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16. Abstract

Two sources of delay during the project development process are utility adjustments and the environmental review and clearance process. There are several efforts underway at the Texas Department of Transportation (TxDOT) to optimize these processes, including recently finished and active research projects. Despite these efforts, the interaction between the utility process and the environmental process is one that has not received proper attention over the years. One of the reasons is that, although the collection of data about existing and abandoned utility installations is part of the environmental data gathering process, in practice the collection of detailed underground utility-related data normally starts in the design phase, which typically occurs after the environmental process is complete.

The purpose of the research was to evaluate the feasibility of (a) obtaining better existing utility data during preliminary design and coordinating this activity with the environmental process; and (b) increasing the level of definition of design components during preliminary design without affecting environmental requirements to support the earlier application of utility processes. The analysis resulted in 10 optimization strategies that address a variety of environmental and utility issues identified through a literature review and meetings with stakeholders throughout the state. The researchers also developed a high detailed business process diagram that integrates environmental and utility functions, with a specific emphasis on the preliminary design phase. To facilitate access to model information, the researchers developed a web-based application called TxDOT Business Process Explorer (TxBPE). TxBPE can be accessed on the Internet, the TxDOT intranet, or from a local or networked computer drive.

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INTEGRATION OF UTILITY AND ENVIRONMENTAL ACTIVITIES IN THE PROJECT DEVELOPMENT PROCESS

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DISCLAIMER

The contents of this document reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This document does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. The engineer in charge of the project was Cesar Quiroga, P.E. (Texas Registration #84274).

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

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LIST OF ACRONYMS, ABBREVIATIONS, AND TERMS

2R	Non-freeway resurfacing or restoration
3R	Non-freeway rehabilitation
4R	New location and reconstruction
5R	Mobility corridor
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADT	Average daily traffic
AJAX	Asynchronous JavaScript and XML
ASCE	American Society of Civil Engineers
BAMS/DSS	Bid Analysis Management System/Decision Support System
BPMN	Business Process Modeling Notation
BR	Bridge replacement
CAD	Computer aided design
Cat Ex	Categorical exclusion
CDA	Comprehensive development agreements
CE	Categorical exclusion
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEU	Continuing education unit
CFR	Code of Federal Regulations
CI	Construction Institute
CRM	Cultural resource management
CSJ	Control section job
CUPS	Cooperative Utility Planning System
DBB	Design-bid-build
DCIS	Design and Construction Information System
DOT	Department of transportation
DTM	Digital terrain model
EA	Environmental assessment
EIS	Environmental impact statement
EMI	Electromagnetic inductive
EPCRA	Emergency Planning and Community Right to Know Act
EPIC	Environmental permits, issues, and commitments
ESA	Environmental site assessment
EST	Environmental Screening Tool
ETAT	Environmental Technical Advisory Team
ETDM	Efficient Transportation Decision Making
ETS	Environmental Tracking System
FDOT	Florida Department of Transportation
FedCenter	Federal Facilities Environmental Stewardship and Compliance Assistance Center
FEMA	Federal Emergency Management Agency
FGDL	Florida Geographic Data Library
FHWA	Federal Highway Administration

FIPS	Federal Information Processing Standard
FMIS	Financial Management Information System
FONSI	Finding of no significant impact
FPAA	Federal project authorization and agreement
FUP	Federal utility procedure
GDOT	Georgia Department of Transportation
GIS	Geographic Information System
GISST	Geographic Information System Screening and Analysis Tool
GLO	General Land Office
HCI	Highway Cost Index
HMM	Hazardous materials management
IDEF0	Integrated Definition for Function Modeling
IDEF3	Integrated Definition for Process Description Capture Method
IE	Internet Explorer
ISA	Initial site assessment
ITD	Integrated Transportation Decision-Making
ITS	Intelligent transportation system
JPEG	Joint photographic experts group
GPR	Ground penetrating radar
LDCA	Location and design concept acceptance
LRTP	Long-range transportation plan – Figure 5
LPA	Local public agency
LUP	Local utility procedure
MaineDOT	Maine Department of Transportation
MDOT	Michigan Department of Transportation
Mn/DOT	Minnesota Department of Transportation
MPH	Miles per hour
MOU	Memorandum of understanding
MPO	Metropolitan planning organization
MS4	Municipal Separate Storm Sewer System
MSHA	Maryland State Highway Administration
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act
NHI	National Highway Institute
NHPA	National Historic Preservation Act
NHS	National Highway System
NRP	Non-reimbursable procedure
NRS	Natural resource management
PCE	Programmatic categorical exclusion
PD	Project development
PDF	Portable document format
PDH	Professional development hour
PDP	Project development process
PNG	Portable network graphics
PS&E	Plans, specifications, and estimate
QA/QC	Quality assurance/quality control

QL	Quality level
QLA	Quality level A
QLB	Quality level B
QLC	Quality level C
QLD	Quality level D
REC	Regional environmental center
RER	Restoration of existing road
ROW	Right of way
ROWIS	Right of Way Information System
RSC	Regional support center
SARA	Superfund Amendments and Reauthorization Act
SEIR	State environmental impact report
SHPO	State Historic Preservation Office
SHRP	Strategic Highway Research Program
SHS	State Highway System
SIS	Strategic Intermodal System
SOU	Standards of uniformity
STIP	Statewide Transportation Improvement Program
SUE	Subsurface utility engineering
SUP	State utility procedure
SVG	Scalable vector graphics
SW3P	Storm water pollution prevention plan
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TESA	Tennessee Environmental Streamlining Agreement
THC	Texas Historical Commission
TMUTCD	Texas Manual on Uniform Traffic Control Devices
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TDOT	Tennessee Department of Transportation
TUC	Texas Utilities Code
TxBPE	TxDOT Business Process Explorer
TxDOT	Texas Department of Transportation
UAR	Utility Accommodation Rules
UCMP	Utility cooperative management process
UIR	Utility Installation Review
USACE	U.S. Army Corps of Engineers
USC	U.S. Code
USFW	U.S. Fish and Wildlife Service
VML	Vector markup language
W3C	World Wide Web Consortium
WF	W iden freeway
XML	Extensible markup language

CHAPTER 1. INTRODUCTION

Streamlined project delivery is one of the five goals outlined in the 2001 Texas Transportation Commission's report "Texas Transportation Partnerships…connecting you to the World" (*1*) to achieve the vision of a more efficient and effective transportation system in Texas. A myriad of factors can cause delays either during the project development process (PDP) or during construction. Two sources of delay frequently mentioned are utility adjustments and the environmental review and clearance process (*2*). One of the critical factors that contribute to inefficiencies is the lack of adequate information about the location and other characteristics of utility facilities that might be affected by a transportation project. Inaccurate and/or incomplete information about those facilities can result in a number of problems, including the following:

- disruptions when utility lines are encountered unexpectedly during construction, either because there was no previous information about them or because their stated location on construction plans was incorrect;
- inadvertent damage to utilities, which can lead to environmental damage or increased risk to the health and safety of construction workers and the public;
- difficulty to locate and characterize underground utilities; and
- delays that can extend the period of project development and/or delivery and increase the total project cost.

District officials frequently cite a lack of early, adequate information about underground utility installations resulting in *unplanned* environmental corrective actions and utility adjustment activities during construction. These unplanned activities are frequent cause for delays during construction, may exacerbate the cost of the project, and increase the impact of construction on motorists and society.

Accurate utility information is critical for the identification of conflicts, including the following:

- interference of utility facilities with highway design features (existing or proposed),
- interference of utility facilities with highway construction activities or phasing,
- interference of planned utility facilities with other existing utility facilities,
- noncompliance of utility facilities with utility accommodation policies, and
- noncompliance of utility facilities with current safety regulations.

Detection of utility conflicts as early as possible during the project development process can help to substantially improve the timely adjustment of utilities and/or allow time to develop alternatives to avoid utility adjustments (*3*, *4*, *5*). Unfortunately, effective communication, cooperation, and coordination are frequently lacking in the project development process to allow for the adoption of cost-effective solution strategies.

The interaction between the utility process and the environmental process is one that has not received proper attention over the years. One of the reasons is that, although the collection of data about existing and abandoned utility installations is part of the environmental data gathering process, in practice the collection of detailed underground utility-related data normally starts in the design phase, which typically occurs after the environmental process is complete.

The environmental process provides an opportunity to identify potential environmental and utility concerns, which makes it appealing to develop strategies to identify synergies between the environmental and utility processes more effectively. In particular, it is of interest to determine whether it is possible to gain efficiencies by moving certain utility-related activities upstream in the project development process and by better integrating those activities with the environmental process.

This report summarizes the work completed to provide an answer to the following questions:

- Is it feasible to obtain better existing utility data during the preliminary design phase and coordinate this activity with the environmental process?
- Is it feasible to increase the level of definition of design components during the preliminary design phase without affecting environmental requirements and processes to support the earlier application of utility processes?

The report is organized as follows:

- Chapter 1 is this introductory chapter.
- Chapter 2 discusses the utility and environmental processes at TxDOT and summarizes practices in other states.
- Chapter 3 discusses impacts resulting from TxDOT's regionalization plan.
- Chapter 4 includes an evaluation of potential optimization strategies.
- Chapter 5 discusses the process to develop an integrated business process model.
- Chapter 6 includes a summary of utility delays and related costs.
- Chapter 7 includes conclusions and recommendations for implementation.

CHAPTER 2. UTILITY AND ENVIRONMENTAL PROCESSES

PROJECT DEVELOPMENT PROCESS AT TXDOT

Getting a project ready for construction at TxDOT generally includes six groups of activities, as follows (Figure 1) (*6*):

- planning and programming,
- preliminary design,
- environmental,
- right of way and utilities,
- plans, specifications, and estimate (PS&E) development, and
- letting.

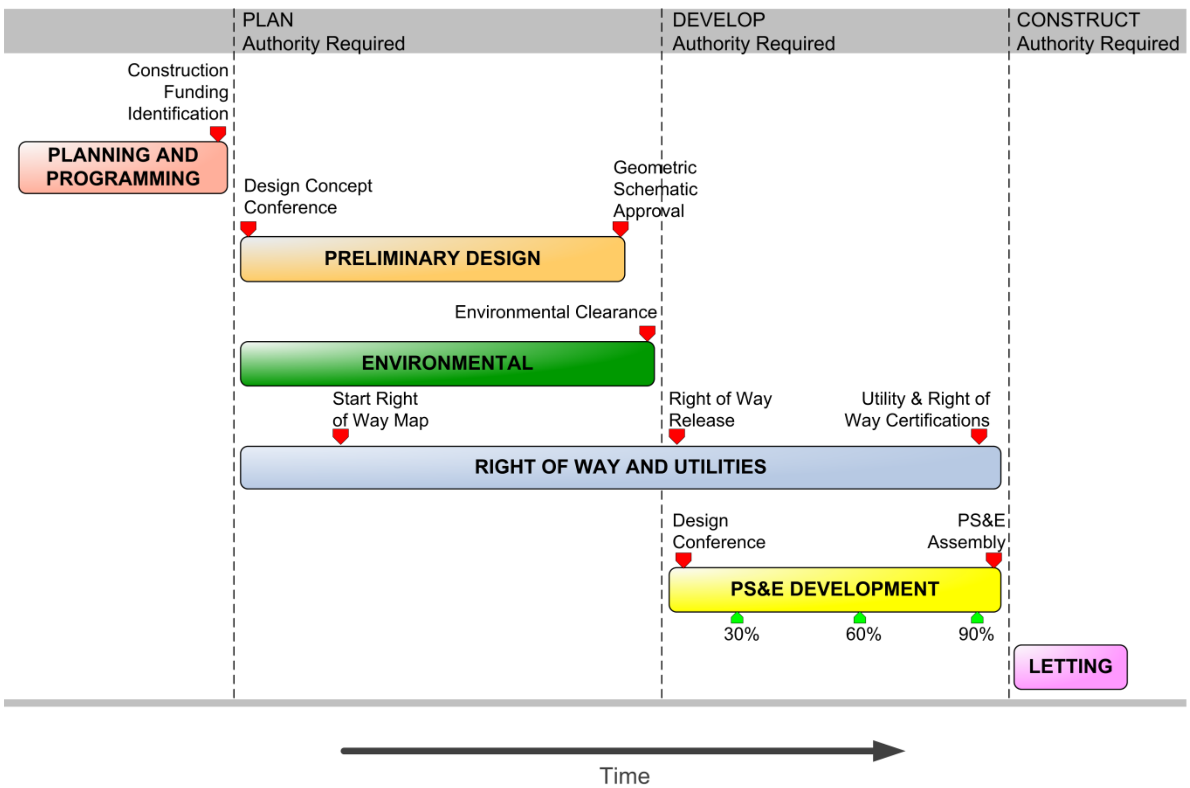


Figure 1. Major Project Development Process Activities at TxDOT (Adapted from [*6*]).

The actual project development process can deviate from the general framework in Figure 1 depending on specific project characteristics and requirements. For example, as Table 1 shows, a project could be non-freeway resurfacing or restoration (2R); non-freeway rehabilitation (3R); new location and reconstruction (4R); mobility corridor (5R); and special facilities. Different design criteria apply in each case, resulting in different groups of PDP tasks, and therefore, different project scopes, durations, and sequencing. Likewise, project delivery methods such as design-build methods can accelerate task durations and alter the sequencing of certain PDP tasks.

Table 1. Highway Project Design Criteria (*7*, *8*).

Type	Description
2R	**Non-freeway resurfacing or restoration projects**. 2R projects consist of non-freeway work on facilities with an average daily traffic (ADT) of up to 3000 and are not on National Highway System (NHS) routes, which propose to restore the pavement to its original condition. Adding through travel lanes is not permitted for 2R projects. However, adding continuous two-way left-turn lanes, acceleration or deceleration lanes, turning lanes, and shoulders are acceptable as long as the existing through lane and shoulder widths are maintained. 2R projects could include upgrading roadway components as needed to maintain the roadway in an acceptable condition.
3R	**Non-freeway rehabilitation projects**. 3R projects consist of non-freeway work that extends the service life and enhance the safety of a roadway. In addition to resurfacing and restoration, 3R projects could include upgrading the geometric design and safety of a transportation facility. However, work does not include adding through travel lanes. Work may include upgrading geometric features such as roadway widening, minor horizontal realignment, and improving bridges to meet current standards for structural loading and to accommodate the approaching roadway width. 3R projects address pavement needs and/or deficiencies and substantially follow the existing horizontal and vertical alignments. The scope of 3R projects ranges from thin overlays and minor safety upgrading to more complete rehabilitation work.
4R	**New location and reconstruction projects**. 4R projects consist of work associated with new locations or reconstructions of transportation facilities such as urban streets, suburban roadways, two-lane rural highways, multilane rural highways, and freeways. In general, the result is a new roadway or upgrade to an existing roadway to meet geometric design criteria for new facilities. In addition to resurfacing, restoration, and rehabilitation, 4R projects could include reconstruction work, which typically involves substantial changes to the road such as additional through lanes, horizontal and/or vertical realignment, and major pavement structure improvements. Reconstruction work includes bridge replacement work.
5R	**Mobility corridor projects**. 5R projects consist of work associated with new locations or reconstructions of facilities intended for high-speed mobility (i.e., design speeds up to 100 miles per hour (mph)). Mobility corridors are intended for long distance travel and could include "multiple modes such as rail, utilities, freight, and passenger" (*8*). A 5R project can include all work associated with 4R projects, but different design standards apply because of the roadway's higher design speed and multiple participating transportation modes.
n/a	**Special facilities**. Special facility projects consist of work associated with facilities that do not fall under any of the previous categories. Examples include off-system bridge replacement and rehabilitation projects, historically significant bridge projects, Texas Parks and Wildlife Department (TPWD) park road projects, and bicycle facilities.

TxDOT usually executes major maintenance projects using 2R design criteria. As a reference, there are three types of maintenance projects at TxDOT (*9*):

- **Routine maintenance**. The purpose of routine maintenance projects is to restore pavement serviceability. Examples include pavement repairs, crack seals, bituminous level-ups, light overlays to restore rideability (maximum 2 inches thick), additional base to restore rideability, and seal coats.

- **Preventive maintenance**. The purpose of preventive maintenance projects is to prevent major deterioration of the pavement. Examples include milling or bituminous level-ups to restore rideability, light overlays (maximum 2 inches thick), seal coats, crack sealing, and micro surfacing.

- **Major maintenance**. The purpose of major maintenance projects is to strengthen the pavement structure to accommodate current and projected future traffic. Examples include reconditioning and stabilizing base and sub-grade, adding base, level-ups, light overlays (maximum 2 inches thick), and seal coats. Pavement widening (as long as the travel way does not exceed 26 feet in width) can be considered maintenance if done to correct a maintenance problem.

Depending on project characteristics, requirements, and status, a highway construction project could have one of the following authorization levels (Figure 1):

- **Plan authorization (formerly Long Range Project)**. This level authorizes TxDOT districts to complete preliminary design activities and right-of-way determination, study route alternatives, perform environmental studies, and hold public hearings.

- **Develop authorization (formerly Priority 2)**. This level authorizes TxDOT districts to prepare construction plans, acquire right of way, and perform utility adjustments. Districts should substantially complete project construction plans, right-of-way acquisition, and utility adjustments prior to moving to the Construct authorization level.

- **Construct authorization (formerly Priority 1)**. This level authorizes TxDOT districts to complete construction documents and award construction contracts.

A small sample of critical documents and/or milestones associated with these authorization levels, which are related to utility and environmental activities, follows:

- **Geometric schematic approval**. For many projects, e.g., for projects requiring control of access or an environmental impact statement (EIS), the Design Division must approve geometric schematics developed in the preliminary engineering design phase before presenting the schematics at a public hearing (*6*). There are exceptions to this requirement, e.g., in the case of rural projects with few abutting property owners. If there are changes to previously approved schematics after the public hearing, the schematics must be resubmitted to the Design Division for final approval.

- **Right-of-way map**. This document includes right-of-way maps, parcel plats, and property descriptions. Preparing the right-of-way map is frequently on the critical path of project development and, as a result, it is essential to have clear, effective means to exchange accurate, relevant right–of-way documentation among all involved parties.

- **Environmental clearance**. Environmental clearance is the process by which a proposed highway project undergoes an assessment to determine potential impacts and consequences and receives clearance to continue with the next phase of development after complying with all applicable environmental laws and regulations. This process involves preparing an environmental document appropriate with the project scope, which could be a categorical exclusion (CE), an environmental assessment (EA), or an EIS. Activities also include conducting a public hearing (as required or appropriate), review and approval by the Environmental Affairs Division (for state-funded projects), and review and concurrence by the Environmental Affairs Division with review and approval by FHWA (for federally funded projects). Most projects require a CE and/or an EA because there are no significant environmental impacts. Projects that have impacts require an EIS.

- **Right-of-way release**. The right-of-way release is an authorization by the Right of Way Division to conduct specific right-of-way and utility-related activities. In reality, there are several types of right-of-way releases, as follows (*10*):

    - full release, which is the traditional right-of-way release that enables the acquisition of right-of-way parcels during the design phase, subject to the submission of documents such as environmental clearance; an approved, final geometric schematic; a right-of-way cost estimate; a district-approved right-of-way map; and approved funding agreements with local public agencies (LPAs), FHWA, and other project stakeholders if applicable;
    - partial release
    - release for advance acquisition (hardship, protective buy, and donation);
    - limited release for utility investigation;
    - partial release for utility work;
    - limited release for utility work only;
    - limited release for appraisal work only; and
    - limited release for relocation assistance only.

    All releases require a right-of-way control section job (CSJ) number. In practice, districts are encouraged to request right-of-way CSJ numbers as early as possible in the project development process to conduct activities such as utility investigations and advance acquisitions. Typical activities that can be charged to the right-of-way CSJ number include appraising, negotiation, closing of transactions, title policies, relocation assistance, eminent domain proceedings, utility agreement processing, utility adjustments, and reimbursement of eligible utility adjustment costs. Preliminary engineering costs that are right-of-way related (such as right-of-way surveys, property descriptions, right-of-way maps, utility investigations, preparing right-of-way cost estimates, and right-of-way staking) are charged to the construction CSJ, not the right-of-way CSJ.

- **Utility and right-of-way certifications**. These certifications, which are included in the PS&E package that districts send to the Design Division at the end of the design phase, document the status of required right-of-way acquisitions and utility adjustments, as well as estimated schedules for pending right-of-way acquisitions and utility adjustments.

UTILITY COORDINATION AND CONFLICT RESOLUTION PROCESS AT TXDOT

The Utility Accommodation Rules (UAR) in the Texas Administrative Code (TAC) and the TxDOT *Right of Way (ROW) Utility Manual* are the main sources of regulation and guidance for the accommodation of utility facilities on the state right of way in Texas (*11*, *12*). In addition, 23 Code of Federal Regulations (CFR) 645 describes requirements that apply to federal aid projects (*13*). The UAR and the utility manual prescribe minimums relative to the accommodation, location, installation, adjustment, and maintenance of utility facilities on the state right of way. However, they also require compliance with other applicable standards, laws, rules, and specifications that are more stringent if they provide a higher degree of protection than required in the UAR (*11*). The rules and guidelines can be traced to utility accommodation policies and guides developed by the American Association of State Highway and Transportation Officials (AASHTO) (*14*, *15*).

The *ROW Utility Manual* describes a utility cooperative management process (UCMP) (called "the process") that TxDOT encourages districts to use for managing utility-related activities in the PDP (*12*). This process includes the following 10 high-level process activities (Figure 2):

- **Activity I (annual meeting)**. TxDOT districts schedule annual meetings with utilities after the Statewide Transportation Improvement Program (STIP) is approved. The purpose of the annual meeting is to present STIP project listings to utilities and examine projects from the utility owners' perspective to identify potential conflicts and impacts. The meeting is also a forum for utilities to provide information about their budget cycles, plans, construction schedules, and customer service requirements.

  It is worth noting that a number of jurisdictions also have utility coordination councils that meet on a regular basis, e.g., monthly, to discuss issues of common interest. Members of the councils typically include representatives of utility owners, transportation agencies (including TxDOT), city and county governments, and other stakeholders. These meetings provide a forum to discuss issues, increase awareness about upcoming infrastructure projects, and encourage collaboration and partnering.

- **Activity II (initial project notification)**. TxDOT provides a preliminary project description, scope, and letting schedule to utilities. TxDOT also sets a date for the design concept conference and requests contacts from utility owners to be assigned to the project.

- **Activity III (preliminary design meeting)**. This activity, now renamed as Design Concept Conference in the PDP manual (*6*), provides an opportunity for TxDOT and utility representatives to discuss general project characteristics, anticipated schedule, and potential impact on utilities before the preliminary design phase starts. This activity also calls for the identification of the anticipated level of involvement by utilities during the preliminary design phase.

- **Activity IV (field verification)**. This activity involves collecting and processing data to identify ownership and other characteristics of existing utility facilities, including horizontal and vertical alignments. Field verification can be obtained using a variety of data sources and techniques, including utility owners and subsurface utility engineering (SUE) techniques.

  For a utility owner to incur reimbursable costs or for TxDOT to retain a SUE consultant, it is necessary to have a right-of-way release in place. In practice, field verifications take place both during the preliminary design and design phases.

- **Activity V (design conference)**. As part of this activity, TxDOT and utility owners discuss design concepts and criteria, right-of-way issues, utility adjustment issues, utility bid process and contracting options, design schedules and construction timelines, and schedule for progress tracking meetings. Utility adjustment issues include need, justification, and scope of work for proposed utility adjustments, UAR compliance, and potential TxDOT design modifications to minimize utility conflicts.

- **Activity VI (intermediate design meetings)**. As part of this activity, there may be several meetings between TxDOT and utility stakeholders at the completion of design stages such as 30, 60, and 90 percent highway design. Participants clarify design concepts from previous meetings, track design progress by all parties, report on right-of-way acquisition, report on the progress of utility adjustments, and discuss progress on the preparation of reimbursable adjustments and escrow agreements.

- **Activity VII (final design and initial construction coordination meeting)**. As part of this activity, TxDOT and utility stakeholders establish priorities and sequencing for any remaining right-of-way acquisition and utility adjustments, discuss utility adjustment plans that are included in the highway contract, finalize details for the preparation of escrow agreements, and schedule the pre-letting utility conference. The project engineer also prepares relevant utility special provisions and special specifications.

- **Activity VIII (pre-letting utility meeting)**. As part of this activity, TxDOT and relevant stakeholders identify the schedule status of items such as right-of-way acquisition, relocation, utility adjustments, and hazardous material remediation; update construction schedules for TxDOT and utility construction; announce special provisions and certifications; and finalize remaining utility designs.

- **Activity IX (utility meeting after award)**. The purpose of this activity is to identify utility construction representatives, establish construction start date (and date of preconstruction conference if held separately), and update status of right-of-way acquisition and utility adjustments. This meeting takes place after award and before construction starts.

- **Activity X (utility coordination meeting during project construction)**. The purpose of this activity is to provide continuous coordination of utility adjustments during the highway construction phase. The frequency and format of meetings for this phase of coordination is at the discretion of the TxDOT project construction engineer.

A component of the UCMP is a utility adjustment sub process (called "the sub process") that describes utility adjustment activities in more detail. The sub process includes descriptions for four major procedures: (a) the federal utility procedure (FUP), (b) the state utility procedure (SUP), (c) the local utility procedure (LUP), and (d) the non-reimbursable procedure (NRP). These procedures differ mainly with respect to contracts and responsibilities of TxDOT, LPAs, and utilities, as well as reimbursement rules and eligibility. The *ROW Utility Manual* includes separate flowcharts for the FUP, SUP, and LUP (Figure 3).

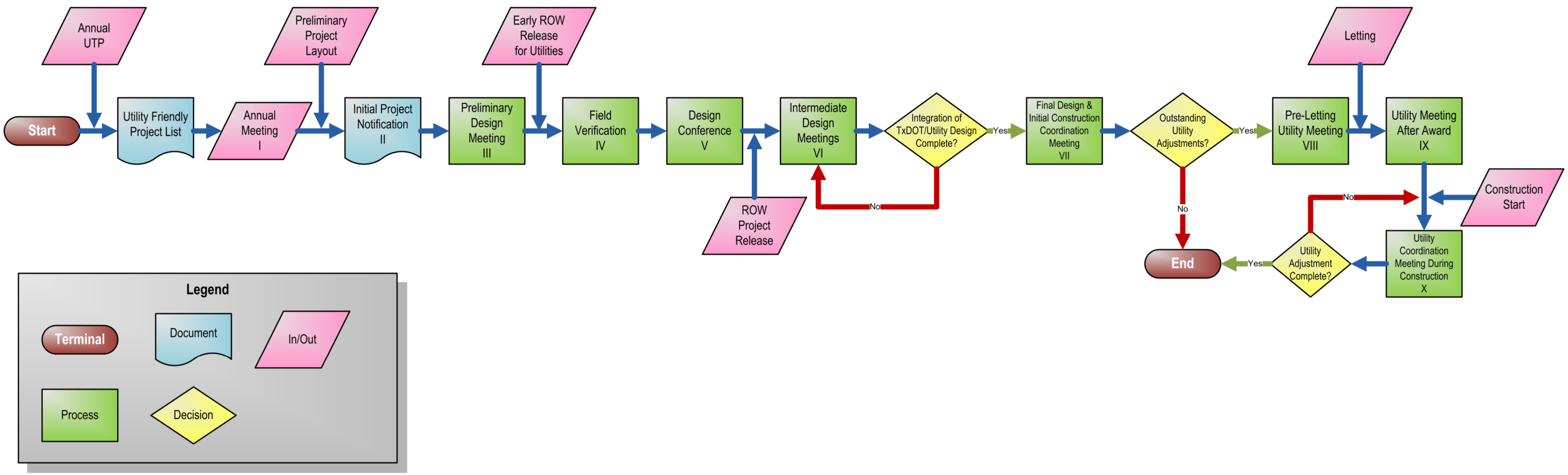


Figure 2. Utility Cooperative Management Process at TxDOT (*12*).

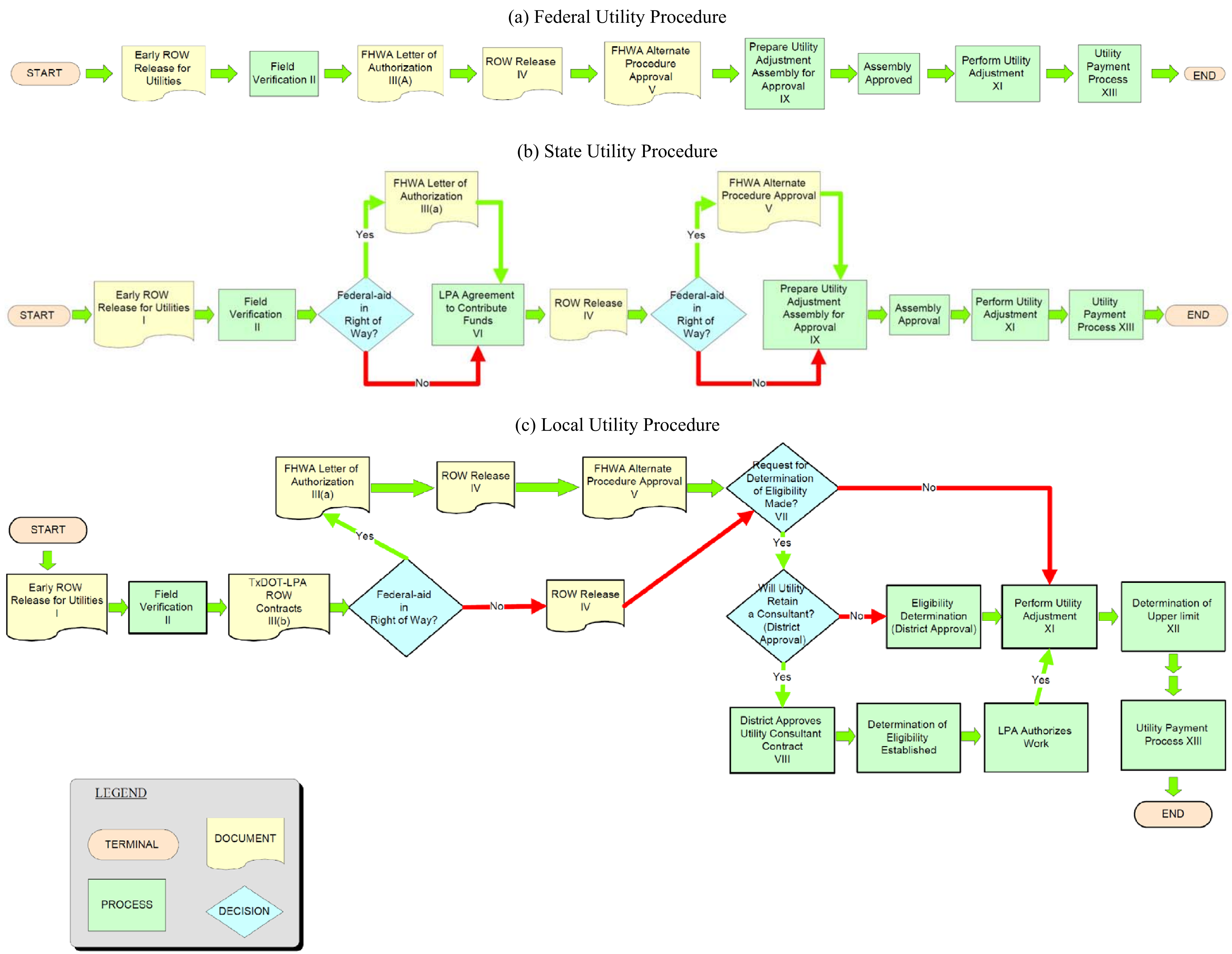


Figure 3. Sub Process Activities. Federal, State, and Local Utility Procedures at TxDOT (12).

The sub process activities are as follows (Figure 3):

- activity I (early right-of-way release for utilities), which facilitates the completion of preliminary utility activities (e.g., location determination, potential utility conflict assessment, and preliminary cost estimate preparation) before the normal right-of-way release;
- activity II (field verification);
- activity IIIa (federal project authorization and agreement (FPAA), which may be requested concurrently with sub process activity V;
- activity IIIb (TxDOT-LPA contracts);
- activity IV (right-of-way release);
- activity V (alternate procedure approval from FHWA);
- activity VI (LPA agreement to contribute funds);
- activity VII (request for determination of eligibility);
- activity VIII (district approves utility consultant contract);
- activity IX (prepare utility adjustment assembly for approval);
- activity XI (perform utility adjustment) (Note: There is no activity X);
- activity XII (determination of upper limit); and
- activity XIII (utility payment process).

Collecting accurate underground utility location information from utilities can be challenging. Typically, TxDOT sends project drawings to utilities with a request to mark up those drawings with relevant utility information. In some cases, utility owners request electronic copies of those drawings, e.g., in Bentley® Microstation™ format. Sometimes, utilities provide electronic as-builts. However, available as-builts are rarely scaled or georeferenced and come in a variety of formats, making it necessary to convert the files to a usable format and adjust their scale and alignment to match the underlying project files.

The lack of confidence in the amount and quality of information provided by utility owners is one of the reasons SUE is used to identify and locate utility installations within the right of way. The national standard guideline American Society of Civil Engineers/Construction Institute (ASCE/CI) 38-02 outlines typical activities in connection with the collection and depiction of utility data (*16*). The guideline describes a quality level (QL) attribute for individual utility features identified, as follows:

- QLD involves collecting data from existing records or oral recollections.

- QLC involves surveying and plotting visible utility appurtenances (e.g., valve covers, junction boxes, and manhole covers) and making inferences about underground linear utility facilities that connect those appurtenances.

- QLB involves the use of surface geophysical methods to determine the approximate *horizontal* position of subsurface utilities.

- QLA involves the determination of accurate *horizontal* and *vertical* utility locations through exposure of underground utility facilities at certain locations.

Collecting information about utilities through existing records, oral recollections, and surveys of visible utility appurtenances is a routine PDP practice, even in the preliminary design phase. By comparison, collecting QLB and QLA data tends to take place during the design phase—normally at the discretion of the project manager. One of the reasons collecting QLB or QLA data does not happen more often is lack of funding to support QLB and QLA data collection and lack of understanding of the perceived net benefits that collecting more detailed, accurate information about utility installations could bring to the project. In some cases, project managers know (or suspect) that most, if not all, utility facilities need to be adjusted anyway and decide that investing resources in QLB or QLA investigations is unnecessary. A relevant question is whether project managers are routinely making the correct decision in this regard. A related question, which this report addresses (see Chapter 4), is whether it is feasible to complete certain QLB or QLA activities during the preliminary design phase.

With the exception of QLA data, which involves exposing and measuring the vertical elevation of underground utility installations at designated locations, the SUE process normally produces horizontal positions (i.e., 2-D data). Technologies such as ground penetrating radar (GPR) and electromagnetic inductive (EMI) arrays are increasingly making it possible to obtain 3-D imagery and depictions of utility installations. This availability is causing some vendors and practitioners to use terms such as "QLB-Plus" or "QLA-Minus" (perhaps due to the lack of a more appropriate qualifier) when referring to elevation data obtained using GPR or EMI array geophysical methods that use 3-D image processing capabilities.

Utility owners are already required, through laws and regulations, to provide adequate, sufficient information about their facilities. Likewise, TxDOT is required to provide timely, adequate information to utility owners about the location of proposed transportation projects. Examples of relevant provisions in regulations, e.g., TAC (*11*), and laws, e.g., the Texas Utilities Code (*17*), follow:

- 43 TAC 21.22 (a) requires TxDOT to provide adequate plans to enable utility owners to determine the future location and characteristics of their adjusted facilities.

- 43 TAC 21.37 (b) (5) requires utility owners to assess whether other utility facilities exist in the proposed installation area and to ensure that the proposed installations are compatible with existing and approved future utility facilities.

- 43 TAC 21.37 (c) (4) requires utility owners to provide plans that include horizontal and vertical alignments of their proposed installations, relationship to existing highway facilities and right-of-way lines, and location of existing utilities that may be affected by the proposed utility facilities. Utility owners must provide this information using TxDOT's survey datum. 43 TAC 21.37 (c) (5) includes a similar requirement for as-built plans or certified as-installed construction plans after completing the adjustment in the field.

- Texas Utilities Code Section 251.107 (b) requires Class A utility owners (defined as utilities other than water, slurry, or wastewater) to provide maps, grid locations, or other identifiers indicating the location of underground facilities to a One-Call notification center and update this information as changes occur or at least quarterly. Interestingly, the notification center is not allowed to require utility owners to conduct a survey of their underground installations. As a side note, there are three notifications centers in Texas: The Lonestar Notification Center, the Texas Excavation Safety System, and the Texas One Call System.

- Texas Utilities Code Section 251.157 (a) requires Class A utility owners to mark the approximate location of their facilities on the ground before excavation starts after receiving notice from a One-Call notification center.

ENVIRONMENTAL PROCESS AT TXDOT

The environmental process, described in the *Environmental Manual* (*18*) and the *Preliminary Review Environmental Process Guidebook* (*19*), includes the following general activities:

- **Preliminary office research**. Early in the project development process, a district environmental coordinator identifies the project purpose and need, scope, and preliminary alternatives. The environmental coordinator also researches the project area using data such as available maps, databases, and survey data. Office research should help to identify environmental issues or concerns that may affect project development.

- **Field survey**. The district environmental coordinator uses on-site field surveys to identify and review existing land use, water resources, and the potential for endangered species habitat, historic and/or archeological sites, hazardous material sites, and other environmental issues that may affect project development.

- **Early coordination**. The purpose of early coordination is to identify county, state, and federal agencies that may have an interest or jurisdiction over a resource that may be affected by some aspect of the project. Early coordination is a critical step in project development to reduce project delays. Coordination typically involves, but is not limited to, historical and archeological resources, biological resources, water resources, and wetlands. Resource agencies include the Texas Historical Commission (THC), TPWD and the U.S. Fish and Wildlife Service (USFW), the Texas Commission on Environmental Quality (TCEQ), and the U.S. Army Corps of Engineers (USACE).

- **Public involvement**. The district conducts public involvement activities to receive comments on the proposed project or proposed alternatives. Public involvement activities might include public notifications, meetings with affected property owners, public meetings, and public hearings.

  The level of public involvement depends on the scope of the project. For example, small projects may only require public notification. However, large complex projects typically require extensive public involvement, including one or more public hearings. Public hearings are held when significant project impacts (or substantial project changes) are identified. An official public hearing takes place after preparing the environmental document (see below).

- **Schematic development and environmental analysis**. The district develops schematic alternatives for the proposed project and evaluates permit and mitigation requirements for alternatives.

- **Environmental document preparation**. Depending on the results of the previous two steps, the district prepares the necessary environmental document, which can be one of the following:

  - **Categorical exclusion**. A CE applies to projects that, based on previous experience, do not involve significant environmental impacts. A "programmatic" CE (PCE) applies to project types that, historically, are classified as CEs.

  - **Environmental assessment**. An EA applies to projects that do not meet requirements for a CE and for which the significance of impacts is unknown.

  - **Environmental impact statement**. An EIS applies to projects that may have significant social, economic, and/or environmental impacts.

- **Environmental review**. The Environmental Affairs Division conducts a review and approval of environmental documents. For projects with federal involvement, this phase includes review and approval by FHWA.

Memoranda of understanding (MOUs) between TxDOT and resource agencies provide formal communication protocols at specific stages in the project development process, primarily after the design concept conference, i.e., after the environmental process starts (*18*). Typically, the MOUs document agency responsibilities related to the review of a highway project and its potential environmental, historical, or archeological impacts; type and timing of information TxDOT must provide; resource agency review timeframe; and other necessary agreements. Following 6 Texas Transportation Code (TTC) 201.607, the MOUs need to be examined and revised every five years (*20*). A brief overview of each MOU follows:

- **MOU with TCEQ**. This MOU focuses on projects that can potentially affect air or water quality and specifies that environmental documentation must comply with NEPA requirements and other environmental rules. In general, TxDOT submits projects requiring an EIS after they have been approved by FHWA (federal aid projects) or TxDOT (state projects).

- **MOU with TPWD**. This MOU focuses on projects such as those with channel modifications, channel realignments, potential effects on mature woody vegetation, or potential effects on threatened or endangered species. In this case, the coordination involves information related to the occurrence of unique or important wildlife, habitats, ecosystems, or other natural resource information, as well as concurrence on potential impacts and mitigation strategies.

- **MOU with THC**. This MOU focuses on projects with a potential to adversely affect cultural resources. The MOU states that TxDOT must identify projects requiring archeological investigation as well as projects that do not require coordination for archeological sites. The MOU also states the TxDOT must identify historic properties within project limits and conduct field surveys for all projects with potentially affected historic properties.

- **MOU with the General Land Office (GLO)**. This MOU focuses on the use of state-owned real property under management of the GLO for highway right-of-way purposes. The MOU states that environmental issues regarding GLO–managed property must be addressed at the USACE Joint Processing Meeting (if USACE has jurisdiction over the affected property, otherwise during the project development process with the appropriate environmental agencies). The MOU also stipulates that all government agencies responsible for the protection and preservation of public lands must coordinate a single environmental response.

A common environmental liability affecting transportation development is the occurrence of contamination on TxDOT-owned or TxDOT-managed property. If the contamination from hazardous substances occurs in the right of way, TxDOT can be responsible regardless of whether TxDOT caused or knew of the contamination. TxDOT can be responsible if it is any of the following:

- a current owner or operator of the facility,
- a former owner or operator at the time of disposal of the hazardous substance,
- the party who arranged for disposal, or
- the party who transported the substance.

Environmental liability may be "joint, several, and strict," meaning that any party identified as responsible must share the cost of cleanup. The most common way to minimize liability is by assessing and managing potential environmental risks as they are discovered, exercising due diligence, and in some cases, using indemnification. Due diligence should involve taking all reasonable measures necessary to minimize liability.

The characterization of hazardous materials is an integral component of the environmental process (*18*, *21*). Following the *Environmental Manual* (*18*), TxDOT's actions to address hazardous material impacts in the PDP are progressive, starting with an initial site assessment (ISA) (which TxDOT recommends for all projects), followed by additional environmental investigations as warranted. It is possible to conduct the ISA as soon as there is reasonable assurance that TxDOT has identified project alternatives.

The additional investigations for hazardous materials could include a Phase I environmental site assessment (ESA) and a Phase II ESA, as follows:

- The Phase I ESA is typically a qualitative investigation using visual observations and review of existing data to recognize potential hazards. It focuses on the discovery of environmental conditions that could affect the intended use of a property.

- The Phase II ESA is a quantitative investigation that involves collection of samples to further define or characterize suspected environmental hazards or risks. This phase could include both non-intrusive geophysical surveys and intrusive sampling of surface water, soil vapor, soil, and groundwater.

It is interesting to note that the distinction between Phase I and Phase II environmental site investigations is somewhat analogous to the distinction between preliminary utility investigations (i.e., QLD and QLC) and more detailed utility investigations (i.e., QLB and QLA) described previously.

Additional tools are available to identify sites that involve the storage, treatment, or distribution of hazardous materials. For example, TCEQ maintains a database of petroleum storage tank facilities and leaking petroleum storage tank facilities. TCEQ also maintains a database of registered hazardous waste generators and waste storage facilities.

Field surveys, data collection, coordination, public involvement, and environmental analysis can extend to the environmental impact associated with existing utility installations. However, the actual focus on existing utility installations is minor compared to other environmental concerns. For example, the *Environmental Manual* (*18*) mentions the word "utility" (in relation to utility installations or adjustments) 14 times and "storage tank" 14 times. In contrast, the same manual mentions "endangered species" 32 times and "habitat" 67 times. The manual also indicates that information about proposed utility adjustments is necessary for the evaluation of potential hazardous material contamination sites. However, the determination of utility adjustments and the development of utility adjustment plans are only normally carried out in the detailed design phase (i.e., after the environmental analysis is usually completed), rendering the requirement to take into consideration proposed utility adjustments irrelevant in practice.

TxDOT's goal is to complete the environmental process prior to the beginning of the engineering design phase. Due to unforeseen circumstances or a compressed letting schedule, the environmental process may stretch into the engineering design phase. Whenever possible, TxDOT tries to avoid this situation because a negative outcome of the environmental process can have a significant impact on project design and/or delivery, therefore increasing TxDOT's risk. In addition, TxDOT does not want to convey the message that it might be "rubber-stamping" the environmental process by developing detailed design plans concurrently with or before completing the environmental analysis.

Several federal laws and regulations govern the environmental process, including the following:

- The National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S. Code (USC) 4321 and following), requires the use of an interdisciplinary approach in planning and decision making for actions that affect the environment (*22*). It requires an assessment of environmental impacts on human environment and consideration of alternatives and mitigation where feasible.

- 23 CFR 771 and 40 CFR 1500-1508 contain federal environmental regulations that are the basis for surface transportation projects (*23*, *24*). In general, 23 CFR 771 requires documentation to demonstrate compliance, an evaluation of alternatives including a no-build alternative, public involvement, and mitigation when necessary. 40 CFR 1500-1508 include procedures for the implementation of NEPA requirements, including how to reduce the length of required assessments and how to reduce project development delays caused by NEPA-required activities. Examples of delay reduction strategies mentioned in the regulation, which are relevant to this research, include the following:

    - integrate the NEPA process into early planning;
    - emphasize interagency cooperation before preparing environmental documents, rather than submitting adversary comments on completed documents;
    - use the scoping process for an early identification of real issues;
    - establish appropriate time limits for the environmental document preparation process;
    - prepare environmental documents early in the process;
    - eliminate redundancy with state and local procedures by providing for joint preparation of environmental documents; and
    - combine environmental documents with other documents.

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended (42 USC 9601 and following), addressed uncontrolled releases of hazardous substances and, in particular, assigned liability to responsible parties to clean up uncontrolled hazardous waste sites (*25*). The 1980 act is also known as the Superfund Act. The Superfund Amendments and Reauthorization Act (SARA) of 1986 revised CERCLA and extended the taxing authority for the Superfund Trust Fund (*25*). It also led to passage of the Emergency Planning and Community Right-to-Know Act (EPCRA), also known as SARA Title III (*26*).

MEETINGS WITH STAKEHOLDERS

The researchers scheduled a series of meetings throughout the state to understand how different TxDOT units implement different PDP phases and activities, gather input from stakeholders about pressing utility and environmental issues, and identify and discuss potential strategies to integrate utility and environmental processes.

There were two rounds of meetings. The first round included meetings with representatives of several divisions (Right of Way, Environmental Affairs, and Design) and districts (Amarillo, Bryan, Corpus Christi, Dallas, Fort Worth, Lubbock, and San Antonio). This round also included a meeting with FHWA Texas Division officials. The second round of meetings took place at the Houston, San Antonio, and Tyler Districts at the end of the research. These final meetings focused on lessons learned, additional discussions about the proposed strategies, and discussions about educational and information dissemination materials.

To assist in the discussion with stakeholders, the researchers generated a detailed activity-level swim lane diagram of the project development process using information from various manuals and flowcharts. Feedback from stakeholders at various meetings enabled the researchers to modify the swim lane diagram as needed. The current version of the swim lane diagram is product 0-6065-P2 and reflects recommended locations of certain PDP tasks that resulted from the development of strategies for integrating utility and environmental processes more effectively. Chapter 4 provides more information about those strategies. Chapter 5 provides more information about the methodology used to develop the activity-level swim lane diagram. In general, the swim lane diagram is intended as a living document that can undergo modifications and updates in response to feedback from stakeholders.

Feedback provided by TxDOT officials during the various meetings included the following:

- **Share of Categorical Exclusion Projects**. Most projects, regardless of the type of district (rural or urban), are relatively small projects that only require a CE environmental document. The number of projects in development that require an EA or an EIS at any given time is small compared to the number of projects that only require a CE. EAs and EISs are typically required for new capacity or new location projects. CEs are normally required for rehabilitation projects that do not include new right of way, added capacity, and do not involve significant social, economic, or environmental impacts. Districts tend to complete CEs in-house and rely on consultants for EAs and EISs. Districts highlighted the need to develop environmental process diagrams that specifically depict the difference in requirements between CEs, EAs, and EISs.

- **Purpose and Need Statements**. Both *Environmental Manual* (*18*) and *Project Development Process Manual* (*6*) include a requirement to prepare a purpose and need document to assist with the identification of environmental requirements. Practices vary among districts regarding the use, timing, and content of this document. For example, it is common to develop a purpose and need document early during the preliminary design phase and update it as needed throughout the project development process (at least through the completion of the environmental process). However, some districts only formalize the purpose and need document around the time of selection of geometric schematic alternatives. In other cases, districts do not prepare a purpose and need document if the only environmental document required is a CE or if the project is a minor project. Districts that prepare purpose and need documents early noted that this practice offers many advantages, including helping the districts to better define the project scope and associated requirements.

- **Environmental Constraint Maps**. Districts use environmental constraint maps early in the environmental process for major projects and projects with a potential for environmental impacts. These maps indicate locations where there might be an impact from an environmental perspective based on the occurrence of sensitive receptors such as schools, public lands, historical sites, churches, river streams, or wetlands.

For the production of the maps, districts use available databases and visual observations. The maps might include obviously major utility facilities, such as high pressure gas pipelines, electric transmission lines, or pump stations, but not necessarily distribution-level facilities or facilities that give the impression on the surface to be relatively "minor," e.g., communication hubs or cable vaults. However, ignoring elements that might appear to be deceptively minor, e.g., small communication hubs, can have serious impacts during design and construction if overlooked during the evaluation of potential constraints. Adding those elements to constraint maps is not a departure from current practice considering that districts frequently indicate on the maps potential areas where there might be significant project delays. Districts highlighted the importance of relying on relevant expertise and experience in determining what elements to include in the constraint map. While districts—and sometimes the Environmental Affairs Division—can prepare environmental constraint maps, it is common to rely on consultants to complete this activity.

It is not common to depict the location of underground petroleum storage tanks on environmental constraint maps under the presumption that the hazardous material analysis already handles the identification of those facilities.

- **Unreported Environmental Hazards**. Schematic development and the environmental process are highly iterative. Normally, the final geometric schematic only happens after preparing the draft environmental document and completing the hazardous material analysis. Districts typically identify hazardous materials by using searches on databases of reported hazardous materials, leaving the discovery of unreported hazards (such as undetected leaking underground petroleum storage tanks or asbestos cement pipes) to the construction phase. The challenge is that districts are absorbing that risk but there is currently not a tool implemented at TxDOT to help the districts measure or estimate the impact of that risk during the project development process.

- **Use of the Term SUE**. Some TxDOT officials expressed reservations about the use of the term "SUE" in connection with utility data collection activities during the project development process, and recommended using alternative terms such as "utility investigations" or "utility exploration." It is worth noting that the level of awareness about standard guideline ASCE/CI 38-02 varied considerably, ranging from no knowledge at all to familiarity with the different quality levels and basic SUE concepts and definitions.

- **Utility Investigations at Different Quality Levels**. Districts frequently have a good idea about existing utility installations on the right of way (but not necessarily their accurate locations) in the case of projects on existing right of way. For projects on new right of way, knowledge about existing utility installation is normally very limited. For the initial utility research phase (i.e., QLD), districts tend to rely on visual observations on the ground and, to a lesser extent, on existing utility permit records. There is considerable variability in document retention practices for utility permit documentation. In addition, the quality of the information that utility companies provide during the permitting process is frequently questionable (and the final location on the ground frequently does not match the information provided with the permit application), reducing the long-term usability of this data resource.

At the discretion of the project manager, districts conduct QLB utility investigations during the design phase when there is reason to believe that some locations might be problematic, e.g., based on the results of the QLC investigation. Districts rarely conduct QLA work. The complexity of the project is usually the main criteria element to determine the required quality level, e.g., a full corridor reconstruction project might warrant QLB and QLA utility investigations, but a bridge rehabilitation project would not. Projects in rural areas rarely undergo QLB and QLA utility investigations.

- **Impact of Unplanned Utility Conflicts on Project Schedule and Cost**. Particularly for major projects, it is common to experience delays during construction because of unplanned utility conflicts. One district official estimated that more than half of all major projects included some type of utility-related delay during construction. However, measuring the total impact on the project can be difficult. For example, highway contractors might adjust their schedule by reassigning resources to other job fronts in order to minimize the total impact of the unplanned utility conflict on the overall project schedule. Furthermore, not all unplanned utility conflicts have a financial impact on the project, e.g., if the highway contractor is able to transfer resources to other fronts and the contractor's total cost does not vary, or the utility company absorbs all the costs related to the unplanned adjustment.

  If appropriate, districts and their highway contractors use change orders to address unplanned utility-related activities. Although change orders address the vast majority of modifications during the construction phase, contractors have additional options, including dispute resolutions and (if a dispute resolution does not work) delay claims. There are many more utility-related change orders than delay claims. Chapter 6 includes a detailed analysis of utility-related change orders and delay claims at TxDOT.

- **Swim Lane Diagrams for Different Design Criteria**. District officials recommended the development of separate PDP swim lane diagrams for different design criteria. Some officials also recommended the development of customized diagrams for individual projects as well as exploring the feasibility of connecting those diagrams with project scheduling software such as Oracle® Primavera®. As described in Chapter 5, the swim lane diagram developed in the research is generic and can be adapted to a wide range of project types or characteristics because the level of disaggregation of the swim lane diagram is at the activity level. This characteristic would make it possible to develop swim lane diagrams for different project design criteria (e.g., 2R, 3R, or 4R in Table 1) or for individual projects. It may be possible to generate swim lane diagrams for different project classifications, e.g., bridge replacement (BR), widen freeway (WF), or restoration of existing road (RER), as described in the *Design and Construction Information System (DCIS) User Manual* (*27*). These classifications provide the opportunity for more disaggregation than the project design criteria classes (and therefore more swim lane diagram options), but it is not clear at this point whether a finer level of disaggregation would be desirable.

- **Low-Level versus High-Level Surveys**. Detailed topographic information is a prerequisite for the definition of many design features. Increasingly, high-resolution, low-altitude aerial photography is available during the preliminary design phase. TxDOT districts frequently team with local agencies (e.g., counties, 9-1-1 districts, appraisal districts, and cities) to collect aerial imagery for a wide range of applications, such as transportation planning, 9-1-1 emergency communications, property tax assessment, and routing. For this type of applications, it is common to collect six-inch resolution aerial imagery, but not necessarily contour elevations.

  A challenge in connection with the acquisition of high-resolution, low-altitude photography during the preliminary design phase is cost effectiveness. This situation is particularly evident in situations in which land use changes rapidly and/or the preliminary design phase takes a long time to complete (rendering the imagery obsolete and forcing the acquisition of new imagery before that phase is complete). Cost of acquisition is an important factor. For example, a low-level survey (2-3 inches in vertical accuracy for a 1,000-ft wide corridor) could cost three times as much as a high-elevation survey (about 1 foot in vertical accuracy for a 3,000-ft wide corridor). In most cases, the high-level survey would be adequate for developing a preliminary digital terrain model (DTM) that enables alternative analysis and the preparation of an approved schematic. To address the issue of cost, one district is considering the option of a dual survey approach for rural corridors, i.e., a high-elevation survey for the planning/preliminary design phase and a low-elevation survey for the design phase.

STATE OF THE PRACTICE IN OTHER STATES

A literature review of state efforts encouraging coordination between environmental and utility processes did not yield examples of practices in this specific area. The scan did reveal examples of initiatives and business practices in related areas that could be considered for implementation at TxDOT. Some of the practices, particularly those that focus on streamlining and stewardship for fulfilling NEPA requirements, have been documented through the Federal Facilities Environmental Stewardship and Compliance Assistance Center (FedCenter) (*28*). A summary of relevant initiatives and practices found follows:

- The Tennessee Department of Transportation (TDOT) implemented an agreement with resource agencies in 2008 called the Tennessee Environmental Streamlining Agreement (TESA) to encourage a coordinated process with those agencies (*29*). The agreement uses "concurrence points" to identify agency concerns about project delays at four key milestones: purpose and need, project alternatives, preliminary draft environmental document, and preferred alternative. A concurrence point is a point where the lead agency requests formal concurrence and the participating agencies provide concurrence or non-concurrence at that stage before proceeding to the next step. More than a dozen resource agencies participate in the agreement.

- The Florida Department of Transportation (FDOT) implemented a process called Efficient Transportation Decision Making (ETDM) that includes an Environmental

Technical Advisory Team (ETAT) (*30*). This team provides coordination services throughout the entire project development process (including long-range transportation planning, programming, schematic design, and design). FDOT uses the ETDM process for all new capacity projects. A more detailed description of the ETAT concept is included in Chapter 4 (under Strategy "Establish Planning Advisory Teams and Support Tools").

- The Maine Department of Transportation (MaineDOT) developed a process called Integrated Transportation Decision-Making (ITD) Process to assist with the planning and development of high profile projects that require an EA or an EIS, i.e., roughly about 10 percent of all projects (*31*). ITD includes 10 steps, including a first step integrated into the transportation planning process. Other activities associated with ITD included a departmental reorganization, a revised PCE process, and monthly meetings with resource agencies. MaineDOT plans to extend the ITD experience to other PDP aspects.

- The Georgia Department of Transportation (GDOT) implemented an interactive training course on methods to determine and avoid utility impacts during design using a process called "utility impact analysis" (*32*). The primary tool of this analysis is a utility conflict matrix that lists all potential utility conflicts. During training, some specific conflicts are reviewed in detail to give the audience a better understanding of how the utility conflict matrix is used and the benefits that can be derived. The training includes a discussion on the costs to adjust a utility, the adjustment process, and the potential impacts on the construction schedule. The training also includes a discussion of the cost to redesign highway features around utility conflict areas and the resulting cost-benefit analysis. The course emphasizes that the financial burden in connection with utility conflict impacts is ultimately absorbed by ratepayers, which are the same as taxpayers.

- The Minnesota Department of Transportation (Mn/DOT) re-engineered its utility coordination process, incorporating national best practices while retaining practices that previously worked well in Minnesota (*33*). To introduce the new coordination process, Mn/DOT developed a two-day training course for Mn/DOT staff, utility owners, consultants, and local government representatives. The two-day course gives Mn/DOT staff and appropriate external parties insight into the new utility coordination process as well as general proactive utility coordination practices. Worth noting in the Mn/DOT practice is the use of Gopher State One Call (GSOC) to request information from utilities at critical points in the PDP, including early identification of utilities, utility verification during design, and before excavation.

- The Michigan Department of Transportation (MDOT) re-designed its utility conflict tracking system in an effort to optimize processes such as updating data, utility relocation tracking, and creating and managing standard forms and other documents. Prior to 2008, MDOT used a process that enabled tracking of utility companies and their associated MDOT control section number(s), but did not allow reliable tracking of utility adjustments (*34*). System enhancements were limited due to the program design platform, and many MDOT offices used some type of Microsoft Word or Excel document to supplement the existing application. The new system provides a snapshot of all utility conflicts, their status, and information such as whether utility relocation has been identified, whether coordination information has been provided to bidders, and whether the utility work is included in the highway contract.

CHAPTER 3. REGIONALIZATION IMPACTS

INTRODUCTION

The TxDOT regionalization initiative is one of the results of the 2009 sunset review process. In August 2007, in preparation for this process, TxDOT submitted a self-assessment to the Sunset Advisory Commission (*35*). In July 2008, Sunset Advisory Commission staff produced a report that included six major recommendations for changes at the department (*36*). One of the recommendations was to increase the transparency of the transportation planning and project development process at TxDOT. In addition to the self-assessment, TxDOT hired consultants to review a number of management and business practices at the department. A review of field operation practices revealed a need for a regionalized approach to increase the efficiency and effectiveness of certain functions and services (*37*). In April 2008, TxDOT established three internal teams (executive, core, and resource) to develop recommendations for implementing organizational and operational changes needed to adopt a regional approach to operations (*38*). In July 2008, the core team recommended a phased approach to restructuring TxDOT using a regionalized structure. In September 2008, TxDOT formed 18 workgroups that conducted workshops to develop plans for regional support centers (RSCs), review current business processes, and determine recommendations for TxDOT's future business operations using four regional centers (Figure 4). The workgroups finalized their reports in November 2008.

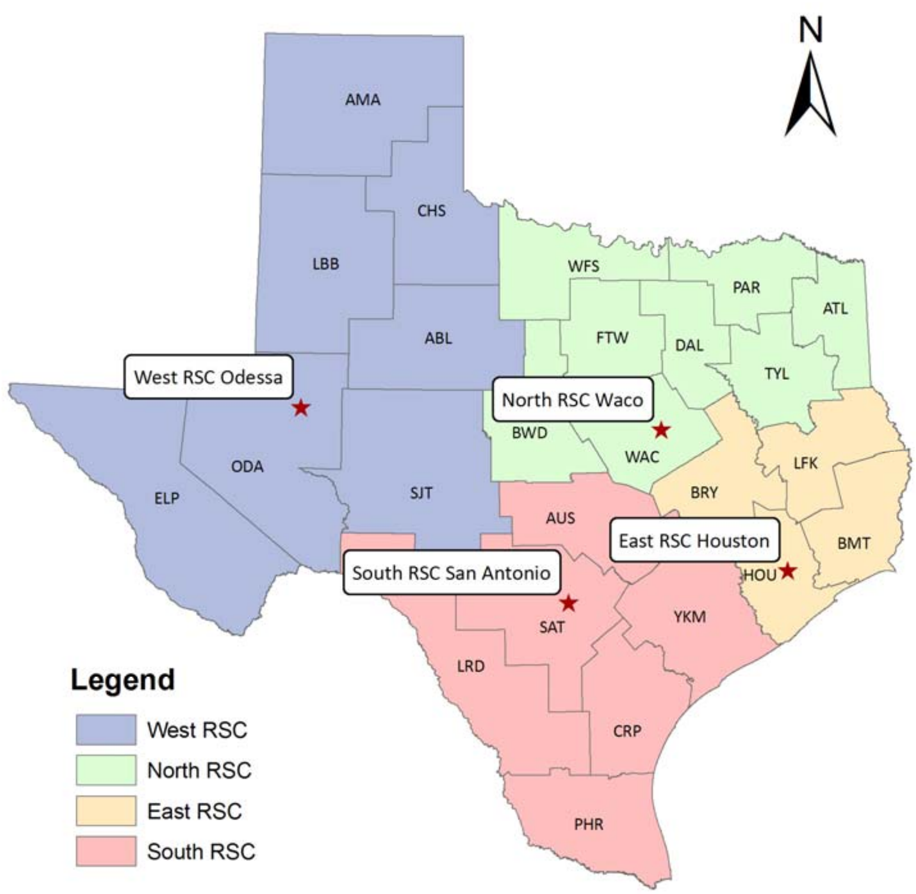


Figure 4. TxDOT Regional Support Centers.

The researchers evaluated the potential impact of regionalization on the optimization strategies developed during the research and/or the integrated business process diagram. This chapter summarizes the results of that evaluation. Chapters 4 and 5 provide more information about the optimization strategies and the business process diagram, respectively. The analysis was conducted at a high level because the regionalization is currently underway and because the amount and detail of the information available on the regionalization plans was limited. The 2008 regionalization workgroup reports and some additional related documents were the main sources of information available.

Of particular interest were the following workgroup reports: environmental, right of way, corridor planning and schematics, and contract management and design resource coordination (*39, 40, 41, 42*). The following sections summarize the impacts and recommended changes to TxDOT environmental or right-of-way business processes.

IMPACTS ON ENVIRONMENTAL BUSINESS PROCESSES

The focus of the environmental workgroup was to outline recommendations for restructuring the PCE review and approval process and the creation of environmental RSCs (called Regional Environmental Centers (RECs) for Excellence in the workgroup report) (*39*). Other processes, e.g., those related to the production of EAs and EISs, were not affected by the restructuring effort.

A review of the environmental workgroup report revealed a number of activities that were not documented in the *Project Development Process Manual* or the *Environmental Manual* (*6, 18*), making it difficult in some cases to determine if those activities were new activities or activities that already were standard practice but not documented in the manuals. Some workgroup recommendations made changes to the hierarchy of documented activities, e.g., several activities in the workgroup report were documented as subtasks of other activities in the manuals. In any case, the researchers compared these changes to the environmental business process model the researchers developed during the research and made changes as needed. This section provides a summary of process changes with a focus on reassigned, new, or previously undocumented activities at districts, RSCs, and the Environmental Affairs Division. The summary does not include activities that do not fit within the focus of the business process model, such as training activities and administrative procedures.

Potentially new or previously undocumented activities at the *district* level include the following:

- **Quality assurance/quality control (QA/QC) activities**. Districts follow newly established TxDOT standards of uniformity (SOUs) in the development of a PCE, perform QA/QC on the PCE documentation, and request exceptions when necessary. Districts also make recommendations for changes to SOUs when appropriate.

- **Populating or maintaining TxDOT databases**. Districts assure that environmental permits, issues, and commitments (EPICs) are in the Environmental Tracking System (ETS) (*43*); that EPICs are complete; and that all required ETS tabs, including public involvement, natural resource management (NRM), and hazardous materials management (HMM) are completed.

- **PCE determination**. Districts keep supporting documentation for the PCE decision, certify that PCE criteria are met, submit documents to RSC for review and certification, and assure that post NEPA commitments are addressed.

- **Development of a PCE**. Districts perform jurisdictional water determinations and delineations, assist with preparing responses to the State Historic Preservation Office (SHPO) and others, provide mechanical trenching equipment, and conduct noise workshops when appropriate.

- **Coordination with the Environmental Affairs Division**. Districts submit requests for technical services to the Environmental Affairs Division, submit documentation needed for coordination, and provide notices of right-of-way entry or right-of-way acquisition.

New activities at the *RSC* level include the following:

- **QA/QC activities**. RSCs ensure consistency and project inclusion in approved transportation improvement programs. RSCs use SOUs to perform QA/QC on PCE documents, make recommendations for changes to SOUs, and deny or request exceptions to SOUs. RSCs maintain copies of responses to districts regarding SOU exceptions.

- **Populating or maintaining TxDOT databases**. RSCs ensure that all required ETS entries are complete prior to letter of authority clearance, certification, or forwarding to the Environmental Affairs Division. RSCs verify completion of applicable tabs in ETS, including public involvement, EPIC, NRM, HMM, and cultural resource management (CRM). RSCs are responsible for completing the ETS NEPA approval entry.

- **PCE determination.** RSCs maintain a record of PCE projects, review documents that justify PCE determinations, and provide a certification of PCE determination on final document or documentation. RSCs also certify that the outcome of post NEPA studies does not change PCE determination and forward certification to district, or elevate project to a higher NEPA level. RSCs sign letter of authority and forward letter, PCE, and certification to the Environmental Affairs Division.

- **Coordination with districts, the Environmental Affairs Division, and FHWA.** RSCs maintain a copy of requests for PCE exceptions and approval or denial from FHWA. RSCs provide support to districts upon request and assist other RSCs with available resources as needed. RSCs notify the Environmental Affairs Division periodically about outstanding permits and assist districts in developing EPICs.

Potentially new or previously undocumented activities at the *division* level include the following:

- **QA/QC activities**. The division uses SOUs to review environmental reports, studies, and activities performed by districts and the division; performs a QA/QC process on PCE documents; and generate continuous improvement recommendations. The division collects recommendations for changes to SOUs, develop new SOUs as needed, and develop a program for administering SOUs. The division reviews classification memos (i.e., PCE versus CE) and submits the classification memorandum to FHWA. The division reviews district requests for exceptions to standard FHWA practices, procedures, requirements, and guidelines, and submits requests to FHWA.

- **Populating or maintaining TxDOT databases**. The division enters coordination dates as required and scans resource agency correspondence into ETS.

- **NEPA process**. The division reviews and approves designs for surveys of historical resources, submits Texas antiquities permit applications to THC as appropriate, and maintains a record to comply with Texas Antiquities Code and National Historic Preservation Act (NHPA) of 1966 requirements (*44*, *45*). TxDOT refers to the procedures to comply with NHPA and its implementation in the Code of Federal Regulations (*46*) as the "Section 106 process."

- **Environmental compliance**. The division performs a periodic review of division, RSC, and district files in connection with PCE projects and selects a random sample of PCE documents and letters of authority for environmental compliance review.

- **Coordination of activities with districts, RSCs, and FHWA**. The division assists districts in developing EPICs as requested and obtaining scientific and professional service contracts for environmental services.

IMPACTS ON RIGHT-OF-WAY BUSINESS PROCESSES

The focus of the right-of-way workgroup was to improve efficiency, transparency, and accountability of the right-of-way and utility processes (*40*). The workgroup focused on all right-of-way functions, not just one function as in the case of the environmental workgroup. It may be worth noting that the right-of-way workgroup report included references to RSC "remote offices," but it was not clear what a "remote office" was or its functions (e.g., if it was the same as an RSC or perhaps a floating office that would provide support to one or more RSCs). For simplicity, this section does not address the "remote office" concept.

As in the case of the environmental workgroup report, a review of the right-of-way workgroup report revealed activities that were not documented in existing manuals, making it difficult in some cases to determine if those activities were new activities or activities that were already standard practice but not documented in the manuals. This section provides a summary of process changes with a focus on reassigned, new, or previously undocumented activities at districts, RSCs, and the Right of Way Division. The summary does not include activities that do not fit within the focus of the business process model, such as training activities and administrative procedures.

At the *district* level, the effect of regionalization on district business processes will be relatively minor (*40*). None of the activities mentioned in the workgroup report were reassigned or previously undocumented activities. The main change in the business process for districts is that districts will coordinate some activities with the RSCs instead of the Right of Way Division. For example, districts will submit payment requests for reimbursable utility adjustments to the RSC instead of the division. Similarly, districts will submit the final right-of-way map to the RSC for project closeout. As requested by an RSC, districts will handle communications with property owners with regard to project programming and design and provide right-of-way staking for property owners.

New activities at the *RSC* level include the following:

- **Activities previously performed by the Right of Way Division**. Examples of activities include the following: review and approve final right-of-way maps; oversee LPA contractual agreements, funding, and acquisition; setup projects in the Right of Way Information System (ROWIS), release, and close out projects; review and approve utility agreements and compensable utility adjustments; process payment requests; and monitor and manage right-of-way expenditures.

- **Coordination with districts, the Right of Way Division, and project stakeholders**. RSCs communicate with property owners and tenants regarding project impacts, assign staff to hire and manage consultants, and coordinate activities related to comprehensive development agreements (CDAs) with the Texas Turnpike Authority. RSCs also support the Assistant Attorney General by providing litigation support.

- **Management, oversight, and organization of district activities**. RSCs submit surplus real estate transaction packets to the Right of Way Division, provide cost estimates for right-of-way projects, manage the property acquisition and condemnation process, and oversee monitoring and remediation of hazardous materials. RSCs also represent districts at public meetings and hearings regarding right-of-way issues.

At the *division* level, the Right of Way Division will focus on administrative oversight, project initiation, support of the Assistant Attorney General, and development of new rules and policies. The division will continue to coordinate employee training and development, develop right-of-way consultant contracts, process relocation appeals, and maintain and archive right-of-way records such as original deeds and final right-of-way maps.

IMPACTS ON PRELIMINARY DESIGN BUSINESS PROCESSES

The focus of the corridor planning and schematics workgroup was to outline recommendations for planning and preliminary design activities that RSCs could undertake (*41*). The workgroup report concluded that corridor studies and preliminary design development could be carried out more effectively by RSCs in the case of smaller districts that have less need and, therefore, less specialized staff for both functions. Advantages of using RSCs for these activities include staff at the regional level being more knowledgeable of new design guidelines, providing increased flexibility, and helping to ensure consistency across district boundaries. The report also suggests that, in the future, RSCs might provide approval for schematics and coordination with FHWA.

A review of the corridor planning and schematics workgroup report revealed a reassignment of responsibilities, as follows. At the *district* level, districts can use RSC staff and resources to develop corridor studies and preliminary design. Smaller districts focus on project delivery, but not on conducting corridor studies and preliminary design (this responsibility is shifted to RSCs). Larger districts continue developing corridor studies and preliminary design, and RSCs augment district activities as needed. In general, if RSC staff is not available, districts can use in-house staff and/or consultants. As a result, both small and large districts need to coordinate corridor studies and preliminary design with RSCs. Since most preliminary design activities can be carried out either by a district or the RSC, the researchers did not create a new swim lane for preliminary design RSCs (see Chapter 5).

At the *RSC* level, RSCs develop corridor studies and preliminary design using in-house staff and/or consultants. RSCs are responsible for tracking projects through the planning process and managing workload in the region.

At the *division* level, the Transportation Planning and Programming Division retains most of its previous responsibilities, including development of digital terrain models, traffic demand forecasting, and coordination with FHWA. The main change for the division is that it will coordinate more with RSCs and less with districts.

IMPACTS ON DESIGN COORDINATION PROCESSES

Detailed design was not one of the 18 functional areas that TxDOT reviewed as part of the regionalization implementation initiative. However, TxDOT formed a workgroup to evaluate contract management and design resource coordination (*42*). The workgroup report concluded that RSCs could improve the management of advanced funding agreements and professional contract services as well as optimize the allocation of internal design resources, which could have an effect on how TxDOT districts develop detailed design.

A summary of recommendations by the workgroup follows. At the *district* level, districts need to identify the need for contracts, communicate the need to the RSC, and otherwise coordinate the use of resources with RSCs. At the *RSC* level, the focus for RSCs is coordination of design resources, development and negotiation of professional services contracts, payment of invoices, and development of advanced funding agreements. At the *division* level, the Design Division establishes policies and procedures, provides training to RSCs and districts, and provides reference materials and subject matter expertise.

Review of the documentation revealed relatively minor impacts of the TxDOT regionalization initiative on the development of PS&E documents. For the purposes of this research, the researchers made minor adjustments to the business process model to highlight changes resulting from the regionalization initiative, but did not create a separate RSC swim lane for PS&E development.

CHAPTER 4. EVALUATION OF OPTIMIZATION STRATEGIES

INTRODUCTION

During the review of current practices and subsequent meetings with TxDOT officials, the researchers identified a number of potential strategies to integrate the utility and environmental processes and to integrate both processes into the project development process more effectively. The list of strategies follows:

- involve environmental and right-of-way staff in planning and programming,
- coordinate environmental and utility data collection,
- require utility owners to verify utility facility information,
- gather some QLB data during preliminary design,
- include some drainage design elements during preliminary design,
- include some design elements during preliminary design,
- address utility issues in constructability review during preliminary design,
- develop and/or update curricula for utility coordination stakeholders.

The review of practices in other states did not reveal specific strategies for integrating environmental and utility processes. However, the review did reveal examples of practices that might be adapted to the situation in Texas in the context of possible optimization of processes. Specific strategies identified include the following:

- establish planning advisory teams and support tools, and
- enhance and coordinate preparation of scopes of services.

The following section includes an analysis of the strategies listed above.

ANALYSIS OF STRATEGIES

Involve Environmental and Right-of-Way Staff in Planning and Programming

Strategy Description

District officials who are not involved in planning typically charge time to a project once Plan Authorization has been issued, the project has been added to DCIS and the Financial Management Information System (FMIS), and the corresponding CSJ number has been identified. The only option for non-planning personnel to become involved in the planning and programming process before the Transportation Planning and Programming Division issues a project CSJ number is by charging to an overhead account.

During planning and programming, the only right-of-way or environmental activities likely to take place are conceptual, e.g., looking for "fatal flaw" elements such as major pipelines and utilities, potential contamination sites, and sensitive receptors. To that end, a district planner might request some limited involvement by environmental or right-of-way section staff.

Realistically, involvement of this staff is on an ad hoc basis and varies from none to very limited (e.g., a few hours as part of a preliminary site visit). The main reason cited for not involving right-of-way and environmental staff was lack of funding to support this activity. It may be worth noting that the threshold for charging time to projects with a CSJ number varies somewhat from district to district.

Involving environmental and right-of-way personnel more formally in the early stages of planning and programming would enable TxDOT to identify major environmental and right-of-way issues systematically, which, in turn, could result in time and money saved during project development and construction. There are no perceived disadvantages associated with this strategy other than some minor burden on planners to involve environmental and right-of-way personnel early in the planning and programming phase. This minor burden is expected to be even lower at districts where environmental staff members are already heavily involved in planning functions. Implementing the strategy would require allocating adequate resources for district right-of-way and environmental staff participation during planning and programming (either by using the same account that planning personnel use or by setting up a generic support account for right-of-way and environmental activities).

Changes to Business Processes and TxDOT Manuals

There are currently no formal PDP environmental or right-of-way activities before Plan authorization. Based on district feedback, activities involving environmental and right-of-way personnel could include the following:

- **Preliminary feedback to planning and programming**. To formalize the feedback some districts already receive from environmental and right-of-way personnel prior to Plan Authorization, there would be a new PDP task in the *Project Development Process Manual* as well as activities and/or references in the *Environmental Manual* and the *ROW Utility Manual*. As described in Chapter 5, the researchers added corresponding activities in the swim lane diagram (under the Environmental and Right of Way and Utilities swim lanes, respectively).

- **Annual meeting with utilities**. The *ROW Utility Manual* describes an annual meeting the director of Transportation Planning and Development at every district should schedule with utilities. The *ROW Utility Manual* also documents that right-of-way and environmental section representatives should attend the meeting. It would be advisable to create a PDP task with a corresponding four-digit PDP code in the *Project Development Process Manual*. This activity would include the development of a "utility-friendly" project list to assist in discussions with the utility industry.

- **Preliminary cost estimate**. PDP Task 1200 (Prepare cost estimate) in the *Project Development Process Manual* requires the calculation of a construction cost estimate and a separate right-of-way cost estimate, including eligible utility adjustment costs. It would be advisable to include in PDP Task 1200 a requirement to involve right-of-way staff for the development of the right-of-way and utility adjustment cost estimates.

A related recommendation would be include right-of-way section staff in the design concept conference (PDP Task 2000) and subsequent (relevant) meetings during project development. Feedback from right-of-way personnel at several districts indicates that project managers frequently do not involve right-of-way personnel until late in the preliminary design phase (and sometimes not until a project is late in the design phase). In some extreme cases, right-of-way section personnel have only learned about a new highway project from a utility owner who has been contacted by the TxDOT district during the design phase and is looking for reference information. Adequate intra-district communications would effectively address this issue.

Establish Planning Advisory Teams and Support Tools

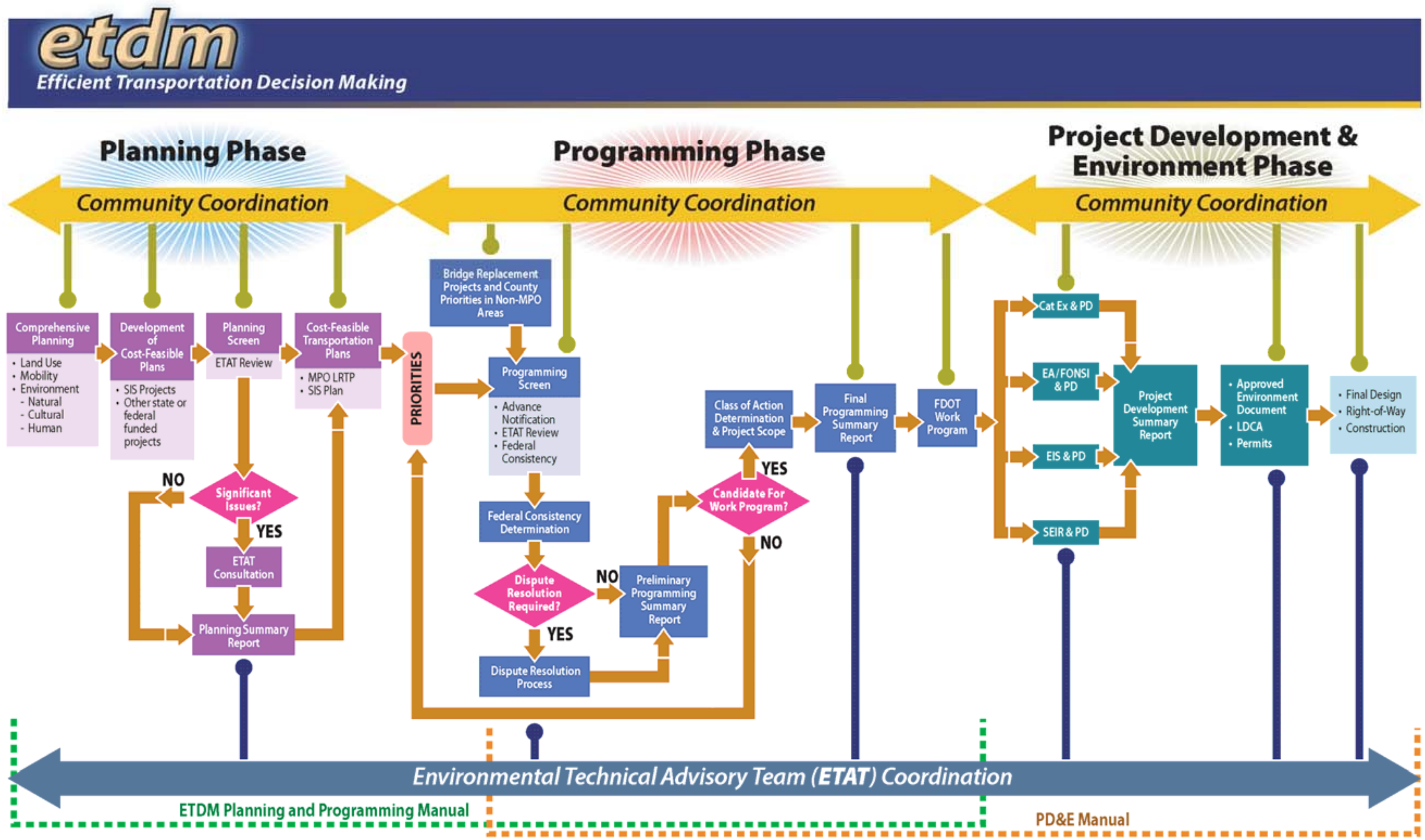
Strategy Description

Although federal regulations clarify that linking the planning process and the NEPA process is voluntary (*47*), there has been an increased awareness in recent years of the importance of using environmental data during planning and programming, i.e., prior to project selection, as a mechanism to provide early support to the NEPA process. Examples of planning strategies that support this process include providing information needed for the purpose and need statement, conducting a preliminary screening of alternatives, providing a basic description of the environmental setting, and conducting a preliminary identification of environmental impacts (*47*). In fact, a number of tools, such as the Geographic Information System Screening and Analysis Tool (GISST) and NEPAssist, which were originally developed for use within the NEPA process, are beginning to be used to support transportation planning activities (*48*).

As mentioned previously, the MOUs between TxDOT and the resource agencies provide formal communication protocols at specific stages in the project development process, primarily after the design concept conference. There are also MOUs between TxDOT and utility interests, which document the relationship between TxDOT and utility companies or between TxDOT and utility trade associations (*12*). These MOUs, which cover topics of interest during the project development process, primarily during the preliminary design and design phases, are voluntary and non-binding (as opposed to the mandatory environmental MOUs).

A complement to the strategy discussed above regarding the involvement of environmental and right-of-way personnel during planning and programming would be to formalize the relationship between TxDOT and resource agencies (in connection with environmental activities) and between TxDOT and utility interests (in connection with utility-related activities) during the planning and programming phase. This formalization would involve establishing planning advisory teams and implementing appropriate support tools. Because the nature of the relationship between TxDOT and resource agencies is different from that between TxDOT and utility interests, the purpose and structure of the planning advisory teams would be different.

An example of an environmental planning advisory team is FDOT's advisory team implementation as part of their ETDM process, which frames the environmental process within the planning and project development phases (*30*). Figure 5 illustrates that relationship.



Note: Acronyms not defined previously include the following:

Cat Ex: Categorical exclusion
FONSI: Finding of no significant impact
LDCA: Location and design concept acceptance
LRTP: Long-range transportation plan
MPO: Metropolitan planning organization
PD: Project development
SEIR: State environmental impact report
SIS: Strategic Intermodal System

Figure 5. Florida's Efficient Transportation Decision Making Process (*30*).

FDOT's ETDM resulted from a consensus process that involved 24 state agencies in Florida. Participants identified three key features to improve the environmental process: early and continuous agency involvement, good data, and opportunity for feedback. Before the implementation of ETDM, interaction among environmental process stakeholder agencies frequently started after FDOT requested a permit, which sometimes occurred well into the design phase. To avoid costly delays and disputes, the ETDM process provides two formal opportunities for agencies to review projects prior to the preliminary design phase: a planning screen and programming screen. Figure 5 and Figure 6 show the timing of the two review opportunities. For comparison purposes, Figure 6 also outlines the TxDOT project development process.

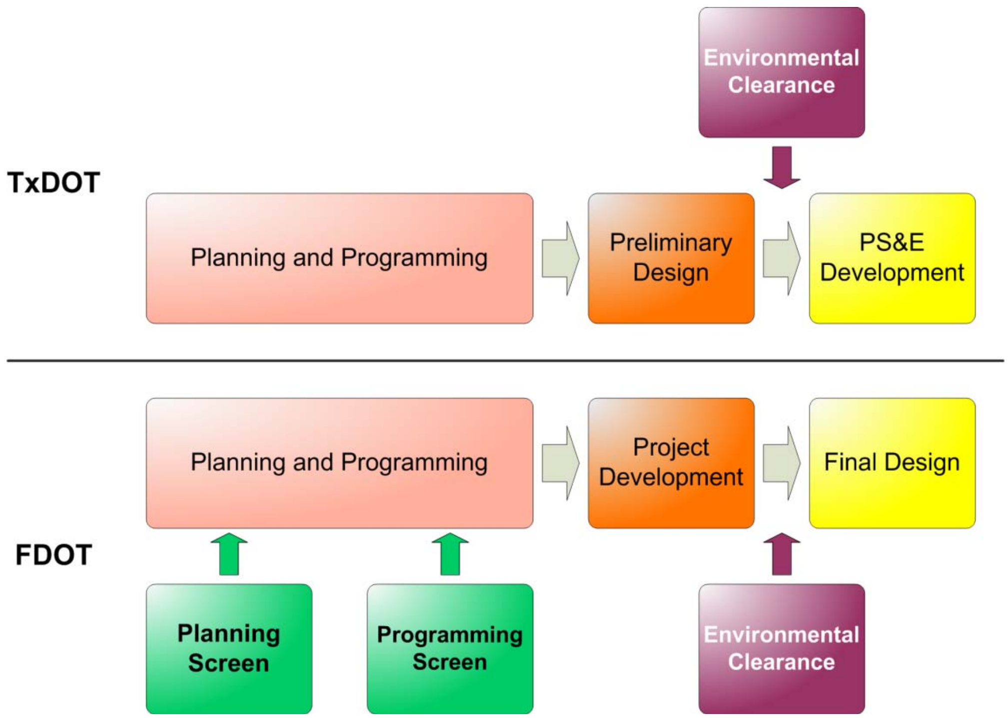


Figure 6. Planning and Programming Screens in the FDOT ETDM Process (TxDOT's PDP Is Shown for Comparison Purposes) (*30*).

The planning screen occurs around the time of preparation of long-term transportation plans to evaluate potential environmental and community effects, avoidance opportunities, mitigation requirements, and associated costs (*49*). Resource agencies review project information and communicate possible effects to project planners to help identify project configurations that minimize adverse effects. Input from those agencies may change project feasibility and cost estimates, and ultimately affect project priority.

The programming screen occurs before project selection to identify environmental issues that need to be addressed during the NEPA process. Resource agency input during the programming screen is more detailed than during the planning screen and includes a dispute resolution option. One of the benefits of the programming screen is that FDOT does not need to prove a finding of no impact by a resource agency. For example, if no resource agency has indicated a potential biological issue during the programming screen, FDOT does not need to prove this finding by conducting a biological assessment during project development (*30*). The result is a scope of work document that focuses on known technical issues. FDOT has developed a guideline that explains the types of projects that require programming screens as a function of project funding source (federal, state, or local) (*50*). Table 2 summarizes that guideline.

Table 2. ETDM Programming Screen Decision Matrix (*50*).

System	Federal Project		State Project Local		Project	
	Responsible Agency	**ETDM Screen**	**Responsible Agency**	**ETDM Screen**	**Responsible Agency**	**ETDM Screen**
State Highway System (SHS) on Strategic Intermodal System (SIS)	FDOT	Yes	FDOT	Yes	FDOT/ Local	Yes
SHS not on SIS	FDOT	Yes	FDOT/ Local	Yes	FDOT/ Local	Yes
Highway not on SHS but on SIS	FDOT/ Local	Yes	FDOT/ Local	Yes/ Local option	FDOT/ Local	Yes/ n/a[1]
Highway not on SHS and not on SIS	FDOT/ Local	Yes	FDOT/ Local	Yes/ Local option	Local	n/a1
Major Public Transit Project	FDOT/ Local	Yes/ Local option	FDOT/ Local	Yes/ Local option	Local	n/a1
Non-Passenger Rail Project	Local	n/a[1]	Local	n/a[1]	Local	n/a[1]

[1] The formal ETDM process is not applicable. However, local agencies can still use EST to manage projects.

To facilitate the ETDM process, FDOT implemented a web-based application called the Environmental Screening Tool (EST) (*30*). EST includes four major components, as follows (Figure 7):

- **Data entry**. FDOT and MPOs enter data into the system. In addition, resource agencies provide environmental data to the Florida Geographic Data Library (FGDL).

- **Geographic Information System (GIS) analysis.** Analysts apply GIS techniques to integrate the data provided in the data entry phase.

- **Project review**. ETAT members have an opportunity to provide online comments. The public has read-only access to the information, although opportunities for commenting exist through traditional public involvement activities such as workshops and hearings.

- **Summary report**. MPO and FDOT ETDM coordinators prepare a report summarizing ETAT comments and, as appropriate, specific study requirements that must be addressed during project development. Each phase of the ETDM process, including planning screen and programming screen, ends with the preparation of a summary report.

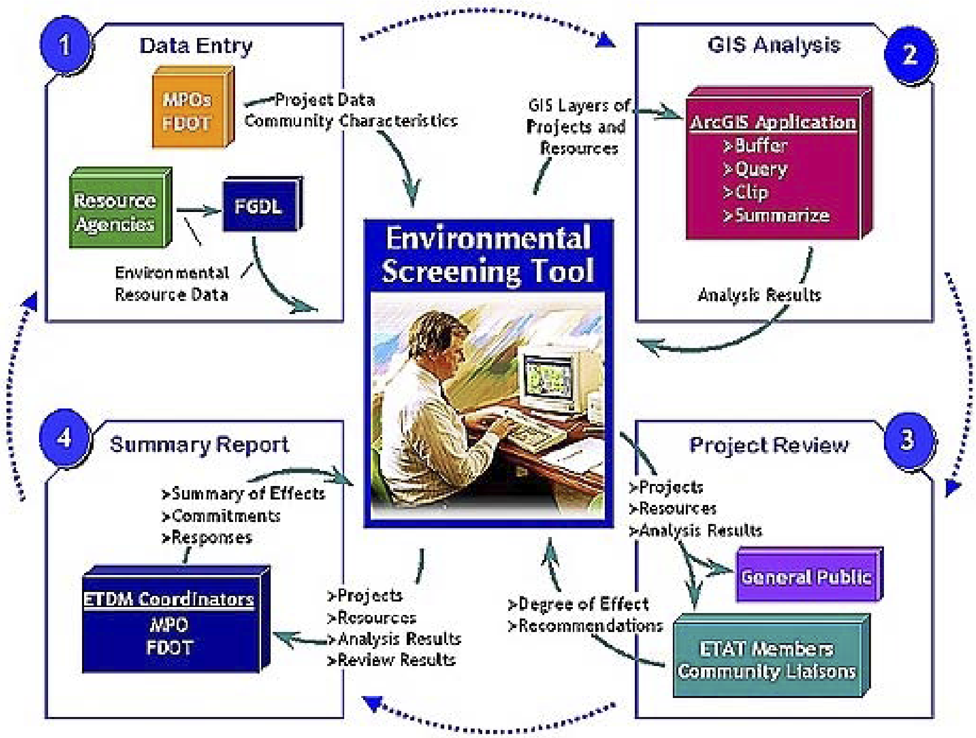


Figure 7. FDOT Environmental Screening Tool (*30*) (Courtesy of FDOT).

Benefits FDOT has reported from the ETDM implementation include the following (*30*):

- agency coordination that fosters a team approach to the identification of solutions, while minimizing contention about the need for transportation projects;
- increased awareness of potential negative project environmental impacts, resulting in modification and even project withdrawals, while enabling better environmental mitigation cost estimates;
- project development evaluations that facilitate the identification of key issues before the start of the preliminary design phase, resulting in better scopes of services and more efficient staff and resource allocations;
- improved dispute resolution process, which eliminates the need for unnecessary evaluations of project alternatives that are not consistent with protection plans;
- less costly environmental studies resulting from early resource agency feedback, leading sometimes to changes in required environmental document (e.g., PCE versus CE);
- shortened project delivery (in one case, the project development process duration was reduced from the originally expected 18-24 months to 15 weeks); and
- better access to information.

Changes to Business Processes and TxDOT Manuals

FDOT's overall positive experience with the ETDM/ETAT process indicates that a similar implementation could be beneficial in Texas. As mentioned previously, because the nature of the relationship between TxDOT and resource agencies is different from that between TxDOT and utility interests, the purpose and structure of the planning advisory teams would be different. Actions to implement the ETDM/ETAT concept in Texas to address environmental concerns include the following:

- **Strengthen and expand existing MOUs with resource agencies**. MOUs would need to include environmental coordination during planning and programming. For the most part, the MOUs with resource agencies in Texas already cover items consistent with FDOT's programming screen elements (although the programming screen in Florida takes place before the NEPA process starts, the purpose of the programming screen is to alert about environmental issues that need to be addressed during the preliminary design phase). However, the existing MOUs at TxDOT do not cover items equivalent to the FDOT planning screen elements. Issues to consider include the following:

    - **MOUs with all resource agencies**. TxDOT has MOUs with four agencies: TCEQ, TPWD, THC, and GLO. While the scope of the existing MOUs would be expanded, new MOUs with other relevant resource agencies may be advisable to ensure the participation of these agencies during planning and programming. Examples of new MOUs include MOUs with USFW, the Natural Resource Conservation Service, the International Boundary and Water Commission, the Federal Emergency Management Agency (FEMA), the National Marine Fisheries Service, USACE, and the U.S. Coast Guard.

    - **Consistency in the use of terminology**. The current MOUs with resource agencies are not consistent in the use of terms such as "early involvement" and "planning." From the context and scope of individual existing MOUs, it is clear that early involvement and planning in those MOUs refer to the preliminary design phase. However, if the MOUs are expanded to include planning and programming, it would be necessary to use precise definitions to avoid any potential confusion among stakeholders.

- **Implement a web-based system similar to FDOT's EST**. The EST system in Florida was instrumental to the success of the ETDM/ETAT implementation by providing a convenient tool that enabled interagency coordination, identification of key project issues by resource agencies, and dispute resolution.

- **Examine the need for enabling legislation and/or rule making changes**. This research examined technical aspects related to the implementation of environmental advisory teams (and expansion of current MOUs with resource agencies) in Texas for transportation planning purposes, but did not address any legislative initiatives and/or rule making changes that may be necessary.

The actions above pertain to environmental activities. For utility-related activities, utility companies do not have regulatory authority over TxDOT, and Texas statutes do not require TxDOT to develop MOUs with utility companies. As a result, a planning-level MOU framework similar to that with resource agencies would not apply for utility interests. A web-based system similar to FDOT's EST that enables resource agencies to provide instructions to TxDOT would not apply either. Clearly, a planning-level MOU framework and web-based application for utilities would need to be different if the purpose is to engage the participation of utility companies during the planning and programming phase. Key elements to encourage the participation of utility stakeholders in this process include the following:

- **Explore the implementation of a multilevel MOU approach with utilities**. A 2008 international scan tour revealed a multilevel MOU practice in Australia that provides flexibility and encourage the participation of the parties involved (*51*). In a typical situation, a high-level MOU sets forth general principles and the intent of both parties to work cooperatively. To ensure the MOU is a living document, the MOU may include attachments and other agreements that discuss specific issues, such as standards, specifications, and general procedures for resolving conflicts. There may also be contract-level details and specific provisions that the higher-level MOU, attachments, or agreements do not address. This MOU structure could be used to identify specific responsibilities and expectations, including those that would be necessary during the planning and programming phase.

- **Implement a web-based planning-level system for utility stakeholders**. This web-based system, which could be called the Cooperative Utility Planning System (CUPS), would enable utility interests to view transportation projects included in the STIP, upload and overlay utility plans, and enable the identification of potential conflicts and impacts. As envisioned, the system would complement the annual meeting that TxDOT districts already schedule with utilities and would serve as a repository of planning-level information for future reference. As appropriate, the system could also include cross references with relevant existing systems at TxDOT, as well as the planning-level web-based system for environmental activities discussed above. In fact, the web-based application for utilities could use some of the same architecture and components as the web-based planning tool for environmental activities, but would have specific user interfaces to address utility-related needs.

The changes to the MOUs and implementation of the web-based systems described above would also require changes to TxDOT manuals, as follows:

- **Project Development Process Manual**. Changes to the PDP manual would be relatively minor and involve descriptions of existing activities, specifically in Chapter 1 (Planning and Programming) and Chapter 3 (Environmental Documentation). PDP Task 3100 (Perform early coordination with review/resource agencies) would require a revision to clearly define the term "early coordination" to include planning and programming activities. It would also be necessary to revise other activities and their definitions that use similar terminology, as well as add new activities to review planning screen data and review programming screen data.

- **Environmental Manual**. The *Environmental Manual* provides information on coordination with state and federal agencies in Chapter 5 (Interagency Coordination) and Chapter 6 (Permits). Both chapters may require changes to specify the details of the new process and coordination between agencies. Alternatively, a planning-level chapter before the current Chapter 2 (Preliminary Survey) could be inserted to describe the new planning-level process.

Coordinate Environmental and Utility Data Collection

Strategy Description

Currently, there is little (if any) coordination between the environmental process and other preliminary design functions concerning the collection of QLD and QLC utility data. District feedback suggests that linkages between QLD and QLC data collection and the environmental process could result in better coordination and earlier detection of critical utility infrastructure such as old oil and gas pipelines as well as underground petroleum storage tanks. Better coordination would still ensure that detailed petroleum storage tank assessments and other hazardous material investigations, which tend to be localized activities, would be kept separately from utility facility assessments.

Utility data collection and environmental investigations share similar processes. Both QLD and QLC utility data collection and initial environmental site assessments use surface observations and a review of existing records to identify potential conflicts and problems. Coordinating both activities would facilitate the exchange of utility and environmental information. Coordination could involve initiating data collection activities concurrently, exchanging partial data, and exchanging the results of both investigations. Readers should note that, although both processes share similar processes, they are sufficiently different and involve personnel with different skill sets. As a result, merging both data collection activities into one combined activity is impractical. In addition, TxDOT uses different contracting mechanisms for utility data collection and environmental data collection. However, just because the activities are different and use different resources does not mean they cannot be coordinated.

Coordinating utility and environmental data collection could also improve the data quality and information output from both activities. For example, an ISA report could include a map showing not just the location of known underground petroleum storage tanks and potential hazardous material sites, but also utility location information. By comparing information from the ISA report with existing QLD and QLC utility data, potential conflicts and adjustment problems could be identified earlier. Further, environmental staff would learn earlier about how utility locations might affect environmental concerns, and likewise, right-of-way section staff would learn if environmental concerns might affect utility adjustment plans.

Changes to Business Processes and TxDOT Manuals

Coordinating utility data collection between environmental and right-of-way groups would use existing processes and activities. In principle, it should be technically feasible. Depending on the project and circumstances, it may be necessary to start one of the data collection activities, (e.g., QLD and QLC data collection) earlier in the PDP process. Implementation would include adding a description of the coordination activities in the PDP manual, adding a requirement to coordinate data collection with right of section personnel in the *Environmental Manual*, and adding a requirement to coordinate data collection with environmental section personnel in the *ROW Utility Manual*. The design concept conference could also offer opportunities for coordination of possible site investigation activities between environmental and right-of-way section personnel.

Enhance and Coordinate Preparation of Scopes of Services

Strategy Description

Coordination of environmental and utility data collection may also be possible by making changes to existing contract and/or scope of work templates to encourage coordination and data exchange. The purpose of coordinating scopes of work conducted by contractors and consultants is to provide a well-defined scope or work, cost, and schedule for projects, with the goal of reducing the likelihood of conflicts with different stakeholders in the contractor's work output. The benefit of coordinating scopes of services would be early identification and potential avoidance of environmental and utility conflicts. For example, utility adjustments in or near suspected areas of contamination could be avoided. Likewise, early utility information could assist in identifying suspected contamination problems earlier in the project.

Issues that could affect implementation of this strategy include differences in contracting practices and timing between environmental and utility data collection activities. The Environmental Affairs Division uses "evergreen" scientific services contracts to hire archeologists, biologists, geologists, historians, and other experts when conducting environmental or cultural assessments for transportation projects, primarily during the preliminary design phase. Districts also use professional services contracts to conduct environmental assessments.

A key consideration in determining whether a district uses scientific or professional services contracts for environmental work is the project development critical path. Districts are more likely to use scientific services contracts when there is adequate time to schedule environmental services in advance to meet project development deadlines. In contrast, districts may use professional services contracts for environmental services if they foresee benefits by controlling the timing and use of services in relation to the letting schedule, which can happen in situations when the schedule to complete pre-design, environmental clearance, design, PS&E assembly, and letting is tight.

Utility engineering investigation contracts and utility coordination contracts (which typically include utility investigation services) are either evergreen contracts or specific-deliverable contracts (used for specific locations or conditions) (*52*). For evergreen contracts, TxDOT uses utility work authorizations for individual assignments, which provide site-specific detail beyond what is included in the standard contract template, such as CSJ number, required quantity of test holes, and meeting requirements. TxDOT uses work authorization documentation to establish a payment basis for later use in case additional work is necessary or if there are issues to resolve with the consultant. Currently, TxDOT has approximately five utility investigation contracts and 45-50 utility coordination contracts. Most utility investigation contracts focus on QLB and QLA data collection work (which can also include QLD and QLC data collection). As mentioned previously, collecting information about utilities through existing records, oral recollections, and surveys of visible utility appurtenances is a routine PDP practice, even in the preliminary design phase. By comparison, collecting QLB and QLA data tends to take place during the design phase—normally at the discretion of the project manager.

Changes to Business Processes and TxDOT Manuals

TxDOT's goal is to finish environmental assessments before entering the design phase. This situation raises the question about the feasibility of coordinating environmental and utility investigation scopes of services since, in practice, most QLB and QLA work takes places during the design phase. A subsequent section includes a discussion of circumstances under which it is possible to conduct some QLB work during the preliminary design phase. Within these constraints, the following opportunities for coordination exist:

- **Coordinate exchange of preliminary data**. This activity would involve exchanging preliminary environmental and utility (mainly QLD and QLC) data, as described in the previous section.

- **Require data exchange throughout the process**. This activity would involve including a requirement in environmental scopes of services to check for the availability of QLD and QLC data and to make the results of the environmental investigation available to contractors who are doing utility investigations (all quality levels, although in most cases it would be QLD, QLC, and some QLB). This activity would also include adding a requirement to utility investigation scopes of services to check for the availability of environmental data and to highlight potentially major issues that surface during the utility investigation phase, which might warrant a closer environmental review. Examples of major issues include evidence of spills, leaking underground storage tanks, materials that contain asbestos, or historic structures.

- **Require coordination for contracts that include both environmental and utility data collection**. In situations where the same consultant does environmental site investigations and utility investigations (either using its own staff or through subcontracts), a provision in the contract and/or work authorizations would ensure that all relevant personnel have access to input data and results from both types of investigations.

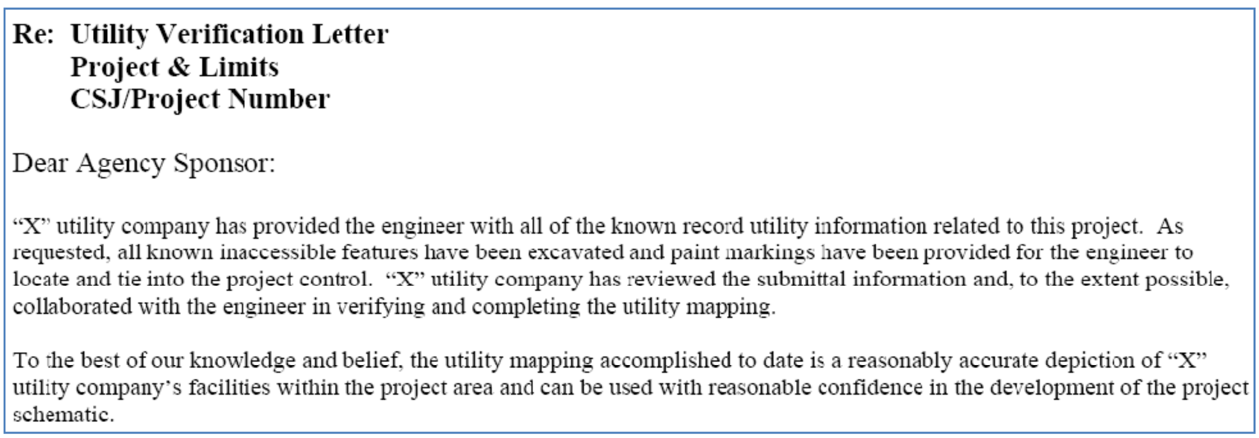
As in the case of the previous strategy, implementation of the scope of service coordination strategy would require adding coordination activities to the PDP manual, adding a requirement to coordinate data collection with right of section personnel in the *Environmental Manual*, and adding a requirement to coordinate data collection with environmental section personnel in the *ROW Utility Manual*. The design concept conference could also offer opportunities for coordination of possible site investigation activities between environmental and right-of-way section personnel. Specific changes in the PDP manual include changes to PDP Task 1000 (Identify project need and scope), PDP Task 2000 (Conduct design concept conference), PDP Task 2640 (Identify existing utilities on geometric schematic), and PDP Task 4200 (Locate existing utilities).

Require Utility Owners to Verify Utility Facility Information

Strategy Description

District feedback indicates the project development process would benefit if utility owners could verify the location and ownership of utility installations identified during QLD or QLC investigations. Most districts require utility owners to provide information about the location and ownership of their installations as part of the QLD utility data collection, although specific requirements vary from district to district. The current practice at the San Antonio District is an interesting example because of what the district requests from utility owners. First, that district asks utility owners to provide a "verification" letter as opposed to simply providing data. Second, as Figure 8 shows, the verification letter is a tool by which utility owners indicate they have:

- provided a copy of all known record utility information related to the project;
- made all known inaccessible features visible (e.g., valve covers that were at grade at one point but are now covered by soil or vegetation) and provided paint markings to enable surveyors to tie those installations to the project control;
- reviewed submitted documentation; and
- collaborated with TxDOT in verifying and completing the utility mapping.



Re: Utility Verification Letter
Project & Limits
CSJ/Project Number

Dear Agency Sponsor:

"X" utility company has provided the engineer with all of the known record utility information related to this project. As requested, all known inaccessible features have been excavated and paint markings have been provided for the engineer to locate and tie into the project control. "X" utility company has reviewed the submittal information and, to the extent possible, collaborated with the engineer in verifying and completing the utility mapping.

To the best of our knowledge and belief, the utility mapping accomplished to date is a reasonably accurate depiction of "X" utility company's facilities within the project area and can be used with reasonable confidence in the development of the project schematic.

Figure 8. San Antonio District Utility Verification Letter.

The San Antonio District has had reasonable success in getting utilities to provide the verification letter. Most utility companies provide the verification letter as requested by TxDOT. In principle, a verification letter like that used by the San Antonio District is useful because of the emphasis it places on complete information from utility owners. The letter also provides a paper trail that can be used for future reference. Further, the letter emphasizes information completeness over location accuracy because of the realization that as-built information provided by utilities is frequently not sufficiently accurate to overlay on project drawings without further verification. However, some utility owners may be reluctant to provide a verification letter in those terms because of the perception of increased liability (e.g., "reasonably accurate depiction" could be interpreted in many different ways, and it is not necessarily clear what "inaccessible features" means) and additional work required on their part, for which they might not be reimbursed.

Verification of utility installations should occur as early as possible to identify potential conflicts. In the current PDP, there are at least two opportunities where verification by utilities during the preliminary design phase is possible:

- **PDP Task 2180 (Obtain information on existing utilities)**. This activity involves reviewing utility as-built construction plans and permit records, reviewing utility locator markers and signs in the field, contacting municipalities adjacent to the project to help identify utilities in the area, and providing a project "footprint" to utilities along with a request for information. This information is needed for each project alternative because the preferred alternative has not been selected yet. In its current form, PDP Task 2180 is roughly consistent with the verification letter in Figure 8, except for the request to uncover inaccessible features.

- **PDP Task 2640 (Identify existing utilities on geometric schematic)**. This activity requires using the preferred alternative schematic as input, overlaying utility-provided as-builts, requesting utility owners to draw their installations on the schematic (particularly useful if a utility does not have usable as-builts or if it prefers not to send copies of as-builts to TxDOT), and developing a utility layout. Notice that PDP Task 2640 feeds into PDP Task 2650 (Identify potential utility conflicts), which produces a utility conflict list and feeds into the development of the final geometric schematic.

  In its current form, PDP Task 2640 does not involve requesting verification from utility owners after completing the utility layout. However, one could argue that verification from utility owners at this point could be at least as useful as verification at PDP Task 2180. In fact, the utility verification letter in Figure 8 already accomplishes this goal in part with the request for utility owners to collaborate with TxDOT in verifying and completing the utility mapping. Still, some utility owners may be reluctant to verify or certify information they did not provide directly, particularly if TxDOT has "interpreted" information provided by utility owners while generating the utility layout.

Changes to Business Processes and TxDOT Manuals

It is technically feasible to add a PDP task (or modify an existing one) to formalize the verification of utility installations. In order to encourage the cooperation and response by utility owners, it would be advisable not to use the utility verification letter in Figure 8, but instead, use a cover letter with check boxes that list actions completed and documents provided to TxDOT. The new letter would be a standardized TxDOT form and would be used for all projects that require utility location information from utility owners. Examples of check boxes to include in the new standardized form include the following:

- Documentation provided to TxDOT:

  ☐ *Paper* copies of all known record information available at the utility in relation to the project, such as as-builts (plan, profile, cross sections, and details), GIS file printouts, survey reports, and survey data

- ☐ *Electronic* copies of all known record information available at the utility in relation to the project, such as as-builts (plan, profile, cross sections, and details), GIS files, survey reports, and survey data
- ☐ Pictures, field coordinates, and other documents to facilitate the location of difficult-to-find features such as valve covers, manhole covers, and handhole covers
- ☐ Marked up printed drawings or maps provided by TxDOT or an authorized consultant
- ☐ Marked up computer aided design (CAD) file(s) provided by TxDOT or an authorized consultant
- ☐ Marked up 2-D portable document format (PDF) file(s) provided by TxDOT or an authorized consultant
- ☐ Marked up 3-D portable PDF file(s) provided by TxDOT or an authorized consultant
- ☐ Marked up GeoPDF file(s) provided by TxDOT or an authorized consultant
- ☐ Marked up or updated GIS file(s) provided by TxDOT or an authorized consultant
- ☐ Marked up or updated features using an online web-based viewer provided by TxDOT or an authorized consultant
- ☐ Other: _________________________

- Field activities:

  - ☐ Exposed surface features such as valve covers, manhole covers, and handhole covers that were partially or completely covered or blocked in the field
  - ☐ Provided paint markings for those features in the field to enable TxDOT surveyors to tie those installations to the project survey control
  - ☐ Marked existing underground utilities on the ground along project (no request from a One-Call notification center was necessary) to enable TxDOT surveyors to tie those locations to the project survey control
  - ☐ Marked existing underground utilities on the ground along project upon request from a One-Call notification center to enable TxDOT surveyors to tie those locations to the project survey control
  - ☐ Other: _________________________

- Other activities:

  - ☐ _________________________
  - ☐ _________________________

One of the advantages of using a standardized form with check boxes is that the form can be dated and, as such, it can serve as a useful record of documentation and information provided by utility owners at different points throughout the project development process, not just in connection with PDP Task 2180 or PDP Task 2640. In fact, TxDOT could use the form to request different pieces of information at different points in time. For example, in connection with PDP Task 2180, TxDOT could use the form to request as-builts for the different project alternatives under consideration. Later, in connection with PDP Task 2640, TxDOT would use the form to request additional information or field activities, e.g., uncovering and/or marking difficult-to-find features such as valve covers or handhole covers, or, if needed depending on project characteristics, marking existing underground utilities on the ground along the project. The same form could also be used to document ground markings the utility owner provides in preparation for QLA test holes as part of PDP Task 4200 (Locate existing utilities). Another advantage of using a standardized form is that, if properly worded, check box options can contribute to eliminate differences in interpretation, which, in turn, can result in higher response rates by utility owners.

For the most part, it does not appear that changes to existing legislation and utility accommodation rules to support the use of the standardized form would be necessary, but if so, the check boxes above could be used to introduce modifications as needed. At this point, the only check boxes that might require changes in legislation and/or rules are the check boxes related to marking existing underground utilities on the ground along the project (particularly if One-Call notification centers are involved). The reason is that the current One-Call legislation only applies within 14 days before an excavation is set to begin (*17*). In some cases, districts have worked through a One-Call notification center to get utility owners to mark their installations even if an excavation is not involved, but this practice is not widespread or necessarily well accepted by the utility industry.

To formalize the use of One-Call locate tickets at different points during the project development process, it would be necessary to introduce changes to the Texas Utilities Code (TUC), most likely 5 TUC 251, and the Texas Administrative Code, most likely 16 TAC 18 (*17*, *53*). Making these changes would be a challenge, but both TxDOT and the utility industry would benefit in the long term. It may be worth noting that other states—12-13 states according to a recent study—allow the use of One-Call "design tickets" (*5*). Other industrialized countries encourage the use of locate tickets during the project development process, as the 2008 international scan on right of way and utilities found in the case of Australia (*51*).

Changes to the PDP manual are also necessary as follows:

- **Focus PDP Task 2180 on QLD data collection.** Verifying utility information for all alternatives at QLD would focus on existing as-built information provided by utility owners. Utility owners would be able to point out major conflicts early enough to influence the decision for a preferred alternative. At the same time, TxDOT would benefit by having more utility information early in the process that would be useful to avoid major utility conflicts in the development process.

- **Focus PDP Task 2640 on QLC (and some QLB) data collection.** Verification of utility information would concentrate on the preferred alternative schematic and include more detailed information provided by utility owners. The information provided would enable TxDOT to conduct a QLC assessment (as well as a QLB assessment in some special cases). If legislation and rules allow it, PDP Task 2640 could also include provisions to initiate locate tickets with an appropriate One-Call notification center.

Gather Some QLB Data during Preliminary Design

Strategy Description

District feedback suggests that collecting some QLB data during preliminary design can be beneficial in situations where the right of way stays the same, e.g., when the project involves widening a road and/or adding extra lanes within the existing available space. Under these conditions, knowing the location of existing underground utility facilities, particularly major longitudinal facilities such as water mains or communication duct banks, becomes critical in order to determine the best course of action (e.g., adjusting the utility facility, modifying the roadway alignment to avoid the utility facility, or protect-in-place). By comparison, for new location projects (Table 1), TxDOT knows from experience that if utility facilities are found within the proposed right of way, those facilities are likely to be adjusted. Under these conditions, the value of collecting QLB data decreases.

Although not related to this discussion, readers should also note that, just because a project is a maintenance project does not mean there are no utility conflicts to resolve. An increasing body of evidence from around the country indicates that seemingly routine overlay projects that require upgrades to pedestrian infrastructure to satisfy Americans with Disabilities Act (ADA) requirements—one of the consequences of the Kinney versus Yerusalim case in Philadelphia (*54*)—end up requiring adjusting utility facilities such as poles or manhole covers.

When done at all, QLB data collection usually takes place during design. One of the reasons for this practice is that collecting QLB is much more expensive than collecting QLD and QLC data, and project managers feel that collecting QLB data is only necessary when absolutely warranted. However, as indicated above, there appears to be value in collecting some targeted QLB data during preliminary design. PDP Task 4200 (Locate existing utilities) in the PDP manual includes some guidance for the collection of underground utility data at different quality levels. It may be worth noting that the guidance for QLB data collection in PDP Task 4200 suggests that the 2-D information derived from QLB data is usually sufficient to accomplish "preliminary engineering goals." However, this wording is in the context of providing support for the placement of storm drainage systems and other design features, which normally take place around 30-60 percent design.

Reasons for collecting QLB data during preliminary design, particularly for projects for which the right of way stays the same, include the following:

- It helps to avoid or reduce delays in the utility adjustment process, particularly if the available space is tight and one of the options under consideration is to move utility facilities to private easements outside the state right of way. In urban areas (more so than in rural areas), private easements are frequently not desirable because of the expense and time it takes to acquire them. Under these conditions, efforts are first made to adjust utilities within the available right of way, which can add to the overall time to adjust those facilities if the process does not sufficiently early.

- Some utility owners, particularly small ones, need extensive notice for utility adjustment planning and budgeting. Collecting QLB data earlier would enable earlier determinations of the potential need for utility adjustments, which would assist in the decision-making and planning process of those utility owners.

- As described with more detail in subsequent sections, QLB data can be used to provide earlier assessments of where to place certain storm drainage system components such as storm water outfalls, which must be cleared by the environmental process and may have right-of-way acquisition requirements.

- Subsurface utility installations frequently remain substantially the same from preliminary design to design. It is common for design project managers not to trust "old" data from the preliminary design stage. However, for projects where the right of way remains the same and the time lag between preliminary design and design is not too long, good-quality subsurface utility data collected during preliminary design could still be used during design. New developments such as the web-based Utility Installation Review (UIR) system, which automated the utility permitting process at TxDOT, could complement QLB data collected for corridors within districts where UIR is active.

- QLB data frequently uncover the existence of underground utility facilities that were not previously detected through QLD or QLC data collection efforts.

Changes to Business Processes and TxDOT Manuals

Issues to consider for the acquisition of QLB data during preliminary design include extent and timing of the data collection. In principle, there is a positive correlation between the extent of QLB data collection and the chances of identifying utility conflicts. In general, as the extent of QLB data collection increases, the corresponding cost also increases. Figure 9 illustrates these relationships.

At the same time, an increasing number of reports in the literature indicate that collecting QLB (and QLA) data results in significant net economic benefits. Examples include the following:

- A 1999 Purdue University study reported cost savings of $4.62 for every $1.00 spent on QLB and QLA data collection (*55*).

- FDOT found that it saved $3 in contractor construction delay claims for every $1 spent on SUE (*56*).

- The Maryland State Highway Administration (MSHA) saved $1.34 million on a project for which the cost of doing SUE was $56,000 (*56*). On another project, the cost savings were $300,000 while the cost of doing SUE was $5,000.

In theory, collecting QLB data for the entire extent of the project could result in the highest possible economic benefit. In reality, districts are rarely—if ever—in a position to spend unlimited resources in the collection of this type of data hoping to maximize the economic benefit. In fact, districts frequently believe they cannot afford to spend any money to collect QLB data. For most projects, therefore, acquisition of QLB data in certain project areas may be the most suitable option. Frequently, there are no obstacles from a technical standpoint, but since the cost of QLB data acquisition is an issue, it becomes critical to prioritize project areas where the added benefits of collecting QLB will most likely outweigh the increased cost of data collection. QLD and QLC data could provide an indication of where to collect QLB data.

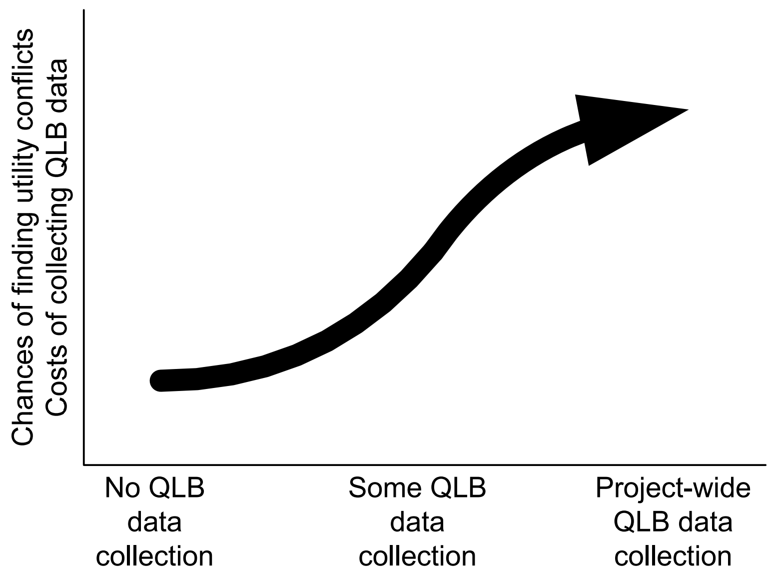


Figure 9. Chances of Finding Utility Conflicts and Costs of QLB Data Collection.

With respect to timing, it appears the most reasonable timeframe to collect QLB during preliminary design occurs around the time of selection and analysis of the preferred geometric alignment (Figure 10). After this point, the benefit of collecting QLB data decreases (since the focus of the analysis changes to preparing the environmental document and completing the preliminary design phase) and only starts increasing again during the design phase.

As discussed in the previous section, the main opportunities for collecting utility data during preliminary design are in conjunction with PDP Task 2180 (Obtain information on existing utilities) and PDP Task 2640 (Identify existing utilities on geometric schematic). In general, collecting QLB data during the evaluation of schematic alternatives (i.e., PDP Task 2180) is not practical or cost-effective, unless the right of way stays the same. Collecting QLB data as part of the analysis of the preferred geometric alignment (i.e., PDP Task 2640) would facilitate the analysis of potential utility conflicts (which is part of PDP Task 2650). Collecting QLB data may also be possible depending on whether a value engineering study is conducted (PDP Task 2700) prior to the review and approval of the final geometric schematic. However, not every project has a value engineering study. The last point in the preliminary design stage for QLB data collection would be after PDP Task 2920 (Obtain approval of final geometric schematic). However, the need for increased data accuracy at this point is low.

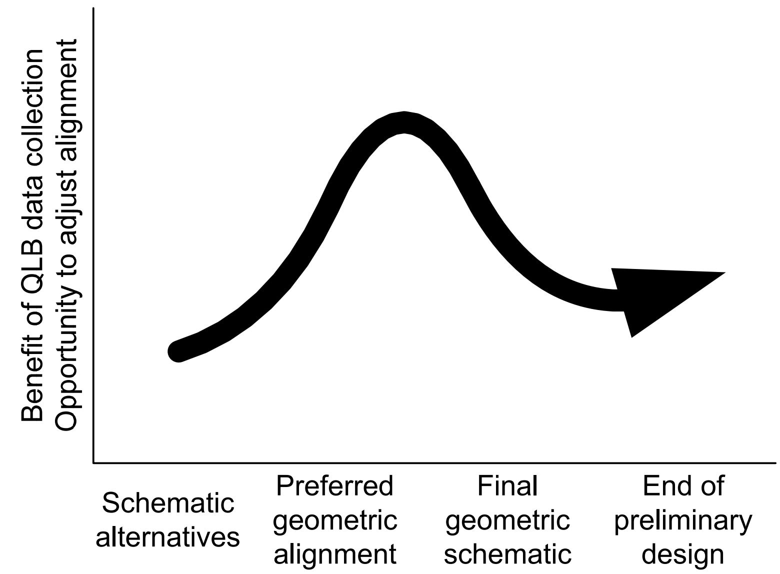


Figure 10. Benefit of QLB Data Collection and Opportunity to Adjust Alignment.

Potential changes in PDP manual activities include the following:

- **PDP Task 2640 (Identify existing utilities in geometric schematic).** It would be necessary to include provisions to support the collection of some QLB data during the preliminary design phase. Ideally, the added material would include guidelines to assist users in determining the conditions under which collecting QLB data would be advisable and/or required. The material would also include a description of the scope of QLC data collection (see previous section).

- **PDP Task 4200 (Locate existing utilities)**. This activity is a design-level activity. However, several changes are necessary to ensure consistency with the modified wording in PDP Task 2640 and to eliminate potential sources of confusion in scope. For completeness, this section would include a description of the four quality levels (QLD, QLC, QLB, and QLA) since quality levels are progressive and inclusive. Although the current material in PDP Task 4200 does not directly mention the ASCE/CI 38-02 standard guideline by name, the number of implicit references in the text makes it obvious that the basis for PDP Task 4200 is that standard guideline. To avoid any confusion among stakeholders, including utility engineering investigation contractors, it would be advisable to use "official" standard ASCE/CI 38-02 quality level definitions.

No changes in the *Environmental Manual* or the *ROW Utility Manual* are necessary.

It would also be advisable to use consistent terminology in PDP manual activity descriptions and activity titles, as well as the utility accommodation rules. For example, PDP Task 4200 includes a definition for "locating" that is roughly consistent with the definition of the term "locating" in

ASCE/CI 38-02 (i.e., exposing an underground utility facility to determine its precise horizontal and vertical position). This definition contradicts the intended purpose of PDP Task 4200 because, even though the activity title includes the term "locate," the scope of the activity is more inclusive. One potential solution to address this issue would be by renaming PDP Task 4200 as "Conduct QLB and QLA utility investigations" or "Conduct detailed utility investigations."

Include Some Drainage Design Elements in Preliminary Design

Strategy Description

Determining new storm sewer horizontal and vertical alignments are typical design tasks. Normally, during preliminary design, it is possible to obtain a high degree of definition for the roadway horizontal alignment (as well as vertical alignments for grade separations). However, schematics usually do not include drainage design elements because the type and amount of information needed to determine the precise horizontal and vertical alignment of storm drainage infrastructure is only available during the design phase. In practice, drainage design is typically completed around 60 percent design—although preliminary drainage layout may be available at 30 percent design.

Many utility conflicts are drainage-related. Drainage design is a significant component of a highway project and, if affected by external factors such as incomplete or inaccurate utility facility information, it can have a negative effect on TxDOT's ability to deliver projects on time. Utility information before drainage design would be helpful. However, most utility owners avoid getting involved in the utility process until about 60 percent design, once there is a clear definition of the roadway—and drainage—horizontal and vertical alignments. Presumably, completing certain elements of the drainage design earlier (without preempting the environmental process) would make it possible to engage utility owners earlier in the process, therefore accelerating the utility process and reducing the risk of potential project delivery delays.

The PDP manual includes the following drainage-related activities during preliminary design:

- **PDP Task 2200 (Obtain hydraulic studies)**. This activity involves determining preliminary drainage structure requirements as well as obtaining and reviewing existing studies.

- **PDP Task 2610 (Perform hydrologic study)**. This activity involves estimating flood magnitudes caused by precipitation. Data compiled include peak runoff (discharge) and discharge hydrographs.

- **PDP Task 2620 (Perform preliminary hydraulic analysis/design)**. This activity involves determining approximate elevations and sizes of cross drainage structures during the preliminary design phase. The analysis also includes other major considerations, e.g., evaluating the need for large storm drain structures, detention ponds, pump stations, and "other" hydraulic facilities (although the manual does not define what "other" hydraulic facilities means), as well as right-of-way requirements.

PDP Task 2200 is a preliminary data collection activity. PDP tasks 2610 and 2620 are part of the development of the preferred geometric alignment.

The PDP manual includes the following drainage-related activities during design:

- After the Design Conference but prior to defining vertical and horizontal alignments (i.e., prior to 30 percent design):
    - **PDP Task 5140 (Refine hydrologic study)**. This activity involves making any needed refinements to the original study to reflect more detailed field survey data, changes in basic design conditions or assumptions, or updates in procedures.
    - **PDP Task 5150 (Prepare stream crossing hydraulics)**. This activity involves establishing a design storm frequency and other criteria as well as determining the size and type of crossing openings. It is interesting to note that the manual highlights the effect of this activity on the assessment of drainage easement needs in areas not already owned or classified as waters of the state, which is a task normally associated with preliminary design.
    - **PDP Task 5160 (Prepare hydraulic report)**. For bridges, bridge-class culverts, and storm drains handling flows greater than 200 cubic feet per second, districts must submit the results of a scour evaluation analysis (not for bridge-class culverts) and a hydraulic calculation sheet (for bridges and bridge-class culverts) along with the structure layout.
- After defining vertical and horizontal alignments (i.e., after 30 percent design):
    - **PDP Task 5540 (Perform hydraulic design for culverts and storm drains)**. This activity includes determining culvert, parallel channel, and storm drain sizes and grades to handle design storm water flows.
    - **PDP Task 5560 (Perform hydraulic design for pump station(s))**. This activity includes pump sizing, foundation design, outfall design, power and control design, and enclosure design for pumping facilities.
    - **PDP Task 5570 (Prepare culvert and storm drain details)**. This activity involves preparing detail sheets for culverts and storm drains.
    - **PDP Task 5590 (Prepare pump station details)**. This activity involves preparing detail sheets for pump stations.
    - **PDP Task 5600 (Design Storm Water Pollution Prevention Plan)**. This activity involves preparing a storm water pollution prevention plan (SW3P) to minimize erosion and siltation during and after construction in accordance with TCEQ regulations (*57*).

Several of these activities highlight the need to take into consideration existing *and* proposed utility installations. However, this goal may be compromised if utility owners are not involved in the process until about 60 percent design.

The *Hydraulic Design Manual* (*58*) provides detailed guidance and recommended procedures for the design of TxDOT drainage facilities. In addition to information about policy, rules, and procedures, the manual covers required data collection, evaluation, and documentation; hydrologic study procedures and requirements; and hydraulic design procedures and requirements for a wide range of structures, including channels, culverts, bridges, storm drains, pump stations, reservoirs, and soil erosion control. The *Roadway Design Manual* (*8*) provides additional information about the design of drainage facilities.

The documentation requirements for different types of structures in the *Hydraulic Design Manual* include a differentiation between preliminary design requirements and design requirements. Nevertheless, there are substantial similarities in documentation requirements between the two phases, which might facilitate the completion of some drainage design elements in the preliminary design phase.

In general, district feedback indicates that drainage structure sizing during preliminary design tends to depend on time availability. In other words, if there is enough time, it may be possible to size elements during preliminary design. Otherwise, this activity is left to the design phase. District feedback also indicates that sizing cross drainage structures during preliminary design may be possible as long as only preliminary calculations are completed. For example, it may be possible to estimate the size and probably the depth of pipe locations, but not produce accurate assessments about inlet locations. In general, it is not clear to what extent districts conduct sizing calculations for other hydraulic structures such as storm drain structures (including outfalls), detention ponds, or pump stations during preliminary design.

Nevertheless, districts expressed a desire to complete certain activities earlier in the project development process, e.g., in the case of outfalls, which must be cleared by the environmental process and may have right-of-way acquisition requirements. The reason is that storm water outfalls are regulated under the Texas Pollutant Discharge Elimination System (TPDES) (*59*). The environmental clearance process for outfalls depends largely on their location and setting. In general, there are two required permits: a construction permit and a local Municipal Separate Storm Sewer System (MS4) permit (*60*). In urban areas, outfalls need to be coordinated with the MS4 permit holder. There are other possible issues associated with outfalls, although TPDES is the primary compliance concern.

Whether to undertake drainage design elements during preliminary design depends on factors such as project type, availability of high-quality vertical elevation data, and project urgency:

- **Project type**. For 2R and 3R projects, the roadway design alignment is essentially the same as the approved schematic because those projects substantially follow the existing horizontal and vertical alignment. Cross sections for those projects usually do not change much from preliminary design to design. As mentioned previously, for projects where the horizontal and vertical alignment is expected to remain the same from preliminary design to design, it is also advisable to collect QLB utility data during preliminary design.

In contrast, for 4R projects, it is common to add capacity and/or substantially deviate from the existing horizontal and vertical alignment. In this case, usually the main purpose of the preliminary design phase is to determine whether the project will fit within the right-of-way width. The approved schematic would show certain features, e.g., culverts, but there would not be data elements such as actual dimensions. Cross sections for 4R projects can vary significantly from preliminary design to design for a number of reasons, including technical reasons and changes in project conditions, particularly in the case of large projects that take a long time to develop. Changes in cross section make it risky to define drainage design elements during preliminary design because of the chance that drainage design elements would need modifications during design. At the same time, by not providing more detail in the preliminary design phase, TxDOT is accepting the risk that unknown factors (e.g., the need for drainage easements or the need to meet environmental requirements for outfalls) will negatively affect the design, right-of-way requirements, and/or project delivery.

- **Vertical elevation data**. Hydraulic design typically requires a high degree of certainty about vertical elevation data. This type of data is normally available during design, e.g., by using high-resolution, low-altitude aerial imagery capable of providing 1-foot contour lines (i.e., about 1/10-foot or 1-inch vertical accuracy) (*61*).

  Increasingly, high-resolution, low-altitude aerial imagery is available through agreements with local and regional agencies. However, aerial imagery cost is still an issue. Low-elevation aerial imagery can be expensive if project development takes a long time and the imagery becomes obsolete by the time a project goes to design, forcing a district to fly the corridor again. One strategy would be to use high-elevation aerial imagery (e.g., at 1-foot vertical accuracy) to develop a preliminary DTM that enables alternative analysis and the preparation of an approved schematic. The downside is that lower-accuracy vertical data are normally not adequate for detailed drainage analysis. Some districts are considering this strategy for preliminary designs on rural corridors.

- **Project urgency**. Some projects have considerable support from the administration and other stakeholders and, as a result, there is a sense of urgency and momentum in getting the projects completed soon. For those projects, it makes sense to increase the level of detail in the preliminary design phase. For drainage design elements to be completed earlier in the process, it would also be necessary to increase the level of detail in the data needed to conduct hydrologic and hydraulic analyses, in particular, survey data and cross sections.

Changes to Business Processes and TxDOT Manuals

Changes to PDP manual activities to support an earlier definition of drainage elements during the preliminary design phase, when feasible, include the following:

- **PDP Task 2620 (Perform preliminary hydraulic analysis/design)**. Currently, this activity describes requirements for cross drainage structures. However, it only describes in passing large storm drain structures, detention ponds, pump stations, and "other" hydraulic facilities. It does not mention outfalls (although they are part of the storm drain system), either outfalls from adjacent land or outfalls that drain runoff out of the state right of way. Further, PDP Task 2620 requires the determination of approximate elevations and sizes of cross drainage structures (and to establish their effects on the roadway profile), but only cost and right-of-way requirements for other hydraulic structures. It would be advisable to require the same level of analysis and documentation (i.e., approximate elevations and sizes) for other hydraulic structures, particularly those that may involve right-of-way acquisition, potential utility conflicts, and environmental review. It would also be advisable to replace the reference to "regulations such as FEMA" to a more generic "environmental regulations."

  For projects that could experience a change in horizontal and/or vertical alignment from preliminary to design (e.g., 4R projects), it would be advisable to include a requirement in PDP Task 2620 to conduct a risk analysis to determine the need to provide more definition in hydraulic components during that phase as opposed to the design phase.

- **PDP Task 5150 (Prepare stream crossing hydraulics)**. Currently, this activity includes a reference to PDP Task 2200 (Obtain hydraulic studies). It would be advisable to replace this reference with a reference to PDP Task 2620 (Perform preliminary hydraulic analysis/design).

- **PDP Task 5540 (Perform hydraulic design for culverts and storm drains)**. It would be advisable to include a reference to PDP Task 2620 (Perform preliminary hydraulic analysis/design).

No changes are necessary in the *Hydraulic Manual* or the *Roadway Design Manual*.

Some of these changes in business process and TxDOT manual activities are intended to encourage an earlier participation by utility owners. Realistically, many utility owners might still wait to get involved until 60 percent design because they do not perceive those incentives to be sufficiently strong or compelling. A strategy TxDOT should consider is to evaluate the feasibility of introducing incentive-based reimbursement to utility owners for eligible items of work, including data collection and preliminary engineering, by pre-established milestones set through coordination with utility owners. Incentive-based reimbursement was one of the implementation ideas that resulted from the 2008 international scan on right of way and utilities (*51*).

Include Some Design Elements in Preliminary Design

Strategy Description

It is critical not to preempt the environmental process during preliminary design, e.g., by showing details on schematics that could give the impression that TxDOT is "designing" the project. This is one the reasons districts do not display certain structures on schematics, such as illumination details, intelligent transportation system (ITS) infrastructure, or signal details.

At the same time, including information in schematics that could be used to assess impacts that can potentially alter the project alignment or to highlight issues related to the environmental process is certainly desirable. Along these lines, some districts already include elements in schematics such as denial-of-access lines, guide sign locations (which they send to the operations section for review and comment, e.g., to assess spacing requirements), and noise wall alignments. As a side note, the previous section discussed circumstances under which drainage structures such as outfalls could be defined during the preliminary design phase.

District feedback indicates that including information about typical structure foundation requirements in schematics could be beneficial to assess potential utility impacts and to assist in the environmental process. Many structures commonly found in transportation projects, such as guide signs, overhead sign bridges, and sign poles, are standardized, including foundation requirements. It turns out that the foundation requirements for many of these structures are quite substantial (*62*). For example, a sign post typically requires a foundation 42 inches in depth and 12 inches in diameter (Figure 11). A traffic signal pole could require a foundation 6-12 feet in depth and 24-42 inches in depth (Figure 12). A high mast illumination pole could require a foundation 19-26 feet in depth and 48-66 inches in diameter (Figure 13).

It should not be the intent of the preliminary design phase to complete the design of typical structures. For this reason, the preliminary design schematic should not replicate or include the standard details. However, the preliminary design schematic could show some relevant high-level information. For example, it could show the anticipated location of certain structures and include a dotted circle and a note to indicate the typical foundation depth (or range of potential foundation depths), as well as a disclaimer that the information provided is approximate and is provided to assist in the assessment of potential project and environmental impacts.

Changes to Business Processes and TxDOT Manuals

Relevant activities in the PDP manual in connection with the development of the geometric schematic already include information about the need to assess certain structures, including the following:

- PDP Task 2530 (Consider impacts on historic structures),
- PDP Task 2550 (Determine guide signing and operational control),
- PDP Task 2590 (Establish preliminary retaining and/or noise wall locations), and
- PDP Task 2660 (Establish preliminary illumination locations).

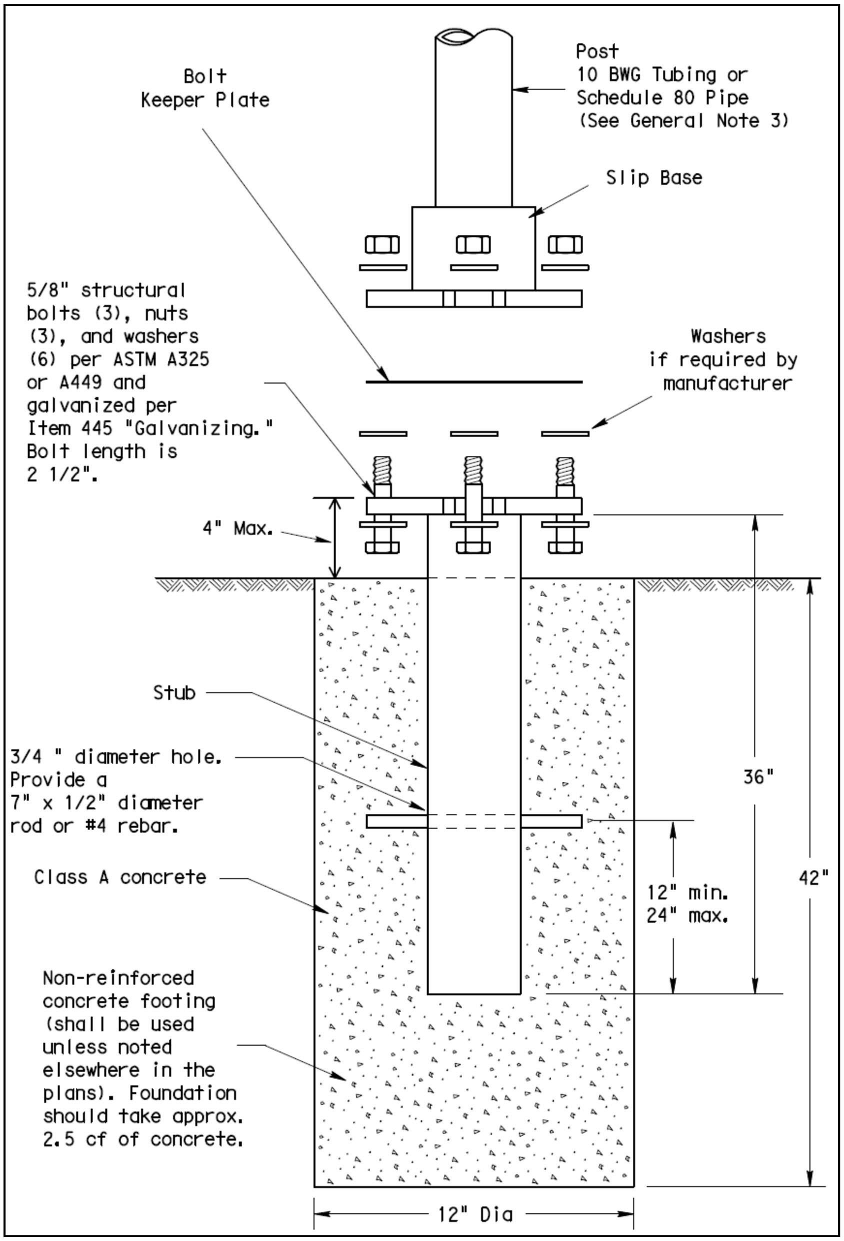


Figure 11. Typical Sign Post Foundation Dimensions (*62*).

FOUNDATION DESIGN TABLE

FDN TYPE	DRILLED SHAFT DIA	REINFORCING STEEL		DRILLED SHAFT LENGTH-ft ④, ⑤, ⑥			ANCHOR BOLT DESIGN ①				FOUNDATION DESIGN LOAD ②		TYPICAL APPLICATION
				TEXAS CONE PENETROMETER N blows/ft									
		VERT BARS	SPIRAL & PITCH	10	15	40	ANCHOR BOLT DIA	Fy (ksi)	BOLT CIR DIA	ANCHOR TYPE	MOMENT K-ft	SHEAR Kips	
24-A	24"	4- #5	#2 at 12"	5.7	5.3	4.5	¾"	36	12 ¾"	1	10	1	Pedestal pole, pedestal mounted controller.
30-A	30"	8- #9	#3 at 6"	11.3	10.3	8.0	1 ½"	55	17"	2	87	3	Mast arm assembly. (see Selection Table)
36-A	36"	10- #9	#3 at 6"	13.2	12.0	9.4	1 ¾"	55	19"	2	131	5	Mast arm assembly. (see Selection Table) 30′ strain pole with or without luminaire.
36-B	36"	12- #9	#3 at 6"	15.2	13.6	10.4	2"	55	21"	2	190	7	Mast arm assembly. (see Selection Table) Strain pole taller than 30′ & strain pole with mast arm
42-A	42"	14- #9	#3 at 6"	17.4	15.6	11.9	2 ¼"	55	23"	2	271	9	Mast arm assembly. (see Selection Table)

FOUNDATION SELECTION TABLE FOR STANDARD MAST ARM PLUS ILSN SUPPORT ASSEMBLIES (ft)

		FDN 30-A	FDN 36-A	FDN 36-B	FDN 42-A
80 MPH DESIGN WIND SPEED	MAX SINGLE ARM LENGTH	32′ ⚠1	48′		
	MAXIMUM DOUBLE ARM LENGTH COMBINATIONS	24′ X 24′			
		28′ X 28′			
		32′ X 28′	32′ X 32′		
			36′ X 36′		
			40′ X 36′		
			44′ X 28′	44′ X 36′	
100 MPH DESIGN WIND SPEED	MAX SINGLE ARM LENGTH	⚠1	36′	44′	
	MAXIMUM DOUBLE ARM LENGTH COMBINATIONS		24′ X 24′		
			28′ X 28′		
			32′ X 24′	32′ X 32′	
				36′ X 36′	
				40′ x24′	40′ X 36′
					44′ x 36′

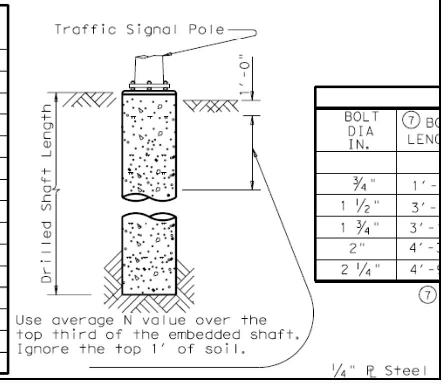


Figure 12. Typical Traffic Signal Pole Foundation Dimensions (*62*).

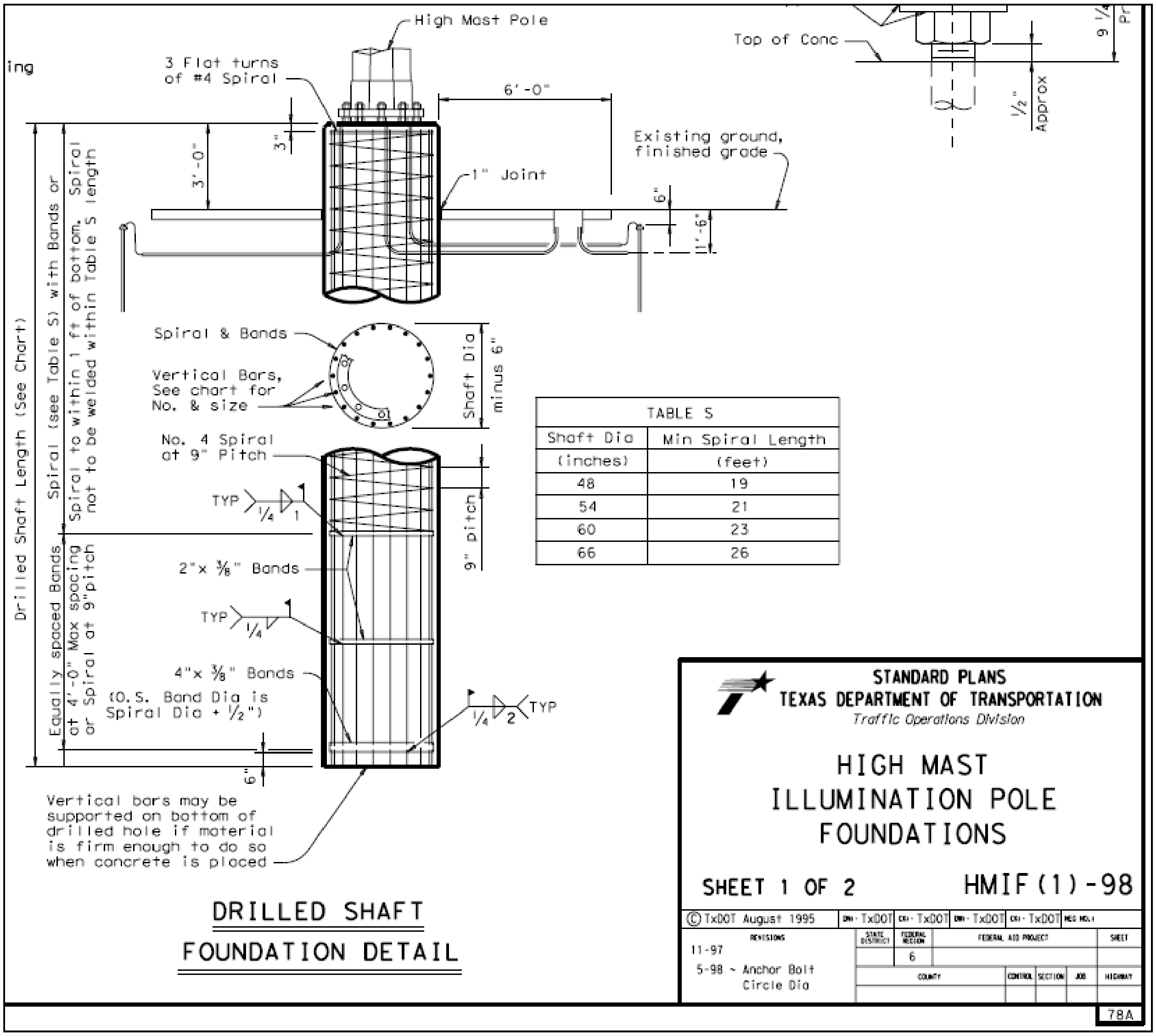


Figure 13. Typical High Mast Illumination Pole Foundation Dimensions (*62*).

Interestingly, PDP Task 2660 includes a reference to the TxDOT Standard Sheets, which provide information about typical foundation footprints and depths (Figure 13). However, other than this general reference, there is not a requirement to provide typical ranges of foundation dimensions. It would be advisable to modify these PDP tasks to provide this information, as well as relevant cross reference information in related PDP tasks, e.g., PDP Task 2650 (Identify potential utility conflicts).

It would also be advisable to update Chapter 1, Section 3 of the *Roadway Design Manual* to include certain structures in the schematic layouts, which are currently not listed (*8*). Examples of elements that are currently missing include the following:

- existing utilities;
- potential utility conflicts;
- typical foundation footprint and depths of major structures such as overhead sign bridges, signal poles, and high-mast illumination poles;
- drainage structures (to the extent that they are needed to address environmental concerns and/or potential utility conflicts);
- major constraints, such as proximity to historic structures, hazardous and/or petroleum materials, threatened or endangered species, wetlands, and noise attenuation requirements.

Address Utility Issues in Constructability Reviews in Preliminary Design

Strategy Description

TxDOT recommends conducting a review of constructability and sequence of work during preliminary design for all projects other than preventive maintenance and 2R projects. District feedback suggests it would be advisable to include utility issues in the constructability review because utility issues play a critical role during construction and can be major sources of delay if not properly coordinated with all the affected stakeholders.

According to PDP Task 2670 (Conduct constructability review), which is part of the process to develop the geometric schematic, the scope of the constructability review includes developing a conceptual construction phasing plan and reviewing requirements for access and operation of construction equipment. To assist in this process, the PDP manual includes references to two publications: the *Texas Manual on Uniform Traffic Control Devices* (TMUTCD) and National Cooperative Highway Research Program (NCHRP) Report 391, *Constructability Review Process for Transportation Facilities Workbook* (*63*, *64*).

The current description and requirements of PDP Task 2670 are too brief, which can make it difficult for readers of the manual to understand what the constructability review should accomplish. For example, although the activity requires the development of a conceptual construction phasing plan, it is not clear at what level of task resolution this plan should be completed. As a result, an analyst would not necessarily conclude that utilities should be part of the analysis. Even if utilities are part of the analysis, they might be treated as a group, which could mask serious construction phasing issues if individual utility installations (e.g., a gas line and a sewer line) are not considered independently. Likewise, PDP Task 2670 requires an analysis of requirements for access and operation of construction equipment, but it does not explicitly consider equipment access needs for adjusting utilities either during design—even though TxDOT's goal is to adjust most if not all utilities prior to letting—or during construction.

Strictly speaking, the constructability review in the current version of PDP Task 2670 falls short in one more respect. Several definitions of "constructability" in the literature, including NCHRP Project 10-42 (Report 391), emphasize that constructability includes the requirement for a project to be usable and maintainable (*64*, *65*, *66*). In other words, a constructability review should not be limited to construction phasing and construction equipment access but should also include how the construction process affects the usability and maintainability of the finished project. In the case of utilities, adding this requirement would involve analyzing the potential impact of the construction (both transportation project *and* utility adjustments) on the future usability and maintainability of both transportation infrastructure *and* utility facilities.

A constructability review that takes into consideration not just what happens during construction but also afterwards would be an iterative activity throughout the project development process. NCHRP Report 391 recognized this requirement and included a framework that runs parallel to the project development process from planning to construction, as shown in Figure 14.

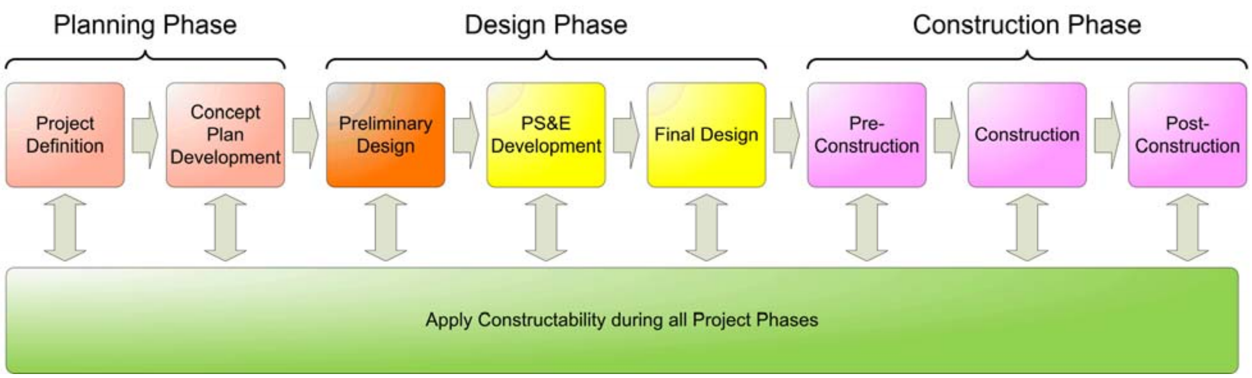


Figure 14. NCHRP Report 391 Constructability Review Framework in the Project Development Process (Adapted from [*64*]).

The current process at TxDOT partially supports this concept. In addition to PDP Task 2670, which takes place during preliminary design, the following design activities include a requirement or a suggestion to consider constructability:

- PDP Task 4500 (Prepare right of way and encroachment certifications),
- PDP Task 5200 (Design final vertical and horizontal alignments), and
- PDP Task 5250 (Review right-of-way requirements).

Changes to Business Processes and TxDOT Manuals

In light of the findings above, it would be advisable to modify the PDP manual as follows:

- **Expand the scope and description of PDP Task 2670**. It would be advisable to increase the level of detail in the description of this activity, while taking into consideration the preliminary nature of the analysis. The description would explicitly include the requirement to take into consideration utility constructability issues. It would also be advisable to include utility owner representatives as part of this review.

- **Add a constructability review activity during design**. It would be advisable to add a PDP task to formally introduce the requirement to conduct a constructability review during the design phase. The level of detail would be greater than the constructability review conducted during preliminary design. The review would also address utility constructability issues and include utility owner representatives. This addition would also entail adding cross references to the new activity, e.g., in PDP tasks 4500, 5200, and 5250.

Along with these PDP tasks, it would be advisable to develop a separate guideline to conduct constructability reviews taking into consideration TxDOT's specific needs. Although NCHRP Report 391 included numerous recommendations, the report was intended for a national audience. In addition, NCHRP Report 391 did not address utility constructability issues or needs.

Develop or Update Curricula for Utility Coordination Stakeholders

Strategy Description

Feedback from district officials indicates there is a need for training and professional development for utility coordination stakeholders, including project planners, design engineers, utility coordinators, managers, utility owners, consultants, and contractors. These stakeholders often struggle with a myriad of federal and state laws and regulations, as well as a large number of procedures and protocols. For these reasons, and for reasons such as personnel turnover, stakeholders frequently lack a basic understanding of concepts, procedures, and requirements, which can lead to substantial delays in the project development process. Developing curricula and comprehensive training materials would improve stakeholder understanding of the utility coordination process, improve familiarity with current laws and regulations, and foster a cooperative utility management approach.

The current availability of utility-related training materials and courses is limited. Examples include the following:

- **TxDOT course "Coordinated Solutions of Utility Conflicts in Transportation Projects" (*67*).** This course provides an overview of the utility cooperative management process, including utility coordination activities, statutes, and utility accommodation rules. The course has not been updated since 2001, and as a result, many laws, regulations, and procedures discussed in the document are outdated.

- **TxDOT course "DES 110: Right-of-Way Considerations during Project Development and Design" (*68*).** The course, which is currently being updated by the Right of Way Division, provides an overview of right-of-way issues, including right-of-way acquisition, right-of-way tasks during project development, right-of-way map production and revision, right-of-way releases, and utility impacts and adjustments.

- **National Highway Institute (NHI) course 134006 "Highway/Utility Issues" (*69*).** This course provides a description of utility accommodation and adjustment issues throughout the project development process. FHWA is currently planning to overhaul this course.

- **TxDOT training materials for the Utility Installation Review system**. The UIR training materials include an introduction to the utility permitting process at TxDOT, along with hands-on exercises that illustrate the use of UIR to submit, review, and approve utility installation requests on the state right of way. The materials can be customized to address the needs of TxDOT officials and utility owners.

Examples of training materials developed by other states include the following:

- **Georgia Department of Transportation**. As mentioned previously, GDOT implemented an interactive training course on methods to determine and avoid utility impacts during design using a utility impact analysis process (*32*). The course includes hands-on exercises to illustrate the use of utility conflict matrices, a cost comparison between adjusting a utility facility versus redesigning highway features around utility conflict areas, and potential construction schedule impacts.

- **Minnesota Department of Transportation**. Mn/DOT developed a two-day training course for staff, utility owners, consultants, and local government representatives to explain its new utility coordination process (*33*). The two-day course gives Mn/DOT staff and appropriate external parties insight into the new utility coordination process as well as general proactive utility coordination practices.

The need for developing training materials has been documented elsewhere. For example, one of the anticipated projects in the Strategic Highway Research Program (SHRP) 2 program deals with the development of training materials for utility coordinators (*70*). Likewise, the 2008 international right-of-way and utility scan tour noted that Australia has undertaken several training initiatives, including coordination with local universities for the development of curricula (mainly in right-of-way-related issues) and coordination with the utility industry to develop training materials and courses for utility personnel (*51*). The scan report recommended several implementation strategies, including developing and/or updating NHI courses, developing training and accreditation programs through university-based extension services, and developing formal degree-seeking curricula.

Changes to Business Processes and TxDOT Manuals

It would be advisable to develop new and/or updated training materials for utility stakeholders at TxDOT. Given the wide range of topics that need to be covered, it would be ideal to develop a two-tier set of training materials and courses, where the first tier provides an introduction to most topics of interest to utility stakeholders and the second tier focuses on specific topics of interest. Each topic could be a training module that would be taught separately or in groups to offer customized training opportunities to stakeholders. Examples of topics include the following:

- current federal and state laws, rules, and regulations;
- transportation project development process, milestones, and constraints;
- utility project development process, milestones, and constraints;
- utility accommodation and permitting;
- utility coordination process, practices, and strategies;

- reading and interpretation of transportation and utility engineering drawings and documentation;
- CAD, GIS, and survey control concepts;
- construction standards and specifications;
- document submission requirements;
- constructability reviews;
- traffic control plans, standards, and procedures;
- utility inspection procedures;
- quantities and cost estimates at different points during the project development process;
- billing and reimbursement procedures;
- development of utility agreements; and
- MOU structure, development, and maintenance.

Ideally, courses and training modules would offer stakeholders the opportunity to obtain continuing education unit (CEU) or professional development hour (PDH) credits. For the development of the training modules, it would be advisable to work with universities and the utility industry.

ADDITIONAL RECOMMENDATIONS TO OPTIMIZE TXDOT MANUALS

The previous section described business process strategies and specific recommendations for changes to TxDOT manuals at the individual activity level. Implementing these recommendations will certainly improve the manuals. However, there are additional recommendations that pertain to improvements to address structural TxDOT manual structure and content issues.

A conclusion from the 2008 Sunset Advisory Commission report was that the TxDOT project development process was too "complicated," making it difficult to understand how important decisions are made (*36*). While the project development process is *complex* (due in part to external factors such as federal and state laws and regulations that TxDOT does not control), TxDOT can certainly control the way it structures, describes, and presents the project development process to internal and external stakeholders to make sure the process appears *less complicated* and *easier to understand*.

An effective strategy to simplify the structure and presentation of the project development process is to harmonize, or otherwise eliminate, sources of inefficiency and redundancy in the description of PDP tasks. A review of several TxDOT manuals during the research led to a number of observations such as the following:

- Redundancy in content and activity descriptions, as well as inconsistencies in information aggregation levels, makes it difficult to understand the process and relate information across manuals. Redundancy is a particularly critical issue because if affects content integrity and TxDOT's ability to describe and present processes consistently across the organization. Examples of content integrity issues include obsolete material in some manuals that do not reflect updates in other manuals and summarization of content in some manuals that oversimplifies and/or distorts the content from other manuals.

- Inconsistencies in the use, structure, and content of supporting documentation such as flowcharts make it difficult to understand the project development process. Chapter 5 describes this issue in more detail.

- Inconsistent activity code designations make it difficult to provide cross references between manuals. For example, some manuals use codes to describe activities (e.g., the PDP manual and, to some degree, the *ROW Utility Manual*), which facilitates creating references for individual activities, but other manuals do not provide this type of information.

- Inconsistent manual structures make it difficult to relate information and provide cross references between manuals. For example, some manuals are organized in volumes (e.g., the *Right of Way Manual*), but other manuals follow different organizational structures.

Eliminating these sources of inefficiency should contribute to a better understanding (and simplification) of the project development process at TxDOT.

It is possible to substantially reduce (or even eliminate) redundancy and inconsistencies across manuals by modifying the TxDOT manual structure from a structure in which each manual is a standalone product to another one in which different manuals are "stackable" modules within a larger coherent structure. Figure 15 illustrates this concept. With the structure, the PDP manual would become a "bookcase" with thematic shelves (e.g., planning and programming, environmental, right of way, utilities, and design). Depending on the specific theme, one or more separate volumes would describe activities that pertain to that theme. Each volume would be a separate document or file that can be easily updated and published as needed without having to affect other volumes or the rest of the "shelf" or "bookcase" structure. Following current TxDOT manual practice, each shelf would be managed by a designated office of primary responsibility.

To eliminate confusion and encourage standardization, each volume would have activities identified by unique activity codes (e.g., following the current PDP manual 4-digit structure) that are not repeated across shelves. For example, all PDP tasks for each volume within the preliminary design "shelf" would use 2000 numbers, all PDP tasks for each volume within the environmental "shelf" would use 3000 numbers, and so on. Information disaggregation could vary across volumes and shelves, but would be as uniform as possible to facilitate adequate understanding of the project development process. Redundancy would be greatly reduced or eliminated by presenting detailed information related to a topic *only once* (in its corresponding shelf and volume), instead of having similar information at different disaggregation and currency levels in different manuals, which is the current practice.

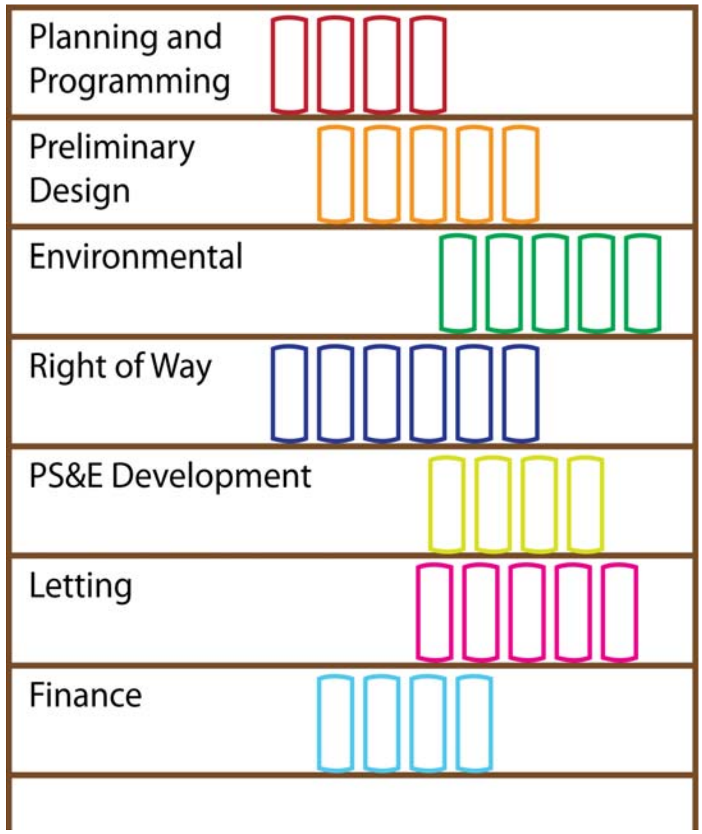


Figure 15. Proposed "Bookcase" Structure for TxDOT Manuals to Describe the Project Development Process.

CHAPTER 5. PROJECT DEVELOPMENT PROCESS DIAGRAMS

INTRODUCTION

This chapter describes the procedure followed to develop a detailed map of TxDOT project development process activities (with a focus on environmental and utility adjustment processes) resulting from a review of current practices, potential regionalization impacts, and the optimization strategies discussed in Chapter 4. The chapter also describes a prototype web-based application called TxDOT Business Process Explorer (TxBPE) the researchers developed to facilitate access to project development process information graphically.

PROJECT DEVELOPMENT PROCESS INFORMATION SOURCES

As with many other organizations, information about business processes at TxDOT resides within two types of information sources: written documentation (such as manuals, memoranda, and flowcharts) that provides information about the process "theory," and oral recollections and feedback from practitioners that provide information about the process "practice." Both sources of information are critical in order to understand how an organization actually works.

To document the process "theory" at TxDOT, the researchers reviewed the structure and supporting documentation (mainly flowcharts and forms) of three TxDOT manuals of interest to this research: the *Project Development Process Manual*, the *ROW Utility Manual*, and the *Environmental Manual*. To document the process "practice," the researchers conducted meetings and workshops throughout the state. As mentioned previously, there were two rounds of meetings. The first round included meetings with representatives of several divisions (Right of Way, Environmental Affairs, and Design) and districts (Amarillo, Bryan, Corpus Christi, Dallas, Fort Worth, Lubbock, and San Antonio). This round also included a meeting with FHWA Texas Division officials. The second round of meetings took place at the Houston, San Antonio, and Tyler districts at the end of the research. The researchers also used results from previous research projects that documented specific aspects of the project development process at TxDOT. The regional meetings provided a unique opportunity to understand differences in practices among districts.

Project Development Process Manual

Manual Structure

As mentioned in Chapter 2, the manual has six chapters, as follows:

- Planning and Programming,
- Preliminary Design,
- Environmental,
- Right of Way Utilities,
- PS&E Development, and
- Letting.

Each chapter includes sections, subsections, and tasks. Tasks typically include topics such as description, responsible party, subtasks, helpful suggestions, critical sequencing, and reference material. Each task has a four-digit code in which the first digit indicates the chapter. For example, Task 2000 (Conduct preliminary design conference) is the first task in Chapter 2 (Preliminary Design). The PDP manual includes almost 200 tasks that apply to a wide range of project types and characteristics.

Task sequencing information in the PDP manual is at a high, aggregated level. Some sections provide a general statement about task sequencing, e.g., “these tasks may be performed concurrently” or “tasks are listed in approximate chronological order.” Although useful, these general statements can be misleading. For example, Chapter 4, Section 4 (Utility Adjustments) contains the following five tasks and a comment that they are listed in approximate chronological order:

- Task 4610 (Coordinate utility adjustment plans),
- Task 4620 (Prepare and execute utility adjustment agreements),
- Task 4630 (Utility owners adjust facilities),
- Task 4640 (Prepare utility clearance certifications), and
- Task 4650 (Reimburse utility owners for eligible adjustment costs).

In reality, some of these tasks may occur concurrently, may be skipped, or may be performed in a different sequence, especially when dealing with more than one utility company.

Information about relationships between chapters, sections, and tasks is frequently missing in the PDP manual. Consider the following examples at different levels of information disaggregation:

- There is little information about the relationship between Chapter 4 (Right of Way Utilities) and Chapter 5 (PS&E Development).

- There is little information about the relationship between Chapter 5, Section 7 (Drainage Design) and Chapter 4, Section 4 (Utility Adjustments).

- In Chapter 5, there is little information about the relationship between Section 4 (Roadway Design) and Section 7 (Drainage Design).

- In Chapter 4, there is no information how Section 3, Task 4400 (Obtain contractual agreements with local public agencies) relates to Section 4, Task 4610 (Coordinate utility adjustment plans).

About two thirds of tasks in the PDP manual contain critical sequencing information. This information is needed to provide insight on when a task should occur in the overall process and in relation to other PDP tasks. However, in some cases, the PDP manual provides information in the critical sequencing section that is more a general warning than a critical path statement, which makes understanding task sequencing difficult. Examples of warnings mentioned in the critical sequencing section include the following:

- "Request traffic data early." This statement does not provide information about sequencing in relation to other tasks. In addition, it does not clarify if "early" means early in the current task or in a previous task.

- "Preliminary design can be as simple as a line diagram showing proposed number of lanes, lane drops, and proposed overhead and large ground mounted, guide signs and their proposed locations." This statement does not provide any information about task sequencing.

- "Begin this task soon after determining its need to avoid project delay." This statement conveys a sense of urgency, perhaps suggesting the task is frequently on the critical path. However, if this is the case, the statement should be more specific about it to avoid any confusion.

Business Process Charts

Figure 16 shows a widely used graphical representation of the PDP process at TxDOT. Although the chart is useful, some chart characteristics warrant further discussion, as follows:

- The rounded boxes in the chart, which represent PDP manual sections, follow the order provided in the PDP manual. Arrows appear to indicate precedence between task groups. Dotted arrows appear to indicate conditional relationships that are relevant only for certain project types. However, the exact meaning of the arrows is not clear since there are no arrow entries in the legend box.

- The size of individual task group boxes has little to do with the actual duration and/or sequence of each task within that group. For example, the "Construction Funding Identification 1600-1680" task group includes Task 1620 (Obtain develop authority) and Task 1630 (Obtain construct authority), both of which tend to take place much later in the process, not at the beginning of the Plan phase as shown in Figure 16.

- Some task groups are shown in sequence in Figure 16, but they can actually occur concurrently. For example, depending on the type of project (or the relative status of utility adjustments versus right-of-way acquisition), "Utility Adjustments 4610-4650" can start before "ROW Appraisals and Acquisition 4400-4500." Similarly, "ROW Map and Property Descriptions 4300" can actually happen concurrently with "ROW and Utility Data Collection 4000-4200" tasks.

- Horizontal segments in the diagram correspond to chapters in the PDP manual, which are organized roughly by function. Although not critical from a business process modeling perspective, Figure 16 is not a true swim lane diagram because the horizontal segments represent functions, not organizational units (which swim lanes typically represent).

ROW Utility Manual

Manual Structure

The *ROW Utility Manual* has 12 chapters that cover a wide range of topics such as relevant laws and regulations; utility coordination during the preliminary design, design, and construction phases; cost estimates, billings, and payments; and forms and agreements. Of particular interest is Chapter 2 of the manual, which includes the following three sections:

- utility cooperative management process – "the process,"
- right-of-way utility adjustment sub process – "the sub process," and
- MOUs with utilities.

As mentioned previously, the sub process includes descriptions of four major utility procedures: the federal utility procedure, the state utility procedure, the local utility procedure, and the non-reimbursable procedure. Activity descriptions typically include a list of participants, activity objectives, and a narrative. Activities in the manual have a number (in roman numerals). However, activity numbers are not unique. For example, there are two activities IV, one at the process level (Field Verification) and a second one at the sub process level (Right of Way Release).

Business Process Charts

Although activity narratives in the manual provide some indication of when activities are supposed to take place, that depiction is not always clear. As a result, a casual reader would have to use the process and sub process diagrams (Figure 2, Figure 3) as the main source of information about presumed activity sequencing. However, the structure of both manual and diagrams would make this process challenging. Issues uncovered during the research (which complement the analysis completed in research project 0-5475 (*71*)), include the following:

- An explicit cross reference between process and sub process diagrams is missing. For example, it is not clear where to connect the sub process diagram "Start" and "End" points to the process diagram, which makes it difficult to understand how the sub process fits into the larger process. Some process and sub process boxes share similar names, e.g., "Early ROW Release for Utilities," "Field Verification," and "ROW Release," which enabled the researchers to use those common elements as anchor points. However, given the ad hoc nature of the diagrams, it is only possible to use the anchor points as rough guidelines. In several cases, the researchers made educated guesses about the location of, and relationship between, common elements and discussed the findings with TxDOT officials.

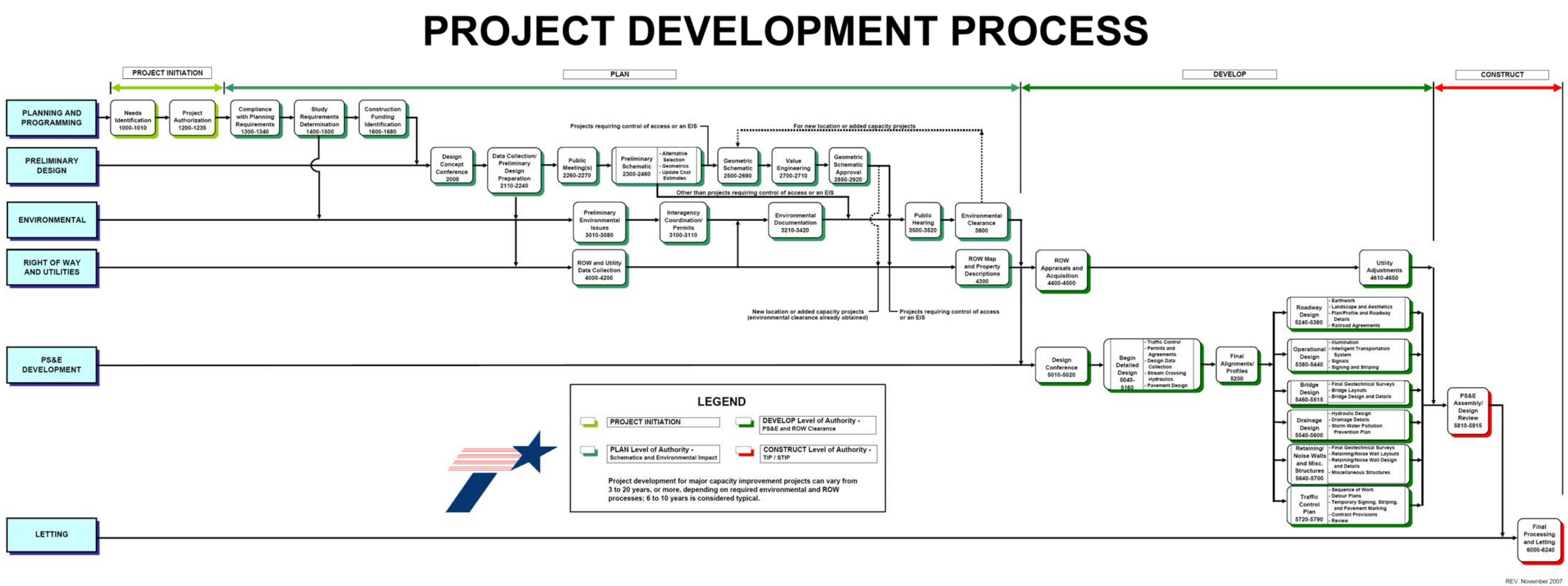


Figure 16. *Project Development Process Manual* Diagram (*6*).

- The process and sub process diagrams use different box types (e.g., “Process,” “Document,” “In/Out,” “Decision,” and “Terminal”) to represent activities. However, the use of different box types is inconsistent, making it difficult to use the diagrams to understand information flows. For example, a document in one diagram could appear as an in/out box in another diagram. Likewise, it is not clear what a process box is or what the difference is between a process box and a document box.

- The size of individual boxes has little to do with the actual duration and/or sequence of each activity. For example, an activity such as field verification appears only once at the beginning of the process. In practice, field verification can span weeks or months and, in fact, can take place concurrently with other activities.

- Some diagram activities, e.g., “Eligibility Determination (District Approval) and “Determination of Eligibility Established,” do not appear in the list of activities in the manual. In Figure 3, those activities appear without an activity number.

Environmental Manual

Manual Structure

The *Environmental Manual* includes seven chapters, as follows:

- Policy and Process Overview,
- Preliminary Survey,
- Environmental Documentation,
- Public Involvement,
- Interagency Coordination,
- Permits, and
- Environmental Commitments.

As opposed to the PDP manual or the *ROW Utility Manual*, the *Environmental Manual* does not assign task codes or activity numbers to individual activities. In general, the *Environmental Manual* contains little information about activity sequencing or the relationship between activities both within and among chapters. This finding is not surprising given the lack of a numbering structure for individual activities. In addition, the published manual does not provide any diagrams to help readers understand the process. Some information related to activity sequencing is available within the chapter narrative. However, this information is not sufficient, making it necessary, in essence, to study the entire manual to develop an understanding of the environmental process.

Chapter 1 (Policy and Process Overview) of the *Environmental Manual* provides some basic information about the environmental process in a narrative format. Section 4 (Roles and Responsibilities) in the same chapter provides a bulleted list of specific roles and responsibilities assigned to different stakeholders (districts, the Environmental Affairs Division, and resource agencies) in connection with the major environmental activities described in Chapters 2 (Preliminary Survey) through 7 (Environmental Commitments) in the manual.

A closer look at the bulleted list of activities in Chapter 1, Section 4 of the manual revealed that not all list items described separate activities. For example, a list item could describe more than one activity or describe a sub activity of another activity. In other instances, a list item contained a note to amplify a previous list item. Further, some list items appeared in multiple subsections.

Business Process Charts

A published business process diagram was not available. However, the Environmental Affairs Division provided a preliminary chart describing environmental activities at TxDOT (Figure 17). The chart is a swim lane diagram that assigns activities to different environmental stakeholders and uses familiar business process modeling objects such as activity boxes, decision boxes, and sequence flow arrows.

While Figure 17 was helpful, the actual diagram implementation had several shortcomings, including the following:

- Some activities lack an input, and some activities lack either an input or an output, making it difficult to map out activities and documents. The diagram also includes decision boxes without inputs and decision boxes that provide only one output option, effectively defeating the purpose of a decision box. Further, some documents are not associated with any activity.

- The diagram mixes activities and documents instead of linking activities by sequence flows and associating documents with activities, making it difficult to derive data flow information from the swim lane diagram.

- On the left side of the diagram, an activity (Districts received comments) and a decision box (District requirement for assistance/notification) are outside the swim lanes and, therefore, are not assigned to any organizational unit. In addition, the diagram does not have a consistent progression from left to right, frequently looping back to previous activities, crossing swim lanes back and forth in the process, which makes the diagram difficult to follow and understand.

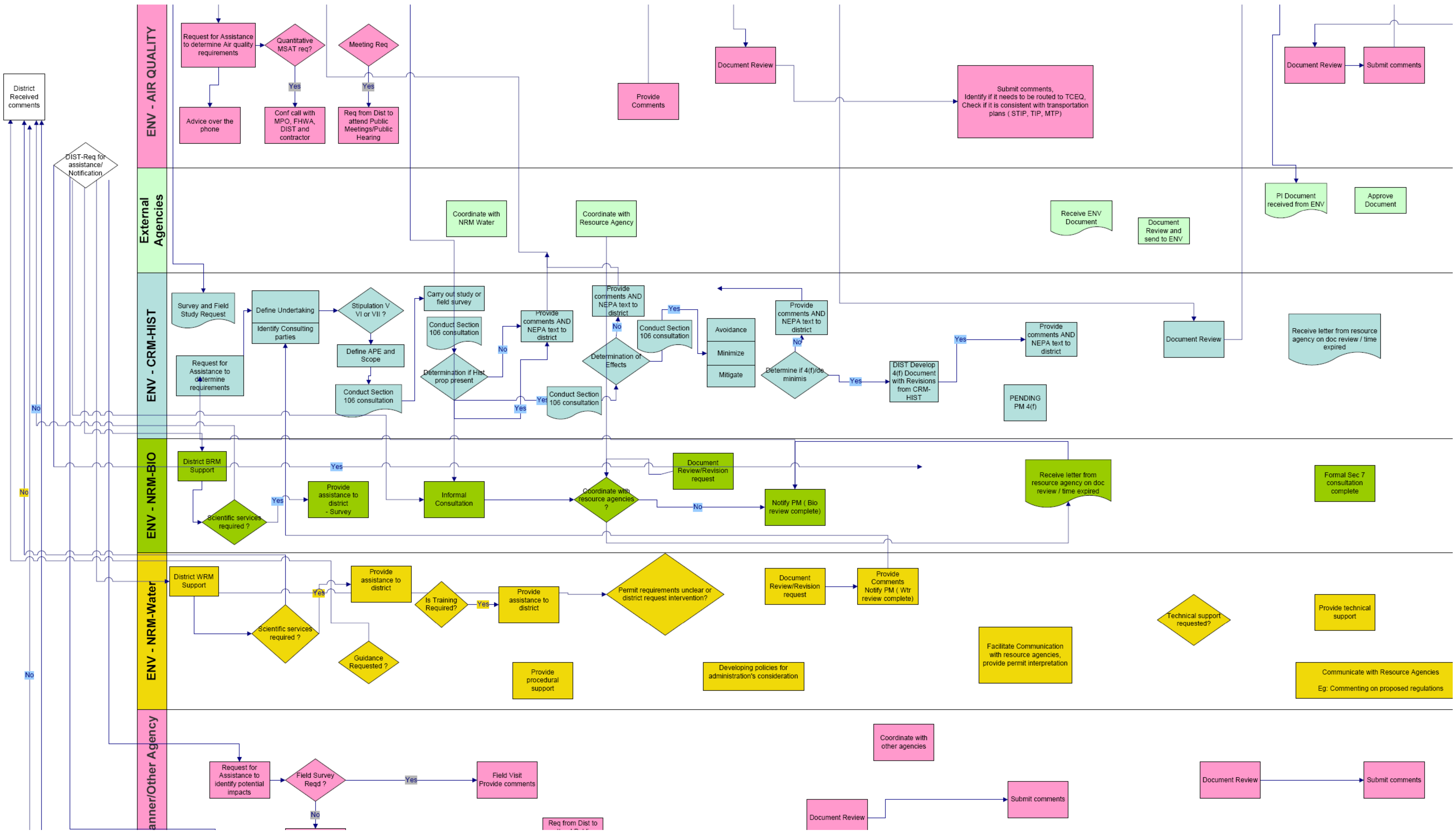


Figure 17. Preliminary Swim Lane Diagram of the Environmental Process (Partial Zoomed-in View).

As mentioned previously, the *Environmental Manual* does not assign task codes or activity numbers to individual activities. In order to structure the business process information in the *Environmental Manual* in a format suitable for inclusion in a generic business process model, the researchers assigned two-letter codes to sections and bulleted lists provided in Chapter 1, Section 4 of the manual, which also correspond to chapters in the manual. Table 3 shows the two-letter activity group codes.

Table 3. Environmental Manual Activity Group Codes.

Environmental Manual Chapter		Code
Number	**Name**	
2	Preliminary Survey	PS
3	Environmental Documentation	ED
4	Public Involvement	PI
5	Interagency Coordination	IC
6	Permits	P
7	Environmental Commitments	C

Although the researchers could have chosen to use chapter numbers instead of activity group codes, the researchers chose codes because the reviewers of the swim lane diagram could identify activity groups in the diagram more easily. In some cases, to ensure consistency, the researchers edited, added, or divided activities in Chapter 1, Section 4 of the manual. In addition, the researchers assigned unique codes to each activity using the two-letter codes in Table 3 and a series of nested activity and sub activity codes. The general syntax was as follows:

EM <two-letter activity group code> <activity code> <sub activity codes>

For simplicity, activity codes reflect the order of the activity listing in the *Environmental Manual*, not necessarily the order in which activities are carried out in practice. Table 4 shows an example of the coding process for an activity that has several sub activities.

Table 4. Environmental Manual Code Example.

Activity	Activity Code
Perform environmental studies and analyses	EM PS 3
Conduct natural resources study	EM PS 3.1
Conduct cultural resources study	EM PS 3.2
Describe impacts to neighborhoods	EM PS 3.2.1
Describe environmental justice issues	EM PS 3.2.2

INTEGRATED BUSINESS PROCESS MODELING

Challenges with Existing Documentation

The previous section documented specific issues found during the review of three TxDOT manuals of interest to this research: the *Project Development Process Manual*, the *ROW Utility*

Manual, and the *Environmental Manual*. A summary of overall lessons learned include the following:

- TxDOT manuals follow different structures and styles. They also lack a common system to arrange and label task and subtasks. For example, the *PDP Manual* provides numbers for all tasks, the *ROW Utility Manual* provides activity numbers but these numbers are not unique, and the *Environmental Manual* does not provide any activity numbers.

- The lack of a consistent numbering system for activities across manuals makes it difficult to cross reference manuals. Cross references are also difficult due to inconsistencies in activity names. For example, a "preliminary design meeting" in one manual could be a "design concept conference" in another manual. Likewise, "perform preliminary right-of-way research" in one manual could be "field verification" in another manual. Providing cross references by using activity narratives is also cumbersome and inefficient because the descriptions and level of detail of the corresponding activities are rarely consistent. There were also several cases where an activity in one manual overlapped with several activities in another manual.

  The degree to which the PDP manual currently references other TxDOT manuals illustrates the complexity of the problem. Many tasks in the PDP manual include a section called "Resource Material" that provides references to TxDOT manuals, research reports, and Internet links in relation to that particular task. In the case of references to manuals, most references are to the manual itself, not to a specific chapter, section, or activity in the manual. Not providing adequate references and linking information can be limiting, particularly for inexperienced users (who need effective access to manual documentation the most).

- TxDOT business process diagrams follow different structures and styles. The diagrams use ad hoc flowcharting methodologies and procedures, which make them incompatible with each other. In addition, the charts are typically high-level diagrams that provide little detail and result in limited connectivity with the corresponding manuals. These characteristics make developing integrated business process models difficult.

  It is worth noting that TxDOT's *Data Architecture* (*72*) provides comprehensive information about requirements for developing data models (such as logical model, physical model, and data dictionaries), but clarifies that TxDOT currently does not have a standard for developing business process models.

Business Process Modeling Options

Several business process modeling options were available for developing a unified business process model to integrate environmental and utility-related activities within the context of the TxDOT project development process, including the following:

- **Integrated Definition for Function Modeling (IDEF0)**. As described in the Federal Information Processing Standard (FIPS) 183, IDEF0 is a business process modeling method that enables users to model processes as a set of interrelated activities or functions for a specific purpose (*73*). In IDEF0 diagrams, boxes represent functions and arrows represent inputs, controls, outputs, mechanisms, or calls, depending on their position relative to the function box.

- **Integrated Definition for Process Description Capture Method (IDEF3)**. IDEF3 is a business process modeling method that complements IDEF0. IDEF3 enables users to capture, manage, and display process information in a form of scenarios displayed as process diagrams (*74*). In IDEF3 diagrams, processes are described as an ordered sequence of events along with objects that participate in those events.

- **Business Process Modeling Notation (BPMN)**. BPMN is a business process modeling method that depicts end-to-end flows of business processes (*75*). There are three basic types of BPMN-based models, including private (internal) business process models, abstract (public) business process models, and collaboration (global) business process models. Collaboration business process models depict interactions among business entities as a sequence of events, activities, and gateways arranged in "pools" and "lanes" along with data objects.

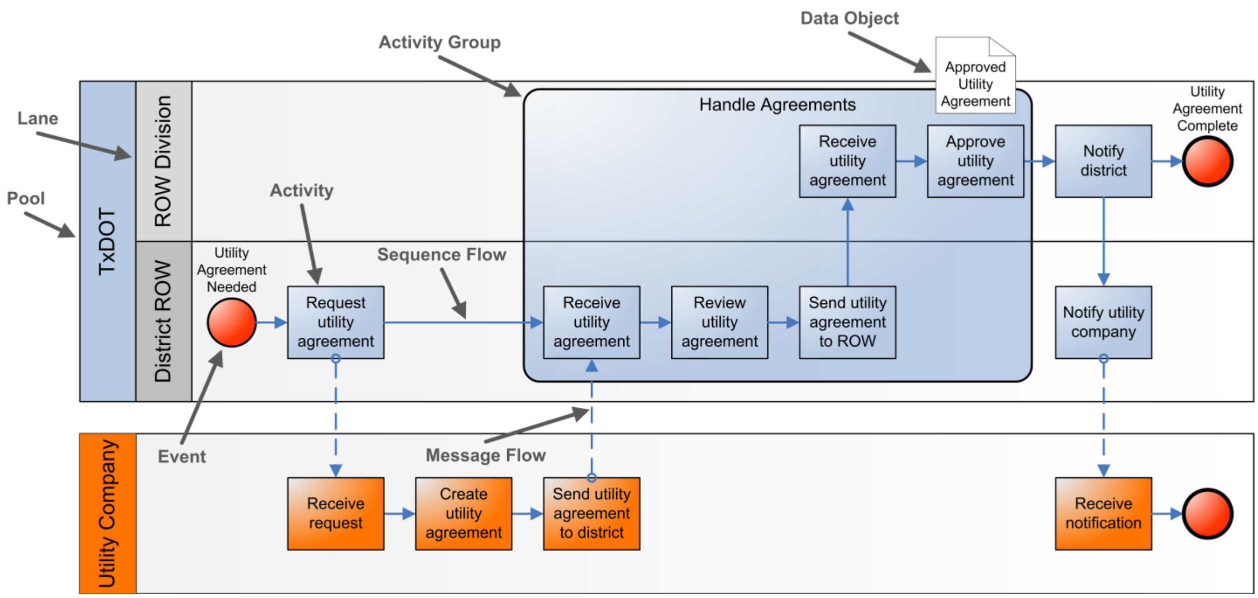
IDEF0 and IDEF3 are useful to model detailed processes such as manufacturing processes, but less useful to convey and discuss model information with users who are not familiar with IDEF components and notation. A major characteristic (and limitation) of IDEF-based models is that users typically see only a small portion of the business process at a time, which makes it difficult to picture the whole process, verify relationships, and derive new relationships between activities. It is also worth noting the federal government recently withdrew 10 federal information processing standards, including FIPS 183, because they were obsolete or were not updated to adopt voluntary industry standards, federal specifications, federal data standards, or current information security practices (*76*).

By comparison, BPMN-based models are designed to present the "whole picture" at once, e.g., by displaying business process flows from beginning to end on the same "sheet," which facilitates model viewing and understanding. In addition, BPMN-based models use components and notation that are similar to the way practitioners conceptualize business processes, which facilitates not just model viewing and understanding but also discussions among practitioners that lead to process optimization more effectively. For these reasons, the researchers decided to develop the unified business process model to integrate environmental and utility-related activities using BPMN.

Business Process Model Development

For testing purposes and for discussions with stakeholders, the researchers used Microsoft® Visio® with a BPMN stencil to produce business process models that could be printed on a single sheet of paper using large format printers. This strategy proved to be beneficial during meetings with TxDOT officials because it was possible to see the whole process at once and mark up the drawing as needed.

For illustration purposes, Figure 18 shows the major components of a collaboration business process model in BPMN using a simple, hypothetical utility agreement approval process that involves two participants (TxDOT and a utility company) and two separate organizational units within TxDOT (the Right of Way Division and the district right-of-way section).



BPMN Component	Description
Swim lane	A pool or a lane.
Pool	Representation of a process participant. A pool is a container for lanes, activities, sequence flows, and other BPMN elements.
Lane	Sub partition of a pool to organize activities.
Activity	Rectangular box that shows units of work that a process participant performs.
Activity Group	Rounded box that arranges a set of related activities into a group.
Sequence Flow	Solid line used to show the order in which activities are processed.
Message Flow	Dashed line that shows messages between process participants.
Event	Round or oval element that indicates the beginning or end of a process.
Data Object	Element associated with an activity that provides information about data that the activity uses or produces.

Figure 18. Example of Collaboration Business Process Model Using BPMN.

Two important development steps were the diagram's "point of view" and level of detail. The diagram's point of view was important because different diagram points of view can produce different models. For this research, the diagram's point of view was TxDOT's point of view, assuming a traditional design-bid-build (DBB) delivery method. A diagram depicting the environmental and/or utility processes from the points of view of resource agencies or utility owners would logically produce diagrams containing similar information but from a different vantage point. To assist diagram readers understand the diagram properly, the researchers included the following disclaimer, which explains the origin and content of the diagram:

> The business process model (BPM) depicted here describes the TxDOT project development process, from "Needs Identification" to "Design Conference," with a focus on environmental and utility adjustment activities. Activities are arranged in swim lanes that represent TxDOT organizational units responsible for completing those activities.
>
> Sequence flows (arrows) connect activities to provide a sense of activity precedence, based on the traditional design-bid-build (DBB) project delivery method. The model is generic to accommodate a wide range of project types. Model variations may be necessary to represent project delivery methods such as comprehensive development agreements (CDAs) and facility concession agreements (FCAs) or to represent individual project characteristics.
>
> The model shows activities at different levels of resolution (or detail). In general, each additional period in the BPM code increases the level of resolution by one level. Not all areas of the model require the same level of resolution to understand the process. As a result, activity resolution levels in the model are not uniform.
>
> Information sources for developing the business process model included the *Project Development Process Manual*, the *Environmental Manual*, the *ROW Utility Manual*, regionalization strategy documents, and meetings with district and division stakeholders. For additional information, see research report FHWA/TX-10/0-6065-1, Integration of Utility and Environmental Activities in the Project Development Process.

With respect to the model's level of detail, an optimum level of information would result in enough content for a productive discussion with practitioners without overburdening participants with too much detailed information. In general, an appropriate level of detail was roughly at the PDP task level. Although the goal was to have a uniform level of detail throughout the model, it proved beneficial for discussion purposes to increase the level of detail in some areas by including subtasks. Overall, the level of detail was consistent with that used for the utility coordination model the researchers developed as part of research project 0-5475 (*71*). For convenience, the researchers decided not to expand the already sizeable 0-5475 business process model (which mostly covered design phase activities) but, instead, decided to create a new model at the same level of detail, but with a primary focus on environmental and utility processes during preliminary design.

To confirm the validity of the model, the researchers discussed the model with stakeholders to verify process information, fill in information gaps, identify integration points between the environmental and utility processes, and edit the diagrams as needed. More specifically, the discussions evolved around the following key topics:

- process activities and associated documents;
- data requirements (type, resolution, and accuracy) and activities to gather the data;
- constraints and/or barriers for collecting relevant data;
- business process milestones;
- sequences and relationships; and
- integration points between the environmental and utility processes.

Business Process Model Structure

The business process model includes the following swim lanes:

- Transportation Planning and Programming (swim lane 1),
- Preliminary Design (swim lane 2),
- Environmental (swim lane 3),
- Right of Way (swim lane 4), and
- PS&E Development (swim lane 5).

The name of a swim lane corresponded to a chapter in the PDP manual. The researchers assigned a code to each activity according to the following syntax:

<swim lane>.<activity group>.<activity>.<sub activities>…

Table 5 illustrates this naming convention with an activity that has several levels of sub activities. Figure 19 illustrates how the diagram depicts activities and sub activities. Figure 19 shows Activity Group 1.4 (Project Authorization) with three activities: Activity 1.4.1 (Prepare cost estimate), Activity 1.4.2 (Obtain approval of PLAN authority), and Activity 1.4.3 (Obtain project specific Minute Order). Activities 1.4.1 and 1.4.2 include sub activities. Notice that Figure 19 also includes examples of documents associated with activities, including a standard right-of-way form (ROW-RM-1), which is associated with Activity 1.4.1 (Prepare cost estimate).

Table 5. Business Process Model Elements and Increasing Level of Detail.

BPM Element	BPM Code	Object Label Example
Swim lane	3	Environmental
Activity group	3.4	Environmental Documentation
Activity	3.4.9	Perform environmental studies and analyses
Second-level activity	3.4.9.9	Perform hazardous materials study
Third-level activity	3.4.9.9.1	Perform hazardous materials assessment and investigation
Fourth-level activity	3.4.9.9.1.2	Review project design and ROW requirements
Fifth-level activity	3.4.9.9.1.2.3	Review proposed utility and pipeline adjustments

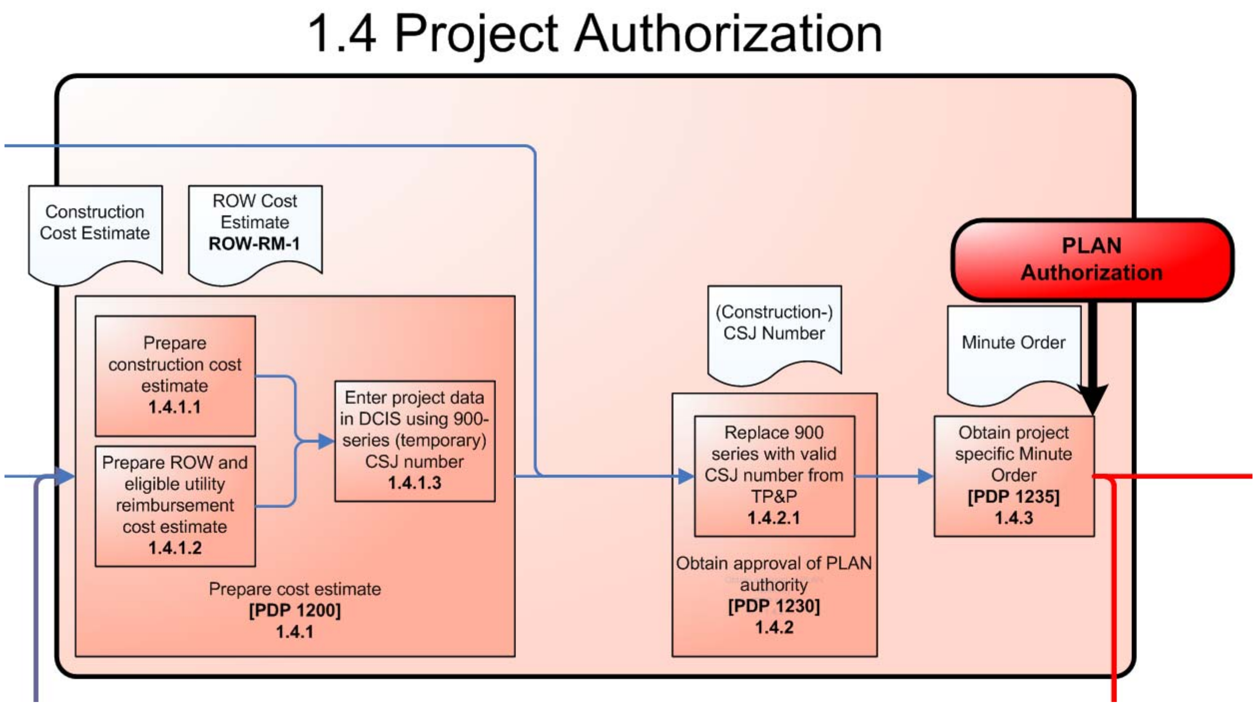


Figure 19. Business Process Model Activities and Sub Activities.

Activities can include references to multiple manuals. For example, Figure 20 includes Activity 2.1.2 (Conduct design concept conference), which includes references to the PDP manual and the *ROW Utility Manual*. In general, each activity in TxBPE includes a description and, as available, several codes that reference the source of the activity. Possible codes include a *ROW Utility Manual* code, a PDP manual code, and an *Environmental Manual* code. Each activity also includes a code that identifies the activity in the model, called business process model code. Figure 21 shows how the codes appear on activities.

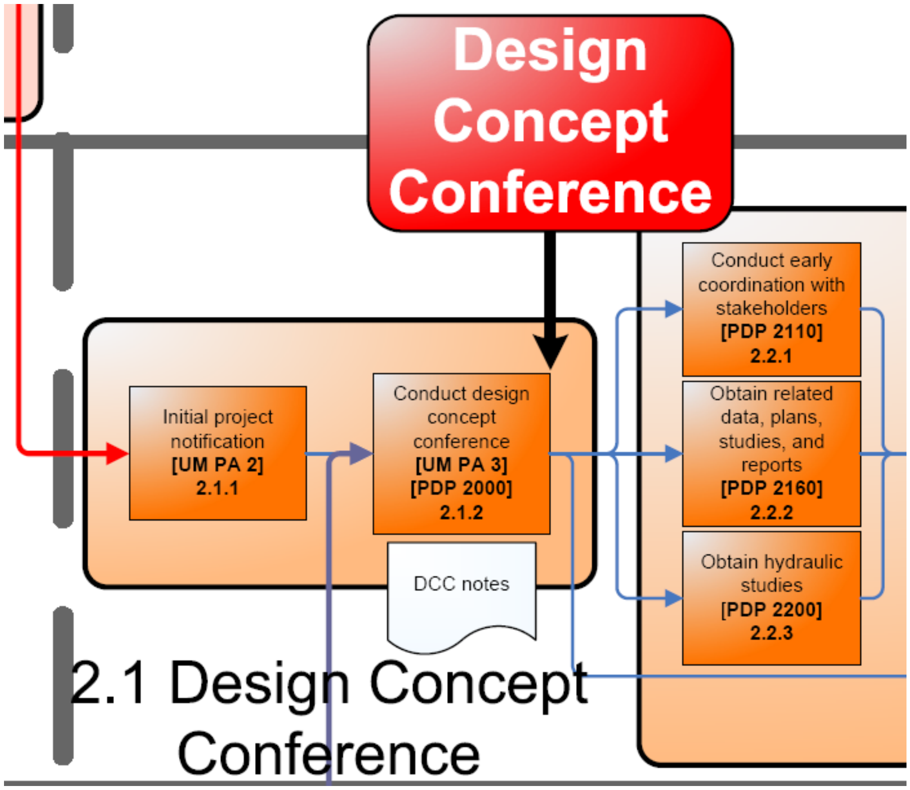


Figure 20. Business Process Model Activities and Multiple Manual References.

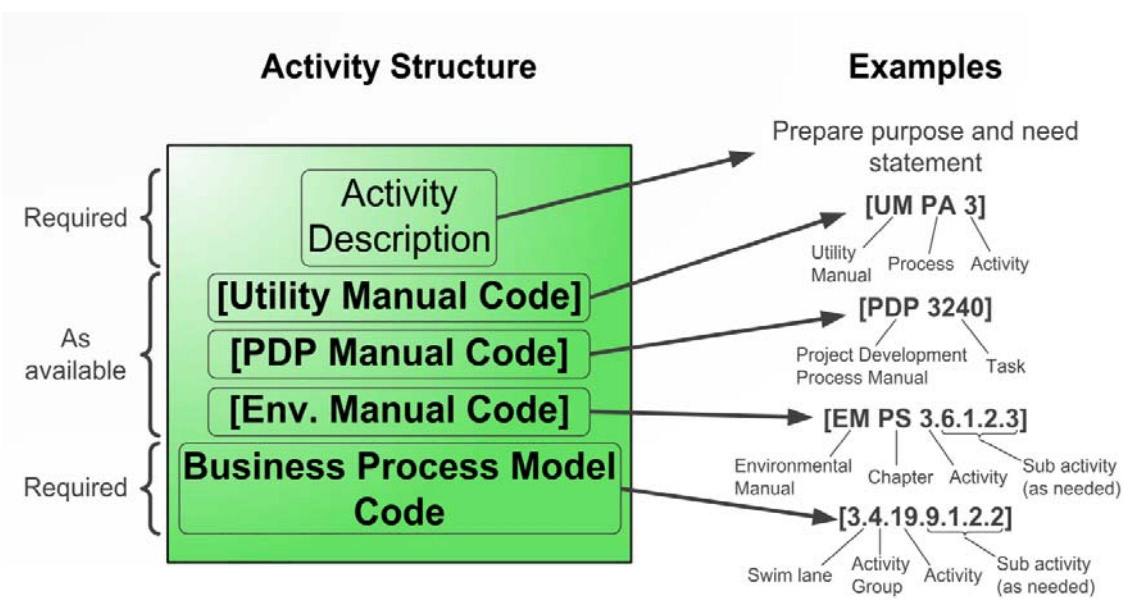


Figure 21. Business Process Model Activity Structure and Examples.

The business process model also uses several other graphical elements. Figure 22 provides an overview along with a definition of these elements.

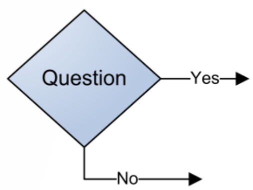
Business Process Model Element		Comment
Summary Activity		A summary activity is an indicator of multiple activities that have been combined into one activity. Summary activities are used when there is a need to aggregate activities to save space and/or reduce the complexity of the model.
Milestone		A milestone is a marker that indicates the end of a sub process or the completion of a set of activities. Milestones typically feature the completion or signing of an important document.
Start/End Marker		A start or end marker is an indicator of the beginning or end of a process.
Decision Point (Gateway)		A decision point is an element that provides alternate sequence flows for a process based on the outcome of a question.
PDP Manual info on timing/sequencing	Text description in pink	Text in pink provides additional information from the PDP manual on the timing or sequence of an activity in the project development process.
PDP Manual info on related tasks	Text description in dark blue	Text in dark blue provides additional information from the PDP manual on related tasks of an activity in the project development process.
PDP Manual activity comment	Text description in red	Text in red provides comments from the PDP manual about an activity.
Researcher's comment	Text description in black	Text in black corresponds to researchers' comments.
PLAN/DEVELOP/ CONSTRUCT Authority Divider		A thick, dashed line indicates the requirement for a certain authority (PLAN, DEVELOP, or CONSTRUCT) from the Texas Transportation Commission to perform an activity.
Major Swim Lane Divider		A thick continuous line indicates the boundary of a major swim lane such as major function groups within TxDOT.
Minor Swim Lane Divider		A thin continuous line indicates the boundary of a minor swim lane such as a district, division, or regional support center within a major swim lane.

Figure 22. Other Business Process Model Elements.

All activities (and activity groups) in the model are color-coded to indicate the swim lane or functional group in which the activity is located. Figure 23 explains the color codes used.

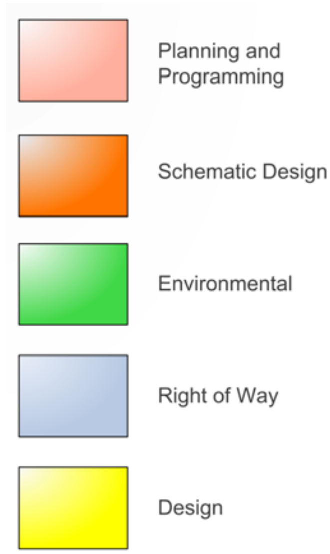


Figure 23. Activity Color Codes.

Sequence flows that cross swim lanes are also color-coded to indicate the swim lane of the source activity (Figure 24). Sequence flows that cross swim lanes are thicker than sequence flows within a swim lane. Sequence flows that connect activities within the same swim lane always use the standard blue color.

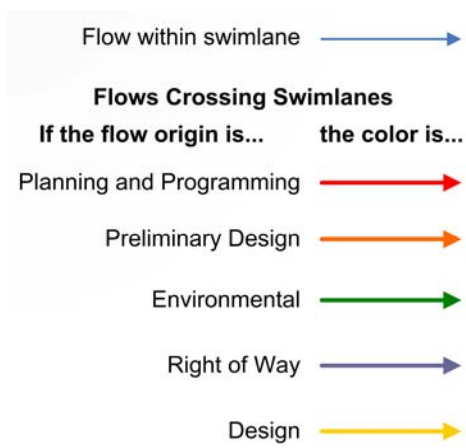


Figure 24. Sequence Flow Color Codes.

To provide a general idea of the whole process at a high level, the researchers also developed an overview diagram (Figure 25). Graphical elements in the overview diagram are limited to swim lanes, activity groups, major milestones, and major sequence flows that are depicted as input/output arrows. Notice the process overview diagram in Figure 25 resembles the (even higher-level) diagram in Figure 1. The overview diagram in Figure 25 also resembles the PDP manual diagram (Figure 16), except Figure 25 focuses on the environmental and utility processes prior to the design phase. Overall, the structure of the overview diagram in Figure 25 has a number of advantages over that in Figure 16, including the following:

- recognition that activity sequencing within the same swim lane is not necessarily linear,
- emphasis on interaction between swim lanes (therefore between different business units) with a focus on activities that can be completed in parallel, and
- depiction of major milestones.

TXDOT BUSINESS PROCESS EXPLORER

When printed at 100 percent scale, the unified business process model that depicts environmental and utility activities during preliminary design is quite large (about 14×5 feet). This size can make it difficult to print and handle the diagram effectively. To facilitate access to model information, the researchers developed the web-based TxBPE application. Although TxBPE is web-based, it is sufficiently flexible so that it can be accessed on the Internet, the TxDOT intranet, or from a local or networked computer drive. TxBPE could be extended to cover all project development activities at TxDOT. The current version of TxBPE focuses on environmental and utility-related activities.

TxBPE presents business process information at the following three levels:

- **Level 1 – Process overview**. Level 1 provides an interactive version of the high-level business process overview in Figure 25.

- **Level 2 – Process details**. Level 2 provides an expanded, detailed view of the business process. Access to Level 2 is possible by clicking any activity group on the Level 1 screen. For example, Figure 26 shows the Level 2 activities associated with Activity Group "Construction Funding Identification."

  In practice, displaying the full Level 2 model on one web page would result in a model that is difficult to read and navigate. To address this issue, the researchers divided the Level 2 model into several sub models, each of which can be accessed separately depending on the Level 1 activity group selected. In general, each sub model only shows a portion of the complete process around the activities associated with the corresponding Level 1 activity group. In addition, a sub models only shows a swim lane if it has an activity in that portion of the model. For example, the PS&E Development swim lane does not have any activities prior to Develop authorization. As a result, most sub models that document activities before Develop authorization do not include any PS&E Development swim lane.

  It was also necessary to divide activity groups that contained a large number of activities into several Level 1 parts. For example, Activity Group "ROW Mapping before Letting" (Figure 25) was subdivided into three Level 1 parts and three Level 2 sub models.

Several activity groups to the right of the Develop authority divider were not part of the scope of research project 0-6065 and are only included in the Level 1 process overview.

- **Level 3 – Activity details**. Level 3 provides access to specific pages of relevant online versions of TxDOT manuals, which provide a detailed description of the activity selected by the user. The current version of TxBPE points to the online TxDOT manuals available on the TxDOT Internet website. For example, Figure 27 shows the Level 3 description associated with Activity "Review scope, cost, and staff requirements of project development." In addition to web pages of online TxDOT manual, Level 3 also provides access to sample documents associated with activities, including forms and other relevant documents from the TxDOT web server.

  For convenience, all Level 3 activity descriptions open in a new browser window. However, if an activity includes references to multiple manuals, clicking on the activity opens multiple browser windows, one window for each manual referenced. Likewise, Level 3 does not provide access to activity descriptions if those activities were new activities the researchers recommended for addition as part of the research (Note: developing the activity descriptions was not part of the research scope).

As Figure 28 shows, TxBPE consists of two main areas: A navigation and information bar on the left and the business process model area on the right. Unless the user hides the navigation bar using the "Hide" button, the navigation bar remains visible on all pages. The navigation bar has five sections, which enable users to navigate to (and through) different model pages, conduct searches, and access additional resource information. Figure 28 provides a description of each of these sections. Users can expand or collapse sections as needed.

As mentioned previously, users can access TxBPE on the Internet, the TxDOT intranet, or from a local or networked computer drive. The third option would still require Internet access in order to retrieve Level 3 documents. Minimum requirements to use TxBPE include the following:

- Access to Internet or the TxDOT intranet,
- Microsoft Internet Explorer (IE) version 6, and
- Adobe Acrobat Reader version 5.

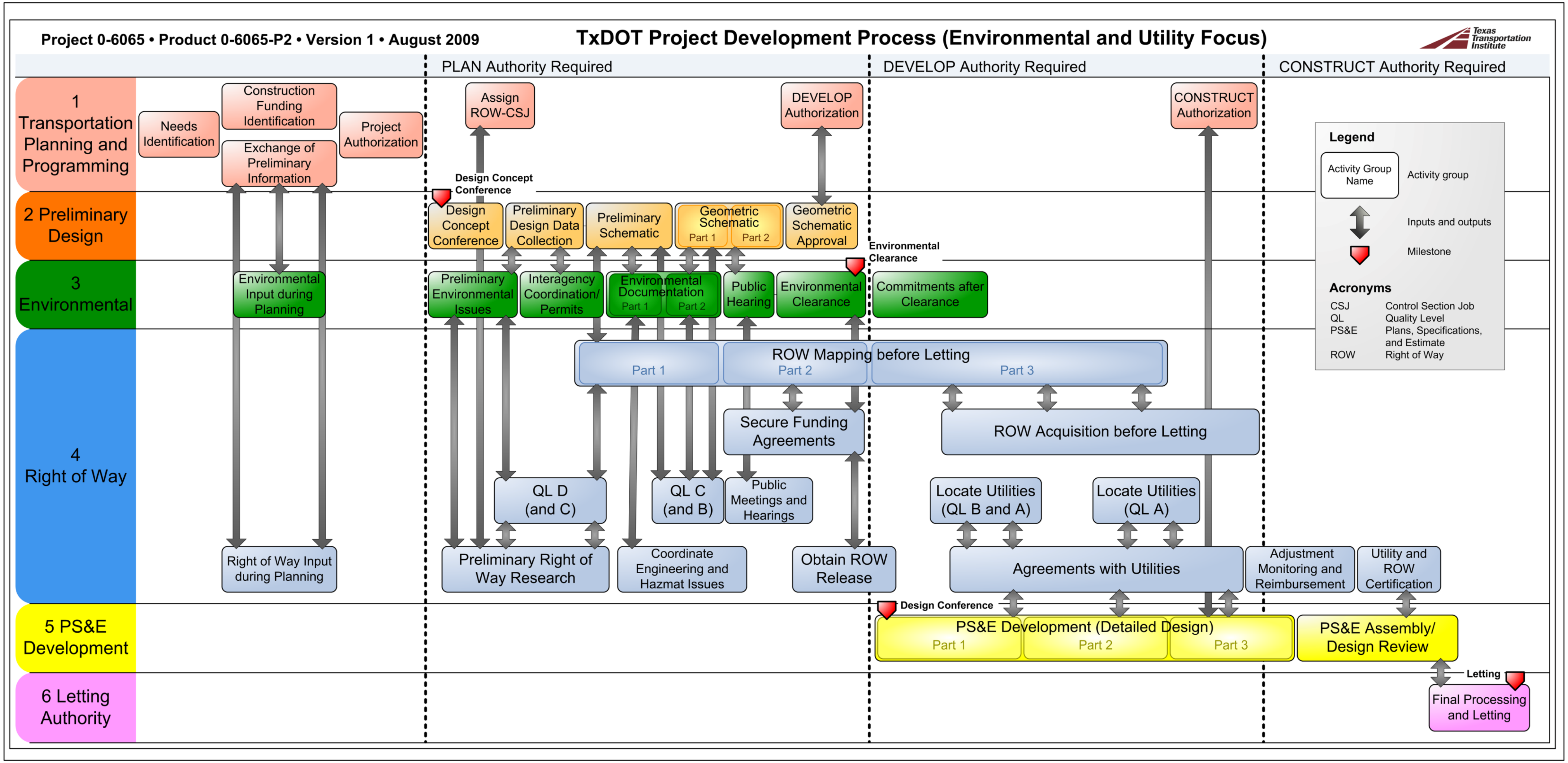


Figure 25. TxDOT Project Development Process Overview Model.

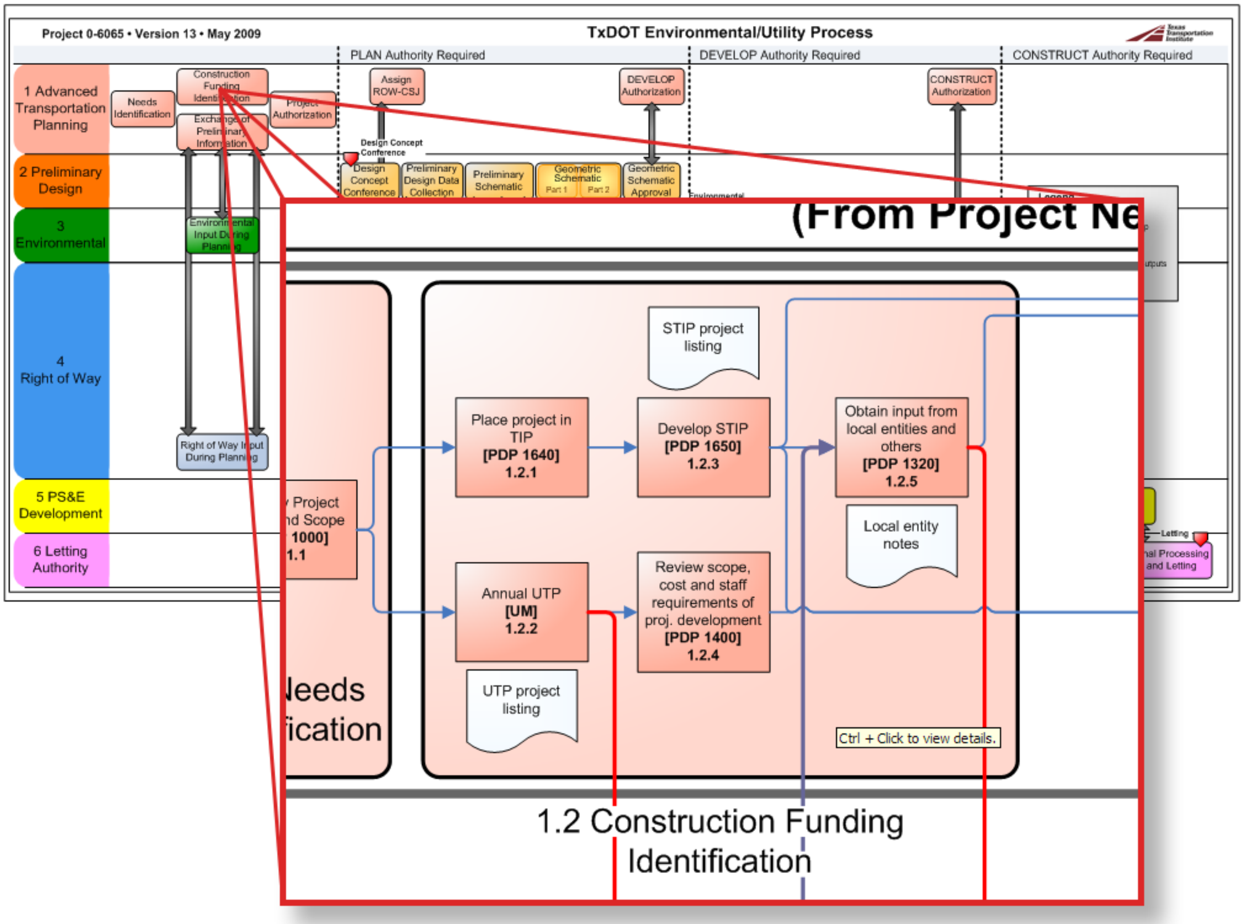


Figure 26. Example of Navigation in TxBPE including Level 1 and Level 2.

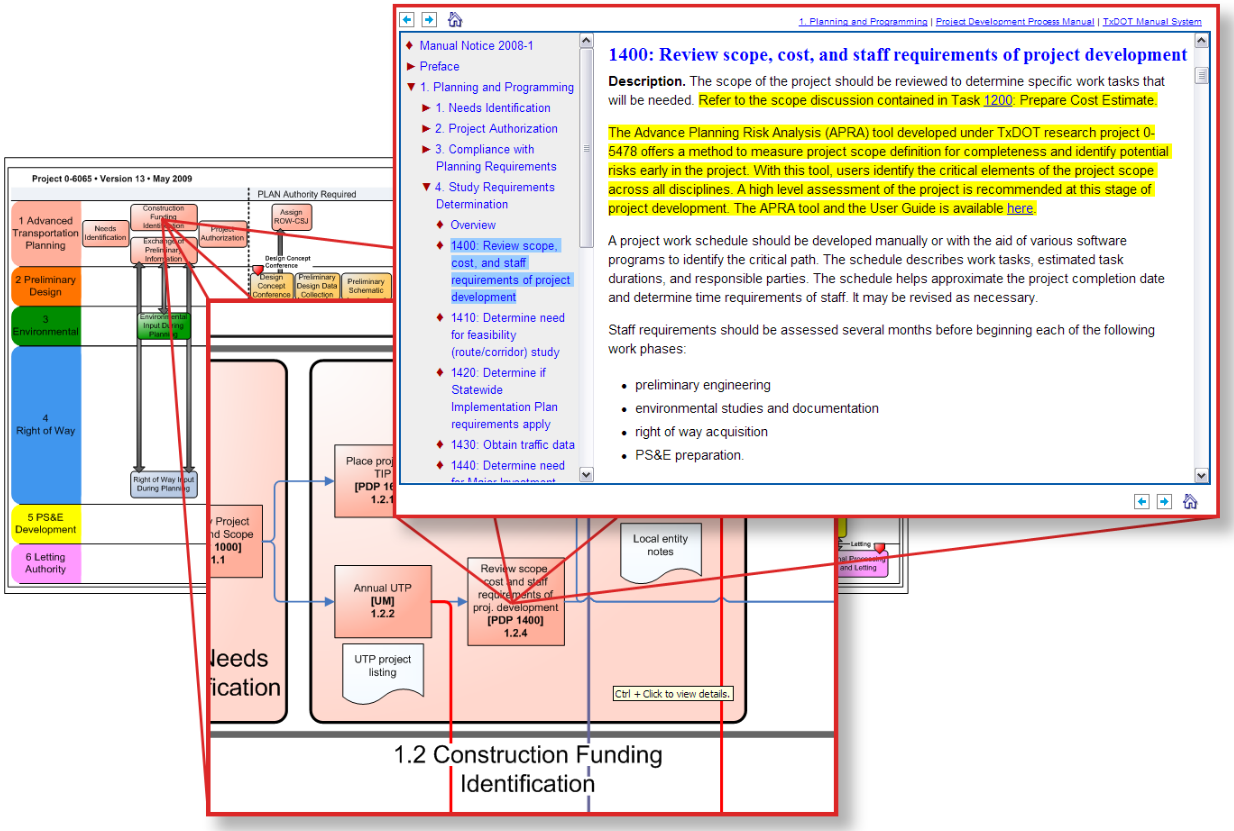
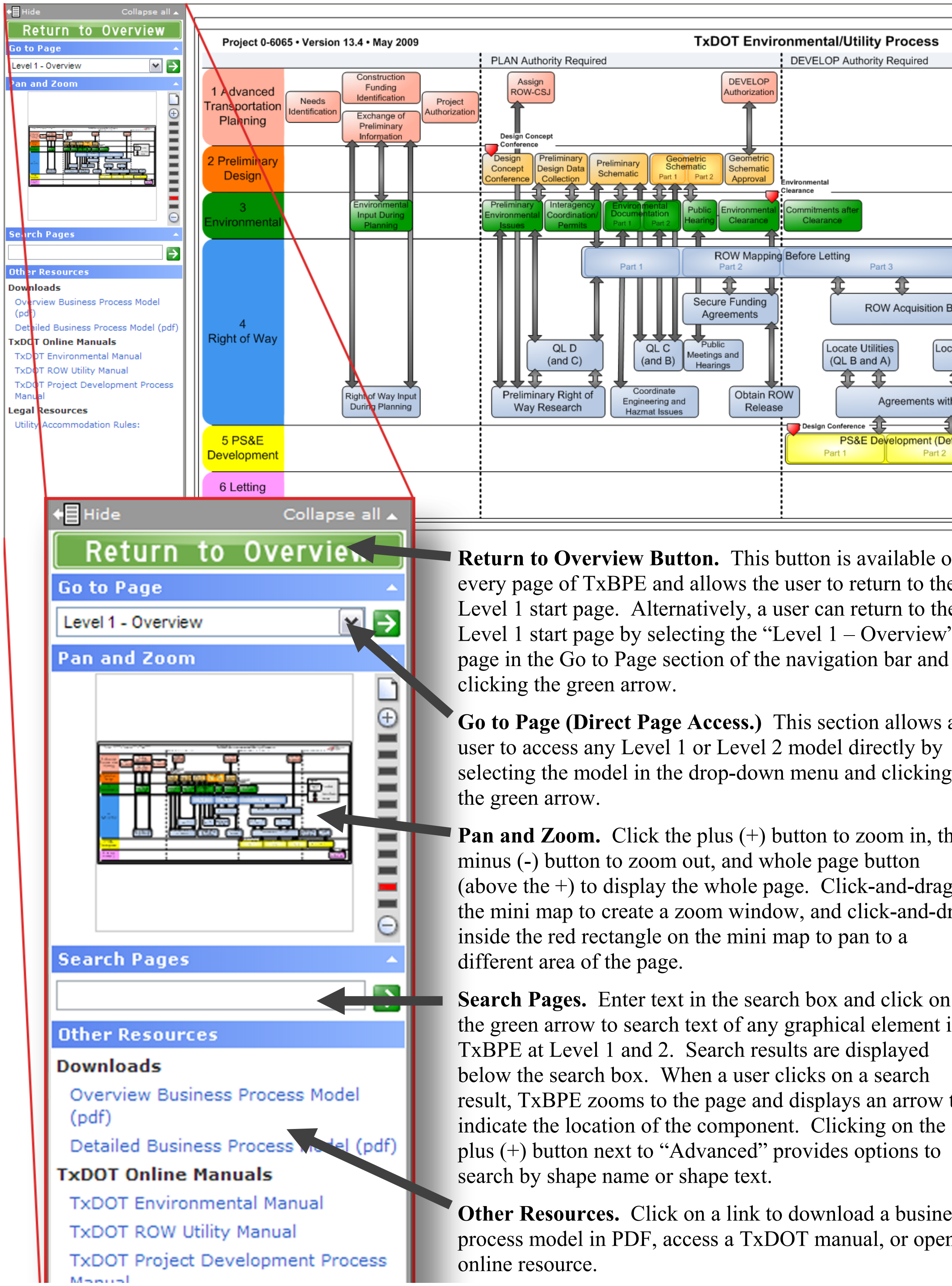


Figure 27. Example of Navigation in TxBPE including Level 1, Level 2, and Level 3.



Return to Overview Button. This button is available on every page of TxBPE and allows the user to return to the Level 1 start page. Alternatively, a user can return to the Level 1 start page by selecting the "Level 1 – Overview" page in the Go to Page section of the navigation bar and clicking the green arrow.

Go to Page (Direct Page Access.) This section allows a user to access any Level 1 or Level 2 model directly by selecting the model in the drop-down menu and clicking the green arrow.

Pan and Zoom. Click the plus (+) button to zoom in, the minus (-) button to zoom out, and whole page button (above the +) to display the whole page. Click-and-drag on the mini map to create a zoom window, and click-and-drag inside the red rectangle on the mini map to pan to a different area of the page.

Search Pages. Enter text in the search box and click on the green arrow to search text of any graphical element in TxBPE at Level 1 and 2. Search results are displayed below the search box. When a user clicks on a search result, TxBPE zooms to the page and displays an arrow to indicate the location of the component. Clicking on the plus (+) button next to "Advanced" provides options to search by shape name or shape text.

Other Resources. Click on a link to download a business process model in PDF, access a TxDOT manual, or open an online resource.

Figure 28. Navigation Bar and Business Process Area in TxBPE.

TXBPE Development

The researchers developed TxBPE from the Visio-format business process model by saving the file as a web page. In practice, the default "Save as Web Page" option in Visio automatically creates a page with a navigation panel similar to that shown in Figure 28. However, this generic output is suitable for simple Visio flowcharts, not for large models, which made it necessary to customize the resulting code. This section summarizes the modifications made.

Visio enables users to select several export formats for graphics, including raster formats such as joint photographic experts group (JPEG) and portable network graphics (PNG), as well as vector formats such as scalable vector graphics (SVG) and vector markup language (VML). An advantage of using a raster format such as JPEG (and increasingly PNG) is compatibility across web browsers. A disadvantage is that Visio does not include a setting to change the image resolution or to generate tiled images, which can result in extremely large image files in situations where a fine image resolution is a critical requirement. In fact, it was not possible to create a raster image in Visio that displayed the Level 2 model with sufficient detail.

By comparison, an advantage of using a vector-based format is that vector files tend to be much smaller than raster files and can be scaled more easily within a web browser environment without affecting the quality of the graphics. A disadvantage is that not all web browsers support all vector-based formats. SVG has a number of advantages, including World Wide Web Consortium (W3C) standard compliance, detailed control over text placement, and native support by several browsers. Internet Explorer does not provide native support for SVG, requiring users to download a plug-in on first use. In addition, SVG files tend to be somewhat larger than VML files. In contrast, VML tends to render graphics faster. However, Internet Explorer is the only major browser that supports VML. Other popular browsers such as Safari and Firefox do not support VML. Because Internet Explorer is the standard web browser in use at TxDOT, the researchers decided to use VML as the vector format for TxBPE.

A problem the researchers encountered while exporting the Level 2 model was that the resulting web page had limited zoom-in capabilities. The default range of available zoom levels within Visio are adequate for relatively small flowcharts, but not large, detailed flowcharts such as that developed as part of the research. After considering several options, the researchers decided to create several sub models from the original Level 2 model. This strategy effectively bypassed the Visio zoom-in limitation. The downside was the need to generate additional models in Visio, even though, strictly speaking, only one model should be necessary. In total, the researchers created 45 sub models from the original Level 2 model.

Another problem encountered was the file size of the main Visio export file. VML is a variation of the extensible markup language (XML), which enables the display of vector graphics in web browsers. The main Visio export file is a text file called data.xml that contains data about all graphical shapes in the model. This file is loaded by default when the application starts. The original XML file was sizable (about 6.3 megabytes), which resulted in significant start-up delays during testing, particularly when accessing TxBPE from a TxDOT web browser (Note: the TxBPE application was residing on a TTI web server in College Station).

To reduce the start-up time, the researchers extracted data from file data.xml into a much smaller file called Page0_data.xml that only included data about the overview page. With this change, when TxBPE starts, the application loads file Page0_data.xml to display the overview page. After a fraction of a second, TxBPE loads file data.xml asynchronously in the background. To enable this behavior, the researchers created several scripts using asynchronous JavaScript and XML (AJAX).

The researchers also modified the search feature function to accelerate search times. By default, the search feature looks for a match of the search term in all attributes inside file data.xml. Most attributes were not relevant to the research, which made it possible to speed up searches considerably by simply limiting the data query to the "Text" attribute in the XML file and by excluding any sub models that were not part of the prototype implementation.

To enable links between Level 2 process details and Level 3 activity details, the researchers created two additional XML files: ModelLink.xml and ActivityLink.xml. File ModelLink.xml contains a listing of more than 200 unique links that can be attached to Level 2 shapes in order to access Level 3 activity details and sample documents. As shown in Figure 29, file ModelLink.xml includes attributes such as record ID, link name, and the actual link to access the web page. For convenience, Figure 29a shows a view of the XML file, while Figure 29b shows data in a tabular format.

(a) XML Text View

```xml
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<Links xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <Link ID="EM ED 7" type="EM">
        <Name>Approve state-funded project documentation</Name>
        <Path>http://onlinemanuals.txdot.gov/txdotmanuals/env/policy_and_process_overview.htm</Path>
        <Code>EM ED 7</Code>
    </Link>
    <Link ID="EM ED 8" type="EM">
        <Name>Forward documents to TRACS</Name>
        <Path>http://onlinemanuals.txdot.gov/txdotmanuals/env/policy_and_process_overview.htm</Path>
        <Code>EM ED 8</Code>
    </Link>
    <Link ID="EM IC 1" type="EM">
        <Name>Discuss resource issues with local offices and resource agencies</Name>
        <Path>http://onlinemanuals.txdot.gov/txdotmanuals/env/interagency_coordination.htm</Path>
        <Code>EM IC 1</Code>
    </Link>
```

(b) XML Table View

ID	type	Name	Path
EM ED 7	EM	Approve state-funded project documentati	http://onlinemanuals.txdot.gov/txdotmanuals/env/policy_and_process_overview.htm
EM PS 3.3.2.1	EM	Assess alternative impact on disadvantage(	http://onlinemanuals.txdot.gov/txdotmanuals/env/social_and_economic_impacts.htm#i1004369
EM PS 3.3.2.11	EM	Assess visual and aesthetic impacts	http://onlinemanuals.txdot.gov/txdotmanuals/env/social_and_economic_impacts.htm#i1004647
EM PI 4	EM	Assist districts in det. appr. public involvem	http://onlinemanuals.txdot.gov/txdotmanuals/env/public_involvement.htm
EM C 7	EM	Assist districts in developing and meeting (	http://onlinemanuals.txdot.gov/txdotmanuals/env/environmental_commitments.htm
EM IC 6	EM	Assist districts in interagency coordination	http://onlinemanuals.txdot.gov/txdotmanuals/env/interagency_coordination.htm
EM PS 8	EM	Assist districts with early coordination of e	http://onlinemanuals.txdot.gov/txdotmanuals/env/preliminary_survey.htm
BECM	DOC	Baseline Env. Constraints Map	Baseline_ECM.pdf

Figure 29. ModelLink.xml File Structure in Text and Table View.

File ActivityLink.xml contains a listing of about 3000 linkages between Level 2 activities and Level 3 activity details. As Figure 30 shows, this file contains IDs of pages where shapes are located, IDs of shapes included in those pages, and IDs of links as described in file ModelLink.xml. Using this relational construct, the researchers avoided a repetition of file names and paths in file ActivityLink.xml and effectively normalized the two tables.

For example, the first record in Figure 29b provides a link to activity "Approve state-funded project documentation," which is included in online version of the *Environmental Manual*. The ID for this link is EM ED 7. As Figure 30b shows, this link appears several times in TxBPE (e.g., in connection with Shape 85 on pages 33, 34, and 35, as well as Shape 170 on page 28).

(a) XML Text View

```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<ActivityLinks xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
    <ActvLink>
        <ActvBox PageID="33" ShapeID="85"/>
        <LinkID>EM ED 7</LinkID>
    </ActvLink>
    <ActvLink>
        <ActvBox PageID="34" ShapeID="85"/>
        <LinkID>EM ED 7</LinkID>
    </ActvLink>
    <ActvLink>
        <ActvBox PageID="35" ShapeID="85"/>
        <LinkID>EM ED 7</LinkID>
    </ActvLink>
```

(b) XML Table View

PageID	ShapeID	LinkID
33	85	EM ED 7
34	85	EM ED 7
35	85	EM ED 7
36	85	EM ED 7
28	170	EM ED 7
11	85	EM ED 7
10	85	EM ED 7
22	47	EM ED 8
29	171	EM ED 8
30	171	EM ED 8
31	87	EM ED 8

Figure 30. ActivityLink.xml File Structure in Text and Table View with Sample Records.

Preliminary testing indicates that TxBPE runs properly on local installations, but additional testing would be necessary for an installation on a central web server that is accessed by a large number of users.

CHAPTER 6. UTILITY DELAYS AND RELATED COSTS

INTRODUCTION

This chapter summarizes the work completed to examine utility delays and related costs. A research objective was to measure the economic impact resulting from planned and unplanned utility adjustments, as well as extract information to infer potential economic benefits that would result from implementing the strategies discussed in Chapter 5. However, the type of data needed to conduct a traditional economic analysis was not available. For example, project cost data, such as project proposal costs, bid item costs, change orders, and delay claims were available. However, data such as number of days of delay and other impacts were mostly unavailable. The process of gathering, reviewing, and analyzing available cost data did enable the researchers to develop an understanding of the type and quality of relevant utility-related cost data that TxDOT collects, which, in turn, enabled the researchers to make general observations about specific deficiencies and formulate recommendations for business process changes.

DATA GATHERING AND PROCESSING

Project Proposal and Bid Cost Data

Project proposal and bid cost data were available from the Trns*port Bid Analysis Management System/Decision Support System (BAMS/DSS) module (*77*). TxDOT uses the BAMS/DSS database to document detailed unit bid data for highway construction projects. The researchers had access to proposal and bid cost records in the BAMS/DSS database for projects that were let from September 1984 to February 2007. Several tables in this database were of interest, including the following:

- **Dproject**. This table contains information about highway projects (72,886 records).
- **Dproposl**. This table contains additional information about the project, including letting date (34,081 records).
- **Dbidders**. This table contains highway contractor bid data (141,167 records).

Change Order Data

Change order data were available from the Trns*port SiteManager Construction Management System module (*77*), which TxDOT uses to track highway construction projects from contract award through the end of the highway construction project. Change orders are available to contractors when a significant change in the character of the work occurs or a time extension is granted (*78*). A significant change in the character of the work occurs if the character of the work of an item differs in kind or nature from the contract and/or a major work item varies more than 25 percent from the original contract quantity. According to the *Construction Contract Administration Manual* (*78*), change orders can occur in a construction project for a variety of reasons, including design errors, contract omissions or changes, unforeseeable site conditions, TxDOT and/or contractor requested changes, third party accommodations, right of way not cleared, and utilities not adjusted. TxDOT groups and categorizes these reasons into categories and assigns a code for each reason (Table 6).

Table 6. Change Order Categories and Reason Codes (*79*).

Category	Code	Change Order Reason
1. Design Error or Omission	1A	Incorrect PS&E (TxDOT design): This code should be used when TxDOT prepared the PS&E and an error and/or omission is discovered, but there is no additional cost to the project, nor any contractor delay, rework or inefficiencies
	1B	Incorrect PS&E (consultant design): This code should be used when a consultant prepared the PS&E and an error and/or omission is discovered, but there is no additional cost to TxDOT, nor any contractor delay, rework or inefficiencies to the project.
	1C	Other: This code should be used when there is an error and/or omission, (TxDOT or consultant) but the cause (all or partial) cannot be assigned to TxDOT or the consultant and other codes in this category are not appropriate.
	1D	Design error or omission that resulted in delay, rework, or inefficiencies (TxDOT design): This code should be used when TxDOT prepared the PS&E and an error and/or omission is discovered and additional cost, contactor delay, rework or inefficiencies occur on the project.
	1E	Design error or omission that resulted in delay, rework, or inefficiencies (Consultant design): This code should be used when a consultant prepared the PS&E and an error and/or omission is discovered and additional cost to TxDOT or contractor delay, rework or inefficiencies occur on the project.
2. Differing Site Conditions (Unforeseeable)	2A	Differing site conditions (unforeseeable): This code should be used when actual site conditions are found to be different than depicted in the plans, soil borings or other project information. Refer to Article 4.3 of the standard specifications.
	2F	Site conditions altered by Act of God: This code should be used when the project is impacted by Acts of God.
	2G	Unadjusted utility (unforeseeable): This code should be used when unknown utilities impact the project.
3. TxDOT Convenience	3B	To address public request and needs after letting: This code should be used when a change is made or work is added to accommodate a public request.
	3E	Reduction of future maintenance: This code should be used when a change is made with the intent of minimizing the need for future maintenance. Coordination should be untaken to determine FHWA participation.
	3F	Additional work desired by TxDOT: This code should be used when TxDOT adds needed work.
	3H	Cost savings opportunity discovered during construction: This code should be used to reduce project cost and/or project duration.
	3I	Implementation of improved technology or better process: This code should be used when improved technologies or better processes are utilized in the project.
	3K	Addition of stock account or material supplied by TxDOT provision: This code should be used to buy material purchased by the contractor and not incorporated into the project. It should also be used when TxDOT supplies material to the contractor that is incorporated in the project.
	3L	Revising safety work/measures desire by TxDOT: This code should be used to revise safety measures on the project. The safety enhancement may be suggested either by TxDOT or the contractor.
	3M	Other: This code should be used for changes to the project for TxDOT convenience where other codes in this category are not appropriate.
	3N	Upgrade to current standards: This code should be used for necessary changes to upgrade to current design standards where standards have changed subsequent to PS&E preparation.
	3O	Time extension: This code should be used to add time to the contract no other work is included in the CO.
4. Third Party Accommodation	4A	Failure of a third party to meet commitment: This code should be used when a third party to the contract fails to fulfill any part of their commitment.
	4B	Third party request for additional work: This code should be used to identify additional work requested by a third party. Generally, this will require a modification to the advance funding agreement.
	4D	Other: This code should be used for third party accommodation where other codes in this category are not appropriate.

Table 6. Change Order Categories and Reason Codes (*79*) (Continued).

Category	Code	Change Order Reason
5. Contractor Convenience 5A		Contractor requested change in traffic control plan or sequence of work: this code should be used for contractor requested change to the traffic control plan or sequence of work and must be acceptable to TxDOT.
	5B	Contractor requested change in materials and/or method of work: This code should be used for a contractor change in materials and/or method of work and must be acceptable to TxDOT.
	5C	Payment for Partnering
	5E	Other: This code should be used for contractor convenience requests where other codes in this category are not appropriate.
	5F	Price adjusted on finished work (price reduced in exchange for acceptance): This code should be used as a reduction in cost for contract items that have deficiencies and TxDOT is willing to accept work at a reduced price.
6. Untimely Right of Way/Utilities	6A	Right of Way not clear (third party responsibility for ROWQ): This code should be used for contractor impacts which are the result of right of way not being cleared on the date(s) specified in the plans where a third party is responsible for the right-of-way acquisition.
	6B	Right of Way not clear (TxDOT responsibility for ROW): This code should be used for contractor impacts, which are the result of right of way not being cleared on the date(s) specified in the plans where TxDOT is responsible for the right-of-way acquisition.
	6C	Utilities not clear: This code should be used for contractor impacts which are the result of known utilities not being adjusted or relocated on the date(s) specified in the plans.
	6D	Other: This code should be used for untimely right of way or utilities where other codes in this category are not appropriate.
7. Termination	7A	Contract termination or significant portion of project eliminated – Design error TxDOT: This code should be used when a project is terminated or a significant portion of a project is eliminated due to a major design error and/or omission where TxDOT prepared the PS&E.
	7B	Contract termination or significant portion of project eliminated – Design error consultant: This code should be used when a project is terminated or a significant portion of a project is eliminated due to a major design error and/or omission where a consultant prepared the PS&E.
	7C	Contract termination or significant portion of project eliminated – Utilities: This code should be used when a project is terminated or a significant portion of a project is eliminated due to a major utility delay or impact. The utility impact could be the result of either a known or an unknown utility.
	7D	Contract termination or significant portion of project eliminated – ROW: This code should be used when a project is terminated or a significant portion of a project is eliminated due to a significant right-of-way acquisition delay.
	7E	Contract termination or significant portion of project eliminated – Third party failure to participate: This code should be used when a project is terminated or a significant portion of a project is eliminated when it becomes known or evident that a third party will not be able or is unwilling to fulfill its obligation under an advanced funding agreement.
	7F	Contract termination or significant portion of project eliminated – Acts of God: This code should be used when a project is terminated or a significant portion of a project is eliminated due to an Act of God.
	7G	Contract termination or significant portion of project eliminated – Other than above: This code should be used when a project is terminated or a significant portion of a project is eliminated due to reasons where other codes in this category are not appropriate.

Although not every contract has change orders, the number of change orders at TxDOT is quite substantial. The researchers had access to 30,043 change order records for projects that were let from July 1999 to February 2007. The change order database in SiteManager includes a number of attributes, of which change order number, contract ID, change order reason, description, and explanation were the most relevant to this research. The change order database also includes line item data, such as item code, description, original and modified quantities, and unit prices. The explanation field was particularly useful because the level of detail in the description field was frequently not enough to characterize change order records properly, which was particularly critical in order to determine whether a change order was utility related. For example, a sample change order record included the following entry in the description field:

Relocate Outdoor Advertising Sign

However, the explanation field contained the following entry (notice the reference to TXU Energy):

> Invoice Reimbursement to the Contractor to relocate the Storage Depot sign of which a portion is an aerial bi-section of TxDOT right of way and is an obstruction to TXU. Being inadvertently left out of Right Of Way Acquisition proceedings for relocation, the sign will ultimately impede construction activities of electric installation. The relocation is recommended by the Waco District Right of Way Office. Location: IH 35 SBFR 2098+50 +/-, 170.0' Lt. +/- New and / or revised plan sheets: Right of Entry & Special Specification 9606-2004 is attached with this change order.

In a Microsoft Access database environment, the researchers joined project proposal and bid data to change order data in order to identify projects with change orders. Utility-related change orders were of particular interest. The analysis included the following activities:

- **Search utility-related change order records**. Using the reason codes in Table 6, the researchers conducted an initial search of change order records for which the reason code was 6A, 6B, 6C, 6D, or 2G. However, a review of the corresponding change order descriptions quickly revealed many inconsistencies in the use of the reason codes. For example, the description associated with many change orders appeared to be completely unrelated to utilities. In other cases, the description was evidently utility-related, but the corresponding reason code was not 6A, 6B, 6C, 6D, or 2G.

- **Search change order (and project) records using keywords**. The researchers searched project and change order descriptions for utility-related keywords and examined each record. The researchers used the keywords listed in Table 7.

Table 7. Keywords Used to Find Utility-Related Change Order and Project Records.

adjusted	CPS	lines	pot hole	TXU
asbestos	duct	manhole	pothole	utilities
AT&T	electric	miscellaneous	SAWS	utility
conduit	fiber	pipe	SBC	valve
conflict	line	pole	sewer	water

- **Search change order records using explanation field data**. Although the keyword search and reason code examination enabled the identification of most utility-related change orders, there were change orders and projects with incomplete or misleading description content and/or reason code. Examples included cases of descriptions that were too brief to enable a determination, descriptions that were missing, and reason codes that were incorrect or missing. To address these issues, the researchers searched explanation field entries in the change order database.

The result was a dataset of 1144 change order records for 431 projects that were let from 1999 to 2007. The total amount of these change orders was about $46 million (unadjusted). The adjusted amount (in January 2008 dollars) was $55 million. For the conversion, the researchers performed the following activities:

- **Obtain project and change order approval dates**. The BAMS/DSS Dproposl table includes a project start date attribute. However, this attribute was not populated. As a result, the researchers used the project letting date from the BAMS/DSS Dproposl table as the project start date. TxDOT provided change order approval dates for the 1144 change order records of interest.

- **Obtain cost adjustment factors and perform calculation**. The researchers used TxDOT Highway Cost Index (HCI) 12-month moving average factors (*80*) to adjust project and change order costs to January 2008 values.

Claim Data

Claim data were available from a database that TxDOT uses to track contract claims. If the district and a contractor cannot resolve a dispute, the contractor may file a claim. Claims are supposed to be a "tool of last resort" and follow the requirements and procedures established in 43 TAC 9.2 (*81*). Table 8 shows the list of contractor claim categories at TxDOT.

Table 8. Contractor Claim Codes and Categories.

Codes	Categories
CA Contract	Administration
CA-Insp	Contract Administration – Inspection
CA-Qty	Contract Administration – Quantities
CA-TA Contract	Administration – Time
CA-Test	Contract Administration – Testing
CIS Change	in Scope
DSC	Differing Site Conditions
EW	Extra Work/Change Orders
HZ Hazardous	Materials
LM Landscap	e/Maintenance Problems
O Other	
PSE	Plans, Specs, Estimates
R	Late Right-of-Way Acquisition
RW Rework	
UK Known	Utility Interference
UU	Unknown Utility Interference
W Bad	Weather

The researchers received 17 contractor claim records for which the category was unknown utility interference (UU claim code) or known utility interference (UK claim code), between June 1996 and October 2007. Compared to the number of utility-related change orders (1144) and the associated number of projects (431), the number of utility-related claims was very low. It is possible that additional delay claims having codes other than UK or UU were utility-related. However, claim data with codes other than UK or UU were not available to the researchers. Table 9 shows a summary of the 17 utility-related claim records, including contract amount, claim amount, settlement amount, and number of days to settle.

Table 9. Utility-Related Contractor Claim Records (UK or UU claim code).

Status	District	Description	Contract Amount*	Claim Amount*	Settlement Amount*	Days to Settle
Settled	Dallas	Contractor is contesting contract time charges and requests overhead compensation based on the contested days.	$9,863,381	$344,412	$34,795	778
Settled	Abilene	Contractor requests compensation for construction suspension and utility adjustments.	$1,535,199	$504,036	$197,959	651
Settled	Abilene	Contractor requests compensation due to failure of the City to complete utility relocations to prevent interference to the contractor.	$1,655,639	$621,627	$291,164	848
Settled	Yoakum	Items of disagreement between contractor and District Engineer include payment for damaged sidewalls, street cuts, barricades, blade work, and erosion control.	$902,412	$219,019	$63,167	210
Settled	Austin	Contractor claims lost productivity in storm sewer operations, wall and road excavation, and flex base operations due to utilities, traffic problems, and reduced work areas. Contractor requests compensation for overhead and interest charges.	$6,867,703	$1,558,692	$402,209	364
Settled	San Angelo	Contractor requests compensation for road section that could not receive asphalt due to seasonal issues.	$4,579,937	$148,823	$0	481
Settled	Ft. Worth	Contractor has 22 issues, the largest for extended jobsite overhead for 8.3 months of delay.	$12,256,116	$1,562,353	$203,436	640
Settled	Ft. Worth	Contractor submitted a total cost claim.	$3,206,767	$1,603,058	$107,770	328
Settled	Pharr	Contractor requests compensation for standby delay, lost productivity, mark-up, additional cost of performance, and costs associated with the takeover and added costs of recovery.	$9,009,004	$3,952,069	$97,667	449
Settled	Atlanta	Past through claim on behalf of subcontractor. The claim has 4 issues, which include damages due to site conditions and utility interference in constructing RCP, concrete culvert, and concrete riprap.	$30,260,158	$258,298	$68,500	246
Settled	Wichita Falls	Contractor requests compensation for utility interference and resulting delays.	$6,271,908	$1,284,873	$85,219	421
Closed	San Angelo	Contractor claims plan errors, design changes and utility conflicts caused work to be delayed. Contractor requests compensation for work not paid.	$427,407	$41,252	$0	832
Closed	Lufkin	Contractor defaulted and refused to finish the contract. Contractor requests compensation for additional work not shown in the plans, material on hand, and the un-paid November estimate.	$151,511	$33,458	$0	3793
Active	Lufkin	Contractor submitted claim for PS&E errors and utility delays.	$3,307,137	$605,591		
Active	Austin	Contractor submitted inefficiency claim, which included 100+ issues.	$141,957,815	$8,345,533		
Active	Waco	Contractor requests a portion of LDs charged and payment for additional months of barricades, plus interest.	$14,169,530	$270,141		
Active	Ft. Worth	Contractor requests compensation for delayed start and termination for convenience that included setting up a portable hot mix plant and home office.	$37,291,010	$409,097		

* Note: All values are expressed in January 2008 dollars.

The total amount of utility-related contractor claims was $18.9 million (unadjusted) or $21.8 million (in January 2008 dollars). Of the 17 claims, 13 claims were settled or closed. The total settlement amount for these claims was $1.2 million (unadjusted) or $1.6 million (in January 2008 dollars). The procedure to adjust the dollar amounts was similar to that used for the change orders. The difference was that, for claim amounts prior to December 1998, the researchers used HCI yearly average factors with a base year of 1992 (*82*) and corrected these factors to a base year of 1997.

ANALYSIS

Project Change Order Cost Data

Utility-Related Delays

One of the main objectives of the analysis was to determine whether it was possible to measure the economic impact of delays in the utility adjustment process on highway project costs. In order to measure delays, it is necessary to have an appropriate record of either relevant time stamps or an explicit representation of the number of days a certain process was delayed. The change order database included several utility delay-related records. The researchers examined the description and explanation fields of each record looking for words and/or phrases such as "delay" or "add days." This examination resulted in 139 change orders, totaling $6.4 million (i.e., about 12 percent of 1144 utility-related change orders or 0.5 percent of 30,043 change orders for projects that were let from July 1999 to February 2007).

An analysis of the 139 utility delay-related change orders in terms of type of information provided indicated the following:

- **Explicit indication of utility delay (55 records totaling $2.8 million)**. In this case, the explanation field explicitly indicated the amount of utility delay, e.g., "we plan to add 17 days to the contract for utility relocations which delayed the contractor."

- **Incomplete utility delay explanation (17 records totaling $1.4 million)**. In this case, the explanation field contained partial information about the duration of the utility delay, e.g., "this change order will compensate the contractor for direct cost incurred from loss time due to utility delays during the months of July, August, September, and November of 2005."

- **Limited utility delay information (67 records totaling $2.2 million)**. In this case, neither change order descriptions nor explanation fields contained utility delay duration or dates. Those fields did indicate the change order was the result of a utility delay.

- **Zero dollar change order (41 records)**. In this case, the most likely scenario was that TxDOT recognized additional days to the contractor (essentially, a no-dollar extension) due to a utility-related delay. However, the explanation field for many of these change order records did not provide an adequate description as to why no cost was involved. In addition, several of these records did not include the duration of the utility delay.

In most cases, the type and amount of information available were not enough to make a reliable determination of utility-related delay. In addition, many change orders included costs for items that were not necessarily related to the utility delay (e.g., barricades, overhead, increases in material costs, and additional work), making it very difficult to measure the actual impact of utility delay on road user costs at the individual project level.

The difficulty to measure utility-related delay reliably highlights a practical difficulty in the application of a provision in the Texas Transportation Code that deals with delays in the utility adjustment process and potential penalties TxDOT can apply if a utility company does not adjust its facilities in a timely fashion. According to 6 TTC 203.094, TxDOT has the authority to reduce the reimbursement to a utility company by 10 percent for every month the adjustment exceeds the limit specified in the utility agreement (*83*). Although most utility adjustments take place during the design phase, a significant number of utility adjustments take place during construction. Under these circumstances, documenting utility delays properly during construction, including change orders, is critical to enable the enforcement of Texas Transportation Code provisions effectively.

At first sight, only 139 utility delay-related change orders (i.e., about 12 percent of 1144 utility-related change orders or 0.5 percent of 30,043 change orders for projects that were let from July 1999 to February 2007) is puzzling considering that utility adjustments are frequently mentioned as one of the most frequent reasons for delays in highway construction (*2*). Upon closer examination, what may be happening is that the low number of utility delay-related change orders is actually a reflection of the effort by project managers and contractors to reallocate resources during construction in order to avoid delays and finish projects on time whenever possible. In other words, project managers and contractors may be experiencing a substantial amount of utility adjustment delays (which they voice in interviews and surveys), but they react to those delays by reallocating resources in such a way that the final impact to the project in terms of project delivery delays is relatively minor.

Planned versus Unplanned Utility Adjustments

Although it was not possible to make explicit statements about utility-related delay, the available information enabled the researchers to make some inferences about *planned* versus *unplanned* utility adjustments. In principle, a *planned* utility adjustment occurs when there is adequate knowledge at the time of letting that a utility adjustment is necessary. Conversely, an *unplanned* adjustment occurs when there is *not* adequate knowledge at the time of letting that a utility adjustment is necessary. Using these definitions, the researchers conducted an analysis to provide a preliminary assessment of *unplanned* utility adjustment impacts.

In general, change orders are unplanned. However, a utility-related (*unplanned*) change order does not automatically mean the utility adjustment is *unplanned* if the contractor knew about the need for the utility adjustment at the time of letting, typically through the triple zero special provision that lists the status of outstanding utility adjustments (Figure 31). The triple zero special provision is based on the utility clearance certification that districts prepare as part of the PS&E process (*6, 84*).

SPECIAL PROVISION

000--1702

Important Notice to Contractors

For this project, Item 000, "Important Notice to Contractors," of the Standard Specifications, is hereby amended with respect to the clauses cited below, and no other clauses or requirements of this Item are waived or changed hereby.

The Contractor's attention is directed to the fact that utility adjustments required for the construction of this project have not been accomplished as of August 27, 2003. The state anticipates that all utility adjustments will be made in sufficient time to prevent any undue delay to the Contractor in his normal operations. An extension of working time will be granted, if necessary, for delays caused by interference beyond the estimated date of utility adjustments.

For the Contractor's information, the following utilities have not been adjusted. The utilities will be adjusted by their owners. The Contractor is invited to review the outstanding utilities with the Area Engineer assigned to this project.

Utility	Approximate Location	Estimated Date of Completion
San Antonio Water Systems (Water)	Throughout Project	Joint Bid
San Antonio Water Systems (Sewer)	Throughout Project	Joint Bid
City Public Service (Gas)	Throughout Project	October 1, 2003
City Public Service (Electric)	Throughout Project	October 1, 2003
Time Warner Communications (Television Cable)	Throughout Project	October 1, 2003
Southwestern Bell Company	Throughout Project	October 1, 2003

Figure 31. Sample Special Provision Showing Pending Utility Adjustments.

As shown in Table 10, the only case a utility adjustment can be considered *unplanned* is if the utility adjustment was not mentioned in the triple zero special provision *and* the change order items were not already included in the original proposal list of items. This methodology assumes a utility adjustment was *planned* if a utility adjustment was known at the time of letting but there was a change order because the actual quantities varied in more than 25 percent from the original contract quantity. Strictly speaking, the modified quantities were probably *unplanned* but the utility adjustment itself was *planned*. For simplicity, the researchers decided to consider this type of utility adjustment *planned*.

Table 10. Planned versus Unplanned Utility Adjustment Selection Criteria.

		Utility adjustment in utility clearance special provision?	
		Yes	No
Change order item(s) in proposal bid item list?	Yes	Planned utility adjustment	Planned utility adjustment
	No	Planned utility adjustment	Unplanned utility adjustment

For the analysis, the researchers randomly used 443 (or 35 percent) of the 1144 utility-related change orders as a mechanism to identify and document utility adjustments. The 443 change orders were associated with 351 projects. The analysis included the following activities:

- **Obtain letting proposals**. The researchers obtained letting proposal documents for projects that contained utility-related change orders from the Plans Online system. Of particular interest in the proposal documentation were the special provisions describing outstanding utility adjustments at the time of letting. TxDOT uses Plans Online to store and deliver project plans and related documentation to internal and external users (*85*). The system contains electronic versions of letting proposal documents from 1994 to the present.

- **Identify whether change order items are included in the project bid item list**. For each change order, the researchers compared available description and explanation content with line items in the proposal bid item list. Specifically, the researchers checked for matching materials (e.g., 400 mm water main pipe) and quantities in both the change order and the bid item list. The search did not include delay items because proposals typically do not include delay in the list of construction items.

  Matching records was a labor-intensive process that nonetheless left considerable room for interpretation. Of the 443 utility-related change orders, the researchers identified 98 change orders that contained items that were also included in the project bid item list. However, of the 443 change orders, there was no clarity with respect to 200 change orders. From the available documentation, the researchers concluded that, of these 200 change orders, 77 change orders contained items that were probably included in the project bid item list. These change orders are included in the list of 98 change orders identified above.

- **Identify whether the utility adjustment is included in the utility clearance special provision**. For each change order, the researchers compared the available description and explanation content with references to outstanding utility adjustments in the utility clearance special provision. Specifically, the researchers checked for common utility owners, utility facility types or descriptions, and locations. Of the 443 utility-related change orders, the researchers identified 215 change orders that included a reference to utilities in the utility clearance special provision.

- **Identify whether the utility adjustment is planned or unplanned**. Using the results of the previous two items and the selection criteria in Table 10, the researchers identified whether a change order included an *unplanned* utility adjustment. As Table 11 shows, of 443 utility-related change orders totaling $19.4 million, 192 change orders totaling $5.3 million included unplanned utility adjustments (i.e., 43 percent by number of change orders or 27 percent by dollar amount). It is worth noting that, as Table 12 shows, 60 change orders totaling $1.7 million, i.e., some 30 percent of unplanned utility adjustment change orders, were probably questionable given the lack of definition regarding whether the change orders included items that were also included in the project bid item list.

It is worth noting that 153 change orders (i.e., 35 percent by number of change orders or 58 percent by dollar amount) fell under the category of *planned* utility adjustments because the utility adjustments were included in the utility clearance special provision, but the change order items were not included in the proposal bid item list. Combined with the 192 *unplanned* utility adjustments, the result is 345 change orders (i.e., 78 percent by number of change orders or 86 percent by dollar amount) that contained *unplanned* utility adjustment elements, either during design or during construction.

Table 11. Planned versus Unplanned Utility Adjustment Analysis Results.

		Totals	**Utility adjustment in utility clearance special provision?**	
			Yes	**No**
	Totals	443 $19.4 million	215 $13.5 million	228 $5.9 million
Change order item(s) in proposal bid item list?	**Yes**	98 $2.8 million	62 $2.2 million	36 $0.6 million
	No	345 $16.6 million	153 $11.3 million	192 $5.3 million

Table 12. Planned versus Unplanned Utility Adjustment Analysis for "Questionable" Change Orders.

		Totals	**Utility adjustment in utility clearance special provision?**	
			Yes	**No**
	Totals	200 $11.4 million	109 $9.1 million	91 $2.3 million
Change order item(s) in proposal bid item list?	**Yes**	77 $2.5 million	46 $2.0 million	31 $0.6 million
	No	123 $8.9 million	63 $7.1 million	60 $1.7 million

General Observations and Lessons Learned

General observations and lessons learned from the analysis of utility-related change order cost data include the following:

- Of 443 utility-related change orders totaling $19.4 million, 191 change orders totaling $5.3 million included unplanned utility adjustments (i.e., 43 percent by number of change orders or 27 percent by dollar amount). Extrapolating these results to the 1144 change orders totaling $55 million for 431 projects that were let from 1999 to 2007, it is likely that some 490 utility-related change orders totaling $15 million included unplanned utility adjustments. If the calculation uses 345 change orders as a reference (i.e., 78 percent by number of change orders or 86 percent by dollar amount that contained *unplanned* utility adjustment elements), extrapolating these results to the 1144 change orders would result in some 890 utility-related change orders totaling $47 million. In other words, the analysis indicates that the monetary impact of unplanned utility adjustments for 431 projects that were let from 1999 to 2007 was probably somewhere between $15 million and $47 million.

- These results notwithstanding, the analysis of the data uncovered deficiencies in the way TxDOT gathers and stores utility-related information in change orders, which has an impact on the effectiveness with which TxDOT documents utility-related issues during construction. A summary of issues and resulting recommendations follows:

    - **Emphasize clarity and completeness in utility clearance special provisions**. The sample provisions the researchers examined were often vague. For example, the special provision would include a list of utility companies, but the location of the adjustment and the type of facility (e.g., 6-inch gas main) would be incomplete or missing. Utility companies frequently manage more than one type of utility facilities (e.g., gas and electric). Without knowing the facility type and other relevant characteristics, it is difficult to associate a change order to the special provision and to the proposal bid item list. In addition, many utility clearance special provisions did not include water and sanitary sewer providers, especially when these providers were part of local government agencies.

    - **Include consistent item, quantity, and cost estimate data in the change order database**. Without a change order item list and a quantity and cost estimate sheet it is very difficult to rely on change order descriptions and explanations alone to understand and document change orders properly. Without that information, it is certainly difficult to verify if change order items were originally included in the project bid item list. Consider the following examples:

        - A change order might simply state that the change order "includes revisions to the sanitary sewer at …" or "additional third party work requested by …"

        - A change order description includes references to multiple items, some of which loosely correspond to items in the bid item list. This situation requires interpreting change order items and costs to establish a difference between planned and unplanned items. Without a clearly defined change order item list it is very difficult to distinguish how much of a change order is the result of a planned or unplanned adjustment.

        - A specific change order item is not on the bid item list but a similar item is. This situation makes it difficult to ascertain whether the change order item was indeed included in the original bid item list.

    - **Use change order reason codes consistently**. A review of change orders revealed many cases in which the reason codes were not consistent with the corresponding change order descriptions. For example, change orders with reason codes 6A, 6B, 6C, 6D, or 2G would have descriptions completely unrelated to utilities. In other cases, the description was evidently utility-related, but the corresponding reason code was not 6A, 6B, 6C, 6D, or 2G. In other cases, there were change orders with incomplete or misleading description content and/or reason code.

Project Claim Cost Data

The analysis of claim data yielded the following results and general observations:

- The total amount of utility-related contractor claims from June 1996 to October 2007 was $21.8 million. Of the 17 utility-related claims reviewed, 13 claims were settled or closed. The total settled amount for these claims was $1.6 million, which is significantly lower than the original amount claimed. Compared to the total change order amount ($55 million for 1144 change orders), the final settled amount for utility-related contractor claims was very low.

- On average, the time to settle utility-related contractor claims was about 492 days (or about 1 year and 4 months). Among the 11 settled contractor claims, the settlement time varied from 210 days to 848 days.

- The number of utility-related claims (17) was significantly lower than the number of utility-related change orders (1144). Although claims are only intended as a "tool of last resort" (which could explain the low number of utility-related claims), it is also possible that some utility-related claims could have been miscoded as not being UU or UK. This hypothesis is based on the researchers' experience while processing change order records.

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

SUMMARY OF FINDINGS

The interaction between the utility process and the environmental process is one that has not received proper attention over the years. The environmental process provides an opportunity to identify potential environmental and utility concerns, which makes it appealing to develop strategies to identify synergies between the environmental and utility processes more effectively. In particular, it is of interest to determine whether it is possible to gain efficiencies by moving certain utility-related activities upstream in the project development process and by better integrating those activities with the environmental process.

This report summarizes the work completed to provide an answer to the following questions:

- Is it feasible to obtain better existing utility data during the preliminary design phase and coordinate this activity with the environmental process?
- Is it feasible to increase the level of definition of design components during the preliminary design phase without affecting environmental requirements and processes to support the earlier application of utility processes?

Utility and Environmental Processes at TxDOT and Other States

The researchers conducted a review of the project development process at TxDOT, with a focus on environmental and utility activities. The analysis included a review of relevant documentation, including TxDOT manuals and business process diagrams, as well as meetings with stakeholders. The meetings with stakeholders enabled the researchers to understand how different TxDOT units implement different project development process phases and activities, gather input from stakeholders about pressing utility and environmental issues, and identify and discuss potential strategies to integrate utility and environmental processes.

There were two rounds of meetings. The first round included meetings with representatives of several divisions (Right of Way, Environmental Affairs, and Design) and districts (Amarillo, Bryan, Corpus Christi, Dallas, Fort Worth, Lubbock, and San Antonio). This round also included a meeting with FHWA Texas Division officials. The second round of meetings took place at the Houston, San Antonio, and Tyler Districts at the end of the research. These final meetings focused on lessons learned, additional discussions about the proposed strategies, and discussions about educational and information dissemination materials.

To assist in the discussion with stakeholders, the researchers generated a detailed activity-level swim lane diagram of the project development process using information from various manuals and flowcharts. Feedback from stakeholders at various meetings enabled the researchers to modify the swim lane diagram as needed. The current version of the swim lane diagram is product 0-6065-P2 and reflects recommended locations of certain PDP tasks that resulted from the development of strategies for integrating utility and environmental processes more effectively. Chapter 4 provides more information about those strategies. Chapter 5 provides more information about the methodology used to develop the activity-level swim lane diagram.

In general, the swim lane diagram is intended as a living document that can undergo modifications and updates in response to feedback from stakeholders.

A literature review of state efforts encouraging coordination between environmental and utility processes did not yield examples of practices in this specific area. The scan did reveal examples of initiatives and business practices in related areas that could be considered for implementation at TxDOT. Of particular interest to TxDOT officials was the implementation of the Efficient Transportation Decision Making process in Florida, which includes an Environmental Technical Advisory Team and a web-based environmental screening tool that enables resource agencies to provide feedback to FDOT officials during the planning and programming phase, i.e., earlier than the typical NEPA process. Also of interest to TxDOT officials were the utility-related training programs developed in Georgia, Minnesota, and Michigan.

Impacts of TxDOT's Regionalization Plan

The TxDOT regionalization initiative is one of the results of the recent sunset review process. The researchers evaluated the potential impact of regionalization on the optimization strategies developed during the research and/or the integrated business process diagram. The analysis was conducted at a high level because TxDOT's regionalization process had just begun and because the amount and detail of the information available on the regionalization plans was limited. The 2008 regionalization workgroup reports and some additional related documents were the main sources of information available. Of particular interest were the following workgroup reports:

- **Environmental workgroup report**. The focus of the environmental workgroup was to outline recommendations for restructuring the PCE review and approval process and the creation of environmental RSCs (called RECs in the workgroup report). Other processes, e.g., those related to the production of EAs and EISs, were not affected by the restructuring effort.

- **Right-of-way workgroup report**. The focus of the right-of-way workgroup was to improve efficiency, transparency, and accountability of the right-of-way and utility processes. The workgroup focused on all right-of-way functions.

- **Corridor planning and schematics workgroup report**. The focus of the corridor planning and schematics workgroup was to outline recommendations for planning and preliminary design activities that RSCs could undertake.

- **Contract management and design resource coordination workgroup report**. Detailed design was not one of the 18 functional areas that TxDOT reviewed as part of the regionalization implementation initiative. However, TxDOT formed a workgroup to evaluate contract management and design resource coordination.

The review of the workgroup reports focused on reassigned, new, or previously undocumented activities at districts, RSCs, and divisions. The review did not include activities that did not fit within the focus of the business process model, such as training activities or administrative procedures. In general, the researchers compared changes documented in the workgroup reports to the business process model the researchers developed during the research and made changes as needed.

Optimization Strategies

During the review of current practices and subsequent meetings with TxDOT officials, the researchers identified a number of potential strategies to integrate the utility and environmental processes and to integrate both processes into the project development process more effectively. Chapter 4 provides a detailed discussion of each of these strategies. In general, the discussion included a description of the strategy as well as a list of proposed changes to business processes and TxDOT manuals. The list of strategies is as follows:

- involve environmental and right-of-way staff in planning and programming,
- establish planning advisory teams and support tools,
- coordinate environmental and utility data collection,
- enhance and coordinate preparation of scopes of services,
- require utility owners to verify utility facility information,
- gather some QLB data during preliminary design,
- include some drainage design elements during preliminary design,
- include some design elements during preliminary design,
- address utility issues in constructability review during preliminary design, and
- develop and/or update curricula for utility coordination stakeholders.

As mentioned previously, the researchers conducted meetings with Houston, San Antonio, and Tyler district officials. The meetings focused on lessons learned, additional discussions about the proposed strategies, and discussions about educational and information dissemination materials.

An additional strategy discussed with stakeholders was related to the need to integrate reference manuals at TxDOT more effectively to address a concerned expressed by the 2008 Sunset Advisory Commission report in the sense that the TxDOT project development process is too "complicated," making it difficult to understand how important decisions are made. A review of several TxDOT manuals led to a number of observations such as redundancy in content and activity descriptions, as well as inconsistencies in information aggregation levels; inconsistencies in the use, structure, and content of supporting documentation such as flowcharts; inconsistent activity code designations; and inconsistent manual structures. Eliminating these sources of inefficiency should contribute to a better understanding (and simplification) of the project development process at TxDOT.

It is possible to substantially reduce (or even eliminate) redundancy and inconsistencies across manuals by modifying the TxDOT manual structure from a structure in which each manual is a standalone product to another one in which different manuals are "stackable" modules within a larger coherent structure (see Figure 15). With the proposed structure, the PDP manual would become a "bookcase" with thematic shelves (e.g., planning and programming, environmental, right of way, utilities, and design). Redundancy would be greatly reduced or eliminated by presenting detailed information related to a topic *only once* (in its corresponding shelf and volume), instead of having similar information at different disaggregation and currency levels in different manuals, which is the current practice.

Integrated Business Process Model and Viewer

A review of existing business process diagrams at TxDOT led to a series of observations. In summary, TxDOT business process diagrams follow different structures and styles; the diagrams use ad hoc flowcharting methodologies and procedures, which make them incompatible with each other, and the charts are typically high-level diagrams that provide little detail and result in limited connectivity with the corresponding manuals. These characteristics make developing integrated business process models difficult. It is worth noting that TxDOT currently does not have a standard for developing business process models (*72*).

The researchers developed an integrated environmental/utility business process model based on a detailed review of current practices, potential regionalization impacts, and the optimization strategies discussed previously. The development also included a prototype web-based application called TxDOT Business Process Explorer to facilitate access to project development process information graphically. Chapter 5 provides a detailed discussion of the process to develop the business process model and TxBPE.

For testing purposes and for discussions with stakeholders, the researchers used Microsoft Visio with a BPMN stencil to produce business process models that could be printed on a single sheet of paper using large format printers. This strategy proved to be beneficial during meetings with TxDOT officials because it was possible to see the whole process at once and mark up the drawing as needed. The business process model includes five swim lanes that correspond to chapters in the PDP manual. Each swim lane includes activity groups and activities at different disaggregation levels. For completeness, activities include references and links to specific sections in existing TxDOT manuals. Activities can include references to multiple manuals. For completeness, the business process model also uses a variety of graphical elements, sequence flows, and color-codes to document functional group, swim lanes, activity groups, and activities.

To provide a general idea of the whole process at a high level, the researchers also developed an overview diagram (Figure 25) that offers several advantages compared to the PDP manual diagram (Figure 16), including the following:

- recognition that activity sequencing within the same swim lane is not necessarily linear,
- emphasis on interaction between swim lanes (therefore between different business units) with a focus on activities that can be completed in parallel, and
- depiction of major milestones.

To facilitate access to model information, the researchers developed the TxBPE application. TxBPE is web-based, but it is sufficiently flexible so that it can be accessed on the Internet, the TxDOT intranet, or from a local or networked computer drive. TxBPE could be extended to cover all project development activities at TxDOT. The current version of TxBPE focuses on environmental and utility-related activities during the preliminary design phase. TxBPE presents business process information at the following three levels:

- Level 1 – Process overview,
- Level 2 – Process details, and
- Level 3 – Activity details.

Preliminary testing indicates that TxBPE runs properly on local installations, but additional testing would be necessary for an installation on a central web server that is accessed by a large number of users.

Utility Delays and Related Costs

A research objective was to measure the economic impact resulting from planned and unplanned utility adjustments, as well as extract information to infer potential economic benefits that would result from implementing the strategies discussed in Chapter 5. However, the type of data needed to conduct a traditional economic analysis was not available. The process of gathering, reviewing, and analyzing available cost data did enable the researchers to develop an understanding of the type and quality of relevant utility-related cost data that TxDOT collects, which, in turn, enabled the researchers to make general observations about specific deficiencies and formulate recommendations for business process changes.

In most cases, the type and amount of information available were not enough to make a reliable determination of utility-related delay. In addition, many change orders included costs for items that were not necessarily related to the utility delay (e.g., barricades, overhead, increases in material costs, and additional work), making it very difficult to measure the actual impact of utility delay on road user costs at the individual project level. Nonetheless, the analysis revealed a very low percentage of utility delay-related change orders (about 12 percent of utility-related change orders or 0.5 percent of all change orders). This low percentage, which at first sight may be puzzling considering that utility adjustments are frequently mentioned as one of the most frequent reasons for delays in highway construction, is a reflection of the effort by project managers and contractors to reallocate resources during construction in order to avoid delays and finish projects on time whenever possible.

Although it was not possible to make explicit statements about utility-related delay, the available information enabled the researchers to make some inferences about *planned* versus *unplanned* utility adjustments. In principle, a *planned* utility adjustment occurs when there is adequate knowledge at the time of letting that a utility adjustment is necessary. Conversely, an *unplanned* adjustment occurs when there is *not* adequate knowledge at the time of letting that a utility adjustment is necessary. An analysis of 1144 utility-related change orders, which totaled $55 million for 431 projects that were let from 1999 to 2007, indicates that the monetary impact of unplanned utility adjustments for the 1144 utility-related change orders was probably somewhere between $15 million and $47 million, depending on the assumptions and factors considered.

An analysis of the data uncovered deficiencies in the way TxDOT gathers and stores utility-related information in change orders, which has an impact on the effectiveness with which TxDOT documents utility-related issues during construction. Specific strategies to address these deficiencies include the following:

- emphasize clarity and completeness in utility clearance special provisions;
- include consistent item, quantity, and cost estimate data in the change order database; and
- use change order reason codes consistently.

Based on information provided by TxDOT, there were 17 utility-related claims totaling $21.8 million from 1996 to 2007. Of the 17 utility-related claims reviewed, 13 claims were settled or closed. The total settled amount for these claims was $1.6 million, which was significantly lower than the original amount claimed. Compared to the total change order amount ($55 million for 1144 change orders), the final settled amount for utility-related contractor claims was very low. On average, the time to settle utility-related contractor claims was about 492 days (or about 1 year and 4 months). Among the 11 settled contractor claims, the settlement time varied from 210 days to 848 days.

RECOMMENDATIONS FOR IMPLEMENTATION

Based on the findings from the previous section, the researchers make the following recommendations:

- **Implement the 10 strategies discussed in Chapter 5**. That chapter describes each strategy in detail as well as a list of proposed changes to business processes and TxDOT manuals. For completeness, the list of 10 strategies follows:
    - involve environmental and right-of-way staff in planning and programming,
    - establish planning advisory teams and support tools,
    - coordinate environmental and utility data collection,
    - enhance and coordinate preparation of scopes of services,
    - require utility owners to verify utility facility information,
    - gather some QLB data during preliminary design,
    - include some drainage design elements during preliminary design,
    - include some design elements during preliminary design,
    - address utility issues in constructability review during preliminary design, and
    - develop and/or update curricula for utility coordination stakeholders.
- **Implement the prototype environmental/utility business process model**. Based on the feedback received from stakeholders across the state, the researchers recommend implementing and disseminating the environmental/utility business process diagram developed during the research. Actual implementation will likely include some refinements to the prototype, including activity disaggregation levels, as well as integration with other project development process components, in particular design-level activities.

The researchers also recommend replacing the current PDP manual diagram with another diagram based on the overview diagram developed in the research (Figure 25), which recognizes that activity sequencing within the same swim lane is not necessarily linear, emphasizes parallel interaction between swim lanes, and depicts major milestones.

- **Implement TxBPE**. The researchers recommend implementing TxBPE to facilitate access to project development process information graphically. Feedback from stakeholders indicates that TxDOT could derive substantial benefits from the implementation of a tool such as TxBPE. Actual implementation will likely include refinements to the prototype web-based application, including a potential reduction in the number of Level 2 sub models and a change in the software platform to facilitate application updates in response to business process changes. Implementation would also include developing the capability to display different versions of the diagram for different types of projects and creating linkages to project scheduling software currently in use at the department based on the updated list of activities described in the detailed swim lane diagram developed as part of this research.

- **Overhaul TxDOT manual structure**. The researchers recommend modifying the TxDOT manual structure from a structure in which each manual is a standalone product to another one in which individual manuals are "stackable" modules within a larger coherent structure. Redundancy would be greatly reduced or eliminated by presenting detailed information related to a topic *only once* (in its corresponding shelf and volume), instead of having similar information at different disaggregation and currency levels in different manuals, which is the current practice.

- **Implement a standard for business process models**. TxDOT currently does not have a standard for developing business process models. Based on the positive response from stakeholders while reviewing the prototype integrated environmental/utility business process model, the researchers recommend adopting BPMN as the standard for developing business process models at TxDOT.

- **Improve utility-related recording practices during letting and construction**. The process of gathering, reviewing, and analyzing available cost data revealed deficiencies in the way TxDOT gathers and records utility data during letting and construction. Specific recommendations to address these deficiencies include the following:

    - emphasize clarity and completeness in utility clearance special provisions;
    - include consistent item, quantity, and cost estimate data in the change order database; and
    - use change order reason codes consistently.

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