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<td>23</td>
</tr>
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</tbody>
</table>
A. INTRODUCTION

The California Multi-Agency CIP Benchmarking Study (\textit{Study}) is a collaborative effort that involves the sharing of ideas and data between several of the largest cities in California. This report presents the findings of several key components of the study including performance benchmarking and best management practices (BMPs).

\textbf{Performance benchmarking} is conducted to establish relationships between project delivery costs and total construction cost (TCC). The \textit{Study} examines how these relationships change over a five-year trailing period. This is a core concept of the \textit{Study} that provides a meaningful benchmark by which participating agencies can assess their project delivery performance and identify potential reasons for differences between them and peers.

\textbf{Best management practices} are discussed between agencies and tracked to provide participating agencies a living archive of practices being implemented by peers, lessons learned through their implementation, and potential benefits to be derived if implemented.

A brief overview of these \textit{Study} components is presented in this executive summary.

B. PERFORMANCE BENCHMARKING

The project data submitted by the agencies are compiled in a customized Microsoft Access® database. This database has served as a repository for the data collected since the inception of the \textit{Study}. Each year, the project database is updated with the inclusion of project data submitted for that \textit{Study} year and updated project data submitted for previous years. The updated 2019 database includes a total of 596 projects, 476 of which belong in the 80th percentile subset by TCC.

\textbf{Project Delivery Costs by Project Type}

Table 1-1 summarizes project delivery cost as a percentage of TCC by each of the four project types in the \textit{Study} for the full range of TCC. Table 1-2 similarly summarizes project delivery cost as a percentage of TCC for the smaller 80th percentile projects based on TCC. The project delivery percentage for a category is the arithmetic average of the project delivery percentages of the individual projects grouped under that category.
### Table 1-1 Average Project Delivery Costs by Project Type (% of TCC) (Full Range of TCC)

<table>
<thead>
<tr>
<th>Type</th>
<th>Design</th>
<th>Construction</th>
<th>Total Project Delivery</th>
<th>Median Total Construction Cost ($MM)</th>
<th>Number of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Facilities</td>
<td>24%</td>
<td>18%</td>
<td>42%</td>
<td>2.70</td>
<td>46</td>
</tr>
<tr>
<td>Parks</td>
<td>27%</td>
<td>20%</td>
<td>47%</td>
<td>0.78</td>
<td>51</td>
</tr>
<tr>
<td>Pipe Systems</td>
<td>22%</td>
<td>21%</td>
<td>43%</td>
<td>1.30</td>
<td>279</td>
</tr>
<tr>
<td>Streets</td>
<td>30%</td>
<td>20%</td>
<td>51%</td>
<td>0.91</td>
<td>179</td>
</tr>
<tr>
<td>Water/Wastewater</td>
<td>24%</td>
<td>21%</td>
<td>45%</td>
<td>3.59</td>
<td>41</td>
</tr>
<tr>
<td>Treatment Plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>All Types</strong></td>
<td>25%</td>
<td>20%</td>
<td>46%</td>
<td>1.23</td>
<td>596</td>
</tr>
</tbody>
</table>

Notes:
1. Project Delivery percentages represent arithmetic averages of the individual projects and do not represent the results from the regression analyses.
2. Project Delivery percentages vary from year to year based on the selection and the composition of the projects in the database.
3. Total excludes projects delivered by alternative delivery mechanisms such as design-build, JOC, and CM@Risk. Projects delivered by alternative techniques are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the Study.

### Table 1-2 Average Project Delivery Costs by Project Type (% of TCC) (80th Percentile Range of TCC)

<table>
<thead>
<tr>
<th>Type</th>
<th>Design</th>
<th>Construction</th>
<th>Total Project Delivery</th>
<th>Median Total Construction Cost ($MM)</th>
<th>Number of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Facilities</td>
<td>26%</td>
<td>19%</td>
<td>45%</td>
<td>1.39</td>
<td>36</td>
</tr>
<tr>
<td>Parks</td>
<td>30%</td>
<td>22%</td>
<td>52%</td>
<td>0.65</td>
<td>40</td>
</tr>
<tr>
<td>Pipe Systems</td>
<td>24%</td>
<td>22%</td>
<td>46%</td>
<td>0.95</td>
<td>223</td>
</tr>
<tr>
<td>Streets</td>
<td>33%</td>
<td>21%</td>
<td>54%</td>
<td>0.57</td>
<td>143</td>
</tr>
<tr>
<td>Water/Wastewater</td>
<td>27%</td>
<td>23%</td>
<td>49%</td>
<td>3.06</td>
<td>32</td>
</tr>
<tr>
<td>Treatment Plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>All Types</strong></td>
<td>27%</td>
<td>21%</td>
<td>48%</td>
<td>0.90</td>
<td>476</td>
</tr>
</tbody>
</table>

Notes:
1. Project Delivery percentages represent arithmetic averages of the individual projects and do not represent the results from the regression analyses.
2. Project Delivery percentages vary from year to year based on the selection and the composition of the projects in the database.
3. Total excludes projects delivered by alternative delivery mechanisms such as design-build, JOC, and CM@Risk. Projects delivered by alternative techniques are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the Study.
Regression Analysis

A regression analysis was performed to understand the relationship between project delivery as a percent of TCC. This analysis is important to establish statistical significance related to the performance benchmarking. The results reflect the agencies' experience with the delivery of capital projects; on a percentage basis projects with lower TCC are more expensive to deliver than projects with higher TCC. Results from the regression analysis methodology are discussed in Appendix B. Appendix B calculates the project delivery percentages differently than observed in Table 1-1 and Table 1-2, as described in detail in Appendix B.

Project Delivery Percentages as Ranges of TCC

In addition to evaluating a subset of projects defined by the lower 80th percentile subset, the project team evaluated the project delivery percentages on further subsets. An analysis was performed on how the project delivery percentage varies across TCC cost ranges.

The results show how the project delivery percentage changes for different ranges of TCC of projects. Projects with higher TCC typically have lower project delivery percentage of TCC and projects with lower TCC typically have a higher project delivery percentage of TCC. The results are further discussed in Chapter 3.

C. BEST MANAGEMENT PRACTICES

At the start of this Study in 2002, the agencies examined over 100 practices used in project delivery. Many practices included those the participants did not commonly use at the time but believed could add value if ultimately implemented as Best Management Practices (BMPs). Each year the agencies look at industry changes in order to identify new BMPs. Each Agency's implementation of these selected practices will continue to be tracked. No new BMPs have been developed in Update 2019, although the agencies are continuing to track their performance on the already developed BMPs.

While a BMP may be developed to address a specific issue, its implementation may affect other elements of project delivery. The participating agencies judged that each of the BMPs favorably impact one of the following categories:

- Cost
- Schedule
- Quality
- Communication
- Environment
- Customer Service

These BMPs continue to be an important element of the Study by providing a reference for participating agencies to identify additional BMPs that may be beneficial to implement or to understand challenges associated with their implementation. The discussion on BMPs is found in Chapter 4 of this report.
D. ACKNOWLEDGEMENTS

This Study is made possible through the generous contributions of each participating agency, city staff, and consultants. Contributors include:

- City of Long Beach/Port of Long Beach
- City of Los Angeles
- City of Sacramento
- City of San Diego
- City of San Francisco
- City of San José
- City of Oakland
- Stantec Consulting, Inc.
- Brookfield Properties

A full list of acknowledgements is presented in Chapter 5. The City of Oakland took a temporary break from participating in the Study. However, previously submitted projects from the City of Oakland are still maintained in the Study.
The California Multi-Agency CIP Benchmarking Study (Study) is a collaborative effort that involves the sharing of ideas and data between several of the largest cities in California. Each participating member contributes to the discussion of lessons learned out of their capital improvement program (CIP) implementation. Through this framework, members of the Study wish to: increase efficiency in delivering services, employ best management practices (BMPs), implement continuous training programs, and develop best-in-class capabilities.

The Study provides a forum for the agencies to share information among themselves via meetings that focus on current issues and a database that serves as both a repository of the agencies’ projects and a tool for data analysis. The purpose of this collaboration is to share the best ideas of the group for the benefit of all and to gather insight on how to address challenges that might appear to be new, but which others may have already faced and addressed successfully.

A. BACKGROUND

In October 2001, the City of Los Angeles, Department of Public Works, Bureau of Engineering initiated the Study with several of the largest cities in California. These cities joined together to form the Project Team for the Study. The Project Team acknowledges that there have been significant benefits derived from collaborating and pooling their project delivery knowledge and experience since the inception of the Study.

The participating agencies currently include:

- City of Long Beach, Department of Public Works and Harbor Department
  Port of Long Beach

- City of Los Angeles, Department of Public Works, Bureau of Engineering

- City of Oakland, Public Works Department, Bureau of Engineering and Construction. City of Oakland took a temporary leave from the Study in 2017

- City of Sacramento, Department of Public Works and Department of Utilities

- City of San Diego, Public Works Department, Engineering and Capital Projects Department

- City and County of San Francisco, Department of Public Works, Building Design and Construction, Infrastructure Design and Construction

- City of San José, Department of Public Works and City Manager’s Office

While the participating agencies have many similarities in terms of function and capital program delivery, it is important to note that a number of factors create differences. Some of
these include organization and cost structure. This is reflected in the “Indirect Rates Applied to Capital Projects” table shown in Appendix C. Variances amongst the agency indirect rates can create measurable delivery cost differences between the agencies for similar projects. However, the large magnitude of projects in the Study database has normalized these differences when data is compiled for major project categories and/or across all project types.

Upon initiation of the Study, it was agreed that published data provided by Study participants should remain anonymous in order to create a positive, non-competitive team environment, conducive to meeting the Study’s goals.

General information on each participating agency is summarized on Table 2-1.

**B. BENEFITS OF PARTICIPATION**

The participating agencies have been very supportive of the Study efforts over the years. The Study is possible only because the agencies believe they are benefiting from their continued participation.

The agencies have expressed many benefits of the Study. Ready access to performance data and BMPs of the largest cities in California helps member agencies in their decision-making process regarding policy and procedural improvements while providing training initiatives for new project

<table>
<thead>
<tr>
<th>Information</th>
<th>Population</th>
<th>Area (sq. mi.)</th>
<th>Website</th>
<th>Government Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>4,040,079</td>
<td>469</td>
<td><a href="http://eng.lacity.org">http://eng.lacity.org</a></td>
<td>Mayor-Council</td>
</tr>
<tr>
<td>Oakland</td>
<td>432,897</td>
<td>66</td>
<td><a href="http://www2.oaklandnet.com/">http://www2.oaklandnet.com/</a></td>
<td>Mayor-Council-Administrator</td>
</tr>
<tr>
<td>Sacramento</td>
<td>508,172</td>
<td>98</td>
<td><a href="http://www.cityofsacramento.org">http://www.cityofsacramento.org</a></td>
<td>Council-Manager</td>
</tr>
<tr>
<td>San Diego</td>
<td>1,420,572</td>
<td>342</td>
<td><a href="http://www.sandiego.gov">http://www.sandiego.gov</a></td>
<td>Mayor-Council</td>
</tr>
<tr>
<td>San Francisco</td>
<td>883,869</td>
<td>49</td>
<td><a href="http://www.sfdpw.org">http://www.sfdpw.org</a></td>
<td>Mayor-Board of Supervisors (11 members)</td>
</tr>
<tr>
<td>San José</td>
<td>1,043,058</td>
<td>178</td>
<td><a href="http://www.sanjoseca.gov">http://www.sanjoseca.gov</a></td>
<td>Mayor-Council-Manager</td>
</tr>
</tbody>
</table>


1. Provisional population estimate for the city as of January 1, 2019.
2. Mayor has veto power.
managers. Sharing project delivery costs provides agencies a higher level of design and construction estimate certainty and a benchmark to assess their individual CIP implementation performance. The tracking and reporting of the Study provides a structured framework for agencies to more seamlessly correlate performance with that of the collective.

The Study, through regular meetings, facilitates the discussion of how executives from each agency are managing and meeting similar challenges. Meetings involve the discussion of timely subjects that prepare agencies in addressing coming issues. The Study helps agency staff better communicate typical CIP challenges, e.g., needed resources with elected officials and community stakeholders.

C. STUDY FOCUS

This year, the participating agencies devoted in-person meeting time to collaborating with each other on pressing issues facing all the agencies. Agency implementation of selected BMPs has been and will continue to be tracked during the Study. A description of the BMP along with their “Perceived Value” is presented in Chapter 4, Best Management Practices.

D. STUDY GOALS

The Study method is described in detail in the first Study report (published in 2002) and modifications to it have been documented in subsequent Study reports. In Update 2019, the agencies made progress on several goals:

1. Collect projects delivered by alternative delivery techniques in the performance database. Over the years, the participating agencies have executed several projects using alternative delivery methods such as design-build and job-order-contracting yielding benefits in areas such as cost, schedule, and overall project delivery. In order to capture such projects as part of the Study, the agencies have decided to collect cost data for projects delivered via alternative methods. This practice was initiated in Update 2011 and continued in Update 2019. However, the agencies decided that these projects would not be analyzed until a sufficient number of projects are collected to facilitate meaningful analyses. In addition, criteria for analysis for projects delivered by alternative delivery techniques needs to be defined. The performance questionnaire was updated in Update 2017 to better categorize alternative delivery projects.

2. Track the adoption of BMPs. The Project Team continued to track the implementation of BMPs in order to link these practices to project delivery performance improvement over time in order to encourage their implementation. Although no new BMPs were adopted for Update 2019, agencies focused on specific challenges implementing BMPs already identified.

3. Continue efficient information sharing with one another through in person meetings. In Update 2019, the Project Team participated in quarterly meetings to exchange ideas, discuss topics of mutual interest and share ideas for addressing common challenges.
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Chapter 3
Performance Benchmarking
Performance benchmarking involves collecting documented project costs and plotting the component costs of project delivery against the total construction cost (TCC). The objective of this exercise is to develop relationships between these variables by performing regression analyses. The results of the regression analyses since Update 2009 have yielded significantly better correlation compared to prior years of the Study. This is primarily due to the adoption of statistical techniques for model selection and significant improvements in the modeling methodology.

The project costs data are collected from the agencies using a Performance Questionnaire created in Microsoft Excel®. Data are then compiled from the questionnaires in Excel® using Visual Basic for Applications (VBA) code. The data are reviewed and vetted and then transferred into the database. A copy of the current Performance Questionnaire can be found in Appendix A. The Performance Questionnaire was updated in Update 2019 to better collect information on sources of funding and regulatory oversight, to clarify change order categories, and to clarify language around predesign and design costs.

Note that the values presented in tables for previous years in this Update 2019 Benchmarking Report may have changed from prior reports due to the addition or update of past projects in Update 2019.

A. STUDY CRITERIA

The following criteria applied to Update 2019 performance benchmarking analyses:

- Total Construction Cost – TCC is the sum of costs associated with the awarded construction contract, net change orders, utility relocation, and construction by agency forces. TCC does not include the cost of land acquisition, environmental monitoring and mitigation, design, or construction management. All projects included in the analyses have a TCC exceeding $100,000. The participating agencies use fully-loaded (direct and indirect) costs for project delivery tasks. (See Appendix C).

- Completion Date – Projects included in the Study analyses were completed on or after January 1, 2014 and before December 31, 2018. Projects with earlier or later completion dates were kept in the database but excluded from the analyses.

- Outlier Elimination – Statistical elimination was used to identify outliers in the performance model. The project delivery percentage of each project in the database was evaluated against all other projects in the same classification. An outlier was identified as a project with
a project delivery percentage outside the range expressed by the following inequality:

\[ m - 3\sigma \leq x \leq m + 3\sigma \]

where \( m \) represents the mean of the project delivery percentage, \( \sigma \) represents the standard deviation of the project delivery percentage for all projects in the same classification, and \( x \) represents the project delivery percentage of a particular project.

It should be noted that this approach, which was first adopted in Update 2008, allows for the inclusion of more data than the approach implemented in previous years. Previously, other methods, including visual inspection, were used for the elimination of outlier data points. The adoption of the current outlier elimination approach was in part allowed by the improved modeling techniques that have been documented in prior Study reports.

Projects confirmed as outliers by this statistical technique were kept in the database but excluded from the analyses. Some of the projects classified as outliers in previous Study years have been included in the performance data analysis, and vice-versa.

- **Project Delivery Method** – All projects analyzed in this Study were delivered through the traditional design-bid-build method. In prior Study years, project costs data were only collected and analyzed for projects delivered using the traditional design-bid-build method. Over the years, the participating agencies have executed several projects using alternative delivery methods such as design-build, construction management at risk, on-call engineering services, and job-order-contracting yielding benefits in areas such as cost, schedule, and overall project delivery. In order to capture such projects as part of the Study, the agencies have decided to collect cost data for projects delivered via alternative methods. However, the agencies decided that these projects will not be analyzed until a sufficient number of projects are collected to facilitate meaningful analyses.

- **Change Order Classification** – To support meaningful change order analyses, the Project Team reported change orders into three classifications. The names of the classifications were revised for Update 2019 for clarity as follows:

  1. Unforeseen/Changed Conditions
  2. Changed Bid Documents/Errors and Omissions
  3. Client/Owner-Initiated Changes

**Project Classifications** – Seventeen project classifications grouped into five project types are used in this Study. The project types and classifications are shown in Table 3-1. The Water/Wastewater Treatment Plant category was added for Update 2018. The agencies identified modifications to the project classifications during meetings preceding Update 2019; these changes will be implemented in Update 2020.
Table 3-1
Project Types and Classifications

<table>
<thead>
<tr>
<th>Project Types</th>
<th>Classifications</th>
</tr>
</thead>
</table>
| Municipal Facilities | • Libraries  
|                  | • Police and Fire Stations  
|                  | • Community Centers, Recreation Centers, Child Care Facilities, Gymnasiums  
|                  | • Other Municipal Facilities (1) |
| Streets | • Widening, New, and Grade Separation  
|          | • Bridges  
|          | • Reconstruction (2)  
|          | • Bike Ways, Pedestrian Ways, and Streetscapes  
|          | • Signals |
| Pipe Systems | • Gravity Systems  
|             | • Pressure Systems  
|             | • Pump Stations  
|             | • Other Pipes |
| Parks | • Playgrounds  
|       | • Sport fields  
|       | • Restrooms |
| Water/Wastewater Treatment Plants | • Water/Wastewater Treatment Plants |

Notes:
1. Projects include design and/or construction activities for parking structures, yards, soil anchors, docks, animal shelters, reservoirs, piers, and animal services centers.
2. Includes curb ramps

B. DATA COLLECTION AND CONFIRMATION

To obtain meaningful results from the performance model, it is essential that the data collected from the agencies are accurate and conform to the Study criteria. The agencies recognize the importance of quality input data and are committed to providing accurate, complete project delivery cost data to support the development of performance models. Project delivery costs are defined as the sum of all agency and consultant costs associated with project planning, design, bid, award, construction management, and closeout activities. Examples of specific activities included in each phase of project delivery are presented in Table 3-2.

For the Update 2019 Study, the agencies completed the questionnaires with comparable, complete, and accurate values. The agencies also review and compare their data collection and confirmation techniques on a regular basis. For example, in the second quarterly meeting during Update 2016, each agency completed questionnaires on three previously submitted projects to compare with original submittals. The values obtained were nearly identical, with differences resulting typically from close-out costs that happen years after the project is completed. In addition, discussion among the Project Team helps clarify and resolve inconsistencies in the data collection methodologies. It also ensures that input data are vetted before projects are submitted for analysis.
Table 3-2
Project Cost Categories

<table>
<thead>
<tr>
<th>Category and Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1) Design Costs:</strong></td>
<td>The design phase (and associated costs) begins with the initial concept development, includes planning as well as design, and ends with the issuance of a construction Notice to Proceed. Design costs consist of direct labor costs, other direct agency costs such as art fees and permits, and consultant services cost associated with planning and design. Design may include the following:</td>
</tr>
</tbody>
</table>
| Predesign | • Complete schematic design documents  
• Review and develop scope  
• Evaluate schedule and budget  
• Review alternative approaches to design and construction  
• Obtain owner approval to proceed  
• Attend hearings and proceedings in connection with the project  
• Prepare feasibility studies  
• Prepare comparative studies of sites, buildings, or locations  
• Provide submissions for governmental approvals  
• Provide services related to future facilities, systems, or equipment  
• Provide services as related to the investigation of existing conditions of site or buildings or to prepare as-built drawings  
• Develop life cycle costs  
• Complete environmental documentation and clearances  
• Monitor and control project costs |
| Design | • Complete design development documents including outline specifications  
• Evaluate budget and schedule against updated construction cost estimate  
• Complete design and specifications  
• Develop bid documents and forms including contracts  
• Complete permit applications  
• Manage right-of-way procurement process  
• Coordinate agency reviews of documents  
• Review substitutions of materials and equipment  
• Prepare additive or deductive alternate documentation  
• Coordinate geotechnical, hazardous material, acoustic or other specialty design requirements  
• Provide interior design services  
• Monitor and control project costs |
| Bid and Award | • Prepare advertisement for bids  
• Qualify bidders  
• Manage the pre-bid conference  
• Evaluate bids  
• Prepare the recommendation for award  
• Obtain approval of contract award from Board/Council  
• Prepare the Notice to Proceed  
• Monitor and control project costs |
<table>
<thead>
<tr>
<th>Category and Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2) Construction Management Costs:</strong></td>
<td>All costs associated with construction management, including closeout costs, are included in this category. Construction management costs consist of direct labor, other agency costs, and consultant usage. Construction management may include the following:</td>
</tr>
</tbody>
</table>
| **Construction** | • Hold pre-construction conference  
• Review and approve schedule and schedule updates  
• Perform on-site management  
• Review shop drawings, samples, and submittals  
• Perform lab work, testing, and inspection  
• Process payment requests  
• Review and negotiate Change Orders  
• Prepare monthly reports to owner and agencies  
• Respond to Requests for Information  
• Develop and implement a project communications plan  
• Perform document control  
• Manage claims  
• Perform final inspections and develop and track punch list |
| **Closeout Phase** | • Commission facilities and equipment  
• Train maintenance and operation personnel  
• Document and track warranty and guarantee information  
• Plan move-in  
• File notices (occupancy, completion, etc.)  
• Check and file as-built documents  
• Monitor and control project costs |
| **3) Total Project Delivery Costs:** | This is the total cost of delivering a capital improvement project, equal to the sum of the design cost and construction management costs indicated above. |
| **4) Change Order Cost:** | Please see the Update 2005 Report for descriptions of the following types of change orders:  
• Changed/unforeseen conditions - This type of change is necessitated by discovery of actual job site conditions that differ from those shown on the contract plans or described in the specifications. These are conditions a designer could not have reasonably been expected to know about during the design of the project.  
• Changes to Bid Documents - This type of change is necessitated by a mistake or oversight in the original contract documents and is required to correct the plans and specifications.  
• Client-Initiated Changes - This type of change results from additions, deletions or revisions to the physical work. |
C. PERFORMANCE DATABASE

The projects data submitted by the agencies are compiled in a customized Microsoft Access® database. This database serves as a repository for the data collected since the inception of the Study. Each year, the projects database is updated with the inclusion of projects data submitted for that Study year.

Table 3-3 summarizes the number of projects included in the database and in the analyses. The 5-year database used for the current analysis contains 596 projects. This total excludes project data completed outside of January 1, 2014 to December 31, 2018, or projects identified as outliers. Projects identified as outliers are not included in the performance data analysis but are retained in the performance database. In addition, projects delivered by alternative delivery are excluded from the analysis but included in the database. The 596 projects selected for analysis do not include projects delivered by alternative delivery. As explained under Subsection A. Study Criteria of this chapter, outlier analysis was performed using statistical techniques to ensure consistency in the selection of outlier data points.

Table 3-3 shows that as the rules for project selection were refined, the number of non-representative and projects with TCC less than $100K have decreased. In addition, only 22 projects have been excluded as outliers in the Update 2019 Study.

In the Study 2002 report, it was recommended that at least 10 projects per classification and a minimum data set of 2,000 projects distributed evenly among classifications, ranges of TCC, and agencies are necessary to achieve statistically-significant results. While over 2,000 projects have been collected in the database, the number of projects analyzed in any Study phase is significantly lower due to the criteria selected for the inclusion of projects in the database. Although the requirement for the minimum number of projects per classification has been met for most project categories, some project classifications occur less frequently and thus have fewer projects in the database.

### Table 3-2

<table>
<thead>
<tr>
<th>Category and Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5) Total Construction Cost (TCC):</strong></td>
<td>This is the direct construction cost, including all change orders during the construction phase (from the issuance of Notice to Proceed to Notice of Completion). The following costs are associated with construction and are included in the TCC:</td>
</tr>
<tr>
<td></td>
<td>• Direct actual construction</td>
</tr>
<tr>
<td></td>
<td>• Total amount of change orders throughout construction</td>
</tr>
<tr>
<td></td>
<td>• Fixtures, furnishing, and equipment (FFE)</td>
</tr>
<tr>
<td></td>
<td>• Utilities relocation</td>
</tr>
<tr>
<td></td>
<td>• Construction work performed by the agency’s staff and other agencies’ staff</td>
</tr>
</tbody>
</table>
The agencies acknowledged that it is vital to the success of the Study to continue increasing the size of the data set, thereby increasing the confidence, consistency, and reliability of results. As previously indicated, there are five project types (Municipal Facilities, Streets, Pipe Systems, Parks, and Water/Wastewater Treatment Plants) and 17 project classifications included in this Study. Table 3-4 summarizes the distribution of projects included in the analyses.

### Table 3-3
**Growth of Database**

<table>
<thead>
<tr>
<th>Study Phase</th>
<th>Submitted Traditional Projects</th>
<th>(a) Alternative Delivery Projects Submitted</th>
<th>(b) Total</th>
<th>(c) TCC &lt;$100K</th>
<th>(d) Non-Representative</th>
<th>(e)=(b)-(a)-(c)-(d)</th>
<th>(f) Project Completion Date before 2014 or in 2019</th>
<th>Excluded</th>
<th>(g) Outliers</th>
<th>Projects in Analyses (h)=(e)-(f)-(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>239</td>
<td>0</td>
<td>239</td>
<td>27</td>
<td>44</td>
<td>168</td>
<td>168</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>II</td>
<td>285</td>
<td>0</td>
<td>285</td>
<td>0</td>
<td>35</td>
<td>250</td>
<td>250</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>III</td>
<td>262</td>
<td>0</td>
<td>262</td>
<td>0</td>
<td>29</td>
<td>233</td>
<td>233</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IV</td>
<td>173</td>
<td>0</td>
<td>173</td>
<td>18</td>
<td>24</td>
<td>131</td>
<td>131</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>V</td>
<td>182</td>
<td>0</td>
<td>182</td>
<td>0</td>
<td>4</td>
<td>177</td>
<td>177</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VI</td>
<td>191</td>
<td>0</td>
<td>191</td>
<td>0</td>
<td>4</td>
<td>188</td>
<td>188</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VII</td>
<td>158</td>
<td>0</td>
<td>158</td>
<td>2</td>
<td>0</td>
<td>157</td>
<td>157</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VIII</td>
<td>149</td>
<td>2</td>
<td>151</td>
<td>2</td>
<td>0</td>
<td>149</td>
<td>149</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IX</td>
<td>173</td>
<td>10</td>
<td>183</td>
<td>2</td>
<td>0</td>
<td>171</td>
<td>171</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>X</td>
<td>121</td>
<td>15</td>
<td>136</td>
<td>1</td>
<td>0</td>
<td>120</td>
<td>120</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>XI</td>
<td>160</td>
<td>15</td>
<td>175</td>
<td>0</td>
<td>4</td>
<td>160</td>
<td>160</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>XII</td>
<td>142</td>
<td>8</td>
<td>150</td>
<td>2</td>
<td>0</td>
<td>141</td>
<td>141</td>
<td>0</td>
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</tr>
<tr>
<td>XIII</td>
<td>145</td>
<td>27</td>
<td>172</td>
<td>0</td>
<td>0</td>
<td>145</td>
<td>143</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>XIV</td>
<td>162</td>
<td>19</td>
<td>181</td>
<td>4</td>
<td>0</td>
<td>158</td>
<td>35</td>
<td>4</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>XV</td>
<td>124</td>
<td>20</td>
<td>144</td>
<td>4</td>
<td>0</td>
<td>120</td>
<td>26</td>
<td>5</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>XVI</td>
<td>98</td>
<td>35</td>
<td>133</td>
<td>1</td>
<td>0</td>
<td>97</td>
<td>4</td>
<td>1</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>XVII</td>
<td>172</td>
<td>45</td>
<td>217</td>
<td>2</td>
<td>0</td>
<td>170</td>
<td>4</td>
<td>8</td>
<td>158</td>
<td></td>
</tr>
<tr>
<td>XVIII</td>
<td>144</td>
<td>28</td>
<td>172</td>
<td>3</td>
<td>0</td>
<td>141</td>
<td>1</td>
<td>4</td>
<td>136</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,080</strong></td>
<td><strong>224</strong></td>
<td><strong>3,304</strong></td>
<td><strong>68</strong></td>
<td><strong>144</strong></td>
<td><strong>2,876</strong></td>
<td><strong>2,258</strong></td>
<td><strong>22</strong></td>
<td><strong>596</strong></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
2. Projects that do not fit *Study* criteria for project classifications and minimum TCC of $100K were omitted from the database.
3. Projects delivered by alternative techniques are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the *Study*.
4. These represent projects delivered by alternative project delivery techniques. These projects are kept in the database, but not analyzed. These projects will be analyzed when a sufficient number of such projects are available to facilitate meaningful analyses.
5. Outliers are identified based on statistical analysis.
### Table 3-4


<table>
<thead>
<tr>
<th>Agency</th>
<th>Long Beach</th>
<th>Los Angeles</th>
<th>Oakland</th>
<th>Sacramento</th>
<th>San Diego</th>
<th>San Francisco</th>
<th>San José</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Facilities</td>
<td>0</td>
<td>16</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>14</td>
<td>5</td>
<td>46</td>
</tr>
<tr>
<td>Comm./Rec. Center/Child Care/Gyms</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Libraries</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Police/Fire Stations</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Other Municipal Facilities</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>Parks</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>13</td>
<td>7</td>
<td>26</td>
<td>51</td>
</tr>
<tr>
<td>Playgrounds</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>2</td>
<td>22</td>
<td>33</td>
</tr>
<tr>
<td>Restrooms</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Sport fields</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Pipe Systems</td>
<td>14</td>
<td>60</td>
<td>12</td>
<td>12</td>
<td>105</td>
<td>1</td>
<td>75</td>
<td>279</td>
</tr>
<tr>
<td>Gravity Systems (Storm Drains/Sewers)</td>
<td>6</td>
<td>46</td>
<td>11</td>
<td>7</td>
<td>59</td>
<td>1</td>
<td>72</td>
<td>202</td>
</tr>
<tr>
<td>Pressure Systems</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>39</td>
<td>0</td>
<td>2</td>
<td>49</td>
</tr>
<tr>
<td>Pump Stations</td>
<td>1</td>
<td>10</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Other Pipes</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Streets</td>
<td>9</td>
<td>18</td>
<td>11</td>
<td>43</td>
<td>32</td>
<td>49</td>
<td>17</td>
<td>179</td>
</tr>
<tr>
<td>Bike/Pedestrian/Streetscapes</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>24</td>
<td>13</td>
<td>2</td>
<td>9</td>
<td>57</td>
</tr>
<tr>
<td>Bridges (New/Retrofit)</td>
<td>2</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Reconstructions</td>
<td>6</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>12</td>
<td>37</td>
<td>1</td>
<td>65</td>
</tr>
<tr>
<td>Signals</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>12</td>
<td>2</td>
<td>10</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>Widening/New/Grade Separations</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>3</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>3</td>
<td>34</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>27</strong></td>
<td><strong>130</strong></td>
<td><strong>25</strong></td>
<td><strong>57</strong></td>
<td><strong>163</strong></td>
<td><strong>71</strong></td>
<td><strong>123</strong></td>
<td><strong>596</strong></td>
</tr>
</tbody>
</table>

**Notes:**
1. Total refers to the projects included in the Update 2019 analyses only. Total excludes projects delivered by alternative delivery methods such as design-build, JOC, on-call engineering services, and CM@Risk. Projects delivered by alternative methods are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the Study.
2. Projects include design and/or construction activities for parking structures, yards, soil anchors, docks, animal shelters, reservoirs, piers, and animal services centers.
D. REGRESSION ANALYSIS RESULTS

During Update 2008, several changes were made to improve the modeling methodology. These included developing a statistically-sound method for outlier analysis, using a linear trendline regression for modeling project costs relationships, and using the upper and lower bounds of a 95 percent confidence interval to estimate the range of the project delivery percentages. Results from the regression analysis methodology are discussed in Appendix B.

It is important to note that the project delivery percentage calculation as described in Appendix B is different from the average project delivery percentage in Section 3, as described in more detail in Appendix B. Section 3 evaluates the arithmetic average project delivery percentage of all projects, while Appendix B calculates the average slope using the least squares fit method.

The following example illustrates the differences in calculation of arithmetic average project delivery percentage in Section 3 and project delivery percentage in Appendix B. Consider 5 projects in the Pipe Project Type having the a1, a2, a3, a4, and a5 as their individual project delivery costs and b1, b2, b3, b4, and b5 as their individual TCC. The project delivery percentages in Section 3 are the arithmetic average of the project delivery percentages represented as:

\[
\text{Project Delivery Percentage} = \frac{(a1+a2+a3+a4+a5)}{(b1+b2+b3+b4+b5)}/5
\]

The project delivery percentage in Appendix B is calculated using the below formula which utilizes the least squares fit method:

\[
\text{Project Delivery Percentage} = \frac{(a1+a2+a3+a4+a5)}{(b1+b2+b3+b4+b5)}
\]

E. CHARACTERISTICS OF DATA ANALYZED

Project performance data were analyzed using the custom database application at both the Project Type level and the Project Classification level (see Table 3-1).

Table 3-5 summarizes characteristics of the projects included in the analyses by project completion year and shows trends in the average TCC values, median TCC values, design costs, construction management costs, and overall project delivery costs. The median value is the value at which 50 percent of the values are above and 50 percent of the values are below.

As indicated in Table 3-5, median project size has fluctuated considerably since 2013. The median TCC increased approximately 36 percent between 2014 and 2015, then decreased by 7 percent in 2016 and increased again in 2018 by 13 percent from 2017. The average TCC also saw annual fluctuations as much as 24 percent between 2014 and 2018. The fluctuations of the calculated median and average TCC could be due to actual changes in construction costs of projects carried out by the agencies and/or changes in which projects are included in the analysis and changes in how data are collected and how TCC is calculated.
### Table 3-5
Project Count and Project Delivery by Completion Year

<table>
<thead>
<tr>
<th>Project Completion Year</th>
<th>Municipal Facilities</th>
<th>Streets</th>
<th>Pipes</th>
<th>Parks</th>
<th>Water/Wastewater Treatment Plants</th>
<th>Total(3)</th>
<th>Average TCC ($MM)</th>
<th>Median TCC ($MM)</th>
<th>Design Cost (% of TCC)</th>
<th>Construction Management Cost (% of TCC)</th>
<th>Project Delivery Cost (% of TCC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>6</td>
<td>50</td>
<td>81</td>
<td>10</td>
<td>1</td>
<td>148</td>
<td>$2.08</td>
<td>$0.97</td>
<td>26%</td>
<td>20%</td>
<td>46%</td>
</tr>
<tr>
<td>2015</td>
<td>12</td>
<td>33</td>
<td>55</td>
<td>8</td>
<td>8</td>
<td>116</td>
<td>$2.58</td>
<td>$1.32</td>
<td>28%</td>
<td>21%</td>
<td>48%</td>
</tr>
<tr>
<td>2016</td>
<td>10</td>
<td>33</td>
<td>49</td>
<td>11</td>
<td>7</td>
<td>110</td>
<td>$3.18</td>
<td>$1.23</td>
<td>24%</td>
<td>20%</td>
<td>44%</td>
</tr>
<tr>
<td>2017</td>
<td>14</td>
<td>45</td>
<td>47</td>
<td>15</td>
<td>13</td>
<td>134</td>
<td>$3.53</td>
<td>$1.24</td>
<td>25%</td>
<td>20%</td>
<td>45%</td>
</tr>
<tr>
<td>2018</td>
<td>4</td>
<td>18</td>
<td>47</td>
<td>7</td>
<td>12</td>
<td>88</td>
<td>$3.62</td>
<td>$1.40</td>
<td>22%</td>
<td>20%</td>
<td>42%</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>179</td>
<td>279</td>
<td>51</td>
<td>41</td>
<td>596</td>
<td>$2.93</td>
<td>$1.23</td>
<td>25%</td>
<td>20%</td>
<td>46%</td>
</tr>
</tbody>
</table>

Notes:
1. Project Delivery percentages represent arithmetic averages of the individual projects and do not represent the results from the regression analyses.
2. Project Delivery percentages vary from year to year based on the selection and the composition of the projects in the database.
3. Total excludes projects delivered by alternative delivery mechanisms such as a design-build, on-call engineering support, JOC, and CM@Risk. Projects delivered by alternative techniques are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the Study.

Possible changes that may have impacted TCC could include: agency personnel turnover that affected productivity and project-specific knowledge; completion of more projects with relatively high TCC in recent years; and increased contractor labor costs. Changes in data collection and analysis that may have impacted median and average TCC values calculated could be due to the elimination of projects with lower TCC values during the outlier analysis.

*Project Delivery Costs by Project Type*

Table 3-6 shows project delivery costs by each of the five project types in the Study for the full range of TCC. The project delivery percentage for a category is the arithmetic average of the project delivery percentages of the individual projects grouped under that category.

Projects belonging to the Municipal Facilities categories have the lowest average project delivery percentage. The Pipes category has the highest number of projects (279) in the Update 2019 database. The Pipe and Streets category projects combined total 77 percent of the projects in the database. The Parks category exhibits one of the highest average project delivery cost, and has the second lowest median TCC. The average project delivery percentage for the overall dataset is 46 percent. These
### Table 3-6
#### Average Project Delivery Costs by Project Type (% of TCC)
(Full Range of TCC)

<table>
<thead>
<tr>
<th>Type</th>
<th>Design 1,2</th>
<th>Construction Management 1,2</th>
<th>Total Project Delivery 1,2</th>
<th>Median Total Construction Cost ($MM)</th>
<th>Number of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Facilities</td>
<td>24%</td>
<td>18%</td>
<td>42%</td>
<td>2.70</td>
<td>46</td>
</tr>
<tr>
<td>Parks</td>
<td>27%</td>
<td>20%</td>
<td>47%</td>
<td>0.78</td>
<td>51</td>
</tr>
<tr>
<td>Pipe Systems</td>
<td>22%</td>
<td>21%</td>
<td>43%</td>
<td>1.30</td>
<td>279</td>
</tr>
<tr>
<td>Streets</td>
<td>30%</td>
<td>20%</td>
<td>51%</td>
<td>0.91</td>
<td>179</td>
</tr>
<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>24%</td>
<td>21%</td>
<td>45%</td>
<td>3.59</td>
<td>41</td>
</tr>
<tr>
<td><strong>All Types</strong></td>
<td><strong>25%</strong></td>
<td><strong>20%</strong></td>
<td><strong>46%</strong></td>
<td><strong>1.23</strong></td>
<td><strong>596</strong></td>
</tr>
</tbody>
</table>

Notes:
1. Project Delivery percentages represent arithmetic averages of the individual projects and do not represent the results from the regression analyses.
2. Project Delivery percentages vary from year to year based on the selection and the composition of the projects in the database.
3. Total excludes projects delivered by alternative delivery mechanisms such as design-build, on-call engineering support, JOC, and CM@Risk. Projects delivered by alternative techniques are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the Study.

percentages have remained relatively stable for the original four project types (Municipal Facilities, Parks, Pipe Systems and Streets) over previous years.

Over the course of the Study, the agencies have observed that the relatively high average project delivery cost of Streets projects is likely due to increasing cost influences of right-of-way acquisition, community outreach requirements, environmental mitigation requirements, and the smaller median total construction cost of these projects.

Table 3-7 shows project delivery costs by each of the five project types in the Study for the 80th percentile subset of TCC (Note: In Update 2009, the concept of looking at a subset of projects was introduced. This subset generally characterizes the projects in the type or classification being examined. This step was taken as it was generally believed that project delivery for the very large projects did not characterize the overall projects in the type of classification being examined.). The trends in the project delivery costs for the projects in the 80th percentile subset of TCC follow that of the projects in the full range of TCC.
Consultant Usage Analysis

Project delivery performance and consultant usage by agency are presented in Table 3-8. The table indicates that on average, 59 percent of the design work and 82 percent of the construction management efforts are completed in-house by the participating agencies. Consultants account for approximately 30 percent of the total project delivery costs while in-house efforts by the participating agencies accounts for the remaining 70 percent of the project delivery costs. From the available data, a clear relationship between the level of in-house effort and project delivery costs cannot be established.

F. OTHER CONSIDERATIONS

Size of the Database

The size of the project database remains relatively the same for each Study update due to the 5-year rolling window criterion for project completion dates; as new projects are added, old projects are excluded from analyses based on age. The participating agencies are challenged to identify as many completed projects as possible that meet the Study criteria. The benefits of projects delivered via alternative delivery techniques can be quantified by including them for analysis in the project database. However, due to the significant difference in delivery mechanisms, those projects will have to be analyzed separately from the rest of the projects in the database.

Table 3-7
Average Project Delivery Costs by Project Type (% of TCC)
(80th Percentile Subset of TCC)

<table>
<thead>
<tr>
<th>Type</th>
<th>Design 12 %</th>
<th>Construction Management 12 %</th>
<th>Total Project Delivery 12 %</th>
<th>Median Total Construction Cost ($MM)</th>
<th>Number of Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Facilities</td>
<td>26%</td>
<td>19%</td>
<td>45%</td>
<td>1.39</td>
<td>36</td>
</tr>
<tr>
<td>Parks</td>
<td>30%</td>
<td>22%</td>
<td>52%</td>
<td>0.65</td>
<td>40</td>
</tr>
<tr>
<td>Pipe Systems</td>
<td>24%</td>
<td>22%</td>
<td>46%</td>
<td>0.95</td>
<td>223</td>
</tr>
<tr>
<td>Streets</td>
<td>33%</td>
<td>21%</td>
<td>54%</td>
<td>0.57</td>
<td>143</td>
</tr>
<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>27%</td>
<td>23%</td>
<td>49%</td>
<td>3.06</td>
<td>32</td>
</tr>
<tr>
<td>All Types</td>
<td>27%</td>
<td>21%</td>
<td>48%</td>
<td>0.90</td>
<td>476</td>
</tr>
</tbody>
</table>

Notes:
1. Project Delivery percentages represent arithmetic averages of the individual projects and do not represent the results from the regression analyses.
2. Project Delivery percentages vary from year to year based on the selection and the composition of the projects in the database.
3. Total excludes projects delivered by alternative delivery mechanisms such as a design-build, on-call engineering support, JOC, and CM@Risk. Projects delivered by alternative techniques are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the Study.
BMP Implementation and Project Delivery Costs

Although it is desirable for project delivery costs to decrease as agency efficiencies increase and BMPs are implemented, this can be confounded by other factors that change annually such as project size, construction cost fluctuations, inflation, competitive bidding environments, or additional environmental regulations. Without more detailed data gathered for each project, these factors cannot be confirmed.

G. SMALLER PROJECT ANALYSIS

In 2009, the Project Team decided to differentiate the projects based on the full set of projects and a subset of “smaller cost projects”. It was hypothesized that projects with smaller total construction cost (TCC) will have a higher project delivery percentage due to costs associated with project delivery which are independent of the size of project. These project delivery costs include:

- regulatory requirements (such as CEQA)
- public involvement and outreach
- right of way acquisition
- project alternatives and scope development
- utility agreements and relocations
- bidding costs and procurement of public contracts

Table 3-8

<table>
<thead>
<tr>
<th>AGENCY</th>
<th>DESIGN ($M)</th>
<th>% of Design ($M)</th>
<th>Construction Management ($)</th>
<th>% of CM ($)</th>
<th>% of TCC ($)</th>
<th>Total % of TCC ($)</th>
<th>Project Delivery ($)</th>
<th>% of PD ($)</th>
<th>TCC ($)</th>
<th>Average ($MM)</th>
<th>Median ($MM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agency A</td>
<td>51.9</td>
<td>77%</td>
<td>15.6</td>
<td>23%</td>
<td>30%</td>
<td>54.2</td>
<td>95%</td>
<td>2.9</td>
<td>5%</td>
<td>20%</td>
<td>106.1</td>
</tr>
<tr>
<td>Agency B</td>
<td>11.9</td>
<td>45%</td>
<td>14.8</td>
<td>55%</td>
<td>27%</td>
<td>10.4</td>
<td>46%</td>
<td>12.4</td>
<td>54%</td>
<td>16%</td>
<td>22.3</td>
</tr>
<tr>
<td>Agency C</td>
<td>19.4</td>
<td>84%</td>
<td>3.6</td>
<td>16%</td>
<td>17%</td>
<td>20.0</td>
<td>95%</td>
<td>1.0</td>
<td>5%</td>
<td>13%</td>
<td>39.4</td>
</tr>
<tr>
<td>Agency D</td>
<td>77.5</td>
<td>47%</td>
<td>86.6</td>
<td>53%</td>
<td>23%</td>
<td>128.8</td>
<td>81%</td>
<td>29.9</td>
<td>19%</td>
<td>25%</td>
<td>206.3</td>
</tr>
<tr>
<td>Agency E</td>
<td>4.2</td>
<td>49%</td>
<td>4.3</td>
<td>51%</td>
<td>28%</td>
<td>3.5</td>
<td>36%</td>
<td>6.1</td>
<td>64%</td>
<td>25%</td>
<td>7.7</td>
</tr>
<tr>
<td>Agency F</td>
<td>27.0</td>
<td>82%</td>
<td>5.8</td>
<td>18%</td>
<td>24%</td>
<td>27.6</td>
<td>97%</td>
<td>0.8</td>
<td>3%</td>
<td>22%</td>
<td>54.6</td>
</tr>
<tr>
<td>Agency G</td>
<td>8.1</td>
<td>47%</td>
<td>9.3</td>
<td>53%</td>
<td>25%</td>
<td>5.3</td>
<td>100%</td>
<td>0.0</td>
<td>0%</td>
<td>14%</td>
<td>13.5</td>
</tr>
<tr>
<td>OVERALL</td>
<td>200.1</td>
<td>59%</td>
<td>140.1</td>
<td>41%</td>
<td>25%</td>
<td>249.8</td>
<td>82%</td>
<td>53.2</td>
<td>18%</td>
<td>20%</td>
<td>449.9</td>
</tr>
</tbody>
</table>

Notes:
1. In-House and Consultant costs are expressed as percentages of total agency Design, CM (Construction Management), and PD (Project Delivery) costs.
2. TCC = Total Construction Cost
3. Design, CM, and PD costs are expressed as percentages of TCC and are unweighted, arithmetic averages of projects by agency.
In Update 2009, it was decided that the “smaller projects” cutoff limit would be the smallest 80 percent of projects ranked by the TCC for each category of projects. For example, if there were 100 street projects, the 80 least expensive TCC street projects would be included in the smaller projects cutoff. The hypothesis was confirmed, and it was found that the smaller projects typically have about a 3 to 5 percent higher project delivery percentage of TCC than the full set of projects.

In Update 2014, the Project Team reconsidered the smaller project cutoff limit, especially since the actual project delivery cost for “small projects” was felt to be much greater than that of the 80th percentile subset of projects. Therefore, an analysis was performed to evaluate the project delivery percentage for the projects in the database based on various TCC cost ranges.

Table 3-9 through Table 3-12 show the project delivery percentages for a range of construction costs by project type. Since the Water/Wastewater Treatment Plant category was new for Update 2018, the Project Team decided to not include cost ranges for this category until more projects are reported. In each project type category, the projects were arranged within four to five cost ranges. More than five cost ranges were not developed because more cost ranges lead to a fewer number of projects in each category, allowing the project delivery percentage to be more easily influenced by projects with extreme (either high or low) project delivery percentages. The cost ranges for each project type were developed in Update 2014 to distribute the projects evenly amongst the cost ranges. The cost ranges in subsequent updates have been the same as the cost ranges in Update 2014 to allow for comparison between Study update years.

In discussing the results presented in the tables below, the Project Team felt that the project delivery percentages shown are more reflective of the actual project delivery costs for small projects and are a useful tool for determining the expected project delivery costs of smaller projects.
### Table 3-9

<table>
<thead>
<tr>
<th>Dollar Ranges of Projects based on TCC</th>
<th>Number of Projects</th>
<th>AVERAGE of projects between Cost X and Cost Y, % TCC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Design %</td>
</tr>
<tr>
<td>X</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>$100,000</td>
<td>800,000</td>
<td>10</td>
</tr>
<tr>
<td>$800,000</td>
<td>3,000,000</td>
<td>16</td>
</tr>
<tr>
<td>$3,000,000</td>
<td>10,000,000</td>
<td>11</td>
</tr>
<tr>
<td>$10,000,000</td>
<td>75,000,000</td>
<td>9</td>
</tr>
</tbody>
</table>

### Table 3-10
Streets (2014-2018) Project Delivery Percentage based on Cost Ranges of TCC

<table>
<thead>
<tr>
<th>Dollar Ranges of Projects based on TCC</th>
<th>Number of Projects</th>
<th>AVERAGE of projects between Cost X and Cost Y, % TCC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Design %</td>
</tr>
<tr>
<td>X</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>$100,000</td>
<td>300,000</td>
<td>37</td>
</tr>
<tr>
<td>$300,000</td>
<td>600,000</td>
<td>38</td>
</tr>
<tr>
<td>$600,000</td>
<td>1,300,000</td>
<td>38</td>
</tr>
<tr>
<td>$1,300,000</td>
<td>2,400,000</td>
<td>24</td>
</tr>
<tr>
<td>$2,400,000</td>
<td>70,000,000</td>
<td>42</td>
</tr>
</tbody>
</table>

### Table 3-11
Pipes (2014-2018) Project Delivery Percentage based on Cost Ranges of TCC

<table>
<thead>
<tr>
<th>Dollar Ranges of Projects based on TCC</th>
<th>Number of Projects</th>
<th>AVERAGE of projects between Cost X and Cost Y, % TCC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Design %</td>
</tr>
<tr>
<td>X</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>$100,000</td>
<td>300,000</td>
<td>15</td>
</tr>
<tr>
<td>$300,000</td>
<td>600,000</td>
<td>45</td>
</tr>
<tr>
<td>$600,000</td>
<td>1,300,000</td>
<td>79</td>
</tr>
<tr>
<td>$1,300,000</td>
<td>2,400,000</td>
<td>61</td>
</tr>
<tr>
<td>$2,400,000</td>
<td>17,000,000</td>
<td>79</td>
</tr>
</tbody>
</table>

### Table 3-12
Parks (2014-2018) Project Delivery Percentage based on Cost Ranges of TCC

<table>
<thead>
<tr>
<th>Dollar Ranges of Projects based on TCC</th>
<th>Number of Projects</th>
<th>AVERAGE of projects between Cost X and Cost Y, % TCC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Design %</td>
</tr>
<tr>
<td>X</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>$100,000</td>
<td>350,000</td>
<td>5</td>
</tr>
<tr>
<td>$350,000</td>
<td>500,000</td>
<td>6</td>
</tr>
<tr>
<td>$500,000</td>
<td>1,000,000</td>
<td>17</td>
</tr>
<tr>
<td>$1,000,000</td>
<td>20,000,000</td>
<td>23</td>
</tr>
</tbody>
</table>
Chapter 4
Best Management Practices
At the onset of this Study in 2002, the agencies examined over 100 practices used in project delivery. Included in this Study were a number of practices that the participants did not commonly use at the time but believed could add value if ultimately implemented as Best Management Practices (BMPs). Each year the agencies look at changes in the industry and reflect on relevant experiences in order to identify new BMPs. Existing BMPs, in some cases, are reworked by the agencies to address specific challenges encountered during implementation. As in the past, agency implementation of these selected practices continues to be tracked during the Study.

A BMP is usually developed to address a specific issue; however, its implementation may affect other elements of project delivery. A BMP that reduces project schedule, for example, may also favorably impact both communication and project costs. While it is not possible to discretely quantify all the benefits of a given BMP, the participating agencies developed an approach to identify the major benefits associated with each BMP. This was accomplished in Update 2010 Study by assigning a Perceived Value to each BMP. The Agencies continue to identify the perceived value of all new BMPs. The participating agencies judge that each of the BMPs favorably impact one of the following categories:

- Cost
- Schedule
- Quality
- Communication
- Environment
- Customer Service
To identify the predominant *Perceived Values* associated with each new BMP, the participating agencies select which Perceived Values are most applicable for their Agency. The responses are then tabulated. A *Perceived Value* receiving three or more votes relative to a BMP is considered to be of significance. If a BMP is not shown to have *Perceived Value* in a certain category, it indicates that the *Perceived Value* received two or less votes relative to a BMP; it does not mean that a BMP has no benefit to that *Perceived Value* category. The majority of the BMPs are assigned a *Perceived Value* of either “cost” or “schedule”, followed by “quality”. This indicates that majority of the agencies found these “Perceived Values” as most applicable to the adopted BMPs.

**A. PROGRESS ON BEST MANAGEMENT PRACTICE IMPLEMENTATION**

BMPs have been included since the *Study 2002* report. For Update 2019, the agencies continued to exchange ideas regarding strategies for implementing various BMPs by using networking opportunities during the face-to-face meetings. Many agencies are pursuing full implementation of the BMPs but have competing priorities such as hiring challenges as a result of prior years’ staffing reductions, furloughs, and the management’s increased involvement in resolving budgetary issues. Constraints continue to limit the full implementation of BMPs for some agencies. In those instances, a BMP is partially implemented by that agency and is noted in **Table 4-1**. Agencies continue to focus their efforts on adherence to BMPs that have been implemented and judged to provide efficiencies in project delivery processes for participating departments.

The key for the following **Table 4-1** is as follows:

**Cities:**
- LA: Los Angeles;
- LB: Long Beach (Port: Port of Long Beach);
- OK: Oakland;
- SC: Sacramento (DT: Dept. of Public Works, DU: Dept. of Utilities),
- SD: San Diego,
- SF: San Francisco,
- SJ: San José

**Level of Implementation:**
- ✓: Implemented,
- PI: Partially implemented,
- NI: No plans to implement at this time,
- TBD: To be determined

The “Ref” column includes a reference number for the item and also includes the year the BMP was added to the Study. If no year is referenced, the item was included in the original 2002 Report.
## Table 4-1
### Implementation of BMPs

<table>
<thead>
<tr>
<th>Cat</th>
<th>Ref.</th>
<th>BMP, Description, and Perceived Value</th>
<th>Implementation and Notes</th>
</tr>
</thead>
</table>
|     | 1.a. | **BMP:** Define capital projects well with respect to scope and budget including community and client approval at the end of the planning phase.  
**Description:** Changes in project scope or budget increase both total construction cost and the cost of project delivery. The later these changes occur in the life of the project, the greater the increase. Reaching and documenting consensus with the community and the client will reduce changes after the project delivery process begins.  
**Perceived Value:** | LA, LB, OK, SC DT, SD, SJ  
SC DU: Community involved after project is better-defined, typically at 30% design.  
SF: SF involves the community early in the process, especially with certain City Agencies, such Rec & Park and Libraries, often as early as the beginning of the Planning & Programming Phase to let them know the project is starting. The scope is further defined/delineated at the end of the planning/conceptual phase, where a preliminary budget is established. Budgets are updated throughout all design phases. |
|     | 1.b. | **BMP:** Complete Feasibility Studies on projects prior to defining budget and scope.  
**Description:** Feasibility studies should be completed early in the process so that issues are identified and either resolved or accommodated within the final definition of scope, budget, and project delivery schedule. This will also reduce overall project delivery costs. Early feasibility studies are particularly important on complex projects and projects with a construction budget greater than $5 million.  
**Perceived Value:** | LA, OK, SC DT  
LB, SD, SJ: When applicable.  
SC DU: Only on complex projects that require a Feasibility Study.  
SF: Provide pre-planning feasibility studies and test fits on larger, more complex or politically sensitive projects. Developed a 1-Page “Project Development MOU” that allows the Client to fund an early phase such as Pre-Planning and/or Conceptual Phase so that the A/E team may work with the client to further define the project scope, provide preliminary pricing, which will in turn allow the client to make informed decisions going forward and provide for a more informed full service MOU. |
<table>
<thead>
<tr>
<th>Cat.</th>
<th>Ref.*</th>
<th>BMP, Description, and Perceived Value</th>
<th>Implementation and Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1.d. | | BMP: Utilize a Board/Council project prioritization system. Description: Departments responsible for project delivery have limited resources. A system will ensure that resources are directed to meet the community’s most critical needs. Perceived Value: ![icon] ![icon] | OK, SC DT, SD  
SF: 10-Year Capital plan developed City-wide and updated on a regular basis. A City-wide Capital Planning Committee composed of major department heads meets monthly and sets priorities and hears presentations by different departments. Individual departments also prioritize projects per their department when they are Bond funded projects. LA: Council establishes oversight committees which develop and manage a priority system and/or process. |
| | | PI | LB: Only on Major and Secondary Street Program, Utility Undergrounding Program, and projects funded by Tidelands and Measure A funding. |
| | | NI | SC DU: Getting closer to approved Asset Management system that would facilitate this BMP, but project drivers vary (permit requirements, projects in other departments, etc). |
| | | TBD | |
| 1.e. | | BMP: Resource load all CIP projects for design and construction. Description: The resources required to deliver projects according to the master CIP schedule mandated by the Board/Council should become part of the CIP. This will facilitate defining performance measures and ensure that there is a common understanding of the resources required to deliver the CIP. Perceived Value: ![icon] ![icon] | LA, OK, SC DT, SJ  
SC DU: Estimate drafting only. SD: Doesn’t include human resource loading. |
| | | PI | LB: Port loads in-house resources required to deliver the Capital Program on a per-project basis. |
| | | TBD | SF: BDC in the process of resource loading projects for long term projections, i.e. 1-3 years utilizing a software program called “10,000 Feet”; already have short term forecasting in place. |
| 1.f. | | BMP: Include a Master Schedule in the CIP that identifies start and finish dates for projects. Description: A master schedule can be used to define resource needs and performance measures. Perceived Value: ![icon] ![icon] | LA, OK, SC DT, SD, SJ  
SC DU: Completion date only estimated, not determined by scheduling analysis. LB: In transition - Project tracking software is being rolled out, full implementation to be complete end of 2020. Port has transitioned. SF: The Capital Plan has a general overall schedule and each department that has Bond measures have overall master schedules for their Bond Programs. |
## Chapter 4
Best Management Practices

<table>
<thead>
<tr>
<th>Cat.</th>
<th>Ref.</th>
<th>BMP, Description, and Perceived Value</th>
<th>Implementation and Notes</th>
</tr>
</thead>
</table>
| Planning | 1.g | BMP: Make an early determination on which environmental document is required and incorporate into the schedule.  
**Description:** Completing the environmental assessment and permitting process influences project schedules and costs. Establish a checklist of potential environmental and permit requirements and examine each project scope against the list early in the planning process.  
**Perceived Value:** | ✓ LA, LB, OK, SC DU, SC DT, SD, SJ, SF |
| Design | 1.i | BMP: Show projects on a Geographical Information System.  
**Description:** Entering and tracking planned projects into a GIS which is available to all private and public sector project planners will reduce the potential for conflicts and re-work.  
**Perceived Value:** | ✓ LA, OK, SC DU, SD, SF, SJ  
LB: In transition - Project tracking software is being rolled out, full implementation to be complete end of 2020.  
SC DT: Currently using Accela ROW Management to tracks projects by various departments and private entities to monitor for potential conflicts. |
| 2.b | BMP: Provide a detailed clear, precise scope, schedule, and budget to designers prior to design start.  
**Description:** Reliability, maintenance, operational requirements, and standard materials and equipment should be clearly defined in advance, approved by the user/client, and included in the design professional’s contract when a consultant is used.  
**Perceived Value:** | ✓ LA, LB, OK, SC DT, SD, SJ  
SC DU: General scope only for simple projects.  
SF: Scope provided for simpler straightforward projects, and in some cases the pre-planning phase used to develop the scope more accurately for the client. Some clients provide a PMP (Project Management Plan) before the start of the project. |
| 2.f | BMP: Define requirements for reliability, maintenance, and operation prior to design initiation.  
**Description:** Reliability, maintenance, operational requirements, and standard materials and equipment should be clearly defined in advance, approved by the user/client, and included in the design professional’s contract when a consultant is used.  
**Perceived Value:** | ✓ LA, LB, OK, SC DT, SD, SJ  
SD: Some Asset types only.  
SF: SF adopting Electronic M&R requirements in Division 0&1 for bidding instead of paper documents.  
NI SC DU |
<table>
<thead>
<tr>
<th>Cat.</th>
<th>Ref.*</th>
<th>BMP, Description, and Perceived Value</th>
<th>Implementation and Notes</th>
</tr>
</thead>
</table>
| 2.i. |       | **BMP:** Adapt successful designs to project sites, whenever possible (e.g. fire stations, gymnasia, etc).  
**Description:** Successful designs of fire stations, police facilities, maintenance facilities, pump stations, and many other projects should be re-used when possible. Site adaptations of successful designs may reduce design costs by half.  
**Perceived Value:** $ |
|       |       | ✓ LA, LB, OK, SC DU, SC DT, SD, SJ  
SF: Accomplished through SF’s detail library, specifications, etc. Provide Lessons Learned sessions on projects with the goal of learning from the project and refining the project delivery approach.  
SF has also created Fire & Police Station Design Guidelines. Full designs of the actual buildings are not easily replicated, however, due to site uniqueness and constraints, but detail libraries, best practices, and design guidelines create great efficiencies and better quality.  
SD: Uses standardized designs for fire stations and comfort stations. |
| 2.k. | 2003  | **BMP:** Train in-house staff to use Green Building Standards.  
**Description:** Communities have a stake in the environment as well as in the cost of operating and maintaining public facilities. Utilizing "Green Building Standards" allows facilities to be built and operated with renewable resources and other environmentally sound practices.  
**Perceived Value:** |
|       | ✓     | ✓ LA, LB, OK, SD, SJ, SF  
SC DT, SC DU  
SF: All projects are required to be LEED Gold. The Bureau of Architecture (BOA) has an internal “Green Building Committee” and also works very closely with the Department of the Environment. They are also in the process of hiring an in-house Green Building Coordinator. SF is also moving towards all projects to be all electric with no natural gas, towards a zero-carbon goal.  
LB: All new projects required to be LEED Silver. Envision certification optional. |
| 2.l. | 2004  | **BMP:** Limit Scope Changes to early stages of design.  
**Description:** It is well known within the industry that the later a change occurs in the construction process, the more costly the change is.  
**Perceived Value:** $ |
|       | ✓     | ✓ LA, LB, OK, SC DT, SJ  
SD, SC DU: Control and minimize, but difficult to eliminate, since clients and engineers come up with new/better solutions in addition to the community and politicians influence.  
SF: BOA states in their MOU that if there are significant design changes after 35% Design (100% DD) on vertical projects, there will be an Add Service. |
| 2.m. | 2004  | **BMP:** Require scope changes during design to be accompanied by budget and schedule approvals.  
**Description:** All scope changes after the initial definition within the design agreement will affect project delivery cost and therefore should be documented. Documentation should include an understanding and acceptance/approval by all stakeholders of the cost and time implications of any changes.  
**Perceived Value:** $ |
|       | ✓     | ✓ LA, LB, OK, SC DT, SD, SJ  
SF: Always the goal, however, not always manageable with some clients. In depth due diligence and good project planning helps this to be more successful.  
NI SC DU |
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<td><strong>BMP, Description, and Perceived Value</strong></td>
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<td></td>
<td>2.n. 2006</td>
<td>BMP: Implement a rotating Request for Quote process for contracting small projects to streamline the bidding and award process during construction. (Include criteria for exemptions from formal Council approval). <strong>Description:</strong> Smaller projects cost more (as a percentage of construction cost) to deliver. One way of reducing the cost of project delivery on small projects is to shorten the bid and award process by setting a threshold amount under which the delivery team may solicit and receive quotes from qualified contractors and award contracts without getting Board/Council prior approval. <strong>Perceived Value:</strong></td>
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<td>✔ OK, SD SF: As-needed job order contracting (JOC) and As-Needed Construction Contracts-Master Agreements for projects/work order packages under $600K; Utilization of Bureau of Building &amp; Repair (BBR) for projects under $600K and are developing an in-house Design-Build process between A/E team and BBR. SJ: Minor contracts (under $600,000), may be awarded without Council approval.</td>
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<td>2.o 2007</td>
<td>BMP: Establish criteria for obtaining independent cost estimates which take in consideration both project characteristics and volatility of the market. <strong>Description:</strong> Having to re-design and re-bid a project on which bids come in over budget can significantly impact project delivery cost. Accurate estimates at the end of each design phase, performed by unbiased, independent, qualified professionals with an understanding of local market conditions will reduce the potential for receiving unexpected bids. <strong>Perceived Value:</strong></td>
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<td></td>
<td></td>
<td>✔ SF: Establishing estimating database</td>
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<td>2.p 2008</td>
<td>BMP: Establish criteria for responsible charge design approval such that it occurs at the lowest appropriate organizational level in order to expedite design completion. <strong>Description:</strong> Many times responsible charge design approval is set at a very high level. This can sometimes result in only one person with limited time who can approve all sheets in a design package. This leads to a bottleneck situation. <strong>Perceived Value:</strong></td>
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<td>✔ LA, LB, SC DT, SC DU, SJ, SF SD: The lowest appropriate level is a Deputy City Engineer.</td>
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<td><strong>BMP: Receive bids electronically.</strong></td>
<td>✓ SD</td>
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<td><strong>Description:</strong> Electronic bidding programs have increased over the last several years. Receiving bids electronically provides a centralized location to store all bid related documents for public access along with ability to increase bidder participation.</td>
<td>PI OK LB: Slowly transitioning to e-Bid; Port: All bids being received electronically.</td>
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<td><strong>Perceived Value:</strong> ![thumbs up] ![thumbs up] ![thumbs up]</td>
<td>SC DT: Consultant proposals are received electronically, currently working on system for construction bid submittals. NI The City has delayed implementation of this process. Found this to be very difficult to meet the needs for the various City departments and funding sources. SF: In process TBD SC DU, SJ LA: BOE is starting to train staff on the new system.</td>
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<td>2.q</td>
<td><strong>BMP: Use of electronic signatures to do direct conversion from CAD to PDF.</strong></td>
<td>✓ SC DT, SC DU, SD, LA</td>
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<td></td>
<td>2010</td>
<td><strong>Description:</strong> Currently wet signatures on all pages is standard practice. This causes scanned files to be very large electronic files. Use of electronic signatures in all but the cover page will reduce file size and allow for easier distribution.</td>
<td>NI OK PI SF: In process and already being used by some divisions. TBD SJ LB Tentative – plan to implement after project tracking software is operational.</td>
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<td><strong>Perceived Value:</strong> ![dollar sign] ![thumbs up] ![thumbs up]</td>
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<td>2.r.</td>
<td><strong>BMP: Have awarding authority to approve plans, advertisement and award of contract in one board/council action.</strong></td>
<td>✓ LB, OK, SC DU SC DT: City Council approval is not required to advertise.</td>
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<td></td>
<td>2011</td>
<td><strong>Description:</strong> Combine approval of plans, advertisement and award of contract by the awarding authority into a single action.</td>
<td>SD: Part of the CIP streamlining, city council approval is obtained once a year on a list of projects to be awarded under a set $ amount as a part of the annual budget hearing. SF: Public Works has sole award authority without a council or board. SJ: The Director of Public Works approves all plans and advertisements; also generally awards contracts $1M or less.</td>
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<td><strong>Perceived Value:</strong> ![dollar sign]</td>
<td>NI LA</td>
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| 2.t. 2011 | **BMP:** Lessen time period between design completion and issuance of notice to proceed. Examples include items such as:  
- Pre-qualification of contractors  
- Good Faith Effort submitted on-line  
- Submittal incentives (i.e., award and material submittals allowed 30 day period; every day early is added to construction contract duration)  
- Have ability to issue contracts within your department  
- Electronic proposal documents provided 48 hours after bid opening; hard copy provided at bid time  
- Contractor’s self-certification  
**Description:** Implementation of new practices such as using an electronic process or pre-qualification in an effort to reduce the overall timeframe from design completion to notice to proceed.  
**Perceived Value:** | LA  
LA: Has an established contractor pre-qualification program  
SD: Has an established contractor pre-qualification program  
PI OK, SC DT, SJ |
| 3.I.a. | **BMP:** Develop and use a standardized Project Delivery Manual.  
**Description:** Standardized procedures streamline project design, bidding, and construction processes. Standardized design management procedures will reduce scope creep and delays in construction document preparation. During construction, standard procedures will reduce response times on RFIs, and add overall clarity and efficiency to the construction management process. Having a standard manual will also reduce the time necessary for project documentation training.  
**Perceived Value:** | LA, SC DT, SD  
LA: Needs updating.  
SC DU, OK, SJ: Needs updating.  
SF: Continually reviewing and updated.  
Hired a “Technical Manager” who oversees QC/QA processes along with the “Technical Committee”. SF has a Construction Administration Manual and a CM Manual. Have a draft PM Manual that can be reviewed with the PM Bureau. Also in the review process of selecting CM Software. |
| 3.II.b. | **BMP:** Perform a formal Value Engineering Study for projects larger than $1 million.  
**Description:** Value Engineering identifies life cycle costs of design elements included in a project and certain alternatives. While the cost of the value engineering process may initially add costs to project delivery, overall project costs will be reduced.  
**Perceived Value:** | LA, LB, SC DT, SC DU  
LA, LB SC DT, SC DU: As needed.  
SJ, SD: As needed.  
SF: Have a VE Tracking spreadsheet when needed on projects that utilizes input from all design disciplines, client, general contractor and sub-contractors, if available.  
NI OK |
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<td>3.III.a</td>
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<td>BMP: Use a formal Quality Management System. <strong>Description</strong>: Quality management should include all activities from the preparation of design documents through the closeout of construction. (Constructability reviews, independent cost estimates, classification and auditing of change orders, etc.) The implementation and tracking of quality control should be formalized on a checklist to ensure application.</td>
<td>OK, SC DT SF: BDC/IDC has a Technical review process that is on the verge of combining with the Design review process, calling it the Design Excellence &amp; QC/QA review process. SF has a formalized constructability review process for all projects over $8M. LB: Staffing cuts have delayed completion; Port: Adopted formal QMS. SD: Some asset types only.</td>
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<td>3.III.b</td>
<td></td>
<td>BMP: Perform and use post-project reviews to identify lessons learned. <strong>Description</strong>: Project Managers should develop formal post project reviews and identify lessons learned. These documents should be made available to PM’s on projects of a similar scope and nature. This BMP will make future project management and delivery more efficient and cost effective.</td>
<td>LA, OK, SC DT, SD, SJ SC DU: For selected projects in one-on-one meetings with design and construction staff. Also includes feedback from client. Intended to promote candid discussion. SF: Have a Lessons Learned process and are tracking all projects that have Lessons Learned.</td>
</tr>
<tr>
<td>3.III.k</td>
<td>2007</td>
<td>BMP: Establish a Utility Coordinating Committee with members from public and private entities. <strong>Description</strong>: Regular meetings of a committee will establish a forum for ideas to improve the utility relocation process and thus improve project progress. Meetings will also be an opportunity for problem projects (relocations) to be discussed.</td>
<td>LA, LB, OK, SC DT, SC DU, SD, SF</td>
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<tr>
<td>3.III.l</td>
<td>2007</td>
<td>BMP: Designate a responsible person for and establish a process of notifications and milestones for utility relocations. <strong>Description</strong>: Identifying a utility relocation specialist within the project delivery team who is familiar with the procedures and contacts within the public and private utility entities will improve communication and problem solving during design and construction.</td>
<td>LA, SC DT, SC DU, SD, SF SJ: Various Divisions/Sections have a utility coordinator and processes as needed.</td>
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| 3.III.m | 2008 | **BMP:** Maintain and regularly update electronic standard contract specifications and related documents as well as technical/special provision.  
**Description:** Standard contract specifications and technical special provisions need to be regularly maintained and updated in order to reduce the amount of time required to create contract bid documents. If a City implements new requirements, the standards should be modified for every project one time instead of each manager having to modify these documents of every project.  
**Perceived Value:** | ✔  
LA, LB, OK, SC DT, SC DU, SD, SJ  
SF: Technical Manager is updating/standardizing specifications and has updated 50 sections. Also have as-needed professional specification writers for hire. |
| 4.I.a. | | **BMP:** Delegate authority to the City Engineer/Public Works Director or other departments to approve change orders to the contingency amount.  
**Description:** Change order work should be authorized as soon as is practically possible in order to avoid potential delays to critical work. Scheduling a significant change order for review and authorization by the Board may delay project progress, even though it may be within the contingency amount allowed in the project budget. Authorization of the City Engineer/Public Works Director to approve changes within the contingency budgeted for changes will ensure that critical changes are acted on promptly and that delays are minimized.  
**Perceived Value:** | ✔  
LB, OK, SC DU, SJ  
LA: Individual CO < $100,000.  
SD: Individual CO < $500,000.  
SF: Reviews start at Bureau level but also need to be approved by Deputy Director & Director of Public Works. |
| 4.I.m. | | **BMP:** Classify types of change orders.  
**Description:** Classification of change orders into categories such as changed conditions, unforeseen conditions, owner requests, or design changes for owner use improves understanding of the project and lessons learned from the data may improve project delivery on similar projects.  
**Perceived Value:** | ✔  
LB, OK, SC DT, SC DU, SD, SJ, LA  
SF: All Change Orders are classified into categories: E&O, Unforseen Conditions, Owner Requests, Code Interpretations/Building Department, Scope Changes, etc. |
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<td>4.II.a.</td>
<td></td>
<td>BMP: Include a formal Dispute Resolution Procedure in all contract agreements. &lt;br&gt;<strong>Description:</strong> Construction is acknowledged as a dispute prone industry. As such, it makes sense to provide options in the contract documents to avoid litigation and to expedite disputes resolution using alternatives to litigation. &lt;br&gt;<strong>Perceived Value:</strong></td>
<td>LA, OK, SC DT, SC DU, SD, SF&lt;br&gt;<strong>SJ:</strong> Formal Dispute Resolution Board for projects &gt; $10 M; smaller projects have less formal Dispute Resolution Procedure.</td>
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<td>NI&lt;br&gt;<strong>LB:</strong> City Attorney will not allow this language in project specifications.</td>
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<td>4.III.a.</td>
<td></td>
<td>BMP: Use a team building process for projects greater than $5 million. &lt;br&gt;<strong>Description:</strong> Partnering is a team-building process that has a proven record of improving working relationships and production, and reducing claims and disputes on construction projects. It is one of several team-building processes that should be used in the interest of reducing conflict and facilitating project delivery. &lt;br&gt;<strong>Perceived Value:</strong></td>
<td>OK, SC DT&lt;br&gt;<strong>SF:</strong> The Mayor requires all city projects over $100K to undergo partnering, although threshold being reviewed. Also tracking partnering through EPM. &lt;br&gt;<strong>LA, LB, SC DU, SD:</strong> As-needed. &lt;br&gt;<strong>SJ:</strong> Facilitated Partnering required for projects &gt; $10M.</td>
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<td>4.IV.a.</td>
<td></td>
<td>BMP: Involve the Construction Management Team prior to completion of design. &lt;br&gt;<strong>Description:</strong> Experienced contractors and construction managers should be included in the design process to make designs more constructible and lower cost. Construction managers and contractors are frequently more experienced about the products and/or equipment as well as construction methods that are readily available. Their contributions to selections and decisions during the design process will facilitate construction procurement, means and methods. &lt;br&gt;<strong>Perceived Value:</strong></td>
<td>LA, LB, OK, SC DT, SC DU, SJ&lt;br&gt;<strong>SD:</strong> Always request a constructability review service from the CM team on all projects. &lt;br&gt;<strong>SF:</strong> Request the internal CM team review all projects for constructability no later than 50% CD. Infrastructure projects are reviewed by CM at 95%. All projects over $5M required to have outside constructability reviews in addition.</td>
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Description: Many approvals are required to process contract payments. Using electronic procedures provides an avenue to expedite the necessary approvals.  
Perceived Value: |
|     | 2010   | SF: Payments completed electronically via first-generation system which was demonstrated back in San Diego around 2008. Pay within the Mayor’s directive of 10 to 15 days and direct deposit is already available to the contractors through BofA.  
SJ: Upon request, City will pay by wire transfer.  
SD: City will pay by wire transfer.  
PI |
|      |        | LB: Currently done for some street related projects; Port: Once Invoice is received, invoice approvals are electronic, actual payment is typically by check, but EFT option is now available with new financial system launched in 2019.  
NI |
|      | 4.IV.c | BMP: Agency should file As-built drawings within 6 months of project completion.  
Description: One of the last tasks for a project is the updating and filing of As-built drawings. Many times, this task is put off for other pressing matters. This BMP establishes a 6 month deadline.  
Perceived Value: |
|     | 2010   | OK, SC DT, SC DU,  
SF: Process currently under review  
LA: Procedures are established in the Bureau of Engineering Project Delivery Manual.  
PI |
|      |        | LB: Being done on a go forward basis. Past projects still backlogged; Port has implemented.  
SD: Has been implemented on sewer and water pipeline projects.  
SJ: Generally yes, however, it depends on post-construction circumstances.  
NI |
|      | 4.V.a. | BMP: Delegate authority below Council to make contract awards under $1 million.  
Description: The time and costs of scheduling and presenting a Council or Board item can be saved and project starts can be expedited if awards on projects with budgets under $1 million can be awarded administratively.  
Perceived Value: |
|     | 2003   | LA, SF, SJ  
LB: Board must approve all contracts over $100,000; Port: Board must approve all contracts over $200,000  
SD: Up to $30M for construction  
NI |
|      |        | OK, SC DT, SC DU |

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<td>4.V.b 2003</td>
<td><strong>BMP</strong>: Establish a pre-qualification process for contractors on large, complex projects. <strong>Description</strong>: Prequalification helps screen contractors for prior performance on similar projects, safety and financial capability thus reducing risk and, ultimately, project delivery cost. <strong>Perceived Value</strong>:</td>
<td>✓ LA, LB, OK, SC DU, SD, SJ SF: Pre-Qualification procedure for project delivery on projects as desired.</td>
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<td>4.V.c 2003</td>
<td><strong>BMP</strong>: Make bid documents available online. <strong>Description</strong>: Making bid documents available online will reduce Agency printing costs. It may also increase bidder participation by making documents easily available to a larger pool of potential bidders and subcontractors. <strong>Perceived Value</strong>:</td>
<td>✓ LA, LB, OK, SC DT, SJ, SD SF: Documents available on line and on CD.</td>
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<td>5.I.f.</td>
<td><strong>BMP</strong>: Assign a client representative to every project. <strong>Description</strong>: Client (end user) representation during the life of the project will expedite decisions on submittals, substitutions, and changes. Their involvement will also help determine intent and streamline the commissioning and occupancy process. <strong>Perceived Value</strong>:</td>
<td>✓ LA, LB, OK, SC DT, SC DU, SD, SJ SF: Have a Client Representative and/or a Client PM for all buildings projects.</td>
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<td>5.I.j 2003</td>
<td><strong>BMP</strong>: Create in-house project management team for small projects. <strong>Description</strong>: It has been documented that the cost of project delivery of small projects is a higher percentage of the construction cost. Establishing a project management team that specializes in smaller projects may lead to economies such as grouping similar projects during permitting and bidding thus reducing project delivery cost. <strong>Perceived Value</strong>:</td>
<td>✓ LB, OK, SJ</td>
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| 5.1.k | 2004 | **BMP:** Institutionalize Project Manager performance and accountability.  
**Description:** Recognize that professional project management requires specific education, training, and experience. Provide for PMI, CCM, or other formal training and certification and establish performance measures for project delivery personnel. | ✓ LA, LB, OK, SC DT, SD, SF, SJ |
| 5.11.d | 2006 | **BMP:** Implement verification procedures to ensure that PM training includes Agency policies, procedures, forms, and standards of practice (scheduling, budgeting, claims avoidance, risk analysis, etc).  
**Description:** The success of a project is influenced significantly by the education and skills of the project manager. Agencies should verify that PM’s know and use the tools available within an Agency and that they are current with industry practices. | ✓ LA, OK, SC DT, SD, SJ |
| 5.11.a | | **BMP:** Provide formal training for Project Managers on a regular basis.  
**Description:** Project Managers come to projects with varying degrees of skill and familiarity with Agency procedures. Orientation and training will improve their ability to deliver the project on the intended schedule. It is also important that updated training is available at least on an annual basis. | ✓ LA, LB, SC DT, SF, SJ OK, SD: In place but needs review and/or refresh. |
| 5.11.b | | **BMP:** Adopt and use a Project Control System on all projects.  
**Description:** A web-based project control system will improve collaboration and documentation during the design and construction process. Questions, answers, proposals, and decisions can be expedited using a collaborative system. | ✓ LA, LB, OK, SC DT, SD, SF, SJ |

Perceived Value:

SC DU: There is interest but no definite plan. Implementation, although partially complete, is taken as far as it can go within our Agency.

SI: SC DU

TBD: SC DU

LA, LB, OK, SC DT, SD, SF, SJ

LA, LB, SC DT, SF, SJ OK, SD

SF: Have training courses for claims avoidance. Needs review and more robust training.

NI |

SC DU

LB, SJ

SC DU
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| 5.III.e | 2006 | BMP: Implement a financial system that tracks expenditures by category to monitor project hard and soft costs during project delivery. **Description:** It is recommended that a system that identifies actual expenditures against planned budgets be made available to project managers to be used as a performance measurement tool. **Perceived Value:** | ✓ LA, LB, OK, SC DT, SD, SJ  
SC DU: Intend to utilize SC DT’s software if it proves to function well with existing PM Database.  
SF: New financial system in place but still working out the kinks. |
| 5.III.f | 2006 | BMP: Implement a Work Breakdown Structure (WBS) to measure progress on project deliverables. **Description:** Getting accurate data on the cost of project delivery depends upon being able to capture and classify expenses to the phases of construction on each project. Ideally, costs would be identified by each of five project delivery phases and coded to particular milestones or deliverables. **Perceived Value:** | ✓ LB, OK, SC DT, SD,  
SF: Recently updated  
PI  
LA, SJ: Costs identified by phase, but not coded to milestones/deliverables  
NI  
SC DU |
| 5.III.g | 2006 | BMP: Monitor “earned value” versus budgeted and actual expenditures during project delivery. **Description:** Soft costs “burn rate” should be proportionate to percent complete during the design and construction phases. Using a program which measures and relates soft cost expenses to earned values permits better tracking and control during project delivery. **Perceived Value:** | ✓ LA, OK, SC DT, SF  
PI  
SD |
| 5.III.h | 2007 | BMP: Include a fixed ROW acquisition milestone schedule and obtain commitments from participating City departments. **Description:** Prolonged ROW acquisition can be avoided if all stakeholders agree on milestones to complete the acquisitions. **Perceived Value:** | ✓ SC DT, SJ  
PI  
LA, LB  
SD: It is difficult to get the commitments side.  
NI  
OK, SC DU, SF |
| 5.III.i | 2008 | BMP: Implement an electronic progress payment/schedule of values system to improve efficiency. **Description:** Reduction in the length of time and inefficiencies in processing of progress payments through the use of electronic means. **Perceived Value:** | ✓ SC DT, SF  
PI  
SJ: Implemented on large, complex projects  
LA, SC DU, SD  
NI  
LB: Current accounting system cannot accommodate a fully electronic approval process; Port: Implemented software and testing this function in the system.  
TBD  
OK |
### Best Management Practices

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| 5.III.j | **BMP:** Implement a schedule tracking system that monitors the actual percent complete against the percent of time elapsed for each identified phase of the approved project schedule.  
**Description:** Establishing a system where a project’s schedule is broken into its phases. Actual percent complete is then measured against time elapsed in each phase throughout the development of the project. This system becomes a tool for management by project managers and supervisors.  
**Perceived Value:** | LA, OK, SC DT, SD  
LB: City uses project tracking software. Port has P6. |
| 2014 | | SC DU, SJ  
SF: Developed the Enterprise Project Management (EPM) which is used for project updates, financial and schedule tracking, and as a reporting tool. Project Leads are responsible for creating the schedules per client department MOUs and tracking actual schedules to baselines. |
| 5.III.k. 2014 | **BMP:** Establish the use of dashboards as a quick way to check project delivery performance for both internal and external reporting that is easy to use, has appropriate level of transparency and is efficient.  
**Description:** The dashboard concept is based on the ability to drill down to multiple levels of data so the user can get the level of detail desired. The level of detail to be provided in each dashboard is at the discretion of each Agency. The external dashboard increases public awareness of the project delivery performance and increases agency accountability. The internal dashboard provides a platform to measure, monitor, evaluate, and report performance to assist in establishing clear business rules and improve internal communication.  
**Perceived Value:** | LA, SD, SF  
OK, SC DT, SJ  
LB: In transition - Project tracking software is being rolled out, full implementation to be complete end of 2020. |
| 2006 | **BMP:** Bundle small projects whenever possible.  
**Description:** Bundling small projects so that they are designed, bid, and constructed together will reduce project delivery cost proportionately.  
**Perceived Value:** | LA, LB, OK, SC DT, SC DU, SD, SF, SJ |
| 5.IV.a | **BMP:** Have a coordinator with expertise in the environmental process within the department delivering the engineering/capital project.  
**Description:** Identifying an environmental specialist within the project delivery team who is familiar with procedures and contacts within the approving entities will reduce permit procurement time and costs.  
**Perceived Value:** | LA, SD, SF  
SJ: Various Divisions/Sections have an environmental coordinator as needed. |
<p>| 2007 | | LB, OK, SC DT, SC DU |</p>
<table>
<thead>
<tr>
<th>Ref.*</th>
<th>BMP, Description, and Perceived Value</th>
<th>Implementation and Notes</th>
</tr>
</thead>
</table>
| 6.c.  | **BMP:** Include a standard consultant contract in the RFQ/RFP with an indemnification clause.  
**Description:** The negotiation of the design contract can be expedited if the consultant understands and agrees to the conditions of the contract at the time a proposal is submitted.  
**Perceived Value:** | ✓ LA, LB, OK, SC DT, SC DU, SF, SJ, SD |
| 6.e.  | **BMP:** Delegate authority to the Public Works Director/City Engineer to approve consultant contracts under $250,000 when a formal RFP selection process is used.  
**Description:** Authorization for the Public Works Director/City Engineer to award consulting contracts ensures earlier start of design and construction management activities and will reduce consultant selection process costs.  
**Perceived Value:** | ✓ SD, SF |
|       | **BMP:** Implement and use a consultant rating system that identifies quality of consultant performance.  
**Description:** The performance of consultants should be tracked so that those who deliver quality services at reasonable costs can be adequately considered for future awards.  
**Perceived Value:** | ✓ LA, OK, SD, SF, SJ |
|       | **BMP:** Implement as-needed, rotating, or on-call contracts for design and construction management work that allow work to be authorized on a task order basis to expedite the delivery of smaller projects.  
**Description:** Establishing an on-call list of qualified consultants with expertise in a variety of design disciplines will expedite the start of the design process.  
**Perceived Value:** | ✓ LA, LB, OK, SC DT, SC DU, SD, SF, SJ |
<table>
<thead>
<tr>
<th>Cat.</th>
<th>Ref.*</th>
<th>BMP, Description, and Perceived Value</th>
<th>Implementation and Notes</th>
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<tr>
<td>Consultant Selection and Use</td>
<td>6.n 2013</td>
<td><strong>BMP</strong>: Determine appropriate consultant costs for professional services agreements. <strong>Description</strong>: Establish a documented agency methodology for analyzing acceptable consultant costs and billing rates for use in contract negotiations. <strong>Perceived Value</strong>:</td>
<td>PI LA, OK, SF, SJ, SD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TBD LB, SC DT, SC DU</td>
<td></td>
</tr>
<tr>
<td>Sustainable Development</td>
<td>7.a. 2009</td>
<td><strong>BMP</strong>: Identify the environmental benefits of the project at the time of award. <strong>Description</strong>: Provide written, environmental benefits to the awarding authority on projects that use sustainable practices or aim to achieve LEED certification. <strong>Perceived Value</strong>:</td>
<td>✓ LA, LB, OK, SC DT, SJ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PI SD TBD SC DU</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SF: For building projects, this is done at the start of planning for the application of LEED. All projects over 10,000 SF required to be LEED Gold.</td>
<td></td>
</tr>
</tbody>
</table>

Key:
LA: Los Angeles; LB: Long Beach (Port: Port of Long Beach); OK: Oakland; SC: Sacramento (DT: Dept. of Transportation, DU: Dept. of Utilities), SD: San Diego, SF: San Francisco, SJ: San José
✓: Implemented, PI: Partially implemented, NI: No plans to implement at this time, TBD: To be determined
* See Process Questionnaire in Appendix C of 2002 Report; year noted indicates this BMP was added later.
CHAPTER 5

Acknowledgements

The participation and contribution of the following individuals to the Study is gratefully appreciated. This work would not have been possible without their contributions.

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APPENDIX A

Performance Questionnaire

California Multi-Agency Benchmarking Study Update 2019 Performance Questionnaire

Agency: ____________________________ Project Name: ____________________________

Project Type: ____________________________ Sustainability Goal: ____________________________

New/Rehab Index: ____________________________ Regulatory and Oversight Requirements: ____________________________

Alternative Project Delivery(7): __________

On-call engineering services does not use pre-negotiated, fixed prices on units of material/labor. Job order contracting (JOC) uses pre-negotiated, fixed prices on units of material/labor.

Description: ____________________________

Comments: ____________________________

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<th>Predesign</th>
<th>Design</th>
<th>Construction Management</th>
<th>Total</th>
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<td>DOLLAR</td>
<td>DOLLAR</td>
<td>DOLLAR</td>
<td>DOLLAR</td>
</tr>
<tr>
<td>% of TCC*</td>
<td>% of TCC*</td>
<td>% of TCC*</td>
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<th>AMOUNT OF CONSTRUCTION CONTRACT</th>
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<td>ENGINEER’S ESTIMATE</td>
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<td>COST OF CHANGE ORDERS</td>
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<tr>
<td>Unforeseen/Changed Conditions</td>
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<td>Documents/Errors and Omissions</td>
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<tr>
<td>Total Change Orders</td>
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<table>
<thead>
<tr>
<th>UTILITY RELOCATION COST</th>
</tr>
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<tbody>
<tr>
<td>CITY FORCES CONSTRUCTION (HARD COSTS ONLY)</td>
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<table>
<thead>
<tr>
<th>TOTAL CONSTRUCTION COST (TCC)</th>
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<tr>
<td>LAND ACQUISITION (ONLY COST OF LAND, NO ASSOCIATED LABOR COST)</td>
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<table>
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<tr>
<th>DATE STARTED TO INCUR CONSTRUCTION MANAGEMENT COSTS (IF AVAILABLE)</th>
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</thead>
<tbody>
<tr>
<td>BID OPENING DATE (IF AVAILABLE)</td>
</tr>
<tr>
<td>CONSTRUCTION COMPLETION DATE</td>
</tr>
</tbody>
</table>

| TOTAL PROJECT COST |
| NUMBER OF BIDS RECEIVED |

(7) Agency costs include all direct costs and can be listed underneath. This value is locked and it is calculated from its items (Items 15 - 19)
The results of the regression analysis performed using the performance model are presented in the following paragraphs.

**Regression Definitions**

A brief overview of the relevant statistical terminology and their definitions is provided in the following paragraphs:

Performance curves produced for this Study are regressions of data, demonstrating how close of a relationship exists between the dependent variable (on the y-axis) and the independent variable (on the x-axis). For instance, a regression curve of design cost versus total construction cost (TCC) would be prepared to evaluate how much of the variability in design cost is due to the TCC value.

The regression trendline can be used as a starting point for evaluating the budget for a suite of projects. Caution and use of professional judgment is required if using the regression trendline to budget an individual project.

**Coefficient of Determination**

A best-fit logarithmic curve is calculated using the least-squares method in Excel®, and a $R^2$ value is displayed. The $R^2$ value, also called the coefficient of determination, is a value between 1 and 0, with a value approaching 0 indicating a poor model and a value approaching 1 indicating a high dependence of the y-value statistic on the x-value statistic.

**Statistical Significance**

To evaluate the statistical significance of the result obtained, the regression analyses included a calculation of p-values. Whereas the $R^2$ value is a descriptive statistic (i.e., describes the current set of data), the p-value is a predictive statistic. It indicates whether there are enough data points to arrive at statistically-significant results and whether the data set could be used to forecast new values. The selection of a desirable p-value is subjective, though 0.10 or 0.05 is typically used as the maximum desirable value.

For the purposes of this Study, a critical p-value of 0.10 was selected. Thus, any result where $p \leq 0.10$ is considered statistically significant. There is no difference between a p-value slightly below 0.10 as one that is far below 0.10. Both results are considered to have equal statistical significance.

For regressions resulting in a p-value above 0.10, additional projects should be added to the database to improve the result. Please see the Study 2002 report.
for additional detail on the connection between the number of projects and p-values. Pump stations and restroom projects had p-values less than 0.1, and therefore the values obtained are not statistically significant.

For each of the regressions, the $R^2$ value and p-value should be considered separately. A high $R^2$ value does not mean the result is statistically-significant, and vice-versa.

The results of the regression analyses are discussed in the remainder of this section. The results of the regression analyses are summarized in Table B-1 and Table B-2. Table B-1 summarizes the performance model results for the full range of TCC while Table B-2 summarizes the results for the 80th percentile subset of TCC. These tables also summarize the design, construction management, and project delivery costs expressed as a percentage of the TCC and the $R^2$ and the p-values for the different project types.

It is important to note that while the slopes of the linear regression models are an expression of the project delivery cost as a percentage of construction, the slopes are not equal to the average and median project delivery percentages shown in Table 3-5, Table 3-6, and Table 3-7. This is due to the fact that the linear trendline is fit by the least squares method.

This is better explained by the following example. Consider 5 projects in the municipal category having the a1, a2, a3, a4, and a5 as their individual project delivery costs and b1, b2, b3, b4, and b5 as their individual TCC. The arithmetic average of the project delivery percentages would be represented as:

$$\text{Project Delivery Percentage} = \frac{a_1 + a_2 + a_3 + a_4 + a_5}{b_1 + b_2 + b_3 + b_4 + b_5}$$

The project delivery percentages presented in Table 3-5 through Table 3-12 are computed using the above formula, which is the average of the individual project delivery percentages.

In the regression analysis, the project delivery percentage is computed in fashion that is more similar to the following formula which represents the average slope of the least squares fit.

$$\text{Project Delivery Percentage} = \frac{a_1 + a_2 + a_3 + a_4 + a_5}{b_1 + b_2 + b_3 + b_4 + b_5}$$

The project delivery percentages presented in Table B-1 and Table B-2 are computed using the above formula.

The plots depicting the regression relationships are shown in this section. It should also be noted that while majority of projects are clustered near the origin of the graph, the slope of the trendline is predominantly governed by the data points scattered at relatively high TCC values. Since the slope of the trendline provides the design, construction management, or the project delivery costs as a percentage of the TCC for a group of projects, the results better reflect the properties of a program of projects rather than that of an individual project. Therefore, the reader must avoid budgeting individual projects based solely on these analyses.
In most cases, the results reflect the agencies’ experience with the delivery of capital projects that on a percentage basis projects with lower TCCs are more expensive to deliver than projects with higher TCCs. Only 3 out of the 16 categories have lower project delivery percentages for the 80th percentile subset of projects than the full range of projects. It is concluded that the model results are reasonable from a statistical perspective.

For projects belonging to the Parks category, there is no increase in the project delivery percentages for projects evaluated in the 80th percentile subset of TCC. Project delivery percentages for projects belonging to the Pipes, Streets and Municipal category exhibit a 13, 16, and 16 percent increase, respectively, than the 80th percentile subset. Comparing the results summarized in Table B-1 and Table B-2 shows that an economy of scale exists in delivering projects with a higher TCC versus those with a lower TCC.

The elimination of auto-correlation in Update 2008 and the use of the linear trendline to describe the relationship between project delivery costs and the TCC have significantly improved the $R^2$ values as compared to the Study years prior to 2008. The linear regression trendline equations are shown in Table B-3.

The reader is cautioned that these tables should only be used as a reference and not for prediction of performance. Readers are urged to review the curves in this section in conjunction with using this table.
## Table B-1
Summary of Performance Models (Full Range of TCC)

<table>
<thead>
<tr>
<th>Project Type or Classification</th>
<th>Number of Projects</th>
<th>Design Cost (% of TCC)</th>
<th>95% CI %</th>
<th>R²</th>
<th>p-value</th>
<th>Construction Management Cost (% of TCC)</th>
<th>95% CI %</th>
<th>R²</th>
<th>p-value</th>
<th>Project Delivery Cost (% of TCC)</th>
<th>95% CI %</th>
<th>R²</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>Municipal Facilities</td>
<td>46</td>
<td>20%</td>
<td>17%-22%</td>
<td>0.85</td>
<td>7.5E-20</td>
<td>11%</td>
<td>10%-12%</td>
<td>0.89</td>
<td>5.6E-23</td>
<td>31%</td>
<td>28%-34%</td>
<td>0.92</td>
<td>3.7E-26</td>
</tr>
<tr>
<td>Libraries</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Police/Fire Stations</td>
<td>12</td>
<td>25%</td>
<td>20%-31%</td>
<td>0.91</td>
<td>4.2E-07</td>
<td>11%</td>
<td>9%-13%</td>
<td>0.93</td>
<td>9.1E-08</td>
<td>36%</td>
<td>32%-41%</td>
<td>0.97</td>
<td>1.2E-09</td>
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<td>Comm./Rec. Center/Child Care/Gyms</td>
<td>11</td>
<td>18%</td>
<td>14%-22%</td>
<td>0.92</td>
<td>6.6E-07</td>
<td>24%</td>
<td>18%-30%</td>
<td>0.89</td>
<td>4.3E-06</td>
<td>42%</td>
<td>34%-51%</td>
<td>0.92</td>
<td>6.4E-07</td>
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<td>Other Municipal</td>
<td>23</td>
<td>14%</td>
<td>12%-16%</td>
<td>0.93</td>
<td>3.5E-14</td>
<td>11%</td>
<td>9%-12%</td>
<td>0.94</td>
<td>3.1E-15</td>
<td>24%</td>
<td>22%-27%</td>
<td>0.94</td>
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<td>Streets</td>
<td>179</td>
<td>17%</td>
<td>16%-18%</td>
<td>0.78</td>
<td>3.4E-61</td>
<td>18%</td>
<td>17%-19%</td>
<td>0.86</td>
<td>1.1E-77</td>
<td>35%</td>
<td>33%-37%</td>
<td>0.91</td>
<td>2.3E-94</td>
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<tr>
<td>Widening/New/Grade Separations</td>
<td>10</td>
<td>13%</td>
<td>12%-15%</td>
<td>0.98</td>
<td>6.4E-09</td>
<td>17%</td>
<td>16%-18%</td>
<td>0.99</td>
<td>2.7E-10</td>
<td>30%</td>
<td>26%-33%</td>
<td>0.99</td>
<td>5.6E-10</td>
</tr>
<tr>
<td>Bridges</td>
<td>15</td>
<td>17%</td>
<td>11%-23%</td>
<td>0.73</td>
<td>2.8E-05</td>
<td>24%</td>
<td>20%-28%</td>
<td>0.92</td>
<td>4.0E-09</td>
<td>41%</td>
<td>33%-49%</td>
<td>0.89</td>
<td>3.4E-08</td>
</tr>
<tr>
<td>Reconstructions</td>
<td>65</td>
<td>24%</td>
<td>22%-27%</td>
<td>0.86</td>
<td>1.2E-28</td>
<td>11%</td>
<td>9%-12%</td>
<td>0.69</td>
<td>6.9E-18</td>
<td>35%</td>
<td>32%-38%</td>
<td>0.92</td>
<td>3.4E-36</td>
</tr>
<tr>
<td>Bike/Pedestrian/Streetscapes</td>
<td>57</td>
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<td>23%-29%</td>
<td>0.82</td>
<td>1.6E-22</td>
<td>20%</td>
<td>18%-23%</td>
<td>0.83</td>
<td>2.7E-23</td>
<td>46%</td>
<td>42%-50%</td>
<td>0.89</td>
<td>1.4E-28</td>
</tr>
<tr>
<td>Signals</td>
<td>32</td>
<td>16%</td>
<td>9%-22%</td>
<td>0.47</td>
<td>1.1E-05</td>
<td>19%</td>
<td>16%-22%</td>
<td>0.85</td>
<td>1.6E-14</td>
<td>35%</td>
<td>28%-41%</td>
<td>0.77</td>
<td>1.5E-11</td>
</tr>
<tr>
<td>Pipes</td>
<td>279</td>
<td>16%</td>
<td>15%-17%</td>
<td>0.74</td>
<td>5.9E-83</td>
<td>16%</td>
<td>15%-17%</td>
<td>0.72</td>
<td>1.4E-79</td>
<td>33%</td>
<td>31%-34%</td>
<td>0.80</td>
<td>1.3E-99</td>
</tr>
<tr>
<td>Gravity Mains</td>
<td>202</td>
<td>17%</td>
<td>16%-18%</td>
<td>0.75</td>
<td>2.1E-62</td>
<td>16%</td>
<td>15%-18%</td>
<td>0.72</td>
<td>9.7E-57</td>
<td>33%</td>
<td>31%-35%</td>
<td>0.80</td>
<td>4.0E-72</td>
</tr>
<tr>
<td>Pressure Systems</td>
<td>49</td>
<td>14%</td>
<td>11%-16%</td>
<td>0.69</td>
<td>1.0E-13</td>
<td>13%</td>
<td>12%-15%</td>
<td>0.84</td>
<td>8.3E-21</td>
<td>27%</td>
<td>23%-31%</td>
<td>0.82</td>
<td>2.6E-19</td>
</tr>
<tr>
<td>Pump Stations</td>
<td>19</td>
<td>17%</td>
<td>14%-21%</td>
<td>0.83</td>
<td>2.6E-08</td>
<td>28%</td>
<td>22%-33%</td>
<td>0.86</td>
<td>4.3E-09</td>
<td>45%</td>
<td>39%-51%</td>
<td>0.93</td>
<td>4.6E-12</td>
</tr>
<tr>
<td>Other Pipes</td>
<td>9</td>
<td>14%</td>
<td>8%-21%</td>
<td>0.76</td>
<td>1.0E-03</td>
<td>31%</td>
<td>21%-40%</td>
<td>0.87</td>
<td>7.9E-05</td>
<td>45%</td>
<td>33%-57%</td>
<td>0.90</td>
<td>2.5E-05</td>
</tr>
<tr>
<td>Parks</td>
<td>51</td>
<td>18%</td>
<td>16%-19%</td>
<td>0.92</td>
<td>5.2E-29</td>
<td>13%</td>
<td>11%-14%</td>
<td>0.88</td>
<td>1.5E-24</td>
<td>30%</td>
<td>28%-33%</td>
<td>0.93</td>
<td>1.8E-30</td>
</tr>
<tr>
<td>Playgrounds</td>
<td>33</td>
<td>19%</td>
<td>16%-22%</td>
<td>0.84</td>
<td>2.7E-14</td>
<td>15%</td>
<td>12%-17%</td>
<td>0.86</td>
<td>2.2E-15</td>
<td>33%</td>
<td>29%-38%</td>
<td>0.88</td>
<td>2.0E-16</td>
</tr>
<tr>
<td>Sport Fields</td>
<td>11</td>
<td>15%</td>
<td>11%-19%</td>
<td>0.88</td>
<td>5.9E-06</td>
<td>9%</td>
<td>6%-13%</td>
<td>0.81</td>
<td>6.0E-05</td>
<td>24%</td>
<td>19%-30%</td>
<td>0.90</td>
<td>3.1E-06</td>
</tr>
<tr>
<td>Restrooms</td>
<td>7</td>
<td>19%</td>
<td>17%-22%</td>
<td>0.99</td>
<td>9.5E-07</td>
<td>14%</td>
<td>12%-17%</td>
<td>0.96</td>
<td>2.1E-05</td>
<td>34%</td>
<td>31%-37%</td>
<td>0.99</td>
<td>9.7E-08</td>
</tr>
<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>41</td>
<td>16%</td>
<td>13%-19%</td>
<td>0.75</td>
<td>9.3E-14</td>
<td>21%</td>
<td>18%-23%</td>
<td>0.89</td>
<td>1.1E-20</td>
<td>36%</td>
<td>32%-41%</td>
<td>0.88</td>
<td>6.1E-20</td>
</tr>
<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>41</td>
<td>16%</td>
<td>13%-19%</td>
<td>0.75</td>
<td>9.3E-14</td>
<td>21%</td>
<td>18%-23%</td>
<td>0.89</td>
<td>1.1E-20</td>
<td>36%</td>
<td>32%-41%</td>
<td>0.88</td>
<td>6.1E-20</td>
</tr>
</tbody>
</table>

Notes:
- TCC = Total Construction Cost; CI = Confidence Interval. The project delivery percentages indicated are the ranges corresponding to the 95 percent confidence intervals on the mean slope of the linear regression trendline. Caution and review of the report text are urged in using this information. Refer to Appendix B for the corresponding regression curves, R² values, and N values for more details.
- 1. Total excludes projects delivered by alternative delivery mechanisms such as design-build, JOC, and CM@Risk. Projects delivered by alternative techniques are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the Study.
Table B-2
Summary of Performance Models (80th Percentile Subset of TCC)

<table>
<thead>
<tr>
<th>Project Type or Classification</th>
<th>Number of Projects</th>
<th>Design Cost (%) of TCC</th>
<th>95% CI (%) of TCC</th>
<th>R²</th>
<th>p-value</th>
<th>Construction Management Cost (%) of TCC</th>
<th>95% CI (%) of TCC</th>
<th>R²</th>
<th>p-value</th>
<th>Project Delivery Cost (%) of TCC</th>
<th>95% CI (%) of TCC</th>
<th>R²</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Facilities</td>
<td>36</td>
<td>18%</td>
<td>15%-22%</td>
<td>0.81</td>
<td>5.3E-14</td>
<td>20%</td>
<td>15%-24%</td>
<td>0.73</td>
<td>2.4E-11</td>
<td>38%</td>
<td>32%-44%</td>
<td>0.81</td>
<td>2.5E-14</td>
</tr>
<tr>
<td>Libraries</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Police/Fire Stations</td>
<td>9</td>
<td>13%</td>
<td>12%-15%</td>
<td>0.98</td>
<td>4.4E-08</td>
<td>18%</td>
<td>14%-21%</td>
<td>0.94</td>
<td>4.7E-06</td>
<td>31%</td>
<td>28%-34%</td>
<td>0.98</td>
<td>1.6E-08</td>
</tr>
<tr>
<td>Comm./Rec. Center/Child Care/Gyms</td>
<td>8</td>
<td>23%</td>
<td>16%-31%</td>
<td>0.88</td>
<td>1.8E-04</td>
<td>33%</td>
<td>19%-46%</td>
<td>0.83</td>
<td>6.4E-04</td>
<td>56%</td>
<td>37%-75%</td>
<td>0.87</td>
<td>2.2E-04</td>
</tr>
<tr>
<td>Other Municipal</td>
<td>18</td>
<td>21%</td>
<td>13%-28%</td>
<td>0.67</td>
<td>1.7E-05</td>
<td>16%</td>
<td>10%-23%</td>
<td>0.65</td>
<td>3.2E-05</td>
<td>37%</td>
<td>24%-50%</td>
<td>0.68</td>
<td>1.3E-05</td>
</tr>
<tr>
<td>Streets</td>
<td>143</td>
<td>22%</td>
<td>19%-24%</td>
<td>0.66</td>
<td>1.1E-03</td>
<td>20%</td>
<td>18%-22%</td>
<td>0.70</td>
<td>8.2E-09</td>
<td>41%</td>
<td>37%-45%</td>
<td>0.75</td>
<td>6.5E-45</td>
</tr>
<tr>
<td>Widening/New/Grade Separations</td>
<td>7</td>
<td>29%</td>
<td>22%-37%</td>
<td>0.94</td>
<td>6.2E-05</td>
<td>30%</td>
<td>19%-40%</td>
<td>0.88</td>
<td>5.1E-04</td>
<td>59%</td>
<td>45%-73%</td>
<td>0.94</td>
<td>5.6E-05</td>
</tr>
<tr>
<td>Bridges</td>
<td>11</td>
<td>27%</td>
<td>19%-35%</td>
<td>0.84</td>
<td>2.4E-05</td>
<td>23%</td>
<td>14%-31%</td>
<td>0.78</td>
<td>1.3E-04</td>
<td>50%</td>
<td>35%-64%</td>
<td>0.85</td>
<td>1.9E-05</td>
</tr>
<tr>
<td>Reconstructions</td>
<td>51</td>
<td>17%</td>
<td>14%-20%</td>
<td>0.68</td>
<td>7.4E-14</td>
<td>14%</td>
<td>12%-16%</td>
<td>0.79</td>
<td>1.7E-18</td>
<td>31%</td>
<td>27%-36%</td>
<td>0.79</td>
<td>1.1E-18</td>
</tr>
<tr>
<td>Bike/Pedestrian/Streetscapes</td>
<td>45</td>
<td>36%</td>
<td>30%-43%</td>
<td>0.73</td>
<td>3.7E-14</td>
<td>23%</td>
<td>20%-26%</td>
<td>0.83</td>
<td>2.2E-18</td>
<td>59%</td>
<td>52%-67%</td>
<td>0.85</td>
<td>1.0E-19</td>
</tr>
<tr>
<td>Signals</td>
<td>25</td>
<td>30%</td>
<td>22%-38%</td>
<td>0.70</td>
<td>1.1E-07</td>
<td>20%</td>
<td>15%-25%</td>
<td>0.75</td>
<td>1.1E-08</td>
<td>50%</td>
<td>41%-59%</td>
<td>0.85</td>
<td>2.3E-11</td>
</tr>
<tr>
<td>Pipes</td>
<td>223</td>
<td>22%</td>
<td>20%-23%</td>
<td>0.76</td>
<td>1.4E-11</td>
<td>19%</td>
<td>18%-20%</td>
<td>0.80</td>
<td>6.3E-09</td>
<td>41%</td>
<td>38%-43%</td>
<td>0.84</td>
<td>1.2E-01</td>
</tr>
<tr>
<td>Gravity Mains</td>
<td>161</td>
<td>22%</td>
<td>20%-23%</td>
<td>0.81</td>
<td>1.1E-08</td>
<td>20%</td>
<td>19%-22%</td>
<td>0.82</td>
<td>2.2E-01</td>
<td>42%</td>
<td>39%-44%</td>
<td>0.86</td>
<td>1.2E-07</td>
</tr>
<tr>
<td>Pressure Systems</td>
<td>39</td>
<td>20%</td>
<td>15%-25%</td>
<td>0.63</td>
<td>9.5E-10</td>
<td>16%</td>
<td>13%-19%</td>
<td>0.77</td>
<td>1.5E-13</td>
<td>36%</td>
<td>30%-43%</td>
<td>0.77</td>
<td>1.5E-13</td>
</tr>
<tr>
<td>Pump Stations</td>
<td>15</td>
<td>20%</td>
<td>17%-23%</td>
<td>0.94</td>
<td>3.5E-10</td>
<td>16%</td>
<td>12%-21%</td>
<td>0.81</td>
<td>2.1E-06</td>
<td>36%</td>
<td>30%-43%</td>
<td>0.92</td>
<td>6.8E-09</td>
</tr>
<tr>
<td>Other Pipes</td>
<td>7</td>
<td>21%</td>
<td>8%-34%</td>
<td>0.73</td>
<td>6.5E-03</td>
<td>22%</td>
<td>4%-41%</td>
<td>0.59</td>
<td>2.6E-02</td>
<td>43%</td>
<td>25%-62%</td>
<td>0.84</td>
<td>1.3E-03</td>
</tr>
<tr>
<td>Parks</td>
<td>40</td>
<td>24%</td>
<td>19%-28%</td>
<td>0.77</td>
<td>6.5E-14</td>
<td>17%</td>
<td>14%-19%</td>
<td>0.81</td>
<td>8.7E-16</td>
<td>41%</td>
<td>35%-46%</td>
<td>0.83</td>
<td>1.1E-06</td>
</tr>
<tr>
<td>Playgrounds</td>
<td>26</td>
<td>23%</td>
<td>19%-28%</td>
<td>0.83</td>
<td>3.4E-11</td>
<td>21%</td>
<td>18%-24%</td>
<td>0.88</td>
<td>6.8E-13</td>
<td>44%</td>
<td>38%-50%</td>
<td>0.90</td>
<td>4.9E-14</td>
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<td>Sport Fields</td>
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<td>0.61</td>
<td>1.3E-02</td>
<td>11%</td>
<td>6%-15%</td>
<td>0.82</td>
<td>7.4E-04</td>
<td>30%</td>
<td>14%-47%</td>
<td>0.73</td>
<td>3.5E-03</td>
</tr>
<tr>
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<td>5</td>
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<td>19%-36%</td>
<td>0.95</td>
<td>8.5E-04</td>
<td>18%</td>
<td>6%-30%</td>
<td>0.80</td>
<td>1.5E-02</td>
<td>45%</td>
<td>25%-66%</td>
<td>0.90</td>
<td>3.7E-03</td>
</tr>
<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>32</td>
<td>27%</td>
<td>21%-32%</td>
<td>0.76</td>
<td>3.1E-11</td>
<td>19%</td>
<td>16%-21%</td>
<td>0.85</td>
<td>2.6E-14</td>
<td>45%</td>
<td>38%-52%</td>
<td>0.84</td>
<td>7.2E-14</td>
</tr>
<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>32</td>
<td>27%</td>
<td>21%-32%</td>
<td>0.76</td>
<td>3.1E-11</td>
<td>19%</td>
<td>16%-21%</td>
<td>0.85</td>
<td>2.6E-14</td>
<td>45%</td>
<td>38%-52%</td>
<td>0.84</td>
<td>7.2E-14</td>
</tr>
</tbody>
</table>

Notes:

TCC = Total Construction Cost; CI = Confidence Interval. The project delivery percentages indicated are the ranges corresponding to the 95 percent confidence intervals on the mean slope of the linear regression trendline. Caution and review of the report text are urged in using this information. Refer to Appendix B for the corresponding regression curves, R² values, and N values for more details.

1. Total excludes projects delivered by alternative delivery mechanisms such as design-build, JOC, and CM@Risk. Projects delivered by alternative techniques are retained in the database but not analyzed. These projects are not included in the projects selected for analysis in the Study.

2. Municipal Facilities – Libraries has too few projects to calculate statistics.
Table B-3  
Summary of Regression Equations

<table>
<thead>
<tr>
<th>Project Type or Classification</th>
<th>Design Cost (x) vs. TCC Full Range of TCC</th>
<th>Design Cost (x) vs. TCC Smaller Project Subset of TCC</th>
<th>CM Cost (x) vs. TCC Full Range of TCC</th>
<th>CM Cost (x) vs. TCC Smaller Project Subset of TCC</th>
<th>Project Delivery Cost (x) vs. TCC Full Range of TCC</th>
<th>Project Delivery Cost (x) vs. TCC Smaller Project Subset of TCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal Facilities</td>
<td>0.1954x</td>
<td>0.1849x</td>
<td>0.1127x</td>
<td>0.1964x</td>
<td>0.3081x</td>
<td>0.3813x</td>
</tr>
<tr>
<td>Libraries¹</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
</tr>
<tr>
<td>Police/Fire Stations</td>
<td>0.2532x</td>
<td>0.1317x</td>
<td>0.1112x</td>
<td>0.1768x</td>
<td>0.3644x</td>
<td>0.3084x</td>
</tr>
<tr>
<td>Comm./Rec. Center/Child Care/Gyms</td>
<td>0.1800x</td>
<td>0.2343x</td>
<td>0.2420x</td>
<td>0.3267x</td>
<td>0.4220x</td>
<td>0.5609x</td>
</tr>
<tr>
<td>Other Municipal</td>
<td>0.1389x</td>
<td>0.2073x</td>
<td>0.1050x</td>
<td>0.1636x</td>
<td>0.2439x</td>
<td>0.3710x</td>
</tr>
<tr>
<td>Streets</td>
<td>0.1709x</td>
<td>0.2173x</td>
<td>0.1795x</td>
<td>0.1967x</td>
<td>0.3504x</td>
<td>0.4139x</td>
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<tr>
<td>Widening/New/Grade Separations</td>
<td>0.1338x</td>
<td>0.2930x</td>
<td>0.1681x</td>
<td>0.2995x</td>
<td>0.3019x</td>
<td>0.5885x</td>
</tr>
<tr>
<td>Bridges</td>
<td>0.1691x</td>
<td>0.2684x</td>
<td>0.2376x</td>
<td>0.2290x</td>
<td>0.4066x</td>
<td>0.4974x</td>
</tr>
<tr>
<td>Reconstructions</td>
<td>0.2425x</td>
<td>0.1692x</td>
<td>0.1070x</td>
<td>0.1418x</td>
<td>0.3495x</td>
<td>0.3110x</td>
</tr>
<tr>
<td>Bike/Pedestrian/Streetscapes</td>
<td>0.2586x</td>
<td>0.3644x</td>
<td>0.2026x</td>
<td>0.2267x</td>
<td>0.4612x</td>
<td>0.5911x</td>
</tr>
<tr>
<td>Signals</td>
<td>0.1550x</td>
<td>0.2983x</td>
<td>0.1900x</td>
<td>0.1992x</td>
<td>0.3450x</td>
<td>0.4974x</td>
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<tr>
<td>Pipes</td>
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<td>0.1631x</td>
<td>0.1904x</td>
<td>0.3255x</td>
<td>0.4065x</td>
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<tr>
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<td>0.1627x</td>
<td>0.2006x</td>
<td>0.3316x</td>
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<td>Pump Stations</td>
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<td>0.2013x</td>
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<td>0.1618x</td>
<td>0.4500x</td>
<td>0.3634x</td>
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<tr>
<td>Other Pipes</td>
<td>0.1433x</td>
<td>0.2309x</td>
<td>0.3058x</td>
<td>0.2234x</td>
<td>0.4491x</td>
<td>0.4347x</td>
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<tr>
<td>Parks</td>
<td>0.1772x</td>
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<td>0.1647x</td>
<td>0.3045x</td>
<td>0.4055x</td>
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<tr>
<td>Playgrounds</td>
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<td>0.1454x</td>
<td>0.2114x</td>
<td>0.3317x</td>
<td>0.4442x</td>
</tr>
<tr>
<td>Sportfields</td>
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<td>0.1921x</td>
<td>0.0946x</td>
<td>0.1087x</td>
<td>0.2442x</td>
<td>0.3008x</td>
</tr>
<tr>
<td>Restrooms¹</td>
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<td>0.2743x</td>
<td>0.1446x</td>
<td>0.1764x</td>
<td>0.3384x</td>
<td>0.4507x</td>
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<tr>
<td>Water/Wastewater Treatment Plants</td>
<td>0.1567x</td>
<td>0.2356x</td>
<td>0.2073x</td>
<td>0.1858x</td>
<td>0.3639x</td>
<td>0.4515x</td>
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<tr>
<td>Water/Wastewater Treatment Plants</td>
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<td>0.2657x</td>
<td>0.2073x</td>
<td>0.1858x</td>
<td>0.3639x</td>
<td>0.4515x</td>
</tr>
</tbody>
</table>

Note:  
TCC = Total Construction Cost; CM = Construction Management.  
1. Municipal Facilities – Libraries has too few projects to calculate statistics for smaller project subset.
CURVES GROUP 1

Design Cost vs Total Construction Cost
### All Projects
**Municipal Facilities - Police/Fire Stations**  
Design vs Total Construction Cost (N=12)

\[ y = 0.2532x \]

**R² = 0.91**

### 80th Percentile Projects
**Municipal Facilities - Police/Fire Stations**  
Design vs Total Construction Cost (N=9)

\[ y = 0.1317x \]

**R² = 0.98**
All Projects
Municipal Facilities - Other
Design vs Total Construction Cost (N=23)

R² = 0.93

y = 0.1389x

80th Percentile Projects
Municipal Facilities - Other
Design vs Total Construction Cost (N=18)

R² = 0.67

y = 0.2073x
Appendix B
Performance Curves

All Projects
Pipes - Other
Design vs Total Construction Cost (N=9)

\[ y = 0.1433x \]
\[ R^2 = 0.76 \]

80th Percentile Projects
Pipes - Other
Design vs Total Construction Cost (N=7)

\[ y = 0.2113x \]
\[ R^2 = 0.73 \]
80th Percentile Projects
Parks - All Classifications
Design vs Total Construction Cost (N=40)

All Projects
Parks - All Classifications
Design vs Total Construction Cost (N=51)
All Projects
Parks - Sportfields
Design vs Total Construction Cost (N=11)

\[ y = 0.1496x \]

R² = 0.88

80th Percentile Projects
Parks - Sportfields
Design vs Total Construction Cost (N=8)

\[ y = 0.1921x \]

R² = 0.61
CURVES GROUP 2

Construction Management Cost vs Total Construction Cost
Appendix B
Performance Curves

80th Percentile Projects: Municipal Facilities - Comm./Rec. Center/Child Care/Gyms

Construction Management vs Total Construction Cost (N=8)

Total Construction Cost ($M) vs Construction Management ($MM)

y = 0.3267x
R² = 0.83

All Projects: Municipal Facilities - Comm./Rec. Center/Child Care/Gyms

Construction Management vs Total Construction Cost (N=11)

Total Construction Cost ($M) vs Construction Management ($MM)

y = 0.242x
R² = 0.89
All Projects
Streets - Bike/Pedestrian/Streetscapes
Construction Management vs Total Construction Cost (N=57)

80th Percentile Projects
Streets - Bike/Pedestrian/Streetscapes
Construction Management vs Total Construction Cost (N=45)

y = 0.2026x
y = 0.2267x

R² = 0.83
All Projects
Streets - Signals
Construction Management vs Total Construction Cost (N=32)

80th Percentile Projects
Streets - Signals
Construction Management vs Total Construction Cost (N=25)
All Projects
Pipes - All Classifications
Construction Management vs Total Construction Cost (N=279)

80th Percentile Projects
Pipes - All Classifications
Construction Management vs Total Construction Cost (N=223)
All Projects
Pipes - Gravity Mains
Construction Management vs Total Construction Cost (N=202)

80th Percentile Projects
Pipes - Gravity Mains
Construction Management vs Total Construction Cost (N=161)
[Graph 1: All Projects
Parks - All Classifications
Construction Management vs Total Construction Cost (N=51)

Construction Management ($MM) vs Total Construction Cost ($MM)

y = 0.1273x, R² = 0.88]

[Graph 2: 80th Percentile Projects
Parks - All Classifications
Construction Management vs Total Construction Cost (N=40)

Construction Management ($MM) vs Total Construction Cost ($MM)

y = 0.1687x, R² = 0.81]
CURVES GROUP 3

Project Delivery Cost vs Total Construction Cost
Appendix B
Performance Curves

All Projects
Streets - All Classifications
Project Delivery vs Total Construction Cost
(N=179)

80th Percentile Projects
Streets - All Classifications
Project Delivery vs Total Construction Cost
(N=143)

\[ y = 0.3504x \]

\[ y = 0.4139x \]

R\(^2\) = 0.91

R\(^2\) = 0.75
All Projects
Streets - Widening/New/Grade Separations
Project Delivery vs Total Construction Cost
(N=10)

80th Percentile Projects
Streets - Widening/New/Grade Separations
Project Delivery vs Total Construction Cost
(N=7)

y = 0.3019x
R² = 0.99

y = 0.5885x
R² = 0.94
Appendix B
Performance Curves

80th Percentile Projects
Pipes - Other (N=77)

[Graph showing Project Delivery vs Total Construction Cost]

All Projects
Pipes - Other (N=8)

[Graph showing Project Delivery vs Total Construction Cost]

Equation: $y = 0.347x$
$R^2 = 0.84$

Equation: $y = 0.446x$
$R^2 = 0.9$
Appendix B
Performance Curves

All Projects
Parks - Playgrounds
Project Delivery vs Total Construction Cost
(N=33)

\[ y = 0.3317x \]

80th Percentile Projects
Parks - Playgrounds
Project Delivery vs Total Construction Cost
(N=26)

\[ y = 0.4442x \]

\[ R^2 = 0.88 \]

\[ R^2 = 0.9 \]
APPENDIX C
INDIRECT RATES
Table C-1
Indirect Rates Applied to Capital Projects

<table>
<thead>
<tr>
<th>Agency</th>
<th>Fringe Benefits</th>
<th>Compensated Time Off</th>
<th>City Overhead</th>
<th>Department Overhead</th>
<th>Agency Overhead</th>
<th>Indirect Rate Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Long Beach Department of Public Works</td>
<td>52.87%</td>
<td>19.03%</td>
<td>0.99%</td>
<td>0.65%</td>
<td>0%</td>
<td>73.54%</td>
</tr>
<tr>
<td>City of Los Angeles (2) Department of Public Works and Bureau of Engineering</td>
<td>46.34%</td>
<td>20.35%</td>
<td>15.42%</td>
<td>14.75%</td>
<td>0%</td>
<td>96.86%</td>
</tr>
<tr>
<td>City of Oakland (4) Department of Engineering &amp; Construction</td>
<td>71.85%</td>
<td>22.90%</td>
<td>20.22%</td>
<td>29.00%</td>
<td>18.90%</td>
<td>162.87%</td>
</tr>
<tr>
<td>City of Sacramento Department of Public Works (FY16 Budgeted)</td>
<td>41.07%</td>
<td>15.03%</td>
<td>21.71%</td>
<td>11.06%</td>
<td>92.45%</td>
<td>181.32%</td>
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<tr>
<td>Department of Utilities (5)</td>
<td>29.26%</td>
<td>18.70%</td>
<td>14.65%</td>
<td>61.16%</td>
<td>42.74%</td>
<td>164.22%</td>
</tr>
<tr>
<td>City of San Diego Engineering and Capital Projects</td>
<td>67.54%</td>
<td>17.20%</td>
<td>0%</td>
<td>132.3%</td>
<td>77.5%</td>
<td>217.04%</td>
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<tr>
<td>City and County of San Francisco Department of Public Works Building Design and Construction Infrastructure Design and Construction</td>
<td>38.07%</td>
<td>24.63%</td>
<td>0%</td>
<td>58.12%</td>
<td>63.41%</td>
<td>184.22%</td>
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<tr>
<td>City of San José Department of Public Works (FY15-16)</td>
<td>75.43%</td>
<td>24.26%</td>
<td>41.13%</td>
<td>16.23%</td>
<td>Included</td>
<td>204.30%</td>
</tr>
</tbody>
</table>

Notes:
1. This value may be different from the sum of overhead values since the compounding formula may vary by agency.
2. Based on averages of all Bureau program overhead rates provided under CAP 37.
3. All costs are captured independently of funding source.
4. The City of Oakland has taken a temporary break from the Study and therefore, indirect rates for the agency have not been updated since Update 2016.
5. Component rates for the City of Sacramento’s Department of Utilities are from 2017.