline present value of life cycle costs for each delivery model and is used as a platform to perform risk analyses.

7.1.1 Capital Costs

Capital costs for the new WRC costs are developed and identified in the Regional Optimization Master Plan. Costs associated with alternative project delivery models are adjusted to reflect inherent differences in the way projects are delivered under each method. Primarily, differences stem from the increased level of collaboration under the alternative delivery models between the different parties involved in the delivery of the project. Specifically, under the D/B model, collaboration and cooperation between the design professional and contractor typically results in construction costs that are lower than they would be under traditional DBB and CMAR. For the purposes of this analysis it was assumed that the greater level of collaboration and cooperation under D/B would result in design and construction costs that were 5% lower than the costs under CMAR. Similarly, for models that involve contract operations of the facility, the input from the operator during design and construction can serve to reduce construction costs even further. For this analysis the reduction was assumed to be 7.5% of the CMAR costs.

Table 7-1 shows the capital costs associated with CMAR, DB, DBO and DBFO based on 2008 dollars while **Table 7-2** breaks down the construction cost for each delivery option.

Table 7-1

New WRC at Roger Road Capital Cost in 2008 Dollars

Roger Road WRC Project	CMAR	DB	DBO	DBFO
Capital Costs				
Design Costs				
Design	$ 22,207,750	$ 20,097,750	$ 20,097,750	$ 20,097,750
Subtotal	$ 22,207,750	$ 20,097,750	$ 20,097,750	$ 20,097,750
Construction Costs				
Labor	$108,988,358	$102,651,144	$ 99,482,538	$ 99,482,538
Materials	$ 89,172,293	$ 83,987,300	$ 81,394,804	$ 81,394,804
Program Management				
Planning	$ 5,275,000	$ 5,275,000	$ 5,275,000	$ 5,275,000
Subtotal	$203,435,650	$191,913,444	$186,152,342	$186,152,342
TOTAL	$225,643,400	$212,011,194	$206,250,092	$206,250,092

Table 7-2
Construction Costs Breakdown in 2008 Dollars

Breakdown of Construction Costs		CMAR	DB	DBO	DBFO
Total Construction Cost		$ 198,160,650	$ 186,638,444	$ 180,877,342	$ 180,877,342
Labor	55.00%	$ 108,988,358	$ 102,651,144	$ 99,482,538	$ 99,482,538
Materials	45.00%	$ 89,172,293	$ 83,987,300	$ 81,394,804	$ 81,394,804

7.1.2 Operation and Maintenance Costs

Operation and maintenance (O&M) costs are those expenses associated with the day-to-day operation of the WRC, once construction is completed. The operation and maintenance costs were developed from costs derived from the systems and processes identified in Regional Optimization Master Plan as well as a Water Cost O&M model calibrated to current costs. Similar to capital costs, O&M costs for alternative project delivery models were adjusted to reflect inherent differences. In this case, the difference in O&M costs between different project delivery methods is the cost reduction resulting from a reduction in staff under the delivery models that involve long term contract operation of the facility. Experience with DBO and DBFO has demonstrated that private companies typically operate facilities with less staff than those used by public agencies. Sensitivity tests were run using two different set of assumptions: (1) a private operator would reduce labor costs by 30% and (2) there would be no difference in labor costs between private and county operation. It was found that this variable did not have a major effect on the relative present value of the different delivery methods.

For this model, O&M costs include costs associated with the ongoing repair and rehabilitation (R&R) of the facility during its useful life. For this analysis it was assumed that the annual R&R costs were equal to 0.5% of the total cost of construction.

Operation and maintenance costs for alternative project delivery methods based on 2008 dollars are listed in **Table 7-3**.

Table 7-3
Annual O&M Costs in 2008 Dollars

Operating & Maintenance Costs	CMAR	DB	DBO	DBFO
Labor	$2,768,000	$2,768,000	$1,937,600	$1,937,600
Energy	$2,342,500	$2,342,500	$2,342,500	$2,342,500
Chemicals (hypochlorite, sodium bisulfite)	$497,700	$497,700	$497,700	$497,700
Capital R&R	$1,378,215	$1,294,607	$1,259,080	$1,276,686
Other (e.g. materials, equipment, supplies)	$317,000	$317,000	$317,000	$317,000
TOTAL	$7,303,415	$7,219,807	$5,094,800	$5,094,800

7.1.3 Financial and Economic Variables

The financial model uses a number of financial and economic variables to project costs over forecast period and to discount these costs back to the present to arrive at a present value of life cycle costs. The financial and economic variables include:

7.1.3.1 Tax Exempt Interest Rate and Term

These variables represent the County's cost to borrow money to fund the design and construction of the WRC. Interest rate and bond term values are used to calculate annual debt service requirements under the CMAR, D/B and DBO delivery models. Under these models, it is assumed that the County will finance the WRC using traditional revenue bonds.

- Assumed County revenue bond interest rate is 5.0% and is estimated using investment grade revenue bond data from the Municipal Bond Buyer Index
- Term is County's historical bond term length – 15 years

7.1.3.2 Private Interest Rate and Term

These variables represent costs associated with debt that a private party would issue to fund the majority of the design and construction of the WRC. Interest rate and bond term values are used to calculate the debt portion of the capital component of the annual service fee that the County would pay a private contractor under the DBFO delivery model.

- Assumed private bond interest rate is 6.5% and is estimated based on the spread in yields between investment grade corporate bonds and the 30 years United States Treasury Bond
- Term length is 30 years

7.1.3.3 Private Cost of Equity

Under the DBFO delivery model it is assumed that the private party will finance the WRC using a combination of debt and equity.

- Assumes that a private party will finance the WRC using 90% debt and 10% equity
- Cost of equity is assumed to be 15%

7.1.3.4 Capital Inflation

Annual capital costs are inflated for the present to the year in which the capital costs are expected to be incurred.

- Annual capital inflation is assumed to be 5.0% based on historical ENR and Handy-Whitman Data

7.1.3.5 Operation and Maintenance Inflation

Projections of annual O&M costs are escalated to account for inflation.

- Assumed annual O&M cost inflation is 2.5% annually based on historical Bureau of Labor Statistics CPI Data, and OMB recommendations and spread between yields on long term US Treasury notes and inflation indexed long term US Treasury products.

7.1.3.6 Energy Inflation

Energy costs are assumed to increase at a greater rate that other O&M costs.

- 50 basis points higher than operation and maintenance inflation

7.1.3.7 Discount Rate

Discount rate is used to discount costs incurred in future years back to the present. For present value calculations, the discount rate is typically set equal to the weighted average cost of capital of the entity making the capital funding decision. In this case, the County is making the capital funding decision and therefore the discount rate is set equal to the County's weighted average cost of capital.

- Pima County's weighted average cost of capital is assumed to be 6.0% based on the County's cost of debt and historical interest and investment earnings.

A summary of the financial and economic variables used in the model can be found on **Table 7-4**.

Table 7-4
Financial and Economic Variables

Interest Rates	Rate & Term (yr)
Tax Exempt	
Debt Series 1	5.00%
Debt Series 2	5.00%
Debt Series 3	5.00%
Private Rates	
Debt Series 1	6.00%
Muni Bond Term	15
Private Bond Term	30
Inflation Rates	**Rate**
Capital Inflation Rate	5.00%
O&M Inflation Rate	2.50%
Energy Inflation Rate	3.00%
Discount Rate (1)	6.00%

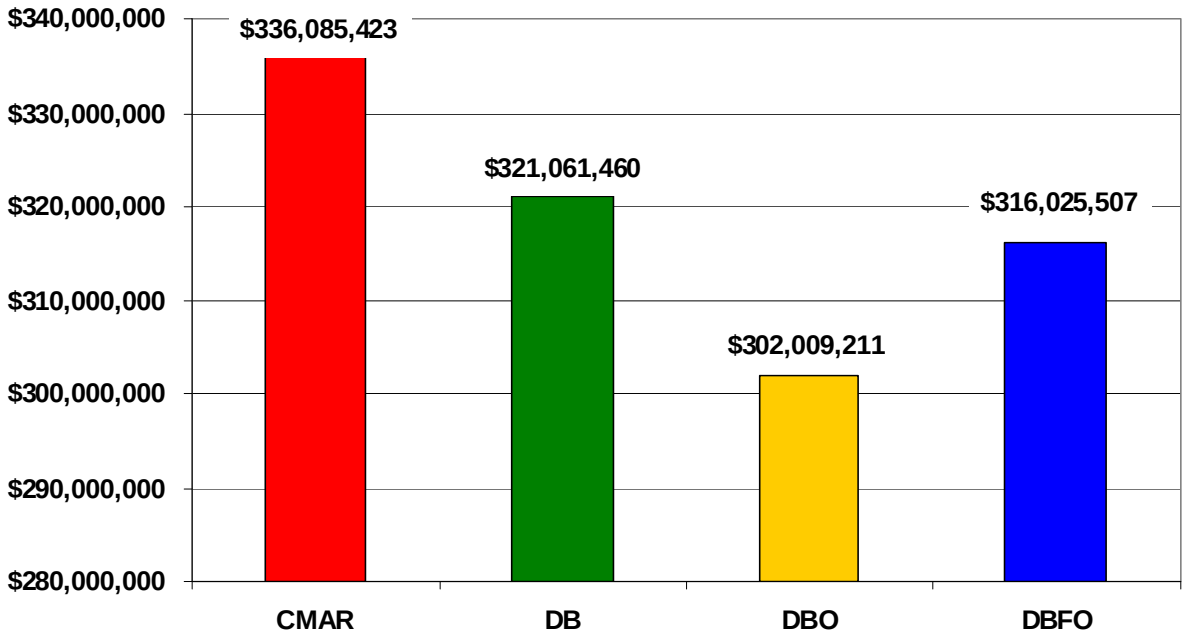
7.1.4 Financial Model Outputs

Key outputs of the financial model are annual cash flow and the present value of project life cycle costs. Present value cost for a specific project delivery method is composed of various components. For CMAR, D/B, DBO, and DBFO, these components include:

- CMAR = Total Life Cycle Cost to County for Design, Construction and Operation
- D/B = Proposed Cost for Design and Construction + Life Cycle Cost of County Operations + Cost of Retained Risks
- DBO = Proposed Cost for Design, Construction and Operation + Cost of Retained Risks
- DBFO = Proposed Cost for Design, Construction, Operation and Financing + Cost of Retained Risks

A graph comparing the baseline life cycle costs for these four alternative project delivery methods is found on **Figure 7-1**.

Figure 7-1
Baseline Present Value of Life Cycle Costs



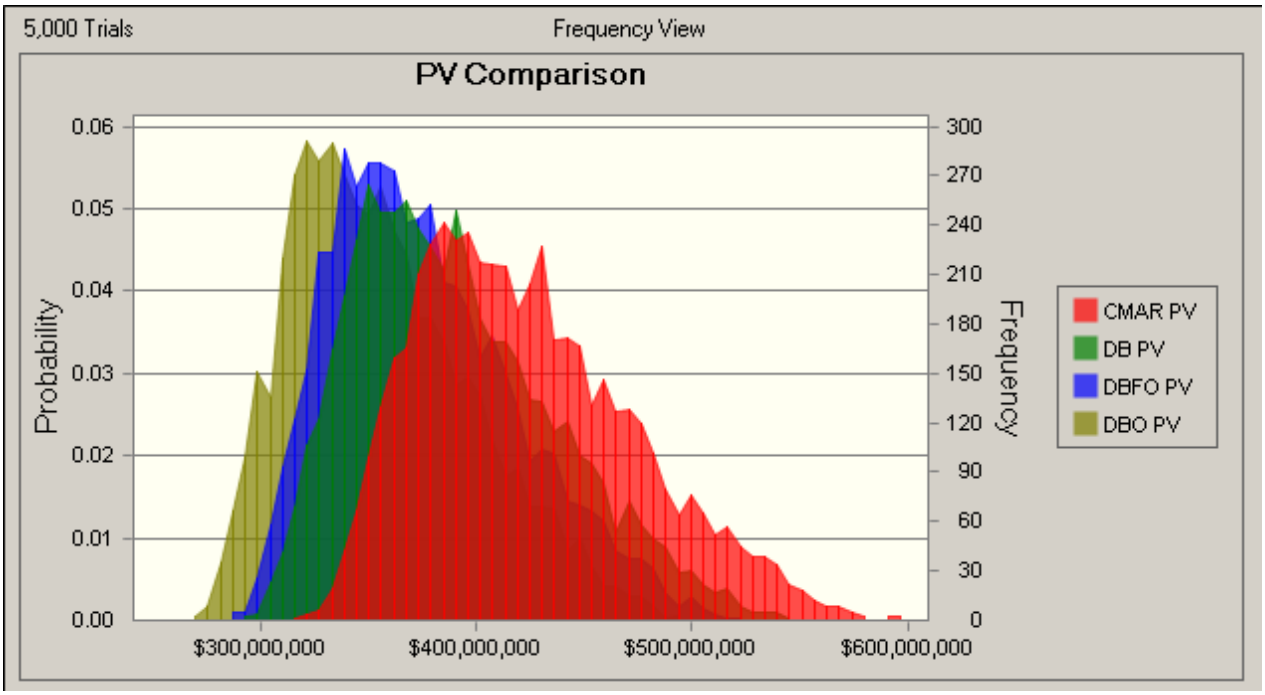
7.2 Risk Model

Using risk analysis software (Crystal Ball®), the financial model was used to analyze the financial and economic impact of risks that were previously determined to be quantifiable. Using the probability distributions that were developed during the risk quantification workshops, a range of probable risk adjusted present values of life cycle costs for each project delivery model was analyzed. The probabilistic inputs were the probability distributions representing the likelihood and consequences of the quantifiable risks while the range of probable outcomes were the range of present value life cycle costs under each delivery method.

7.2.1 Risk Model Results

Risk analysis results are presented both graphically and numerically. The graphical presentation of the risk model results show the range of probable present value of life cycle costs for the DBO delivery model is lower than the range of probable present values of life cycle costs for the other three delivery models. Additionally, the fact that curve for DBO is "taller" than the curves for the other methods indicates that the range of probable life cycle costs for DBO is smaller, indicating that DBO is less risky than the other delivery methods. The risk analysis results are shown in **Figure 7-2**.

Figure 7-2
Risk Adjusted Present Value Comparison



A variety of numerical results are provided from the risk analysis with the most informative being the mean value and a 90% certainty value. Mean value is the average of the present values of life cycle costs generated for all of the 5,000 trials that were run for the analysis and can be viewed as a reasonable estimate of the expected present value of life cycle costs under each delivery model.

The 90% certainty value is the value for which there is a 90% level of certainty that under the modeling and risk assumptions, the actual present value of costs will be equal to or less than that value. In other words, there is a 90% chance that the present value of costs will not be greater than the 90% certainty value.

Baseline, risk adjusted mean and 90% certainty values for each of the project delivery methods are shown in **Table 7-5**.

Table 7-5
Results of Risk Analysis

	Baseline PV	Risk Adjusted	
		Mean PV	90% PV
CMAR	$336,085,423	$423,780,812	$495,616,568
DB	$321,061,460	$390,176,222	$456,675,965
DBO	$302,009,211	$356,377,830	$416,529,501
DBFO	$316,025,507	$376,108,057	$437,409,864

Comparison of the mean present values and the 90% certainty values in the table above reveals that under the assumptions used in the financial and risk analysis, the DBO delivery method has both the lowest risk adjusted mean present value of costs and the lowest 90% certainty value while CMAR has the highest risk adjusted mean present value and highest 90% certainty value. Additionally, it appears that there is less financial risk associated with the DBO option.

Another useful means of comparing results under each of the delivery methods is to compare the savings relative to CMAR that could be realized by using an alternative project delivery model. The percent savings relative to CMAR for each of the alternative delivery models is shown in **Table 7-6**.

Table 7-6
Savings Relative to CMAR

	Total	Δ from CMAR	%Δ
90% Confidence			
CMAR	$ 495,616,568	$ -	0.0%
DB	$ 456,675,965	$ 38,940,603	7.9%
DBO	$ 416,529,501	$ 79,087,067	16.0%
DBFO	$ 437,409,864	$ 58,206,704	11.7%
Mean			
CMAR	$ 423,780,812	$ -	0.0%
DB	$ 390,176,222	$ 33,604,590	7.9%
DBO	$ 356,377,830	$ 67,402,982	15.9%
DBFO	$ 376,108,057	$ 47,672,756	11.2%

All of the alternative delivery models provide the County with the opportunity for cost savings relative to CMAR. Of the options examined, DBO offered the greatest potential for savings.

7.3 Sensitivity Analysis

An earlier section of this report discussed the financial and economic variables that are incorporated into the financial and risk analysis. While every effort was made to ensure the validity of the assumptions made with respect to these variables, it is useful to get an understanding of how the model outputs would change if the baseline assumptions with respect to these variables change. In order to gain this

understanding, the model's sensitivity to changes in a number of the baseline assumptions was analyzed. Results of these sensitivity analyses are shown in the above tables.

The results of the sensitivity analyses demonstrate that DBO is the most cost effective delivery approach under all but the most extreme assumptions.

7.4 Tornado Diagram

The analysis of risk incorporates risk into the financial analysis by adding variability with respect to certain key variables. This variability is defined by the probability distributions that were developed for each quantifiable risk during the risk quantification workshops. This variability impacts the results of the model in different ways and to varying degrees. As such, it is useful to know which risks have the most impact on the model outcomes. The use of a tornado diagram is a graphical method used to show risk sensitivity on the overall variability of the risk model. Tornado diagrams showing the relative impact of each risk under each of the four delivery methods analyzed are provided in **Appendix C**. Tornado diagrams are useful because they identify which risks are the greatest contributor to the overall risk for each method being used. This information can prove useful as the County works to mitigate the risks associated with the delivery of the WRC.

Section 8 Recommendation

The delivery method providing the lowest present value of life cycle costs is the DBO option. The recommendation is the use of DBO as the chosen delivery method because it fits well with this specific project. This "Greenfield" project has many reasons why it lends itself to the use of DBO as a delivery method, which include:

- Meeting Qualitative Success Criteria
- Lowest Risk Adjusted Life Cycle Cost
- Meeting Delivery Schedule
- Potential Cost Savings Associated with Innovation
- History of DBO Project Success

With any of the delivery options, issues are present and the DBO method is no different. The DBO issues include:

- Workforce Issues
- BOS Acceptance
- Public Financing Availability through Voter Approval
- Market Interest with DBO Project Delivery
- Special Interests

A summary of the alternative project delivery results by cost, qualitative scorings and ranking is shown in **Table 8-1.** Costs include baseline and risk adjusted present values. The qualitative score is determined using Multiple Criteria Analysis. The DBO delivery option provided the lowest present value costs as well as was the best to address risks with the highest qualitative score.

If all outstanding issues necessary to implement DBO cannot be reconciled, D/B remains a viable option that has a proven history. Most likely the reason DBO would not be implemented would be because of the inability to rectify all the issues necessary to obtain the "O". DBFO would be the preferred second option but if DBO cannot be implemented, then DBFO would most probably not be implementable.

Table 8-1
Results Summary Table

	Baseline PV	Risk Adjusted		Qualitative Score	Rank
		Mean PV	90% PV		
CMAR	$336,085,423	$423,780,812	$495,616,568	452	4
DB	$321,061,460	$390,176,222	$456,675,965	538	3
DBO	$302,009,211	$356,377,830	$416,529,501	602	1
DBFO	$316,025,507	$376,108,057	$437,409,864	566	2

Section 9 Conclusion

Based on the various studies of risk, financial considerations and other related criteria, the option best suited for the new WRC at Roger Road is the DBO delivery method. However, there are items that the County must resolve before this method can be employed. If these items can be sufficiently addressed, DBO provides the lowest risk adjusted life cycle costs and gets the project completed within the desired timeframe. If DBO cannot be used because of outstanding concerns, D/B is the recommended option.

Section 10 References

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APPENDIX A

Risk Mitigation Plan

Financial Risks

1. Interest Rate – Debt Series 1

Debt Series 1 is a risk associated with the interest rate in 2008. A high interest would obviously lead to a higher overall cost for the project. An increase in interest rate can occur at any time during the project.

Mitigation Plan

High level review by Pima County of the Financial Management Plan required.

2. Interest Rate – Debt Series 2

A risk associated with the new WRC at Roger Road is the interest rate in 2010 with Debt Series 2. The project is dependent on the interest rate during a given year and fluctuations can lead to higher overall costs for the project. An increase in the interest rate may happen at any time during the life of the project.

Mitigation Plan

High level review by Pima County of the Financial Management Plan required.

3. Interest Rate – Debt Series 3

Debt Series 3 is a risk that the interest rate will not be as expected during 2012. The WRC at Roger Road will be financed with bonds and changes to the interest rate will affect the overall project cost. This change in interest rate may occur during any point of the project.

Mitigation Plan

High level review by Pima County of the Financial Management Plan required.

4. Interest Rate – Private

The risk involved with private interest rate is only relevant when DBFO is the chosen delivery option.

Mitigation Plan

High level review by Pima County of the Financial Management Plan required.

5. Capital Inflation

Capital inflation can results in a higher cost to construct the facility than previously estimated. This may be caused by a combination of higher costs for labor and materials that results in a higher overall capital project cost. Capital inflation may occur during any point of the Design and Construction portion of the project. The effect of capital inflation includes higher costs but may also result in a desire to re-design or omit portions of the project to save money. If a redesign is desired, then additional time may be necessary.

Mitigation Plan

Mitigation of this risk would be extremely beneficial to the project and the County. One way to minimize the risk is for the contractor to try and "lock" prices from suppliers, distributers and laborers as early in the process as possible. If some prices can be guaranteed early on, then there are fewer variables that could lead to capital inflation. In addition, the project should be well coordinated and planned so that it is not unnecessarily extended. The more time that goes on between the start and finish of the project results in more chance of capital inflation. While inflation is expected during a project of this length, diminishing any unnecessary lag time can help make early estimates more accurate.

6. O&M Inflation

Operation and maintenance inflation is tied to higher actual costs to operate and maintain the facility compared to what was initially expected. Increase in O&M inflation can occur at any point during the life of the facility and can be tied to various issues like higher staffing costs or higher costs to maintain older equipment and processes.

Mitigation Plan
To lessen the effects associated with O&M inflation, the facilities should be designed to work effectively during their expected lifetime. In addition, the selection of high quality, durable, and long lasting products can help minimize overall operation and maintenance costs.

7. Energy Inflation

This risk is related to the possibility the energy costs will be different than those anticipated during the design phase of the project. Changes in energy prices can occur at any point during the lifetime of the project and will impact operations cost.

Mitigation Plan
Changes to the price of energy are expected during the facility's life. To mitigate the unexpected and unforeseen changes, designing the facility to be energy efficient would be a way to diminish the scale energy inflation would have on the facility. If the WRC decides to obtain LEED certification, then the facility will be designed to be an environmentally and energy friendly facility. In addition, the use of the abundant sunlight in Arizona as solar energy may be looked at to determine whether it can be used. To mitigate the effects of energy inflation, designing an efficient and effective facility as well as using available natural resources to power the facility would help minimize some of the risks associated with energy inflation. It is also possible that co-generation to generate power will be used which would be independent of external inflation factors.

O&M Risks

1. Scope Changes for Operations

Scope changes during the Operations period are a risk that is inherent in this project. The need to change the scope of the project may occur at any time during process. These changes could be related to meeting a lower or revised regulation or to make a process or piece of equipment more efficient. The effect of requiring a change in scope would probably mean additional work and costs.

Mitigation Plan
The risk of scope changes during Operations can be mitigated by planning ahead during the design stage and being aware of what design standards should be meet. It is important to review current regulations because those are to be adhered to in the plant's associated permits. But in addition, researching and working with the permitting groups to determine if there are changes expected or being discussed that may occur during the lifetime of the facility. Performing the proper due diligence during the design phase and including meaningful involvement of O&M staff in the design can help mitigate some of the risks associated with scope changes.

2. Maintain Equipment for Warranty

A risk with the new WRC at Roger Road is detrimental effects associated with improper maintenance of the equipment and facilities. Issues related to maintenance can creep up during the construction phase if testing or operation is not administered in the correct fashion. Following the construction phase is when maintenance problems may occur and can produce large financial impacts to the County. Maintenance issues can be caused by non-descript instructions, improper training of the staff in charge or operator error.

Mitigation Plan
The new WRC at Roger Road will house many new facilities and equipment. Improper maintenance is a large issue in that it creates costs that could otherwise be avoided. A way to reduce the risk is to make sure proper documentation is available and that it is clear and concise. In addition, appropriate training may be necessary for specific equipment and should be provided to all associated staff. Continuous and regular inspection of the equipment will help reduce the risks in that small issues can be addressed before compounding of problems occurs resulting in larger financial and operational issues.

3. Facility Maintenance and Operations

A risk with the new WRC at Roger Road is improper maintenance and operation of the facility. Errors with operation and maintenance of the plant equipment can occur at any time during the life of the facility and can be caused by various issues. Improper training and insufficient product literature are some of the reasons. Problems with the operations and maintenance of the facility may lead to a wide range of issues including shorter life of the equipment, equipment requiring frequent work and replacement, inefficient functioning of plant and increased costs to operate and maintain facility.

Mitigation Plan
The risks associated with operation and maintenance problems can be lessened by taking proper precautions early on to care for the equipment. Included in proper operation and maintenance would be understanding product documentation and making sure all staff is clear on the operation of equipment, proper training of staff to run equipment and providing staff that is qualified to handle equipment. In addition, regularly checking on equipment and staff would help minimize this risk.

4. Capital Repair and Replacement

Capital repair and replacement (R&R) of equipment is a risk where the proper steps are not taken to repair and replace equipment as needed or required. This issue may be caused by negligence or not having enough knowledge of equipment. The effects associated with this problem range from higher than expected repair and replacement costs or even failures in the plant which require shut downs.

Mitigation Plan
The mitigation of capital repair and replacement problems can be done by taking the proper steps on a regular basis to care for the equipment. There are obviously unforeseen issues, which lead to a failure in equipment; but overall, equipment can regularly be inspected and monitored to determine if it is functioning as expected. Regular checks on the equipment and being aware of when replacement of various parts must be done should be a constant practice to help maintain the functioning of the facility. In addition, insuring that adequate budgets are established for R&R is a way of mitigating that such events drastically inflate that total project cost.

5. Latent Defect – Design

Latent defect is where operation and maintenance costs are higher than expected due to a design defect. The cause of a design defect that has yet to have surfaced immediately is difficult to prepare for and is a risk with the new WRC. A design defect can occur at any point during the Design stage of the project but may not be evident till much later in the life of the facility. The effect could range in level based on the size of the design defect. If the design error is found during the construction process, steps may be possible to correct or at least lessen the effect.

Mitigation Plan
A plan to mitigate a latent defect during the Design stage includes due diligence during the Design, Construction, and Operations phases. Signs of a defect may include cosmetic issues with equipment, improper functioning of equipment or inefficient processes. If these signs are identified, appropriate steps should be taken to determine the cause and if it is design related. Catching these defects during the Construction phase may be possible and appropriate steps can reduce or even eliminate the issue.

6. Latent Defect – Construction

Latent defect during the Construction phase of the project would result in higher than expected operation and maintenance costs due to a construction defect. These defects can be caused by various means and can occur at any time during the Construction phase of the facility. But this latent defect may not be

revealed till after Construction has ended and the facility is in operation. The effect of a construction error may range from minimal work to drastic changes to correct the effect of the defect.

Mitigation Plan
To minimize the associated risk, construction during the new WRC should be done following proper standards and regulations as well as staying true to associated Contract Documents. Testing and checking of the equipment should be performed to identify any early warning signs of defect and should be immediately addressed. After construction, regular and continuous checks of the plant may help alert staff to an issue, which can be corrected before it becomes larger and disastrous.

7. Energy Consumption

A risk associated with the operation and maintenance of the facility would include energy consumption. Following the design and construction of the new WRC, the Operations phase may show higher than expected energy consumption of the plant processes. The cause of this could be design or construction issues or improper operation of the equipment. This could lead to increased energy costs and an inefficient treatment facility. Additional work or equipment may be required to offset the change in expected energy consumption.

Mitigation Plan
A risk associated with the new WRC is a variation in energy consumption during the life of the facility. The impacts include higher costs and may include unexpected performance. To mitigate this risk, proper steps during the Design phase should be taken to determine the amount of energy required for each process and how energy consumption may change during the life of the facility. During the Construction phase, the facility should be constructed according to the Contract Documents and following proper standards and regulations. During the early start-up of the facility, any issues related to energy consumption should be immediately brought up to determine if changes should be made. Addressing such issues early on in the life of the facility may make it easier to correct.

Capital – Design Risks

1. Failure to Create Output Specs

During the design phase, the County may fail to properly specify what it wants or needs from the facilities and therefore result in continued problems during the project. Various causes can be associated with this risk including not understanding the standards and regulations requiring conformance and not being aware of the various options. This issue may lead to a delay in the entire project and may increase the costs of the project.

Mitigation Plan
To decrease this risk, proper work must be done early on to understand what the County requires from the facility in terms of performance. In addition, being aware of regulations that shall impact the facility and being fully informed regarding the options available is necessary to produce a project fitting within the County's scope.

2. Design Scope Changes – Owner Initiated

Design scope changes initiated by the owner are encountered during the Design phase. The desire to make a change by the owner may be based on a change in regulation or standard requiring modification. A change may also be desired for various other reasons related to County operations and preferences. These modifications occur during the Design stage of the project and the effects can be a change in estimated cost of the project and may also increase the time required to design the project.

Mitigation Plan
To reduce the risk, the County should employ the proper due diligence early in the project to determine what they would like to see as an outcome from this project. Then the County shall pass along this information on to the design engineer and clarify their expectations. Checks between the designer and the County during various stages of the design phase would also be helpful and reduce the chance that large portions have been designed only to be re-designed.

3. Technical Inadequacy

Technical inadequacy is a risk that occurs following construction of the project and one that is difficult to predict. Although the facility may have been designed and constructed properly, the facility or one of its components may fail to perform as expected. This is an issue that is unexpected since all steps were taken to correctly design and construct the facility. The cause for such issues may remain unknown but the effect is a failed portion of the facility that will require additional work, which may increase the project cost and time required.

Mitigation Plan
Reducing the risk associated with technical inadequacy is difficult because it was initially designed and constructed correctly. The best way to minimize the chance is to design and construct the facility using the proper standards and requirements and compare the design to previous projects with similar systems. The facilities may be similar, but understanding and designing for the varied site conditions can help minimize the risk.

4. Design Review Not Completed in a Timely Manner

If the design review for the project is not completed in a timely manner, there would probably be changes to the overall timeframe for the project and there may be cost impacts to the County. Not having review completed in a timely manner may be caused by time management issues or unclear design documents. Delays with reviews would most likely lead to a longer timeline for the project.

Mitigation Plan
Mitigation of this issue can be resolved by proper communication to determine the progress of design review. If clarification of design documents is required, then the appropriate resources should be contacted. The new WRC is on a deadline to meet ADEQ regulations and therefore impacts associated with delays are very detrimental to the success of the project. Another mitigation step is to clearly establish who is responsible for reviews and when the reviews are to be completed.

5. Design Schedule

Design schedule is another issue in that there is a risk that the design will take longer than expected and planned for. The cause of a delay in design schedule can include various changes desired in the design, previous designs requiring re-design, poor design and communication issues. The effect of such issues would include a longer timeline for the project, which can affect the ability of the facility to meet ADEQ standards as well as the inability to accommodate the growing service area in the City of Tucson.

Mitigation Plan
Delays in the design schedule will have an impact on the entire project in terms of timeframe and costs. Early in the Design process, the County must voice exact expectations from the facility. It then becomes the design engineer's task to work effectively and efficiently to produce drawings for review at appropriate stages of the project. All designs shall be thorough and all issues should be voiced immediately and changes made in response to comments. If there is a desire by the client to make design changes, they should be discussed with the design engineer so alterations and appropriate measures can be taken. The drawings delivered to the County should be complete and of a high quality. Employing the appropriate staff at the right time is also a key to mitigating the risks associated with the design schedule.

6. Design Approval

A risk component of the new WRC is that regulatory approval of the design will be delayed. There are various pieces included with this project and each requires various permits to proceed ahead. The cause of a delay may include a design that does not meet standards, delay in getting paperwork to permitting agency and delay within the permitting agency itself. The result of a delay in design approval may be a delay in the overall project timeline and additional costs associated with redesigning portions that were not regulation standard.

Mitigation Plan
To mitigate the risk associated with a delay in regulatory approval, sufficient time and effort should be placed in obtaining the required information. One way would be to keep in contact with the permitting agency to determine exactly what is required and when so that the process continues progressing. Also, during the Design phase, using the regulations provided for design is imperative to gain approval. Extra time should also be provided for delays within the permitting agency.

7. Regulation Change – Design

A risk associated with the new WRC is a regulation change occurring during the Design phase. The cause of this is solely on the entity in charge of specific regulations and standards but will directly affect design of the project. Such a change may require additional time for design as well as the possibility of increasing the cost of the project.

Mitigation Plan
This risk can be lessened by being aware of all regulations and standards being proposed. If there is discussion about changing a limit or standard early on in the process, then it can be incorporated easier than if other portions of the project are designed around it. Maintaining

contact with the entities in charge of the regulations can help the team remain aware of any expected changes.

8. Occupancy Risk

A risk the County faces is the inability to secure an Occupancy Permit at the end of construction. This may be caused by changed standards, poor construction or inadequate design. This would drastically affect the project in that the facility could not be used by the County and additional time and capital would be required to gain an Occupancy Permit.

Mitigation Plan
The risk of not obtaining an Occupancy Permit can be mitigated by designing the facility to meet regulations and standards as well as construct the facility with the same detail. Communication with the appropriate entity is necessary during the entire process to determine how the facility is to be designed and to clarify requirements.

9. 208 Plan Amendment, Corps of Engineer Permit and State Environmental Permit
A major risk associated with the new WRC is not gaining necessary approval for the various permits required. Three such permitting issues of concern include the 208 Plan Amendment, the Corps of Engineers (COE) permit and the State Environmental Permit (ADEQ). If this amendment and these permits are not approved there would be serious delays in the project and more costs associated with revising paperwork.

Mitigation Plan
The risks of these permits being denied can be lessened by providing enough time for their preparation and approval. Maintaining contact with members of the permitting agencies will help keep the process progressing forward. Sufficient time should also be set aside to update or revise paperwork necessary for all the permits.

Capital – Construction Risks

1. Design Errors

During the Construction phase of the project, a risk is that an error or emission results in the need for a Change Order. This is a risk common with a facility of this magnitude and is caused during the Design phase. Design errors can occur for reasons including bad design or improper supplementary information. The effect may include a Change Order which can impact the project timeline and total project cost.

Mitigation Plan
To mitigate the risk associated with design errors, various members of the design team, the owner and the construction workers should review the drawings for correctness in design. If problems are encountered, they can be immediately identified and corrected. Design errors can drastically impact a project's performance and cost to construct, operate and maintain.

2. Construction Scope Changes – Owner Initiated

Another construction related risk is change to the construction scope initiated by the County. If the County desires changes to the design at this stage of the project, the effects may result in delays during construction to address these issues, higher overall capital costs and a longer project timeline. The cause for such changes may be County preference or the need to meet changed standards. The timing of this project is important because there are requirements to meet lower regulations and standards of the effluent that is discharged into the Santa Cruz River as well as an expected increase in population within the new WRC's service area.

Mitigation Plan
Owner initiated changes during construction is a risk that can be mitigated by effective communication during various stages of the project. The County should communicate to the design engineer what they desire from the facility. In addition, working with permitting agencies to determine if any changes are coming in the future that can be incorporated into the project will keep the project up to standard. Clear communication and involvement by all internal County stakeholders in assuring that there is agreement on the project goals and approach at the initiation of the project design is vital to minimizing this risk.

3. Cost of Construction Materials

A large risk associated with the new WRC is fluctuations in the cost of construction materials. The costs of materials changes regularly and affect the overall cost of the project. In addition, the availability of specific materials and extreme costs may require redesign to use a different material than initially desired. The effects would include a change in project cost and may include additional time.

Mitigation Plan
The variability of material prices is something that is an inherent risk with construction. Work should be done to lock-in prices for materials early on during the Construction phase to eliminate some variability. In addition, the amount and material required should be checked with the supplier to make sure that it is available during the time required. To mitigate this risk, the contractor needs to take the appropriate steps with suppliers to guarantee prices, if possible.

4. Shortage in Labor Supply

A shortage of qualified labor available during construction of the new WRC at Roger Road is a risk with this project. The cause of this may be selecting a contractor ill-equipped to handle the work associated with this project or bad timing of construction. The effect would be a delay in the project timeline, which may impact the price of the project.

Mitigation Plan
To lessen the associated risk, the selection of a contractor with appropriate staff to handle the project is necessary so that project deadlines can be achieved. In addition, all involved should be aware of the timeline of the project and if work in the surrounding area may impact the laborers available for the new WRC. To mitigate this risk, the selected contractor should have qualified staff available.

5. Contaminants Specific to WRC

A risk associated with this facility is the discovery of soil contaminants or other environmental concern encountered during the Construction phase. This risk may be caused by careless site studies, which resulted in the selection of a site difficult to construct on. The effects associated would include delays during construction and higher costs. The contaminants may need to be disposed of in a way that requires immense amounts of time and costs.

Mitigation Plan

Contaminants found at the new WRC can drastically affect the facility and may require safe removal, which would increase time and costs. Mitigation of this risk would be a thorough site investigation to determine if there are any locations that may be inappropriate to construct the facility. In addition, past studies of the surrounding area may provide an indication as to what is expected on the proposed site.

6. Geotech Specific to WRC

Geotechnical specifics for the site have the risk of returning results showing that subsurface conditions are not conducive to construction. The cause of this may be improper early site studies and thorough tests on the site. This issue would result in large problems in terms of meeting regulation and capacity deadlines as well as having to find an alternate site for construction. A geotechnical problem on site would require time and capital to address and would change the outlook for the entire project.

Mitigation Plan

Proper subsurface conditions on site are imperative to proper construction and functioning of equipment so any issues would result in big problems. Depending on the magnitude of the problems on site, there may have to be the redesign of structures, equipment and even the relocation of the site. To mitigate this risk, the selected site needs to be thoroughly inspected by the appropriate authorities to determine if construction is feasible.

7. Inexperienced/Weak Contractor

A big risk that will play a role in the alternative delivery method selected is a contractor's experience. If DBB is the selected delivery method, the probability of being partnered with a weak contractor is greater than for the other delivery methods. The other delivery methods allow for review of the contractor to determine if their qualifications match what is desired for the project. A weak contractor may result in a lesser final product that is not constructed with the best standards. This may result in a facility with higher replacement, repair, operation, and maintenance issues.

Mitigation Plan

Anticipating a weak contractor results in designing the project with the most basic information and extensive details made available which may not be the case with a more seasoned contractor. An inexperienced contractor can be the cause of poor construction of the facilities, increased costs and a lengthened construction period. To mitigate this, the selection of the appropriate delivery method is required based on the owner's expectations. If a weak contractor is selected, more frequent checks and through designs will be required. Thorough reference checks during the contractor selection process are needed.

8. Cultural Resources

Cultural resources found on site are a possible risk for the new WRC at Roger Road. The state of Arizona is known for a rich native history and various objects of major significance have been identified through its history. While extremely important to preserve these discoveries, there impact on the project can be significant. The uncovering of a valuable cultural resource would require proper excavation and study of the site, which would take time. In addition, costs could be impacted if the site can no longer be constructed on.

Mitigation Plan

To mitigate the risk, appropriate studies of the site are required prior to construction by the Office of the Pima County Cultural Resources and Historic Preservation. A member should be on site during geotechnical studies to determine if anything of significance is on site and should be immediately contacted if something of question is found during construction. The earlier such an issue is brought to light, the quicker it can be resolved.

APPENDIX B

Quantifiable Risk Analysis Tables

Table B-1
Likely Impacts of Risks Under CMAR

	CMAR				
	Chance of Occurrence	High	Most Likely	Low	Impact
Financial					
Cost impact					
Interest rate - Debt Series 1	100%	3%	0%	-1%	Interest Rate on first debt service
Interest rate - Debt Series 2	100%	3.5%	0%	-1.5%	Interest Rate on second debt service
Interest rate - Debt Series 3	100%	4%	0%	-2%	Interest Rate on third debt service
Interest rate - private	0%				Interest Rate on DBFO financing
Capital Inflation	100%	3%	0%	-1%	Escalator for Design/Construction phase
O&M Inflation	100%	3%	0%	-1%	Escalator for 30 year O&M phase
Energy Inflation	100%	3%	0%	-1%	Escalator for Energy for 30 year phase
Design					
Cost Impact					
Failure to create output specs	100%	4%	3%	2%	Design Cost component of Capital
Design Scope Changes - Owner initiated	100%	10%	5%	0%	Design Cost component of Capital
Technical Inadequacy	10%	7.5%	1.5%	0%	Total Capital
Delay Impact					
Design Review Req. not completed in timely manner	100%	2.5	1	0	Delays construction, resulting in higher risk to total Capital Costs
		1.04%	0.42%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Design Schedule	20%	6	3	1	Delays construction, resulting in higher risk to total Capital Costs **
		2.50%	1.25%	0.42%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Construction					
Cost Impact					
Design Errors	100%	5%	2%	1%	Total Capital
Construction Scope changes-owner initiated	100%	10%	5%	2%	Total Capital
Cost of Construction Materials	75%	10%	5%	-2%	Materials component of Capital
Shortage in Labor Supply	75%	15%	8%	5%	Labor component of Capital
Contaminates specific to WRC	50%	0.5%	0.25%	0%	Total Capital
Geotech specific to WRC	30%	1%	0.05%	0%	Total Capital
Delay Impact					
Inexperienced/Weak Contractor	30%	2	1	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		0.83%	0.42%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Contaminates specific to WRC	50%	4	2	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		1.67%	0.83%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Cultural Resources	100%	6	0.75	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		2.50%	0.31%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
O & M					
Cost Impact					
Scope Changes for Operations	100%	1%	0.1%	0%	Total O&M
Maintain Equipment for Warranty	100%	15%	5%	1%	Other component of O&M (e.g. materials, equipment, supplies)
Facility Maintenance & Operations	100%	8%	2.5%	0%	Total O&M

Table B-2
Likely Impacts of Risks Under DB

	DB				
	Chance of Occurrence	High	Most Likely	Low	Description
Financial					
Cost impact					
Interest rate - Debt Series 1	100%	3%	0%	-1%	Interest Rate on first debt service
Interest rate - Debt Series 2	100%	3.5%	0%	-1.5%	Interest Rate on second debt service
Interest rate - Debt Series 3	100%	4%	0%	-2%	Interest Rate on third debt service
Interest rate - private	0%				Interest Rate on DBFO financing
Capital Inflation	100%	3%	0%	-1%	Escalator for Design/Construction phase
O&M Inflation	100%	3%	0%	-1%	Escalator for 30 year O&M phase
Energy Inflation	100%	3%	0%	-1%	Escalator for Energy for 30 year phase
Design					
Cost Impact					
Failure to create output specs	100%	4%	3%	2%	Design Cost component of Capital
Design Scope Changes - Owner initiated	75%	10%	5%	0%	Design Cost component of Capital
Technical Inadequacy	10%	7.5%	1.5%	0%	Total Capital
Delay Impact					
Design Review Req. not completed in timely manner	0%				Delays construction, resulting in higher risk to total Capital Costs
Design Schedule	5%	3	(1)	(2)	Delays construction, resulting in higher risk to total Capital Costs **
		1.25%	-0.42%	-0.83%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Construction					
Cost Impact					
Design Errors	100%	3%	1%	0%	Total Capital
Construction Scope changes-owner initiated	25%	5%	2%	0%	Total Capital
Cost of Construction Materials	75%	15%	10%	-2%	Materials component of Capital
Shortage in Labor Supply	75%	15%	8%	5%	Labor component of Capital
Contaminates specific to WRC	50%	0.5%	0.25%	0%	Total Capital
Geotech specific to WRC	30%	1%	0.05%	0%	Total Capital
Delay Impact					
Inexperienced/Weak Contractor	15%	2	1	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		0.83%	0.42%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Contaminates specific to WRC	50%	4	2	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		1.67%	0.83%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Cultural Resources	100%	6	0.75	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		2.50%	0.31%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
O & M					
Cost Impact					
Scope Changes for Operations	100%	1%	0.1%	0%	Total O&M
Maintain Equipment for Warranty	100%	15%	5%	1%	Other component of O&M (e.g. materials, equipment, supplies)
Facility Maintenance & Operations	100%	8%	2.5%	0%	Total O&M
Capital R & R	100%	15%	5%	2%	R&R component (capital reinvestment)
Latent Defect-Design	100%	3%	0.5%	0%	Total O&M
Latent Defect-Construction	100%	5%	1%	0%	Total O&M
Energy Consumption	100%	2%	-1%	-2%	Energy component of O&M

Table B-3
Likely Impacts of Risks Under DBO

	DBO				
	Chance of Occurrence	High	Most Likely	Low	Description
Financial					
Cost impact					
Interest rate - Debt Series 1	100%	3%	0%	-1%	Interest Rate on first debt service
Interest rate - Debt Series 2	100%	3.5%	0%	-1.5%	Interest Rate on second debt service
Interest rate - Debt Series 3	100%	4%	0%	-2%	Interest Rate on third debt service
Interest rate - private	0%				Interest Rate on DBFO financing
Capital Inflation	100%	3%	0%	-1%	Escalator for Design/Construction phase
O&M Inflation	100%	3%	0%	-1%	Escalator for 30 year O&M phase
Energy Inflation	100%	3%	0%	-1%	Escalator for Energy for 30 year phase
Design					
Cost Impact					
Failure to create output specs	80%	4%	3%	2%	Design Cost component of Capital
Design Scope Changes - Owner initiated	50%	5%	0%	0%	Design Cost component of Capital
Technical Inadequacy	5%	7.5%	1.5%	0%	Total Capital
Delay Impact					
Design Review Req. not completed in timely manner	0%				Delays construction, resulting in higher risk to total Capital Costs
Design Schedule	5%	3	(1)	(2)	Delays construction, resulting in higher risk to total Capital Costs **
		1.25%	-0.42%	-0.83%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Construction					
Cost Impact					
Design Errors	100%	2%	1%	0%	Total Capital
Construction Scope changes-owner initiated	5%	2%	0.5%	0%	Total Capital
Cost of Construction Materials	75%	15%	10%	-2%	Materials component of Capital
Shortage in Labor Supply	75%	15%	8%	5%	Labor component of Capital
Contaminates specific to WRC	50%	0.5%	0.25%	0%	Total Capital
Geotech specific to WRC	30%	1%	0.05%	0%	Total Capital
Delay Impact					
Inexperienced/Weak Contractor	15%	2	1	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		0.83%	0.42%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Contaminates specific to WRC	50%	4	2	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		1.67%	0.83%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Cultural Resources	100%	6	0.75	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		2.50%	0.31%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
O & M					
Cost Impact					
Scope Changes for Operations	25%***	1%	0.1%	0%	Total O&M
Maintain Equipment for Warranty	25%***	15%	5%	1%	Other component of O&M (e.g. materials, equipment, supplies)
Facility Maintenance & Operations	25%***	6%	2%	0%	Total O&M

Table B-4
Likely Impacts of Risks Under DBFO

	DBFO				
	Chance of Occurrence	High	Most Likely	Low	Description
Financial					
Cost impact					
Interest rate - Debt Series 1	0%				Interest Rate on first debt service
Interest rate - Debt Series 2	0%				Interest Rate on second debt service
Interest rate - Debt Series 3	0%				Interest Rate on third debt service
Interest rate - private	100%	3%	0%	-1%	Interest Rate on DBFO financing
Capital Inflation	100%	3%	0%	-1%	Escalator for Design/Construction phase
O&M Inflation	100%	3%	0%	-1%	Escalator for 30 year O&M phase
Energy Inflation	100%	3%	0%	-1%	Escalator for Energy for 30 year phase
Design					
Cost Impact					
Failure to create output specs	80%	4%	3%	2%	Design Cost component of Capital
Design Scope Changes - Owner initiated	50%	5%	0%	0%	Design Cost component of Capital
Technical Inadequacy	5%	7.5%	1.5%	0%	Total Capital
Delay Impact					
Design Review Req. not completed in timely ma	0%				Delays construction, resulting in higher risk to total Capital Costs
Design Schedule	5%	3	(1)	(2)	Delays construction, resulting in higher risk to total Capital Costs **
		1.25%	-0.42%	-0.83%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Construction					
Cost Impact					
Design Errors	100%	2%	1%	0%	Total Capital
Construction Scope changes-owner initiated	5%	2%	0.5%	0%	Total Capital
Cost of Construction Materials	75%	15%	10%	-2%	Materials component of Capital
Shortage in Labor Supply	75%	15%	8%	5%	Labor component of Capital
Contaminates specific to WRC	50%	0.5%	0.25%	0%	Total Capital
Geotech specific to WRC	30%	1%	0.05%	0%	Total Capital
Delay Impact					
Inexperienced/Weak Contractor	15%	2	1	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		0.83%	0.42%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Contaminates specific to WRC	50%	4	2	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		1.67%	0.83%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
Cultural Resources	100%	6	0.75	0	Delays construction, resulting in higher risk to construction component of Capital Costs
		2.50%	0.31%	0.00%	The delays are converted to a % impact on capital costs based on an estimate for monthly inflation.*
O & M					
Cost Impact					
Scope Changes for Operations	25%***	1%	0.1%	0%	Total O&M
Maintain Equipment for Warranty	25%***	15%	5%	1%	Other component of O&M (e.g. materials, equipment, supplies)
Facility Maintenance & Operations	25%***	6%	2%	0%	Total O&M

APPENDIX C

Tornado Diagrams

Figure C-1
Construction Manager at Risk Tornado Diagram

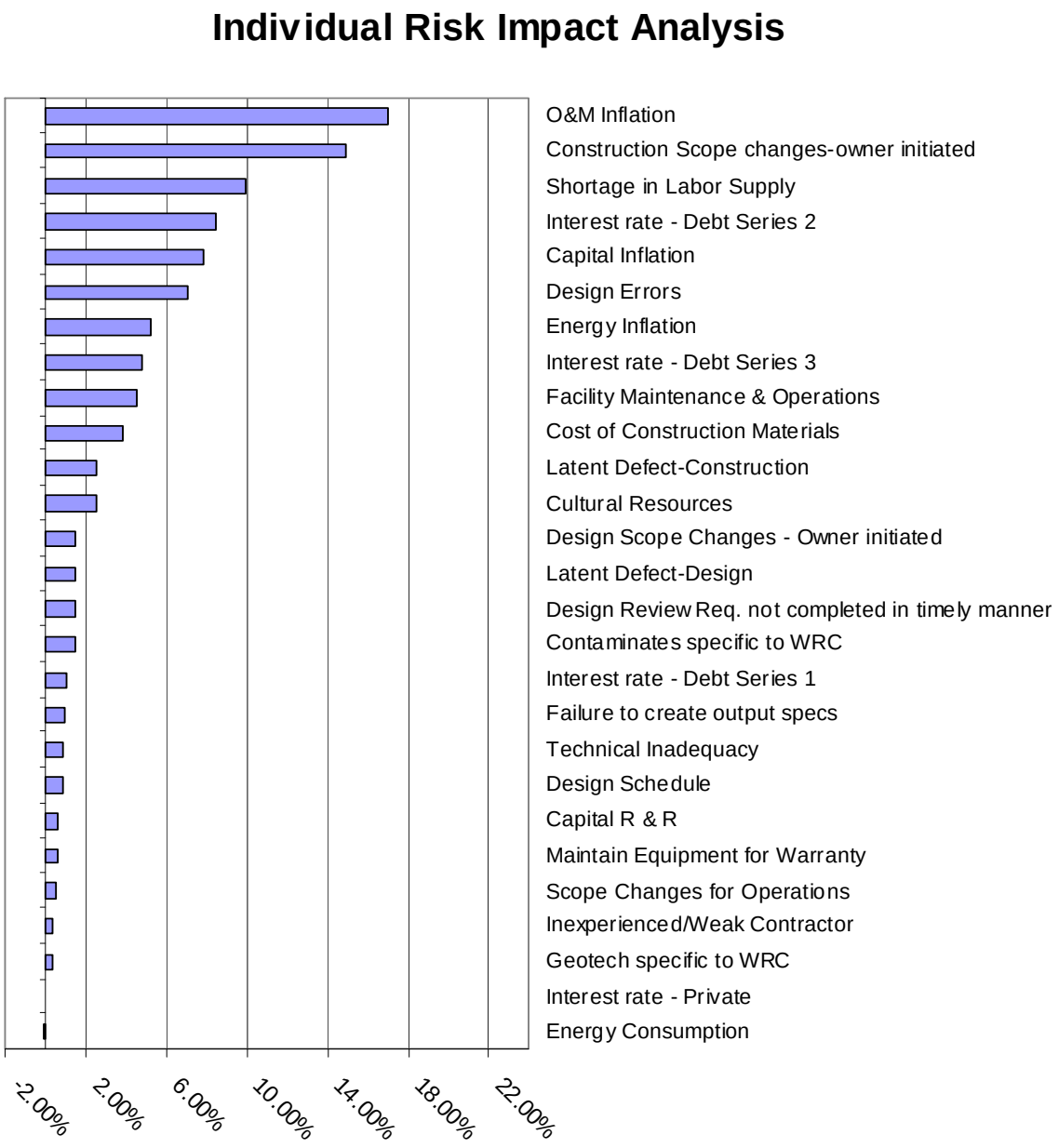


Figure C-2
Design/Build Tornado Diagram

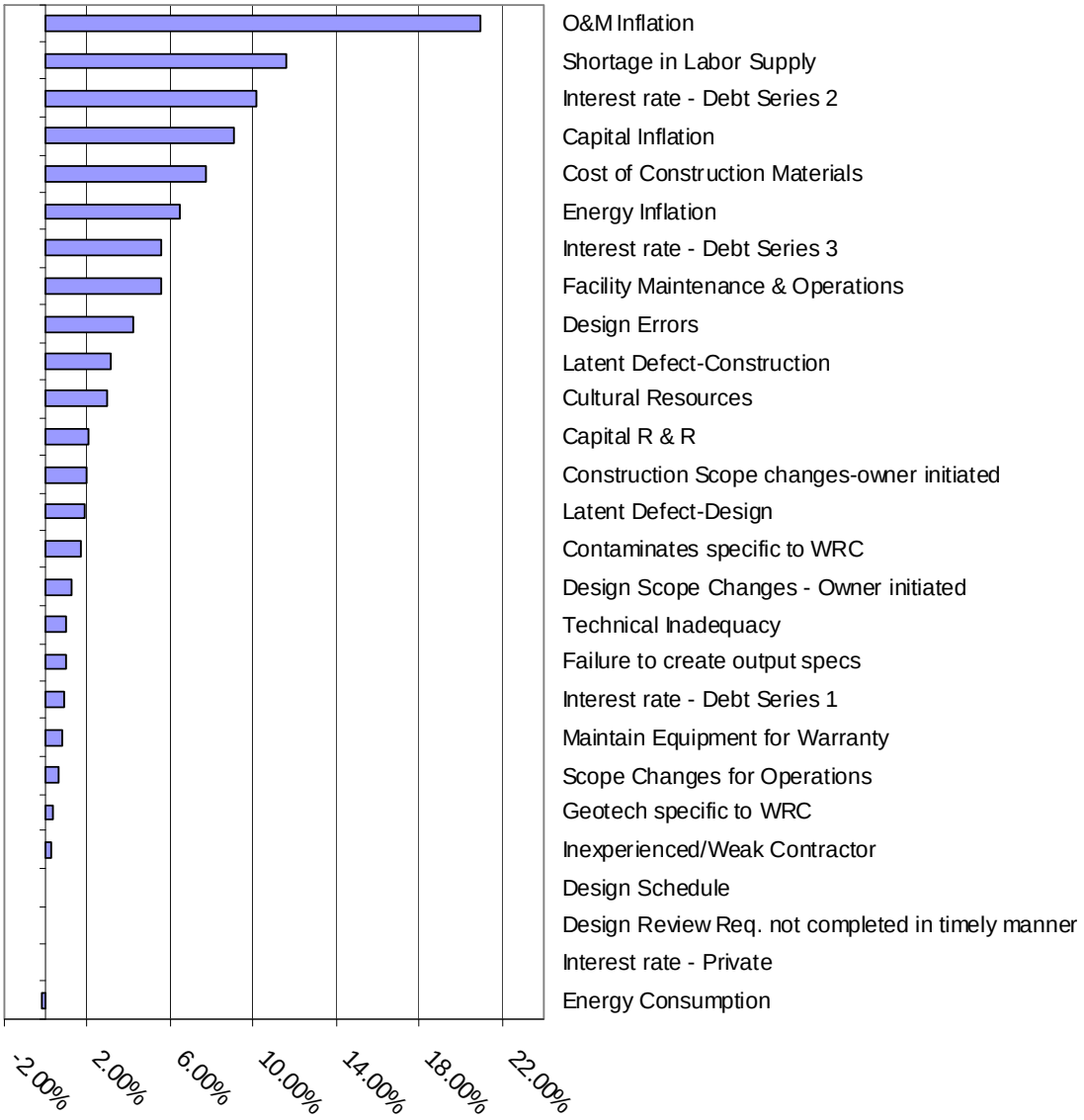


Figure C-3
Design/Build/Operate Tornado Diagram

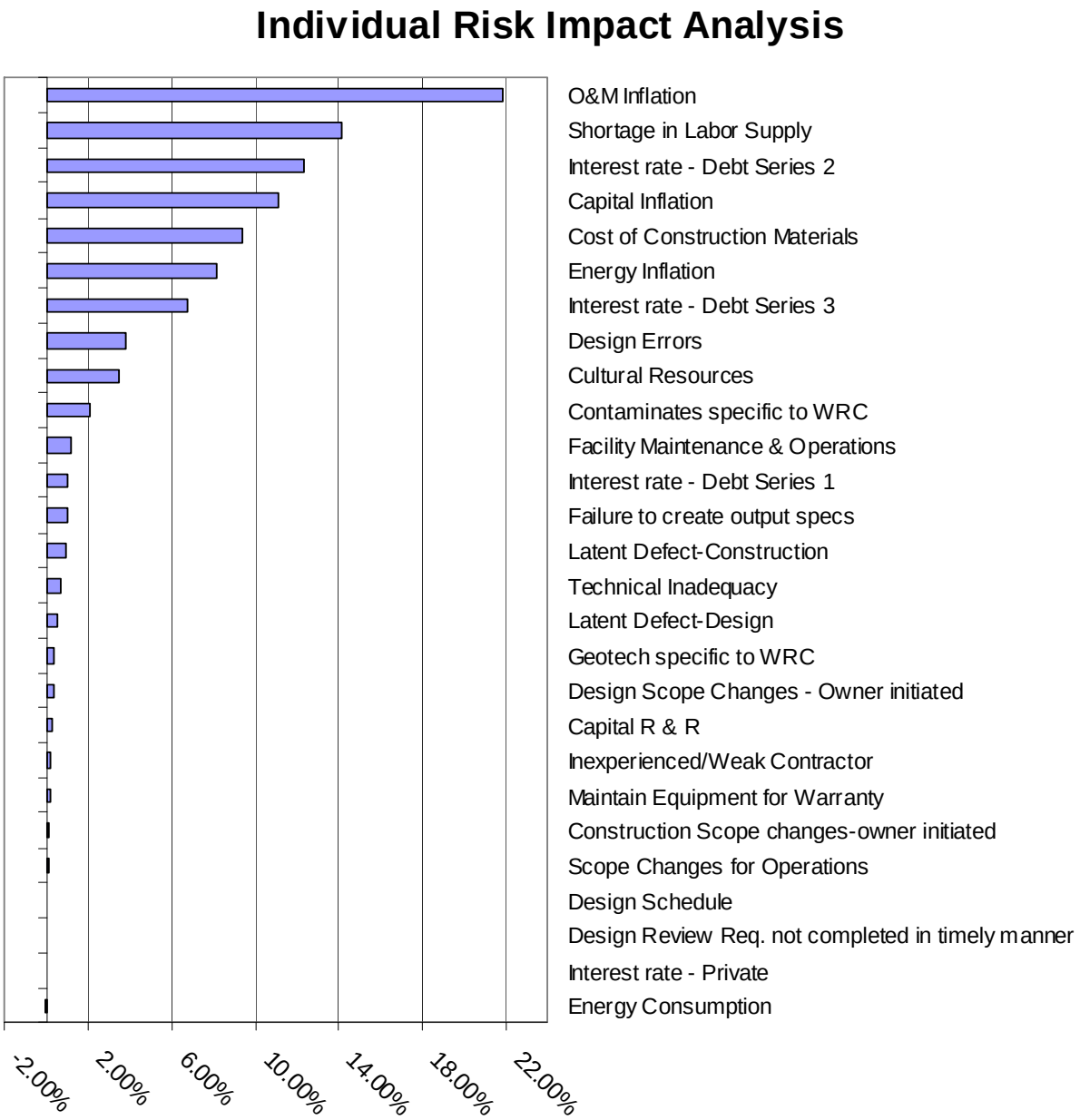
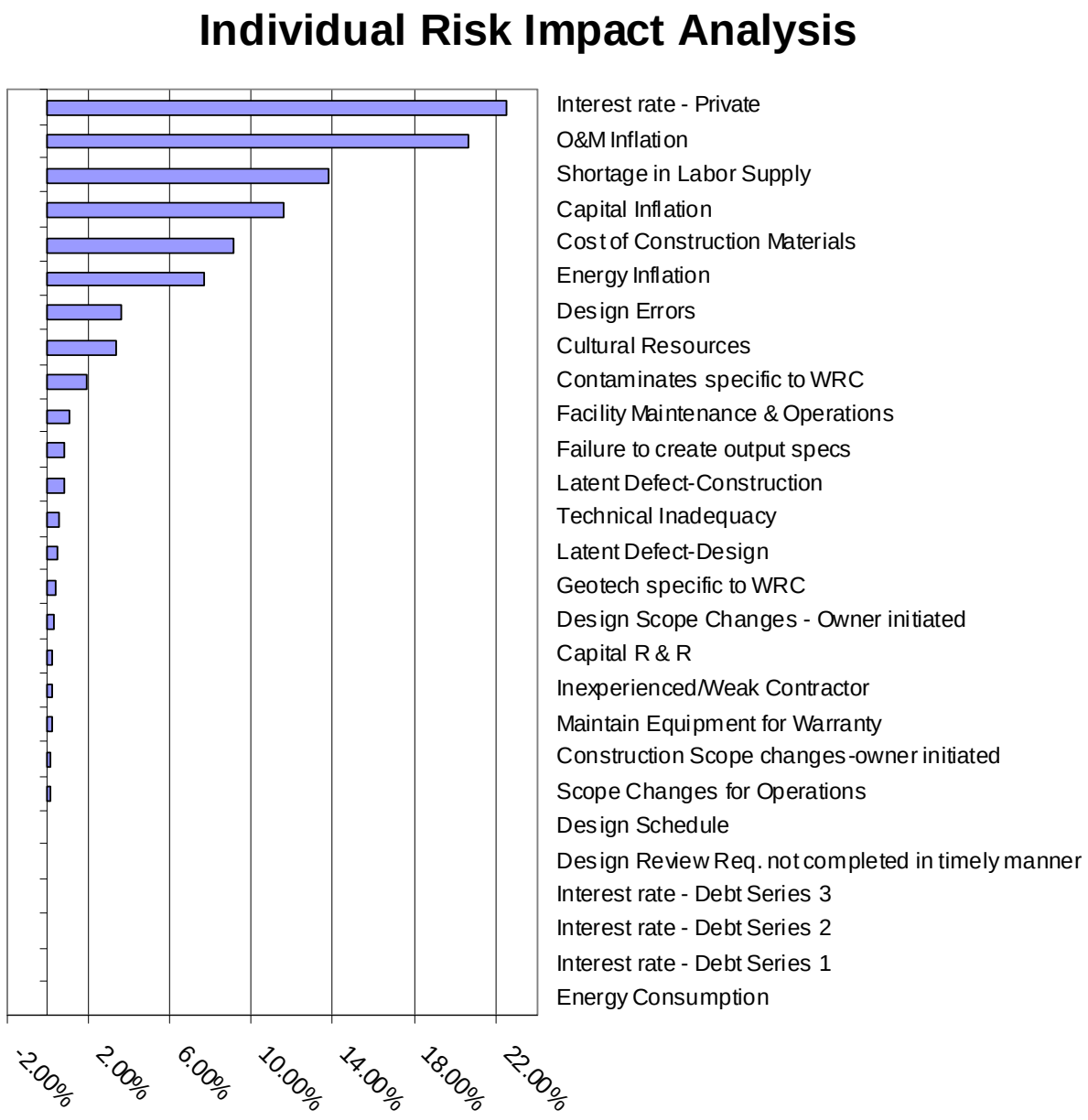


Figure C-4
Design/Build/Finance/Operate Tornado Diagram



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