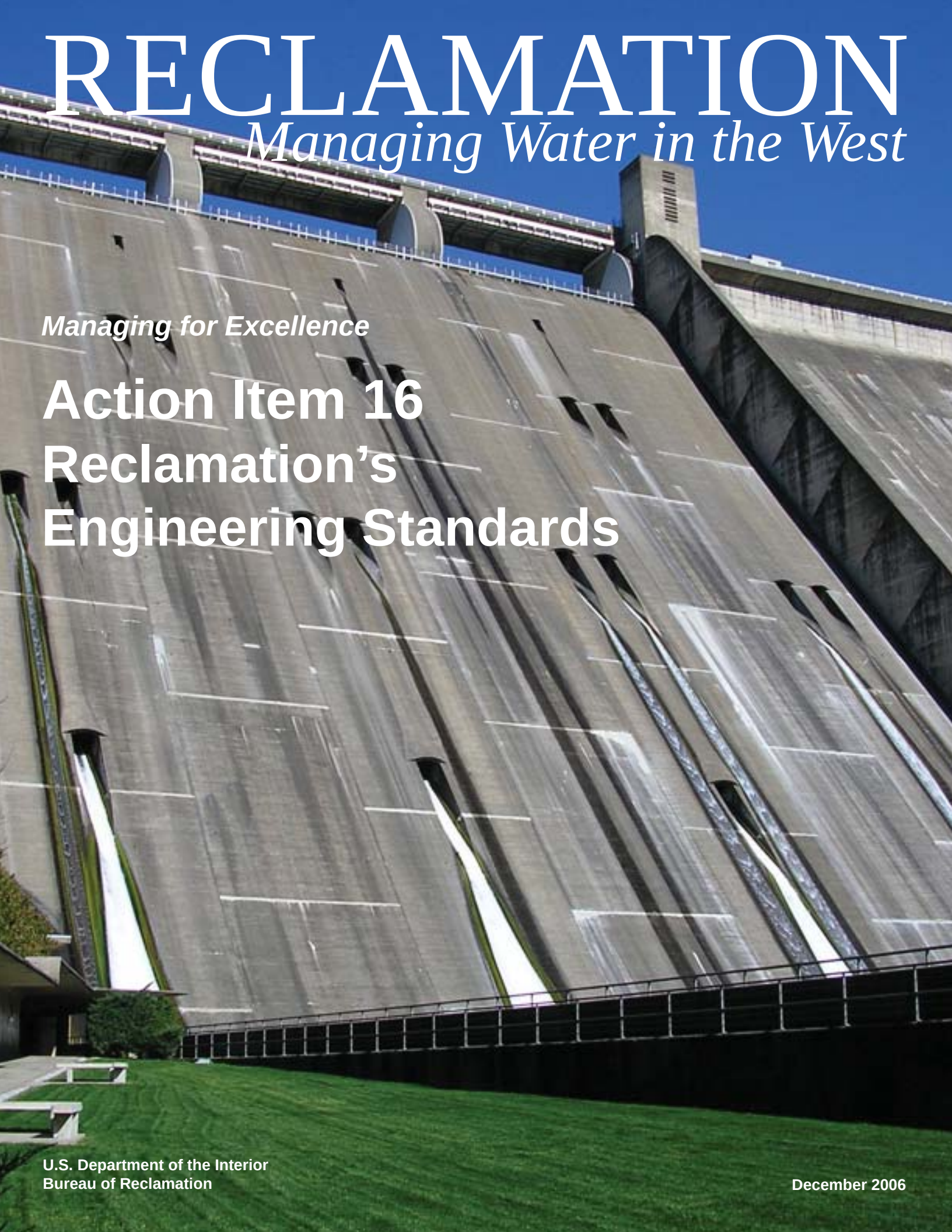
RECLAMATION

Managing Water in the West



Managing for Excellence

Action Item 16 Reclamation's Engineering Standards

U.S. Department of the Interior
Bureau of Reclamation

December 2006

RECLAMATION

Managing Water in the West

Managing for Excellence: Action Item 16

"Analyze Reclamation's engineering standards; both the appropriateness of them and how they are applied internally and externally."

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Executive Summary

In response to the National Academy of Sciences' National Research Council 2006 report entitled, *Managing Construction and Infrastructure in the 21st Century Bureau of Reclamation*, the Bureau of Reclamation (Reclamation) produced its *Managing for Excellence Action Plan*, which includes Action Item 16: "Analyze Reclamation's engineering standards; both the appropriateness of them and how they are applied internally and externally." This report addresses Action Item 16.

The report was prepared by a team of eight Reclamation employees familiar with Reclamation's design and construction activities and representing a cross-section of Reclamation's organization. Data were gathered via interviews and written responses to questionnaires. The audience for data collection was Reclamation staff, other agencies, private engineering firms, and Reclamation Water Districts, as well as input from public meetings. The team evaluated Reclamation's engineering standards in four areas: design data collection, closeout process, design process, and design standards.

The team concluded that Reclamation's process to collect design data and to capture "lessons learned" via a closeout process are similar to those employed by others in the industry, but there is room for improvement across Reclamation in both areas.

Reclamation's design processes are also similar to processes used by others in the industry. While Reclamation's cost to produce designs are perceived to be higher than others, the limited data that has been collected on selective Reclamation and architect and engineering firm projects indicate the gap between the two approaches narrows when all costs are considered. Most stakeholders believe Reclamation's design are more complete and provide for lower operation and maintenance costs.

In light of their obligation to pay for and/or operate and maintain many of the features designed and constructed by Reclamation, most stakeholders want to have more input to decisions made during the design process (including, but not limited to, applicable design standards and service life requirements). The team concluded that Reclamation's current design processes need to be augmented to ensure this input is captured and integrated in a timely manner, and that its design processes be reviewed to evaluate the potential to reduce costs.

While no one questioned the need for Reclamation to apply its internal design standards to high hazard[1] features like dams, many would like Reclamation to adopt what they view as less conservative national standards for low hazard features. Reclamation has long recognized the value of national standards as evidenced by the active participation and leadership by Reclamation technical staff in their development. Reclamation has steadily moved toward the integration of (or replacement by) available national standards in nearly all of its design activities and internal design standards. However, like most of the agencies surveyed for this report, Reclamation has also developed internal design standards that it employs as a means to capture the agency's corporate experience in applying engineering judgment and relevant national standards to the design of individual project features. The team concluded Reclamation has a legitimate need for internal standards, but acknowledges the standards must be better maintained and must accommodate the application of sound engineering judgment to individual designs.

[1] When used in this report, the terms "high hazard" and "high risk" relate to work on facilities that could potentially effect public safety and or have high economic consequences in the event of a failure. The team is not attempting to define or restrict the definition of high hazard and/or high risk facilities.

1.0 Introduction

In 2004, the Bureau of Reclamation asked the National Academy of Sciences' National Research Council (NRC) to review Reclamation's organization, business practices, culture, and capabilities for managing construction and infrastructure in the 21st century. As a result, in early 2006 the NRC published *Managing Construction and Infrastructure in the 21st Century Bureau of Reclamation* (NAS Report). The NAS Report recognizes the need for policies, directive and standards and their importance in ensuring that our infrastructure remains strong and healthy. The report states:

> "If Reclamation wants to demonstrate consistency throughout the organization under its style of decentralized management, it will need clear, detailed policy directives and standards to enable all elements to implement a uniform, structured approach. A delicate balance needs to be maintained so as not to impede decentralized units from demonstrating initiative and increasing their capabilities. At the same time, the committee emphasizes that the bureau as the Owner has the responsibility to ensure that its facilities are planned, designed, constructed, and managed with a level of quality that is consistent throughout the organization."[2]

Reclamation's *Managing for Excellence Action Plan* provides a process and time frame to Reclamation teams tasked with pursuing action items resulting from the NAS recommendations. Engineering and Design Services is one of the functional areas identified. A component of this functional area involves engineering design services and states, "Action Item 16: Analyze Reclamation's engineering standards, both the appropriateness of them and how they are applied internal and externally." The Engineering and Standards Team (Team) was tasked with addressing Action Item 16, and this report presents their results.

[2] pp. 4-5, Executive Summary, *Managing Construction and Infrastructure in the 21st Century Bureau of Reclamation*, Committee on Organizing to Manage Construction and Infrastructure in the 21st Century Bureau of Reclamation, Board on Infrastructure and the Constructed Environment, Division of Engineering and Physical Sciences, National Research Council of the National Academies of Science.

2.0 Background

Until 1994, Reclamation had well-defined engineering standards in the form of its Reclamation Instructions, design standards, design manuals, technical memoranda and other documents. In 1994, a major reorganization took place that included the sunsetting of all policies and standards contained in the Reclamation Instructions. The reorganization also resulted in consolidation of the Assistant Commissioner Engineering and Research and the Assistant Commissioner Resource Management organizations into a Technical Service Center and a decentralization of decision-making. The Technical Service Center was left with no technical policies or standards to operate under or authority to create new policies and instructed to operate as an independent, fully reimbursable, fee-for-service organization. The new TSC continued to rely on the sunset Reclamation Instructions and previously produced guidance for design services.

Reclamation staff in the Technical Service Center and, to a lesser degree, in the regional, area, and field offices, thereafter used the sunset Reclamation Instructions as guidelines in providing engineering services and even developed a few draft guidelines for assistance between 1994 and 2000. In 2000, a Reclamation Manual Policy, FAC-P03, "Performing Design and Construction Activities," was issued and conveyed the authority to develop and implement engineering policies to the Director of the Technical Service Center. Few engineering Directives and Standards have been issued since this policy was issued, so many staff members continue to use the old Reclamation Instructions and the draft guidelines that have since been developed.

3.0 Definition of the Action Item 16 Task

The Engineering Standards Team approached Action Item 16 from the perspective that all engineering standards have a direct link to design activities, and that Reclamation's engineering standards are, in fact, regarded as design standards. The Team divided the process of providing good engineering products into four key elements:

- Design Data Collection
- Design Standards
- Design Process
- Close-out Process

These four elements were the focus of the data collection necessary to determine past and current Reclamation, private and other public sector practices and to identify best practices and make recommendations to Reclamation management.

3.1 Report Framework

The Engineering Standards Team developed its findings and recommendations in the following five phases:

Phase I – Identify and review Reclamation use of internal and external engineering standards with focus on matching standards to risk.

Phase II – Collect and review internal policies and reports related to engineering standards and their application within Reclamation.

Phase III – Review engineering standards, risk, guidelines, and liabilities related to work performed by external entities for their customers
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Phase IV – Meet with external entities to assess their design practices.

Phase V – Using the information developed from Phases I through IV make recommendations on the engineering practices Reclamation should employ in the future.

3.2 Engineering Standards Team

The Engineering Standards Team included the following Reclamation employees:

- Bruce Barrett, Area Manager, Provo Area Office, Provo, UT
- Bill Bruninga, Deputy Area Manager, Hoover Dam Facility Manager, Boulder City, NV
- Larry Hieb, Operations and Maintenance/Technical Services Manager, Snake River Area Office-East, Burley, ID
- Jerry Kelso (Team Lead), Area Manager, Upper Columbia Area Office, Yakima, WA
- Lowell Pimley, Chief of the Civil Engineering Services Division, Technical Service Center, Denver, CO
- Roberta Ries, Management Analyst, Upper Columbia Area Office, Yakima, WA
- Larry Schoessler, Supervisor, Construction Services Group, Regional Office, Billings, MT
- Jim Zeiger, Manager, Electrical Design Group, Infrastructure Services Division, Technical Service Center, Denver, CO

4.0 Engineering Standards Background

4.1 Engineering Standards Terms, Concepts, and Definitions as Used in this Report

The term “Reclamation engineering standards” as used in this report includes all the internally developed design manuals, design standards, engineering monographs, technical memoranda, and commonly accepted practices applied within Reclamation for engineering purposes, particularly engineering design. These standards are located on Reclamation’s Intranet at http://intra.usbr.gov/~tcg/techdocs/.

The most commonly used engineering standards in the United States are referred to as national standards or industry standards. This report refers to these standards as national standards. These national standards include engineering codes and standards published by national and international standards organizations, such as the American Water Works Association (AWWA), American Institute of Steel Construction (AISC), American Concrete Institute (ACI), International Building Code (IBC), American Society for Testing Materials (ASTM), National Association of Corrosion Engineers (NACE), Institute of Electrical and Electronics Engineers (IEEE), and others. While some of these national standards provide guidance on accepted design procedures for various project features, many focus on standardized testing procedures, requirements for materials composition, and design aids for certain project components. Proper application of these standards requires a significant amount of engineering judgment either on a case-by-case basis or via the development and use of organizational guidance.

In recognition of these considerations, some public and private entities promulgate and follow their own specialized engineering standards. An entity generally does so when, based on its own specialized experiences, it has determined that national standards are either inadequate, inappropriate, or do not exist for aspects of the engineering work performed by the entity. Internal standards are also developed by Owners (including Reclamation) to provide guidance on how to integrate national standards and codes into a comprehensive project feature design.

An example of a design practice, considered by many to be a Reclamation design standard, involves the use of casing pipe around carrier pipe through embankments. Users and beneficiaries of Reclamation designs sometimes question the need to use both a casing pipe/structure and a carrier pipe (installed within the casing pipe/structure) when installing a pipe through an embankment (instead of simply installing the carrier pipe directly within the embankment material). Over the years, Reclamation has found that circular conduits installed

within a water retaining embankment can create preferential seepage paths through the embankment.

More recently, the Federal Emergency Management Administration (FEMA) National Dam Safety Program sponsored the development of the publication "FEMA 484 – Conduits through Embankment Dams" in 2005. The document endorses the use of a rigid casing structure when penetrating an embankment dam. The document was developed in consultation with Reclamation, the Association of State Dam Safety Officials, the Federal Energy Regulatory Commission, the Natural Resources Conservation Service, and the United States Army Corps of Engineers.

Numerous other Federal and non-Federal entities that require the use of casing pipes include, but are not limited to, the Federal Highway Administration (interstate crossings), California Department of Water Resources (levee crossings), and most railroads.

Thus, while Reclamation is always willing to discuss its designs with stakeholders, when performance and safety is involved, the agency must fulfill its obligation to ensure public safety. Reclamation will consider requests to evaluate lesser cost alternatives in its design decision making, however it will weigh such requests carefully along with its responsibility to protect the public from a potential dam failure.

4.2 Evolution of Engineering Standards in Reclamation

Early in Reclamation's history, external standards did not exist or adequately address much of the engineering work performed by Reclamation. For example, there were no standards to address dam or canal design. Reclamation developed the needed engineering standards and improved upon them over the many decades of its large construction activities. Over time, many of Reclamation's engineering standards were adopted for use in national standards and by public and private entities in their specialized standards.

Prior to 1994, Reclamation maintained and followed internal policies and practices that were published and maintained in a set of documents entitled "Reclamation Instructions." Part 131 of these Reclamation Instructions pertained to engineering standards and stated, "…The Assistant Commissioner, Engineering and Research (ACER), is responsible for establishing design criteria and engineering and technical standards for all design work… ." The Assistant Commissioner, Engineering and Research organization and its predecessors developed a comprehensive set of engineering standards, including design manuals, engineering monographs, technical memoranda, and design standards to reflect Reclamation's design philosophy.

After operating for several years without formal engineering policies and standards (1994-2000), the Reclamation Instructions were partly replaced by new policy as the "Reclamation Manual." Reclamation began issuing new policy and practices related to its engineering through the Reclamation Manual in 2000.

Reclamation Manual Policy FAC P03 (dated 2/11/00) and Directives and Standards FAC 03-03 (dated 7/9/04) apply to all Reclamation design activities that require the application of engineering principles and practices. These directives and standards provide that design activities must be performed in accordance with established Reclamation design criteria; Reclamation engineering, architectural, or technical standards; and approved national design standards. They state that to allow consistent application of applicable Reclamation and industry standards, the Director of Reclamation's Technical Services Center is responsible for establishing and maintaining or identifying design criteria and engineering and technical standards for all Reclamation design work.

The Director of Reclamation's Technical Service Center has provided limited guidance to Reclamation regarding engineering standards since the above noted Reclamation Manual documents were published. Except for dam safety related standards, the engineering standards that were developed prior to 1994 have not been comprehensively updated or maintained since 1994, with the majority not updated for many years prior to 1994. Additionally, there has been no guidance issued to Reclamation by the Director of the Technical Service Center on which national standards are appropriate for Reclamation's engineering work.

Reclamation's pre-1994 engineering standards and the few guidelines drafted since 1994 are posted on Reclamation's Intranet (on the Technical Service Center's Intranet website).

5.0 Reclamation's Current Use of Internal and External Engineering Standards

The Engineering Standards Team distributed questionnaires Reclamation-wide (Technical Service Center, regional, area, field and construction offices) to understand how Reclamation's internal design providers and Reclamation's internal design clients perceived the design process, how design is approached, and what standards are applied. This questionnaire is included in this report as Appendix A. The Team received 41 responses to the internal questionnaire from all components of the organization. The responses to the questionnaire are summarized in sections 5.1, 5.2, 5.3, and 5.4 by each of the four areas evaluated

by the Engineering Standards Team: design data collection, design standards, design process, and close-out.

5.1 Design Data Collection

Reclamation field offices generally collect design data for Reclamation projects following Reclamation's Draft Design Data Collection Guidelines, which were based on previously developed guidelines in the Reclamation Instructions Series 130 Part 133. These updated guidelines have been posted in draft form on the Technical Service Center's Intranet site since 2001. The Engineering Standards Team members noted some improvement in the completeness of design data packages provided to designers since the guidelines were posted. However, information collected for this report indicates that some Reclamation field offices do not know the guidelines exist, and therefore, have not used them when preparing for a construction project. It is also apparent from the information collected that there are inconsistent levels of design data collection experience and specialized expertise at field offices. This fact, combined with an inconsistent awareness of existing Reclamation guidelines are likely causing problems in timely preparation of complete design data packages.

5.2 Design Standards

Reclamation staff generally believes Reclamation's standards are more thorough and conservative than national standards and generally lead to higher quality, longer life end products.

The majority of Reclamation design groups use Reclamation's old standards supplemented by national standards to prepare designs. A minority of the design groups, primarily at area and a few field offices use only national standards.

When codes are used, most offices consider them to be national standards. The distinction between a national code and a design standard is important in that most of the internal and external organizations surveyed for this report seem to equate the two. There is an important difference, which is discussed later in this report.

Generally, Reclamation design groups prefer to use national standards, except for high hazard/high risk[3] facilities or where no applicable national standards exist. Reclamation staff believes Reclamation's standards should be used where high hazard/risk dictates application of robust design considerations.

[3] When used in this report, the terms "high hazard" and "high risk" relate to work on facilities that could potentially effect public safety and or have high economic consequences in the event of a failure. The team is not attempting to define or restrict the definition of high hazard and/or high risk facilities.

Reclamation's designers generally expect a reasonable degree of quality control during construction. If they understand there will be less construction quality control than a typical Reclamation project, they sometimes make adjustments to their designs to make them less susceptible to variations in contractor construction quality.

Reclamation designers sometimes adjust their designs and applications of design standards for economic factors, but not if safety would be compromised by the change. Deviations from design standards are generally documented. The design standards used by Reclamation do not generally set specific service life expectations, but the standards have evolved in a manner that provides a long service life.

Performance specifications are generally used on service contracts with mixed results. The engineering standards cited for performance specifications are generally the same ones used for prescriptive designs.

5.3 Design Process

Reclamation staff generally believes that Reclamation designs are better/more thorough, resulting in a better end product, but may cost more to produce than designs prepared by architect and engineering firms. Reclamation staff generally believes that construction costs may be higher for Reclamation produced designs, but that service life is generally longer and long-term operation and maintenance costs are lower. Reclamation staff would generally like to see national standards used whenever practical.

Reclamation's Final Design Process Guidelines are often used to help manage the design process. About half of the Reclamation offices that receive Reclamation design services are involved with the design process prior to final design; the remainder tends to become involved once final design begins. Agreement between Reclamation's design groups and the offices that receive design services on scope and content is usually sought early in the design process. The Engineering Standards Team noted that adequate communication during the design process generally is the goal, although it is not always achieved. Significant communications and partnerships are required throughout the design process to ensure the designers and clients work well together to develop a design that meets the project objectives.

Reclamation offices are generally directly involved in scheduling design work as fiscal year based budgets and available funding dictate. Adequate communications are generally recognized as a necessity for reaching consensus on the design schedule. Failure to reach consensus on a cost estimate or schedule can result in Reclamation client offices performing the work themselves or seeking services from architect and engineering firms.

Reclamation offices that receive design services from Reclamation's design groups are generally involved with design review during the design process and tend to focus more on technical reviews than reviews for life safety and economy. Reclamation offices generally determine the type and number of design reviews. The Final Design Process is typically used as a guide for making these determinations. Generally, there is Reclamation office buy-in to design cost estimates. Generally, the design engineering staff prepares task based estimates. Estimates are generally based on experience from previous jobs, historical costs, and percent of construction cost for comparison with industry standards.

Reclamation design providers typically determine the scope of proposed Reclamation design services and communicate with the Reclamation offices to reach a consensus. A majority of the offices consult with others outside the office when evaluating design cost estimates. If agreement cannot be reached, then reducing the scope, deferring the work, or using other design service providers are options. Most designs are completed at a cost within 20 percent of the original estimate.

In general, high hazard/risk facilities often are determined to justify higher design and construction costs, due to the higher level of consequences of potential failure. Generally, the Reclamation offices do not perceive differences in acceptable design, construction costs, and operations and maintenance costs between power and water facilities. However, design of power features may often be more robust than that for water facilities due to potentially high economic consequences related to an operational failure of power features.

5.4 Close-Out Process

Reclamation offices recognize the importance of a close-out and "lessons learned" process, but there is considerable room for improvement.

6.0 Engineering Standards and Practices Outside of Reclamation

6.1 Reclamation Water Users

The Engineering Standards Team solicited written comments from 14 Water User organizations (also referred to as Districts). Many of these Water User organizations were surveyed face-to-face or via telephone; the remainder submitted written comments to a prepared questionnaire.

The Water User questionnaire was designed in recognition of the relationship between Reclamation and Water User organizations. The Districts surveyed have contractual arrangements with Reclamation to operate and maintain project transferred works and are generally responsible for a portion of the costs for Reclamation operated and maintained multi-purpose project facilities. The questionnaire was specifically designed to assess Districts' practices and their experience or perception of Reclamation's practices in the areas of design standards, design process, and close-out process. A complete list of the organizations surveyed and the questionnaire used are provided in Appendix B. The responses to the questionnaire are summarized in sections 6.1.1, 6.1.2 and 6.1.3 by each of the three areas evaluated by the Engineering Standards Team: design standards, design process, and close-out.

6.1.1 Design Standards

The Water User organizations generally perceive Reclamation's design standards to be more conservative than national standards. However, the majority of the water user organizations stated that higher standards were necessary to reduce the risk of failure to critical structures and have resulted in long-lasting facilities and reasonable maintenance costs. A couple of the Districts believe that Reclamation's conservative approach may lead to a lack of innovation or creativity on projects that have limited longevity requirements. They believe that typically Reclamation provides long-life design despite the Districts' willingness to accept a project feature with a relatively short design life. The Districts feel this approach is more costly to them without added value.

The Districts generally believe the size and complexity of the project should govern the design standards and that Reclamation should select the appropriate standards for the facility being designed, which could involve the application of both Reclamation's internal standards as well as national standards. Reclamation's standards are generally perceived as pertinent to the types of facilities that have been constructed during the life of the agency.

Some of the Districts believe that national standards could be applied on smaller projects, such as diversions, canals, pipelines, etc. A few Districts suggested that Reclamation utilize only national standards, and one District suggested using performance specifications rather than prescriptive specifications whenever applicable.

When questioned about service life criteria, the Districts generally expect a durable facility with a lengthy service life. Districts consider service life when they obtain non-Reclamation designs for facilities they are responsible for in order to maximize durability and minimize follow-on operation and maintenance costs. A service life of 50-75 years for civil features, 30-40 years for electrical and mechanical components, and 15 years for electronic components are the general expectations.

Reclamation standards are applied by the Districts when appropriate, as are national standards, internal operation and maintenance experience, and the judgment of the District's designer when determining service life requirements.

The Districts consider both life safety and economic risks when designing components or facilities. While they are always aware of the economic impacts of a project, they generally do not make adjustments to a design for purely economic reasons. They prefer a good design that does not compromise life safety. If a design is adjusted for economic reasons, it is generally for a feature that can be repaired quickly and inexpensively if it fails, and does no pose a safety risk.

6.1.2 Design Process

The majority of the Water User organizations want to be involved, at their option, in all phases of the design process, from planning to operation and maintenance, depending on the complexity and requirements of the District (cost and operation and maintenance requirements). One District suggested that Reclamation conduct a workshop to explain the basics of irrigation system engineering design so that Districts would have a better understanding of what considerations are important. Several Districts have had very positive experiences with Reclamation design and management staff while participating in the design process and would like to see their involvement continue, if not expanded. Most believe they have the staff and technical resources to participate in the design process, but some may not have the financial resources to do so on every project. The type and complexity of work would influence the level of District involvement. Some Districts want to be fully involved in anything that Reclamation designs that may affect them, regardless of the complexity. Most Districts do not desire direct involvement in Federal compliance activities, structural design calculations, geotechnical investigations, dam design issues, or in facilities that are secondary to their operations and minimally affect their finances.

The Districts are generally satisfied with the design process and desire to be partners with Reclamation in that process. They want to be able to provide input early, understand the design concepts, status of design work, costs, and timeframe of the work. A few feel the design decision process (levels of decision making, e.g., regional, area, and field office) could be streamlined to develop a more effective way to coordinate with the Districts' operation and maintenance organizations. One District suggested allowing Districts to do the design and procurement for smaller jobs, and another suggested that Reclamation privatize its design process, allowing the private sector to design projects under the supervision of Reclamation. While there are many positive experiences in Districts' level of involvement, there is room for improvement.

The Districts perceive that Reclamation designs are generally comparable to designs prepared by architect and engineering firms. They believe Reclamation designs are more costly to prepare and perhaps more costly to construct than designs prepared by architect and engineering firms. The majority of the Districts

believe that Reclamation designed and constructed facilities are less expensive to operate and maintain over the long-run. Some of the Districts credit their involvement in the Reclamation's design process with producing a design that reflects the reasonable operations and maintenance costs. Most Districts believe that Reclamation's designs are more complete and minimize the margin of error.

6.1.3 Close-Out Process

Most of the Districts are not aware of, or have not been participants in, a close-out process, but some indicated an interest in participating with Reclamation in such a process. Although there is no formal process, many of the Districts are in favor of such a process. Several Districts noted that Reclamation is good at providing operation and maintenance manuals for their projects, which takes a collaborative effort among the District, Reclamation, and the construction contractor.

6.2 External Entities

The Engineering Standards Team collected information from representatives of private sector design service providers as well as other "owners/operators" of major civil works related to water and power. The external entity questionnaire was developed to solicit relevant information about the entities use of engineering standards in the areas of design data collection, design standards, design process, and close-out process.

Three architect and engineering firms and five Water/Power Utilities and Federal/State Agencies (Owners) were surveyed. A complete listing of the organizations surveyed and the questionnaire are provided in Appendix C.

6.2.1 Design Data Collection

The Owners generally develop internal guidelines to assist their design staff in identifying design data needs and work with their local offices or operation and maintenance forces to gather the needed information.

The architect and engineering firms generally are involved in work that tends to be more varied and, therefore, do not lend itself to standardization. Consequently, they tend to rely on the individual expertise of their designers to identify data needs on a case-by-case basis and then to work with client and local government entities to gather information. Field explorations are typically contracted out to local specialty contractors.

6.2.2 Design Standards

The architect and engineering firms generally use national standards and sometimes refer to Reclamation, the United States Army Corps of Engineers, and other public agency standards and then apply professional judgment to determine the proper application of the standards. The Owners tend to use a blend of national standards; other agency standards such as those of Reclamation, the

United States Army Corps of Engineers, and the Federal Energy Regulatory Commission; and internally created standards.

None of the organizations made specific adjustments to their design standards to reflect differing levels of construction inspection. The organizations generally consider service life and economic risks, such as operation and maintenance replacement life cycle costs, in developing standards or deciding on which design standards to apply to their projects. This practice is more prevalent in designs for electrical equipment. Most of the organizations made little to no distinction in their approach to design standards applied to power facilities versus water facilities. However, they did note that electrical and mechanical components of both types of facilities typically are assumed to have shorter service lives than the civil features of either power or water facilities. They also noted that minimizing operation and maintenance costs tend to be more of a consideration for power facility designs than for water related facilities.

All of the organizations indicated they would not lower standards if it would affect the risk to public safety. Some architect and engineering firms noted that they would go above minimum standards for high hazard facilities. One firm noted that it might use a less severe or shorter recurrence interval earthquake load for a low hazard dam.

The general consensus of the architect and engineering firms and Owners was that Reclamation design standards have been proven effective over the years and are compatible with the standards used elsewhere in the industry. Many of the organizations surveyed have either used Reclamation standards as a basis for their internal standards or as a starting point from which they apply their own professional judgment for proper application. Some of the architect and engineering firms noted that Reclamation standards tend to be more conservative than some national standards, while others voiced concern that Reclamation should do a better job of keeping its standards up to date. Two of the architect and engineering firms indicated that their recent experience illustrated Reclamation's flexibility in applying its standards to projects funded by others.

6.2.3 Design Process

The overall perception of Reclamation's design activities tended to fall into two camps. The architect and engineering firms believe that Reclamation's designs were more expensive to produce, while the Owners surveyed believe that Reclamation has retained a strong technical capability which the agency effectively applies to its design activities.

The architect and engineering firms uniformly believe Reclamation's costs are higher than their costs to complete similar designs. The firms' opinions on the reasons for this perceived difference ranged from a lack of competition between Reclamation's designers and others, to a design approach that was developed for very large projects but is now applied to smaller projects, to an acknowledgement that Reclamation seemed to do more analysis such as structural and hydraulic

modeling than an architect and engineering firm typically would. One architect and engineering firm believed Reclamation also took significantly longer to produce a design than an architect and engineering firm would. In contrast, the Owners either did not have an opinion on this issue or believe strongly that the true cost of contracting for design work, such as procurement of architect and engineering firm services, architect and engineering firm fees, needed Owner technical reviews, and subsequent architect and engineering firm re-work to address technical review comments are significantly higher than using the Owner's in-house design services.

The architect and engineering firms were less uniform in their assessment of the cost to construct a Reclamation-produced design compared the cost to construct a design produced by their firms. Some thought the cost would be similar, while another thought the construction costs would be higher for Reclamation designs, although this firm acknowledged the belief that the higher cost to construct Reclamation designs could be due to Federal procurement regulations requirements resulting in higher bids on Reclamation projects. One firm noted that Reclamation tends to provide more on-site construction management staff than an architect and engineering firm typically does, which could increase the total cost of the project.

Many of the Owners were not sure about the relative construction costs resulting from Reclamation versus architect and engineering firm designs. One agency believes that initial construction costs for Reclamation design projects may be higher than for a comparable architect and engineering firm designed project.

The architect and engineering firms said they assumed the cost to operate and maintain projects designed by Reclamation would be similar to those designed by their firms but acknowledged that they had little data to support that belief. While most of the Owners surveyed were not sure about the relative costs, one agency believes the operation and maintenance costs for Reclamation designs would likely be significantly lower than for an architect and engineering firm produced design.

The topic of client involvement in the design process was also discussed during the interviews. All of the organizations seek client involvement as early in the process as practicable and whenever possible throughout the development of the final designs. This involvement includes coming to an agreement on the design concept to be used on the project, usually between the 15 to 30-percent design stages. The process used to reach consensus varied slightly among the organizations with the Owners generally having a more formalized process. All entities emphasized the need for effective communications to ensure both the design provider and client came to a common understanding of the appropriate design concept. In rare cases, where this consensus could not be reached, most of the organizations agreed to yield to the wishes of the clients, unless the issue was related to safety.

All organizations also believe that client input to scheduling of designs is critical to the design process. All of the organizations work with their clients early in the design process to establish workable schedules. The architect and engineering firms typically set the schedule as part of the service contract they sign with their clients. Owners typically work with their internal clients to set priorities for various projects and then assign resources accordingly. Similar to the design concept discussions, effective and extensive communication with the client is used to develop a consensus on the design schedule.

The number and nature of design reviews conducted as part of the design process also were discussed during the interviews. Nearly all of the organizations conduct a minimum of three general reviews of the designs at the 30-, 60-, and 90-percent design stages. These reviews are conducted by internal technical staff, construction staff, and the client, when the client chooses to participate. While the scope of reviews performed at these stages varies among organizations, at some time during the design process, technical, life safety, and economic aspects of the project are reviewed by someone outside of the design team. The Owners tend to have more formalized economic reviews in place at various stages of the project planning and design development. The nature of technical reviews also varies among the organizations, but they tend to be well defined and diligently pursued in all organizations. Most of the organizations have processes in place to meet the intent of what Reclamation describes as a peer review, an independent review of the design for adherence to sound engineering practice and appropriate standards. Owners also tend to use very well defined processes for independent technical reviews. The reviews are generally conducted by in-house resources. Independent design verification reviews are generally conducted at the 10-, 50-, and 90-percent design stages, particularly when the design is performed by an outside entity. None of the organizations indicated that their processes to design water facilities differ from their processes to design power facilities.

The processes used to estimate the cost to complete designs were somewhat consistent among the organizations, while the processes to evaluate the reasonableness of those estimates varied. Most of the organizations base their estimated design costs on evaluation of the level of effort required for each task to be completed in developing the design. All of the organizations subject these estimates to some type of internal review. The architect and engineering firms generally look at American Society of Civil Engineering guidelines to gauge design costs as a percentage of construction costs, although one firm noted that these guidelines are often too low for embankment dam work. The Owners generally review their estimates against agency guidelines, which often set limits on the design costs as a percentage of construction costs (similar in concept to the American Society of Civil Engineering guidelines). But the agencies generally use a higher percentage–particularly for electrical and mechanical designs.

Most of the organizations believe that their initial cost estimates for completion of designs prove to be quite accurate, often within 5 to 15 percent. The architect and engineering firms did, however, note that while they try to accommodate some changes in the scope of their design work, they do track changes in scope and do so very closely with certain clients due to their history with the client. The firms request changes to their original cost estimate as needed to match the revised scope. Owners typically do not track scope changes as closely. But, in some cases, the project manager must discuss the cost escalation with a management review board if the design costs go over the initial estimate by more than 10 percent.

When reviewing cost estimates for designs performed by others, such as when an utility/agency contracts design work to an architect and engineering firm or when an architect and engineering firm sub-contracts work to another design entity, the processes used by the organizations to judge the reasonableness of the costs for these services vary. Most of the architect and engineering firms indicated they have in-house experts review the cost estimate and compare the proposed costs against similar jobs completed recently. The Owners surveyed use similar processes, although some develop specific estimates for the cost of doing the work in-house as a comparison. None of the respondents use the "percent of construction" metric to evaluate these estimates.

Client involvement in the review of cost estimates for design work is fairly consistent among the organizations. architect and engineering firms noted that some clients develop in-house estimates to complete the design work and then compare their estimate to the architect and engineering firm estimate. The process to reach consensus with the client on design fees varies among the organizations surveyed, with the architect and engineering firms typically pursuing a more aggressive approach to working with the client to gain a common understanding of the design needs by reviewing the estimate in detail.

6.2.4 Close-out Process

The organizations all recognize the benefit of a close-out and "lessons learned" process, but most of them struggle to implement a formal process on a consistent basis.

All of the architect and engineering firms had processes in place, with actual application ranging from rarely (usually on jobs that did not go well) to routinely (for large jobs only). Reasons cited for the inconsistent application of the process included budget pressures as well as resource conflicts such as a need to work on a new project as soon as the design work on one project is completed.

The Owners surveyed had a similarly wide range of applications of the process but, in general; tend to have more formalized close-out processes. In particular, the power utilities surveyed have very structured close-out processes in place. They have effective methodologies for capturing and disseminating "lessons

learned" to others in their organization, often via a "lessons learned" database accessible on the organization's Intranet system.

7.0 Key Findings

7.1 Design Data Collection

7.1.1 Data Collection Process

Reclamation has had design data collection guidelines in draft form since 2001; they are based on and intended to replace Reclamation Instruction Series 130 Part 133 (sunset 1994). These guidelines were developed by Reclamation's Technical Service Center and reviewed and approved by Reclamation's Design and Construction Coordination Team. However, they are not always followed. In fact, some offices are unaware of the existence of these guidelines, which sometimes results in inefficient design data collection.

Organizations with repeating portfolios (repetitive type work) generally follow structured, internally created design data collection standards and involve the users or beneficiaries in design data collection. This is particularly true of large water and power project owners.

Architect and engineering firms generally rely on the judgment of their designers to determine design data needs on a case by case basis.

7.1.2 Discussion

Reclamation uses internal guidelines (currently in draft form in Reclamation's case) to assist its technical staff in planning a design data collection program that will provide critical data to the designers in a timely manner. When those guidelines are used, they are effective.

The Engineering Standards Team is concerned that there is wide range of practices employed in Reclamation and that the draft design data collection guidelines are not consistently used. There is an appreciable level of misunderstanding or lack of understanding of design data collection needs. Offices that have a large suite of construction activities generally understand and follow good design data collection practices. However, many offices in Reclamation do not understand the importance of collecting good design data, particularly as it relates to production of efficient designs.

7.2 Design Standards

7.2.1 Standards Used

All Reclamation Instructions were sunset in 1994, including the documents that assigned responsibility for development and maintenance of design standards to the Assistant Commissioner, Engineering and Research. In 2000, Reclamation issued policy that assigned responsibility for design standards to the Director of the Technical Service Center. Thus, while responsibility for Reclamations design standards were somewhat in limbo during the 1990s, the standards themselves continued to be used to varying degrees across the agency; limited updates have been made over the last decade. Reclamation currently uses a blend of national standards, a few updated guidelines, and older design standards. The extent of use varies with the design requirement, the type of work being performed, and the group doing the design.

Reclamation geotechnical designers use more Reclamation derived standards because Reclamation standards in this area are more "state-of-the-art." Reclamation civil and structural engineering practices, such as dam appurtenant structures, pumping plants, water conveyance structures and equipment, typically use a blend of national and Reclamation standards. Reclamation staff who design electrical and mechanical systems predominantly use national standards.

Architect and engineering firms surveyed use national standards and may consult Federal or State agency standards. Owners surveyed tend to use a blend of national standards, Federal agency, and internally produced standards for design projects. All the Owners and architect and engineering firms recognize Reclamation's older standards, and the majority still refers to them occasionally either in developing their standards or during their engineering processes. Water user organizations would like to see national standards applied to low risk facilities, but generally do not question Reclamation's design standards when applied to high risk facilities.

7.2.2 Design Adjustments and Design Life

None of the external organizations surveyed make adjustments to designs to reflect the degree of construction supervision. Nor do they lower standards that affect public safety, but if public safety was not a consideration, they may consider trade-offs between life cycle cost and initial capital investment.

Reclamation does not compromise life safety in its designs. For non-life safety related work, many, but not all, Reclamation designs consider economic trade-offs. Many, but not all, other Owners and architect and engineering firms surveyed consider service life and economic risks in designs. The most prevalent use of this approach is in electrical and mechanical applications.

In general, all entities surveyed assume that the design life for civil features is longer than for electrical or mechanical components.

7.2.3 Perception of Reclamation Standards

Most architect and engineering firms surveyed noted that Reclamation standards are more conservative than theirs. One firm believes that Reclamation tends to rely on Reclamation standards rather than on applying professional judgment to site specific conditions. Some architect and engineering firms noted their recent experience with Reclamation is illustrative of Reclamation's flexibility in its application of standards on projects funded by others. One firm indicated that Reclamation should update design standards frequently if Reclamation intends to follow them.

Most Water Users surveyed believe that Reclamation standards are more conservative than national standards. However, most recognized the necessity for higher standards because of the nature of Reclamation's structures, particularly high hazard/risk structures. Some Water Users believe Reclamation over-designs its low hazard/risk structures. Water Users expect durable facilities with lengthy service lives from Reclamation designs.

7.2.4 Discussion

The Reclamation Manual Policy FAC P03, "Performing Design and Construction Activities," states the Director of the Technical Service Center prescribes the engineering technical standards and guidelines to promote consistent application. Guidelines that have been developed under this responsibility are not consistently applied by many Reclamation offices. Further, the general belief throughout Reclamation is that the Technical Service Center is a technical services organization only, with no authority to make or enforce policy. Another factor that affects the creation and application of consistent standards Reclamation-wide is the decentralized organization's tendency toward autonomy. This desire poses a dilemma for Reclamation, because as the National Academy of Sciences report points out, highly decentralized organizations need agency-wide non-discretionary policies and standards in order to be collectively an organization of excellence.

Most of the users or beneficiaries of Reclamation's design services surveyed would like Reclamation to use national standards when possible, but they also acknowledge that Reclamation's experience and associated design standards should be utilized on high hazard/high risk facilities.

The architect and engineering firms surveyed embrace the use of national standards and generally rely on the engineering judgment of individual designers to determine the proper application of these standards. The Engineering Standards Team believes that the architect and engineering firms have adopted this approach in recognition of the fact that most national standards are not design standards, but rather focus on detailed design and material properties for individual components of a feature or a larger integrated and complex system. Therefore proper application and integration of these national standards into a comprehensive design requires a level of professional knowledge that varies with the complexity of the project feature.

The Owners surveyed tended to use national standards and generally rely on the designers' judgment to determine the proper application of the standards. However, they typically augment their designers' engineering judgment with organization-specific adjustments to the standards to reflect their organizations experience and requirements.

When an organization such as Reclamation or the Owners surveyed have a recurring need to produce designs for relatively complex project features such as pipeline systems, pumping plants, and dams, many conclude that the development of an organizational design "standard" is an efficient method to capture the organization's corporate experience with that type of feature. The use of these guide documents avoids the need for each designer to "reinvent the wheel" every time the organization needs to produce such a design. Owners tend to more commonly have the need for such recurring designs as opposed to architect and engineering firms whose design activities tend to be more diverse. The Engineering Standards Team believes this is the reason Reclamation and the Owners surveyed place more reliance on such documents, while architect and engineering firms tend to place more reliance on their designers' engineering judgment for each project.

Many outside of the Reclamation design community appear to believe Reclamation primarily relies on a set of rigidly enforced internally developed standards. That, in reality, has not been the case for many years. Much like the Owners surveyed, Reclamation has steadily moved towards the integration of available and applicable national standards in nearly all of its design activities, including designs of features for which it has internal design standards. In fact, Reclamation technical staff is actively engaged in the development of many national standards through committee membership with national organizations ranging from the American Water Works Association to the National Association of Corrosion Engineers.

Reclamation's design standards can give a designer a head start on a project by providing examples of what approaches and which national standards have been proven to work in the past. The Engineering Standards Team acknowledges that many Reclamation designers may be reluctant to waiver from past proven design approaches. However, proper use of Reclamation's design standards does not preclude the need to apply sound engineering judgment to accommodate site-specific technical considerations, as well as project-specific considerations and recommendations of the users and beneficiaries of Reclamation designs.

Much of Reclamation's recent focus in developing and updating its design standards has been in areas where such standards are not available or have been judged, primarily by Reclamation technical staff, to be insufficient to meet Reclamation's needs. This approach is most evident in the design of dam safety modifications and power plant operation and maintenance manuals, but has also

been occurring for non-traditional project features such as fishery structures, although practices applicable to such features have mostly been captured in research reports and design manuals.

Updates to Reclamation's design standards in other areas have lagged behind the ones noted above for a variety of reasons. In some cases, the nature of Reclamation's construction needs has evolved so that certain designs are less frequently needed and it did not make sense to invest limited available funding to update these standards, such as standards for housing facilities. In other cases, the emergence of viable national standards has eliminated the need for a Reclamation-specific standard such as national pipe design standards. In other cases, needs for technical guidance in non-engineering disciplines have received higher priorities for the limited funding.

7.3 Design Process

7.3.1 Client/Customer Involvement

All organizations surveyed seek client involvement as early as practicable in the design process, usually between the 15 to 30-percent design stage. All organizations emphasize the need for effective communication with clients to reach consensus on design concepts. In rare cases when consensus cannot be reached, the design providers defer to the client except for safety considerations. If the parties reach an impasse, clients of architect and engineering firms are free to take their business elsewhere, while Owner clients are less likely to take business elsewhere.

Most Water Districts surveyed are involved in some phase of the design process. Some are involved in all phases, and others are involved only in planning and review of designs. The majority of Water Users want to be involved in all phases of process and have technical staff who could participate but not necessarily the financial resources to do so. Districts stated their need for involvement varies with the type and complexity of the work. Design work involving an activity that they would have financial responsibility for requires more involvement than those facilities that are secondary to operating structures such as footbridges. Water Users generally do not desire direct involvement in federal compliance activities, structural design calculations, geotechnical investigations or dam design issues. Water Users desire to be partners with Reclamation in the design process to understand design concepts, status of design work, costs, and timeframe of the work.

7.3.1.1 Design Scheduling

All organizations surveyed involve their design clients in scheduling designs. Architect and engineering firms typically establish schedules as part of their service contract. Owners and Reclamation typically work with their internal clients to establish priorities for the work. Architect and engineering firms try to accommodate accelerated schedules by reallocating resources. Owners and

Reclamation tend to do the same using more formal processes. In the rare cases when consensus on schedule cannot be reached, clients of architect and engineering firms are free to take their business elsewhere. Owner and Reclamation clients tend to focus on adjusting priorities and perhaps scope.

7.3.1.2 Design Reviews

Most design providers surveyed conduct at least three general design reviews, typically at the 30-, 60- and 90-percent design stages. Reviews are conducted by internal technical resources and clients, when they choose to participate. All organizations include technical, life safety, and economic considerations in these reviews, which are performed by staff outside the design team. Owners and Reclamation tend to have more formal economic reviews during the planning process. All organizations have well documented and comprehensive guidelines for their technical reviews. Owners who contracted designs to architect and engineering firms performed oversight reviews throughout the design process. None of the organizations indicated that their process for designs varied between water and power facilities.

7.3.2 Design Estimates

Design estimates are generally task based and are prepared by design engineering staff based on past experience, previous work, and historical costs. All organizations surveyed subject their design cost estimates to an internal review. Reclamation's design providers prepare the original design estimates, and they are generally within 15 to 20 percent of final design costs. External design providers state their estimates are usually within 5 to 15 percent of their final design costs. architect and engineering firms noted that they track changes in scope of work and request change orders as needed. If the client does not accept the design cost estimate, the designers revaluate the scope of services and communicate with the client. If consensus on the design cost estimate cannot be reached, architect and engineering firm work generally goes to another contractor. Owners and Reclamation may reduce the scope of the design or defer the work, or, in Reclamation's case, the design client may decide to contract with an architect and engineering firm.

In general, design providers surveyed believe high hazard/risk facilities often justify higher costs for design and construction, due to the higher level of consequences of potential failure.

7.3.3 Perception of Reclamation Design Process versus that Used by Architect and Engineering Firms

Some Reclamation offices surveyed that use Reclamation design services would like Reclamation to increase its flexibility in use of national standards and architect and engineering firms. Others believe that the quality of Reclamation designs is better/more thorough than architect and engineering firm designs, resulting in a better end product, but that they may cost more than designs provided by architect and engineering firms. Most Reclamation offices believe

that construction costs may be higher for Reclamation produced designs but service life is generally longer and long-term operation and maintenance costs are lower.

Architect and engineering firms surveyed believe that Reclamation designs are more expensive to produce. Some suggested the following as possible reasons:

1. Lack of competition between Reclamation designers and others.
2. Processes developed for large projects are now applied to smaller ones.
3. Reclamation performs more analysis than architect and engineering firms typically do.

Some architect and engineering firms said they believe Reclamation designs are more expensive to construct, although they do not know if this is a result of design approaches or Federal procurement regulations and requirements, such as the Davis-Bacon Act. Some architect and engineering firms assume costs for operations and maintenance would be similar regardless of design entity.

Owners surveyed generally believe that Reclamation has retained strong technical capabilities which it effectively applies to its design activities. Some Owners also noted that the true cost to contract designs is higher than to do the work in-house. Owners are not sure about the relative costs to construct, but believe additional construction costs are offset by lower life-cycle costs. Some Owners think that operations and maintenance costs for Reclamation designs probably are lower than for architect and engineering firm produced designs.

The Water Users surveyed perceive that Reclamation designs are comparable to architect and engineering firm prepared designs. They believe designs produced by Reclamation cost more to prepare and may cost more to construct than designs produced by architect and engineering firms. The majority of the Districts believe that Reclamation designed and constructed facilities are less expensive to operate and maintain over the long-run. Most Districts also believe that Reclamation's designs are more complete and minimize the margin of error. One of the Water Users suggested that Reclamation significantly expand its use of performance specifications versus the development of prescriptive designs as a means of reducing the cost for preparing designs and construction specifications.

7.3.4 Discussion

The process used by Reclamation to incorporate client reviews throughout the design development, as captured in Reclamation's Final Design Process, is similar to processes used by other Owners, architect and engineering firms, and the Water Districts surveyed. The current process appears to provide sufficient flexibility to meet the needs of Reclamation and the users and beneficiaries of Reclamation's designs, if it is followed.

While this process provides opportunities for involvement by users and beneficiaries of Reclamation's design services in the development of designs, it is clear from the surveys conducted that virtually all of the Water Districts want more involvement in the development of Reclamation designs for their projects. It is also clear that those Districts who feel they are treated as a design partner rather than simply as a recipient of the design services are much more satisfied with Reclamation's performance on the design. However, even the Districts with the most positive of these experiences noted that Reclamation's cost to produce designs are higher than what are viewed as comparable costs for architect and engineering firm produced designs.

One District suggested Reclamation change its strategy for design development from one that relies predominately on development and portrayal of prescriptive designs to one that relies more heavily on the development of performance specifications. Reclamation does use performance specifications to solicit manufacturers' designs for certain components used in its construction projects. This approach is more often used for electrical and mechanical components of new construction or for replacement of existing equipment. Most Reclamation bid documents, therefore, contain both prescriptive designs and performance specifications. Reclamation has occasionally used performance specifications for civil features with mixed results because, unlike equipment and other removable structures, once the specified product is completed, it is difficult or impracticable to remove and replace the feature at the contractor's cost if the contractor does not comply with performance requirements.

While there are indications that architect and engineering firms in many cases produce bidding documents for a lower cost than Reclamation, what is less clear is if the total cost of producing the bid package, covering the costs for contractor supplied designs and reviewing those designs (where performance specs are used extensively), and closing out the construction contract (including claims) varies significantly between a Reclamation- and an architect and engineering firm-produced design. Collecting data to make this more comprehensive comparison has proven difficult (not just for Reclamation but for the entire construction industry). The limited data that has been collected on selective Reclamation and architect and engineering firm projects indicate the gap between the two approaches narrows when all costs are considered. The owners surveyed, who had converted from in-house to externally contracted designs believe that contracting is more expensive than internally prepared designs, all costs considered. Most of the Districts surveyed did acknowledge that Reclamation-produced designs tend to have a longer service life and often have lower operation and maintenance costs than architect and engineering firm-produced designs. The Districts also noted the critical role played by the local Reclamation office in establishing and maintaining good communications between the District and the Reclamation office producing the designs.

7.4 Close-out Process

The concept of a formal close-out process with identified "lessons learned" has long been recognized as a best practice for organizations involved in all types of team-related activities. Reclamation and nearly every organization surveyed recognize the benefit of such a process, but many, including Reclamation, struggle to implement a formal process on a consistent basis.

7.4.1 Discussion

Outside of Reclamation's Technical Service Center formal Project Management initiative and Reclamation's Dam Safety Project Management Guidelines, Reclamation does not have a formal close-out process for design projects. If Reclamation is to benefit from such a program, it will need to develop an easily completed process and provide for the funding to cover the costs for completing the process.

8.0 Conclusions

8.1 Design Data Collection

The Engineering Standards Team concludes that Reclamation's Draft Design Data Collection guidelines should be more consistently followed across the agency. Local Reclamation offices that do not routinely develop design data packages or collect the data should delegate responsibility for these functions to the other Reclamation offices that have this expertise.

8.2 Design Standards

The Engineering Standards Team concludes that Reclamation has a legitimate need for internal design standards. This is particularly true for high hazard / high risk projects and project features such as dams and appurtenant structures affecting the safety of the dam. This is also true for cases where specialized Reclamation needs are not adequately addressed by available national standards, such as heavier design floor loads for service bays in pumping and power plants that reflect the plants' operations and maintenance needs. However, the Team also believes there are opportunities for Reclamation to adopt more national standards in lieu of maintaining Reclamation-specific standards.

The Engineering Standards Team concludes that Reclamation's use of its design standards needs to integrate sound engineering judgment with applicable national

standards, site specific technical considerations, and project specific considerations to the extent that public safety is not compromised.

Finally, the Engineering Standards Team concludes that Reclamation needs to better manage and organize its design standards, make development of the standards more transparent to its stakeholders, and make the standards more readily accessible for all Reclamation offices, Reclamation stakeholders, and members of the American public.

8.3 Design Process

The Engineering Standards Team concludes that many Districts value, and are willing to pay a little more for, a Reclamation-produced design if they have an opportunity to provide input to the designers and see that Reclamation is responsive to their input, particularly regarding constructability, operations and maintenance, and design robustness considerations. The Team believes that much of the concern voiced by the users and beneficiaries of Reclamation's designs regarding the conservatism of Reclamation design standards would be addressed if this level of interaction was ensured during the design process.

The Engineering Standards Team has also concludes that the local Reclamation office, through which the users and beneficiaries of Reclamation's designs communicate their input to the designers, must ensure this communication occurs in a timely manner. Outstanding communication processes by the local Reclamation office were cited by several of those surveyed as a key element in virtually every successful design experience with Reclamation.

In light of the widespread perception that Reclamation design costs are higher than comparable designs produced by others, the Engineering Standards Team concludes Reclamation should evaluate its current design production techniques to assess the potential for more efficient approaches. This review should include an assessment of the applicability of performance specifications in lieu of prescriptive designs for a variety of project components.

8.4 Close-out Process

The Engineering Standards Team concludes that Reclamation needs a close-out process for its design projects, but the Team also notes that most organizations in the design industry lack the financial resources, time, staff resources, and/or discipline to consistently complete these processes. The Team also recognizes Reclamation and the users and beneficiaries of Reclamation's designs may need to fund whatever close-out process is to be employed.

The Engineering Standards Team believes that Reclamation needs to develop a streamlined close-out process (perhaps based on the Dam Safety model) focused

on gathering just a few key facts related the “lessons learned” during the design development and ensure these lessons are readily available to all Reclamation staff involved in design and construction activities.

9.0 Best Practices – Recommendations

9.1 Design Data Collection

Best Practice: A consistent design data collection process, with client involvement, results in more consistency and continuity Reclamation-wide. This in-turn results in products that are likewise more consistent.

Recommendations:

- Finalize the draft data collection guidelines.
- Distribute the design data guidelines in a manner which ensures all Reclamation offices are aware of their existence and of the benefits of their use. Implement the guidelines Reclamation-wide. Provide training as needed.
- Assign design data collection responsibilities for each region to one or more offices in that region which possess the necessary expertise to collect the data in a timely manner with either in-house staff or through contractors. This concept would be modeled after the regional construction office model. The team does not recommend that offices staff to specifically perform this task, rather Reclamation should take advantage of the staff that already has the skills and capabilities to perform this task.

9.2 Design Standards

Best Practice: Clear and concise engineering policies and standards ensure consistency and continuity regardless of who develops the design.

Recommendations:

- The Director of the Technical Service Center should assemble a team, including retired Reclamation design staff if needed, to comprehensively review the old Reclamation Instructions, Series 130, and all Reclamation design standards such as formal design standards, design manuals, engineering monographs, technical memoranda, and commonly accepted practices to identify:

  - Standards to be retained as is, including Reclamation design standards for high hazard / high risk projects and project features.
  - Standards to be updated by Reclamation ensuring they utilize and reference all applicable current national standards.
  - Standards to be eliminated including alternative sources for design guidance such as applicable national standards.
  - Standards that don't currently exist and need to be established.
- Current funding for the TSC is inadequate to perform the preceding. Therefore, Reclamation will need to provide the additional funding to accomplish this activity.
- Conduct the preceding review in a manner that allows input from all Reclamation offices as well as Reclamation's water and power users.
- The Technical Service Center should ensure that the needed internal standards identified in the preceding are updated and/or created. This activity will, by its nature, be an ongoing process that will need to be supported by adequate funding
- Formally announce the selection of each current standard for use by Reclamation, the update of each out-of-date standard, and each decision to eliminate un-needed Reclamation standards to all Reclamation Offices.
- Post Reclamation Design Standards on Reclamation's Internet Webpage to ensure they are readily accessible.
- The Technical Service Center, in consultation with the Dam Safety Office, should maintain and update internal standards for Dam Safety, new dam design, and other high hazard/high risk facilities.

9.3 Design Process

Best Practice: Clear and concise policies and standards regarding the total design process furthers consistency in highly decentralized organizations. Communication of the policies, standards, and processes is also important and necessary to ensure that the design client (Reclamation, another agency, or a Water User organization) is fully aware of the proposed project and every step of the process.

Recommendations:

- Prepare a letter, under the Commissioner's signature, that communicates the responsibility of the Director of the Technical Service Center to develop directives and standards related to design and engineering and the provision of the design and construction related Reclamation Manual documents. Include in this letter a clear statement of the need for all of Reclamation to comply with design policies.
- Supplement the "Final Design Process" with recommended procedures to establish and implement a Communications Plan between stakeholders, local Reclamation office(s), and the design provider (either in-house or

architect and engineering firms) to ensure critical stakeholder input can be integrated into the development of designs.

- The Reclamation Design and Construction Coordination Team should evaluate more efficient methods to produce Reclamation designs, including an assessment of the impact to total project cost of using more performance based specifications and off-the-shelf components in lieu of prescriptive designs.
- In response to the internal and external criticism regarding the cost of Reclamation designs and the time required to produce a product, Reclamation should monitor internal schedules and costs and collect the same for externally prepared designs and other documents to determine:
  - o How accurate the original cost estimate was for the proposed work.
  - o How many changes were required and at what cost.
    - Changes in scope
    - Changes in cost estimate
    - Changes in schedule
- Regional Directors should determine capabilities of area and field offices to interact with and coordinate with stakeholders on design and construction projects, and designate a project leader (FAC 03-03) for those area offices that do not have capability
- Regional directors should ensure that those delegated the authority to perform program functions initiate the appropriate technical and economic dialog between the producers and receivers of design services.

9.4 Close-Out Process

Best Practice: A close-out process ensures project closure and provides valuable information for use in future design processes. It is particularly valuable to a decentralized design services organization.

Recommendations:

- The Reclamation Design and Construction Coordination Team should develop guidelines and/or standards for a non-discretionary close-out process that involves the users and beneficiaries of Reclamation's designs.
- The Director of the Technical Service Center should develop a directive and standard to communicate the close-out process to all Reclamation offices.
- Develop a web-based close-out questionnaire that can be e-mailed to all organizations involved in a design.
- Task one individual within each region to input the responses into an agency-wide read-only accessible database available for reference by future project managers.

10.0 Implementation

The following table proposes an implementation schedule for the recommendations developed by the Engineering Standards Team.

TASK/SUBTASK	RESPONSIBLE	WHEN
Design Data Collection		
Finalize Draft Data Collection Guidelines	Director, TSC	February 2007
Distribute and Implement	Director, TSC/ Director, OPPS	February 2007
Identify Offices with Data Collection Skills	Regional Directors/ Area Managers	February 2007
Assign Regional Responsibilities		February 2007
Design Standards		
Comprehensive Review of Old Reclamation Instructions (R.I. Series 130 Part 133) Current Standards and Guidelines	Director, TSC	
Assemble Team		March 2007
Involve all Reclamation offices and Stakeholders in review		Throughout Review
Complete Review		October 2007
Develop Plan		November 2007
Update and/or create necessary internal standards (implement according to Plan)		October 2008
Review Funding	Reclamation Leadership Team	Immediately
Reallocate to provide additional funding needed for policy and standard review and development	Reclamation Leadership Team	As soon as possible
Formally announce current standards to be used throughout Reclamation	Director, TSC	Ongoing
Post Reclamation Design Standards and Guidelines on the Internet	Director, TSC	Ongoing
Maintain and update internal standards	Director, TSC	Ongoing
Design Process		
Formally communicate the responsibility of the Director, TSC (as Executive Sponsor for the Reclamation Design and Construction Coordination Team) to develop non-discretionary policies and standards	Commissioner	Immediately
Supplement the Final Design Process with a Communications Plan	Director, TSC; RDCCT	October 2007
Evaluate Methods to Produce More Efficient Designs	Director, TSC; RDCCT	December 2007
Database for Costs of Internally and Externally Prepared Designs	Director, TSC; RDCCT	December 2007
Assess Area/Field Office Capabilities to Interact and Coordinate Design & Construction Projects with Stakeholders	Regional Directors	June 2007
Assign Project Leaders where necessary		June 2007
Close-Out Process		
Develop Guidelines & Standards for an Non-discretionary Process	Director, TSC; RDCCT	October 2007
Develop D&S for close-out process	Director, TSC; RDCCT	December 2007
Develop Close-Out Process Web Site	Director, TSC; RDCCT	December 2007

Please check all that apply.

__ Responding as a client of Reclamation design services.
__ Responding as a provider of Reclamation design services.
__ Located in a Regional Office.
__ Located in an Area Office or equivalent.
__ Located in a Field Office of an Area Office.
__ Located in a Regional Construction Office independent or separate from a Regional Office design group.

If a question below is not pertinent to you, please insert "NA".

Design Data Collection

1. How are design data collected?

2. Are there written design data collection guidelines and procedures that are followed?

    a. If so, what guidelines are used?

    b. If not, how are data requirements determined?

3. Is the Client involved in design data collection?

    a. If so, when is the client involved?

    b. How is the client involved?

Design Standards

1. What design standards are used either in-house, at the Region, TSC, or via A&E's?

2. If and when codes are used, what are they generally and how are they applied?

3. Are design standards adjusted to accommodate the degree of construction management, primarily inspection, that will be provided?

    a. If so, how are the adjustments made?

    b. Are decisions to deviate from standards documented?

4. Are the standards used for designs based on assessments or tradeoffs related to costs versus safety or economic risks? If so, how are the decisions decided and documented?

5. Are specific service life criteria designated for features or structures related to design efforts? If so what, if any, design standard applications or decisions are used to assure the service life is achieved?

6. If performance specifications are used, what design standards are used?

7. Is the client involved in selection of standards to be applied in a design?

    a. If so, what process is used to reach consensus with the client on the standards?

    b. What happens if consensus cannot be reached?

8. What design standards would you like to see Reclamation use and why?

    a. Internal standards?

    b. National standards?

9. What is your perception of Reclamation's design standards versus other standards used in industry?

Design Process

1. How are you involved in the design process?

    a. Planning phase?

    b. Conceptual designs?

    c. Final design?

    d. Procurement phase?

    e. Construction phase?

    f. O&M phase?

    g. Other (please describe)?

2. At what stage do you get client agreement on design concepts?

    a. What process do you use to reach consensus with the client on the design concepts?

    b. What happens if consensus cannot be reached?

3. Is the client involved in the scheduling of designs?

    a. If so, how is the client involved?

b. What process is used to reach consensus with the client on the schedule for a design?

c. What happens if consensus cannot be reached?

4. What processes are used to produce designs, either in-house, at the Regional Office, TSC, or via A&E's?

5. What level or types of design reviews are performed and who performs the reviews?

a. Technical?

b. Peer?

c. Client?

d. Life safety?

e. Economic?

6. Who decides what level or type of reviews will be performed?

7. How are design cost estimates prepared?

a. What standards or processes are used when estimating in-house design costs?

b. What standards or processes are used to evaluate the reasonableness of estimates provided by others including A&E firms?

8. Is the client involved in the development or review of design cost estimates?

a. If so, is there client buy-in to design cost estimates?

b. What process is used to reach consensus with the client on the design costs?

c. What happens if consensus cannot be reached?

9. How accurate are the initial design cost estimates typically?

10. How is the design requirement addressed, if the design cost estimate or total project cost is judged to be too high?

a. Independently by local decision?

b. With involvement of others, e.g. designers, A&E firms, and clients?

11. What solutions are typically used in the situations described in question 10?

a. Reduce project scope?

b. Adjust design standards?

c. Look at use of performance specifications vs. prescriptive designs?

d. Defer work until a later date when additional funds are available?

e. Others?

12. Who makes the final decisions on the course of action to address design costs that are judged to be too high?

13. Are designs for high consequence or high hazard facilities approached differently than those for low consequence or low hazard facilities with regard to:

a. Acceptable design costs? If so, please explain.

b. Acceptable construction costs? If so, please explain.

c. Acceptable operations and maintenance costs? If so, please explain.

d. Service Life Assumptions. If so, please explain.

e. Others?

14. Are designs for water facilities approached differently than those for power facilities with regard to:

a. Acceptable design costs? If so, please explain.

b. Acceptable construction costs? If so, please explain.

c. Acceptable operations and maintenance costs? If so, please explain.

d. Service life assumptions? If so, please explain.

e. Others?

15. In your experience, what level of involvement from your organization typically works well in the design process?

16. What would you like to see changed, if anything, in Reclamation's design processes?

17. What is your perception of Reclamation designs versus A&E firm designs?

    a. Cost to prepare?

    b. Cost to construct?

    c. Resulting cost to operate and maintain designed product?

    d. Overall impression?

Close-Out Process

1. Is there a close-out or lessons learned process?

    a. If so, how is this process performed?

    b. Who is involved (client, other Reclamation offices)?

    c. How is the information gained used?

WATER USER ORGANIZATIONS CONTACTED:

PN Region

East Columbia Basin Irrigation District, Othello, WA
Sunnyside Valley Irrigation District, Sunnyside, WA

MP Region

San Luis – Delta Mendota Water District, Tracy, CA
Westlands Water District, Fresno, CA

UC Region

Central Utah Water Conservancy District, Orem, UT
Emery Water Conservancy District, Emery County, UT
Weber Basin Conservancy District, Layton, UT
Middle Rio Grande Conservancy District, Albuquerque, NM
Uintah Water Conservancy District, Vernal, UT

LC Region

Metropolitan Water District, Los Angeles, CA
Salt River Project, Tempe, AZ

GP Region

Cameron County Irrigation District No. 2, San Benito, TX
Fort Shaw Irrigation District, Fort Shaw, MT
Northern Colorado Water Conservancy District, Berthoud, CO

CLIENT SPECIFIC QUESTIONS

Design Standards:

1. What is your perception of Reclamation's design standards vs. other standards used in industry?

2. What standards would you like to see Reclamation use for specification preparation?
    a. Internal standards?
    b. National standards?

3. Does your organization designate specific service life criteria for various components of your facilities? If so, what (if any) design standards do you use to achieve this service life?

1. Do you adjust design standards used on your facilities based on risk (life safety or economic risk) when Reclamation designs are not involved?
    a. If so, how do you decide what adjustments are acceptable or what standards to use?

Design Process:

1. How are you involved/or are you involved in Reclamation's design process (please describe you involvement for each project phase that applies)?
    a. Planning Phase (Pre-Authorization)
    b. Conceptual Designs
    c. Final Design
    d. Procurement Phase
    e. Construction Phase
    f. O&M Phase
    g. Other (please describe)

2. How and when would you like to be involved in the process?
    a. Planning Phase
    b. Conceptual Designs
    c. Final Design
    d. Procurement Phase
    e. Construction Phase
    f. O&M Phase
    g. Other (please describe)

3. Do you feel you have the resources to provide input to the design process?
    a. Staff / Technical
    b. Monetary

4. Does your need for involvement vary with the types and complexity of the work?
    a. Please give examples of types of projects which require your direct involvement.
    b. Please give examples of types of projects which do not require your direct involvement.

5. In your experience, what level of involvement from your organization typically works well in the design process?
    a. Provide examples

6. What would you like to see change in Reclamation's design process (please provide your assessment of the pro's and con's of the desired change(s) you've identified)?

7. What is your perception of Reclamation's designs vs. A&E firm designs?
    a. Cost to prepare
    b. Cost to construct
    c. Cost to operate and maintain
    d. Overall impression

Close-Out Process

1. Is there a close-out or lessons learned process?
    a. If so, how is this process performed?
    b. Who is involved (contractors, Reclamation offices, others)?
    c. How is the information gained used?

EXTERNAL ENTITIES CONTACTED:

Architect and Engineering Firms

Montgomery Watson Harza, Denver, CO
CH_2MHill, Boise, ID
URS, Denver, CO

Other Owners

Tennessee Valley Authority, Knoxville, TN
U.S. Army Corps of Engineers, Washington, DC
California Department of Water Resources, Sacramento, CA
BC Hydro, Vancouver, BC, Canada
Pacific Gas and Electric, Sacramento, CA

EXTERNAL ENTITY SPECIFIC QUESTIONS (COE, A&E, PMA)

Design Data Collection

1. How is design data collected for your projects?

2. Do you have or use written design data collection guidelines and procedures?
    a. If so, what guidelines do you use?
    b. If not, how do you determine what data is required?

Design Standards

1. What is your perception of Reclamation's design standards vs. other standards used in industry?

2. Does your organization designate specific service life criteria for various components of your facilities? If so, what (if any) design standards do you use to achieve this service life?

3. Do you adjust design standards used based on risk (life safety or economic risk)?
    a. If so, how do you decide?

4. Does your organization approach designs for water and power facilities differently with regard to:
    a. Service Life Assumptions (if yes – please explain)
    b. Acceptable operations and maintenance costs (if yes – please explain)
    c. Others?

5. What standards does your organization use for specification preparation?

6. To the best of your knowledge, are Reclamation's specifications standards compatible with yours?
    a. Yes
    b. No
    c. Don't Know

Design Process:

1. What is your perception of Reclamation's designs vs. designs prepared by others (your organization, A&E's, etc.) with regard to:
    a. Cost to prepare
    b. Cost to construct
    c. Cost to operate and maintain
    d. Overall impression

2. Does your organization approach designs for water and power facilities

differently with regard to:

a. Acceptable design costs (if yes – please explain)
b. Acceptable construction costs (if yes – please explain)
c. Acceptable operations and maintenance costs (if yes – please explain)
d. Others?

3. Do you have any suggested changes to Reclamation's design process (including design standards used)? If so, please provide your assessment of the pro's and con's of the desired change(s) you've identified.

Close-Out Process

1. Do you have a close-out or "lessons learned" process? If so,
   a. How is this process performed?
   b. Who is involved? (Client, contractors, Reclamation, others)
   c. Other offices in your organization? What offices?
   d. How is the information gained used?